ISLAMIC REPUBLIC OF PAKISTAN

The Project for Technical Support to Auto Parts Manufacturing Industry

Guidelines/Manuals for consulting services to auto-parts suppliers (English Version)

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Islamic Republic of Pakistan
Small and Medium Enterprises Development Authority – (SMEDA)

Islamic Republic of Pakistan

The Project for Technical Support to Auto Parts Manufacturing Industry

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ものづくり指導手引書 (英語版)

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Contents

1. Purpose of Teaching / Coaching

The project support system members, SMEDA,PAAPAM engineers and local consultants, who are beneficiaries of JICA Experts OJT on technical support to auto-parts manufacturing industry are required to conduct their consulting services to auto parts manufacturing factories regarding Japanese method of production management such as productivity, quality assurance and other individual work fields.

The guidelines/manuals are being positioned as their teaching materials when they are to start their consulting services newly to auto parts manufacturing industries here in Pakistan by themselves when JICA Experts left the country. The final goal focuses on teaching the industry to reach the internationally competitive and high level to guarantee the parts with imported product level.

The members are to realize to teach/coach not only auto-parts manufacturing industry but also other sector of manufacturing industry here in Pakistan.

2. Basic Policy of Teaching / Coaching

The guidelines/manuals requires the 8 following points which lead basic idea of required manufacturing method.

Basic 1: Realizing that the basic of manufacturing is fostering human resources in your factory.

Basic 2: Required factory management starts from 5S implementation.

Basic 3: Required kaizen implementation starts from elimination of MURI(Unreasonable),MURA(Inconsistency) and MUDA(Waste).

Basic 4: Required manufacturing operation starts from insured operational conditions.

Basic 5: Required quality assurance starts from realization on quality first and implementation of process completion and in-stage quality creation.

Basic 6: Required on-site/floor management starts from 3-GEN policy and implementation of visualization.

Basic 7: Required continuous improvement starts from implementation of repetitive PDCA cycle.

Basic 8: Required preventive management of defects starts from implementation of 4M changing points management.

3. Policy and Guideline of Teaching / Coaching

3.1 Policy of teaching/coaching

(1) Realization on Quality First：To keep competitiveness in terms of product`s quality level.

Step 1: To execute competitiveness of the products in the region (domestic territory).

Step 2: To reach the internationally high level of the product in terms of quality competitiveness.
* Quality creation from design development to be conducted.

(2) To conduct high level customer satisfaction (Quality, costing, delivery and after services)

(3) Required concern kept on factory environment and operation safety.

(4) To provide the utmost contribution to the community.

(5) To structure win-win relationship with all stake-holders.

3.2 Guideline

(1) Start from the grasping the present condition of shop floor
  1) Organization, factory situation, working condition, person in-charge
  2) Parts manufactured, volumes, drawing, specification, standards
  3) Current tasks, the past counter-measures conducted
  4) Confirm the factory's task and teaching request by the consultants

(2) Start of teaching/coaching;
  1) Analyze of teaching/coaching contents
  2) Decide its priority on teaching/coaching
  3) Scheduling of teaching/coaching
  4) Conduct teaching/coaching(whole factory improvement, productivity, quality management and others if any)

4. Contents of Guidelines / Manuals

Per the Records of Discussion between Government of Pakistan(SMEDA) and Japan(JICA),fundamental skills of the project support system members such as SMEDA/PAAPAM engineers and local consultants are required to be developed.

The 9 following points are being materialized.

Each item shows grand design of teaching/coaching as its essential part, using the self-evident charts and conduct teaching/coaching by using graph as well as case studies. Each point includes 3 stages such as;

(A) Introductory level;
(B) Required standard level;
(C) Advanced level.

It will help the teaching/coaching applied to any kind level of the target factories.

A: Introductory, B: Standard, C: Advanced

No		A	B	C
1	**Confirmation of Parts Development Capability** (Understanding of OEM Production Diagram / Requirement Specification Diagram) (Drawing Development) (Flow of Development (approved drawing design – mass production)) (Other (recent development requirements etc.))	○	○	○ ○
2	**Use of Standards Documents** (Understanding Standards Documents) (Design Standard, Quality Standard and Work Standard) (Building of Standard Compliant Implementation System)	○	○	○
3	**Production Engineering** (Basic for manufacturing) (Production / Process Planning) (Lay-out, Machine, Man, Scheduling and planning) (Investment, Profitability Plan, Business Plan)	○	○ ○	○
4	**Quality Management** (Quality Monitoring) (Defect Proactive Response / 4M Change Point Control) (Quality Control in PPAP) (QC 7 Tools)	○ ○ ○	○	
5	**Production Management** (Understanding FIFO, In-process Item and Stock) (Order-Production-Shipping Flow and Production Planning)	○		

6	**Kaizen/Improvement Capability** (Enthusiasm and Action of Top Management) (KPI Monitoring) (QC Circle) (Cp / Cpk, PPAP) (Process FMEA) (Enhancement Team Power, Horizontal Development, Skill Hand Down)	○ ○ ○	 ○ ○	
7	**Corporate Power** (Confirmation of Vision, Mission, and Quality policy) (Cooperate Culture and HR Management) (Future Concept) (Strategic Management Approach BSC)	 ○		 ○
8	**Factory Management** (5S / 5T Activities) (Visual Control) (Formulation of System / Method in the Factory)	○	 ○	 ○
9	**Individual Work Fields** (Gas Welding) (Resistance Welding + Aluminum Welding)	○ ○		
10	**Press, Die and Mold** (Mold / Die and Press Process) (Press Facilities) (Maintenance of Press and Press Die)	 ○ ○ ○		
11	**Machining** (Lathe, Milling) (Drilling) (Reamer, Thread Cutting) (Grinding Process) (Gear Machining) (Tightening)	 ○ ○ ○ ○ ○ ○		
12	**Other Individual Technical Skills** (Parts Point Process) (Aluminum Material) (Aluminum Casting) (Plating) (Heat Treatment) (Forging)	 ○ ○ ○ ○ ○ ○		

5. Individual Work Fields of Teaching

5.1 Confirmation of Parts Development Capability

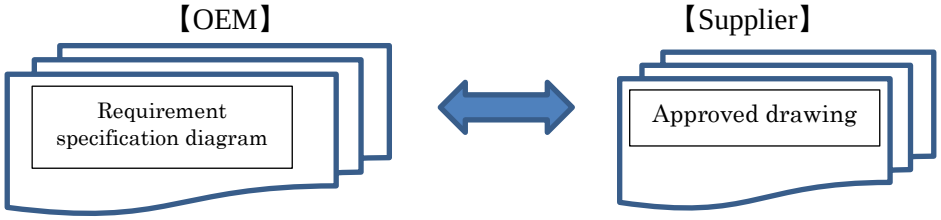
① Understanding of OEM Production Diagram / Requirement Specification Diagram

No	Contents	A	B	C
1	(1) Definition of a part targeted for a figure of demand specifications： Generally, referred to as a purchased item, it indicates a part that the OEM partly designs because the supplier mainly has parts（※1）having performance/function or basic know-how for achieving the function. Request specifications for parts development and production are presented from the OEM, detailed design (production drawing) is made by supplier, and OEM is developed in a form approved by OEM. e.g.(※1)：H-VAC, Brake, Lamp, Steering(Gear/Wheel), Starter, A lternator, Meter Assy, Switch, Sensor, Wire/Harness/ Hose, audio, etc. (2) Detailed item grasp as confirmation of parts development capability： New inquiry information from the client is requested as follows. Design specification：Requirement specification diagram（Spec Control Drawing） Mass production conditions：Production / Quality Requirements in APQP(Advanced Product Quality Planning:TS16949 Requirements) On the other hand, the OEM provides the production drawing and all the parts which are produced and delivered based on this drawing and they are defined as “outsourced item” for the “purchased item”. ＊In Pakistan, only few OEM's suppliers have purchased items that are compliant with the required specification diagrams, and outsourced items supplied by OEMs are mainly used. However, it is anticipated that parts handled by purchased items (parts corresponding to required specifications) will increase in the future improvement requirement improvement rate.	○		

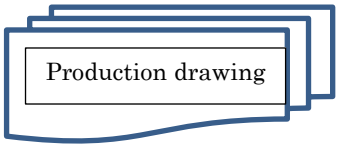
② Drawing Development

1	Outline of drawing development： Drawings received from customers can be roughly divided into requested specification drawings and OEM production diagrams. (1) Requirement specification diagram (Spec Control Drawing)： Specification request diagram for detailed design of parts production ・Describe dimension data (including CAD data), required function, usage environment, technical standards to be complied, legal requirements and standards, safety standards, environmental standards, hazardous substances, required performance (durability times, warranty years, vehicle interfaces ・Suppliers (parts manufacturing companies) are responsible for detailed design of parts and products, and quality assurance due to design is supplier`s responsibility. (2) OEM Designing Production Drawing ・It refers to design drawings that OEM can produce and the suppliers will produce according to this drawing. In some cases, it is accepted as part of the above requirement specification diagram. In this case, the following application form is submitted to OEM including this production drawing. (3)Approval application drawing (Approval Drawing) The supplier submits the approval application drawing (production drawing) for which the supplier has adjusted and specified the specification details to the manufacturer. (Depending on the OEM, it is	○		

called a receipt drawing)。
After receiving approval from the OEM, this approval application drawing will be the design drawing from a prototype as a production drawing to the start of mass production.

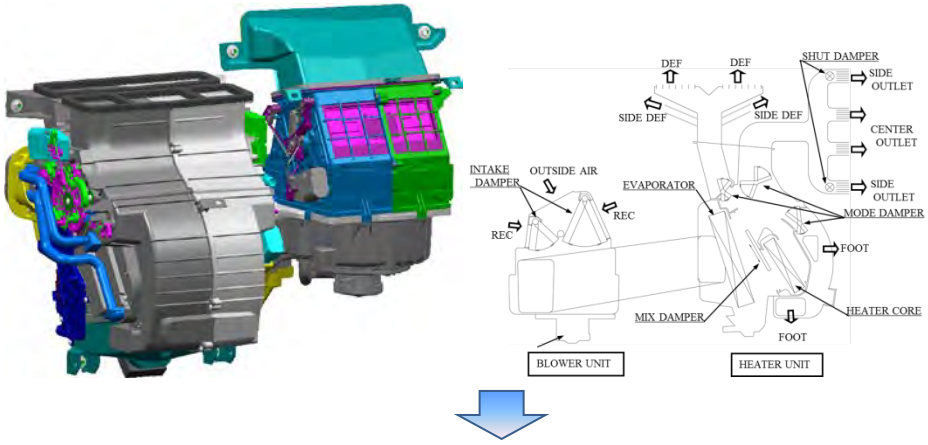


Production drawing(Approval drawing/Receipt drawing)：This drawing shows the above approval drawing or a manufacturing drawing constituting the drawing and the supplier describes all design information (dimensional data, shape, construction method, material, performance [durability performance, environment]). Products are manufactured according to this, the quality responsibility as a vehicle often becomes a client responsibility (the responsibility range is determined by the development contract)



＊Drawing type：Depending on the manufacturer, there are cases where it is layered separately from design drawing, manufacturing drawing, and inspection drawing. For drawings approval, only design drawings are submitted. Manufacturing approval is done by vans and purchasing.

【Image of required specification】
Required specifications (OEM)



Based on the OEM requirement specification, Supplier submits detailed specification, production drawing, approval drawing showing detailed specification, and OEM approves it.

＜Supplementary matter＞

＊Along with the expansion of current regulations in the future, we anticipate that the era in which not only parts production but also as a development maker is needed to come to PAKISTAN. And we propose the following items that will be necessary in the future.

A. Training advanced technology :

・To strengthen QCDET (quality, cost, delivery date, engineer [people], technology [equipment]) and product development capability that can surpass other manufacturers to make the characteristics (features)

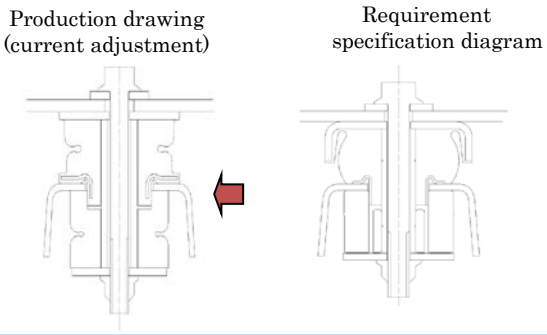
B. Shelving technology :

・Accumulate and standardize the intrinsic technology (4M), analysis method (CAD, CAM, CAE) obtained by developing and completing new products.
To have a database (technology withdrawal box) in advance to respond to needs from clients (OEMs) or from market information and keep new technologies, new mechanisms, differentiation, and intellectual property (including software) organized.

C. By conducting a benchmark (other company survey), supplier need to grasp the competence of other companies and make effective use of products and products that can surpass other companies with QCD.
Be sure to turn PDCA efficiently so that there is no loss of just timing and opportunity loss for new orders.

D. When reflecting specifications to be added or changed as required know-how not in the required specification of OEM, technical backing and market performance are presented in the design review.

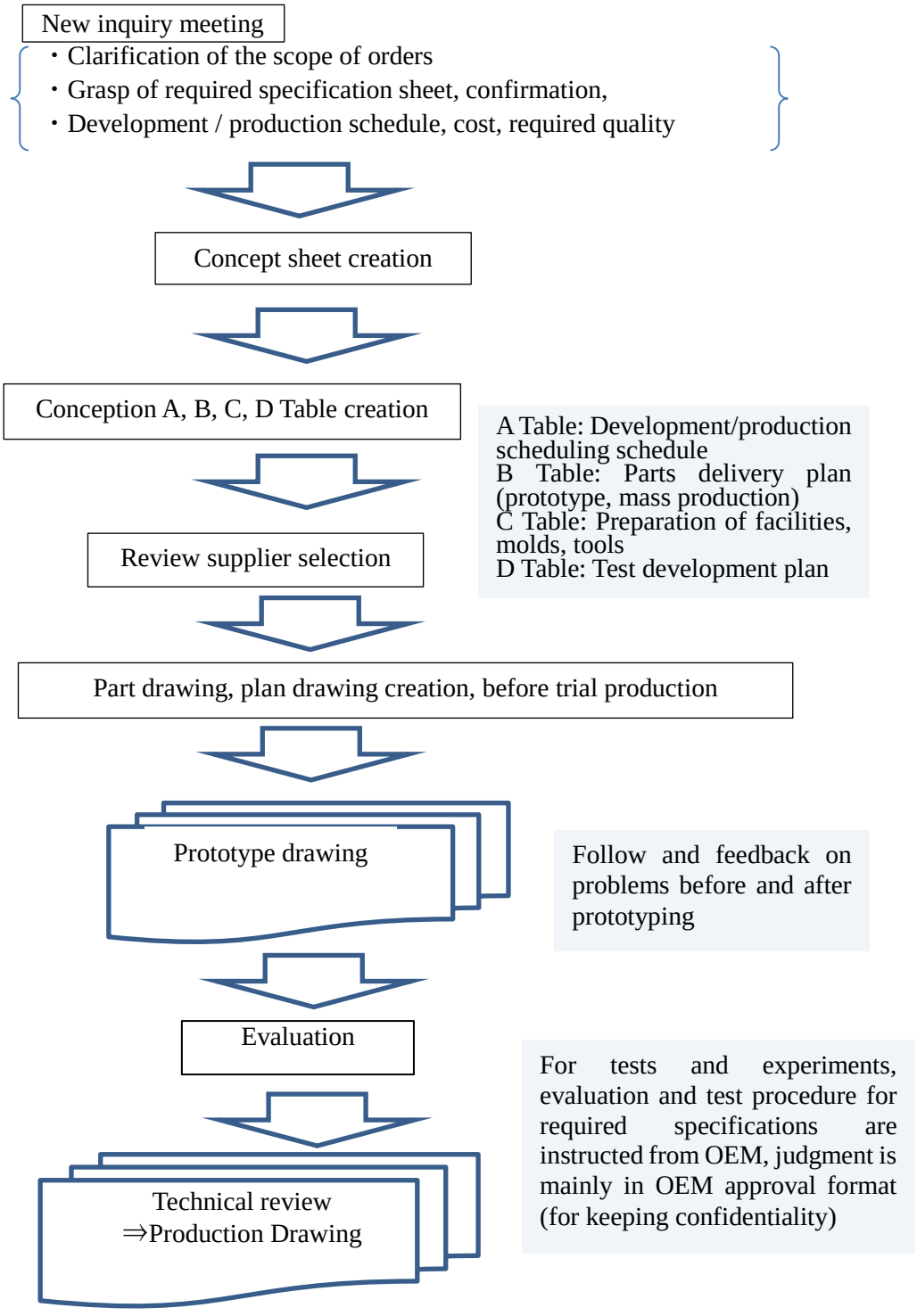
・Example : Body Mount



When adopting a conventional product (present adjustment product) with a different form to the required specification, certify that there is no difference in specifications, performance, reliability required for OEM, market performance, etc. and get approval.

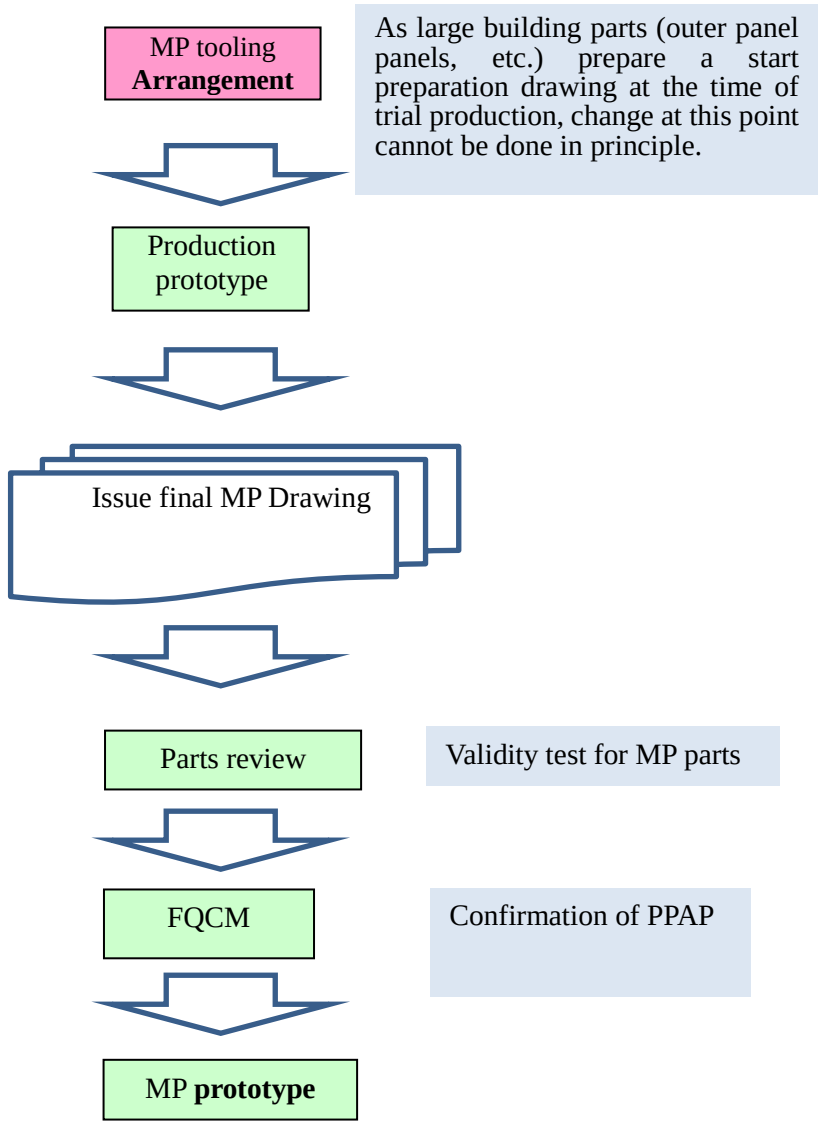
③ Flow of development (approved drawing design - mass production)

1	Development flow Request specification drawing is issued from the client as described above, and from the point of view in the approval diagram exchange, the designing by manufacturer side will start, and the development starts. (1) Approved diagram design :		○	

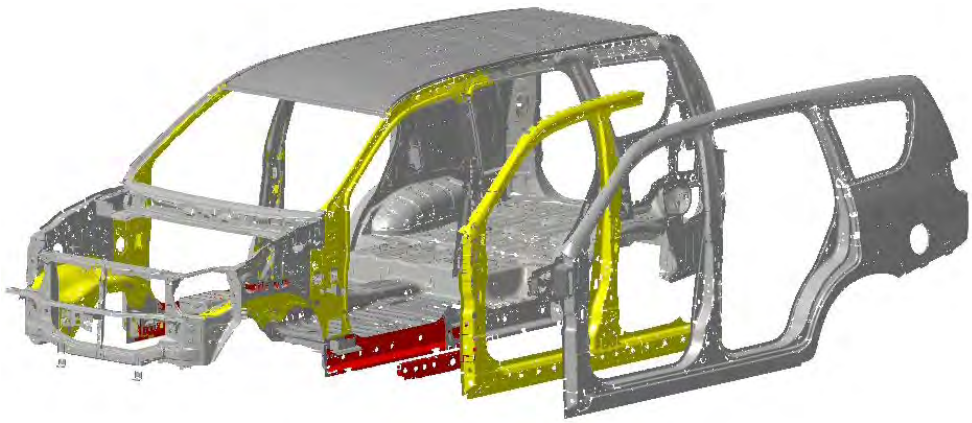


(2) Flow to mass production start

Prototype ⇒ Mass production drawing is issued after design review and mass production preparation is done.



④ Other (recent development requirements etc.)

1	(1) Design in : Supplier direct design development to OEM vehicles regardless of required specifications. This activity is a stage until vehicle concept, design are decided, competing several companies for superiority in function, vehicle assembling ability, quality, and taking an optimal solution selection method. ⇒ Many are adopted for newly developed parts (2)Design review In the case of parts requiring particularly high supplier know-how in the approval application drawing to be submitted for the OEM requirement specification, design review by the supplier may be required in some cases. The supplier verifies the compatibility of the required specifications of the OEM against the required specifications that are difficult to develop / study in detail by OEM, explains to the OEM, makes recommendations, and correct if the required specification is required. (3) Partial importance rank We attach importance rank to parts that affects safety quality (※2) legal requirement (※3) and serious productivity (※4) on parts or components as a whole. (e.g.: A-Parts, S-Parts: OEM designation differs.) Assurance that the target parts satisfy the reliability required from the OEM. Specific examples are shown below. ・Perform durability reliability test, life test (test until breakdown) ・OEM side confirmation of sample parts ・Production assurance such as process audit and plant certification (stipulated by PPAP) ※2 : Travel function parts such as brake, suspension, steering, Passenger protection parts such as airbags, seatbelts, seats, door latches, Tow board, center pillar reinforce, crash performance such as instrument panel, Parts which can affect passenger injury. Parts which can lead to fire such as fuel tank / pipe, canister etc. ※3 : Regulatory parts such as exhaust gas related devices, lamp / turn signal etc. ※4 : Parts leading to critical function malfunction such as ECU, fuel pump, AT shift lever etc. Engine stall, shift lock etc. 【Example of A Parts in Body: Colored part】 			○

2	<u>Examples of requirements used in the development process</u> (Order Development) Examples of requirements used in the development process (Formation of order) (1) : Order: Create a detailed development schedule. Order approval Detailed development schedule (2) : Design planning stage: basic design drawing, design basic concept, benchmark, preparation for FMEA, etc. (3) : Produce prototype correspondence drawing: creation of request for quotation. (4) : Technical review / parts review: Reflected in design review, non-common part reduction table, basic functional test. (5) : Design improvement reflective prototype: reduction of non-common parts, development test, problem handling in finished vehicles, problem, clarification of MP specifications (6) : Design Review: Master Schedule Chart, Detailed Design Configuration, Benchmark Analysis, Clarification of Customer Specifications, Past Problem Prevention (7) : Concept sheet (8) : MP tooling adjustment: Create parts list, set MP drawing number, issue production preparation drawing, issue actual drawing of the car (9) : Issue official drawing of MP (10) : Prototype production (11) : Confirmation test for specs confirmation: appearance improvement, actual vehicle equivalent ride test (12) : Part review: inspection method, standard, measures to avoid mistakes	○ ○ ○ ○	 ○ ○ ○ ○ ○ ○ ○	 ○ ○

5.2 Use of Standards Documents

① Understanding the Standards Documents

No	Contents	A	B	C
1	**Understanding the standard** **With standard** Daily business activities, which may be considered as production activities for the sake of clarity here, are executed according to specific rules (drawings, specifications, purchase agreement, etc.) for delivering the products with functions / performances agreed to with customers. Standard is the document which describes clearly the organization's system and specific methods in order to carry out such rules. It is said that standardization to rule the activity by standard document. The key to successful day-to-day activities and management is maintaining and KAIZEN the standard. While adhering to the technical, management and work place standards that we currently have, we also KAIZEN the current process to raise the current standard to a high level. As the quality of work processes improves, fewer errors, fewer internal defects, fewer reworks, shorter lead times, and fewer materials used. Quality improvement means improved profitability, and the starting point is standard. In order to create a documented standard, to drive standardization and to be successful, we need to do four things: (1) What users can do (2) What you can follow (3) Easy to understand (4) Continue to improve the standards There are some cases in which management does not comply the standard themselves in Pakistan, but this is out of the question. It should be emphasized that the 5S activities are effective in providing education and guidance so that employees can take the lead without thinking about adhering to the standards. **Main features / effects of the standard** It reflects the knowledge and know-how cultivated by the activities of each company, and the specific features are described below. 1. It shows the easiest, safest and best way to work. 2. It is very effective in retaining know-how and expertise. (It is effective for formalizing tacit knowledge.) 3. It serves as a basis for maintaining the current status, and also serves as a basis for defeating the current status by KAIZEN. 4. It is effective for worker training and goal setting. In addition to documents, illustration, photos, etc. are also valid. 5. Updating the standard leads to the prevention of mistakes and the minimization of variations.	○		

② Design standard, quality standard and work standard

1	**Design standard, quality standard and work standard** Among the clearly written rules necessary to satisfy the quality demanded by customers, design standards, quality standards and work standards are particularly important in production activities. (The company also has management standards such as work regulations, but it is not covered here.) **With design criteria** In order to meet customer requirements for quality at the lowest cost and in the shortest time, the standard clearly stated the best methods and procedures to be achieved by using the management resources owned by each company. Design is divided into product design and process design. The following process design standards need to be implemented in Pakistan's manufacturing industry. **Process design standard** a. Process design is a design document of how to make things, and it defines the procedures, materials, equipment, time, and number of personnel required to make things. This is an important task in the manufacturing industry, since the amount of investment, cost and profit ratio are almost determined in process design. At this stage, it will be important to carry out cost control and to avoid situations in which mass production has actually started and no profits. b. Specifying rules for making process design documents becomes process design standards. The process design document changes depending on the proficiency level and knowledge of the engineer who creates it, and the productivity of the worker of the factory of the target product, even if the preconditions are the same. The continuous improvement throughout the entire production activity should be implemented. An example is shown. * Read the required work from the drawing and estimate the work time. If the target cost cannot be achieved, improvement will be necessary. In this case, simply reducing the individual work time results in a loss of quality. * For example, when the same operation is repeated several times, man-hours can be reduced by reducing attachment and detachment to a jig by making or KAIZEN a jig. * Consider changing the layout of the work area and shortening the access distance / time to parts. * If 5S activities are conducted, it is easy to optimize parts storage. **Quality standard** Quality includes the quality of the work of developing, producing and selling a product or service, but here we will describe the creation and delivery of the product on site. Product warranties in the market require arrangements with the customer. It starts with the purchase of materials necessary to make a product, and clearly documents the rules of manufacture and shipping. That is, it is a rule necessary to perform resource management (people, equipment, materials, work method and measurement) performed on site. The minimum requirement is that the person in charge, the method, and the criteria for measurement and judgment are clear. The following standards are listed as an example. * Acceptance inspection standard * Outsourcing control standard * Inspection standard for each process * Final inspection standard * Shipping standard * Equipment inspection, maintenance standard * Inventory management standard ... etc. **Working standard** With regard to the work content that the worker carries out for each process, the procedure of human operation and machine operation is defined as the best one at present so that the same result can be obtained regardless of who carries out. Necessary to optimize safety, quality and efficiency. It goes without saying that it is necessary to constantly improve, but		○	

	at a minimum, it is necessary to specify 1.operation procedure, 2.important points, 3.reasons, 4.description of abnormal situation and action for abnormal situation occurrence. Workers will be quicker to remember and easier to execute if the reason is known. The following is an effective method for creating work standards. * Create small people group including work person in charge of work. Workers themselves are also easy to implement by participating in creation. * By making a group, the knowledge and know-how possessed by each are reflected, and can also foster fellowship. * Workers themselves understand the importance of their work by analyzing their work, and foster a sense of responsibility and a sense of role. Work standards are the safest and easiest way for workers, and the most cost-effective and productive way for companies to guarantee quality to their customers. It is expected that work standards will be created that incorporate the company's assets such as knowledge and know-how possessed by each company.			

③ Building of standard-compliant implementation system

1	**Building of standard-compliant implementation system** It starts with a firm understanding of how important standards are. At the GEMBA, there are two major activities on a daily basis regarding management resources (4M) management. Keeping the status quo and kaizen. Maintaining the status quo means maintaining and managing the status quo according to existing standards. The second is to raise the standard itself with KAIZEN. Site supervisors work on either of two functions and deliver some results on QCD (Quality, Cost, and Delivery). Companies achieve QCD, that is, deliver products that exceed the quality required by the customer on a due date on a reasonable price basis, satisfy the customer, gain the trust of the customer, and increase the creditworthiness of the company. As a result it leads to increase of sales and profit. You need 4M management on a daily basis to realize the QCD that customers want, and you need a standard to implement efficiently. Every time a problem or abnormality occurs, the supervisor investigates it, identifies the cause, corrects the existing standard or introduces a new standard, and implements measures to prevent the recurrence of the problem. The standard is one of three major KAIZEN activities: standardization, elimination of waste, 5S, and provides excellent results for QCD. Standardization, elimination of waste, and 5S are low-cost activities that do not require large investment based on common sense, and can be introduced immediately. However, it is difficult to carry it out continuously, and it is necessary to establish the self-discipline necessary to maintain it. If the importance of standardization is understood, it will be possible to "Building a standard-compliant implementation system". “Building of standards-compliant” requires “Building of self-discipline”. Will be shown how to do it as one example. The first step is for management to show a firm determination to carry out standards-based activities. If management does not show that they are highly motivated, self-disciplined, and keen on Kaizen, employee will not work to maintain and improve standards and QCD. It is not possible to achieve the goal (customer's requirements) and satisfy the customer. The fact that posters (5S activities, safety first, safety gear wear, etc.) are posted but no activities are being done is a fraudulent example for employees and a bad example of becoming a company that is not trusted by employees. It needs to be recognized this fact. If this problem is solved, it can proceed to the next step. Needless to say, self-disciplined workers are reliable, work on time, maintain a clean, tidy and secure working environment and adhere to existing standards. List examples of ways to make workers acquire self-discipline (in random order). Each company should consider and implement these. As it is often said, having knowledge and just knowing, is useless and results do not come out. * Continue 5S activities. (The 5th of 5S activities is “Shituke”, i.e. self-discipline.) * Clearly communicate what you expect. * Conduct an assessment. Feedback the results.			○

	* Introduce a reward system. (Reward the effort.) * Participate in the standard settings. (The participants' attitudes and awareness change.) * Teach a method and explain the reason. * Show and share successful examples. * Create an environment in which work hard together with peers. (Competition among divisions is also effective.) * Create an environment in which work together with colleagues at work. (Making a standard in a small group.) * Accept questions freely. (If you are not convinced, you will not do it.) * Create a corporate culture to praise. * Introduce Kaizen proposal system. * Introduce a QC circle. Perform process verification frequently. * Not neglect to do KAIZEN about standard. Self-discipline means that all management and employees work according to pre-agreed rules. The activities of all participants can also be expected to develop into TQM and TPM activities.			

5.3 Production Engineering

① Basic for manufacturing

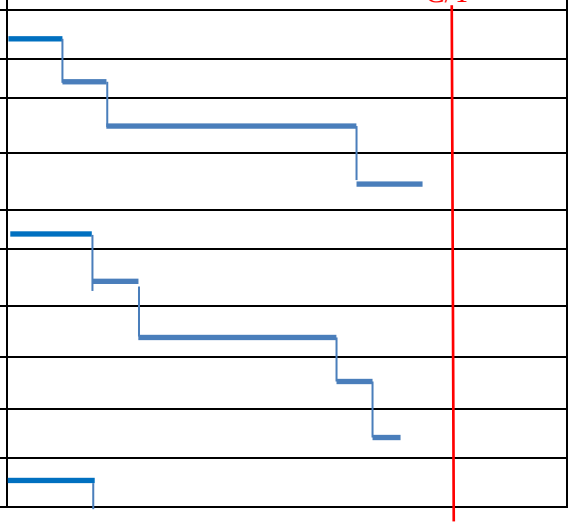
NO	Contents	A	B	C
1	<u>Manufacturing starts by confirming the production conditions</u> 1)Produced parts, planned volume, production preparation, confirming production and shipment scheduling 2)Confirming OEM production drawing, OEM specification and OEM standards documents Case-1 : Explicit instruction of specification and standards in the drawing(Japanese OEM mainly) Case-2 : No instruction of specification and standards in the drawing, separate material data/documents.(EU and US OEMs mainly) 3)Need to obtain and confirm every required information from OEM such as Drawing, specification, standards on design/quality/testing/operation/inspection etc. Reconciling the contents with the factory situation.	○		
2	<u>Basic for manufacturing</u> 1) Fundamental rule is to manufacture based on production drawing, required specification and standards documents. Japanese car assembly OEMs reach internationally recognized level. Therefore it is required standard for auto-parts makers to prove the capability of parts manufacturing per the required specification from major OEMs. 2) When encountering the case of non-compliance with OEM production drawing, required specification, standards documents, the suppliers are to consult with OEMs and obtain their approval finally. ① Non-procurement of materials required→ approval for substitute materials ② No-existing of relative equipment→ approval for substitute process and alternative work operation 3) Response from OEMs towards substitution request(various replies from OEMs) ① category-1 : No substitute→ when no applicable to drawing, change supplier. ② category-2 : potential substitute, assuming required safety and durable quality guaranteed ③ category-3 : substitute, obey to OEM's required quality		○	
3	<u>Approval from OEM on production preparation plan</u> 1) Approval required for process plan, QC process plan, equipment/jig & fixture plan, testing and inspection plan 2) Confirmation of production equipment and arrangement of jig & fixture（=To decide OEMs or in-house assets） 3) Approval required for on production preparation ,SOP and shipping schedule plan 4) Approval required for first part inspection condition, steady state testing condition, inspection schedule 5) Claims handling-coping/routing/negotiation of guarantee		○	
4	<u>Start of production preparation and SOP</u> 1) Set of production equipment, jig & fixtures (conception/design/estimates/evaluation/order and follow-up) 2) Procurement of materials (confirmed schedule, search suppliers, estimates, evaluation, order and follow-up) 3) Production trial, first part inspection, SOP planning 4) SOP(in-house order, man power allocation, confirming emergency measures）		○	

5	<u>Production maintenance after SOP, handling changed condition</u> 1) Planning of daily and hourly production volume and results control 2) Traceability(worker in charge per each process and each part, inspection records and shipping records) 3) 4M changing point management (pro-active and reactive measures at each changing point and its record keeping) 4) Defect policy/management (root-cause, counter-measures and roll-out to similar case)			○

② Production/Process planning

No	Contents	A	B	C
1	<u>To confirm Process contents in production</u> 1) To calculate Cycle time per Production volume 2) To plan Operation process & man-hour at each job 3) To plan required number of operators	○		
2	To make Operation process planning (FUNDOSHI) 1) To set up Standard Operation hour for each job 2) To make Operation process plan 3) Take notice on 2 or more operators job jointly 4) No inclusion of emergency allowance 5) To minimize operators moving distance 6) To minimize operators free time (to give another job) 7) To calculate number of operators including line keepers		○	
3	<u>To Make Action Plan at each process</u> 1)To make detailed process planning & layout 2)To plan required equipment, jig fixtures & tools 3)To make Operation Standard, Inspection standard 4)To make Inspection & Production record sheet		○	
4	Countermeasure & Preventive management 1) To make Countermeasure against emergency 2) To set up system for 4M change point management			○

Step	Job	Job description	Operation seconds C/T
1	1	Grip Parts & move to Jig	
	2	Set Parts into Jig & Clamp	
	3	Welding	
	4	Remove Parts from Jig	
2	5	Receive Parts & Clamp	
	6	Hand weld-nuts & set	
	7	Projection welding	
	8	Remove Parts from Welder	
	9	Put parts into Pallet	
3	1	Set Parts into Jig	



③ Layout, Machine, Man, Scheduling and Planning

No	Contents	A	B	C
1	**What is Layout plan of a factory？** Describe the layout plan for the most critical parts produced in the new plan of parts manufacturing industry. In parts manufacturing industry almost 80% of quality & productivity is determined during designing stage is well known but from the production side especially productivity point of view, it is said that 80% of quality is decided in layout. Therefore, factory layout plan plays the key role to determine the productivity, hence the concepts and methods described below are also applicable to improve existing factory layout.	○		
2	**Basic concept of layout planning：** Incorporate the following points when making a layout plan. 1. High Quality: Top requirement to win market competition. 2. High Productivity: Mandatory for higher profits. 3. Appropriate Investment: Mandatory for higher profits. 4. Safe & Healthy Work Environment: Worker protection requirement 5. Disaster Prevention Measures: Fire, earthquake, and theft prevention measures. 6. Visual Control of Production: Production status visual control system provision. 7. Future Developments: Increase in production & models handling provision. 8. CSR activities: Promote corporate social activities for the surrounding area & society.		○	
3	**Layout Planning Process steps** The specific procedures and key points of layout plan are described below. Consider layout plan by following these steps and record all those proposals on paper in chronological order, which could be utilized for later layout changes in future. 1. Draft production planning parameters: Production parts, annual production volume, and annual production plan. 2. Draft in-house operation facilities: Basic manufacturing process 3. Annual Production Schedule: Receiving Order, order raw material, production, stock, delivery schedule/volume 4. Draft Annual Production Lots & Production Sequence: 5. Annual Production Line wise & calculate Machine CT: 6. Prepare Annual Production Line wise & Machine standard operation sheet (FUNDOSHI): 7. Prepare annual production line straight line layout: In case of machines set operation time. 8. Describe the required production machines, jigs, racks, pallets in the above mentioned straight line layout. Incorporate the concepts of 5T & FIFO. 9. Describe the material, in-process parts, production parts flow frequency from factory IN & OUT gates for the above mentioned straight line layout. 10. Draft factory layout plan: Factory size, consider space in between pillars, and in principle based on minimum logistic flow concept draft layout, allocate machines & production lines by utilizing factory space effectively. 11. In the above-mentioned layout plan describe worker location & movement range (Based on FUNDOSHI)		○	

	12. For the above-mentioned layout specify, 1) Gemba (workshop)QC area, 2) Visual Control area, training room etc., 13. For the above-mentioned layout specify, 1) Factory office, office toilet, 2) Factory Entrance & Exit, Factory Toilet, 3) Power Room, Store, Material Store, Delivery Space, 4) Canteen etc., Describe factory appearance, worker flow and emergency exits, also calculate separately the store, raw material store, delivery area, draft the specifications and size. 14. Draft layout plan adjustable with further expansion on an annual basis. 1) Incorporate future expansion (1st term ～) 15. Connect the factory machines & lights with power source, 1) Electricity (Power wiring & lights wiring), 2) Plumbing work (Water, Air, Gas, Drain) layout draft 16. Power source specification (Incoming transformation electricity, water source, water treatment) plan and final location & construction specification, draft. 17. To factory plot site, 1) Factory building layout drawing, 2) Passages inside the building, 3) Parking Area, 4) Allocate Maintenance room, etc. 18. Check the final logistics flow, man flow, power flow and layout plan will be complete. ＊ Note 1 : There are certain constraints about land & factory layout depending on area, customs and religion. In such a case maximum effort to be carried out to consider this. ＊ Note 2 : Consider factory building direction in the land plot by daylight, wind & rain direction, appearance from the road. ＊ Note 3 : Regarding air pollution and waste water treatment follow the environmental regulation of local area.			

④ Investment, profitability plan, business plan

<table>
<tr><th>No</th><th>Contents</th><th>A</th><th>B</th><th>C</th></tr>
<tr><td>1</td><td><u>What is Investment:</u>
An investment is the funding for a business on the purpose of earning a profit. Figuratively speaking, investing a large amount of money for the benefit of the future. This manual targets capital investment of Auto parts suppliers to fund equipment arrangements for the purpose of producing new products (auto parts) in order to respond to customer orders and for direct market expansion.
Capital investment can be broadly divided into two types. One is a capital investment on tangible fixed assets such as factory or machine tool for manufacturing goods (visible). On the other hand, there are also capital investments in invisible objects such as development costs of products. This is called intangible fixed assets. The range of Intangible fixed assets are wide for example, investments in personal computer software, patent rights, trademark rights, etc. which are necessary for management and development. These are invisible unlike factories and machines.
The continuation of the capital investment by the company means the whole company is focusing on economic growth. If you want to know the growth of a company, it may be effective to check the amount of capital investment.</td><td>○</td><td></td><td></td></tr>
<tr><td>2</td><td><u>Approach of investment plan:</u>
This section describes the way in which the automotive parts suppliers subject to this manual invest in equipment for the production of parts. In this case, the investment should be planned with the minimum amount for the target project of the new part production to be managed. At this time, consider, judge and decide the use of the existing facilities by sharing, diversion, remodeling and modification.
The breakdown of investment items in case of Japan is shown below.
<table><tr><td></td><td>General-purpose investment</td><td>Dedicated investment</td></tr><tr><td>1 case 100,000 yen or more & durable life 1 year or more</td><td>construction cost</td><td>Fixed asset reserve cost</td></tr><tr><td>Other than those above</td><td>departmental expenses</td><td>Non fixed asset reserve cost</td></tr></table></td><td></td><td>○</td><td></td></tr>
<tr><td>3</td><td><u>Breakdown example of investment plan：</u>
Below is a breakdown example of the investment plan. Specific figures are excluded
(Unit: Rs Million)
<table><tr><td rowspan="2"></td><td colspan="3">Capital expenditure</td><td rowspan="2">Non-fixed reserve costs（Excluded number）</td><td rowspan="2">Main contents</td></tr><tr><td>Construction cost</td><td>Fixed preparation cost</td><td>Total</td></tr><tr><td>Sheet metal</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Weld assembly</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Resin</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Rigging</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Inspection jig</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Total</td><td></td><td></td><td></td><td></td><td></td></tr></table></td><td></td><td>○</td><td></td></tr>
</table>

Timing of implementation （Capital expenditure）	First half of 2019	Second half of 2019	First half of 2020	Second half of 2020	Total

4 ○

Profitability plan：

The profitability plan is to consider how much profit will be made in the business that will start from now on. Even if there is a high volume of sales, there may be no profit. The purpose of business is to create profit not sales. Therefore, it is necessary to fully verify how to create a profit.

For capital investment that raises production capacity, the profit or cash obtained by subtracting the expenses (such as direct material costs, depreciation cost, interest expenses, etc.) from the income (the increase of sales) expected from the investment, To evaluate profitability by comparing it with the investment amount.

It is easy to understand the financial plan by creating a table showing the Cumulative profit and loss for each period or year from the first year of investment. An example is shown below.

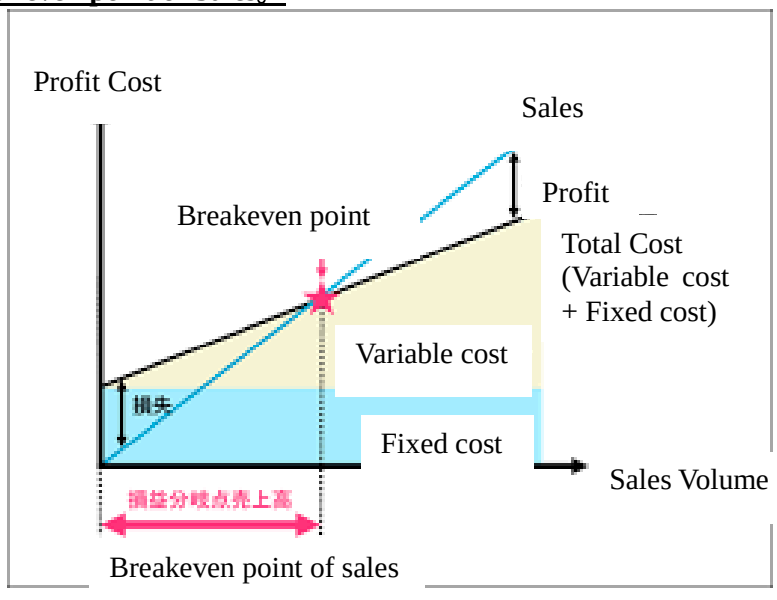
(Unit: Rs Million)

Overall profit and loss plan	2019	2020	2021	2022	Total
Production volume					
Marginal profit fluctuation①					
Fix cost increase②					
Profit increase①－②					

(Marginal profit＝Total sales－variable cost)

The specific investment evaluation method of the new investment project implementation judgment in small and medium enterprises will be described at ⑤Standard of business operation judgment below. Profitability can be judged by calculating whether sales volume over breakeven point of sales can be expected and whether the company can lower the breakeven point of sales by suppressing fixed costs and variable costs.

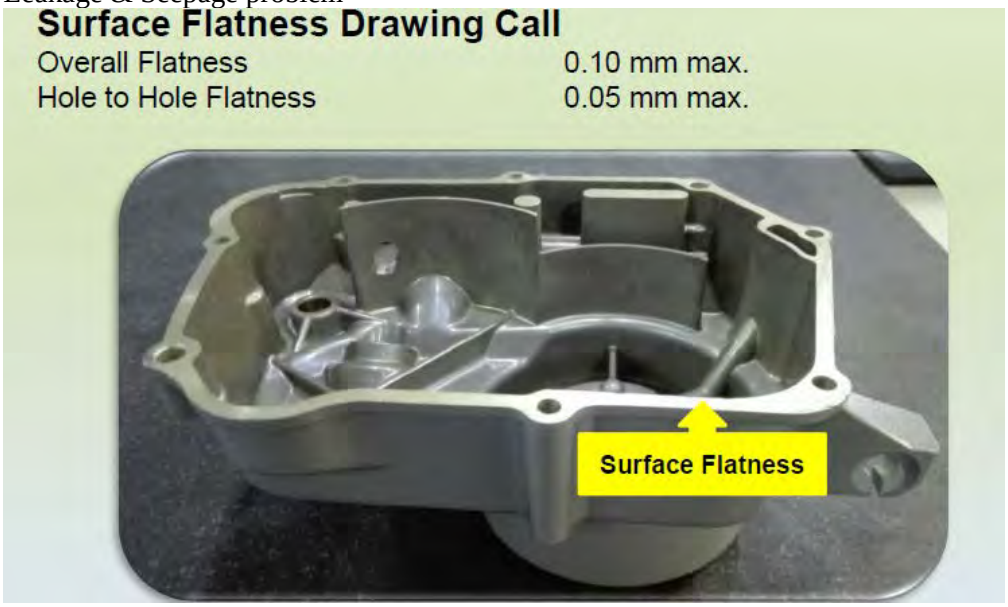
Breakeven point of Sales。

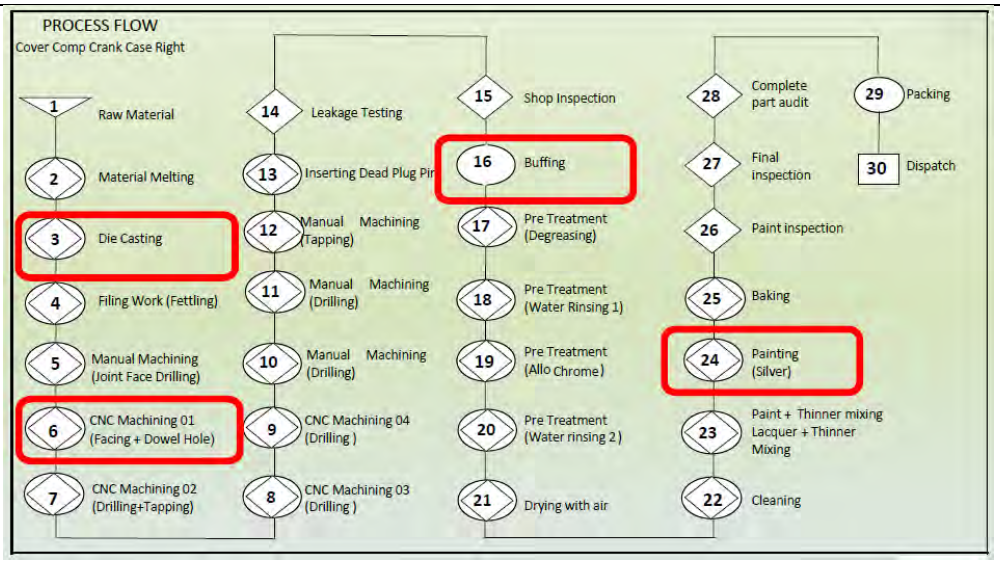


5	**Business plan：** A business plan is to set numerical targets, management policies, strategies, etc. as the specific indicators when starting a new business. It will lead to clarifying financial management and action plan for continuing the business, and helping to understand the investors and business partners. Business plan will also lead to clarifying financial management and action plan for continuing the business, and helps to understand the investors and business partners. The following contents should be included in the business plan and the plan should be evaluated by ⑤Business implementation decision described below. Implement and promote the business (project) by approving as a company. 1. Necessary reasons for the project (Back ground, purpose) 2. Precondition (Product overview, target market / customer and production planning) 3. Investment plan (capital investment amount) 4. Profitability plan 5. Scheduling (Model fix, production start plan, construction method plan, investment and loan examination, metalworking, trial Mass production, shipping) 6. Issues and responses			○
6	**Standard of business operation judgment：** The following three items are generally used as a business implementation decision (Decision making for project investment). It is important to make a final decision based on the anticipation of the future of the company, using these data as a guide for determining implementation or as an effort target. Refer to the technical book for each formula 1. Return on Investment ＞ Target○○%（Must be above interest rate） 2. Pay Back ＜ Target○○months（Service life・Less than borrowing period is desirable) 3. Net Present Value ＞ Target○○%（NPV>0 is an investment requirement） In addition, at the final decision stage, it is desirable to formulate a response policy and specific measures for the following issues in each project. Task: ① How do you consider the risks that may occur in the future? (National situation, demand fluctuation, material cost, labor cost, selling price fluctuation, etc.) ② What is the burden and risk for building a relationship with an external organization to meet customer demand? ③ Is it possible to establish a win-win relationship with customers and partners?			○

5.4 Quality Management

① Quality Monitoring
Example: ISQC and its application

No	Contents	A	B	C
1	Given below is an example of improvement utilizing idea of ISQC as one of the Quality Monitoring method. **1. ISQC (In Stage Quality Creation)** One of the Quality Control Tool implemented by some of the Japanese Car manufacturing OEMs. It is a concept of a self-completion system that checks, resolves and complete the defects within process which occur without carrying them over to the finished products. **1) Purpose** (1) Establishing and Standardization of Production style to achieve required Quality for each process. (2) Determine Process wise Production Quality checking procedures based on Production Standards. **2) The Target** (1) To investigate precise root cause and simplification of countermeasures by clearly determining the defect occurrence process. (2) By eliminating manual repair work of finished products by eradication of secondary defects due to reworking. (3) Reduction of the finished product reworking man-hours Inspection : The root cause of the defect might not known and the countermeasure is difficult of defects once comes in flow in the middle of some process, even by inspection of finished product. Defect Countermeasure : Analyze all processes to find out root cause of defect and take the counter measures for all the process which have relative reasons, and implement inspection. **2. Implementation Example (Case Crank RH)** Quality improvement in 'Surface Flatness of Cover Crank Case Right 70cc' to avoid Leakage & Seepage problem  Countermeasures were taken for the flatness which were out of tolerance given after milling process. 1) Machining process and factor analysis (Fig1 : Process Analysis)	○		



【**Conventional Concept**】

Because it is a defect after Milling process therefore root cause was investigated only in process and countermeasures were carried out. (Example: Distortion when Clamping in machining, Cutter cutting parameters, etc.)

【**ISQC Concept**】

Take the counter measure for root cause process against all processes.

(1)Analyze all processes and extract Indirect reasons which generated defects in Milling process.

(Ex: Clamping Failure ←Datum height variation ← Casting mold shifting [Casting])

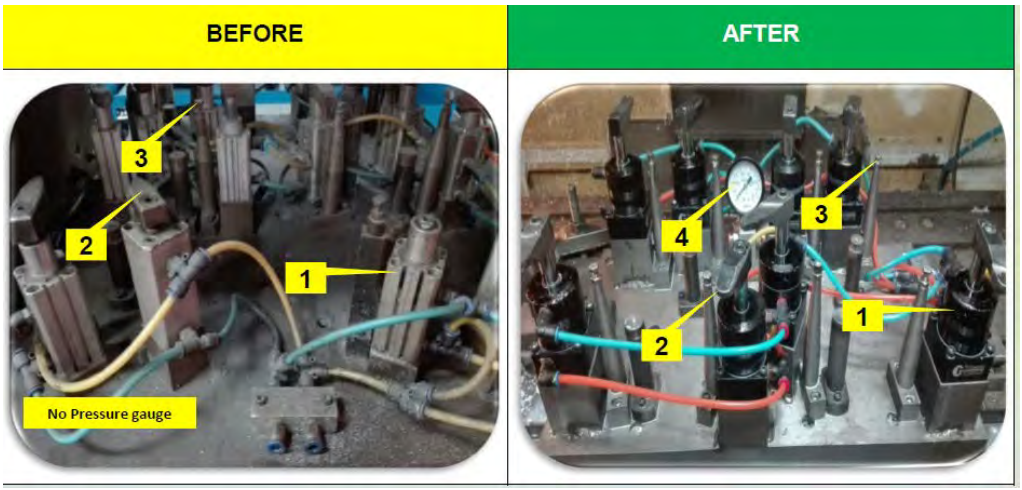
(2)Milling is OK, but the finished product has flatness defect.

(Ex: Buffing Defect [Buffing Process]) (Distortion after Paint process ← Heat Distortion of Baking Oven)

2) Consider Measures of Defect Root Cause Process

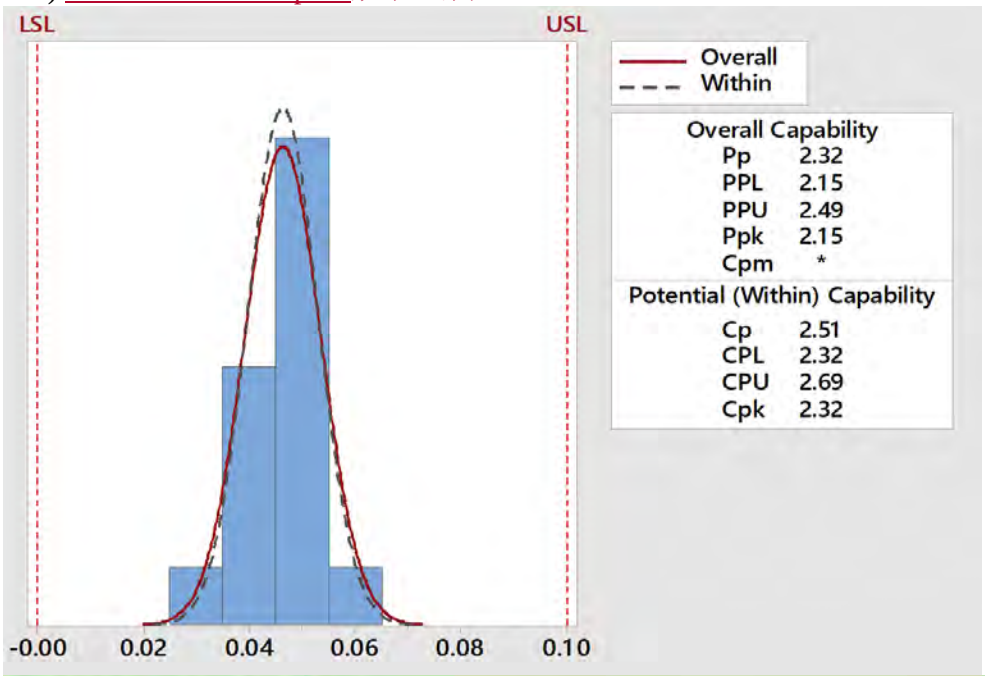
Sr #	Major Causes	Actions
	Flatness NG due to multiple reasons at multiple process stages:	**In order to improve flatness, various actions have been taken:**
1	Inherent variation in machining process	Process variation minimize (Machining fixtures improved, machining parameters optimization etc.)
2	Machining cutting tools are of low quality	Cutting tools are replaced with high quality tools
3	Improper handling and placing of parts at production floor	Parts handling and placement is improved
4	Paint stick on machined face during painting process	Paint sticking completely removed from face
5	Casting play / twisting causing flatness NG	Casting twisting is controlled
6	Final quality check was not strong causing excessive defect outflow to customer	Strong and effective Quality Gates added at production line and final quality station
7	Leakage testing machine can't check leakage from face	Leakage testing machine upgradation is in-process

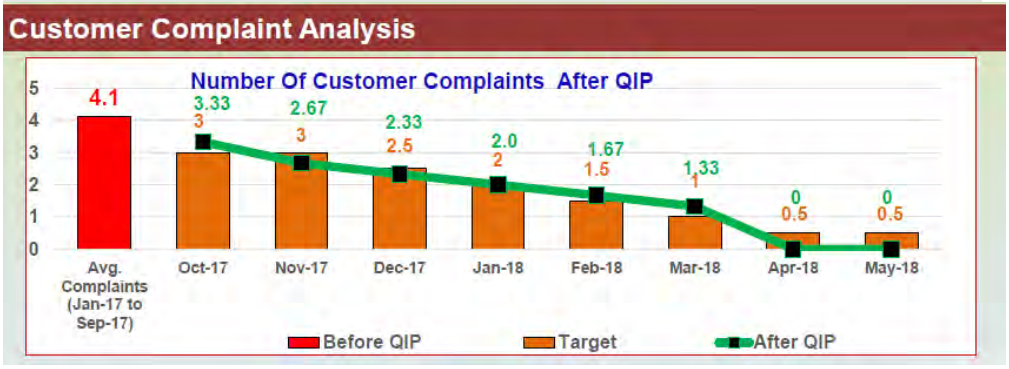
3) Implement Counter measures



Countermeasure1: Addition and minimization of holding clamp surface
Old fixture replaced with new fixture to minimize the flatness in the part
Countermeasure 2 : Improvement of Baking Oven drying tray (for uniform heating)

4) Confirmation of Impact ~~効果の確認~~





○

② Defect proactive response/4M change point control

No	Contents	A	B	C
	Required management task (application items from suppliers) (1) Design changes (Requirements including changes in places not described in the drawings) (2) 4 M changing points (excluding MAN change point) (3) Changes of Tier-1,Tier-2 onwards (4) Changes of shipping box, pallet, packing style (5) Changes of inspection method, management parameters, management conditions (6) Changes of supply parts (7) Change management system ① Election of Change Manager; A person in charge of change management and manager responsible for the establishment of MP maintenance system ② Preparation/making of Change management guideline; Based on "4M Change Notification", the change management manager adds management items for the Customers, and defines management methods so that changes do not leak/miss at each factory and department, and establishes control points sheet and plans control scheduling. ③ Management of Tier-1,2 and subsequent suppliers; The change manager is responsible for managing the contents of change for Tier-1,2 and subsequent suppliers, as well as establishing and operating the same management guidelines. (Just for reference) Per PPAP rules, suppliers are required to submit mandatory documents ①when changes od parts structure, ②material change、③when used new tools, die/molds, ④ when production line changes, equipment changes, ⑤ when manufacturing place change,⑥when supplier or outsourced company change, ⑦when process/engineering drawing change,⑧when inspection change,⑨ when procurement of material change,⑩when appearance change.	○		

4M change point management;

Changes that affect design quality, manufacturing quality and productivity shown in the table below-mentioned(Man, Machine, Material, Method defined per PPAP)

4Mchange points notification standards

Large group	Small group	contents	notify
Machine	Equipment change	Equipment-new and updated	○
		Equipment-modified	○
		Modified off-Line (electric/air power source etc.)	○
		Modified off-Line (security)	×
	Equipment Factor change	Shaft/bearing change (process ,Assy, measuring unit)	○
		Shaft/bearing change (Conveyor system etc.)	×
		Guide unit, slide surface change (Process, Assy, measuring unit)	○
		Guide unit. Slide surface change, (Conveyor system etc.)	×
		Actuator change (process, Assy ,measuring unit)	○
		Actuator change (Conveyor system etc.)	×
		Censor change (process, Assy checking)	○
		Censor change (motion detection)	×
		Weld timer unit change (compensation timer, constant current timer)	○
		Sequencer, control unit change	○
		Part change in direct contact with target parts (guide, conveyer roller)	○
	Jig change	Dies/molds modification	○
		New die, updated (modified)	○
		Jig change (locater, knock, Pad, pallet etc.)	○
		Replacing jig (locater, knock, Pad, pallet etc.)	×
	Tool change	Machine tool change (process tool, electrode, Assy tool, clamp tool	○
		Specified tool change	○
		Tightening tool change (pulse wrench, impact wrench etc.)	○
		Tool for general work change	×
		Replacing tool	×
	Inspection jig change	Inspection jig change	○
		Replacing inspection jig	×
	Measuring tool change	Automatic measuring tool change (automatic leak tester change etc.))	○
		Manual measuring tool change (air micro etc.)	○
		General measuring tool change (dial gauge, QL wrench etc.)	○
		Replacing tools	×
	Machine parameter change (if change done under strong control of self-control by suppliers in the registered fields with thorough proof, no need to notify exceptionally)	Casting Parameters (pour & molds temp., cooling, pour pressure etc.)	○
		Forging Parameters (forging pressure, temperature etc.)	○
		Sintering Parameters (temperature, time etc.)	○
		Plating Parameters (pre-treatment) (Viscosity, CD, temp., time etc.)	○
		Heat treat Parameters(temp., time, cool Parameters, gas flow rate)	○
		Press Parameters (pressure, wrinkle pressing pressure etc.)	○
		Injection molding Parameters (molding pressure, temp., time etc.)	○
		Adhesive Parameters (adhesive pressure, temperature, time etc.)	○
		Welding PM (weld current, voltage, electrode tip dia, pressure, time etc.)	○
		Paint PM (pre-treatment) (Viscosity, temp., air pressure, dry time etc.)	○
		Grinding Parameters(RPM, feed, cutting fluid viscosity etc.)	○
		Press Fit, Caulking Parameters (insert pressure, insert speed etc.)	○
		Automatic Tightening Parameters (tightening parameter, oil quantity etc.)	○
		In line Measuring Parameters (pressure, measure time, setting judgement range, accuracy test etc.)	○
		Washing Parameters (pressure, washing detergent, Washing liquid viscosity, and filter mesh etc.)	○
		Soldering Parameters (temperature, time, flux etc.)	○

	4M change point management table/sheet; (1) A basic management board is attached for implementing 4M change point management on site. Experts explain the excel sheet at a production site during the regular Circuit activities. In addition, the example management table/sheet which Japanese OEM used is shown as a reference below-mentioned. (2) The important point in the contents described in the management table/control chart is to keep a record of the production history after the occurrence of the Change point. Make it possible to trace the situation of the occurrence when issues/problems occur in the future (Traceability). As a specific example, keep a record of the target production lot number and production serial number.  1401...Format with example of 4  1402...Example of 4M C.P. control			

③ Quality control in PPAP
Product quality requirements, inspection standards, traceability,

No	Contents	A	B	C
1	**1. PPAP and APQP** **1) PPAP (Production Parts Approval Process)** PPAP in ISO / TS 16949 is the only requirement for core tools and is also called "production part approval process", which is the new product part specification before mass production, customer's approval procedure in mass production process. After determining the production specifications with APQP, it is necessary to notify the customer and obtain consent / approval for changes related to product realization that affect customer requirements in managing defects and parts and other changes. When changing the content that may affect the product, based on the customer's prior approval, the influence of the change is considered, and it is required to submit related technical data such as verification and validation performed, data, samples, etc. In addition, it is essential to manufacture samples for PPAP under the same conditions as for mass production. **2) APQP (Advanced Product Quality Planning and Control Plan)** APQP is one of the core tools (core techniques) called "Advanced Product Quality Planning", and it defines the operation procedure of a new product development project. This "Advanced Product Quality Planning" work is to develop a new product that meets the needs and expectations of the customer, obtain customer approval, and shift to sales production, indicating a guideline for the operation method of the whole new product development project is. (The project operation procedure, i.e., project management, is advancing in the United States in particular, and among them is an excellent operation method often found in Japanese companies that perform product design and process design simultaneously and in parallel) =>APQP required to suppliers is often used as an Action Plan for confirming and approving PPAPs defined for OEM preparation-production preparation schedule in a timely manner. =>The APQP required to the supplier is often used as an action plan to timely review and approve the development and manufacturing preparation schedules requested by the OEM. **(1) Five APQP promotion steps** The APQP promotion steps are roughly divided into five stages. 2. Planning stage: Establishing the basic concept of new product 3. Product design phase: Design specific product details based on the basic concept	○		

4. Process design phase: Designing the manufacturing process of the designed product
5. Product / process validation stage: A stage to validate the designed product and process
6. Mass production stage: Continuous delivery of customer-approved products based on the contract

(2) Items to be confirmed.

The following confirmation items are required in ISO.

1. Product quality planning basis
2. Plan and define program
3. Product design and development
4. Process design and development
5. Product and process validation
6. Feedback, assessment and corrective action
7. Control plan methodology

Followings are presented as a control plan method.

a. Product Quality Planning Checklist
b. Analysis method
c. Reference document
d. Feasibility study report
e. Product quality plan summary · approval
f. Glossary of terms
g. Index
h.

2. Specific application of automobile parts

Although the above description is in ISO, the actual use differs depending on the product, and for OEMs, specific procedures are specified by each OEM based on ISO regulations. In JICA Project, this has been explained as a QMS in the Work Shop etc., but the excerpt is described below.

1) PPAP request case

After production specifications are determined by APQP, OEMs request to be notified and approved when changes such as new products, process changes, and material changes occur.

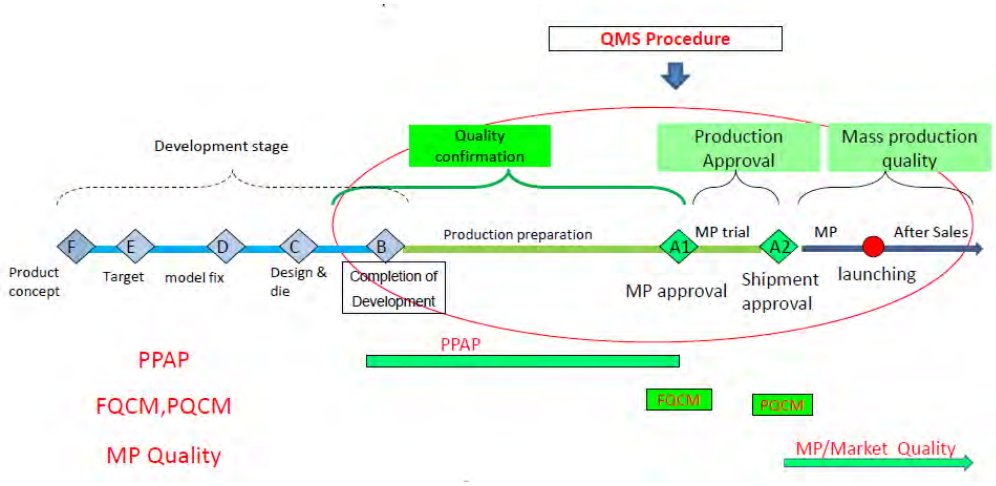
Typical cases where PPAP (production part approval process) is required.

3. New product or new part
4. Change of parts to be supplied
5. Correction of parts defects (measures against defects)
6. Change of design document (design change etc.)
7. Renovation of facilities, large-scale change of layout / production place
8. Product Renewal (addition or change due to improvement etc.)

2) Position of PPAP in preparation for production

Automobile parts are indicated to each supplier in concrete items by each OEM according to the requirements of ISO regulations from the importance in terms of quality.

Show an example (from QMS data).



The entire QMS is <B> Development complete → After sales (red circle in Figure 1)
PPAP is treated as <B>: development completed → <A1>: correspondence to mass production start.

3) PPAP requirements and requirement levels

PPAP requirements and submission level (level that OEM decides and requires submission from supplier) are divided into 5 stages, and it is coordinated with OEM in advance to decide submission level. Normally level 3 is applied as the standard level.
The requirements and submission levels are as shown in Table 1 below.

○

Table 1: PPAP requirements and submission levels (A: Required, B: By arrangement,-: Not required)

Submission Material		PPAPレベル				
		1	2	3	4	5
1	Design Record (Latest drawing)	-	A	A	A	A
2	Authorized Engineering Change Documents	-	A	A	A	A
3	Cover Page, Customer Engineering Approval	A	A	A	A	A
4	Design Failure Mode and Effects analysis(Design FMEA)	-	-	A	A	A
5	Process Flow Diagrams	-	-	A	A	A
6	Process Failure Mode and Effects Analysis (process FMEA)	-	-	A	A	A
7	Control Plan	-	-	A	A	A
8	MSA（Measurement System Analysis）	-	-	A	A	A
9	Dimensional Results	-	A	A	A	A
10	Material Test Results	-	-	A	A	A
11	Initial Process Studies	-	-	A	A	A
12	Qualified Laboratory Documentation	-	-	B	B	B
13	Appearance Approval Report(AAR)	A	A	A	A	A
14	Sample Production Parts）	-	A	A	-	A
15	Master Sample	-	A	A	-	A
16	Checking Aids	-	-	A	A	A
17	Customer-Specific Requirements	-	A	A	A	A
18	Part Submission Warrant(PSW)	A	A	A	A	A
-	Process Audit	-	-	-	-	A

4) Example of actual requirements for automobile parts

The present situation is that automobile parts are instructed to each supplier in specific

items by each OEM based on the requirements of the ISO standard by the importance of quality. An example is shown in Table 3 (QMS explanatory material)

Table 3: Example of requirements

Required items in ISO	**Actual example at OEM (QMS explanation)**
2.2.1 Design document Design Record	・Receipt drawing (Supplier's drawing) (For detailed procedures and required documents, refer to "5-1 Checking Component Development Capability")
2.2.2 Approved Design Change Documents	
2.2.3 Customer Engineering Department Approval	
2.2.4 Design FMEA	・Design FMEA
2.2.5 Process flow chart	・Floor layout / process chart
2.2.6 Process FMEA	・Process FMEA
2.2.7 Control Plan	・QC process chart (Control Plan)
	・Test confirmation
2.2.8 Measurement system analysis and survey	・Inspection standard
2.2.9 Dimension measurement result	・Pilot sample (n = 5)
	・Pilot sample inspection report (n = 10)
	・Inspection results of all items for pilot sample (shown in red)
2.2.10 Material Performance Test Results	・Reliability / Probability test result (n = 3)
2.2.11 Initial process analysis	・Initial process capability investigation (Cpk / Ppk) result
2.2.12 Conformity Testing Laboratory Documents	
2.2.13 Appearance Approval Report (AAR)	
2.2.14 Production Parts (Customer Evaluation) Sample	
2.2.15 Master (standard) sample	・Master sample (standard sample), limit sample
2.2.16 Inspection aids	・Verifier plan
2.2.17 Customer Specific Requirements	・Delivery package form setting document
	・Lot management notification form
	・ Secondary and subsequent business partner management table
2.2.18 Parts Submission Warranty (PSW)	・Parts shipment guarantee (PSW)

As an example of the above, attach a sample of an examination confirmation and an examination standard document (see below).

10 Inspection Procedure(E_Sam

5) Actual correspondence of APQP

As described in 1-2), the actual operation is that APQP as a development production plan in OEM requires suppliers to conduct and submit PPAP specific submission, confirmation and approval process plan as APQP for suppliers. An example is shown in Table 4.

(□-□: Submission-Approval)

Table 4: APQP Examples

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Quality gate			QG						3						2						1	
								F-testing														
productionschedule						★ Test		★ F try						★ PJ		★ PL		★ PT	★ PP	M		
	item	**form**	**due date**																			
PPAP	Quality Manager	1.2-01	1month	□																		
	design change grade	1.3-01	3			□																
	APQP(Advanced Product Quality Planning)	1.4-01	3			□																
	Design FMEA	2.3－01	3			□																
	Production preparation plan	3.1-01	3			□																
	Floor L/O	－	3			□																
	Process FMEA	3.3(2)-01	3,9			□ P						□ Fin										
	Specification sheet of parts packa	3.4－01	3,12			□ P									□ Fin							
	Tier 1,2 supplier control sheet	3.7(1)-01	12												□							
	pilot sample(n=5)	4.6-01～02	11											□								
	ISIR(n=10)	4.6-01～02	each p-trial											□		□		□	□			
	(Cpk)Result	－												□		□		□	□			
	Inspection confirmation sheet	3.8-01	Pre:1month to PJ,Approval: 1month to PP											□ pre				□ rep	□ AP			
	Inspection standard sheet	3.8-05												□ pre				□ rep	□ AP			
	QC process chart	3.8(1)-01												□ pre				□ rep	□ AP			
	Approval ofPPAP	4.7－01	1month to PP															□ rep	□ AP			
	PSW(Parts supply warranty)	4.7－02																□ rep	□ AP			
	Pilot samplae Inspection report(n=	4.6-01～02																□ rep	□ AP			
	inspectionresult of pilot sample(on darawing,important	indicate in DRWG																□ rep	□ AP			
	Lot control requirement(safety parts)	5.4-02													□ 通			□	□ AP			
	Parts history record	1.6-01																□ rep	□ AP			
	reliability/ES-testing(n=3)	2.6-01													□ p			□ rep	□ AP			
	initial quality control	4.8-01	Plan:after PPAP result:1m after MP																□ P		□ resu	□ AP

6) Purpose and effect of PPAP

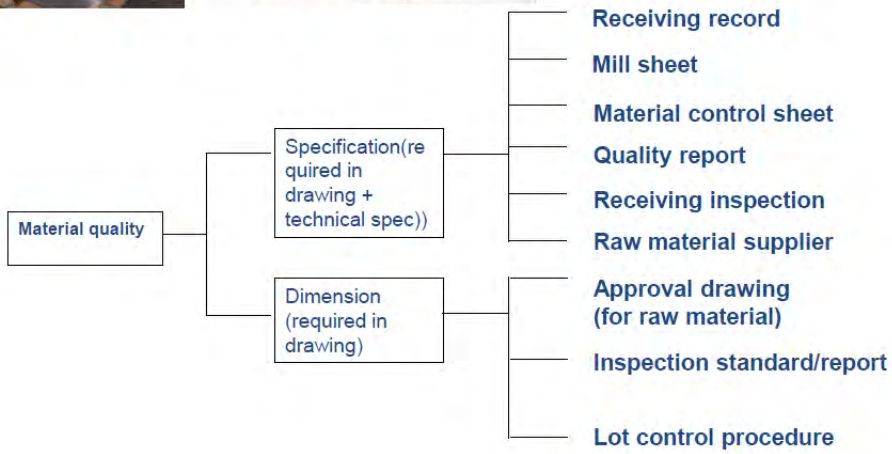
Required condition of parts procurement＝It shows how suppliers be ready to meet with the requirements from OEM as well as to understand appropriate know-how to procure materials and parts in line with the quality assurance condition.

7) Traceability

In order to cope with important defects and market measures (recalls) in recent automobile parts, it is necessary to track the defect history of shipments and traceability is required. For this reason, for important parts and safety parts (eg, airbags, brakes, steering related parts), it is customary that this requirement is added to the PPAP requirement 2.2.17 customer specific requirements.

(1) Material management

Figure 2: Example of material traceability



It is important that each delivery lot of material and quality history be linked to the actual product.

(2) Lot management and display on products

Traceability management requires lot management of production parts and its display. Please refer to the attached for an example of the management procedure.

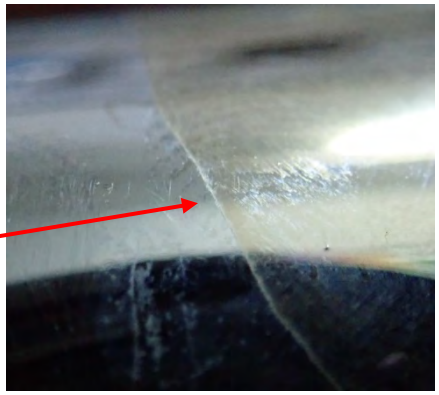
PP13_Lot管理(Lot Control).pptx

3. Problems with PAKISTAN, examples of improvement

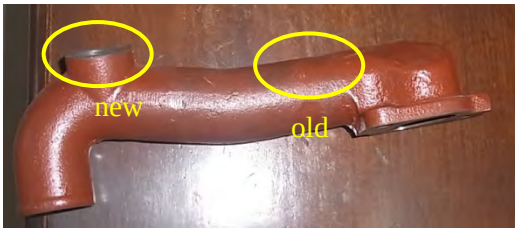
1) Accurate understanding of OEM requirements

The drawings and the specifications required there are not understood correctly. Or, because the content is unknown, it is skipped and not reflected in the manufacturing quality.

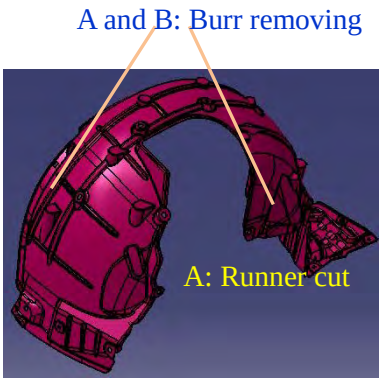
(1) Case 1: Drawing (Ni-Cr plating). Actual product (Ni plating): Ni-Cr plating is required for Fork Pipe of suspension due to sliding part. Actually, only Ni plating was a cause of plating peeling.



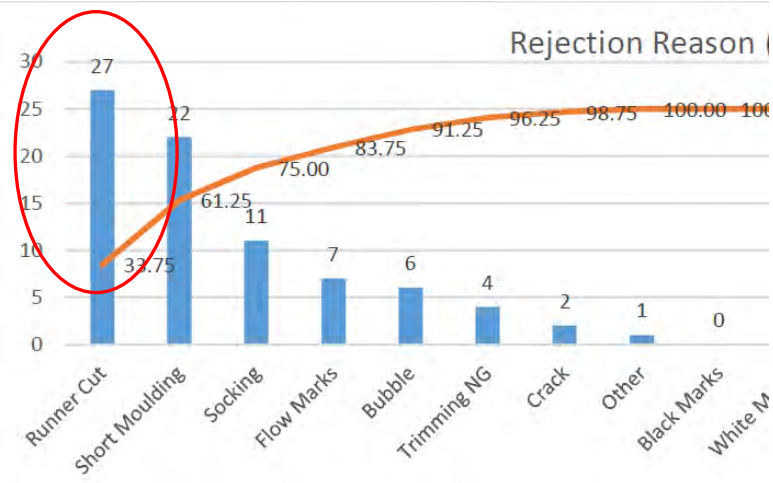
(2) **Since the design change information was not reflected on the production inspection tool, the old product continued to be delivered and the OEM side became NG.** =>Failure that did not occur if PPAP 2.2.1-3 design change procedure and 2.2.16 inspection aid procedure were performed correctly.



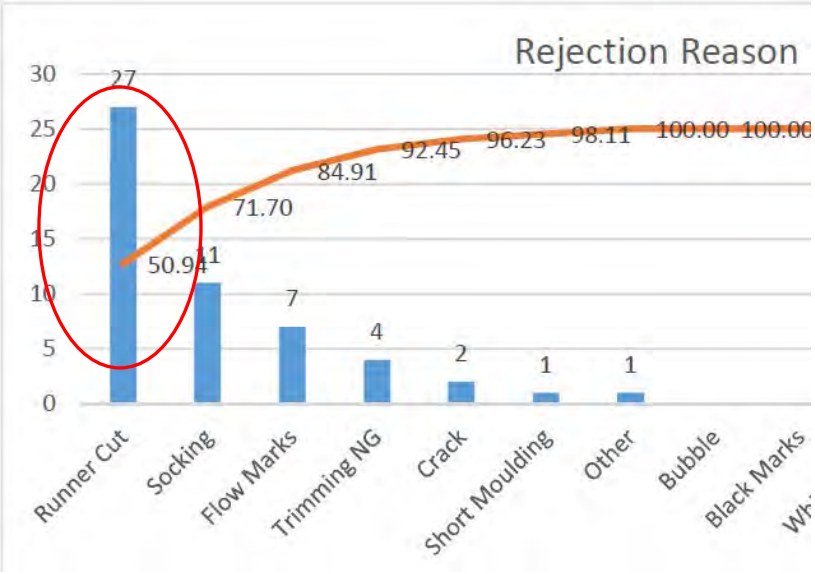
④ QC 7 Tools

No	Contents	A	B	C
1	**1. Definition of QC 7 Tools** Details are omitted in this manual. Here, actual application examples and usage methods are described, and mainly address measures for actual on-site improvement. **2. QC 7 Tools** 1) Pareto diagram 2) Cause and effect diagram, Characteristic diagram, Ishikawa diagram 3) Check sheet 4) Histogram 5) Scatter diagram 6) Control chart 7) Stratification **3. Application example** **1) Pareto diagram: Countermeasures against burr removal (fender)** **A: Injection process**  B: Assembly Process   Process / Runner Cut / Burr Removal A: Injection / O / O B: Assembly / — / O Problem: Defective finish on the burr removal part (Undercut) At the beginning, it was dealing with burr finishing work defects in the assembly process, but the defects were not reduced. Since this work was done in both the injection and assembly processes, created a Pareto chart of both processes.	○		

Deburring trouble (All Process)



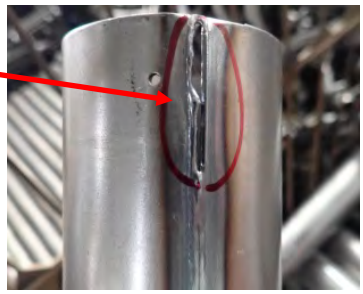
Deburring trouble (Injection Process)



As a result of Pareto analysis, it was found that the deburring failure occurred at almost 100% injection process. As a result, measures for tool improvement and work guidance were implemented, and burr removal defects were improved.

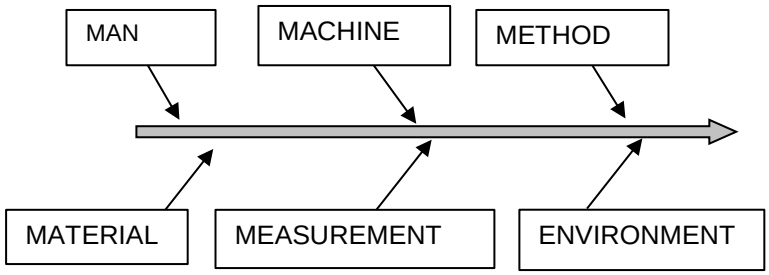
2) Cause and effect diagram (TIG welding defect: Muffler)

Failure: Melting off at TIG welding



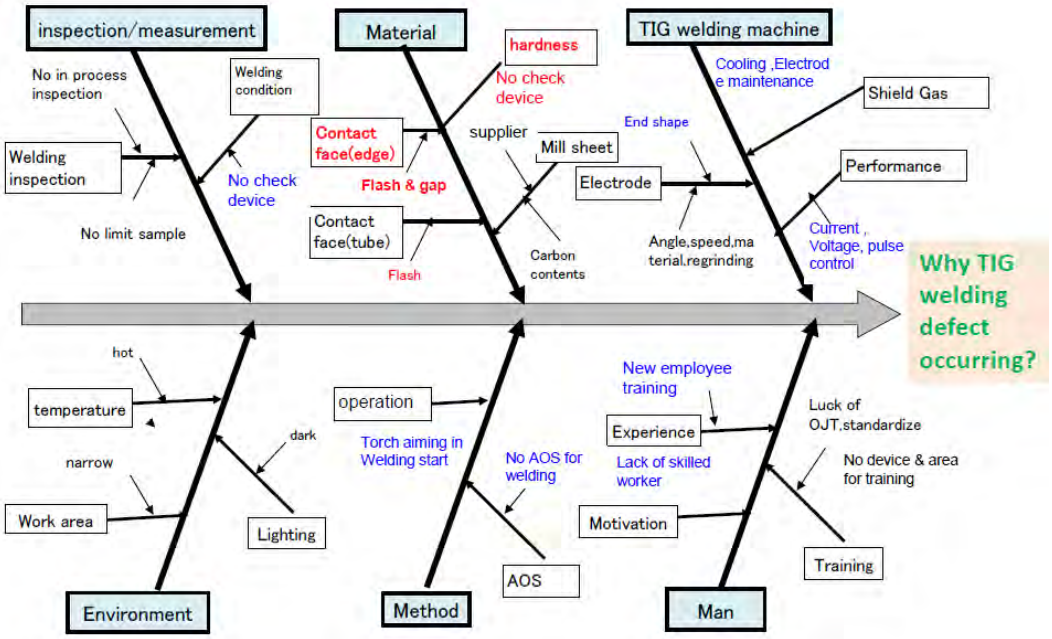
(1) How to create cause and effect diagram.

a. Decide problems(Effect)
   Example: Why does TIG welding failure occur?
   Bad example: Weld defect reduction (Cause ≠ countermeasures)
b. Define the factor of causes based on 5M+1E
c. Describe actual using word in GENBA (parts, machine, process, etc.)
d. Describe Main fish bone based on 5M+1E



e. Fill in the middle bones and small bones. Consider the factors that cause the characteristics of the large bone to create the middle bone, and then create the small bone.
f. In order to make small bones, it is necessary to assess the important causes by repeating why, why, why....
g. Check the omissions in description.
h. Create a diagram by brainstorming of related members.
i. Make Check mark to major influence factors.
j. For the main cause of the problem, plan and advance KAIZEN activities. (Advance the KAIZEN circle).

(2) Cause and effect diagram



(3) Factor analysis (from the cause of failure, repeat "Why" five times to investigate the root cause.)

5W

1H

Welding is unstable welding.

Why burn through of welding?

Welding conditions are varied. welding condition

Why unstable welding?

Variation of distance

Why variation occurring?

Forming is varied: Flash of end contact face of tube

Loosen of torch mount & feeder

Why variation of distance occurring?

Spring back after bending.

Why Forming varied

Countermeasures

Flatness reforming = add pre form press

Hardness is too high = material control

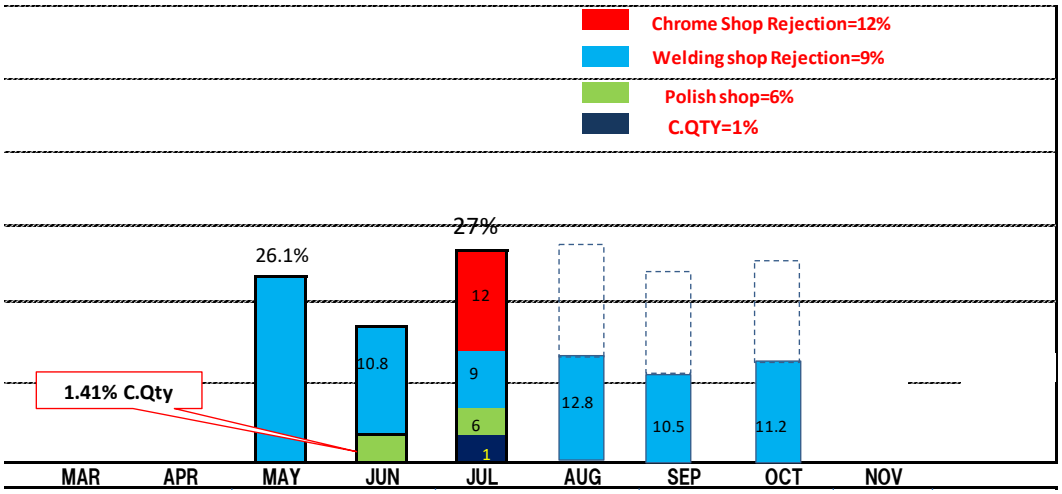
Feed thread change

(4) Countermeasure execution, effect confirmation

Pre hitting before welding (in progress)

Hardness checker of panel (Implementing)

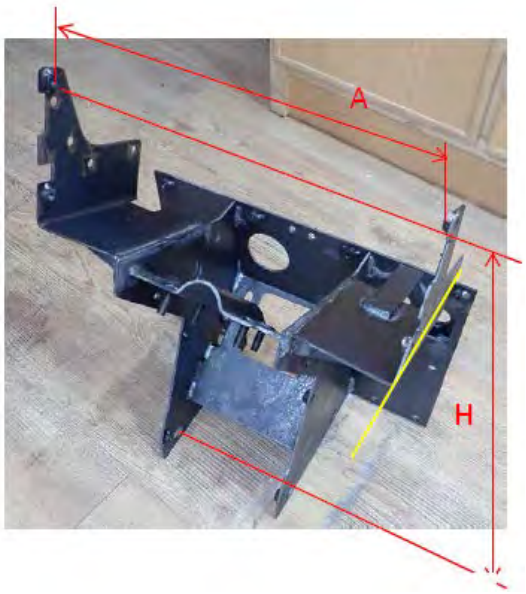
Torch adjuster (Implementing)



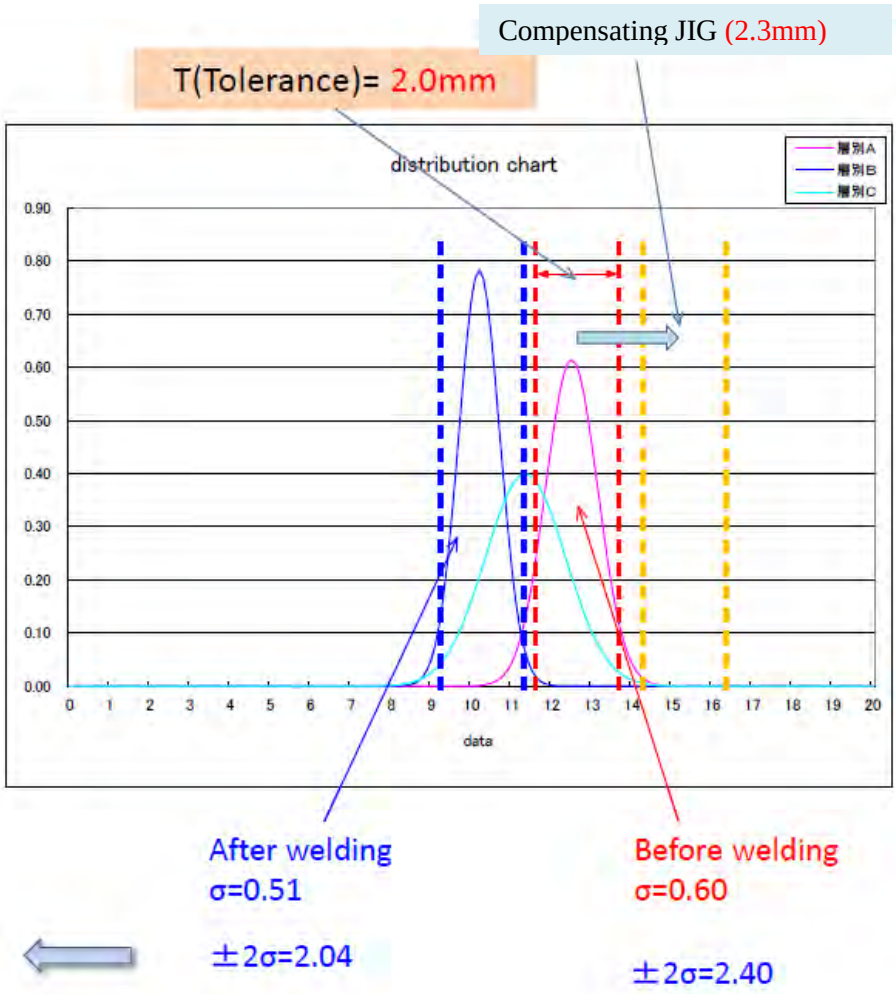
3) Histogram, scatter chart

Defect: Welding distortion

The amount of distortion due to welding was analyzed using histograms before and after welding, and welding distortion was improved by assembling that reflected the occurrence of welding distortion.



(1) Histogram creation before and after welding

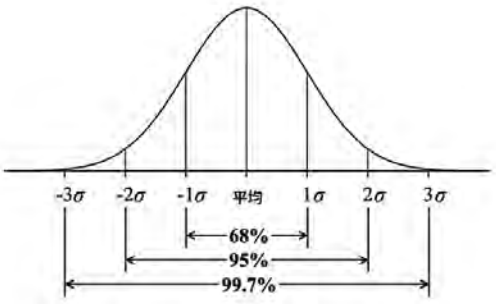


T：公差

±2σ≦T(95%OK)

(2) Measures

Originally, 3σ or less is desirable, but the welding variation is large with respect to the tolerance. Therefore, since it is not within 3σ, it is determined whether or not the correction is made with a determination criterion of 2σ or less, and the correction amount is determined to be 2.3 mm.
(Theoretically, 5% correction is required)



(3) Effect confirmation, standardization

Rework: 100% (all reworked) 2 2% or less

4) Stratification: Investigate the occurrence of each defect at 4M and analyze the cause factor and the degree of influence and take measures.

Defect: Run out (The correction factor for a run out tolerance of 0.1 mm after machining is as high as 3.5%. Target is 0.1% or less)

(1) Run-out data of each worker

How to proceed with analysis

Decide what to stratify.

Determine the "quality characteristics" and the "quantity range".

Quantity range: the size of the entire N.

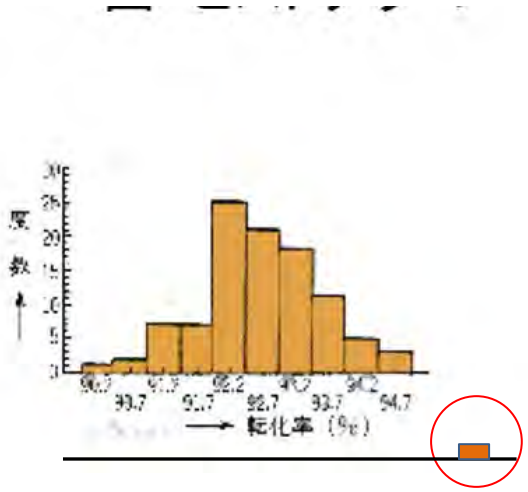
Grab the overall quality figure. Generally, it is represented by "histogram".

Investigate the cause of the fluctuation of run out. The cause of "Fluctuation" is investigated by using "Cause and effect diagram" etc. And the factor of "Cause and effect diagram" becomes an item of "stratification".

Frequency table

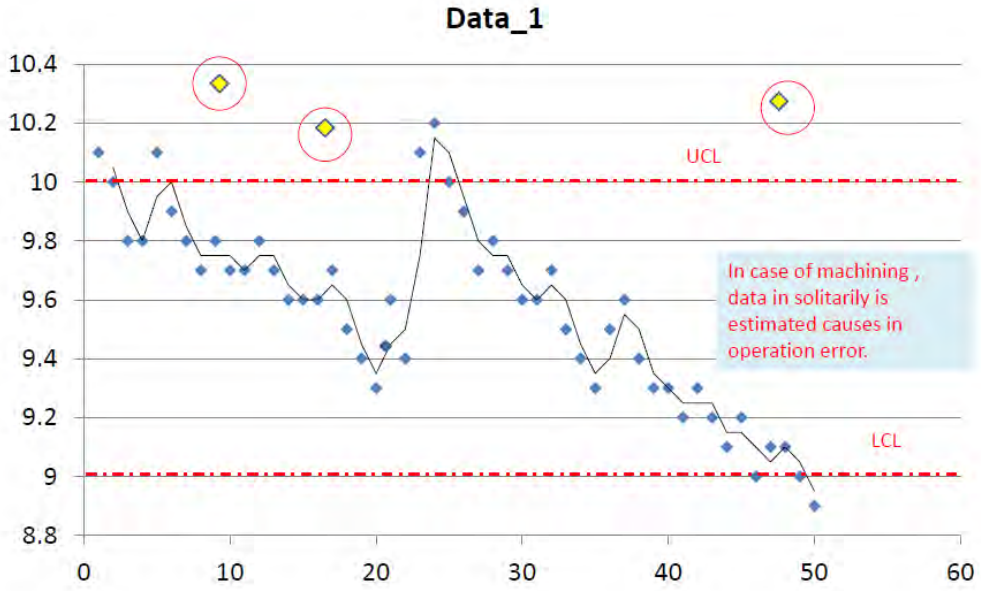
区　間	マ　ー　ク	度数
89.95～90.45	丨	1
90.45～90.95	丨	2
90.95～91.45	正丨	7
91.45～91.95	正丨	7
91.95～92.45	正正正正丅	25
92.45～92.95	正正正正丨	21
92.95～93.45	正正正丅	18
93.45～93.95	正正丨	11
93.95～94.45	正	5
94.45～94.95	丅	3
合　計	—	100

Histogram



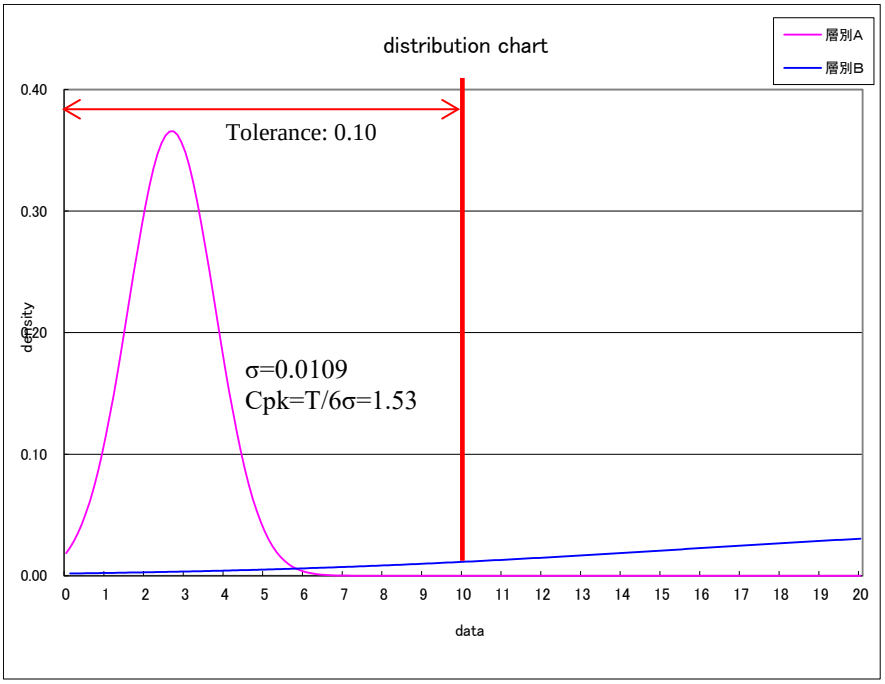
Data that is separated is often a factor other than Machine.

(2) Continuous machining result data for each worker



(3) Factor analysis, measures

With the exception of the above singular point (o), Cpk is 1.33 or more, and it has been found that some workers do not have this singular point at all. In the subsequent survey, the cause was found to be insufficient cleaning at the time of installation, revised the work standard, and improved it now. (Rework rate: 0.06%)



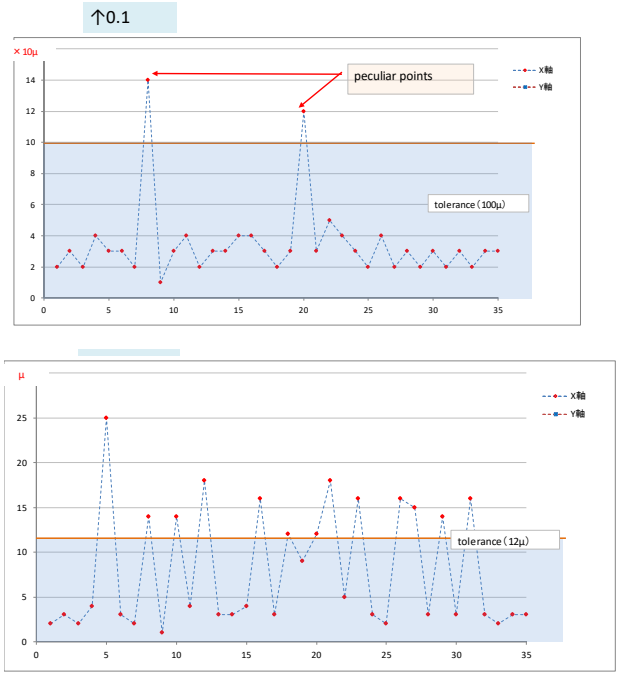
(4) Reference

Analysis example (Example of machining)

The machining accuracy seems to be stable, but suddenly the machining accuracy may deteriorate.

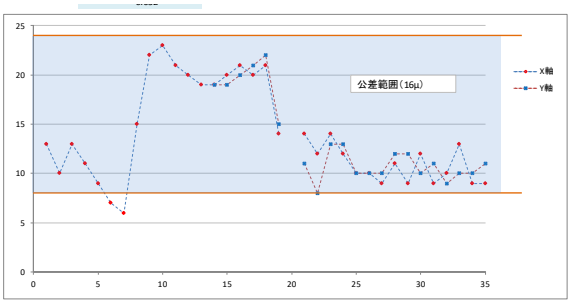
(In this example): In such a case, it is not a mechanical factor, but often an external factor such as dust adhering to the working method or jig, and analysis of factors other than machines is also included.

The variation in machining accuracy is large and always changing. There is no machine capability (machine accuracy is poor)



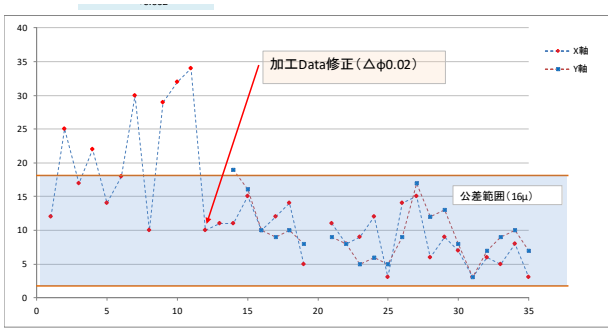
If machining accuracy falls regularly, it is often a tooling factor.

(In this example): it was due to the formation of the composition of the cutting edge.



The initial stage is variable and eventually becomes stable. It is often an equipment factor.

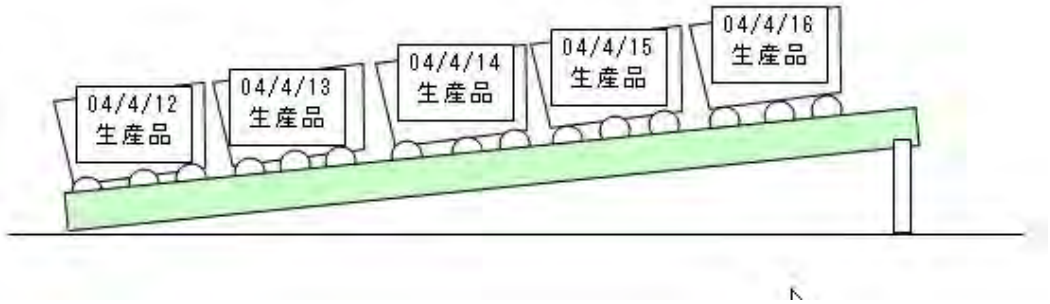
(In this example): Oil pressure is unstable (A low pressure clamp was adopted to prevent distortion of the product. While the temperature of the low pressure clamp was low, the clamping force was decreasing or fluctuating.)



5.5 Production Management

① Understanding FIFO, in-process items and stock

No	Contents	A	B	C
1	FIFO ※First-in first-out, it is the same with factories and homes. What you purchased first should be used first ⇒ Basic rule The basis of inventory management is "First in First Out", in a wide range of industries from manufacturing to sales and retail, first-in-first-out is a basic yet very important inventory management method. The subject matter is the first-in first-out in the inventory management, but why first-in first-out can not be implemented? What will happen when first-in first-out is not implemented? What is the proper way of implementing first-in first-out? These 3 points will be explained below. This is essential for the managers who are facing difficulties with proper inventory management. The reason why first-in first-out can not be performed in inventory management The following four causes can be considered when first-in first-out is not performed in inventory control despite the fact that rules are firmly established. Site workers are not following the rules Even if there are rules, first-in-first-out will not be performed if the on-site workers do not follow them. One of the reasons why workers do not observe the rules is that "They do not understand the rules" and "The rules does not have the force and workers are working freely". It is difficult to understand whether the stock is “new or old” Even though the workers understand that first-in first-out means "using old parts and raw materials first", but there are many cases where the modification has not been done for the implementation. It will be difficult to implement first-in-first-out if it is not possible to determine which stock is new and which is old at a glance. There are many opinions that even though the date of arrival and lot number in clearly illustrated, first-in first-out can not be performed." Clearly, this will cause delays in work, and as a result, first-in first-out will not be performed. In this case, scolding the worker as a manager causes rather a negative effect. It can be said that it is the manager`s responsibility that efficiency improvement is not considered.	○		



3S of stock yard is not thorough

There is a large number of stocks and frequent replacement work is required
Problems caused by not proper implementation of first-in first-out

・Causes defection
・It becomes difficult to grasp the exact number of stocks

The points for proper implementation of first-in first-out

(1) Post work instructions at an easy-to-see location on the site
(2) Managers regularly conduct on-site inspections
(3) Modify the site so that it is easy to understand the "expiration date" of stocks

(3-1) Color seal control

Example
Products arrived at 9:00：Yellow
Products arrived at 11:00: Green
Products arrived at 13:00: Blue

(3-2) Location Control

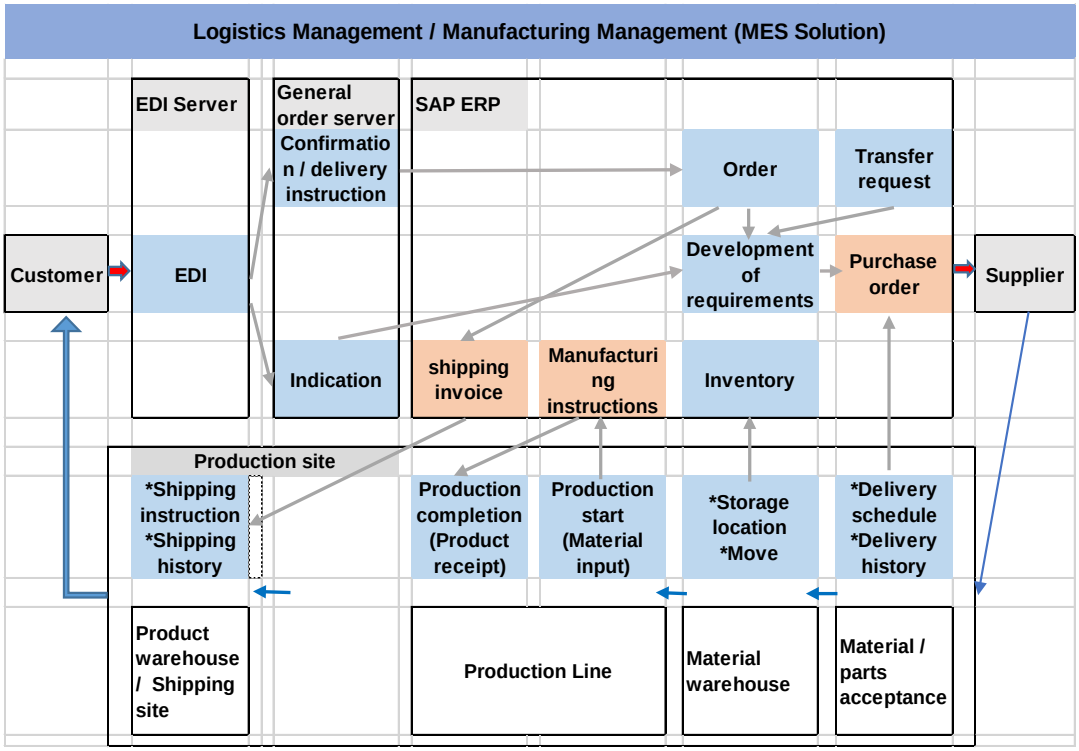
(4)Implement 3S daily and weekly
(5)Modify the site to reduce replacements

2	Practical teaching example of Pakistan (1) TM Rubber (Color seal example) 5S selection from TMR presentation (2) Standard Engineering（FIFO Sequential Trial） (P217) Standard EE FIFO 21MAR20 (3) Shaheen Automotive（FIFO site example） Observation 26 May 2019.xlsx		○	

	(4) Omar Jibran Karachi (FIFO Inclined shelf)  OMAR JIBRAN FIFO Inclined She			

② Order-production-shipping flow and production planning

No	Contents	A	B	C
1	**Order-Production-Shipping flow:** The flow from order acceptance to delivery is, in the case of an auto part, a make-to-order production with a production plan based on an order from an OEM. In addition to make-to-order production, there is prospective production, and the company predicts demand, makes a production plan, and produces and ships. This is mainly for the aftermarket. Here, the case of make-to-order production from OEM is described. **1. Confirmation of order information, input to in-house system** Order date, Orderer name, Order item & Part number, Order quantity, Delivery date & destination, Unit price, Production instruction etc. **2. In-house production instruction => Production plan** Inventory confirmation, Required specification, Material arrangement, Process design & production schedule, Shipping schedule, Personnel planning, etc. **3. Prototype** Prototype production, Design and production of Mold & jig design / production, Trial manufacture, Quality check **4. Production** Material acceptance inspection, Material supply to production process, production, In-process inspection, Finished product inspection, Quality judgment, Shipping preparation etc. **5. Shipment** Shipping inspection, Shipping method confirmation, Shipping & delivery note creation, Shipment, Customer receipt confirmation, etc. **6. Record input** Enter shipping record => Sales slip => Accounting procedure	○		
2	**Order-Production-Shipping flow (Case study):** The following is a flow chart of the case where order information is imported into the Electric Data Interchange (EDI) system in the company, and the processes from order acceptance to production and shipment are managed by ERP. The flowchart written in Japanese is described immediately below that in English. Look at both and deepen your understanding of information and the flow of things.		○	



Order - production - shipment flow diagram (example):

Production_planning.pptx

3 **Production planning:** ○

1) As in the case of ①Order - Production - shipment flow described above, the case of make-to-order production from an OEM is described here.

The basic elements of manufacturing, which is the core of the manufacturing industry, are as follows.

I. Products required by customers,
II. Only the quantity requested by the customer
III. With the quality required by customers
IV. Deliver on the date specified by the customer

In order to execute these things efficiently, it is the most important task to plan the production system and preparation for work.

The production plan is to plan the production system and the contents of preparatory work in time series. The key control point in production planning is to do the following with respect to the contents of production instructions.

I. Inventory check
II. Amount and delivery date of required materials
III. Preparation schedule of mold and jig etc.
IV. Daily and hourly production schedule
V. Shipment schedule.

2) The creation of FUNDOSHI is very effective to newly calculate the required process, equipment and personnel required for production. Production efficiency can also be planned extremely efficiently by finely setting it using FUNDOSHI.
As a note on the introduction of FUNDOSHI, when producing for the first time, workers

and equipment may not be able to cope with the standard time set in FUNDOSHI at the initial stage, and training will be promoted until the process is mastered enough.

3) In the case where a self-produced sales product or a customer presents a long-term production sales plan, or when there is a line establishment or sales discontinued product, it is necessary to cope with the following planning operations in addition.

I. Make a sales plan based on the business plan, demand forecast, and information provided by customers, and make a long-term production plan of several months to one year based on the sales plan.

II. Make a plan based on the prospect of about one year when involved in investment such as installation or remodeling of lines and facilities. In production management of existing lines, etc., make a production plan with a prospect of around 3 months.

III. If there is a discontinued product or a new product launched, identify the timing and quantity at which the sales volume and production volume will fluctuate significantly, and prepare a response plan.

IV. After planning the production plan, plan and prepare the resources (4M) required for production.

4

Production plan (basic case):

As in the case of 1) above, template cases are introduced for monthly-based production planning in the case of make-to-order production from an OEM.

Production plan (Project example):

Set up a key 20 parts, and build a system that monitors production volume (D) from production planning (A), actual inventory (B), minimum inventory (C) to weekly (E). [Basic formula: D = A + C−B] In the initial stage, this was handled with Excel softwere, but at present,

this algorithm is diverted, target parts are increased, and a dedicated system is being introduced.

Effect: With the theoretical stock maintained, the production volume requirements can be properly met. **As a result, we could reduce the cost of purchasing materials by 12%.**

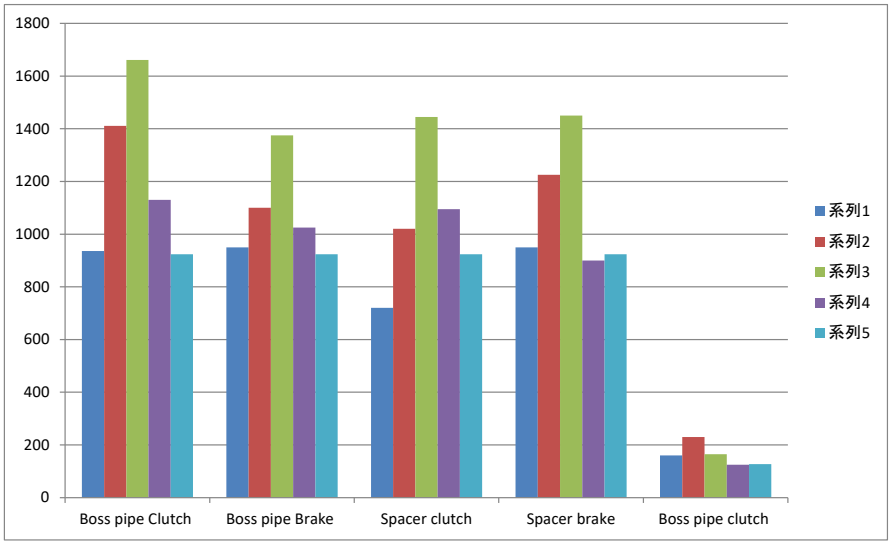
Actual management table (Sample)

E A B C D

Consumption History Chart For Target 20 Parts (july.2018)					
S.#	Part Name	Model	Monthly Schedule	Closing Stock (previous month)	Order QTY
1	Boss pipe Clutch	YLA	1386	2000	310
2	Boss pipe Brake	YLA	1386	1450	860
3	Spacer clutch	YLA	1386	1200	1110
4	Spacer brake	YLA	1386	1300	1010
5	Boss pipe clutch	YN3	191	225	93

LEAD TIME (Day)	Issuance and Balance Main Store				Minimum Order QTY level, based on 15 days safety stock w.r.t lead time
	Week 1	Week 2	Week 3	Week 4	
5	936	1411	1661	1130	924
5	950	1100	1375	1025	924
5	720	1020	1445	1095	924
5	950	1225	1450	900	924
5	160	230	165	125	127

Figure 1: Weekly inventory transition monitor（E）



5.6 Kaizen / Improvement Capability

① Enthusiasm and action of top management

No	Contents	A	B	C
1	<u>The most basic point to improve the factory</u> In order to develop improvement capabilities, it is fundamental to have an organization, organizational structure, awareness within the company that can reliably implement these 7 items. (1) Enthusiasm of top management、Elimination of 3M、PDCA < Most basic 3 points > (2) Self improvement starting with 5S、5T <5S, 5T, creation of action plan for self improvement, follow up results> (3) Continuation of ＫＰＩ monitoring < After achieving the goal, set further improvement goal > (4) Promotion of horizontal development < Conduct improvement activity + KPI Monitoring to new issues > (5) Implementation of hand down activity < Posting of JICA activity materials, implementation of internal improvement activity committees, etc. > (6) 「Various Manuals」 and 「Various Standards」 < Create, post, report at presentation, and utilize within the company > (7) Implementation of improvement proposal system < Includes improvement suggestions for Manuals and Standards >  Kaizen slogan.pptx	○		
2	<u>Enthusiasm of Top Management</u> The enthusiasm of Top management is the most effective matter among the implementing departments of improvement to promote, continue, Horizontal development and hand down. In Pakistan, it is important for top management to promote its own improvement activities top-down. Also in this project, the Top Management of each suppliers has promised to actively participate in this activity in the Commitment sheet, which was exchanged between suppliers and SMEDA / JICA.	○		

② KPI Monitoring

No	Contents	A	B	C
1	KPI Monitoring: In order to confirm the effects of improvement activities and implement further improvements, it is important to quantify the effects and monitor them. The KPI monitoring sheet adopted in the JICA Auto Parts Project is made to manage the data monthly. Also, monthly "observation," "action," and "results" are specified in the sheet, therefore the monitoring is “visible” for all the members.  Format of KPI Monitoring.xlsx		○	

③ QC Circle

No	Contents	A	B	C
1	**QC Circle** **Background of QC circle birth** In order to develop Japan, which has few resources, it is highly dependent on exports, and it was mainly exported to machinery and metal products, but it is said to be "cheap, but bad", and the quality improvement was an issue. A training based on statistical quality control by Dr. Deming in 1950 triggered the introduction of quality control at each company after 1950. In addition, the usefulness of quality control has been accepted by each company. Because each company understood that to provide things that customers are satisfied with will improve the business performance of the company. The department manager and specialized staff were in charge of the practice, but QC activities were being promoted in the field front lines under the names of "Work study meeting" and "Workplace social gathering". “GEMBA and QC” magazine (the current “QC Circle " magazine) was published in April 1962, and called for “Should have a QC circle that all the workers participate which mainly by the chief or group leader act”. In line with the purpose of "Work study meeting" and "Workplace social gathering", QC circle was born in each company and QC circle activity started. **Basic philosophy of QC circle activity** * Demonstrate human ability and bring out unlimited possibilities. * Respect humanity and create a lively, bright workplace. * Contribute to the improvement and development of corporate constitution. In QC circle activities started in Japan, companies in Asian countries, Western countries, South American countries and about 80 countries / regions are actively introducing and promoting QC circle (small group) activities.	○		

Evolution QC circle activities

Pakistan currently has many companies are working to introduce, but in Japan, efforts are being made in response to environmental changes. It may good to use this in Pakistan. It is important to have the solid purpose for working on QC circle activities and to be succeeded.

The environment in which work and organization are located has largely changed from the past, and it is required to change activities in a better way in response to changes in the environment. In response to this, structural reform of QC circle called "e-QCC / evolution QC Circle" is being promoted.

Three visions of e-QCC (Union of Japanese Scientists and Engineers)

Establish and establish an evolved QC circle activity.

Vision 1: Activities to increase the value of “individuals” and share emotions (personal development)

Vision 2: Activities to achieve self in business integrated activities (contribution to business results)

Vision 3: Aim for activities that are used in a wide range of departments, regardless of their form.

The three visions of the “evolved QC circle activity” presented by the "Union of Japanese Scientists and Engineers" QC circle headquarters correspond closely to the environmental changes of these workplaces and organizations. The attached PDF file “Evolution QC Circle Activity” is a reference for the contents specifically proposed.

e-QCC Activity.pdf

Advantages of QC circle activities (based on basic principles)

Show the tangible and intangible benefits of QC circle activities and small group activities based on the basic principle. It is a property that only the companies, small groups, and people who participated in the project can obtain.

1. I want to improve myself / I want to do a better job ➡ Study QC thinking and methods ➡ Use what I studied and learned ➡ Become understanding well on rational perspectives, scientific methods, problem solving skills ➡ Grow as human beings
2. Gatherings of people in work place have sufficient knowledge and experience about practice. And they are peers who know each other well ➡ Sufficient discussion ➡ Enlighten each other / team work ➡ The workplace becomes brighter
3. Various problems in the workplace ➡ Clarification of problems ➡ Determination of the theme to be taken ➡ Analysis of factors ➡ Consideration and implementation of measures ➡ Problem solving ➡ Improve the corporate constitution.

In addition, problem solving brings a sense of accomplishment to the QC circle, leading to individual ability improvement and self-realization.

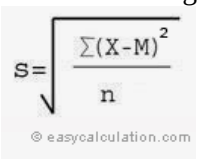
About the theme of QC circle activity

Here are some suggestions for thinking about what the theme should be, starting with QC circle activities. The theme is KAIZEN / Improvement of QCDSME, which is an important matter in the field.

QCDSME	Points of improvement activities
Q: Maintain and improve quality	* Reduction of in-process defect * Improvement of process ability

		* Minimization of variation * Reduction of pokamisu * Relapse prevention measures * Promotion of standardization			
	C: Reduce costs	* Improvement of yield * Reduction of working time * Reduction of man-hour * Reduction of setup time * Improvement of equipment operation rate * Improvement of layout			
	D: Strict delivery date	* Creating and executing production plan * Creating and implementing maintenance plan of equipment / tools			
	S: Ensure safety	* Thorough wearing of protective equipment * Reduction of fatigue * Reduction of hiyari hat * Implementation of 5S activities			
	M: Improve morale	* Activation of KAIZEN proposal * Measures to improve attendance rate * Activate QC circle activities * Establishment of evaluation and commendation system * Appropriate staffing			
	E: Improve the environment	* Reduce waste of materials / energy * Implementation of environmental protection measures * Reuse of scrap			
	Implementation example of a company in Pakistan One of the model case suppliers won first place at the QC circle presentation hosted by the customer. Presentation was conducted in line with the QC story. **QC Story (tool for summarization and reporting)** This section provides references for presenting the results of QC circle activities inside and outside the company. 1. Selection of theme: Use matrix diagram etc. and indicate the reason for choosing the theme 2. Current situation recognition and goal setting: data collection by 5-Gen principle. The goal setting indicates what, when, and how much to improve. 3. Creation of activity plan: Activity item and then delivery date and role assignment for each item. 4. Factor analysis: Use characteristic factor diagrams as an example 5. Examination and implementation of measures: Also decide how to confirm the effect 6. Confirmation of effect: Evaluate by comparison of aim and results. Evaluate tangible and intangible effects 7. Establish standardization and management: Change the process and establish it in the organization 8. Reflection and future issues QC circle activity implementation is highly recommended. The following books have been published by QC Circle Headquarters in order to know more in detail. An English version is also available for reference. Fundamentals of QC Circles ISBN 978-4-8171-9271-4 How to Operate QC Circle Activities ISBN 978-4-8171-9272-1				○

④ Cp/Cpk, PPAP

No	Contents	A	B	C
	Outline of Process Capability Indices (Cp, Cpk) **1. <u>Process Capability and Process Capability Index (Cp)</u>** When comparing merits and demerits of most of the production lines or merits and demerits among various processes workers, it express the percentile of probability in order to manufacture the products according to customer specification, it is called "Manufacturing Capability" = "Process Capability", the numeric values are called "Process Capability Index (Cp)". **2. <u>Calculation formula of Process Capability Index (Cp)</u>** Cp ＝ The numerical value obtained by dividing the standard width of "the quality characteristic" by 6σ. Specifically, it will be described below (at first, from the explanation of terms). ＊Critical to Quality = The most important factor affecting the quality of products in each line (Critical to Quality: Length, weight, hardness, flatness, concentricity, resistance value etc.) ＊Manufacturers make products to fit within a certain range for each quality characteristic. The range is called a standard. The difference between the maximum value and the minimum value is called the standard width. ＊σ ＝ Standard deviation is a statistical name that indicates the variation of numerical data groups.  X ＝ measured value M ＝ Mean value ($\bar{x}$) n ＝ The number of data ＊6σ ＝ Numerical value 6 times of the Standard Deviation σ From the above explanation, the formula for Cp is shown again below. **:ess capability index Cp** = (upper limit standard value-lower limit standard σ e) / 6σ (Upper limit specification value-Lower limit specification value) has been set in advance as a product standard. Therefore, the standard deviation σ affects Cp. Variation large = Cp small Variation small = Cp large **<u>That is, the larger the Cp, the better the factory line.</u>** Condition: The process is a completely controlled process = On the control chart, the variation is within the upper and lower limit standard values, and the average value is the center value of the standard range = Following normal distribution The formula for calculating the probability of fitting within the standard = process capability index is as described above. However, It is a reality that the center of the actual product is not the center of the standard range. Therefore, in practice, a calculation formula that can be considered even when it deviates from the standard center value is used. It is shown below.		○	

3. Practical process capability index (Cpk) formula (k = Katayori = Deviation)

In practice, the average value deviates from the central value ➔ Cp : ×
In practice, use calculation formula to correct deviation ➔ Cpk : ✓

Select the smaller value as Cpk

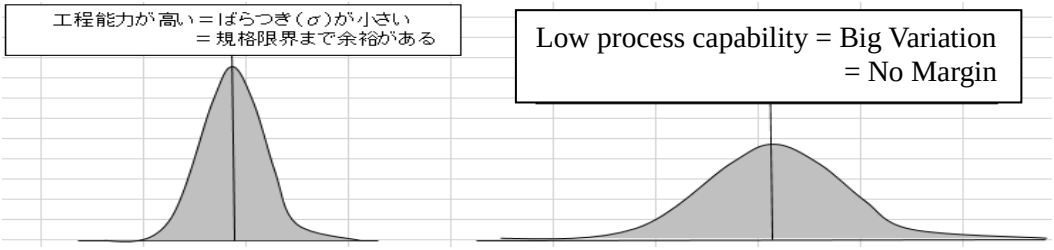
Cpk(L.L.) = (Mean Defect rate=50% **tandard value)/ 3 σ**

Cpk(U.L.) = (U. L. Standard value − Mean value)/ 3 σ

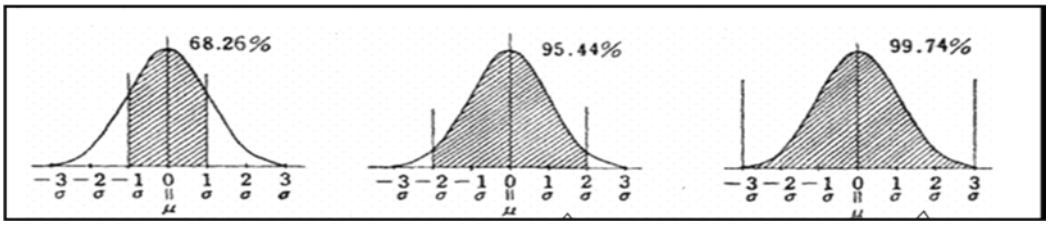
High process capability = Small Variation

4. Process Capability and Variation

Next, the variation in the case of high process capability and low process capability will be explained graphically.

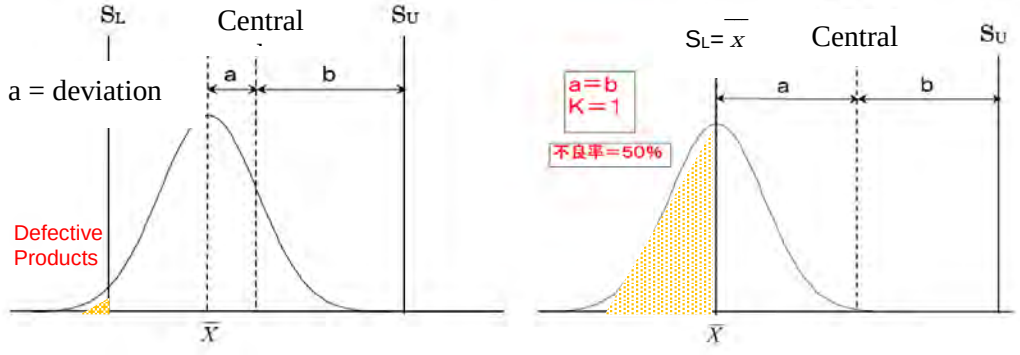


5. Relationship between normal distribution and standard deviation



6. Relationship of Practical process capability index (Cpk) and defect ratio

Finally, the meaning of the Cpk variation is shown in the graph.



	<u>Utilization of process capability index</u> The Skill Olympics held in Pakistan revealed that although Cp and Cpk can be calculated, how to use them cannot be understood. Currently, calculation of Cp and Cpk and histogram can be easily obtained by using personal computer software. On the other hand, the meaning of the formula cannot be understood, and in some cases, apparently anomalous numerical values are used as they are. Once a calculator should be used to calculate Cp and Cpk and write a histogram by yourself. By properly understanding and utilizing the process capability index, it can be used for investigation of causes of failure occurrence, measures, reduction of inspection and rework, and profit improvement. The materials used in the special seminar is attached as reference materials.  Outline of Process Capabilit			

⑤ Process FMEA

No	Contents	A	B	C
1	**1. What is FMEA (Failure Mode and Effects Analysis)?** FMEA can be described as a systematic procedure of activities (a) Recognize and evaluate the failure of a product/process and the effects of the failure, (b) Identify actions that could eliminate or reduce the chance of the potential failure occurring, (c) Document the entire process. It is complementary to the process of defining what a design or process must do to satisfy the customer. **2. Outline of FMEA** FMEA will make is possible to predict failure modes occur in the lowest parts & devices consist of the system and proceeds with the analysis. For example, by switching the system with a car, it can predict and analyze the defects and how they are effecting the vehicle. Moreover, if switch device to work then it will show the operational defects and how vehicle is getting effected, what kind of trouble will customer will face can be analyzed. In this way it will spot the defects mode hidden in the product/process and will evaluate each type of failure mode's level of occurrence, detection, and impact by expressing it in figure and it is a tool to take counter measures beforehand.	○		

2	**3. Benefits of FMEA** **1) Visible Benefit** ① Make a potential failure mode be tangible, prevent a failure from happening. ② Reduce process changes. ③ Reduce complains from a subsequent or downstream assembly operation. ④ Reduce a man-hour and cost. ⑤ Make an operation effective, and improve a detection of defects. ⑥ Make plant maintenance prioritized and effective. **2) Tangible effect** ① Hidden failures (defects) mode will become apparent and prior prevention will be possible. ② Reduction of process changes ③ Reduction of next process claims ④ Man hour and cost reduction ⑤ Operation efficiency and defect detection enhancement ⑥ Focus and streamlining the Machine management	○		
3	**1. Procedure of FMEA** 1) [Step – 1] : Preparations (1) Manufacturing production recognition (Design Engineer has to attend along with documents such as Design FMEA etc.) (2) Apprehension of process (check by Process Flow Diagram etc.) (Note) Also be warned about supplementary processes such as washing process, transfer between processes, storage, parts supply etc. (3) Determination of target process and analysis level (to be considered up to what unit) (4) Previous quality issues information of similar processes (Process name & failure Mode) (5) Participants : Prod. Engineering, Design, QA, Inspection, Production and (Vendors) 2) [Step-2] : Select the target Parts & Process (1) Determine according to the following principles; (2) Process where frequent machine problems or defective items produced. (3) New process or process with no experience (4) Process where quality defect relates to a serious problem. Others, process by decision of design engineer Refer the Concrete sample of procedure=>[Appendix 1:Selection of target parts/process] 3) [Step – 3] : Process Function Recording Describe clearly and concisely. (This will be important information such as consideration of Failure mode concept and importance will be important information) 4) [Step – 4] : Description of Failure Modes List all Failure modes expected to occur in process based on the process function, processing points concepts etc. (Consider what causes the failures with the presumption that failure always occur.) [Examples of Failure Modes] Mechanical System: Breakage, cracks, deformation, dropping-off, detachment, peel-off, deterioration, discoloration, corrosion, abrasion, seizure, loosening, vibration and noise etc. Electrical System: Short Circuit, melting loss, opening, welding penetration, disconnection, overheating etc. Others: heat-up, degeneration, melting, freezing, dirt, bad odor, roughness, eccentricity, assembly mistake, casting blow holes, washing liquid residual and dents etc.		○	

5) [Step – 5] : Description of Failure modes effects and evaluation priority level

1. Description of Failure Mode Effects

- When process defect occurs, simply express the mechanism that influences the function and how it effects the assembly parts or the system (such as not in operation or noise etc.). (Design Engineer) (consider it as the reaction from customer viewpoint)
- Example : Excessive Cylinder surface roughness ・・・Seal leakage due to Cup scratches, fast wear & tear of axle bearing metal.

2. Priority evaluation of failure mode

- By utilizing "market quality claims of past similar products", "delivery defects, in-process defects, information (process capacity)" as much as possible evaluate objectively by comparison with "Evaluation Criteria" the 3 Evaluation items which are "importance", "occurrence frequency", "detection level"

3. Comprehensive Evaluation of Failure Mode Priority

- RPN (Risk Priority Number : Risk factors & priority level ranking number)
  ＝ "S : Importance Rank" ＊ "O: Occurrence Frequency Rank" ＊ "D: Detection Rank"

6) Description of Reason of Failure Mode

(1) Identify possible causes of failure modes (Occurrence mechanism prediction).
(Consider how failures can be avoided, eliminate all possible reasons of failure.)

Example: *Such as Jig setting mistakes, locating mistakes, lack of cooling, insufficient Chuck pressure etc*

7) [Step – 7] : Description of countermeasures and their implementation procedure

(1) Determine the need of countermeasure by countermeasure need judgment criteria.
(2) For failure modes with priority reduction required will be,
① Occurrence frequency reduction,
② In sequence of improvement method detection, consider the countermeasures perceptive and contents.

(Note): When factors are complicated then conduction FTA analysis separately is effective.

(3) Try utmost to take countermeasures in terms of machinery, equipment, Jigs improvement and furthermore feed back to design to consider production & assembly standards etc., for preventive measures proceeding in advance. Avoid depending on human conditions (Operation warnings etc.).

8) [Step – 8] : Description of other necessary items

(1) Clearly describe the responsible department (or in-charge), due date, measures results etc., and curtail to ensure corrective action implementation.

9) [Step – 9] : Implementation Results and Follow-up

(1) Verify by market information feedback, whether there was not any overlook of failure mode or priority level evaluation was appropriate?

2. Implementation Timing

(1) Prior to process FMEA method & process planning, implement at the timing when the results can be reflected in process method & process plan.
(The concept will be clear and implement it up to procurement of machinery)
(Note-1) From the initial stage of development, determine the target (No. of cases) of process assurance ratio in terms of "design & equipment" and start activities.
(Note-2) Strengthen the cooperation with design department and check the results of FMEA for reference.

(2) Review all processes in accordance with the progress of process & method specifically. (Final will be mass production)

3. Issues to implement FMEA and how to handle them

1) Consider to Implement

It is better to implement FMEA for every thing that constitutes the process yet it will take long time. Therefore, priority will be given to implement it for the items ascertained from past experience and safety items. It is necessary to exclude the items with less impact.

2) Implementation of Countermeasures

As a result of consideration, the number of items which need countermeasures with exceeding the prescribed score often increases but in such a case consider prioritizing with higher marks to implement countermeasures first is very important. (Implement it from the high Risk items)

Appendix 1 Selection of target parts & process

Make sure to implement FMEA for any of the following conditions;

(1) For **Parts / Process grade class "A" or above** ・・・ Table1 -1 Parts / Process Grades Categories.Hence, safety related parts and critical quality characteristic parts has to be more than "B".

(Note-1) It could be skipped when assessed the possibility of similar defects as in conventional process for parts manufacturing process.

(Note-2) Critical quality characteristic parts class "B", only it can be implemented to the relevant process.

(2) By the results of design FMEA, if assessed that "It will effect the production process"

(3) For the process with the history of critical defect occurrences.
(Important Information・・・Recall, Improvement countermeasures, and other special inspections such as pre-delivery inspection etc., has to be carried out.)

(4) For those processes when Quality Assurance department determines need of Process FMEA. Others, also implement for the processes with low capacity etc., since past.

【Table 1-1: Parts grade】

(Final Judgement) Out of each grade of "parts", "usage conditions", "usage results", "method", highest grade will be final judgement grade

Category	Medium	Small		Grade
Parts * 1	New	When structure & material design is different from actual		S
	Similar	When structure & material design is partially different from actual		B
	Same	When structure & material design is same as conventional		C
Usage Conditions	Different	Used portion is different from conventional product		A
	Similar	Used portion is similar to conventional product		B
	Identical	Used portion is same as conventional		C
Usage Results	New	No previous record		A
	Similar	Actual production record at other factories		B
	Same	Previous experience of similar product		C
	New	Previous experience of exactly same parts		D
Method	New Method	Absolutely no previous experience		S
		Actual record at other factories		A
	Similar Process	New Line		A
		Same Line	New machine required	B
			Special Tools & Jigs required	B
			Gauge & inspection jig required to ensure Integrated tolerance	B
	Same Process	Same Line		D

*1: Design department will decide

Appendix 2 Worksheet Preparation Procedures

1) Evaluation

① Operation Points & Contents Extraction ・・・List up all the operation points and details.

② Find out the Failure Mode ・・・ Write down possible failure modes for each work contents.

③ Evaluation・・・Evaluate "priority" "occurrence frequency" and "Detection Level" on the basis of each evaluation standards.

・Priority・・・Table 2-2, Priority Evaluation Standards

・Occurrence Frequency・・・Table 2– 3, Occurrence Frequency Standards

・Detection Level・・・Table2 – 4, Detection Level Evaluation Standards

④ RPN Calculation・・・Calculate RPN (Risk Priority Number).
(RPN = Priority Rank X Occurrence Frequency Rank X Detection Level Rank)

2) Countermeasure Study・・・Consider countermeasure in sequence of "Structure measures", "Machine measures", "Method measures".

⑤ Structure study ・・・Ensure the part design (such as no assembly mistake possible)

⑥ Machine Response・・・consider including POKAYOKE.

⑦ Method ・・・Clearly define the rules and ensure practical operation.

⑧ Inspection ・・・If countermeasure in terms of "Structure, Machine & method", strengthen the inspection.

3) Conduct Re-Inspection

⑨ Re-assessment (Occurrence Frequency & detection level) ・・・Incorporate the counter measures and review "occurrence frequency" and "detection level".

⑩ Re-calculate RPN・・・ Re-calculate RPN
(consider countermeasure till RPN 100 achieved)

5. Countermeasure Need Assessment Standards & Procedure

- Implement countermeasure for those cases whose RPN exceeds 100.
- If RPN do not exceed 100 and individual evaluation points of "Priority", "occurrence frequency" are high from 9 to 10 then consider taking countermeasure.

(Note-1) Countermeasure priority sequence will be
①occurrence frequency reduction, ②detection level enhancement.

(Note-2) As for countermeasure method, avoid man conditions,
①Consider Design, ②Machine handling, ③Managing by Method, and
④ Inspection.

【Table 2-1. FMEA evaluation sheet】

No.	Process	Process Function	Quality characteristics	Failure Mode	Failure Effect		Priority	Reason for Failure	Occurrence Frequency	Inspection Control Method	Detection level	RPN	Counter measure View Point	Counter Measure	In-Charge	Schedule	Result After Counter Measure				
					Parts	Finished Vehicle (System)											Implement Conditions	Priority	Occurrence Rate	Detection Level	RPN
	①	②	③	④	⑤		⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰			

[Work Sheet making procedure]

eavluation_work_sheet.pptx

【Table 2-2. Priority (S) Evaluation Standards】

Impact	Standards (impact to user)	Standards (impact to production line)	RANK (evaluation marks)
Risk (No signs)	• Without any signs, contravene with vehicle safety and legal regulations. Very critical	• Without signs but worker is in danger.	10
Risk (Signs present)	• Without any signs, contravene with vehicle safety and legal regulations. Critical	• Without signs but worker is in danger.	9
Priority Extremely high	• Unable to operate vehicle/function (Major malfunction)	• Causes great trouble at production line. (100% Rejection)	8
Priority High	• Able to operate vehicle/function but user feels very dissatisfied due to decline in functionality.	• Small-scale disruption at production line (Products segregation, partial rejection)	7
Priority Medium	• Able to operate vehicle/function but user feels very dissatisfied because of features related to comfort & convenience malfunction.	• Small-scale disruption at production line (partial rejection・・・No segregation of parts)	6
Priority Low	• Able to operate vehicle/function but user feels very dissatisfied to a certain extent because inadequate operation of comfort & convenience features.	• Small-scale disruption of the production line (100% Repair)	5
Priority Extremely Low	• Defects related to senses such as appearance and abnormal noise. Most of the users (above 75%) notice the defect.	• Small-scale disruption at production line (Parts segregation, some repair)	4
Minor	• Defects related to senses such as appearance and abnormal noise. Many users (above 50%) notice the defect.	• Small-scale disruption of the production line (a small quantity on line repair)	3
Extremely insignificant	• Defects related to senses such as appearance and abnormal noise. Users with discernment sense (above 25%) notice the defects.	• Small-scale disruption of the production line (just some parts on line repair at same place)	2
Nil	• The user can not recognize the impact	• No impact	1

Impact to line will be as per QS9000 Reference Manual "Process FMEA".

【Table 2-3. Occurrence Frequency (O) Evaluation Standards】

Possibility of Defect Occurrence	Occurrence Frequency	Cpk	Defect Ratio	RANK (evaluation marks)
Extremely high (Continuously)	• Defect occurs definitely.	0.33<	Above 1/2	10
	• Inevitably failure occurs	≧0.33	1/3	9
High (Frequently)	• Previously, defect occurred frequently in similar processes.	≧0.57	1/8	8
	• Previously, defect occurred frequently in similar processes.	≧0.67	1/20	7
Moderate (Occasionally)	• Previously, defect occurred occasionally in similar processes.	≧0.83	1/80	6
	• Previously, defect occurred occasionally in similar processes.	≧1.00	1/400	5
	• Previously, defect occurred rarely in similar process.	≧1.17	1/2000	4
Low (Barely)	• Previously, defect occurred very rarely in similar process.	≧1.33	1/15000	3
	• Previously, it occurred just once in a similar process No recurrence, defect is not likely to occur.	≧1.50	1/150000	2
Extremely Low (Unlikely to occur)	• No previous history of occurrence in similar process. Defect occurrence is almost inconsiderable.	≧1.67	Below 1/150000	1

【Table 2-4. Detection Level (D) Evaluation Standards】

Detection Level	Standard	Inspection & Checking method *			Inspection & Checking Details	RANK (evaluation marks)
		A	B	C		
Almost impossible	• No detection method			○	• No inspection & checking	10
Extremely Rare	• Almost not detectable			○	• Indirect and sampling inspection only	9
Rare	• Detection possibility is low			○	• Visual inspection by worker only	8
Extremely Low				○	• Double check of worker's visual inspection	7
Low	• Possible to find out		○	○	• Statistical management by control sheets etc.	6
Medium			○		• 100% inspection by measuring instrument in later process.	5
Slightly higher	• Highly possible to detect	○	○		• Definitely discover in later process or at initial parts check process.	4
High		○	○		• Definitely discover in self process or in multiple later processes.	3
Extremely high	• Almost detectable	○	○		• Automatic inspection in operation process and automatically stops.	2
	• Surely detectable	○			• Defect will not occur due to product and process design.	1

＊ A: Inspection by POKAYOKE, automatic measuring device, etc. (Fool Proofed)

B：Inspection with gauge by man (Gauging)

C: Reading & visual inspection by man (Manual Inspection)

⑥ Enhancement Team power, horizontal development, skill hand down

No	Contents	A	B	C
	Principle: Top management and the kaizen implementation team members should work together to develop the entire factory team. (1) During PT activities, even if the Kaizen guidance was given to the Team, that was not communicated to Top management, and the Improvement effort was stopped. Top management should always keep track of the activities of Kaizen implementation Team and take necessary measures. (2) Immediately expand the contents of JICA Expert teaching/coaching in the factory. The teaching/coaching contents of the day, sharing of root causes, and countermeasures in future, etc. Every morning, or weekly according to the power of the factory, Top management to put all the related parties and holding a morning meeting regarding the issues/task. (3) Make it a practice to record at every teaching/coaching meeting, to all members of Kaizen Implementation Team. Without recording of the issues/task, there is no improvement. (4) Top management teaches/coaches OWNERSHIP concept to all Kaizen implementation Team members at the above-stated morning session. It is essential for Kaizen implementation that "this factory is my own factory". At the same time, it is also the determined feeling and passion that Top management would really embody the improvement or resolve the issues/task in the factory.			○
	Horizontal Development: Horizontal Development is one of the important processes of the Innovation. The word is from the "Toyota Way of the Manufacturing Method" and it is to develop and succeed Kaizen Implementation cases in one process done into another process, and further spread it into the entire factory, and innovate the whole company. For example, by transmitting the contents decided in one department to an organization that is not in the direct command system, such as the next (neighbor) in the horizontal direction and sharing the facts, methods and resolution, it is one of the ways of thinking as in-house knowledge and know-how fostered. Usually, since the organization has a pyramid structure from the Top management level to the bottom, and if the organization has firm corporate governance, such information can be transmitted laterally through the official route, however there is no horizontal flow of work achievements as information/instruction command system. The concept of this horizontal development is one of the mechanism by which organizations, departments, factories, etc., in a parallel relationship cooperate with one another. It can be said that it is a way of thinking and system. **(1) <u>Examples of teaching/coaching:</u>** ① <u>Horizontal development on parameter control of CO_2 Arc Welding</u> Optimal condition by trial and error method of welding parameters (voltage/current value, CO2 gas flow rate, welding wire supply speed, torch angle, torch feed speed, tip interval length etc.)of the welding machine which show problems with CO2 Arc welding quality set. ② For the other CO2 arc-welding, set the optimum condition by the same method as above by horizontal development. At this time, it is easy to find the optimum condition here by using the above result (the above optimum parameters) as a bench mark and using that parameters before and after it.			

(2) Cover Clutch for 2 wheelers(4 ~ 6 cavity)- aluminum casting defects on cavities：

① Major defects are blow holes, flow lines, causes are over flow position shape, number of gates and shape.
② As blow holes are often solved by improving the overflow position and the shape of the cavity, adjust the overflow position and shape so that the blow hole generation location goes to the overflow portion from the flow of aluminum.
③ As long as there are 2 gates in each cavity ,the flow line will not disappear. Crush one.
④ The parameter conditions that have been successfully improved by the above measures can be expanded horizontally and applied to the shape setting of the similar aluminum casting cavity issues.

(3) KPI monitoring（QA monitoring）：

① JICA project has implemented KPI improvement activities by setting KPI targets based on the strategic management method"Balance Scorecard"for each of 5 perspectives:financial,customer satisfaction,factory management,production and others.
② Furthermore, for model case suppliers selected by JICA Experts, 3 target parts have been selected for each supplier,and KPI monitoring has been carried out with regard to the most critical quality issue in the factory operation.
③ Implement the above quality monitoring in addition to the model case suppliers and expand Parts QA monitoring to be implemented by horizontal development to aim for Quality improvement across the whole company.
④ When carrying out the above KPI monitoring, do analyzing the issue and find the counter-measures by doing Observation / Activity / Result, keeping recording regularly for future use.

Skills Hand-down activities:

Know-how and technical skills acquired in teaching/coaching session with JICA Experts cannot be developed as only individual posession, in order to develop a company, it is necessary to convey this know-how and skills to the same department and to other departments in the above horizontal development way. As a result, each individual will be able to be enhanced through the development of the company. Furthermore, in order to further develop a company in future, not only the horizontal development, but also the vertical development, ie, to the young and junior staff in the company and members who will become management candidates in future could be done same. If those know-how and skills can be transmitted, it could be further improve and develop in the future as a benchmark. Skills Hand–down activities are the action to convey the know-how and skills as stated above to the juniors properly, including the horizontal development. Concretely, it includes Kaizen improvement Board, posting of Kaizen graphs or materials, training rooms (Dojyo or QCC), monitoring activities, and holding of a skill competition etc. It is important to enhance Human Resources who could transmit the existing know-how and technical skills held in the Company for long time.

WAY of thinking in the teaching/coaching of this Project:

① Way of Skills hand-down

Skills Hand-down activities practice the basic concept of Japanese Way of Manufacturing, of which essence is the enhancement of Human resources.

Support system members	Parts suppliers
• Hand-down plan（＊1）	• change of in-house environment(promotion of visualization)
• Teaching on-site	• promotion of in-house publication & documentation
• exchange activities w/Model case suppliers	• establishing in-house training system(including .OJT）
• Manual making on skills	• Set up of Dojyo（＊2）
	• holding Skills competition inside and outside the company

Inheritance of high-quality, high-performance manufacturing by transmitting skills required

（＊1）= transferee, successor, transfer skills, skills, target level, teaching materials, schedule, location setting

（＊2）= improve the perfection degree in 6 stages: ”I know” ”Can” ”Can understand the principle”, ”Can be good” ”Able to apply”, ”Can create”.

② Manufacturing is Enhancement of Human resources

MP days: Human beings are regarded as negative factors and replaced with machines as much as possible.

Various/small quantity days: Make full use of Human ability, reduce cost, give top priority to Quality.

Enhancing HR with high ability and leadership is essential, furthermore, these are continued by improvement of know-how and skills, and its correct transmission

Teaching/coaching of skills required and transmission at the Skill teaching Dojyo (In Japan, most of the companies introduced 2000 onwards)

Skill training, developing for further creative level and enhancement of HR

Concrete Tools:

(1) Kaizen Board

0202…KAIZEN ACTIVITY BOARD

(2) Posting Kaizen graphs/materials
(3) Training room (Dojyo set-up)
(4) QC Circle activities
(5) Monitoring activities
(6) Various in-house training session
(7) Skills Competitions

5.7 Corporate Power

① Confirmation of VISION, MISSION, QUALITY POLICY

No	Contents	A	B	C
	Confirmation of Corporate Power: JICA Auto-Parts Technology Transfer Project started with the selection of the Target suppliers from member companies of the PAAPAM. Then, first of all, OEM and PAAPAM recommended the candidate suppliers (auto-parts manufacturing companies), while SMEDA and JICA experts evaluated and selected the final suppliers based on the documents review per the standard of the supplier selection criteria, following the site audit by all JICA Experts, including the interview with TOP management with the confirmation of the current situation of the production line. Out of approximately 350 member suppliers of PAAPAM, Team selected 52 suppliers which require JICA Experts' teaching/coaching support. The selection criteria includes VISION,MISSION and QUALITY POLICY which assure the Corporate Power and its potential development probability, Team advised the all suppliers which do not have such basic rules to set up those 3 basic rules as soon as possible. These 3 guidelines are basic rules to confirm the present and future Corporate Power. After the end of the project, SMEDA/PAAPAM team should start by confirming these 3 guidelines for the suppliers as they continue to select new Target suppliers.		○	
	VISION and MISSION: Management guidelines are required to maintain and develop the company. Without those guidelines, the company cannot analyse based on what they are doing now, endeavor to make it a little better, and having hope to in the future. Whether top-down activities, bottom-up activities, the company management or employees cannot make decisions on what to do, No each in-house department or its employees cannot move forward or not at all. Therefore, it is necessary to firstly and clearly show in the entire company as a MISSION aimed at the continuous improvement for the current situation. On that basis, it is also important to set as VISION (future image) by what you want to become in the future based on this MISSION.			
	Confirmation of VISION: For the company, VISION has the following 2 meanings. When evaluating the company, it is important to firstly confirm whether the future image based on the above is properly set and sufficiently infiltrated in the company. 1) From the perspective of the customer (society): What kind of result has it brought to the future that has accumulated the present? 2) From the perspective of the strategy of the company: The future image of the company that should be. VISION means what we want to do in the future of the company. VISION means what we want to in the future of the company. By defining that the company is an organization to realize such a future. Stakeholders (customer, employee, stockholder etc.) can understand the company policy. **Example of VISION 1 (ANA Holding Japan):** ANA Group aims to be the world's leading airline group with the customer satisfaction and the value creation.			
	Confirmation of MISSION : It is easy for the company to understand MISSION in 2 aspects. Then as described in 2 above, it is necessary to set the MISSION from the following viewpoint before setting the VISION, and to confirm whether it is notified and understood throughout the company as well as VISION.			

1) Customer(Social)Perspective:
What is the significance of our Presence for Customers?
For example, what kind of the significance does the presence of the Factory, service and the company mean to the customer?
2) Company perspective:
What value is it for us to offer? For example, how do you offer marketing and what products?
Above 1.and 2.basically it should be same contents, only with the different viewpoints.
With the MISSION being articulated, all the people involved can be united for the end.

Example of MISSION（Mitsubishi Motors Japan）

1) Provide new experiences for our customers with creative products and service excellence.
2) Make positive contributions to the sustainable development of our society.
3) Act sincerely as a trusted company.
4) Enhance stakeholder value by leveraging the Alliance.

QUALITY POLICY:

Needless to say, Quality first is the most important policy of the Manufacturing Industries. Each company should set it as QUALITY POLICY with the contents appropriate to its current situation and the future image.

By setting QUALITY POLICY together with the VISION and the MISSION setting described above, the ideal form of manufacturing industry should became clearer.

Confirmation of QUALITY POLICY:

When carrying out the Supplier Evaluation and Selection,it is necessary to confirm the contents of QUALITY POLICY including the evaluation whether it is suitable for each supplier.

QUALITY POLICY of Toyota Japan case(Initiative to improve Quality):

Toyota sees quality as the combination of product quality, sales and service quality, and the quality of work performed by each employee that serves as the foundation supporting the other aspects of quality.

We also believe that products and services that gain the confidence of customers can be created only when each employee, who engages in every process from development, purchasing, production, and sales to after-sales service activities, builds in quality and implements the quality assurance cycle.

The origins of quality lie in the spirit of audit and improvement, and Toyota's unchanging MONOZUKURI (manufacturing) pursues ever higher quality through continuous improvement based on repeated implementation of PDCA cycle.

② Corporate culture and HR management

No	Contents	A	B	C
1	Corporate culture and HR management: Project has 2 major goals; (1) Quality and productivity improvement activities are spread to Auto-Parts suppliers and SMEs in other sectors; (2) Competitiveness of auto-parts suppliers is strengthened. While SMEDA/JICA team have carried out required teaching/coaching to 52 Target Suppliers in 4 year PT period, team has acknowledged the HR management issues as their main problem. The following is just for their reference to tackle the issues and also for the Support System team (SMEDA/PAAPAM and local Consultants) for their continuing teaching /coaching to other suppliers and ones in other sectors. First of all, all parties (suppliers and SMEDA/PAAPAM and Local consultants) should understand the basic rule. We need "Treasures people" as the basic Corporate culture. This concept is the basic tool in Japanese manufacturing sectors which show their successful HR management after the World War II. During SMEDA/JICA Team's teaching/coaching to the Target Suppliers, HR issue has emerged the critical issues which most of the Target suppliers has been suffering. ―Team like to share how far TOP management of each supplier understood and clarified this issue of HR management to lead their factories in a successful manner. (A) Customer First policy: This is Top management's responsibility to assure that factory is completely ready to start manufacturing the parts in good quality and designated delivery time per the requirements of OEM drawing and their order. From SMEDA/JICA Team observation on kaizen activity effects done by each supplier during 4 year PT period the team found its difference on Quality and productivity improvement implementation through and by means of Top management's learning/activities/back to the JET teaching basic during 4 year project activities. Out of 52 suppliers who joined SMEDA/JICA Auto-parts project, Team are enforced to select only 17 suppliers as Model case suppliers in the project. (1) Team requests each Top management of the target suppliers in the following manner; As management of the factory, how many Supervisors are assigned and located in each manufacturing shop, especially the critical and top prioritized shop area for the factory operation to satisfy OEM requirements? (2) During the regular Circuit teaching/coaching done by SMEDA/JICA team, the Team has reviewed the factory on-site operation by individual work-field Experts and indirect shops for whole factory management area by whole management area Experts in the day, submitting teaching/coaching materials made by SMEDA.JICA Team to the Target Suppliers by the following day. (3) Upon receipt of the teaching/coaching materials from SMEDA/JICA Team, each Supervisor are required to understand what JICA Experts taught/coached on-site in the target area which requires kaizen implementation-100%.If not understood to a satisfactory degree, please do not hesitate to listen to the Experts in charge till you understood 100%.	○		

	(4) Taking a variety of operation improvement occasion in the factory such as Managers meeting or QCC (Quality Circle), please be requested to share what you obtained from SMEDA/JICA Team-not only successful case of Kaizen implementation action but even failed case which will help your future implementation of kaizen in the similar case. (5) To assure Kaizen effects into your factory operation, please make it a rule to standardize and make your operation manual in the target shop based on SMEDA /JICA Team instruction.			
2	What is the Human Resources required to assure a good factory operation? Purpose: Technical transfer Japanese manufacturing method into Pakistani factories; A: Understanding rule and principles of the manufacturing is good enough? Please be shared that At the skills Olympic held in March 2019,participants performed well for the given task, but according to the observation by the organizers of the Event, they cleared the task only by trial and error, and shows the lack of standpoint of the rule and principle required at the normal operation in the factory. Factory management should firmly recognize this point, and will arrange engineers from the Faculty of Engineering at Pakistani Universities or industrial high school as the supervisors of the target shops. According to JICA Experts observation, the indirect departments of the factory has the corresponding engineers, but there is no enough staffing on the level required for on-site managers. B: What is the responsibility of SUPERVISOR assigned in the target shop? -Whether he understands the requirement contents and its Quality level requested by OEM? -Whether he understands the contents of the drawing and its Quality level and he could assure the production system required? -Whether he obtains the required knowledge/technical skills/experience? C: Factory management should keep this in mind and foster/enhance Supervisors. In order to do this, make the required education (in-house OJT, external training seminars, other educational training such as JICA program etc.) and invest in education occasion to enhance the Pakistani manufacturing HR. C: The factory's Supervisor is the key-person in the Kaizen implementation in the factory. He(She) is required to plat an active role as a guardian of an optimal factory production system, such as thorough In-House Standards operation rules, thorough implementation of Standard operation flows and keep necessary parts and stock of inventory (Hyoujun Temochi). In order to do so, they are required to play an active part as the core person of the factory. It includes creating rules of the Standard work for each Target Shop area, most optimal practice, review of their implementation, behavior management of workers placed, guidance if necessary and so on.		○	

3	C: Measures in HR management; Most of the issues/task required from the suppliers are Retension and Absentee issues. As JICA Expert show some cause /effect cases from his HR management experience in Japan, USA and India, there are measure ideas showed in the attached materials. (Retension) ① Goal-setting ② Higher goal setting for management candidate ③ Big brother concept (Absenteeism) ① Stable scheduling ② Planned leave schedule ⇒Please read the attached material "HR Management" and teach/coach the following contents of the guidance based on each factory situation.		○	
	Lastly, requirements for Top Management in the factory; A:To penetrate Customer First policy in the factory; As top management, please be required to assure that your factory's production system is per OEM requirements, The required 4M (machine, materials, method, and HR (Man)) is ready per the Requirements of OEM? Your employee is not saying that we to purchase materials from the market, though not even per the Drawing requirements of OEM? B: HR Enhancement of the factory; As top management, please be requested to assure that your factory has good number of SUPERVISORS who can keep good quality production line but also assure the oprimal production system based on OEM requirements at all times. C: Please penetrate Treasures people concept in the factory; As top management, please review OWNERSHIP concept is being penetrated enough in your factory? Your investment in HR enhancement enough? Your employee responsibility is good enough? (Do you understand that all of your employees are working in a healthy and good environment?) ⇒Please review the attached "HR Management" material for the betterment of your factory operation.  HR policy Policy A .pptx			○

③ Future Concept

No	Contents	A	B	C
	Future concept The future concept is a summary of how you want the company to be in the future at the present time, when you decide the future plan. The word that specifies the slogan in a single word is called VISION (future image) here and although the explanation and confirmation of the VISION have been described in the above ①VISION, an example of the formulation procedure in the case of formulating specific contents of the future concept in the item list form will be shown below. **1. Create the new management philosophy** Management philosophy is the basic purpose of management. This management philosophy is the following. (1) Increase employee income and management for happiness including future family (2) Management that gives customers pleasure, trouble solution, and excitement. **2. Create a marketing plan for Growth** With the current product service as the core, what product service will be developed in the next five years, and consider to what customers and how will it be sold. **3. Create a target sales profit plan** Plan the structure of sales to what kind of customers, what kind of product, how many and how much profit business will make. **4. Create an organizational chart of business and personnel** To achieve the target sales plan in 5 years, the single person should not operate the same job for a long period of time. New business will occur and the number of employees also increase. Plan the corresponding step-by-step organization. **5. Create a profit sharing system and a profit use plan** Profit sharing is to decide how to distribute the results (profits) of each half year to the employees. The employee's motivation cannot be expected unless the employee's remuneration is divided into fixed remuneration and performance remuneration. **6. Create a facility plan** Try to improve your company by increasing the facilities for production, cleaning the office regularly, improving the work environment. Do not forget to create an investment recovery plan. **7. Create a system which employees can expect** Most of the Small and medium-sized enterprises does not have their rules, regulations and mechanisms. Therefore, it is important for the company to incorporate the contents such as, what is the reason of your salary and how it will change? Is there a bonus? How will you be evaluated when you achieve good results? What happens if you get sick? To its management and make the employee understand and foster a sense of unity between employee and management in an effort to maintain and improve together with the employees. **8. Create a relationship plan with the customer** Create relationship plan with your current customers and their response plans, as well as development plans for new customers.		○	

9. <u>Create relationship plans with business partners and industry</u>

Create a plan of the relationship with current business partners, new business partners, and the industry groups which the company belong.

10. <u>Plan for service contribution to the corporate community</u>

Formulate policies on dealing with surrounding communities as a company to improve relationships.

With the dream and hope of top management as possible after 5 years.

Create a vision for the 10 contents mentioned above with the dream and hope of top management in 5 years if possible.

No matter the past, even if the company is facing the difficulties now, it is the top management`s responsibility to figure out the future.

It is important to portray the possibility which is embraced by dreams and hope in the future by your own hands. The road of thanks and fulfilling days. This road continues to happiness and success.

The future is the possibility. The way to success is to live in the possibilities of the future. Walk straight forward and stay on the path which you have decided. Make sure to be definite and wise.

<u>5 years plan</u>

The ①Future concept mentioned above shows the development procedure as a goal of the company within five years. This five years is a period that is often used as a maximum investment recovery period when manufacturing companies plan to invest in facilities in the future. Therefore, it is important to formulate a concrete business plan for the next five years = five years.

Below is an example of the 5-years plan development procedure. As each target subject, you should consider based on the 1～10 contents mentioned at ①Future concept above.

1. <u>Goal setting after one year</u>

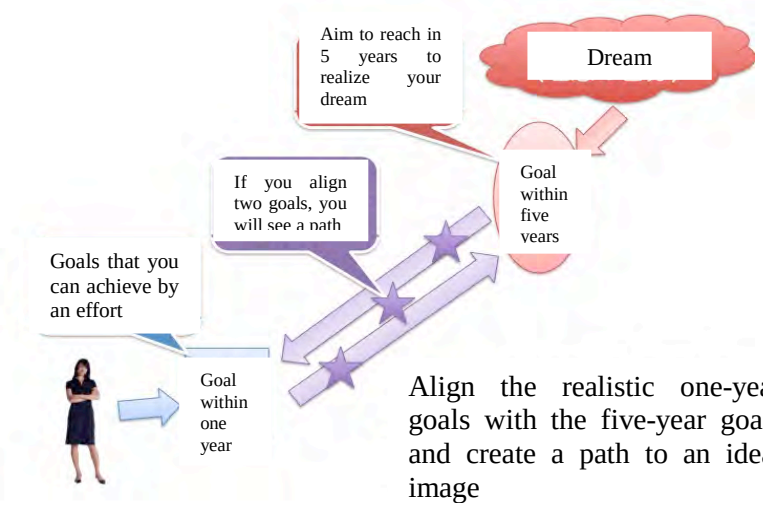
In the current situation of the company, set the realistic goals that can be achieved with effort.

2. <u>Goal setting after five years</u>

Set the goals that you want to reach in five years to actualize the future vision.

3. <u>Goal setting after 2~4 years</u>

Align the realistic one-year goals with the five-year goals created based on the future vision, establish a path to an ideal image, and set the goals for each year.



Align the realistic one-year goals with the five-year goals and create a path to an ideal image

(Reference：The Driving Force of Japan -Small and Medium Enterprises-)

In order to promote the potential of Japanese small and medium enterprises to the world, the program will focus on the companies' spirit, quality supported by technology, and the corporate culture that is being passed down through generations. What are the characteristics and the strength of those companies, which are said to be one of the driving forces of Japan?

Measures to Improve Corporate Power and Technology

This manual is a summary of the contents so that teaching and transmission of manufacturing can be effectively performed, based on the guidance to the automobile parts manufacturing industry by JICA experts with the main objective of improving quality and productivity.

In order to further improve corporate power and technology, it is necessary to conduct activities beyond the content of this manual.

When a company request the consultation on further implementation of improvement, it is effective to give advice on the possibility and measures for the company at each stage based on the following contents.

1. Establishment and operation of manufacturing Dojo

The establishment and operation of the manufacturing Dojo has already been explained and taught mostly to Model Case Suppliers. The Manufacturing Dojo is a developed form of the Training Room, and its purpose is as follows.

1) To be used for various in-house meetings (Meeting Room function)
2) To be used as the place for in-house information exchange (Obeya Room function)
3) To be used for In-house training sessions (Training & Practice Room function)
4) To be used as the place for various in-house experiments (Experiment Room function)

Inside the Manufacturing Dojo, information which are directly linked to the above mentioned purposes such as regular and daily KPI monitoring, education and experiment dates (plans & results), quality, production, sales, service information, safety and environmental information should be posted and used effectively.

＊ An information management sheet for the Manufacturing Dojo for Model Case Supplier and a flowchart showing the background of setting up the manufacturing Dojo in Japan are attached.


MODEL CASE Suppliers Step-up


ものづくりは人づくり.pptx

2. OJT Implementation

Through this project, OJT local consultant members were invited to attend circuit visit to the suppliers every time, and they were asked by experts to understand the current situation of each supplier, how to proceed the teaching/ coaching, and the instruction content for each suppliers. Even for the members of the suppliers, it is important for them to participate in the following two OJTs, and Promote awareness and knowledge of employees and transfer of technology.

1) Provide a place for discussion of issues by management, current staff, staff who might be in charge in future and related parties, and have them to participate and understand the current situation and issues which they are facing.
2) Assign staff who might be in charge in future and members of related departments as OJT for routine and daily work.

3) As for the related discussion and the OJT assignment work, create and implement rules for each related members to report the purpose, issues, details of the activities, and results.

3. <u>Hold and participate in skill and technology competitions, and conduct reflection of the results</u>

In this project, the First Skills Olympic was held in March 2019 with the support of the Japanese OEMs in Pakistan, which was aimed to confirm the results of the circuit visit to the target suppliers and to share the information related to this project. The Skills Olympic will be held regularly by PAAPAM in the future and is expected to contribute to the development of the manufacturing in Pakistan.

As mentioned above, there are various types of skill and technology competitions from the top Skills Olympic to competitions in each company, however the purpose is to confirm the result of improvement of daily skills and technology and to share the information. By participating in these events and to consider your own results and aim for further improvement, it will contribute to the improvement of corporate power and technology.

The continuous activity is required.

4. <u>Participation in external training</u>

In addition to receiving practical training and OJT within a company, by receiving training at an external organization, the staff can update their personal knowledge and experience and by sharing the training results within the company, the corporate power will be improved.

As for external training programs and exhibitions, it is important to grasp the information of OEMs, PAAPAM, and other industries, and to plan how to correspond as a company, and put it into a budget to be taken into business.

As the Japanese information, there are various trade fairs and exhibitions hosted by JETRO in Pakistan, therefore it is important to keep an eye on JETRO HP.

5. <u>Introduction of foreign technology, technical alliance</u>

When producing and shipping products for OEMs, it may be conditional for the supplier to conduct technical introduction and technology alliance with a designated vendor.

The reason might be because the OEMs have an adoption record in their home country or third country, and the production of this product requires special know-how and patent. The other reason is because there are important processes and control methods in securing quality and it is to judge by the OEMS that production cannot be done excluding it.

In such a case, the supplier will first decide whether to conduct technical introduction and technology alliance or not, based on the profitability and future plan

Also, even if there are no conditions from the OEMs, please consider the introduction of the most appropriate technology for the supplier in anticipation of the improvement of the supplier's skills and technology, the strengthening of the competitiveness and the future business development.

In addition, as for the technical introduction and technology alliance, pay attention to trends and acquisition of preferential treatment measures such as the development policy of auto parts manufacturing industry in Pakistan, parts import regulations, parts localization laws and regulations, introduction of external technology, etc.

The Japanese corporate information can be obtained for free from JETRO HP or JETRO's business matching site TTPP, as mentioned above.

6. <u>Introduction of foreign capital</u>

One of the developed form of the item 5 mentioned above is the introduction of foreign capital.

The form of introduction can be divided into direct investment and indirect investment depending on whether it involves management participation or corporate control.

Even when introducing foreign capital, certain restrictions may be imposed by the laws

	and treaties of Pakistan, Therefore it is necessary to grasp and respond to the latest information from EDB etc. 1) Direct investment includes the establishment of subsidiaries / branches or joint ventures, participatory acquisition of shares, transfer of technology, etc. 2) Indirect investment includes securities investment, foreign bonds, loans from financial institutions (including loans) **7. <u>Establishment of joint venture company</u>** A typical example of direct investment in the manufacturing industry is the establishment of a joint venture in Pakistan. The targets are fields and products that require technical introduction in particular, and their manufacturing suppliers are selected as the partner of joint venture. As an example, there is a pattern in which the Pakistani side provides land and buildings and the foreign capital side transfers production equipment and technology. With regard to the joint venture ratio, it is often the case that each compensation is assessed with a lawyer, an accountant, etc. to determine the ratio. Even when establishing a joint venture, there are restrictions due to the laws and treaties of Pakistan, therefore it is necessary to grasp the latest information from EDB etc. and respond. In the case of a joint venture with a Japanese company, it is also worthwhile to consult with JETRO's Karachi office once.			

④ Strategic Management Approach BSC

No	Contents	A	B	C
1	<u>Strategic Management Approach</u> In business management, it is almost shared with each company that various data utilization is not indispensable for business management, and a large amount of data is accumulated daily in the company. Nevertheless, there are surprisingly few cases in which data is used in corporate management. The decisive factor is the lack or business strategy. Although sales and profit performance targets are disclosed, it is rare that strategies to achieve them are clearly stated in a company, therefore it cannot be said that the staff is always properly performing activities in line with the business goals. Hear, the term "Strategic Management Approach" is used to manage data in accordance with business goals so that corporate activities can be carried out properly for the development of a company and this approach can be achieved by concrete specification of strategy at practical level, 1. Goal setting 2. Execution plan 3. Execution 4. Evaluate. As the representative example, "BSC" will be explained below. In addition, business strategy can be simply explained as to fight by taking advantage of the strengths of the company.		○	
2	<u>Process outline of management strategy</u> Before introducing the BSC, the process of general management strategy will be mentioned below. (1) Formulation of strategy ① Analyze and evaluate the external factor of the company or competitor (capability, resources, etc.) . ② Set goals based on the above assessment. The goals can be long-term to short-term depending on the level. ③ Develop a strategy by defining the necessary plans and tools to achieve those goals. (2) Strategy execution ① Allocate resources (such as funds) necessary to execute the strategy. ② Establish a command line (hierarchical structure) or some alternative structure (e.g. project team). ③ Assign permissions and responsibilities to groups and members in the organization. ④ Manage process execution. Allocate resources and change processes as needed. (3) Evaluation of strategy ① Assess the effectiveness (reasonability, feasibility, legitimacy, etc.) of the strategy through KPI monitoring. ② If the strategy is not effective or changes in circumstances occur, change the strategy as necessary.		○	
3	<u>What is BSC</u> BSC = Balanced Scorecard is to set business goals by clarifying the vision (future image) and strategic mission. However this goal does not only include the business performance represented in financial figures, but also 4 perspective which define the key success factor (KSF) for the realization of vision and mission. In addition, key goals indicator (KGI) and key performance indicator (KPIs) is set in order to measure the degree of achievement and the data which meet the business goals so that corporate activities can be carried out properly. By grasping the progress of the strategy by KPI, it is possible to evaluate the balanced performance. It is a concrete activity for a company to confirm the evaluation result and to implement an action plan for achieving the goal. It is also required to change and re-form a strategy if necessary. The 4 perspectives are "Financial Perspective", "Customer Perspective", "Internal Business Process", "Learning and Growth Perspective" The outline of the management strategy by BSC is shown below.			○

The outline history of this method is as follows.

- ＊ 1992 BSC methods was invented by 2 professors of Harvard Business School as Business performance evaluation way
- ＊ 2001 Japanese corporations started to adopt this method as Comprehensive Strategic Management way
- ＊ 2006 Harvard Business School revised the BSC method at the occasion of Harvard Business Revue 30th Anniversary year in 2006 while most of the companies in the world tend to follow this methods afterwards.

4

Outline of BSC`s process

Above-stated strategic management approach on the 4 perspective is the main characteristic of BSC and showed in the following manner.

○

5

SWOT analysis

In order to achieve the goal, conduct self-analysis on company, departments and individual in terms of 4 categories (Strength, weakness, opportunities and threats) to decide optimal use of management resources in response to environmental changes and setting strategic target items

○

Based on the given SWOT, the goal is set after judging whether the goal is achieved.

However, do not forget the fundamentally important goals and high-priority goals.

	Helpful	Harmful
Internal Factor	Strengths	Weaknesses
External Factor	Opportunities	Threats

6

Example of BSC

(1) The following are the examples of the Strategic Goal such as Key Success Factor (KSF), Key Goal Indicator (KGI) and Key Performance Indicator (KPI).

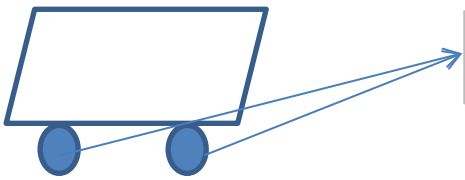
	Financial perspective	Customer perspective	Internal Biz process (Plant Management & Production) perspective	Leaning & Growth perspective
Strategic Goal	Profitability Improvement	Customer satisfaction improvement	Increase of actual production time	Reduction of early retiree ratio
KSF	High price products sales increase	High quality	Strict punctuality	Employee satisfaction improvement
KGI	High price products sales Ratio (%)	Market share (%)	Ratio on actual production time (%)	Early retire Ratio (△10%)
KPI	High price products promotion campaign times (times/Mo.)	Number of guests (person/Mo)	Observance frequency on actual production time punctuality (times/Mo.)	In-house event number (times/Mo.)

(2) An example of a personal evaluation introduced by Kaneki expert in a Chinese company in 2011 is shown below.

BSC for Kaneki in Chinese Corporation

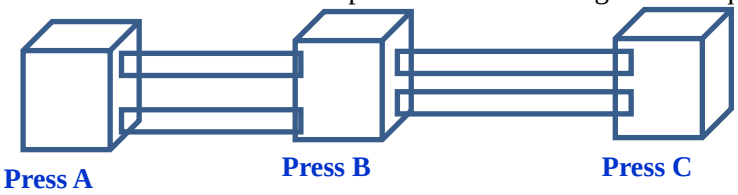
5.8 Factory Management

① 5S/5T Activities

NO	Contents	A	B	C
①	5S/5T For whole factory improvement by implementing 5S/5T tools Under-said shows essence of target suppliers' actual situation to improve. Stamping/Press Area; ※ 5S/5T improvement is most difficult in Sheet Metal area, and occupancy ratio is higher as compared to other areas therefore it becomes bottleneck in most of suppliers JICA team visited. Material Storage: Since most of press machines are single Die type, therefore to store materials near the press machines is good for work efficiency but it is difficult to implement 5S where small sized press machines installed in a narrow space. As a countermeasure for this is, production quantity and model which is described on Delivery Instruction Slip coming from delivery date 3 days earlier and firm order 1 day prior to production only store the required quantity of Sheet Metal material in a sequence at a short distance and attach a Tag with Part Description, Part No., etc. Moreover, also make arrangements for die change similarly. In case of minimum almost 20 to 30 cm2 carry out lot production with approx. Less than 2000 pcs as intended quantity (it may vary company wise), will not cause any trouble to production efficiency and storage place and common items lots will be consolidated. IN→PROCESS→OUT of Press Machine In principle, materials storage →Press Process→ Finished Goods (Parts)→Scrap（punched drop scrap, left over scrap）→ Generally scrap. How to Set in Order? : Arrange the materials in order in the bins in order to easily count the quantity. Consider better placing conditions in order to avoid time loss of re-counting. Do not pile up scrap, the key point is don't place directly on the floor. It creates additional work load (MUDA) wastage of time collecting again later and also quality gets effected due to sticking of trash, causing MUDA to clean or wash later. It has to be stored on some specific rack or simple trolley which can be prepared by simply fixing caster wheels to plywood sheet. To use trolley or roller with casters, just attach casters with plywood board, it must be easy job. Fix a can or bin under the machine for dropping scrap and empty the bin periodically  ⇒dispose-off periodically.	○		

Oil spills in some press machines (i.e. draw parts), so clean up periodically including the surrounding area. It has to be incorporated in Die maintenance schedule. If material sliding is not smooth it becomes cracks and wrinkles origin (which can be eliminated by maintenance)

It was observed at some places where single chute was provided instead of in process bins or cages in order to eliminate space wastage. This is a way of Kaizen (improvement). (Picture does not show the chute but some press machines arranged in a sequence line)



Press machines cannot be used for ever therefore, Die Base, Punch Die, Fly Wheel, Axles and Belts has to be cleaned frequently.

Repaint where paint has been peeled-off because it is important to prevent from rust.

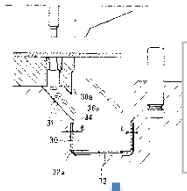
In Press and Sheet Metal area the most difficult is the material storage area. In fact, there are many process such as, shearing, sorting and setting in order by width, length & thickness after cutting by Slicer at a size of workpiece. In this area we observed some issues such as "space cannot be utilized effectively when there is no defined storage place, no specific production schedule therefore kept close for some reason, things are placed even on the passage, etc." in many companies actually.

FIFO has to be implemented by clearly describing part number, part name, material, storage date & duration as per the data of production control and over all quantity general management.

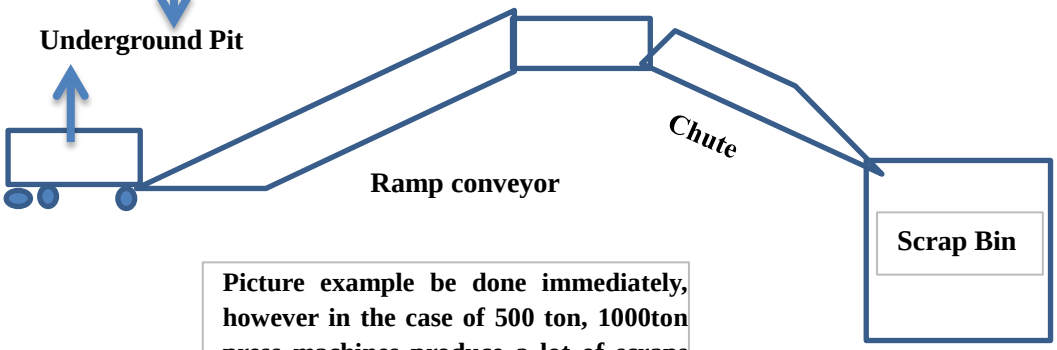
Chipping scrap has to be transported separately by trash bins and has to be regularly disposed-off by contractor and it has to be controlled by weight to avoid scrap loss.
Special steel, steel bands, aluminum, brass and copper plate are costly therefore, organize separate place to store them.

To dispose-off this type of scrap, determine the specified contractor and make him collect on a regular basis.

If possible to invest, then make a pit in the basement for scrap after press process, lift up all the scrap outdoors with ramp conveyor from the pit and fill into fixed bins, it will reduce manpower, maintain safety, prevent contamination of surroundings (if scrap is scattered on the floor the plant looks dirty ⇒it makes bad impression in Japan, it is one of the way of handling scrap as manufacturing factory)



Practical example of Scrap handling-basement pit
5S implementation



Picture example be done immediately, however in the case of 500 ton, 1000ton press machines produce a lot of scraps therefore, consider as suggestion.

Key Points

1) No use of rusted materials in principle.
2) Rusted powder after press processing might be attached to die and punch.
3) Draw products might be cleaned by plating or pre-treatment, all attached materials of dies affect quality degradation.
4) To avoid such defects, cover the transparent polythene sheet for rust prevention, add apply oil, and use zinc steel plate subject to OEM approval.
5) To avoid unnecessary order and inventory.
6) Do not leave it in the air as much as possible → prevent it to get contact with oxygen.

Key Point for Storage of Dies & Molds

While teaching/coaching to the Target suppliers in 1st Term, this point was one of the difficult task which we could not get the solution easily. Die/molds storage place is where the methods of storage is not easily decided.

First of all, consider how they should be stored. As JICA Experts, same lessons were given to the suppliers repeatedly.

1) Prepare necessary racks for storage. Most of suppliers prepared per our instruction, while some not completed.
2) Store the currently-used die/molds which need for SOP near the press machine area. Old type die/molds are to be stored separately. Fix the place for storage, attach a tag with part shape, and covered with nylon bag for safety.
3) The best way to set up die/molds in line with the production instruction process, but it might be better to spare 1 or 2 die/molds considering sudden production increase from OEM.
4) Do not keep the bigger Dies/molds too high in order to reduce lifter work load of the Die set-up, and set in order.
5) In case if finished goods require piecing, bending, drawing and trimming process, set in order horizontally in process sequence. However, some case requires large tonnage of press machine, it might be good idea to indicate where the required die/molds for next process are stored on the array molds.

This picture is example of color coding, it is easy for identification, and fix a chain for safety to prevent from potential falling risk.

IMPORTANT:
Die/molds are company assets, so clarify whether the die/molds belong to OEM or factory. Maintain an asset ledger book to record necessary information such as purchase amount, specification of die/molds, depreciation and improve to clearly display which die/mold is currently in use, dispose-off if unnecessary ones. Maintain record and keep on updating.

Welding Area

(Arc welding, MIG, MAG, TIG, Spot welding, Projection welding, Brazing, Acetylene Gas)

It is exactly true that the welding shop is dirty, smelly, bad with air and it is difficult to keep cleaning and cleanliness in a normal condition. But, In order to produce defect-free parts, as principle of manufacturing, it is necessary to keep 5S rules.

Arc Welding

While placing work on the work table, the table is scattered with welded powder, sludge, and sometimes the residual use end of the arc welding rod.

How to improve → To prevent arc sludge (splashing) from scattering as far as possible, provide protective metal plate (protective wall) so as not to scatter, periodically collect dust and place in specified place. Establish waste disposal site. In that case prepare the can lid.

⇒ To prevent dust fires.

While one part feed is basic operation, possible badge production based on the size and location of parts, however, to prevent scattering as much as possible.

To prevent from potential falling with chain, gas cylinders lying at the fixed place by the wall, including CO2, acetylene, oxygen, argon including inert gas etc.

Welding machine- Voltage, ammeter breakage and wiring breakage, bare wires as putting wires in U-shaped bending to outlets,

⇒It absolutely prohibited.

- Check of tangling for electric wire, gas tube etc.
- Inspection of insertion of plug socket and pulling out,

⇒If no crimp sense when you plug in, immediately replace or modify it.

Work clamp jig is not a welding practice board. So confirmation board to be provided and check the arc weld condition, bead height, width and wave pitch. → End of the fixture not to be bead heap.

Store the work standard/ procedure/ manual in a fixed place, so that anyone can identify part name and number, prohibiting to put it cluttered.

(Be prepared to respond when OEM process audit) → To set in order.

TIG/MIG/MAG Welding

1) TIG

①Always clean up tungsten rod and holder chuck part, not prevent voltage drop Probe, current checker is easy to check. (After guidance here, suppliers increased to purchase it.)

②Control of diameter of tungsten rod

③Prepare shelves for the identical ones as φ 2, 3, 4, etc. and store them separately. In doing so, keep them from moisture, putting in a nylon bag with drying material is good.

④As workplace is likely to be dirty with arc dust, in → Process → out operation to be conducted cyclically and move smoothly, before and after work and minimizing the between process distance.

⑤To devise to prevent scattering. Install the shielding plate, considering ventilation

MIG/MAG Welding

①Like TIG, material coil wire on the jet side to be managed and storage control of the fixing jig, Write the part number and part name to clarify.

②To clean weld control panel, pressure gauge, ammeter, surface indicator needle of voltmeter to keep good condition.

③Check periodically whether piping of various cylinders are not tangled, the tube is color-coded or rupture of the wire, leakage is not present.

④Since sputtering dust is always scattered, clean regularly.

⑤Collect dust as much as possible, and clean it, collect it in one place, set a can with a lid,

⑥To keep outside the factory. → In that case, set up roof so that rainwater will not affect. Specify dust collector. The dangerous thing is the critical point where moisture in dust (even rare) cause small explosion. It is very dangerous.

⑦MIG, MAG welding manually, special machine welding that can move automatically also show scattering of wire chip, preparing separate can and dispose the used and collected ones

<u>Surface Finishing, Polishing, Grinding</u>

Grinders, Hand Grinder, Air Grinder (Leutor),Shearing (thin plate grinding whetstone) It is a 3K workplace, tight, dirty, smelly, also dangerous → This is due to the metallic powder which occurs at the finishing process, so if mistaken, it may cause fire hazard and dust explosion.

One Japanese company is doing casting, shot, deburring of magnesium, but absolutely avoiding dust scattering.

Dust collector and vacuum drawing pipe to collect all outside of the building, all into the dust collecting tank where dare to small explosion reaction to protect a massive explosion. → We add moisture to the dust-trapped Mg, causing chemical reaction.

The meaning to install the equipment outdoors the building is to prevent serious large explosion inside the building. It is considered when designing the building.

In fact, harmony between zinc, aluminum and iron powder with moisture reaching→ ignition critical point will rarely occur under ambient drying conditions and humidity, but in Japan with high humidity it occasionally happens.

Dry air here in Pakistan, there may be less outbreak. It would be too easy thought. Factory management should understand that rainy season has such a danger.

Please refer Neighboring Reference: Indian Mg factory is similar to Japan.

They have Fire countermeasure device and for Dust collection →They have a small explosion device.

<u>Factory Actual Situation to Share</u>

Rework site for deburr filing, Hand Grinder, Air Grinder (Leutor), Grinder, endless manually work, sandpaper.

For larger machines, polishing disc, material cutting shear (vertical thin plate grinding wheel disc).

Although site was visited, dust adhered to the soil floor, or the floor surface was roughened, it is just dusty.

In Pakistan dirt, tiles and a variety of floors are not cleaned up.

Tools attached with lining code of hand grinder are cluttered, and grinding whetstone, spanner, wrench and hammer left in disorder.

It is very dangerous for walking workers, and it may cause crack for thin plate grinding whetstone.

Surface finishing of 1 mm or less with grinding disc, this is also sparking constantly, the spark ,falling dust as time passes. Please remember it cramped and hard to clean after making laminated surfaces.

Air Grinder (Leutor), thin plate grindstone wheel disc, As with the above, when left over tools are damaged and difficult to handle. Thin plate grinding wheel discs, convenient to slice metal material, but once forced to apply the side, it may be a danger of bursting, which will crumble in a moment. It is extremely dangerous. When a broken chip enters the eyes it becomes a big disaster.

The most dangerous work to note, there are few protective covers on the rotating machine.

Counter Measures

When surface polishing is carried out, still dust is generated, then it is hard to see. At the time of cleaning, make brightly as possible, gather dust with a hand light. Dish in a can with a lid.

Clean the adhered dust with a small brush, wipe it off with a waste cloth, and clean the machine and the floor.

Air grinder (Leutor) and grinding stone are sintered bodies and are bonded with binders, so when remaining amount is small ,it may crack and destruct, so leaving surplus amount, (3 mm, 5 mm) and replace.

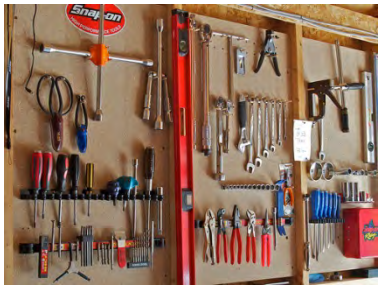
It is also 5S implementation to obtain instruction manual which varies per whetstone type (rough, medium, finishing) of the sanding machine and grinding machine and keep safety of employees.

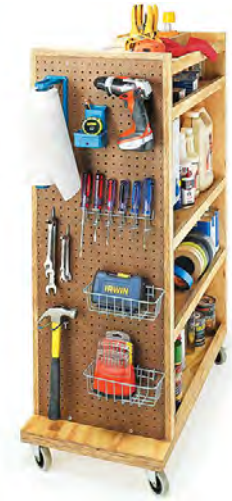
To keep in mind when filler with hand cloth ripping may insert your fingers while using it Rubber glove and leather glove may be better than cotton gloves, but at least stop bare hands.

Since the file is easily clogged, periodically insert chips, clean up by metal brushes and return to the original storage properly. Sort by size and organize it in order so that anyone can use them.

Slab polishing（risky to side use due to thinness）

Medium finishing (graphite included), super steel finishing (WC)





Safety Measure

1)Wear guard glasses
2)Apron
3)Safety shoes
4)Ear plug
5)Leather glove when hold works
6)dust mask

Dust bin

Dust collector

FYI;
To decide which one your factory to select based on the factory situation, making your policy how to protect factory environment in prior.

②Visual control

NO	Contents	A	B	C
①	As mentioned in ① of the 5S5T activities above, in Japanese-style manufacturing, to improve the 6 goals(Q,C,D,S,M,E) it is important to visualize (such as display of data) the 5S5T method and 3 Gen policy attempt, observation results, specific measures and its results. This visualization is the Visual control. Visual control is a control which that the normal stage and abnormal stage of the object can be determined easily and the treatment for the abnormality is clear. In other words, this is the mechanism which the object under control visually inform the abnormality to the workers, and the treatment of the anomaly is promptly performed. In other words, if it is not possible to determine something as abnormal by looking at it, for example, in a graph where it is not possible to read why a change in situation is in KPI monitoring, it cannot be said that this graph of visual control. Here, it is important that not only by the person in charge at the work site but also by a third person can notice the abnormality. In addition, it is important that abnormality can be judged reflexively without thinking about abnormality. Furthermore, it is important that "the correct judgment" does not cause a workers to make a wrong judgment.	○		
②	Human Error It is said that "people make mistakes and errors." The three stages of human error are: ① Mistake of recognition and confirmation (Errors that occur in the process until information from the five senses, such as eyes, ears, nose, touch, etc., is recognized in the sensory center of the brain) ② Mistake in judgment and memory (An error that occurs in the process of making a decision on the adaptive action and issuing an action command from the motor center by judging the recognized situation) ③ Mistake of operation (Error in the process of movement of hands and feet by movement command from the motor center, or an error caused by omission) It is said that the most frequent mistake among these is ② Mistake in judgement and memory. Therefore, information that can be correctly judged by everyone instantly is the one which uses color-coded display, lamp display, sign (icon) display, picture or manga display, card display, graph display, etc. These information is so-called "image information". In other words, it is important to implement control that can be seen even if you don’t want to see it, this is visual control. The most representative case of visual control is traffic signs. The number of people judging from traffic signs is numerous for children and adults. Furthermore, it is necessary to make a momentary judgment from traffic accident prevention. There are various indications drawn on the road, such as intersection signal, no entry sign, one-way sign, no right turn sign, no parking sign, road construction sign. In these signs, character information is written only to a supplementary level.	○		

③	Purpose of Visual Control ① Prevention of disasters, accidents, breakdowns, defects in quality by early detection and treatment of abnormalities ② Prevention of disasters, accidents, breakdowns, defects in quality by prevention of miss confirmation, miss judgment, miss operation, oblivion and easy mistakes. ③ Efficiency of every job.		○	
④	Target of visual control and examples Although all control operations such as factory operation, production, purchasing, and personnel management are covered, the following is an example in the case of a production factory in particular.			○

Control Target	Examples of Visual Control	Purpose
Health and safety control	・Dangerous goods indication ・Organic solvent storage indication ・Fire extinguisher storage indication ・Safety indication ・Pointing and calling indication ・Danger point indication ・Emergency exit indication ・Cleaning assignment map ・Cleaning tool shelf	Disaster prevention
Quality Control	・Pokayoke setting mark ・Defective product repair item box ・Display of sudden change of quality ・Measuring tool control board ・Quality control board	Prevent delivery defects Process defect prevention
Production Control	・Production ramp display per production progress time ・Production instruction Kanban ・Step change instruction lamp ・Shipping instruction Kanban ・Planned stop indication	Non-delivery prevention Efficiency improvement of production control
Inventory control	・Display of maximum and minimum stock ・Location display ・Display of actual product photo ・In-process product fixed position indication	Inventory Reduction
Equipment Management	・Liquid contamination indication ・Refueling tank level indication ・Oil type label ・Inspection point mark ・Direction of rotation display ・Pressure gauge display of normal and abnormal condition ・Flow direction display ・Valve open / close display ・Temperature display ・Air flow display ・Vibration display・Inspection window display ・Filter clogging display ・Bolt / nut type matching mark ・Inspection map ・Inspection menu card ・Inspection order indication	Failure prevention Efficiency improvement of cleaning refueling inspection
Site Control	・Distribution of personnel on the day ・Multi-functional worker development map ・Hourly volume display ・Display of sudden change point of work	Efficient staffing skill up
Policy Control	・Policy control board ・Activity board graph display	Thorough policy control
Other Controls	・Equipment initial management activity board ・Initial flow activity board ・Consumable tool and instrument purchase price display board ・5S diagnostic map	Vertical start up Cost reduction awareness
Indirect Work	・Filing display ・Destination display board ・Attachment of Working order card	Working efficiency
Activation of activity	・Circle activity board ・Zero defection Nobori ・Karakuri Kaizen Nobori ・Improvement point sticker	Activation of activity

⑤

<u>Teaching Cases in Pakistan Project</u>

(1) KAIZEN ACTIVITY BOARD

Among the above control targets, it is particularly important that information on plant operation, key information to be managed, and data to be collectively displayed in the plant and be widely shared from the management layer to the workers.

(Case example attached below)

○

	 0202...KAIZEN ACTIVITY BOARD  1200...KPI example with obs (2) KPI Monitoring Sheet In contrast to the conventional Japanese KPI monitoring sheet, this project specifically describes the main points of Observation, Activity, Result for monthly data, and even if workers other than the relevant department sees the data, they can understand the data fluctuation situation in monitoring. (Example attached above)			

③Formulation of system/method in the factory

NO	Contents	A	B	C
①	Purpose; In-house organization to realize other items stated in this manual-it is continuous implementation of Kaizen by factory workers themselves, and the ability to implement endless kaizen efforts including above-stated purpose through Support System (SMEDA/PAAPAM/ Local consultants), it is necessary to formulate a mechanism in the factory and its sustainable management which are necessary for guiding quality and productivity improvement in the future. To; Support system members: SMEDA,PAAPAM engineers and Local Consultants： Firstly, promote the in-house formulation of sustainability and Self-initiated Kaizen methods, which have been taught/coached during the regular Circuit visits. ① Specifically, 6 JICA FORMATS which are the products of 2 year Circuit activities. To share the contents of teaching/coaching materials (Minutes, teaching materials, kaizen before/after records etc.) with all members in the factory at the occasion of Managers Meeting, QCC (Quality Circle). ② To proceed with Kaizen effects dissemination, be sure to use Kaizen Progress Sheets (Before/After Kaizen, and picture records) to share the information not only with the Kaizen implementation Team members but also with all the company members and share the Kaizen issues/task so that all members are ready to take necessary action when new issue coming next. ③ SUPERVISOR and the plant manager use SUMMARY SHEET which used in the final/last Circuit visits, take up the issues/task for the factory on Critical/high priority basis, using KPI monitoring method, and proceed the issues by analyzing ROOT CAUSE and carrying out study, leading to solve the issues by the most suitable Counter-measures. Implementation results must be recorded as internal property and to be used for the next potential issues/task. ④ Based on the fact that maintenance of standards in the factory, and a sufficient understanding of its contents have not been installed, the way of proceeding with standard work should be rebuilt/formulated for each Target Shop and operation (especially, the contents of Standard work), visualize the work flow, and thoroughly confirm the provision of the standard hand-held (parts stock) required. As for the contents of Standard work, SUPERVISOR for each target shop should incorporate into the Operation manual the method of work by the best practice worker level in the work-field. And make sure that OP manual is provided and updated in the fields of work at all times. All shops in the factory should be prepared by such OP manual finally. Plant manager, together with SUPERVISOR, shall manage on a shop basis whether the quality level requested by OEM is assured ,or whoever working, and the 100% Quantity of the required parts is well planned to meet the delivery date. ⑤ As the plant manager's instruction, confirm/assure that 4M system is in the range of OEM requirements at all times, encourage the realization of OEM requirements, always confirm with CEO whether required 4M factor have been assured in order to thoroughly implement OEM First factory operations. As a specific example, it is impossible for person –in-charge being absent leading no Circuit activities in vain. Materials cannot be different from the Drawing specification. It is the CEO and the Plant manager's responsibility to ensure that the minimum REQUIREMENT from OEM as a parts produce's realization. （SMEDA/PAAPAM: Support system management） ① In the regular Circuit activities, the following were realized as the issue/task of Pakistani manufacturing/auto-parts sector.	○		

	-Human resources who understand the rule and principles of the manufacturing are not assigned as plant operation leader/SUPERVISOR. Therefore, there is no guarantee/assurance that the contents of the guidance of JICA Experts will be sustained as a factory property at the daily operation level or longer term, though temporarily transferred. ② Therefore, SMEDA management is required to request the following to JICA PAK Office. A: From the supplier CEO, TOT (teaching on teacher/SUPERVISORS) is required for the person who will be in charge of factory Standard operation assurance. TOP management cannot teach to those level of factory staff due to lack of skill and on-site experience. B: It is necessary to upgrade and increase the number of staff in the auto-parts industry in Pakistan, and from now onwards it will be essential to strengthen on-site guidance at school or educational institutions as well as on-site teaching/coaching at all factories. C: It is essential to realize long-term technological transfer that will be beneficial for Pakistan and the assurance to sustainability.			

5.9 Individual Work Fields

Ⅰ Welding and Tools

① Gas Welding

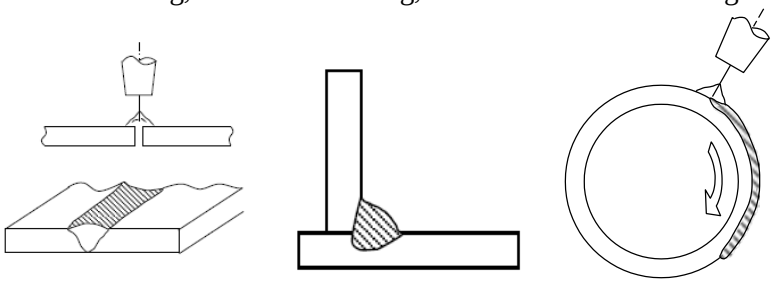
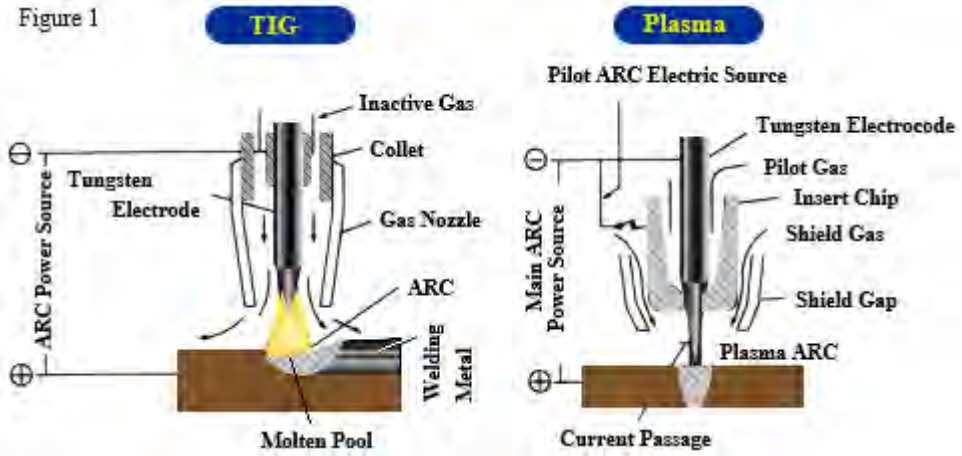
NO	CONTENTS	A	B	C
①	<u>Melt welding Methods</u> 1)Gas shielded melt weld ① welding form Butt welding, Fillet welding, Circumferential welding  2) Kinds of Gas Shielded Arc Welding Metal electrode rod or wire is used as a filler metal, and there are 3 types depending on the type of shield gas. It is better for welding efficiency and cost, and it is widely used for mass production. CO_2 weld：CO_2 100% MIG weld：Ar98%, O_2 2% MAG weld：Ar70%, Co2 30%(mainly argon gas) 3) TIG weld (Tungsten Inert Gas welding): Welding method in which the electrode is made of tungsten and the filler metal is separately added or the base material itself is melted. Mainly use Ar for shield gas (This is used for high precision welding). The defect is small and the appearance is clean, hence the welding speed is slow. 4) Plasma Welding When the arc passes through the hole of the water-cooled insert chip and is transferred to the base material, the arc generated from the electrode is squeezed by the water-cooled insert chip, and the plasma gas with high energy density is ejected from the insert tip hole. The ejected plasma gas is further squeezed by the shield gas (thermal pinch) and transferred to the base material. ① Since the thermal convergence is good, the bead width is narrow, high speed welding is possible, welding distortion is small. (Welding of Forged Gear and Shaft is common.) ② Arc directivity is high, therefore, it is suitable for fillet welding. ③ Spatter do not occur. ④ Since electrode consumption is small, high quality welding is possible for a long time and it is suitable for automatic welding. ⑤ Low running cost. (The welding machine is more expensive than TIG welding machine.)	○		

Figure 1



5) Laser welding

Method of joining by local melting with laser light.

The device is composed of a laser oscillator, a condensing optical system, a driving system, and a shielding gas system.

As the laser oscillator advances to higher power, CO 2 laser and YAG laser are used. The laser oscillated by the oscillator is guided to the condensing optical system through the optical path. In case of CO2 the laser will be transmitted by turning back by the mirror. In case of YAG the laser will be transmitted by the optical fiber and will also be transmitted by the mirror. The condensing optical system is constituted by a parabolic surface mirror, a condensing lens, and converges transmitted light to an appropriate size. Usually, shielding gas (Ar, He, N 2) is sprayed to the weld metal part to prevent oxidation of the weld metal part.

① High-speed deep penetration welding is possible (part requiring strength)

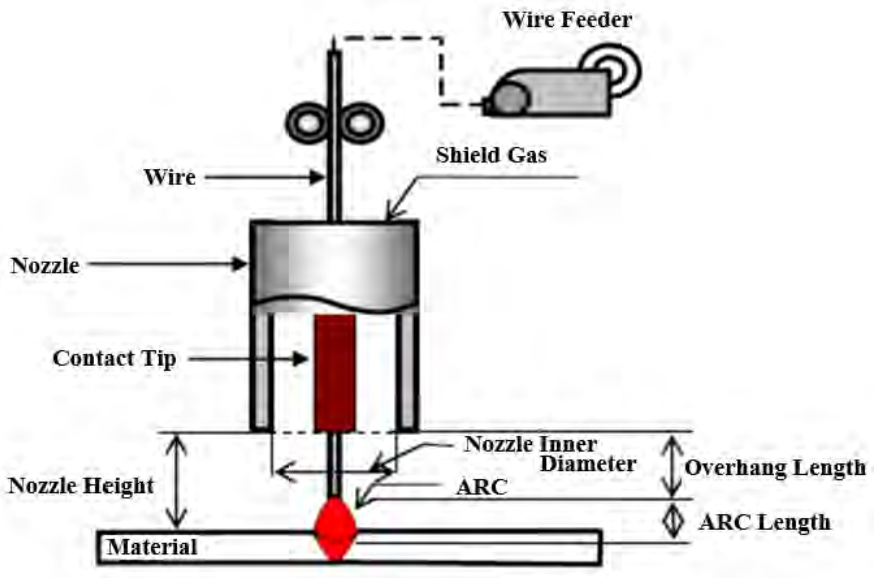
② It is used for precision welding because welding heat influence and welding deformation is extremely small

<u>Welding Standard Parameters and Setting, Confirmation Method</u>

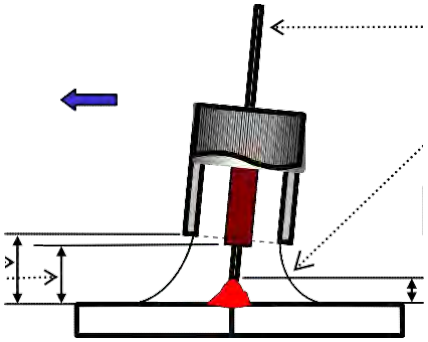
(CO2, MIG, MAG)

(1) Basic setting

① Setting around the torch



Because of gas shield effect
Although Lt ≧ Ln (Nozzle height) is desirable,
Lt = Ln - 1 to 2 mm is often taken into account in consideration of the tip point maintenance.



Lt: Tip height (Tip to Work)

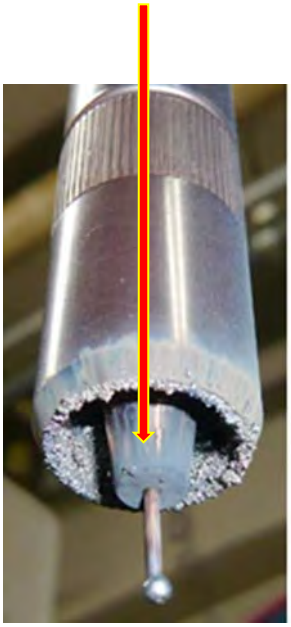
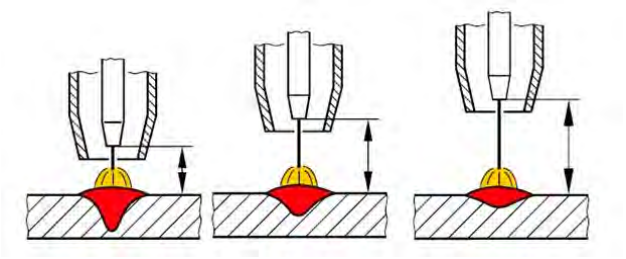


Image of Lt and penetration



a) Overhang length (mm)

Wire diameter (mm)	0.8	1.0	1.2	1.6
Overhang length (mm)	12-14	13-16	16-20	

Welding current (A)	150	<250	>250
Overhang Length(mm)	12-16	14-18	16-20

b) Gas flow rate

Welding current (A)	Nozzle diameter （mm）	Gas flow(L/Min)	Wire diameter(mm)
130	14	15	0.8-0.9
200	17	18	1.0-1.2
250	20	21	1.2-1.6

(Indication：Nozzle length≒Gas flow)

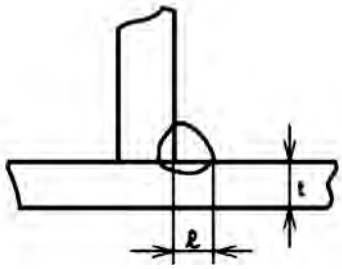
(2)Influence of welding conditions

・Torch reverse welding ・Bead width is narrow, surplus becomes high ・Deep penetration. Bubbles tend to be	Welding speed fast slow Bead width small large Penetration shallow deep Sputtering many few

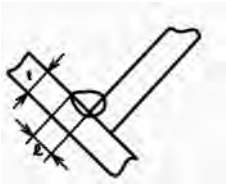
generated	
・Nozzle height (high) ・Shielding effect diminish and blowhole occurs	Nozzle height (low) Sputter clogging Long time welding failure due to overheating
・High chip height ・Current is decreased causing lack of penetration, ・Bead unbalance occurred	Wire diameter Small (thin) Large (thick) Sputtering small quantity Arc small (unstable) Deep penetration shallow
Shield gas Less spattering and blowholes occur CO2, Argon deep penetration	Welding current small Large Penetration shallow deep Small spatter particles small Large
Arc length Short Long Bead narrow wide Surplus high low Penetration shallow Deep	Fat on the surface of base metal If it is lot, it causes blow hole

(3) Standard parameters for gas welding

（Fillet Welding）

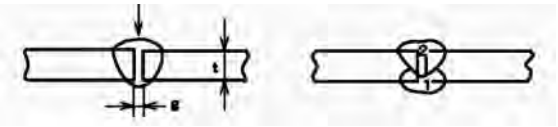


Thickness t(mm)	Length ℓ (mm)	Wire Dia. (mmφ)	Weld Amperes (A)	ARC Voltage (V)	Weld Speed (cm／min)	CO_2 Flow Rate (ℓ／min)
1.2	2.5～3.0	0.9, 1.0	70～100	18～19	50～60	10～15
1.6	2.5～3.0	0.9～1.2	90～120	18～20	50～60	10～15
2.0	3.0～3.5	0.9～1.2	100～130	19～20	50～60	15～20
2.3	3.0～3.5	0.9～1.2	120～140	19～21	50～60	15～20
3.2	3.0～4.0	0.9～1.2	130～170	19～21	45～55	15～20
4.5	4.0～4.5	1.2	190～230	22～24	45～55	15～20
6.0	5.0～6.0	1.2	250～280	26～29	40～50	15～20
9.0	6.0～7.0	1.2	280～300	29～32	35～40	15～20
12.0	7.0～8.0	1.2	300～340	32～34	30～35	20～25



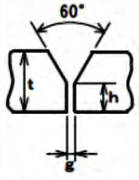
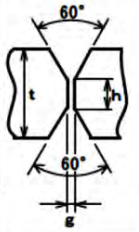
Thickness t (mm)	Length ℓ (mm)	Wire Dia. (mm φ)	Weld Amperes (A)	ARC Voltage (V)	Weld Speed (cm/min)	CO_2 Flow Rate (ℓ/min)
1.2	2.5～3.0	0.9, 1.0	70～100	18～19	50～60	10～15
1.6	2.5～3.0	0.9～1.2	90～120	18～20	50～60	10～15
2.0	3.0～3.5	0.9～1.2	100～130	19～20	50～60	15～20
2.3	3.0～3.5	0.9～1.2	120～140	19～21	50～60	15～20
3.2	3.0～4.0	0.9～1.2	130～170	20～22	45～55	15～20
4.5	4.0～4.5	1.2	200～250	23～26	45～55	15～20
6.0	5.0～6.0	1.2	280～300	29～32	40～50	15～20
9.0	6.0～8.0	1.2	300～350	32～34	40～45	15～20
12.0	10.0～12.0	1.2	320～350	33～36	25～35	20～25

(Horizontal Fillet welding)

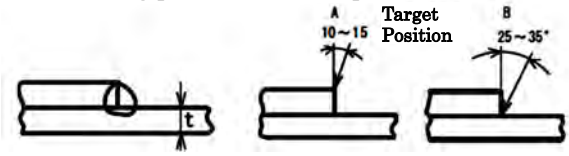


Thickness t (mm)	Route gap g (mm)	Wire Dia. (mm φ)	Weld Amp. (A)	ARC Voltage (V)	Weld Speed (cm/min)	CO_2 Flow Rate (ℓ/min)	No. of Layers
1.2	0	0.9, 1.0	70～80	17～18	45～55	10	1
1.6	0	0.9, 1.0	80～100	18～19	45～55	10～15	1
2.0	0～0.5	0.9, 1.0	100～110	19～20	50～55	10～15	1
2.3	0.5～1.0	0.9～1.2	110～130	19～20	50～55	10～15	1
3.2	1.0～1.2	0.9～1.2	130～150	19～21	40～50	10～15	1
4.5	1.2～1.5	1.2	150～170	21～23	40～50	10～15	1
6.0	1.2～1.5	1.2	220～260	24～26	40～50	15～20	Fr. 1 Rr. 1 — 2
9.0	1.2～1.5	1.2	320～340	32～34	45～55	15～20	Fr. 1 Rr. 1 — 2

(4) V shape, X shape groove parameters example

Thickness t (mm)	Groove Shape	Route Gap g (mm)	Route Surface h (mm)	Wire Dia. (mm φ)	Weld Amp. (A)	ARC Voltage (V)	Weld Speed (cm/min)	CO_2 Flow Rate (ℓ/min)	No. of Layers
12		0～0.5	4～6	1.2	300～350	32～35	30～40	20～25	Front — 2
					300～350	32～35	45～50	20～25	Back
				1.6	380～420	36～39	35～40	20～25	Front
					380～420	36～39	45～50	20～25	Back
16		0～0.5	4～6	1.2	300～350	32～35	25～30	20～25	Front — 2
					300～350	32～35	30～35	20～25	Back
				1.6	380～420	36～39	30～35	20～25	Front
					380～420	36～39	35～40	20～25	Back
16		0	4～6	1.2	300～350	32～35	30～35	20～25	Front — 2
					300～350	32～35	30～35	20～25	Back
				1.6	380～420	36～39	35～40	20～25	Front
					380～420	36～39	35～40	20～25	Back
19		0	5～7	1.6	400～450	36～42	25～30	20～25	Front — 2
					400～450	36～42	25～30	20～25	Back
				1.6	400～420	36～39	45～50	20～25	1 Fr. — 4
					400～420	36～39	35～40	20～25	2 Rr.
25		0	5～7	1.6	400～420	36～39	40～45	20～25	1 Fr. — 4
					420～450	39～42	30～35	20～25	2 Rr.

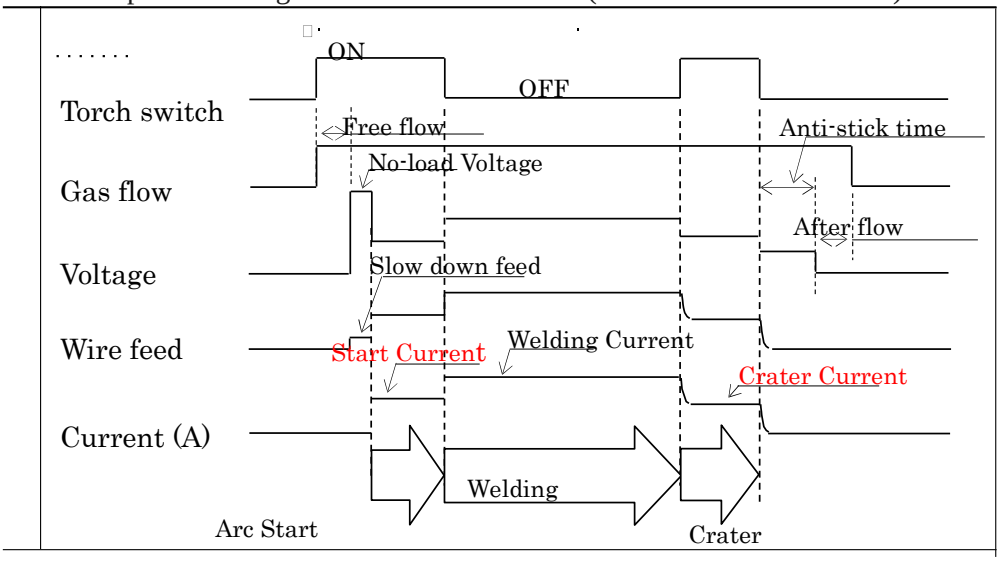
(5) Overlapped fillet welding parameters Example



Thickness t (mm)	Wire Dia. (mm φ)	Weld Amp. (A)	ARC Voltage (V)	Weld Speed (cm/min)	Target Position	CO_2 Flow Rate (ℓ/min)
1.2	0.8~1.0	80~100	18~19	45~55	A	10~15
1.6	0.8~1.2	100~120	18~20	45~55	A	10~15
2.0	1.0~1.2	100~130	18~20	45~55	A or B	15~20
2.3	1.0~1.2	120~140	19~21	45~50	B	15~20
3.2	1.0~1.2	130~160	19~22	45~50	B	15~20
4.5	1.2	150~200	21~24	40~45	B	15~20

(6) Welding Parameter Control

1) The following parameters are controlled in three stages of start current, main welding, and crater treatment.
Examples of timing charts are shown below. (1 case of crater treatment)

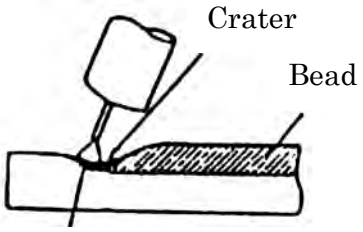


① At the start of welding

At the start, there is a short-circuit transition region and it is necessary to lower the welding current (Start Current). If welding current is added suddenly without doing this, it causes melt down.
With the latest welding machines, the above sequence is built in and Can adjust time and amount each time.

② Crater treatment

Crater filler is generated at the welding end part, which may affect the welding strength, cracks, and become defects, so crater treatment is performed to prevent this.

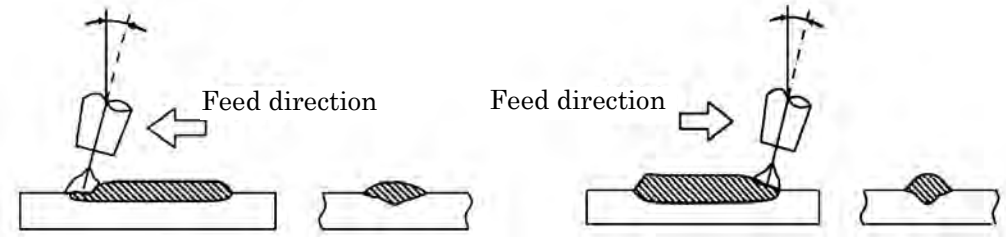


(7) Welding direction and torch position

①Welding direction

Direct welding

Direction	Width of bead	surplus	penetration	sputter	
Advance	Wide	Low	Shallow	Lot	Torch angle within 10 ° (This is the reason for pin hole)
Recession	Narrow	High	Deep	Few	



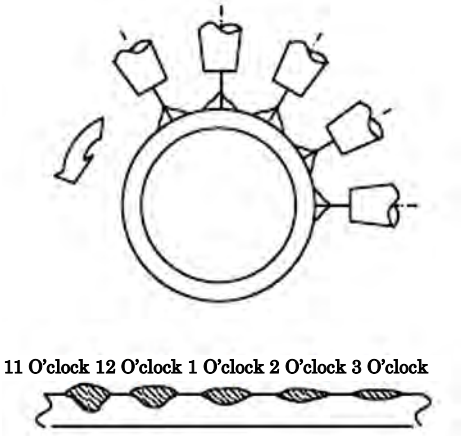
② Circumferential Welding

Depending on the direction of rotation and the position of torch whether the arc is generated in the molten pool or between it and the base metal, the direction of sputter generation, the frequency of welding of sputter, penetration depth, bead width, and surplus height may change.

For plate thickness of usually 3 mm or less, weld around 2 o'clock in the figure. When the torch angle is in the direction of 2 to 3 o'clock, there is little surplus without melting down.

Although it becomes a bead with a good appearance, the molten metal falls into a granular shape during welding, which adheres at the end portion and becomes excessively large.

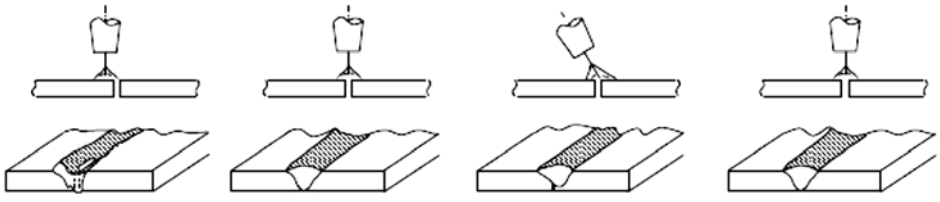
For high current welding exceeding 3 mm, weld in 2 o'clock to 1 o'clock direction.



③ Aim of the Torch

It tends to melt down if the aim is bad. This is because the heat input of the arc concentrates on the base material on one side in the thin plate, it is locally heated and melted down.

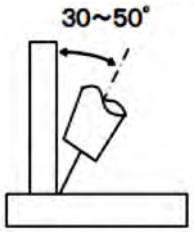
This is particularly noticeable in CO2. Since MIG / MAG has good wettability, the weld metal is a bridging effect (Gate) on both sides of the base material and the heat input of the arc equally enters the metal on the left and right sides of the joint, therefore the melting down is small compared to one in CO2 case.



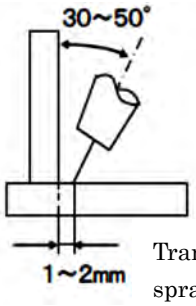
(8) Torch angle and Bead form

① During fillet welding

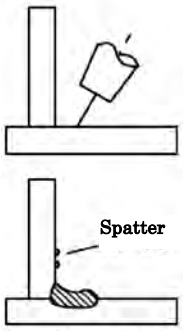
Poor angles causes welding defects such as sputtering, undercutting, and fusion failure. Even with horizontal mixed fillet welding with mixed gas, it is possible to easily form beads of equal length. The wire aiming position and torch angle in horizontal fillet welding are shown in the figure.



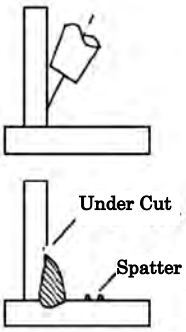
Transition in short Arc <250A



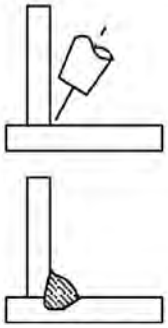
Transition in spray arc >250A



Under position aiming



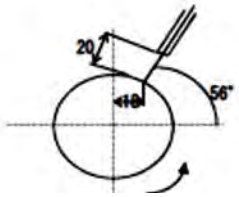
Upper position aiming

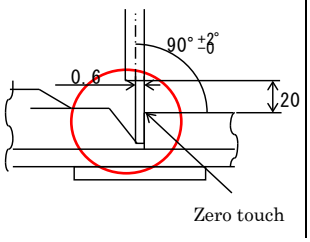


Appropriate aiming

(9) Mass-production case

Example of circumferential welding with back metal with a thickness of 5 mm





(10) Welding quality check

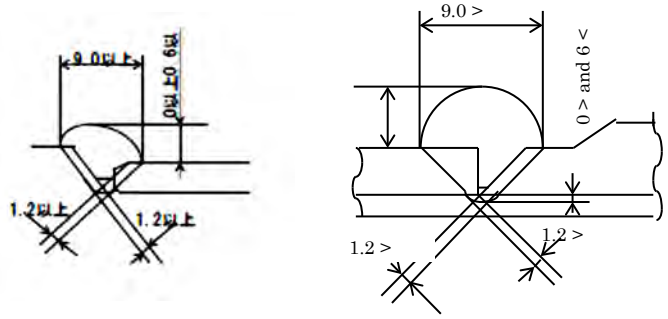
F Fusion welding is often used for critical parts around the chassis (Suspension arm, Propeller shaft, axle housing, etc.), and reliable quality assurance and reliability are required. An example of quality standards and inspection confirmation for this is shown below.

① Section macro

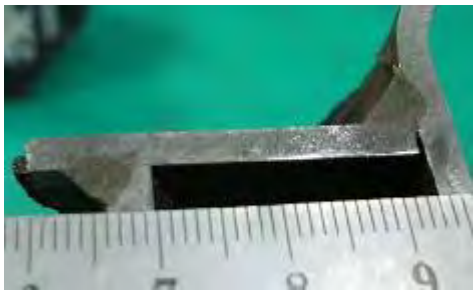
Periodically conduct destructive testing of welded parts, macro check cross section.

(Welding macro check with 18% nitric acid by picric acid)

1. Provisions based on inspection standards (example)



2. Actual Confirmation (example)



3. Inspection standard (example)

a) Welding parameter (example)

b) Inspection standard

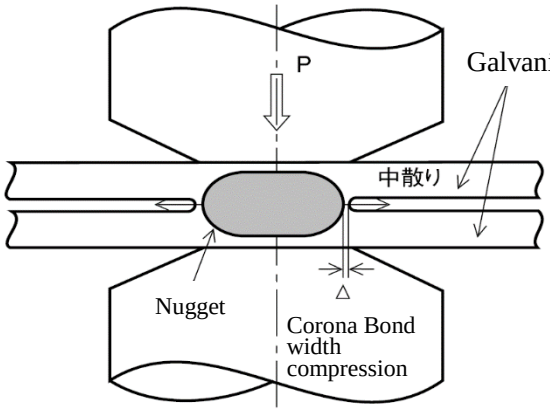
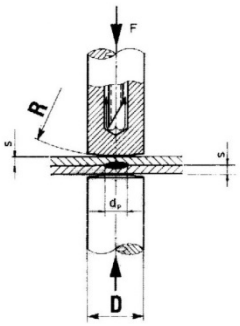
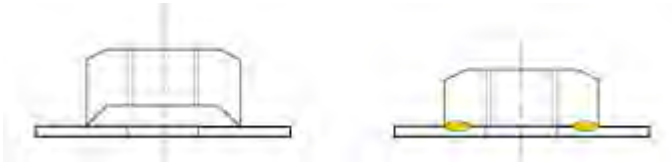
item		Cover	g & Co
seald gas	type	Ar＋CO2	←
	Q	20 l/m	←
wire	dia	1.2 mm	←
	mark	MG-51T	←
		DS1A	←
Amp		300	280
Volt		30	30
Speed		53sec	53sec
time		—	—
clearance		—	—

quality control point		checking method			
contents	scketch	check	spec	interval	チェック者
1) welding condition		gauge	description	1／2H	worker
2) torch pos.		visual			
3) bead		nogguis	ring ≧8mm cover≧ 5mm		
4)bead off set		visual	None		
5) bead appearance	blow hole, under cut, melt hole	visual	None	all	
6) spatta on ring face	spatta	visual	less than 1mm		

c) Treatment procedure, Tool change

Feed back	othe inspection	
1)～4) ・ report to leader、check ＮＧ pa ・ condition adjusting ・torch position 5) ・ clean torch、repalcing tip ・ check condition 6) ・ check condition ・ remove spatta	1) leakage inspection ・ All parts by inspector 2) inspection by QC ・ interval check :dimension、appearance （１／day） ・ Cutting macro check : １time ／day、	
	Tip	remark
	1torch １／200u (repalace)	・ Arc cut ditector

②Resistance welding +Aluminum welding

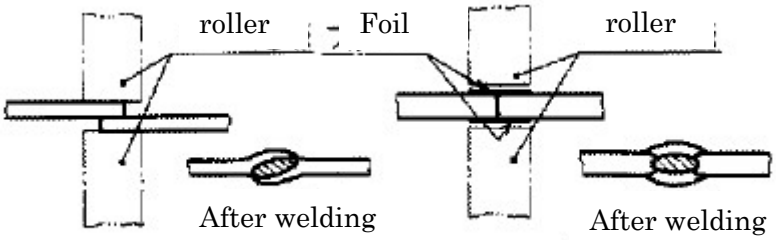
No	Contents	A	B	C
	<u>Resistance welding</u> (1) Heat resistance : Heat generation is a direct relationship among electric current, resistance and current time  $Q=I^2 RT\ [J]$ Q: Calorific/Heating Power [J] I: Current [A] R: electrical resistance [Ω] T: Current time [Sec] V: Voltage [V]	○		
	<u>Variation of resistance welding</u> (1) lap welding 1) Embossing type（Spot welding） Using sheet metal（outer panel of vehicle）  (2)Solid projection (Projection welding） General using for welding nut  (3)Seam welding：can be continuous weld line. Using for fuel tank ,wheel rim for 2-wheel vehicle, etc 	○		

2) Butt welding

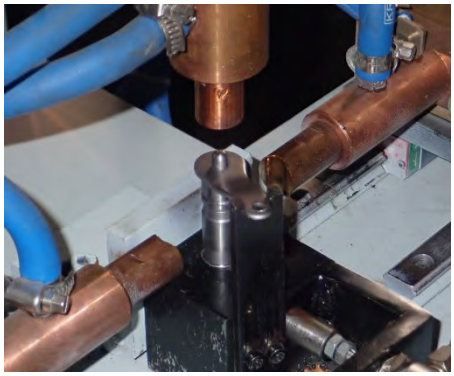
- Flash butt welding : Heat generated in discharge between both material contact face. Even though rough surface of welding, can be welded such as rails of train.
- Up set welding : Electric current with pressure of welding surface. Need finished surface of welding(Wheel for automobile , chassis)

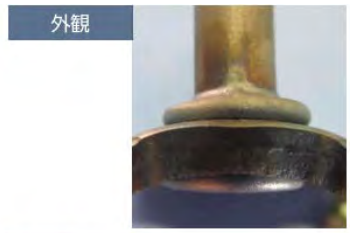
3) solid state welding

- Mushroom welding



- Hot rivet

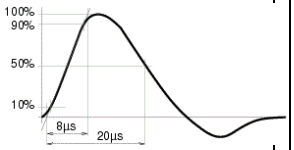




Variation and specification of Welding Transformer

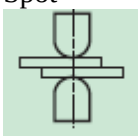
(1) Variation of welding transformer: AC, Inverter DC and Condenser type are major using

(2) characteristic

	Single phase exchange 	DC inverter 	Condenser 
Electric capacity	large	middle ～ small (3phase)	very small (AC×15%)
Appearance	○	◎	◎
Output stability	PLC timer◎	PLC timer◎	◎
operation	◎	◎	○～△
cost	◎	○	○～△
Characteristic	• low cost, low efficiency (power ratio20-40%) • mild steel, SUS	• high efficiency (power ratio-90%) Middle size Al, non-steel alloy	• small electrical capacity • projection, spot welding for

		・ Zic plate	Aluminum =>for short cycle & large current welding ・ finishing surface & output current are stable

Most of the welding machine in Pakistan are AC type, Low Initial cost but quality and running cost (economize on electricity) are inferior.

		AC	DC-Inverter	Condenser
Spot 	Steel, SUS	○	◎	△ (small nugget)
	Cu alloy	×(large current)	◎	◎
	Aluminum(※)	△(large current)	◎	◎
Projection 	steel、SUS	○	◎	◎
	Cu alloy	×	△	△ (Heat balance)
	Aluminum**(※)**	×	×	×

※Spot welding between steel and Aluminum are impossible

Operation for Welding

(1)Spot welding

1)Spot welding process(method)

i. Direct spot

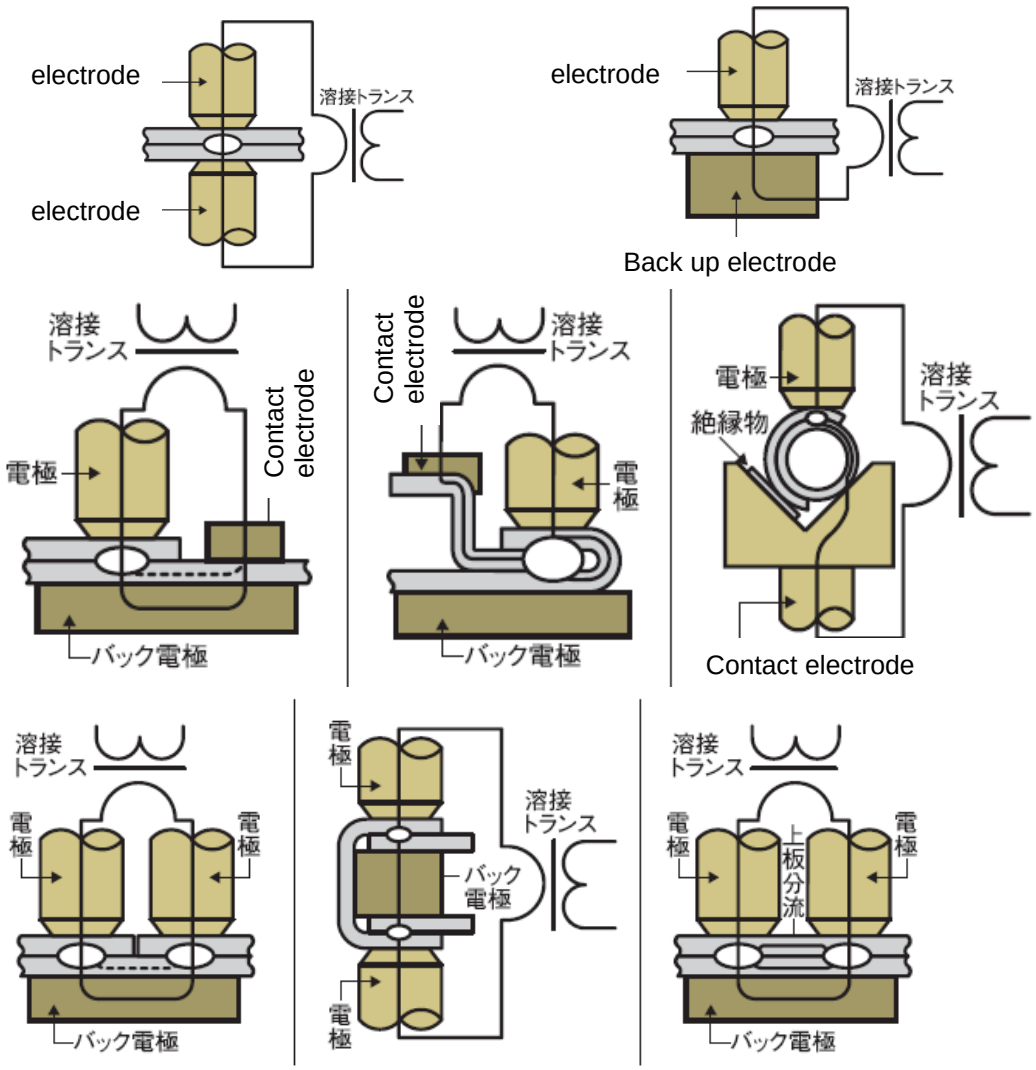
Turn Electricity in Directly to upper and lower electrode
(ordinary process of spot welding)

ii. In direct spot

When it has insulator under parts, electrode can be conducted one side only.
It need in direct welding.

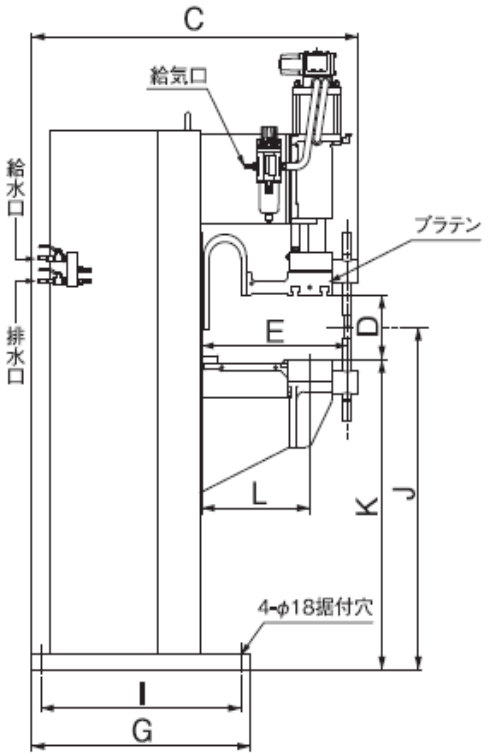
iii. Series spot

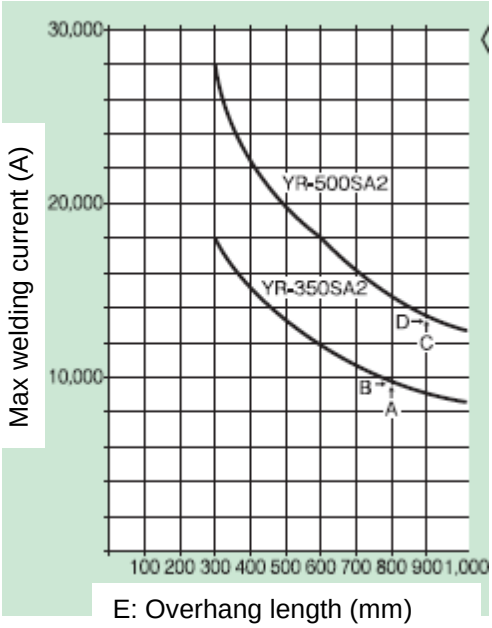
In order to hold welding pressure and conduct, Intermediate electrode (Buck electrode) is used to a parts with complex structure. (available multi spot)



(2) Relation between Overhang length and welding condition

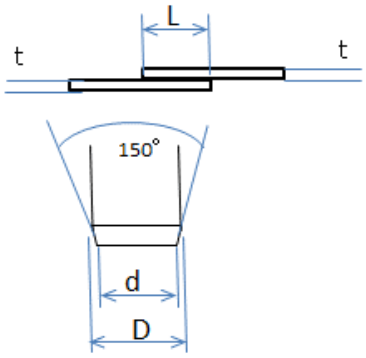
Overhang length of welding arm called pocket depth (length E of the figure).Welding machine is required maximum current depend on the pocket depth in order to control electrical current variation due to deformation of welding arm. Refer the following table as Standard value (PNASONIC: 350 and 500KVA). If using over current than standard value, welding condition is value and arm or electrode broken in worst case.





(3) (reference)standard condition for spot welding（Mild steel: ie SPCC）

t (mm)	Electrode max d (mm)	Electrode min D (mm)	Min Pitch (mm)	Min Lap (mm)	A-Class Time (Cycle)	A-Class P (Kgf)	A-Class Amp (KA)	B-Class Time (Cycle)	B-Class P (Kgf)	B-Class Amp (KA)	C-Class Time (Cycle)	C-Class P (Kgf)	C-Class Amp (KA)
0.4	3.2	12.0	8	10	4	120	5.4	8	75	4.4	20	40	3.5
0.5	3.5	12.0	9	11	5	135	6.0	10	90	5.0	23	45	3.9
0.6	4.0	12.0	10	11	6	150	6.6	12	100	5.5	26	50	4.3
0.8	4.5	12.0	12	11	8	175	8.0	16	120	6.4	32	70	5.0
1.0	5.0	12.0	18	12	10	220	9.0	20	150	7.2	36	85	5.6
1.2	5.5	12.0	20	14	12	275	10.0	23	175	8.0	42	100	6.1
1.4	6.0	12.0	24	15	14	320	10.8	26	200	8.6	46	120	6.6
1.6	6.3	13.0	27	16	16	370	11.6	30	230	9.2	52	135	7.1
1.8	6.7	16.0	31	17	18	430	12.5	33	260	9.8	54	155	7.6
2.0	7.0	16.0	35	18	20	480	13.2	38	300	10.4	60	175	8.0
2.3	7.6	16.0	40	20	24	570	14.4	43	330	11.0	65	200	8.6
2.8	8.5	16.0	45	21	28	700	16.0	52	430	12.4	76	230	9.5
3.2	9.0	16.0	50	22	32	820	17.4	60	480	13.2	84	285	10.2



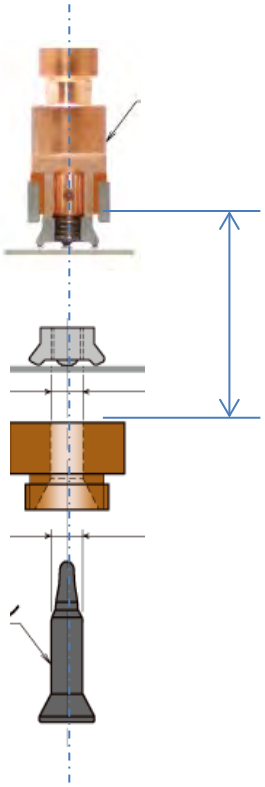
Same thickness, 2-plates, without plating or painting
SPS 30-32kgf/mm2

Electrode material: RWMA Class-2(Permittivity 75%, hardness HR B75)

Min. pitch: Minimum pitch without electric leakage to adjacent other spot

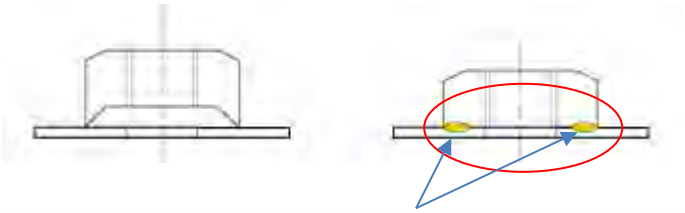
(4) projection welding

1) Important point of projection welding



Appropriate range of projection welding condition is small, excessive welding force causes insufficient welding heat due to electric resistance decreasing.
Excessive welding current causes melting of projection, even though makes cycle short can't be achieved normal welding.

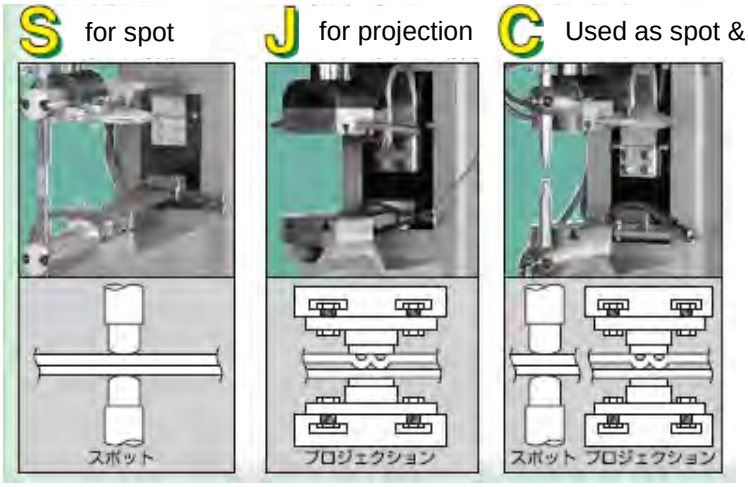
Important point is to keep parallel between upper & lower electrode in order to progress of same crashing during welding at multiple points (Projection) of Nut is required.



Same melting speed in both projection are required. If welding Nut has tilt when welding, only tilted projection progress will melt, and other projection can't be melted. Causes lack of welding strength.

2) Type of Spot/Projection Welding Machine

Projection welding machine is designed large power supply automatically in case of the low resistance of welding in order to compensate the current when the resistance decreases due to the crushing of the projection, and the pressure device is designed to maintain the parallelism between the electrodes to keep high rigidity.



3) Actual case in Pakistan

- Most of projection welding are implemented using spot welding machine in Pakistan, It makes single projection welding due to wrong Parallelism of projection nut caused by poor rigidity of welding arm.
- Also, wrong parallelism of electrode and location of nut without fixing pin, can't be synchronized welding of all projection. Causes welding Peel off or break off of welding. Therefore most of supplier are implementing tack welding which are not required in drawing.

(Example of spot welding issue)

Welding machine for spot was diverted to projection welding. Lack of Welding strength caused by slanted projection due to wrong parallelism of upper/lower electrode.

(Countermeasure)

- Use welding machine exclusively for projection
- Use Nut location pin (KCF material is best)
- Change welding condition in standard (table)

<u>Controlled range of welding condition</u>

(1) Quick heating right after welding start is important in order to keep heat generation. First source of welding start needs to progress welding with stable.
In case of plating panel, difficult to generate first source of welding start due to easy to occur electric dispersion on the contact plane. Therefore appropriate condition needs to shift low welding force and large current.
Projection welding depend on welding machine which has extra performance of output and welding force. Need testing trial in advance before production.

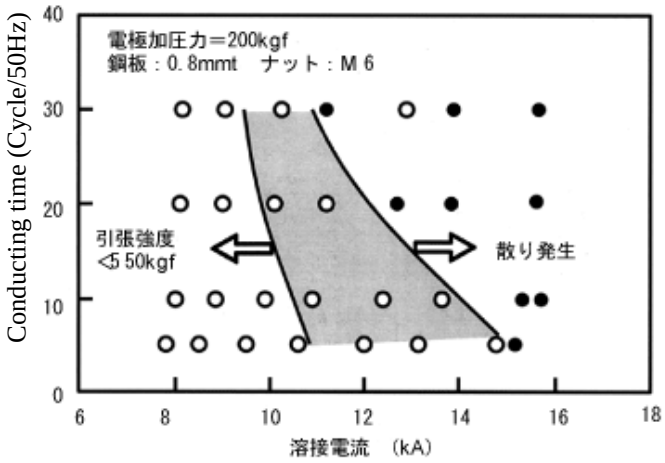
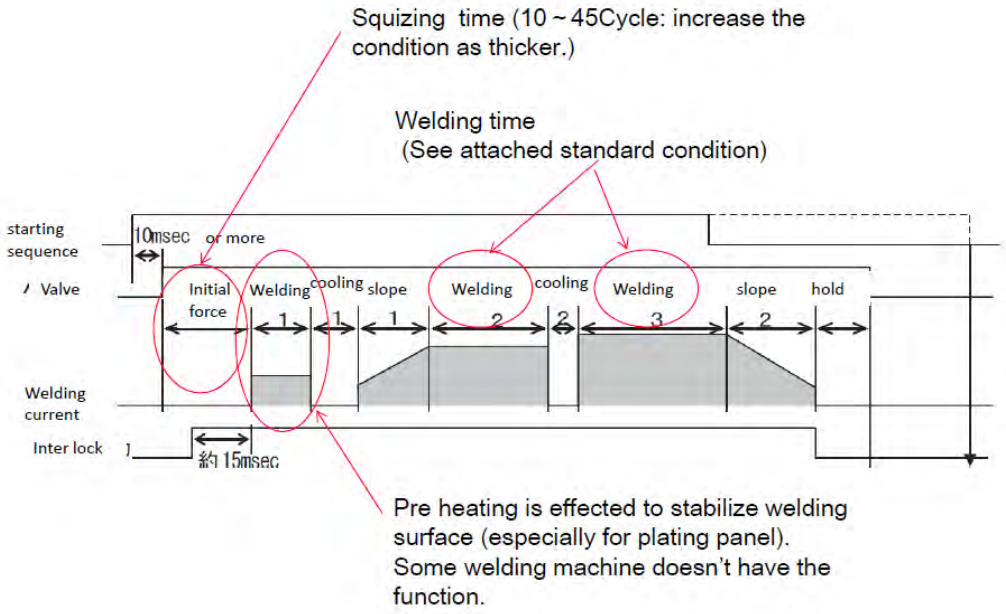


図 1　　Weld loop of projection nut

(2) Welding cycle (Sample)

②



(3) load ration of welding

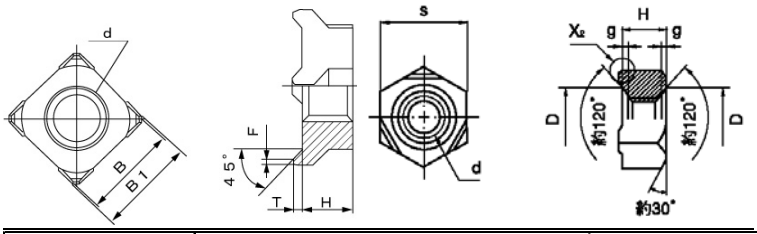
Welding machine should be controlled electric load ratio to protect machine and control quality of welding. Load ration can be calculated following formula.

$$\frac{\text{Number of spot per min} \times \text{conduct cycle per spot}}{60\text{sec} \times \text{frequency (Hz)}} \times 100(\%)\text{---(A)}$$

$$\left[\frac{\text{Max current} \times 0.9}{\text{Welding current (actual)}}\right]^2 \times \text{rated usage rate(rated value\%)---(B)}$$

Judgement criteria :　(A)≦(B)

(4) Standard condition for projection nut



Condition		Class A				class B			
Projection	NUT Size	T	Welding time	Electrode Force	Current	Welding time	Electrode Force	Current	torque
		mm	Cycle	KN	KA	Cycle	KN	KA	Nm
4-Projection	M6	1.2	6	2.4	12.0	12	1.8	9.5	
		2.3	6	2.7	13.5	12	2.1	10.5	50
		4.0	6	3.0	15.0	12	2.4	11.5	
	M8	1.2	6	2.7	13.0	12	2.4	11.0	
		2.3	6	3.0	14.3	12	2.7	12.0	100
		4.0	6	3.3	15.0	12	3.0	13.0	
	M10	1.2	6	3.6	14.5	12	3.0	13.0	
		2.3	6	3.9	16.0	12	3.3	14.5	170
		4.0	6	4.2	17.5	12	3.9	16.0	
3-projection	M6	1.2	6	2.4	12.0	12	1.8	10.0	
		2.3	6	2.7	13.5	12	2.3	11.0	45
		4.0	6	3.0	15.0	12	2.6	12.0	
	M8	1.2	6	3.0	14.5	12	2.6	11.0	
		2.3	6	3.3	15.5	12	2.9	12.0	83
		4.0	6	3.6	17.0	12	3.2	13.0	
	M10	1.2	6	3.6	16.0	12	3.0	13.0	
		2.3	6	3.9	1.5	12	3.3	13.5	153
		4.0	6	4.2	19.0	12	3.9	15.0	

Welding for aluminum

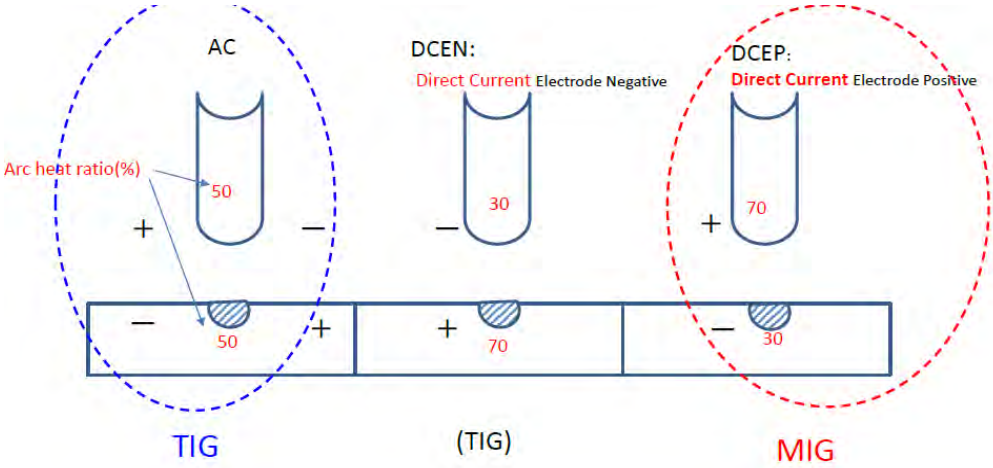
(1) Arc welding

For Aluminum MIG welding: Can be accepted DCEP machine (DC welding machine) only⇒If using AC or DCEN, welding material (parts) is melt down due to heat balance of material larger than welding wire.

(Detail of DCEN,DCEP is shown as (2))

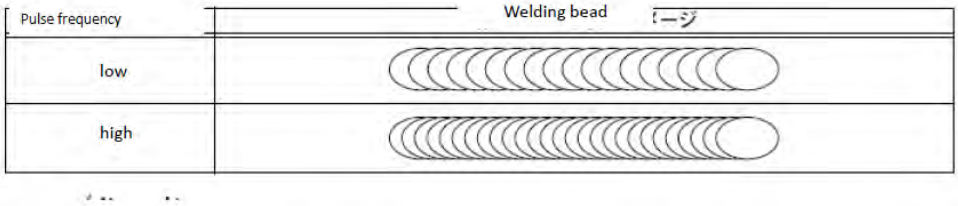
方式（出力） / 項目	Single Phase-AC 出力は交流	Inverter-DC 直流	Condenser high Max パルス直流
Electric capacity	large	Medium-small	Very small
appearance	good	Very good	Very good
stability	good	good	good
operation	Easy	Easy	Difficult
usage	Low cost	aluminum	For projection

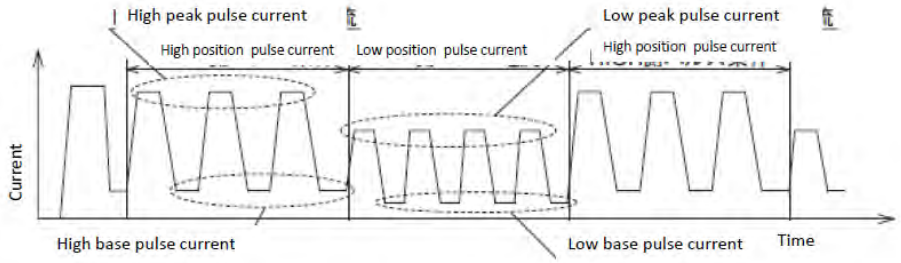
(2) AC, DCEN (Direct Current Electrode Negative) and DCEP (Direct Current Electrode Positive)



	AC	DCEN	DCEP
Penetration	Normal	Deep	Small
Arc length	Normal	Short	Long
W diameter	Normal	thin	Large size
Welding	Steel ,AL TIG	AL TIG(large size)	AL MIG

Major kinds of DCEP welding are short MIG (using short arc with constant current) and pulse MIG (Alternately current of base & pulse current). Pulse MIG can be obtained better efficiency and good appearance of welding bead. Applied welding under 6mm thickness material.

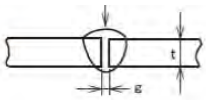




(3)Recommended condition for Aluminum alloy (#5000-6000material)

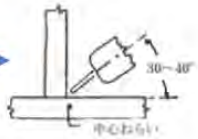
Aluminum pulse MIG

I shape butt welding



Thickness t(mm)	Wire (mmΦ)	Amp (A)	Voltage (V)	Feed speed (cm/min)	over hang (mm)	Gas (L/min)
1.5	1.2	60-80	16-18	60-80	12-15	20
2.0	1.2	70-80	17-18	40-50	15	20
3.0	1.2	80-100	17-20	40-50	15	20
4.0	1.2	90-120	18-21	40-50	15	20
6.0	1.2/1.6	150-180	20-23	40-50	715-18	20

Horizontal Fillet welding



Thickness t(mm)	Wire (mmΦ)	Amp (A)	Voltage (V)	Feed speed (cm/min)	over hang (mm)	Gas (L/min)
1.5	1.2	60-80	16-18	60	15	15-20
3.0	1.2	100-120	19-21	60	15	15-20
6.0	1.2/16	150-180	20-23	50-60	15	20

Aluminum MIG short welding

I shape butt welding

Thickness t(mm)	Wire (mmΦ)	Amp (A)	Voltage (V)	Feed speed (cm/min)	over hang (mm)	Gas (L/min)
3.0	1.2	120-140	20-22	60-80	15	20
4.0	1.2	150-170	22-24	60-80	15-18	20
6.0	1.6	180-210	23-25	40-60	17-20	20-25

Horizontal Fillet welding

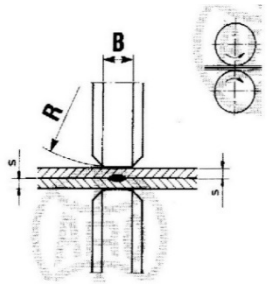
Thickness t(mm)	Wire (mmΦ)	Amp (A)	Voltage (V)	Feed speed (cm/min)	over hang (mm)	Gas (L/min)
3.0	1.2	140-160	21-22	60-70	15	15-20
4.0	1.2	150-170	22-24	50-60	15-18	15-20
6.0	1.6	200-230	24-26	50-65	17-20	20-25

1)Spot welding for aluminum alloy

Welding machine of Aluminum alloy needs huge capacity & precisely control of welding condition due to low specific resistance, high thermal conduction and effected to surface condition such as oxide film. Hence normal use of welding machine for Aluminum is DC-Inverter or Condenser type

(AC type can't be applied due to necessary of huge capacity and difficult to current control.).

Conductive pattern is called single impulse which can be one shot conduct without holding.



2)welding condition（Example）

=>3phase rectification

Aluminum alloy		Tip		Welding pressure (Kgf)		Welding time(Cycle)			Amp(A)		
Material	t	Φ	R	Welding	Farge	Slope	Welding	After	Pre	Welding	After
2024 7075	0.6	16	75	230	500	2	4	4	7000	22000	11500
	0.8			270	580		5		8000	24500	13000
	1			310	660		6	5	9000	27000	14500
	1.2			350	750	3	7		10000	29500	16500
	1.6		150	450	950		10	6	11500	35000	20500
	2			560	1140		12	7	13000	40000	25000
	2.5	20		730	1540	4	16	8	15500	47000	31000
	3			1090	2180	5	19	10	17500	54000	40000
5052 6061	0.6	16	75	210	440	2	4	4	6500	21000	11000
	0.8			240	520		5		7500	23000	12500
	1			270	590		6	5	8000	25000	14000
	1.2			300	660	3	7		9000	27000	15500
	1.6		150	380	820		10	6	10000	31000	18500
	2			450	1000		12	7	12000	36000	22000
	2.5	20		590	1270	4	16	8	14000	42000	27000
	3			790	1630	5	19	10	17000	50000	34000

5.10 Press, Die and Mold

① Mold/Die and Press Process

No	Contents	A	B	C
①	Press Die **(1) Purpose** A metal plate material is put in a die portion of a die and pressure-deformed in an upper and lower integral die portion, and a predetermined shape is punch out, bent and formed. **(2) Classification by processing method** 1) Punching (Blank and Piercing): Die and punch are used to plastically deform and punch a workpiece plate. 2) Bending (Bend): Bending the plate with a die and punch 3) Drawing (Drawing): Drawing with a die and punch 4) Compression processing (coining): A coining process to make patterns on the top and bottom, front and back. 5) Bonding process (Rebetting) **(3) Classification by process** 1) Single shot type (tandem): 1 process 2) Transfer (processing by transfer feeding): Transfer materials by transfer feeding to process two or more steps. 3) Progressive feeding type (progressive): Perforating, bending, drawing processing is sequentially performed on a band material, and one product is processed with one punch. i. complex type ii. Process into a cut surface with no fracture surface such as fine blanking type (precision punching) and tooth shape. **(4) Die of car** Case of die   	○		

1) Design / production process (Table 3)

Design illustration ↓ Mockup ↓ Parts design ↓ Die & Mold design ↓ Mass production car	Designers design it Life-size mock-up model Take 3D data from Mock-up mode, and create automobile inner data Part Drawing →Process Design→Die Drawing→Die or mold Making Part made using actual Die or Mold → ASSY

2) Automobile parts

i. Press parts: Side panel, Door, Bonnet, Roof, Fender, Floor, Dashboard panel

ii. Plastic parts: Bumper, Mirror, Light, Instrument panel, Door trim, Hose, Connector

(5) Automobile Process Design (Example)

1) Side Panel Outer Process Design

Draw ----- Sheet Metal Draw process (3 Dimensional)
Trimming ----- Cutting extra material
Bending ----- Bending process
Piercing ----- Making necessary holes

2) Side Panel Outer Model design

Wrinkle & cracks occur in Draw process. Therefore, draw process is carried out by holding material at Die Face at first.

In addition, forming simulations are conducted to presume the possible defects and consider the counter measures at prior stage.

(6) Automobile Die Designing

1) Digitalization of Dies & Molds

In old days, 2 dimensional drawings consist of plan view and cross section view were main but with the advancement of stereographically data conversion to 3 dimensional, all stages from designing to completion of dies & molds has been "completely digitalized".

(7) Prior forecast by CAD, CAE

1) Dies making

Previously the defects which were not know till the completion of Dies can be determined at designing stage and counter measure are carried out.

2) Effectiveness of Virtual Plant

By simulating plant/factory in computer environment, the issues which were not known till the completion of actual dies could be listed out before hand and can be rectified. Hence, it has become possible to complete in short time period.

3)Plastic Molds Process (Manufacturing process changed by utilizing CAE)

By CAE, defect root cause can be considered at designing stage for parts designing as well as Mold designing.

⇩

Improve the product Quality in Mass Production

⇩

Strive to reduce manufacturing process & cost down as well

Conventional Process

Product Design → **OTS** → Die Design→ Die Mfg.→ **Correction**→ Mass production

* OTS: Off Tool Sample (Trial)

Process utilizing CAE

Flow Analysis by CAE, Mold Strength Analysis, Mold Cooling Analysis

Product Design → ~~**OTS**~~ → Die Design → Die Mfg. → **Correction** → Mass Production

4) CAD

Utilizing digital technology ← Design technology, Processing & Planning Technology

- 2 dimensional CAD:
  Computerization of drawings and special mention of lines, points and dimension.
- 3 dimensional CAD:
  Wire Frame Model(Frame skeleton)
  Surface Model (A model in which paper is stuck on the surface of a frame)
  Solid Model (Model representing the shape as a solid)

(8) Dies & Molds Manufacturing Process Flow

1) From ordering to CAD design of drawing data → input to CAM → CNC programing for machining → Die & Mold machining on CNC control device → Machining.

2) Initial study of the Mold
Product drawing from ordering company (CAD Data)
(A system to produce molded parts quickly) accomplished.

3) Initial Study
Gate for the molded part, runner, eject, basic structure, size, selection of injection molding material, molded part cost, properties of molding material, expected molding defects, and mold manufacturing cost.

4)CAE (Molding Simulation)
Resin flow analysis software: To presume flow conditions, cooling, deformation, and fluidity condition.
Content that can be analyzed: Filling analysis, holding pressure analysis, cooling analysis, deviation deformation analysis, fiber orientation analysis and the stress acting on the glass fiber mold can be analyzed.

5)Molding Good's Base Drawing design
Points to be considered
- Expected Shrinkage Ratio (0.2～2%)
- Releasing Properties countermeasure
- Provision of Ejectors
- Gate
- PL (determine Parting Line)
- Distribution of Cavity & Core and Overflow
- Slider, Core, etc.

6) Mold Structure
Structure of Cavity & Core and Mold Base, etc.

7)Drawing inspection

8)Part drawing designing
Machining dimension tolerances, machining surface roughness, metal material, hardening heat treatment process.

9) Process designing of machining, machining scheduling and cost estimate is carried out.

(9) How the molds are manufactured

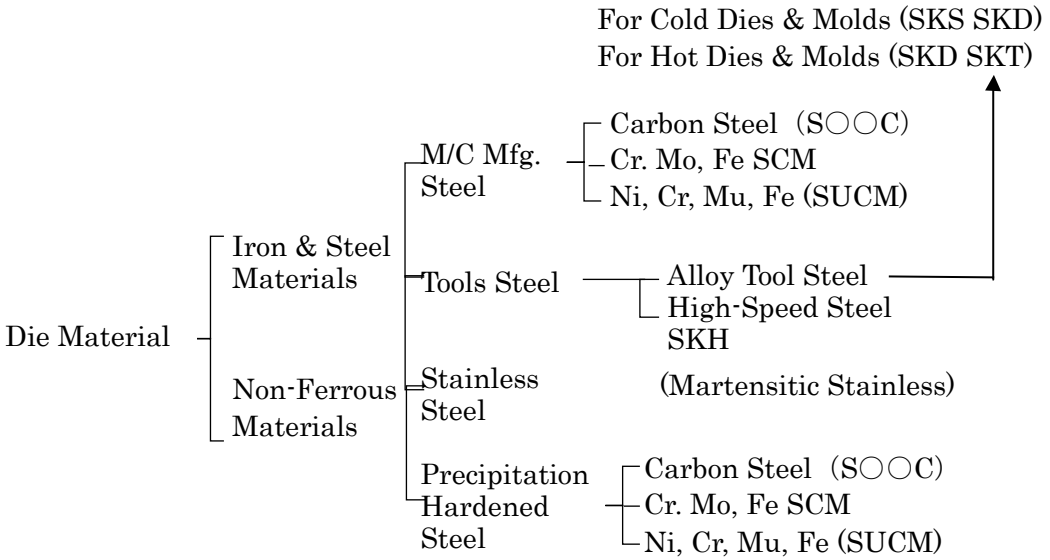
1) Removal Processing
- Cutting → Ball End Mill & Milling, Cutting Speed & Depth, Pick feed
- EDM (Electric Discharge Machining)
- Grinding Process

Forming・・・Deform the material
Additional Machining・・・Joining the material together
CNC Machining・・・Parameters such as Positioning, Locus, Tooling, Jigs, Machining Speed, etc.

2) Mold manufacturing by Machining Center
Primarily using a rotary tool, with automatic tool change function is subjected to multi machining without changing mounting position of machining workpiece by numerically controlled machine tool.（JIS）

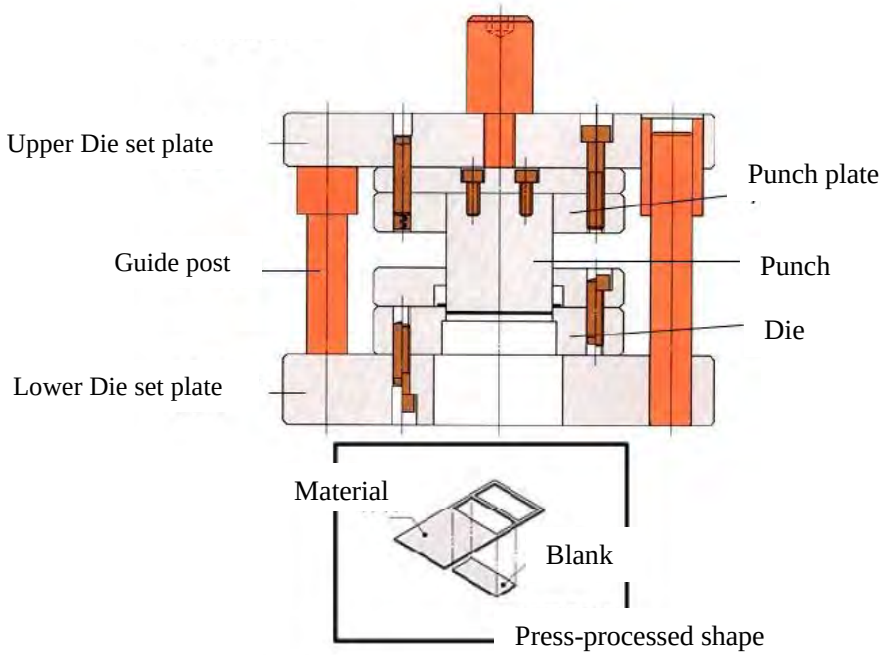
(10) Mold Material

1) Iron and Impurities (P, S, Mu, Si) (Iron and Carbon of Alloy)
2) Special Steel & Tooling Steel: Carbon Steel + additives such as G, Mo, Mu, and V → Special Steel, Alloy Tool Steel



* For Cold Tools Steel (For Press edged cutting tools)
Carbide forming elements such as High Carbon, Chromium (Cr), Vanadium (V), Tungsten (W), are added for higher wear resistance of materials.
* For Hot Tools Steel (Die Casting, Forging, Extrusion processing)

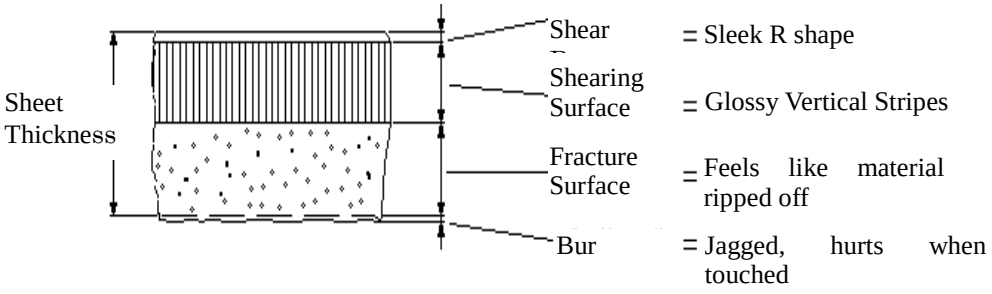
Press Forming Method

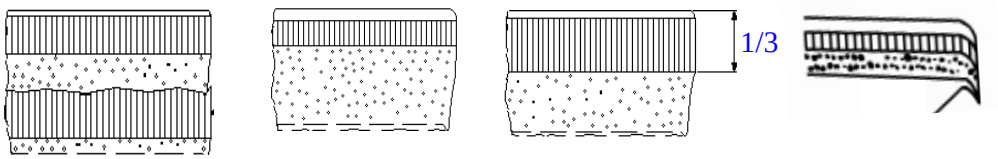


(1) Blank (withdrawal) mold

1) Clearance

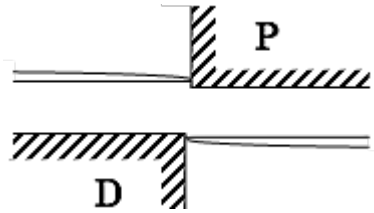
Place the material between the punch and the die with proper clearance and apply tension to it to cause the break phenomenon to separate the material. The evaluation of shear processing is made by the flatness of the product and the situation of the cut surface, as well as the dimensional accuracy. Figure below shows a basic form of shear, in which a cut surface has a sag, a shear surface, a fracture surface and a burr. The state of the cut surface changes due to differences in the work material, the punch speed, the clearance between the punch and the die, and the like. When the clearance is large (d), the cracks generated from both cutting edges are offset and become torn, the squareness of the sheared surface becomes extremely bad, and the sag and burr are also large. If the clearance is appropriate, the cracks generated from the punch side and the die side smoothly match as in (c) following sagging and shearing. The length of the sheared surface at that time is generally about 1/3 of the plate thickness.





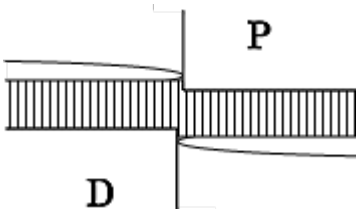
(a) Minimum **(b) Small** **(c) Appropriate** **(d) Large**

(i)



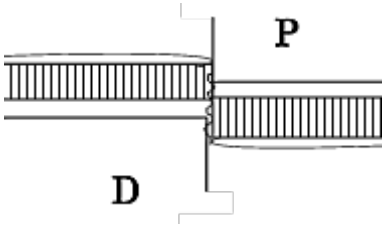
Plastic Deformation, Shear Droop

(ii)



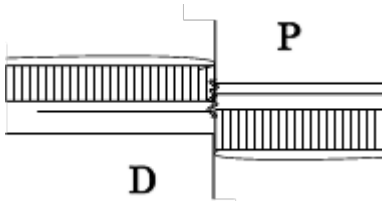
Shear Shearing Surface Created

(iii)



Fracture Breakage Occurs

(iv)



Stamping Enters in the Die

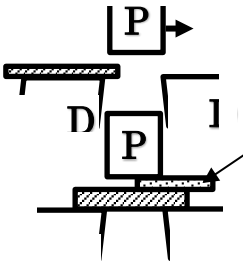
① It is easy to crack when cutting edge is sharp
② Die wear out could prevented by crack
③ Heavy force required until it comes to breakage
④ Easy to break if the material is harder
⑤ Generally less burrs and die wear out will also be reduced if breakage from Punch and breakage from Die coincide.

2) Counter measures for BURR

(i) Accident Life Countermeasures

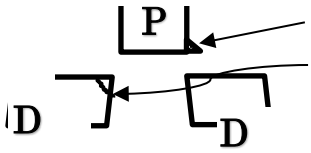
①Material Positioning defect

②Scrap removal defect



(ii) Grinding Burr

Blade edges get damaged due to two pieces punching, half punching, scrap clogging, and burning due to heat up, and cause Burrs (earlier than actual life of Punch).



Remove the burr by polishing
Slightly chips off due to grinding burr

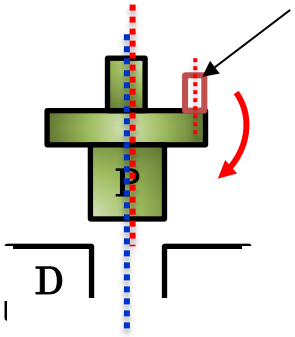
(iii) Punch & die material NG

① HRC required hardness is 58 ～ 60
It will be NG if softer or harder than this mentioned hardness.
Hardening → Tempering
(Quenching & tempering has to be done.)

② Un-even Clearance

③ Stiffness (Die, Punch, Die Hold)

(iv) Eccentric Load



If it is shifted towards this side,

If the machine center and Load center is shifted, life will be shorter in proportion to its wear out condition.

If machine load center and reaction force due to operation is shifted then rotation force applies and causes biting (chipping off). (Punch & Die)

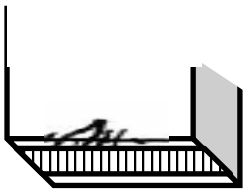
3) Burr Occurrence

(i) It occurs partially at straight line portions etc.

Root Cause: Cutting tool partially chips off.

Root cause of cutting tip

①Grinding burrs dropping in
②Dust and other abnormal particles biting
③Die and processing material heating up
④Lack of Heat Treatment of Punch & Die
⑤Two Pieces dropping or Half cutting
⑥Chipping off due to blank piece clogging and balance out (Eccentricity)

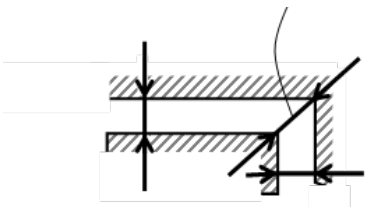


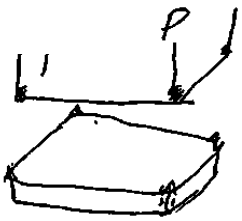
(ii) Big sharp burrs at the corner

Root Cause:

① Compression stress occurs
② Change in Clearance

Clearance is wider at this area.

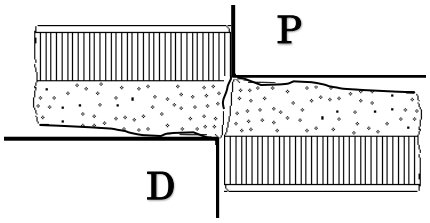




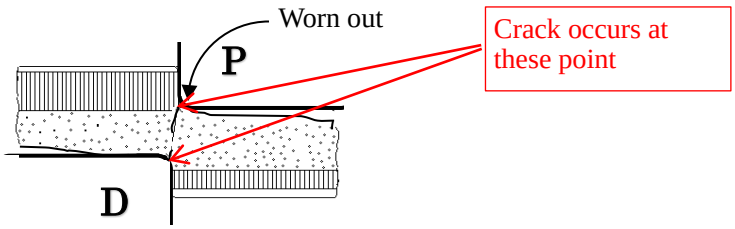
Burr Occurrence・・・occurs at the last moment of Fracture

(iii)Burr do not occur if fracture position is close to cutting edge of Punch and breakage or crack from Die generated by the cutting edge.

Stress occurs at the cutting edge simultaneously due to which fracture position is slightly shifted causing very little Burr.

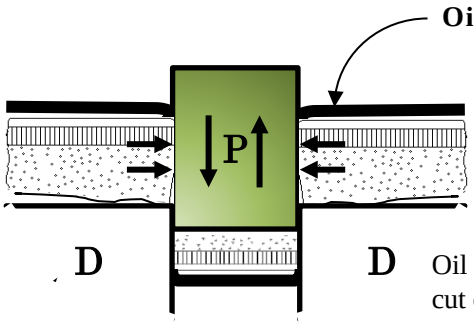


Acute angle no longer exists due to wear of cutting edge causing fracture position shifting to upward.
Crack occurs from the point where it is not worn out and is the most common reason for big burrs.



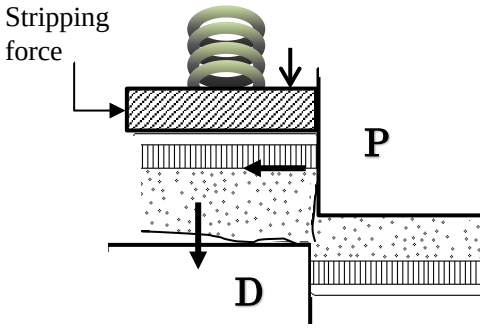
(iv) Fracture occurs from Punch & Die both sides and there is no shifting in between.
Biting (Flare) Ratio: Fracture timing is decided by the material (Material & Hardness) but actually it varies and will be fast as sharp is the cutting edge and as slow as it is in raw state. If clearance is high and if excessively worn out either Punch or Die used, fracture will occur from one side and thick, causing larger burrs.

(v) Improve the side surface of cutting edge and Sheet Metal sliding in order to avoid burring.
A strong friction occurs between side surface of Punch & Die and Sheet Metal, cutting edge side and shearing surface which comes in contact is newly made without oil layer while oil layer on the cutting edge side also gets removed due to heavy friction. Hence, friction & burning occurs.
Moreover, heat generated due to plasticity deformation or fracture when shearing also accumulates in vicinity of cutting edge causing temperature increase around it. Therefore, chipping due to Punch side insertion & releasing and dragged tear off due to burning when stripping occurs.



(vi) Tensile force applies in vicinity of cutting edge

In blanking sheet metal gets pressed by Die & Punch, and tensile force occurs causing fracture. However, if the sheet metal pulling hold force is weaker, then it will not cut the material properly and not only the cutting edge friction will be high but also it will become the reason for burrs. Therefore to avoid this it is very effective measure to hold the material by preventing it to move.



4) Die maintenance

Blanking & Piercing

(i) Punch & Die Clearance t = 10% Ordinary Type
t = 20% Rough Type } **SPHC**

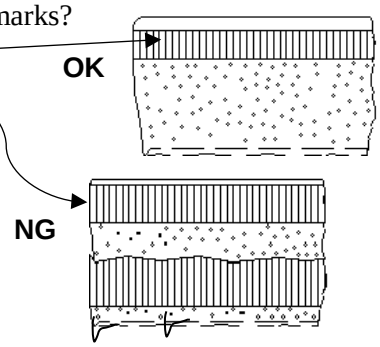
Burr will be produced if Clearance is wider but check the existing Press machine accuracy, and from the reliability of Die Guides15% to 20% will be considered appropriate.

(ii) Aren't there any chipping or damages of Punch & Die?

For Die checking make sure to place final piece on it.

In case of Blanking & Piercing;

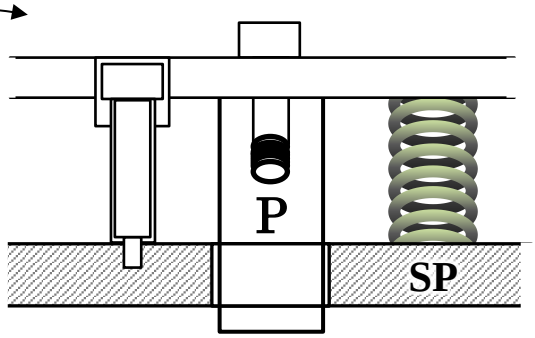
①Wear level of Punch sharp edge area
②Whether there are any galling marks on Punch & Die Hole side?
③Whether there is any cutting dust or hit marks?
④Blanked part cutting surface condition
⑤Blanking scrap clogging condition



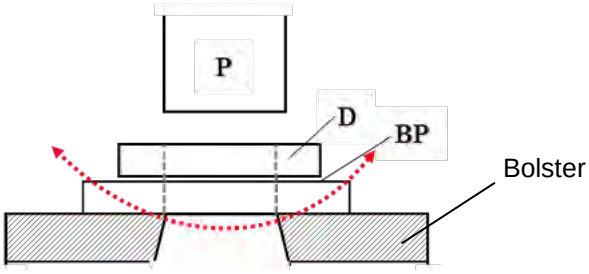
(iii) Boolts Looseness

① Punch & Die straight Bolt
② Punch Pin & Die Pin's Bolt
③ Hanging Bold
④ Shank Looseness

Stripper Flatness & Punch Guides



(iv) What about distortion of Punch Plate & Die Plate, and Scratches & Dents?
There is possibility of deflection & dents of Press Machine Bolster surface.
To bring the load center in the middle, even if there is 40T Press machine it is not sure the 40T will apply to center and if Die Plate can resist the 40T then due to relief hole of the Bolster the Die will bear dents.

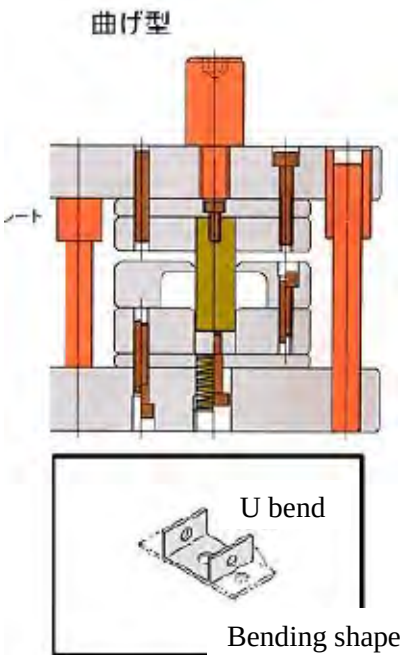


★ Whether the most imminent condition of parts produced currently are with appropriate parameter can be verified directly by your own eyes? Blanking conditions, bending, and draw of finished product has to be determined. !!

★ By ensuring to check the maintenance as much as possible will link to assurance of next production parts. If you careless of the work quality will get worsened even more than the previous conditions, and quality gets extremely worse after some quantity is produced.

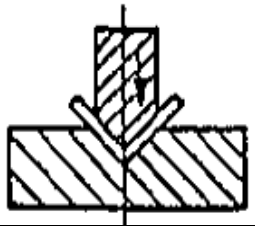
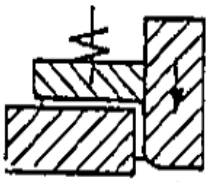
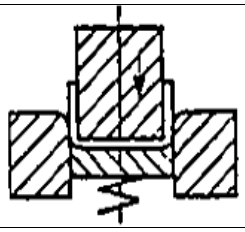
5) Confirmation work at the time of installation
(i) The die and processing conditions must match the performance of the press machine.
(ii) The upper and lower surfaces of the die and the upper surface of the slide lower surface bolster of the machine are cleaned.
(iii) The shape center of the die and the load center of the machine are the same.
(iv) The mounting of the die should be parallel to the top of the bolster.
(v) The feed line of the press and the shape center line of the mold should be in agreement.
(vi) The mounting bracket (clamp) must hold the die firmly.

・ Bending die



・ Basics of bending and drawing

a) Types of bending

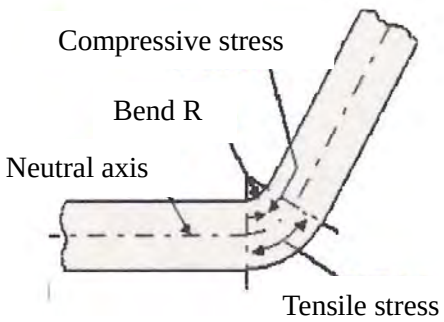
Name	Processing content
V bend	
L bend	
U bend	

b) Bending basics

In the bending operation, the cross section has a stress relationship as shown in the figure below.

(i) Bent cross-sectional shape

A compressive stress acts on the inside of the neutral axis, and a tensile stress acts on the outside.

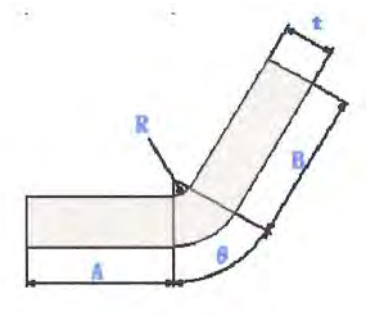


The neutral axis moves slightly inward at the bending portion, not necessarily at the center of the plate thickness.

When the bending external force is removed, the bending angle is opened (spring back) by the action of the residual compressive stress and tensile stress therein. The harder the material, the stronger this spring back phenomenon.

(ii) Bending deployment dimension calculation method

The neutral axis of the bending portion is 40 to 45% of the plate thickness depending on the plate thickness and the bending angle, and the empirical value is adopted in calculation.



$$L=A+(R+t\times 40\sim 45)\times 2\pi\times\theta/360+B$$

(iii) Simple calculation method

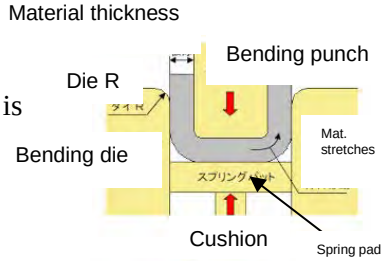
In the case of right angle bending, there is a simplified method described on the right.

L = A + B + 1 / 2t

(iv) Configuration of die in bending

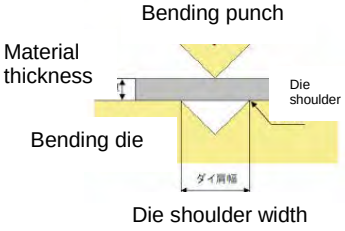
* U-bending die configuration

It is also called drawing processing. It is common in bending die and this configuration is adopted for most bending processes. The main parts consist of bending punches, dies and spring pads.



* Configuration of V bending mold

Generally referred to as Yaben bending, it is often used for simple bending and the like. Mainly composed of bending punch and die, the cost is much cheaper than U-bending structure. However, it becomes processing of only one place bending.

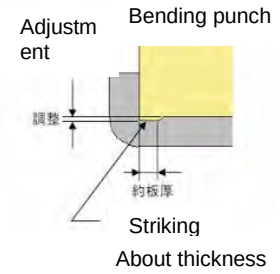


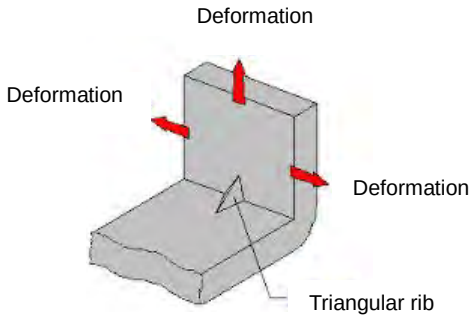
c) Spring back measures

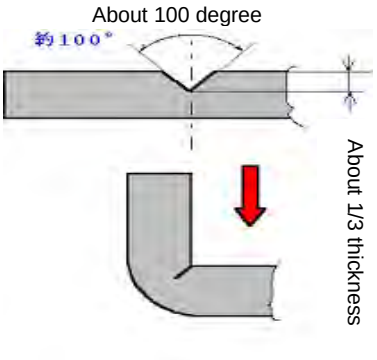
* In U-bending structure, manufacture molds considering spring back measures.

(i) Provide a protruding protrusion at the tip of the bending punch.

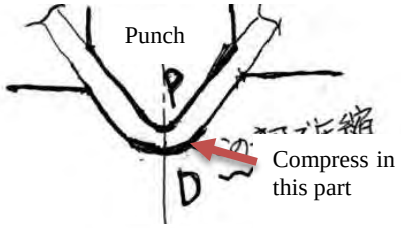
There are methods such as striking type and striking a wedge-shaped V-notch in the process before bending. In addition, in many cases, it also serves as a countermeasure against spring back and a countermeasure against being pulled by bending.



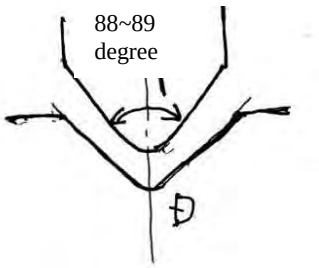




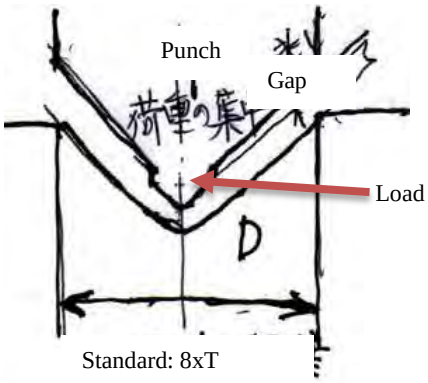
(ii) Concentration of load on bended place



Reduce the tip R so that the load is concentrated on the bend.



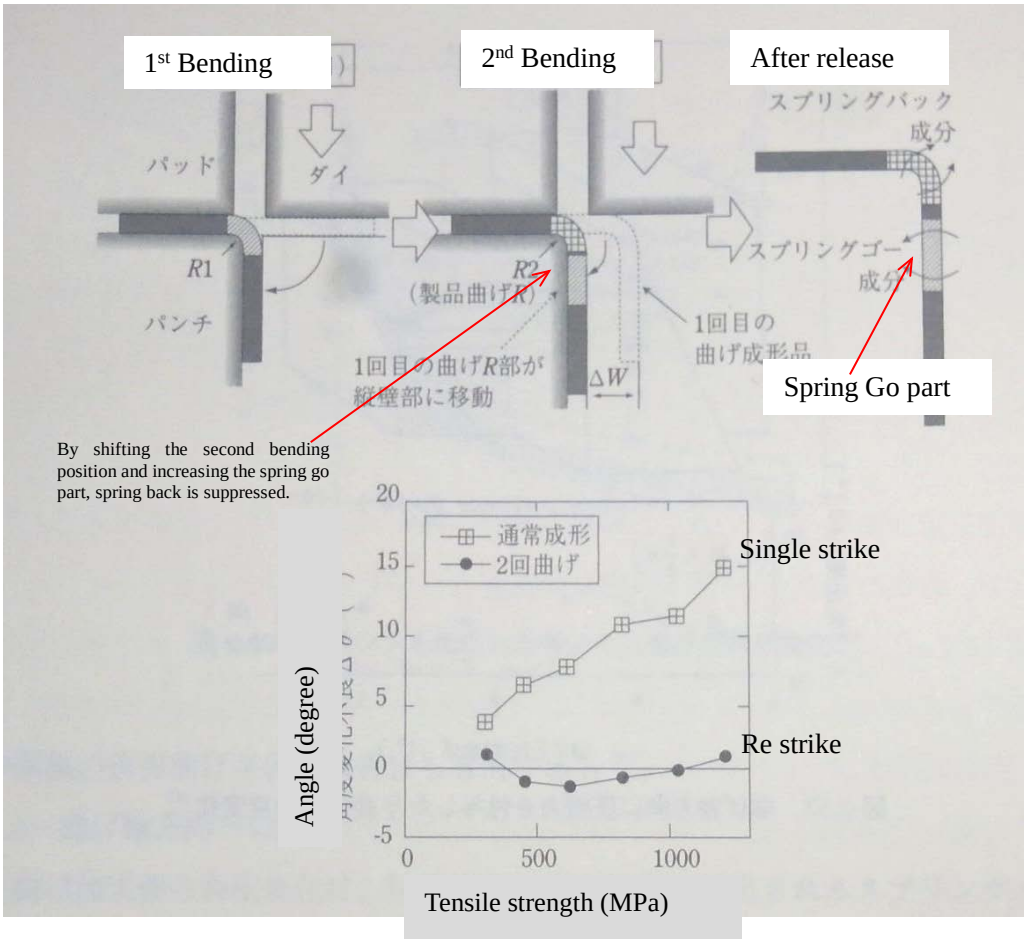
In the case of 90° bending, apply a spring back allowance to the punch.



The tip is shaped as a hit form to concentrate the load.

*T: Material thickness

(iii) Double bending: Spring Back Spring Go



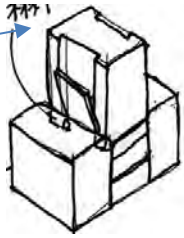
d) Cause of angle defect and its countermeasure

Defective condition	Cause	Countermeasure
The angle opens	Large clearance Cushion pressure is strong	Reduce the clearance
	Cushion pressure is strong	Reduce cushion pad pressure
	Punch R is large	Make R smaller
	Short engagement between punch and die	30° taper on the die shoulder
	Not enough pressure on the bend	Apply a hit form. Reduce the punch angle.
Vertical surface	Die bites / Sticking	Make the die shoulder R larger.

scratches		Reduce the slide lowering speed. Polish the sides of the die. Use processing oil.
	Unevenness	*1
	There is a step between the die and the punched part	Adjustment of clearance

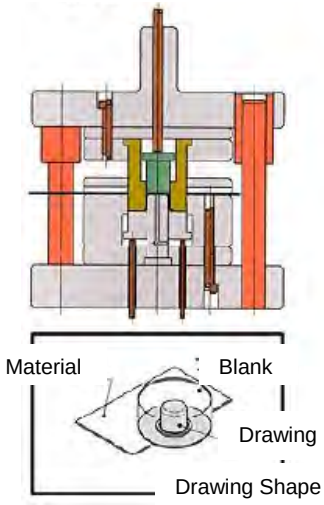
*1: How to make the clearance constant

Make the guides which hold the material longer than the bending part

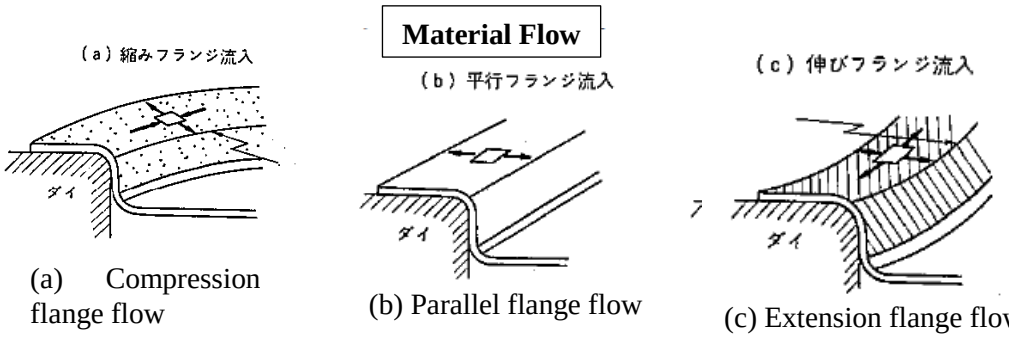


(2) Drawing die

In drawing, a flat plate material is sandwiched between a punch and a die, and is formed along the shape of the punch or die while applying compressive force or tensile force to the material.



There are three types of drawing, in terms of the flow form of the material in below figure “Material Flow”, three types: Compression flange, Parallel flange, and Extension flange. These are the basis of the cylindrical aperture, the square tube aperture, and the irregular aperture.



(a) Compression flange flow

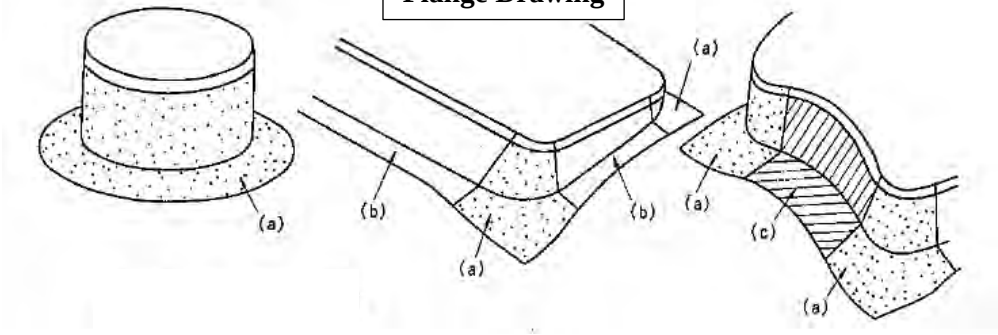
(b) Parallel flange flow

(c) Extension flange flow

Figure “Basic configuration of the drawing die” shows a basic die for drawing. When the punch is lowered, the material of the flange portion of below figure “Flange Drawing” is drawn into the cylindrical portion while receiving compressive stress (C) from the circumferential direction. When the reduction rate is high, this compressive stress causes the flange portion to wrinkle (buckling phenomenon). In order to prevent this, a crease holder is used but the flow resistance is increased. In this case, the forming stress acting

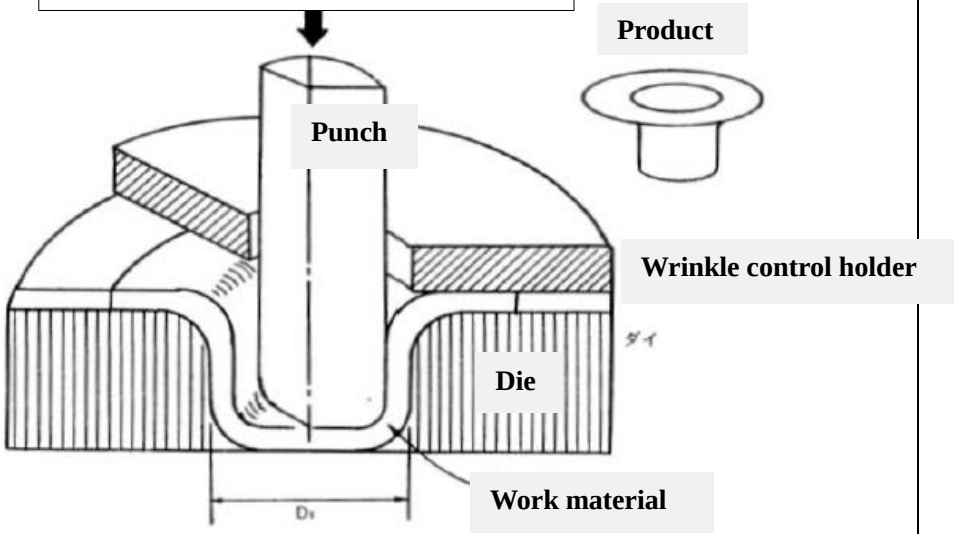
on the punch is also increased, and fracture occurs when the material at the corner of the bottom of the cylinder cannot withstand the tensile stress. Therefore, in order to relieve the stress acting on the material, it is necessary to adjust the clearance between the punch

Flange Drawing

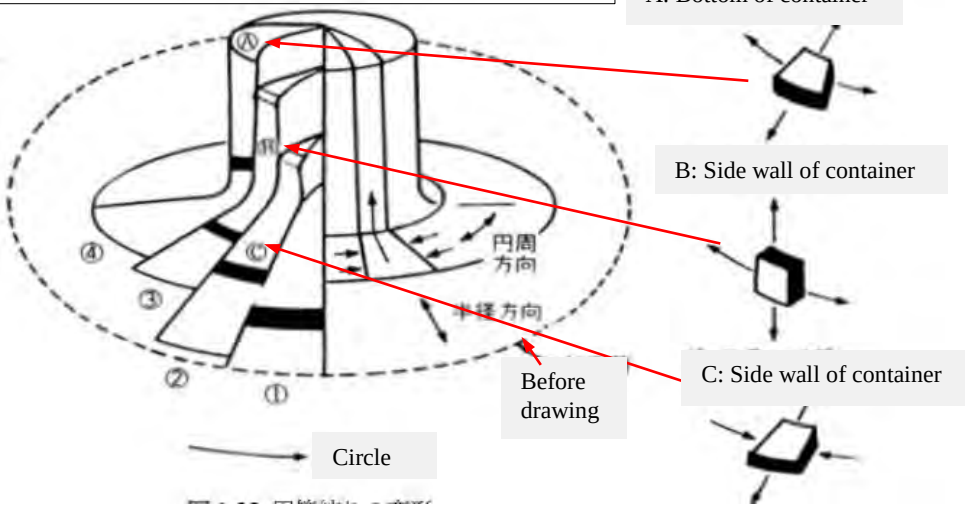


and the die, the approach shape, and the forming speed. Therefore, drawing with a large reduction ratio divides the process into multiple processes.

Basic Configuration of the Drawing Die



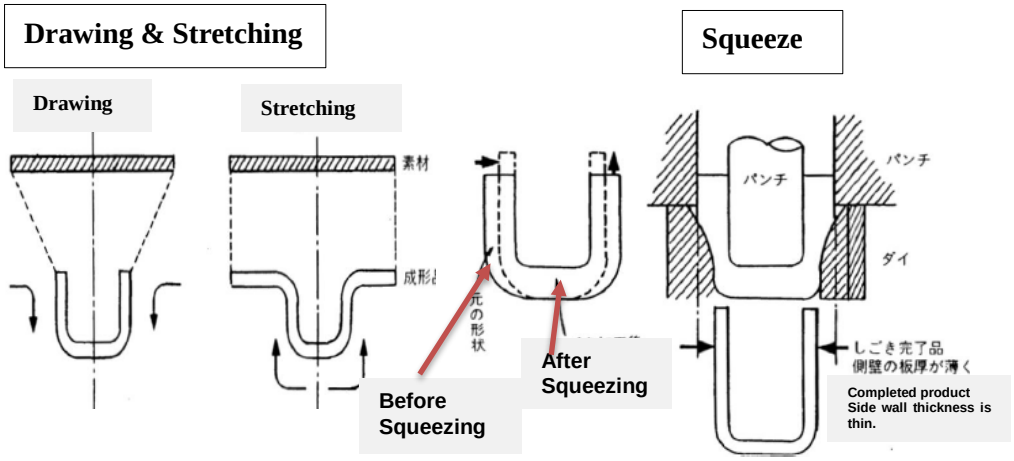
Deformation of Work Material at Cylindrical Drawing



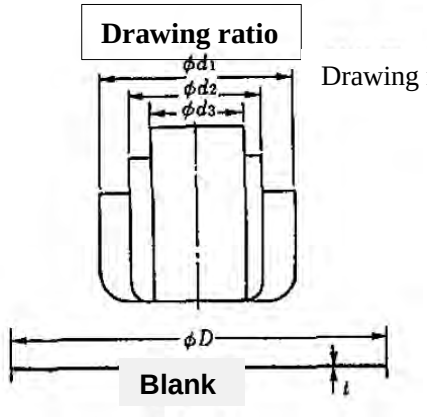
(3) Stretch Forming

As a method of processing the same shape as drawing, there is stretch forming in below figure “Drawing & Stretching”. This is different from the drawing in which the

material is drawn in, and the peripheral material is fixed and formed only by elongation, so the thickness decreases. The squeeze process of figure “Squeeze” is used to increase the dimensional accuracy and surface roughness of the throttle side wall portion.



Below figure shows the average first drawing ratio (m1) and the re-drawing ratio (mn) of various materials. The initial drawing ratio is as high as 0.50 to 0.6, but the second and subsequent re-drawing ratio are 0.7 to 0.85.



Drawing ratio: m = d / D

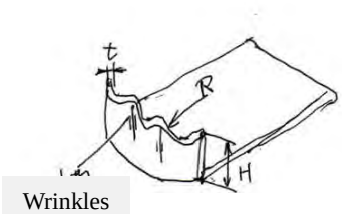
Material	Drawing ratio (m1)	Re drawing ratio (m_n)
SPCD	0.55-0.60	0.75-0.80
SPCE	0.48-0.55	0.75-0.80
SUS	0.50-0.55	0.80-0.85
Cu	0.53-0.60	0.70-
Aluminum Alloy	0.53-0.60	0.75-0.85

→

②

(4) Measures against defects in drawing

1) Wrinkles in shrink flange forming



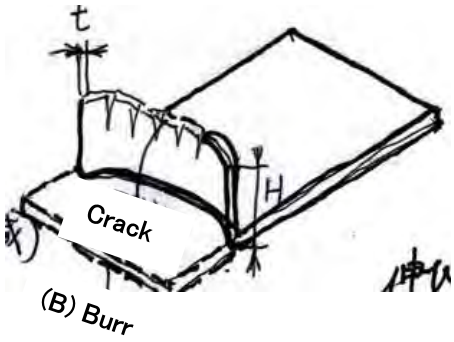
Wrinkles

i. Increase the arc radius
ii. Lower the flange height
iii. Increase die R
iv. Increase the material thickness (increase the buckling strength)
v. Decrease the clearance (*)
vi. Use the wrinkle control holder

(*) As the flange plate thickness increases (≒30%), the clearance does not increase up to the maximum increase rate of the plate thickness

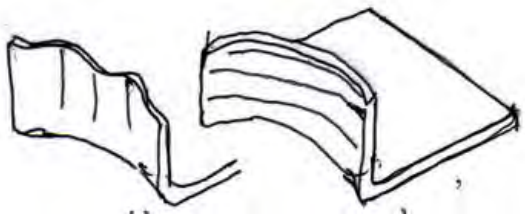
○

2) Wrinkle and crack in stretch flange forming



i. Increase the arc radius
ii. Decrease the flange height (H)
iii. Eliminate burrs on flange end (B)
iv. Make the clearance smaller
(Slightly more squeezing)
v. Improve the punch R and side surface roughness

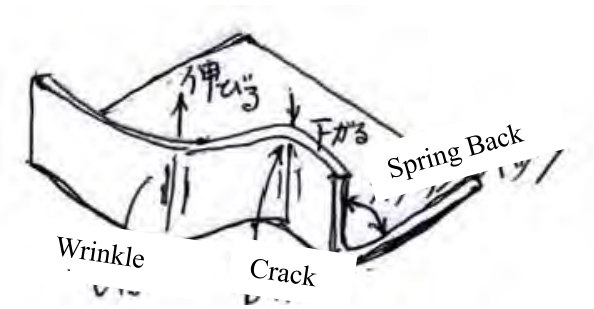
3) Flange wave in stretch flange forming

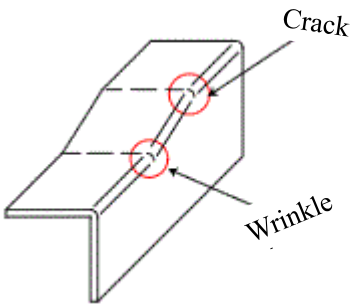


Phenomenon distorted by spring back near the flange end face when thin material.

i. Make the clearance smaller
ii. Deepen the engagement between the punch and the die

4) Flange deformation in Juggling (composite shape)



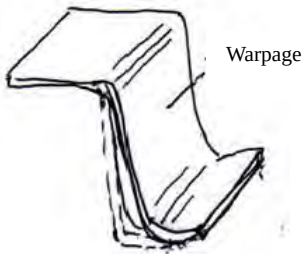


Simple bending
Stretch flange
Shrink flange

} The coexistence of three processes makes the movement of the material complicated and causes defects

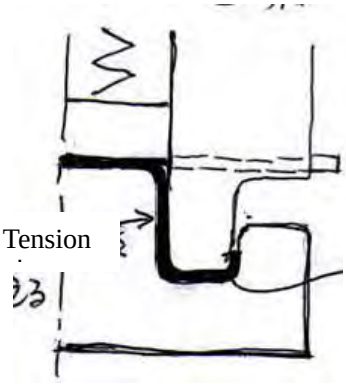
i. Change the clearance depending on the part as shown below
Simple bending = Material thickness
Stretch flange ≦ Material thickness
Shrinking flange > Material thickness

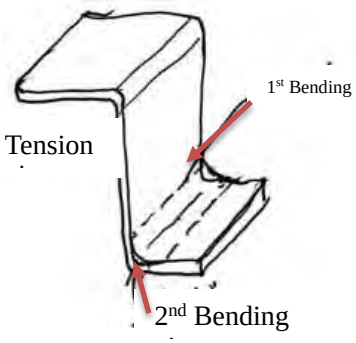
5) Warpage measures for flanges
①Process in 2 steps (process so that tension acts on the flange)
i) 1st process: process R largely
ii) 2nd process: Work to pull the processed R small



②Balance bending

Apply tension near bottom dead center





6) Spring back measures for flange forming

①Two processes

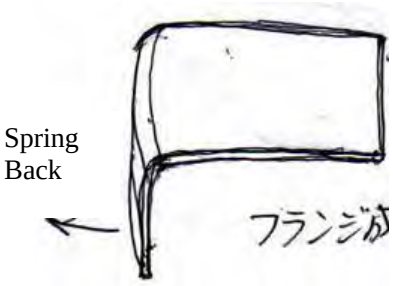
i.) Large R in 1st. pocess

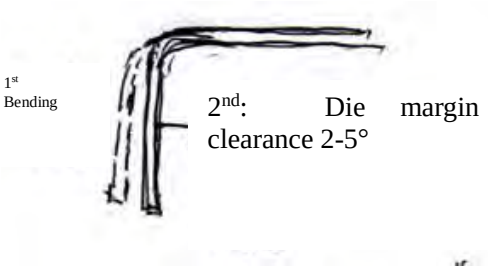
ii.) Apply regular R in 2nd process

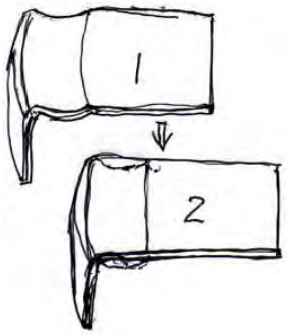
②Reverse warpage of web (Spring Go)

i) 1st process: Warpage by pad pressure

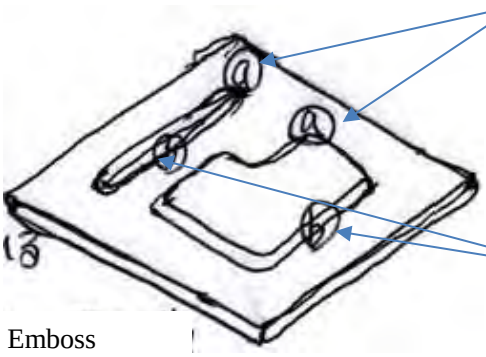
ii) 2nd process: Return the warpage of web







7) Crack in bead emboss



[Crack in part a]

① Increase both corner R and punch R (Elements of elongation are large and can be broken locally)

②Improve punch surface roughness (Use of processing oil)

[crack in part b]

①Increase 1 punch R

② Raise punch surface roughness (use processing oil)

Make corner R large

Emboss corner R

③	**(5) High Tensile Strength Steel (HTSS)** A steel material with a tensile strength of 370 MP or more is usually called High Tensile Strength Steel (HTSS), and it is often used for inner and outer plates in recent automobiles. 1) Specifications of HTSS Precipitation strengthening The fine precipitates which are carbides of Ti, Nb and V become dislocation obstacles and prevent dislocation of atoms of the material. As a result, a steel plate having a strength greater than that of a normal pressed steel plate (270 MP) can be obtained. High tensile strength steel plates with a tensile strength of 340 MPa to 790 MPa are called high tensile strength steel plates, and those with a tensile strength of 980 MPa or higher are called ultra-high tensile strength steel plates. 2) Press forming correspondence Details are explained to each supplier in the attached document. Please refer.  High_tensle_S_B.pptx			○

②Press Facilities

No	Contents	A	B	C
①	**<u>Press Machine</u>** **(1) Types of the press machine** 1)Classification by the drive method a. Crank press Power source letting a slide make a vertical motion is a mechanical press machine, and there are crank mechanism and screw mechanism in mechanical structure and converts the power that saved mechanically into the vertical motion of the slide. For example, in the case of a crank type, it gives a flywheel rotary motion with a motor, and power is transmitted to crank through a clutch as power source and turns into a vertical motion by a connecting rod. With the press machine which the productivity is in high level, it being used as most common one. b. Hydraulic Press Power source letting a slide make a vertical motion is the hydraulic press machine, the oil pressure type. By operating a pump by a motor and send oil with the pressure to the cylinder and move the piston in the cylinder, convert it into the vertical motion of the slide. The characteristic of the Hydraulic Press is that it can change the length of the stroke, processing speed and pressurization power freely, it being suitable for deep drawing processing(e.g. :fuel tank) However, in the case of an accident and oil leak during oil pressure device maintenance, it becomes uncontrollable with self-weight of the slide and risk of a slide fall potential. From the safety and the productivity is inferior to a machine type, it is restrictively used in late years. 2)Classification from a Form a. C type press It called C type press as frame part of C seen from the side of the machine, also called gap press. Because near side of the machine is vacant, it being superior in universality of the work, but a frame maybe warped when load of the press is too heavy. This called uncorking and becomes the factor of falling processing precision. The ability for pressurization is the basic up to 250.  AIDA Hi Flex press b. Gate type press Also called the straight side press which has 4 pillars of the frame to 4 angles of the frame. Rigidity is strong, and the large press machine more than 250 tons adopt this type ability for pressurization.  AIDA Hi Flex press	○		

c. Transfer press

A mechanical press machine used in the press line processing consecutively lot of processes, Regarding a form which is gate type and large –scale, capable for long time continuation. Product is supplied to the transfer press from a previous process by the feeder called transfer feeder automatically ,and supplied to the next process automatically after having completed press working.

T/F press
ASAHI SEIKI

d. Servo press

In the case of high precision press with the die of complicated shape, it is necessary to control slide speed and process it. But it makes slow of whole slide movement, having a problem of productivity down. However, in the case of Servo press, it drops the movement of the slide of the pressurization part, and the movement that the vertical motion gives higher speed and its productivity improves drastically.

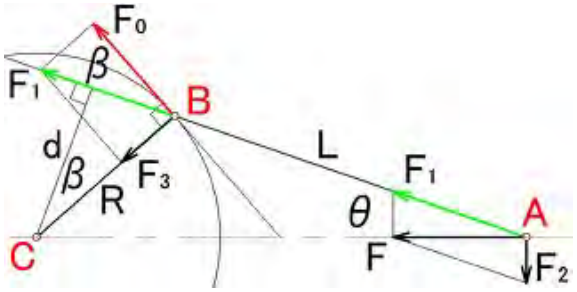
Servo press
AMADA TPW

(2)Setting of crank press

1)A stroke and press ability

a. load in the bottom dead center

Crank press converts rotary motion of the flywheel into reciprocating motion through a link and calculation shows that load becomes infinite at the bottom dead center.

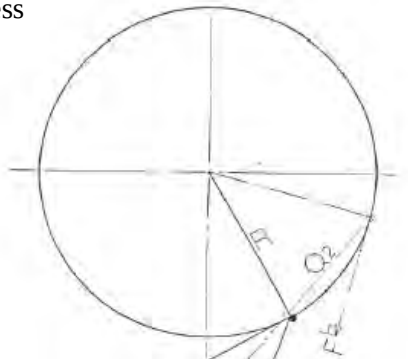


$T=R\times F_0$
$F=\cos\theta/d\times T$
At bottom dead center$\theta=0,d=0$
It means $F=\infty$

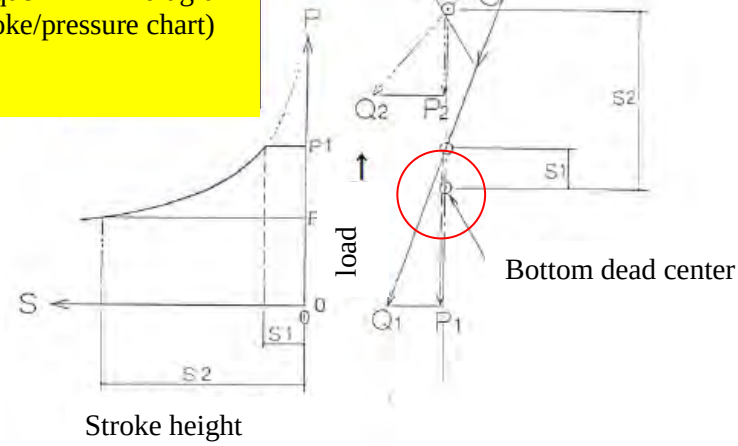
b. torque ability

c. Vertical load (P) changes due to calculation by a position of the con Rod. As the above figure shows, at the calculation by a position of the con Rod. As the above figure shows, at the place of higher position(S2) than rating ability outbreak position(S1) on the bottom dead center, permission load(P2) becomes smaller than pressure ability(P1),even press of same pressure ability based on torque ability, load is different by stroke length of transport and the press. When it surpass ability for torque, crankshaft and drive gear becoming overloaded and a clutch slips and cannot mold.

Torque ability of crank press



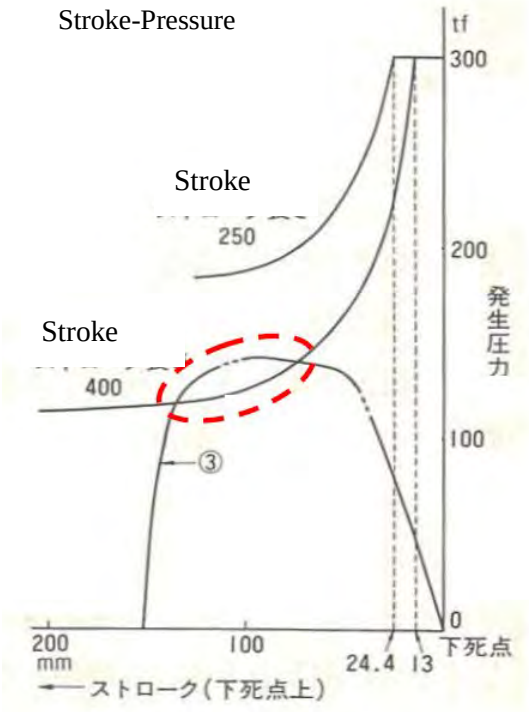
Torque diagram (stroke/pressure chart)



Stroke height

Torque ability is expressed by the position on the bottom dead center of the slide and trip curve indicating relation with pressure load. As for figure2.5, without change of torque of crank shaft, it shows ability of torque in case of 250mm and 400mm. This shows ability for torque decrease if stroke of slide becomes long. Above figure diagram shows a load curve of the reducing work of 150mm depth, in the case of 250mm stroke press, unable to take out a product and in the case of 400mm stroke, it shows shortage of torque ability.

Stroke-Pressure



2) work ability, setting press ability

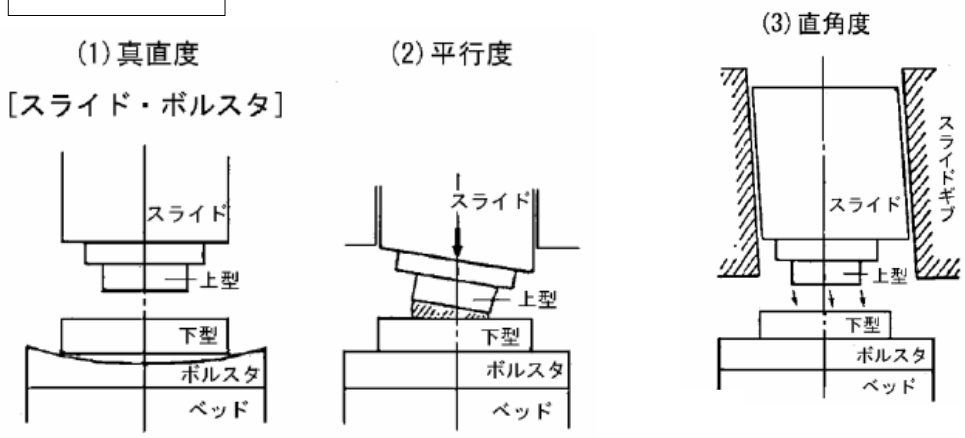
The molding by the machine press is carried out by consuming the rotary energy of flywheel. Therefore, the number of revolutions of the flywheel falls every one work and revives it by motor. Work ability means that no dropping of the number of production and continuity of work. The ability of press is established with the design rigidity of a frame and the bed with work ability (motor and capacity of flywheel). Please refer attachment for the basic explanation.

プレス能力説明K1.pptx

3) Press precision

By JIS requirement, main items of static precision are straightness, a parallelism degree, a direct angle of a slide and the bolster described in figure below as for standard and its confirmation method, please see “5,9③maintenance”

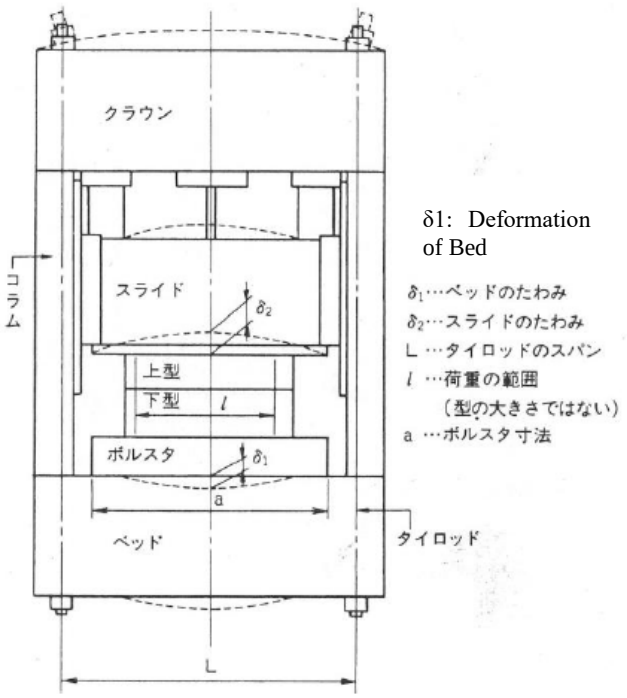
Press Precision



4) press rigidity

a. longitudinal stiffness

A slide and a bolster bend and tie-rod lengthened showed in figure 2.8 at work. For guided rigidity of the press, there is a rigidity value which indicates the bend situation of a slide and a bolster when uniformity distributed load acted on 2/3 of the work area. Just to be sure, the right and left dimensions of the work side show center of a slide or bolster bending 0.1mm.

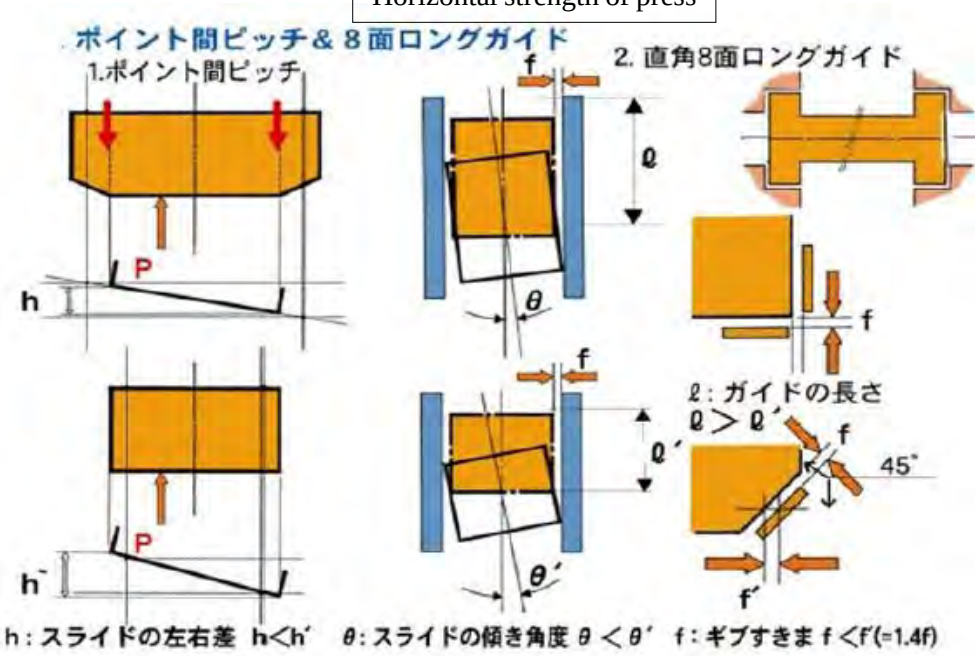


Longitudinal stiffness of press

b. Side rigidity

As for the press molding of many processes, prejudiced mind load in below figure “Horizontal strength of press”.

Horizontal strength of press

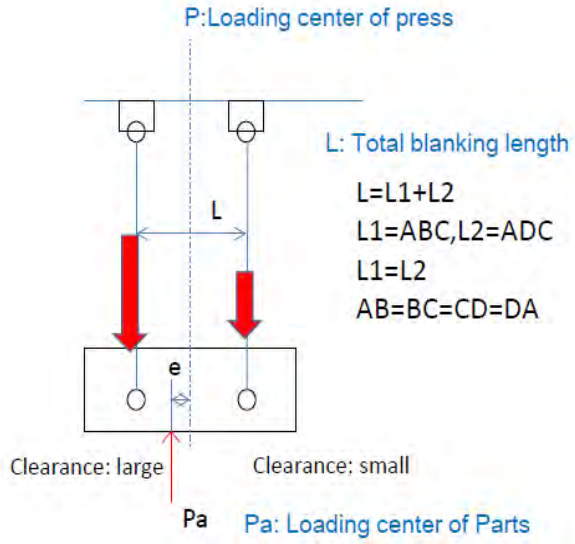


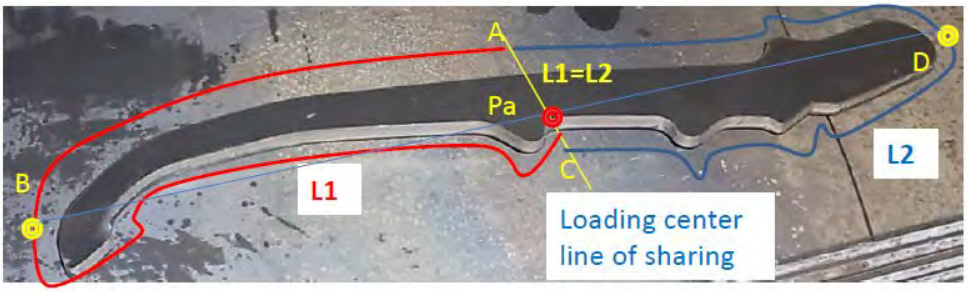
Zero cannot be avoided, a slide being inclined and moves horizontally, make adversely affecting on product precision and die life. Therefore, to raise the permission eccentric load, the press taking measures to increase the number of pressure point to 2 or 4 from 1. Furthermore, by opening PHS between the tray pressure points of figure and lengthen slide guide structure, and strengthening side rigidity per the structure of 8 right angle guides and pre-road guide, maintains precision.

c. Load center (center of working force when dies work)

As a method to take measure for side rigidity in the part side, put a press machine and the load center of the part together.

In the case of example, big burring occurs in the blanking process due to press ability shortage, where deburring required for all parts in 30 seconds, but it being reduced by putting the load center together.





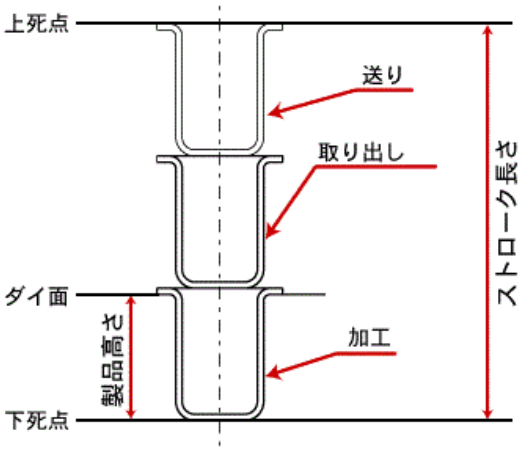
Please refer the attached material for Actual calculation & adjustment method⇒

Loading center_8thMar18.

5)Stroke setting

・ In the case of drawing process which needs load from the high position, confirm ability for torque by process pressure curve whether it can generate ability for pressurization from which position: how many mm from the bottom dead center.

Extracted stroke



・ Stroke length (mm)

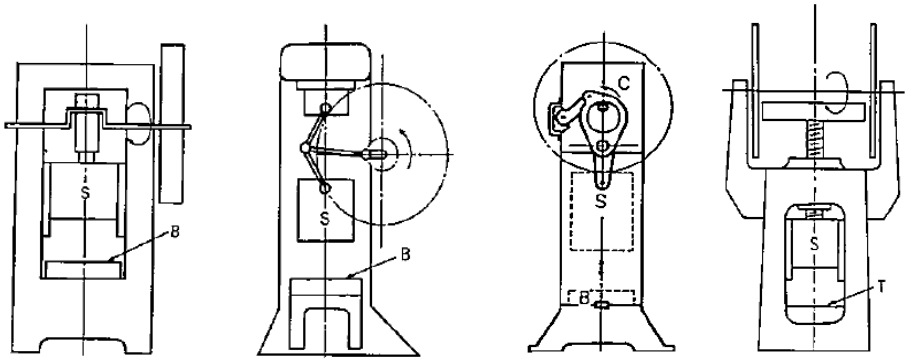
Suitable stroke length for press processing method is fixed by a slide's movement distance in one process (distance from the position of top dead center of the slide to bottom dead center).when used in blanking, shorter length is required and when bending or drawing transfer processing case, stroke length which is approximately 3 times of the molding height is required with the consideration of automatic conveyance effect.

6)Characteristic of mechanical press

As previously described, crank press needs to match torque range of capacity with a using stroke. Various kinds of variation for widening the choice option in a mechanical press exist. Typical examples;

a. Four types shown as below;

Mechanical type

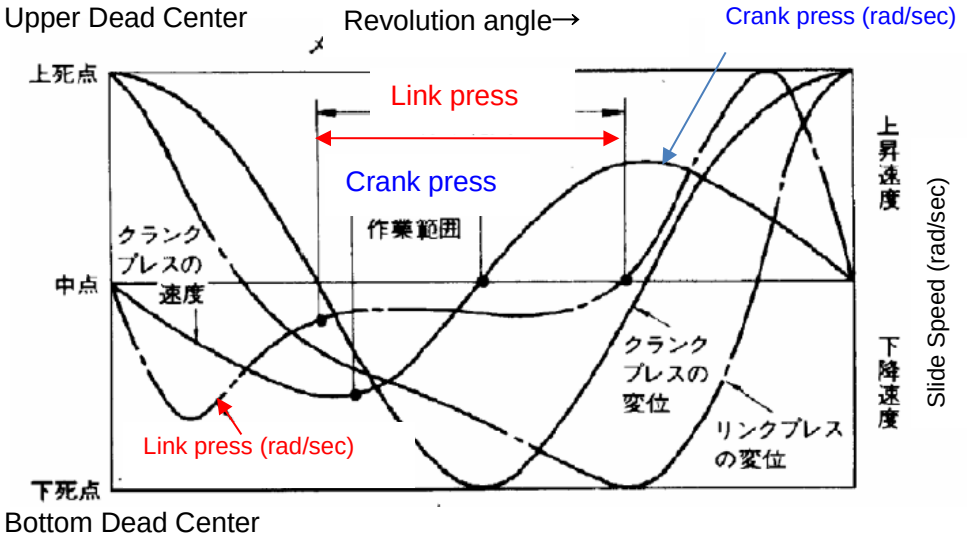


Crank Press　Knuckle Press　Link Press　Friction Press

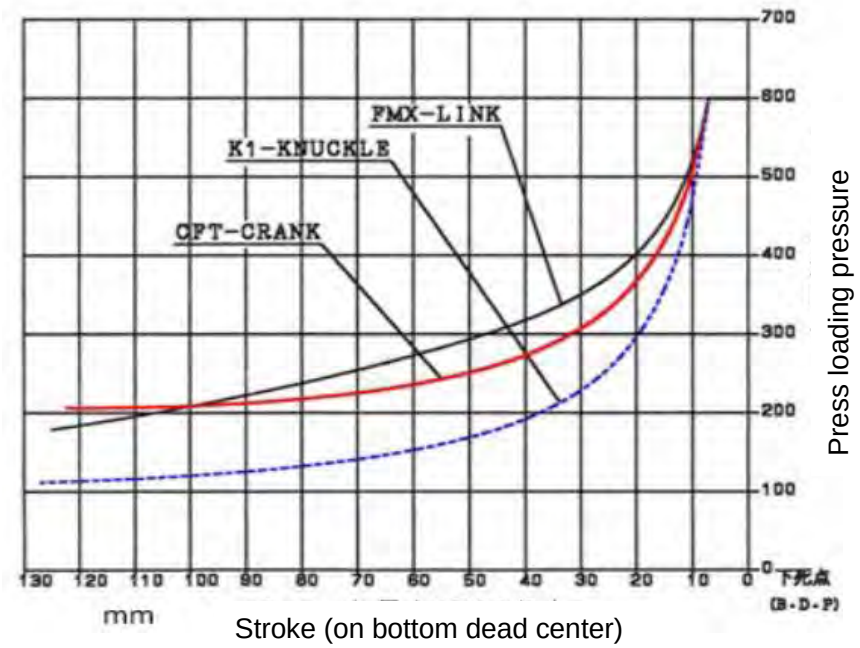
b. Torque ability

Velocity characteristic and torque ability in crank, knuckle and link press are shown in below figures comparing velocity characteristic, link press decreases velocity from the high position on the bottom dead center, it becoming constant tendency. Velocity change rises rapidly when passing bottom dead center. As for knuckle press, of which velocity is the slowest in the neighborhood of bottom dead center, and same tendency during the rising process and conveyance of supply/discharge of materials difficult. Recently, knuckle mechanism which has fast feeding back mechanism is developed. Crank press has the in-between characteristic of both. Link press is the most superior, as for torque ability, link press is the No.1 and crank press, knuckle press is the following the order.

Velocity Characteristic



Torque Ability



(3)Stroke of the mold

1) Die height

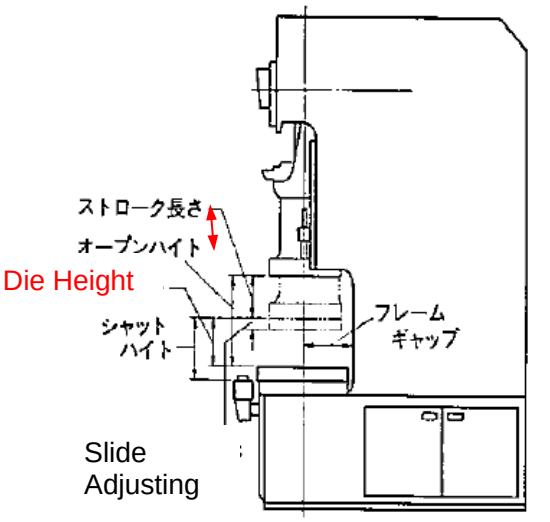
i. Die Height of press machine

It is the dimensions from the top surface of bolster plate to bottom face of the slide when putting up a slide adjustment screw to the upper limit, and move the slide stroke to the bottom dead center.

Not possible to install the die of a higher than these dimensions. If a die of which die height is less than this height, slide adjustment is possible to adjust. Aside from a range of slide adjustment quantity, in the case of lower die height, putting a plate for height adjustment in a die bottom or top, and install it.

When the die height fluctuates, it enforces to turn a lot of adjustment screws of the press machine, suffering of die exchange time, to unify the die height of the die as the way of same press machine used and reduce the adjustment quantity.

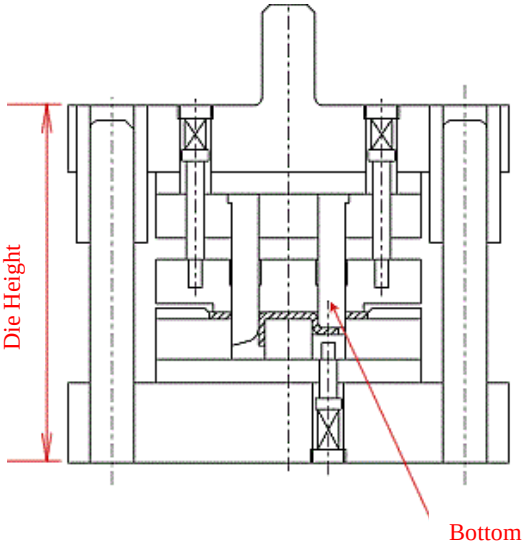
Specification of Mechanical Press



ii. Die Height of molds

It shows the height from the die holder undersurface to punch holder top surface where a punch and die is engaged and processing completed .Like the blanking mold, of which structure is punch getting into the depth with the die, deciding the depth of entering the die, and decide height at that time as die height of the die.

Mold Die Height



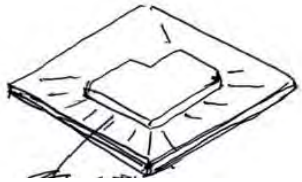
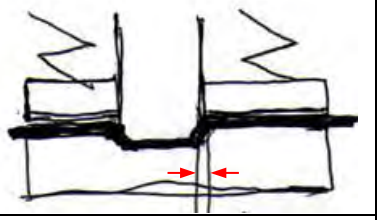
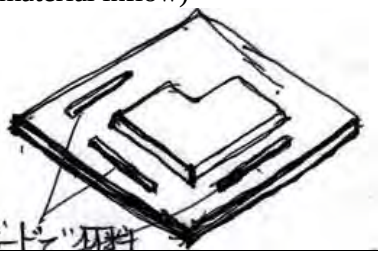
(4) Checkpoints in press process setting

In summary, below figures show the checkpoints in order to define press machine capabilities and specifications. Molding load is fixed by molding method and work materials as well as product size.

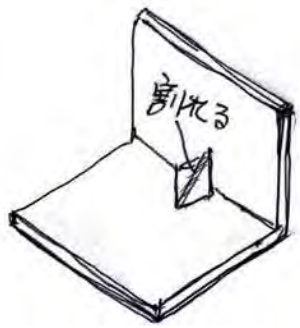
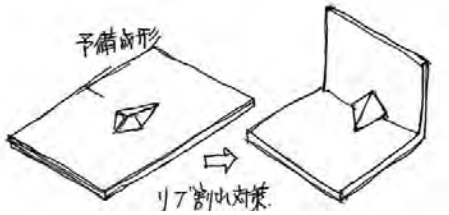
② **Defect Counter-Measures on Compound Molding Process (Advanced Case)** ○

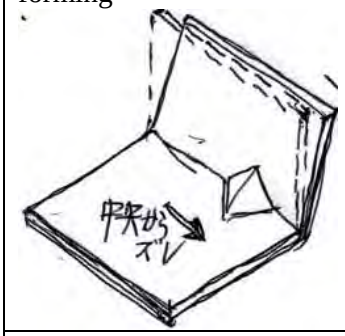
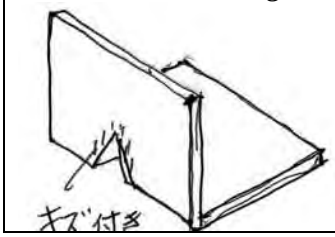
Actual auto-parts have a lot of compound processing which combine the basic bending and drawing process. Countermeasures of defects on basic method(blank, bend and draw) listed in"5-9-①press process and molds", therefore Cases which are inspected in the regular Circuit teaching/coaching to target suppliers in Pakistan are shown here, so please apply in your next similar situations.

(1)Bead embossing

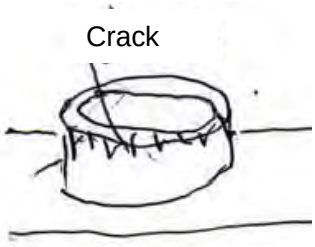
Phenomenon	Root cause	Counter-measures
 Surface distorted	Imbalance of sliding of materials	Strengthen pad control 
		Make clearance of straight line part smaller 
		With bead, give balancing on distortion of materials(limiting material inflow) 

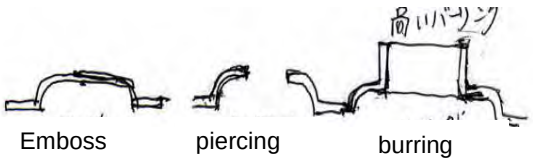
(2) Rib forming

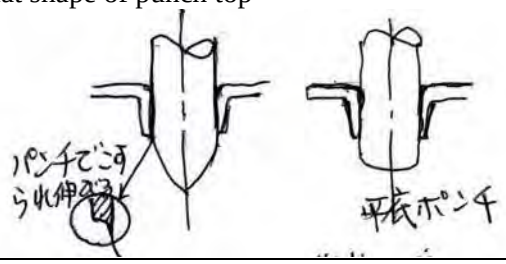
Phenomenon	Root cause	Counter-measures
Rib break 	When rib size is big, material elongation allowance is short and break	Perform preparatory molding 
		Lower rib mount

Phenomenon	Root cause	Counter-measure
Flange tilting of unsymmetrical position rib forming 	Flange tilting due to unbalancing of tensile force between right & left of material.	Move to center position of rib.
Scratch of rib forming 	Scuffing in press stroke	・make rib small ・Polishing of rib forming punch ・Change press oil more large thickness of oil film

(3)Burring

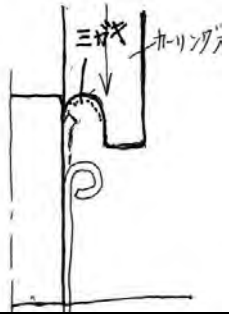
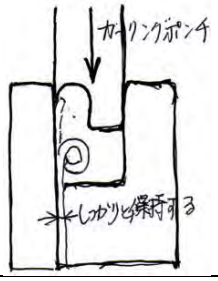
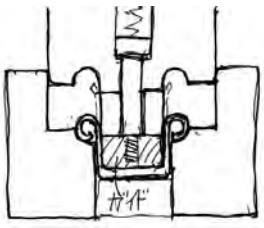
Face end crack 	Tilting flange due to uneven pulling force of panel	・Make primary hole large （Burring with primary hole extension） ・Punching direction should be from burr occurrence side ・Improving cutting edge of primary hole ・Ironing burring(Burring clearance: sheet thickness ×70%）
Insufficient of burring height		・Ironing burring（makes flange thickness thin）

	・ Add embossing process ・ make diameter of primary hole small	

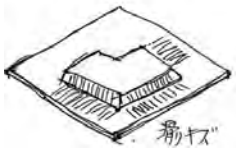
Phenomenon	Root cause	Counter-measure
Cutting chip remains in combination process of primary hole & burring	Dull sharpness of punch	Punch blade maintenance （Wrong maintenance）
Flange end braking (crack) in tapping process after burring.	insufficient tapping strength due to lack of sheet thickness	・Same clearance aheet thickness and burring clearance（regular burring） ＊high rigidty in root,so in top that rigidity becomes low⇒because of clearance is 60-70% of sheet thickness）
Fluff burr in tapping after burring process.	Flat shape of punch top 	
	Chamfering of burring pilot hol	
	Inner dia finishing after burring	

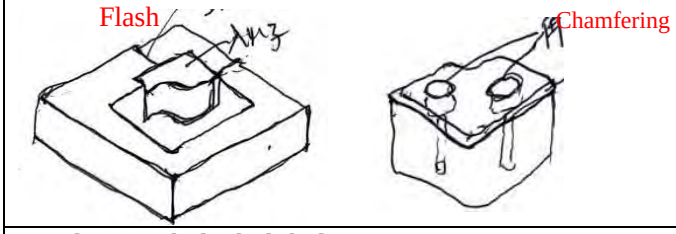
(4)Curling

Phenomenon	Root cause	Counter-measure
Deformation of side wall part 	Perform preparatory molding  Materials transform buckled along a punch and molded. Preparatory molding is around 60 degrees.	
	・improve roughness on curling punch surface. ・material maintenance improvement	

Phenomenon	Counter-measures
Curling does not give perfect circle	Preparatory molding required
	Roughness of curling punch surface is improved 
	Wind up so that burring side becomes inward, Prevent buckling of the part besides curl molding by axis pressure  

(5)Drawing forming

Phenomenon	Root cause	Counter-measures
Slide crack 	Slide crack on die face of materials ・die shoulder ・surface of die, pad & stripper Around draw bead	Improve die face roughness
		Use processing oil
		Make smoother on die face(凸凹)
		Adjust pressing force
		Use vinyl film
Scuff defect	contamination material of die	Protect dust（sand ,dust）
		De-burring
		Clean up die

		Optimization of die material and heat treatment (low hardness died is scorched)
Die guide	improve mating surface 	
	Crack on air hole ,bolt hole	
	Sliding face state of punch/pads and knockout	

(6)points of the drawing molding;

1)Process design（to balance costing and quality in Pakistan）

a. data bank of the past results(case –studies)
b. the image how the process going on
c. examine processing contents from both sides of materials and die
d. predict the movement and flow state of materials during the processing
e. processing balance at compound process and diaphragm process
f. Corner R shape and size of the mold
g. Preparation of defect prediction and counter-measures

2)preventive measures on wrinkle and crack occurrence is to find a neutral point (phenomenon point)

For example：Cylinder drawing⇒axial pulling⇒crack

Compression of the circumference direction⇒wrinkle

Drawing factors and crack/wrinkle relation

factors	crack	Wrinkle
Cushion pressure	strong	Weak
Roughness of die/wrinkle control face	large(rough)	small(smooth)
Die R	small	Large
Lubricating oil（lubricity）	low	High
Diaphragm ratio	small	Large
Drawing speed	high	Low
Material Ductility (elongation)	small	large

a. Types

rubber, spring urethane⇒high in first pressure ,so it becomes stronger as compress it highly

oil air pressure⇒easy to adjust pressure

＊ Diaphragm needs initial pressurization（power to perform material holding）

b. Defects and cushion pressure

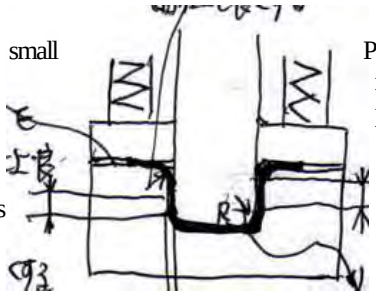
rubber, spring, poor parallelism degree of urethane end face, bending and buckling

↓

Partial holding without uniform pressure provided

Die R：Smooth

Cushion plate: small roughness



Punch side: a little increasing roughness in order to hold pressing load by friction

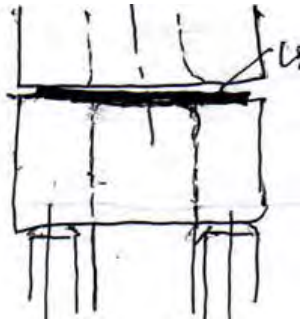
Die side face: roughness decreasing

Punch R : large

c. Uneven cushion pins

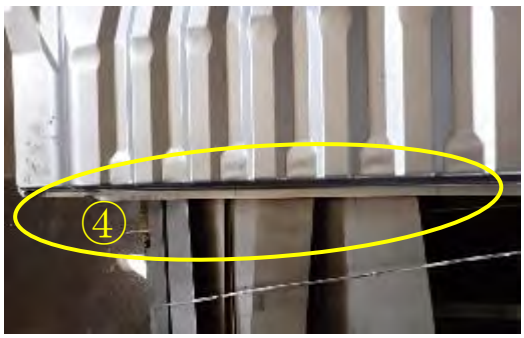
Wrong Parallelism between die & cushion plate due to cushion pin height variation

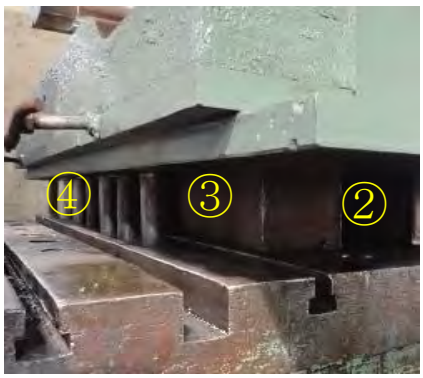
d. wrong parallel degrees between die and blank holder



Wrinkle: wrong fitting between die & cushion

<Cases>





Possibility of difference of panel holding strength between right and left side of Back Panel due to no cushion pin in X (②, ③) direction. Varied wrinkle condition among ④ position due to varied cushion pin length causes unstable holding pressure of panel.

1)Draw speed

Crank press is slow at neighborhood area of bottom dead center, but at45-60 degree

area, it becomes faster.be careful of it.

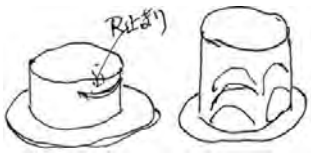
2)Burr of blanking：effective by press controlling

3)material formability : SPH and Zin-coating materials show poor diaphragm characteristic.

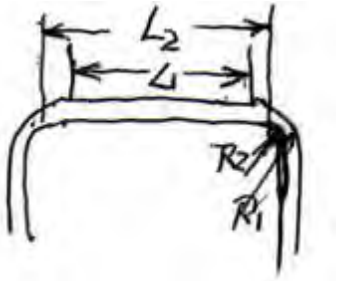
4) Cylindrical drawing

Many cases in 2 wheeler plant in PAKISTAN. Major defects and relative counter-measures are explained.

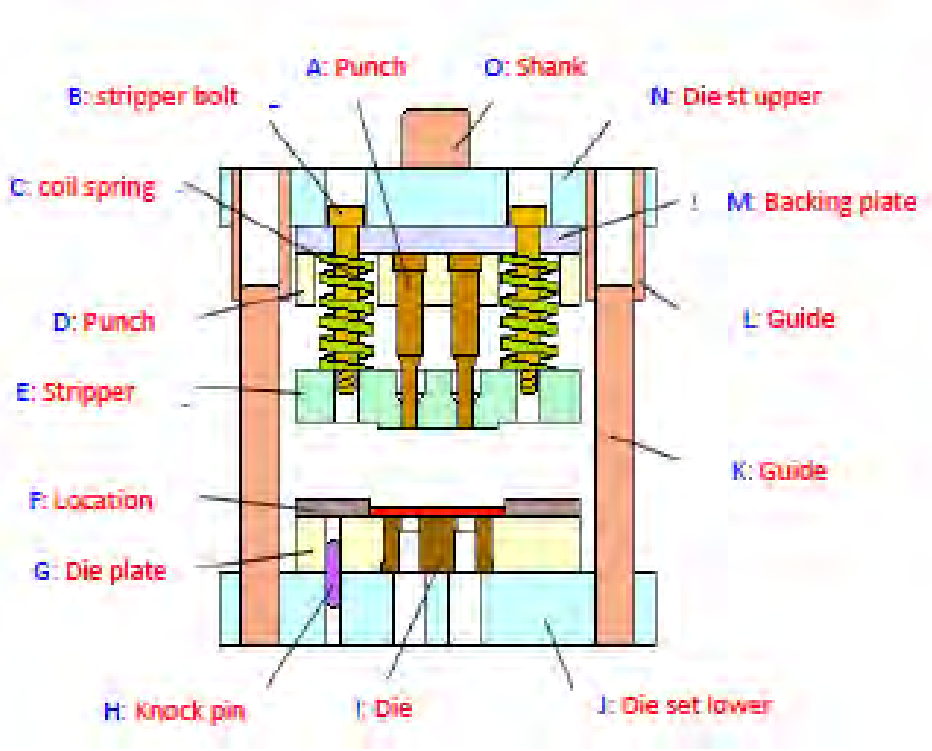
(1)wrinkle

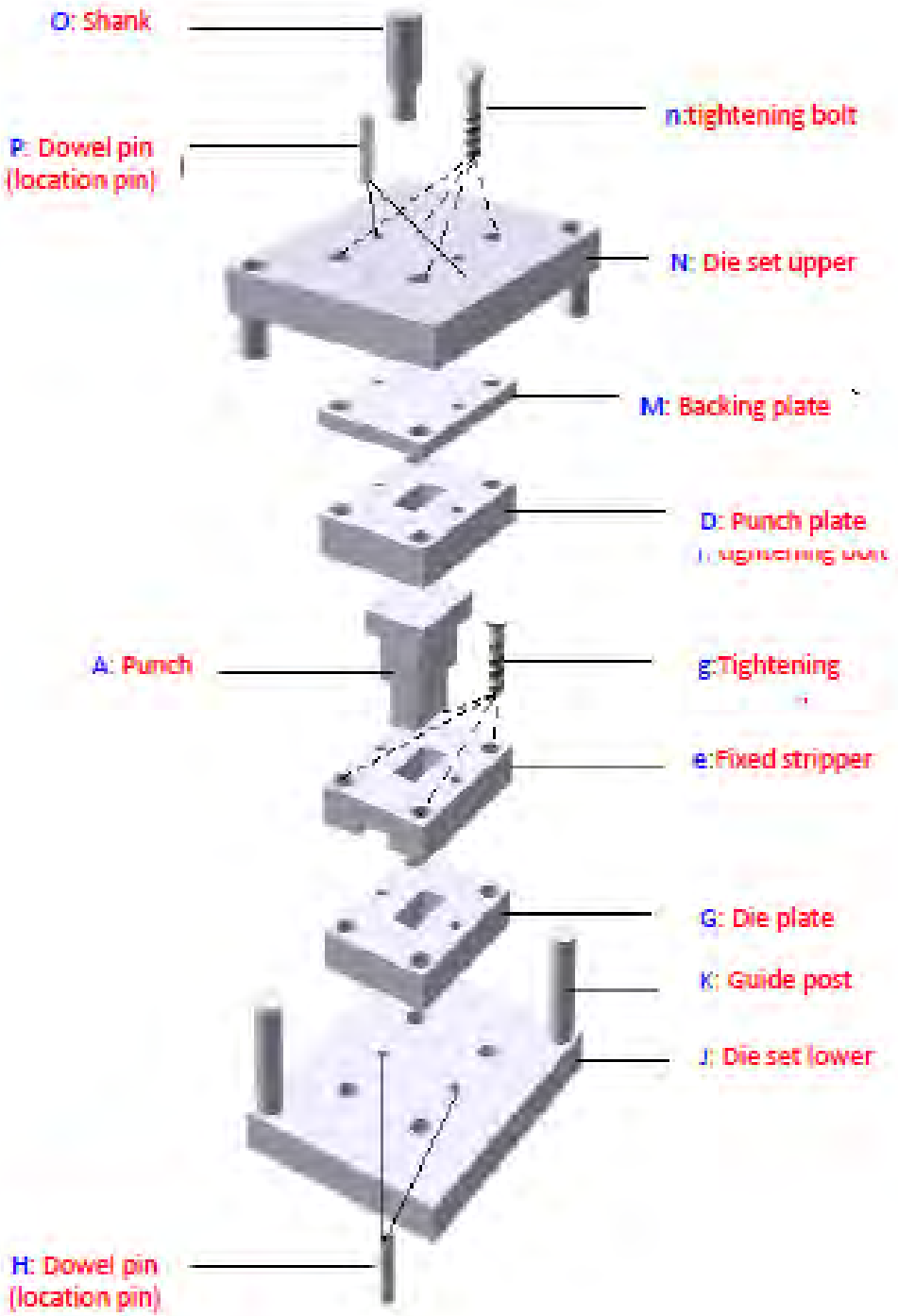
Phenomenon	Root cause	Counter-measures
Wrinkle over whole flange circumference parts		Raise cushion pressure
		Cushion change from rubber , spring into oil pressure
		Drop viscosity of diaphragm, decrease quantity
Partial wrinkle of flange circumference parts 	Imbalance of cushion inclination	Uniform cushion pin's length Confirm workability
		Parallel degree of die and wrinkle preventing surfaces
		Fix parallel degree of cushion spring end face and bending
		Fix burrs of blanking and warpage
		Fix surface crack & dirt of die or cushion
Crack (erupt of the bottom) 	Most of cracks occur at the joint part of R of bottom and straight line part.at point of maximum tensile stress	Diaphragm rate is small
		Strong cushion pressure
		Inappropriate cushion pressure (spring constant)
		Rough face of die pressing surface
		Small corner R of punch and die
		Slow speed of drawing
		Inappropriate cushion kinds of wrinkle press
		Poor lubricious of diaphragm oil
Arc-formed crack of side wall part	Lot of Defects when rolling materials (impurities, rolling crack)	
Side wall length break 	Delayed crack Delayed break: hydrogen toughness	・stop draw condition and add ironing ・baking after plating

Shape deformation

Phenomenon	Root cause	Counter-measures
Flange part becomes square		
Swell at bottom	Secure exhaust at oil hole and air hole of punch	
	Punch R in draw process and defect position of straight line part⇒necessary to have longer pre-process for the straight line part of the bottom($L_2 > L_1$) （swell occurs in reverse case） 	
	Imbalance of draw height	
	Weak face press at the bottom	
Dents at bottom	When slide rises, inside becomes minus number pressure	
	Unreasonable eject of product (knock-out)	
	Without oil flow between product and knock-out, liquid pressure pressing the face	
Thickness un-uniformity	Unavoidable in deep drawing process ⇒ add ironing at restrictive process of compound processes	

③Maintenance of Press and Press Die

No	Contents	A	B	C
①	<u>Die maintenance</u> **(1) Concept of mold maintenance** Instead of dealing with the problems that occur, take precautionary measures so as not to cause them. This is the concept of Preventive Maintenance. 1) To grasp the material origin, the die accuracy, and the variation of the material 2) Make a maintenance plan that matches the equipment and the die based on the actual failure results. **(2) Check sheet of press die (example)** The check sheet Sample provided to each Pakistan supplier is shown below, for reference. Make an action plan based on these.  	○		


O: Shank
n:tightening bolt
P: Dowel pin
(location pin)
N: Die set upper
M: Backing plate
D: Punch plate
A: Punch
g:Tightening
e:Fixed stripper
G: Die plate
K: Guide post
J: Die set lower
H: Dowel pin
(location pin)

Check sheet for press die (Example): Check sheet attached at the end.

Control point	Checking items/method	Symbol	Interval(K-shot) day	200	400	600	800	Remark
Prevention Burr (Punch, Guide, Guide post & Stripper)	1) Polsh the worn of punch & die.	A		1 Polish		1	1 Replace	Confirming the processing quality of the product.
	Checking burr		1					
	2)Scuffing of guide post	K,L				1 (check)	1	Is there no eccentric load? Since the guide post and the bush are combined parts, replace them as a set.
	3) Worn out of urethane / spring for holding stripper	C		1 check			1 change	Urethane is short life. Change interval should be set individually.
Stripper	Scuffing of guide between punch & stripper	A				1		Confirm the side force due to error shot in double pane or mistaken feed .
	Stripper plate tilting	E				1		The part is warped due to the eccentric pressure applied by the tilt of the stripper plate.
	Contact between material & die. Lack of releasing gap	e				1		
	Pressure plate tilting	e			1			Defect of bending angle, piercing burr and eccentric deformation of drawing
	Balancing of clearance	A, I			1			Confirm the status of burr occurring
	Entwining panel to stropper	E	1					Feed mistaken due to feed timing error
	spring	C		1 Check		1	1 (Change)	Damage of spring, To Replace bolt in deformation of hexagon head of bolt.
	Damage/loosen of bolt(hanger bolt)	B			1 Check		1 Change	
Spacer	Spacer shifted	D	1 die change		1			Wrap the paper to prevent moving of spacer
	Scrap clogged, crack of die	I	1 check			1 change		Visual check in work start
	Deformation & crack in the bottom of Die.	G				1 repair		
	Die spacer moving	D				1		Dowel pin for prevention of die spacer moving
	Side pressure on outer clamping	G			1			Investigate causes by evaluating occurring trend
Dead end control	Height block	P		1 Check			1 change	Check the hit condition on the stroke alignment block. In the case of work-hardened materials (such as AL) with bottomed molds, standardization of mold height is set in each process to determine the quality (confirmation of crushed state)
Die fitment	Dowel Pin	H		1 check			1 change	When the die dismantling, the fit becomes loose and rattling occurs.
	Insert die & punch	i	1 check	As required				Set replacement frequency for each part. Be careful of reverse insertion of blocky inserts. (Pokayoke with projections and marks)
Blanking die	Punch	A		1 check			1 change	Sharing line of panel has to be near point of corner R of die blade end point. The position of the crack is shifted due to the wear, so the worn part is polished and returned to the original height of die by shim, welding or the like.
	Small diameter punch	A'	1 check	As required				Clogging of the die causes wear and breakage. Replace both punch and die. (Better to use insert die)

Check Sheet for die (Sample) ⇒

Die_Check Sheet(Sample).xl

(3) Maintenance work

Correctly attach cutting tools and workpieces in an appropriate manner.

1) Jig: Positioning and fixing of workpiece, guide of cutting tool (bush)
   Positioning mechanism, tightening mechanism, guide mechanism
   Chucks, Machine vice tilting table indexing table, Equerry, Pallet, Plate
2) Mounting tool: Mount a work and cutting tool on the machine tool.

Positioning mechanism and tightening mechanism
- General-purpose mounting tool
- Car mounting tool
- Multipurpose mounting tool
- Assembly type mounting tool

3) Purpose of jig And mounting tool:
- *Simplification of work, saving skills
- *Productivity improvement (multiple installation, simultaneous processing)
- *Machining accuracy improvement and quality stabilization
- *Establish safety work

4) Mounting tool positioning mechanism:
①Positioning mechanism by fixed plane
②Positioning by pins
③Positioning with adjustment screw
④Positioning by V block
⑤Positioning by hole standard

5) Positioning method
① Depending on the condition of the surface of the work
②Large work piece of radius
③Depending on the size of processing load
④Depending on the direction of processing load

6) Tightening mechanism: Clamping parts (tightening parts)
①Clamp
②Attachment
③Jack
④Stepped support
⑤Clamping unit (unit for tightening)

(4) Main tightening mechanism in machine repair

1) Drilling machine fixtures

Drill installation and removal

①Tapered shank drill (using sleeve and drift)

Clean the spindle of the drilling machine and insert the sleeved drill into the spindle hole and attach it with light impact. To remove it, insert the drift into the shaft hole and tap lightly with a wooden hammer. At this time, if you do not support the drill with your left hand, the drill will drop.

② Straight shaft drill

Clean the spindle hole of the drilling machine and insert the drill chuck shank into the spindle hole. Apply a light impact and mount the drill chuck on the main shaft. Turn the chuck by hand, spread the nails, insert a straight drill, turn the drill by hand and lightly tighten and check the center of rotation (flexure) of the drill and fix it.

③ Reamer installation

Same as straight drill.

How to attach the work

① Vice
② Fasteners
③ Clamps

2) Jig and fixture for lathe

① Mounting of the cutting tool: Align the cutting edge with the center of the workpiece. Keep the overhang length of the tool as short as possible.

②Drill installation: Center hole drill, Drill (taper, straight) — Use of drill chuck

・Clean the hole of the lathe tailstock and attach the drill chuck of taper shank.
Center drill, Straight shank drill

・Back the lathe tailstock and pull out the chuck. Insert a taper drill with a shank

attached to the taper drill while lightly impact the tailstock.

3) Mounting of the workpiece

① 3 jaw interlocking chuck (Stroll Chuck)
② 4 jaw single acting chuck (Independent chuck)
③ Mounting by centers
Standard Center, Half Center, Rotating Center, Umbrella Center,
Both Centers, Mandrill

4) Mounting jig for the workpiece

① Machine Vice
② Clamp
③ Mounting by the scale
④ Installation using a ramp
⑤ Circular table installation
⑥ Mounting with a universal index table

5) Mounting jig for grinding machine

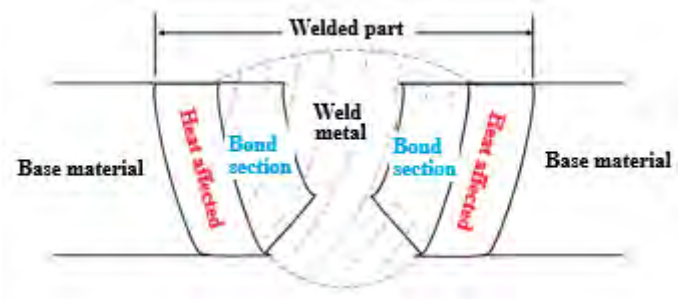
Grinding wheel installation
① Mounting on flange (Make balance)
② Installation to grinding machine

Mounting and fixing of workpieces

①Universal mounting on surface grinding machines: Electromagnetic chuck
② Fixing by auxiliary block
③ Fixing by angle rest
④ Mass block fixing
⑤ Wax (adhesive) fixing
⑥ By vacuum chuck or freezing chuck
⑦ Chuck mounting
⑧ Center mounting
⑨ Mandrel mounting

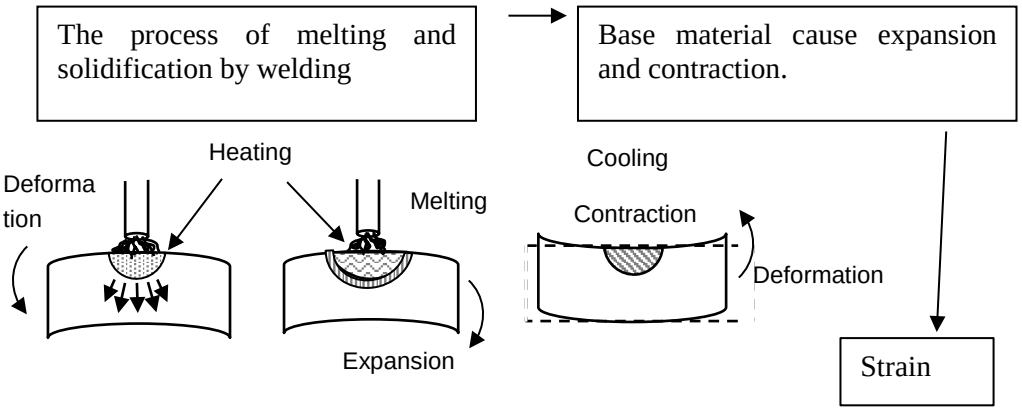
(5) Welding repair of mold

1) Welded structure

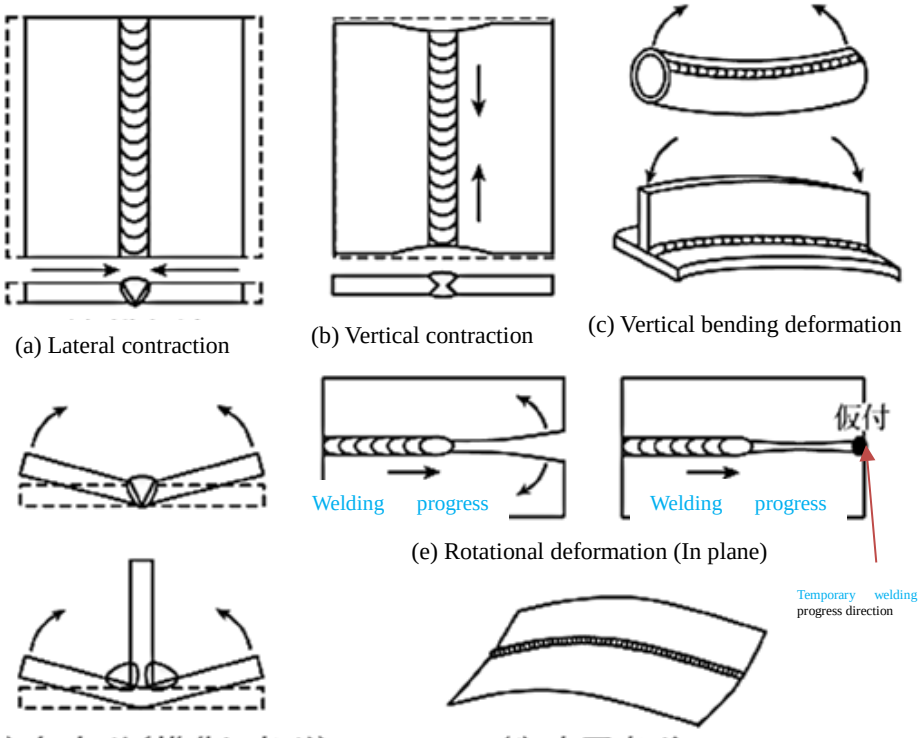


- **Bond part** (coarse grain area): In this part, the temperature becomes 1250 ° C. or higher, and the crystal grains become coarse. In the case of a steel containing a large amount of alloying elements, a martensitic structure precipitates and is easily hardened and easily broken.
- **Heat affected part**: In this part, the temperature is 1250 ° C to 1100 ° C. Fine and coarse grains are mixed.
- **Outside the heat-affected zone**: In this zone the temperature is between 1100 and 900.degree. Ferrite and pearlite grains become smaller and become more tenacious.

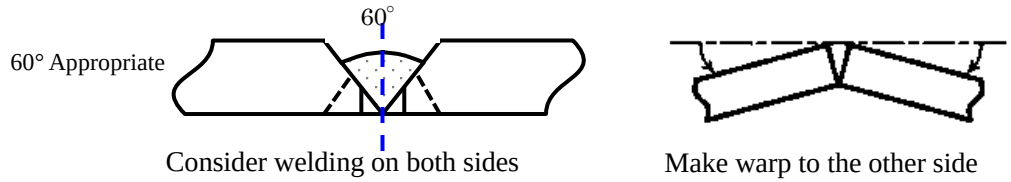
2) Residual stress and deformation



Base material is deformed.
Horizontal contraction, longitudinal contraction, lateral bending deformation
Longitudinal bending deformation, buckling deformation, rotational deformation
Residual stress remains in the material deformed by welding.
Heat treatment to eliminate stress. The annealing treatment is maintained at 600-650° C. and gradually cooled to 200° C.



3) To reduce welding distortion
   a) Consider the groove shape.
   b) Do not heat the base material more than necessary.
   c) Use reverse strain.
   d) Use a restraint jig. (Use of clamp)
   e) Consider the welding order. (Split method, symmetry method, back step method)



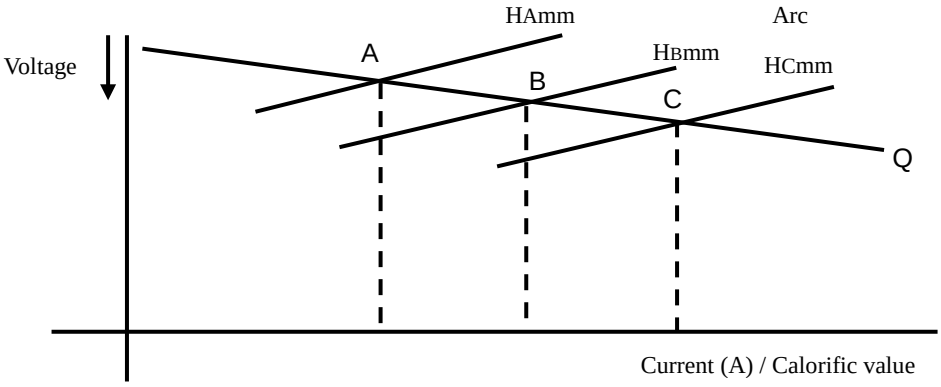
Consider welding on both sides

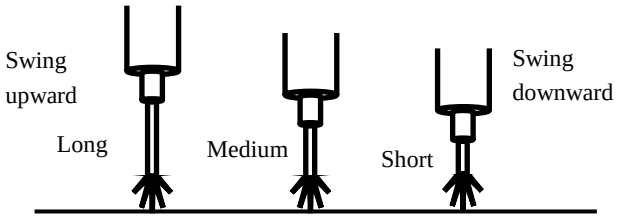
Make warp to the other side

4) Semi-automatic arc welding

a. In order to keep the arc length constant, it is controlled so that there is no change in voltage.

Constant voltage characteristics - Constant speed feed method





i. Safe welding with arc HBmm — Power supply output characteristics
Point B of current-voltage characteristics

ii. As the handshakes downward and approaches HCmm, the current (heat quantity) increases and the wire melts quickly and return to point B.

iii. As approach HAmm,

The current decreases and the wire melting rate decreases, returning to point B

Arc length self-control function

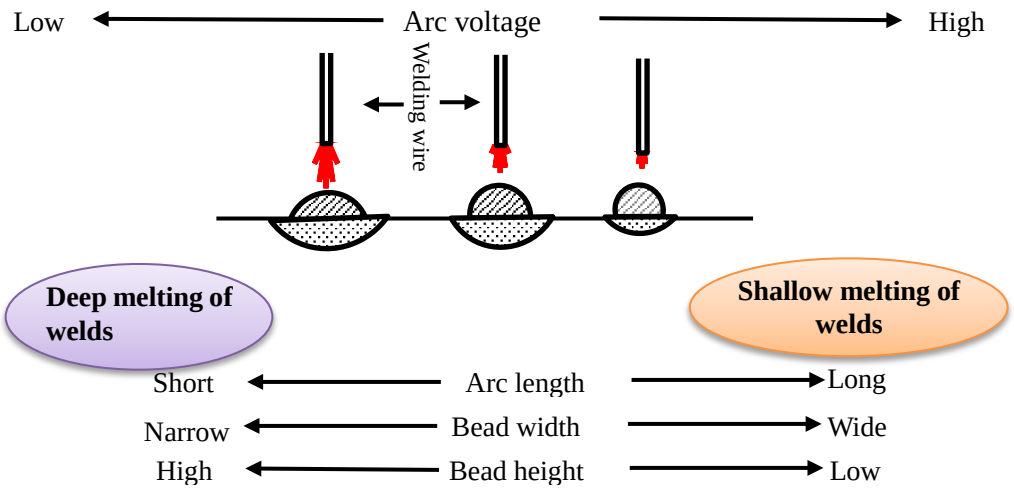
b. Basic welding conditions

Welding current, arc voltage adjustment: High current ➡ Wire feeding speed is faster.

(The melt speed increases as the current increases.)

Central setting function

(Function that welder sets voltage automatically for set current value.)



4) Welding material, welding condition

The welding repair method of SKD11 is shown as an example.

Pre-heating and post-heating before and after welding should be done carefully to prevent cracks in the repair area.

Die repairing(welding)

Press Machine Maintenance

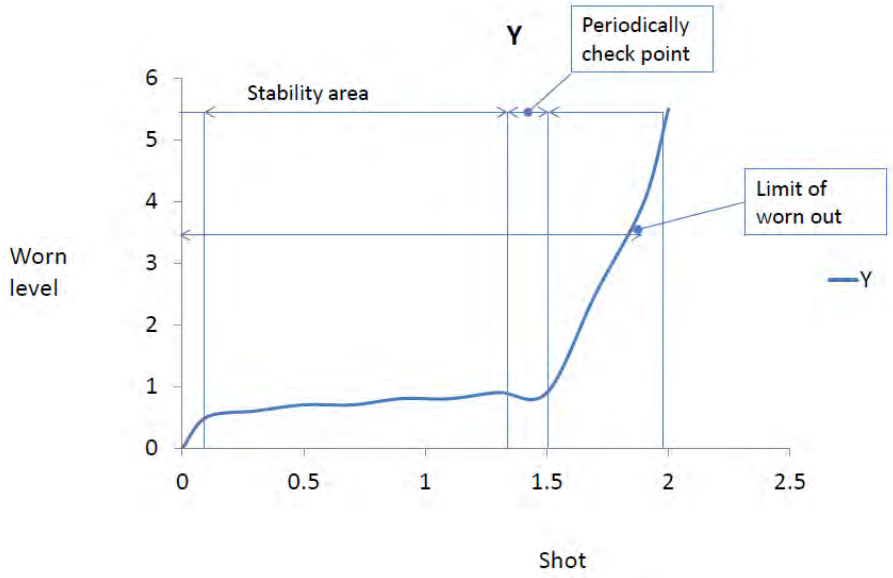
(1) Concept of maintenance

In Pakistan, oil leaks, abnormal noises, and functional checks are mainly conducted at all suppliers. However, the concept of preventive maintenance to prevent problems in advance has not yet penetrated. In this manual, the functions and accuracy of the equipment itself are properly maintained, and further, the main focus is on measures from the standpoint of Preventive Maintenance without causing equipment failure.

1) Failure curve:

As shown in figure below, from the stability area (Stability Area), there is a limit of worn out in which wear progresses rapidly. Checks and maintenance should be carried out properly at the time of the periodic check point (Y) during the stable period and the service limit period.

Failure curve:



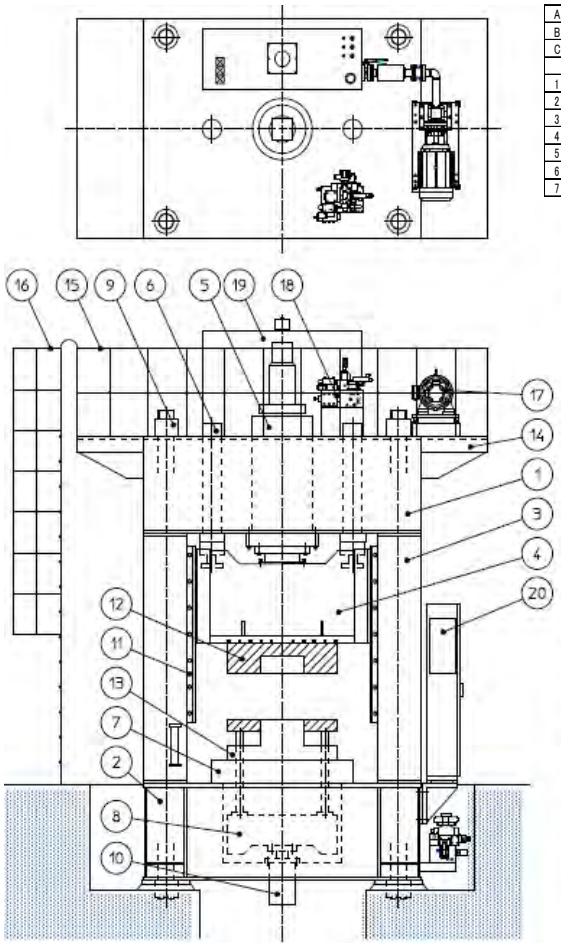
For this purpose, it is necessary to determine an appropriate inspection interval for each part or unit, instead of uniformly determining the timing for inspections and repairs.

Periodical check sample:

Periodically check	Shot (× 100)			
	200	400	600	800
Re-grinding(punch)	○	○	○	○
Polishing drawing die	○	○	○	○
Check spring	○	○	○	○
Cleaning , overhauling	○	○	○	○
Polishing stripper		○		○
Polishing pilot punch		○		○
Knock out height adjustment		○		○
Spring change				○
Regrinding stripper				○
Stripper bolt check				○

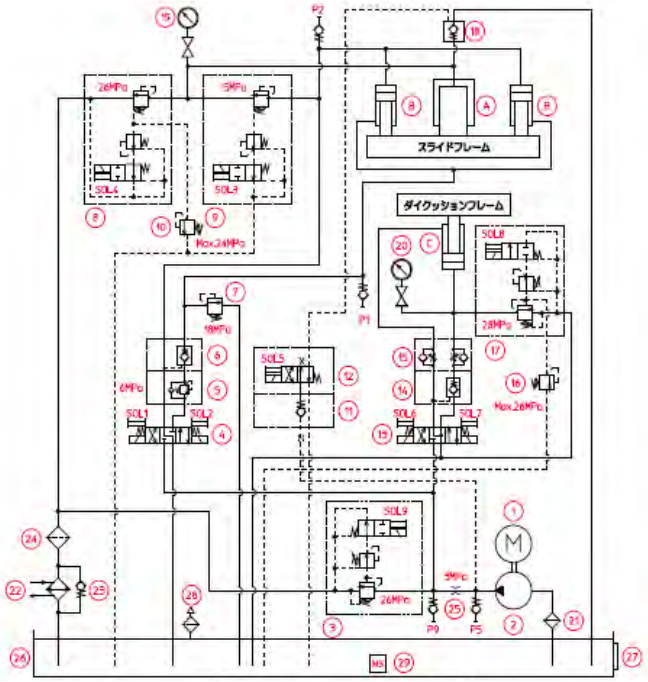
2) Check sheet (Example)

In particular, large hydraulic presses often take time to recover from failures. The example shows an example of a regular inspection / confirmation sheet in the case of a hydraulic press. (Full-text description in attached File including English)



A	Main Cylinder	8	Relief valve(balance piston)	19	Main pressure gauge
B	Side Cylinder	9	Sequence valve(blaance piston	20	Die cushion pressure gauge
C	Die Cushion Cylinder	10	Relief valve(Direct)	21	Suction Filter
		11	Check valve	22	Oil Cooler
1	Motor	12	Sol Valve	23	Check valve
2	Oil Pump	13	Sol Valve	24	return Filter
3	Relief valve(Balance Piston)	14	Pilot control check valve	25	Choke
4	Sol. Valve	15	Slow return check valve	26	Oil Tank
5	Counter balance valve	16	Relief valve(Direct)	27	Thermo meter
6	Pilot control check valve	17	Relief valve(Balance Piston)	28	Air breaser
7	Relief valve(Direct)	18	Pre fill valve	29	Micro Separaror

① Crown (Upper Frame)
② Bed (Lower frame)
③ Uplight(Side Frame)
④ Slide frame
⑤ Main cylinder
⑥ Side cylinder
⑦ Bolster
⑧ Die cushion frame
⑨ Tie rod,Nut
⑩ Die chushion Cylinder
⑪ Slide Gib
⑫ Upper Die
⑬ Lower Die
⑭ Platform
⑮ hand rail
⑯ ladder
⑰ Pump, Motor Unit
⑱ Vulve Unit
⑲ Oil Tank
⑳ Control Panel



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7	Relief valve(Direct)	18	Pre fill valve	29	Micro Separaror

Check Sheet for hydraulic press (Example)

Parts	Checking items/method	Interval				Remark
		Daily	Weekly	Momthly	Annually	
Main parts of Press	1) Looseness of bolt(Mainparts of press,foundation) -> Wrench			1time		Properly tightened
	2) whether machines are not in abnormal situation -> Visual control			1time		To clarify no crack or damage
	3) whether no abnormal situation in bolt or nut of each sliding portion -> visual control			1time		To clarify no loosening
Cylinder	1) To clarify no abnormal situation in cylinder funtion or surface defect -> visual ciontrol		1time			To clarify no defect of oil leakage etc.
	2) To clarify loosening in tighting bolts -> Hexagonal wrench			1time		To clarify tightening per requirements
	3) To clarify tightening of packing -> Hexagonal wrench			1time		To clarify tightening in uniform
Slide	1) To clarify no abnormal situation in appearance, sliding part -> Visual control		1time			To clarify no crack or damage
	2) To clarify worn out situation of sliding part		1time			To clarify no partial damage of the sliding part
	3) To clarify grease lubrication situation -> Visual control	1time				
Oil Tank	1) To clarify no abnormal situation in apperance -> Visual control		1			To clarify no oil leakage
	2) Oil leakage -> Visual control		1time			To clarify no oil leakage
	3) Oil quantity -> To confirm by oil level scaler		1time			To clarify whether quantity is more than half
	4) Oil dergradation -> Visual control (Confirm inside the tank)			1time		To change it within 2,000 hours
	5) To check purification of air breezer filter -> Visual control			1time		Filter purification etc.
	6) To confirm adhesion of iron in magnet separater -> Visual control				3	To confirm no adhesion of iron, or exclusion of iron
	7) Oil temperature -> To confirm by oil temperature thermomitor	1time				Appropriate range of oil temperature 20~50 degreeC, most appropriate 35~48 degreeC

Geat valve,Stop Valve,Through valve,Drain cock	1) To confirm handle distance situation	1time				To confirm no loosening	
Parts	Inspection items/methods	Interval				Remarks	
		Daily	Weekly	Monthly	Annually		
Oil pump	1) Abnormal noise -> to measure by device				2 times	To memory normal noise	
	2) Temperature -> Toch by hand or confirm by thermomiter				2 times	To confirm abnormal fever	
	3) Pressure holding situation -> to confirm pressure device	1 time				To confirm minimum fluctuation of pressure	
	4) Oil leakage -> Visual control			1 time		To confirm no oil leakage	
	5) Discharge flow quantity -> To measure speed of sliding up and down				2 times		
Motor	1) To confirm no abnormal situation of pump conjugation (coupling) -> Visual control				2 times	Conjugated normaly	
	2) Axis deviation -> Visual control				2 times	No deviation	
Suction filter	1) Filter clogging -> Visual control		1 time	※ 1 time		To clean up monthly	
Releafing valve	1) To confirm lock situation of handle -> Visual control	1 time				To confirm no loosening	
	setting value and working range -> To confirm pressure device	1 time				Within regulated range	
Throttle valve	1) Confirm setting position (Handle lock condition) -> visual control	1 time				No loosening situation	
Pressure gauge	1) Pressure situation -> Visual control	1 time				To confirm needle show 0~10kg/cm^2 when no burden	
Pressure switch	1) Confirm working condition -> Visual control		1 time			To confirm workbility in normal	
oil temprature	1) No abnormal existence in appearance -> Visual control	1 time				Within the normal range±1%	
	2) Work situation (Confirm instructed output)						
Oil cooler	1) Cooling capacity -> Confirm with oil temperature gauge	1 time				Thermostat ON at oil temperature 48 degree C, OFF at 35 degree C (unplug water in winter season)	
	2) Water leak -> Visual control		1 time			No leakage	
Flexible hose	1) To clarify no abnormal situation in appearance → visual control		1 time				
	2) Tightening situation -> Visual control	1 time				No bolt loosening	
Piping	1) Oil leakage -> Visual control		1 time			No oil leakage	
	Tightening condition -> Visual control		1 time			No loosening of tightening bolt	

2) Inspection items of electric system

Part name	Inspection items and methods	Interval				Remarks
		Daily	Weekly	Monthly	Annually	
Wiring	1) Confirm abnormal situation in apperance				2 times	To confirm no damage or aging
	2) To measure insulation resistence at primary side -> Mega ohm tester				2 times	To confirm more than 2MΩ
	3) To check grounding conductor				2 times	To confirm installation in normal
On/Off switch	1) To confirm abnormal in SW -> Visual control	1 time				No clattering or Bias
	2) To check workbility by changing ON/OFF at several times -> By operation	1 time				To confirm operation at On/OFF position
Electric motor	1) No abnormal in appearance -> Visual control				2 times	No crack, damage or dirty
	2) Work situation -> Visual control				2 times	No abnormal noise or vibration
	3) To measure insulation resistance -> Mega ohm tester				2 times	More than 2MΩ
Indicator light	1) To confirm indicator light by switch on -> Visual control	1 time				
Limit switch	1) No abnormal in appearance -> Visual control		1 time			No worn-out,crack damage and dirty
	2) Workbility -> Visual control	1 time				To work in normal
Electric relay	1) No abnormal in grounding -> Visual control				2 times	No significant discoloration or burnout
	2) No abnormal between movable and fixed iron core -> Visual control				2 times	No foreign substance or dust atatched
	3) To check no abnormal in coil -> Visual control				2 times	No significant discoloration or burnout
Other parts	1) To check abnormal in appearance				2 times	No worn-out,crack, damage or dirty
Thermal relay	1) To check rated value -> Visual control				2 times	To confirm rated value by makers
Switch board, control board operation board,terminal boxes etc.	1) No existence of foreign substance -> Visual control				2 times	No oil, dust or foreign substance
	2) To check no abnormal in terminal -> By screwdriver				2 times	No loosening or big loss of combustion
Mounting parts(various)	1) To check screw dropout, or loosening -> by driver				2 times	To tightening properly
	2) To check seismic isolation device such as spring, rubber etc. -> Visual control				2 times	No loosening, deformation or degradation of seismic isolator

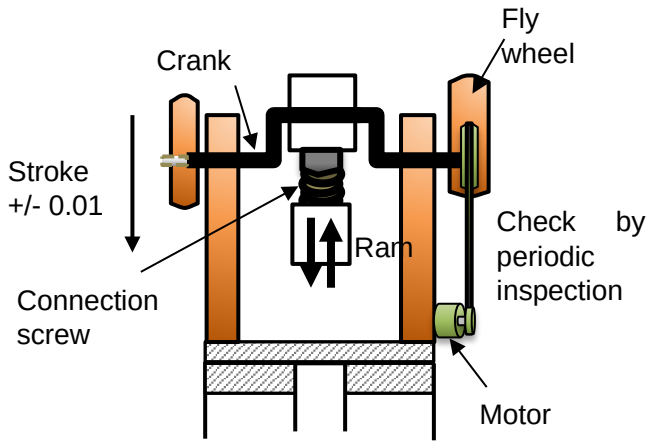
Check Sheet for hydraulic press (Example)⇒

Press_Check Sheet(Sample).xl

(3) Static accuracy check

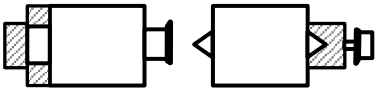
1) Verticality of ram slide

①Always move vertically to the press bed

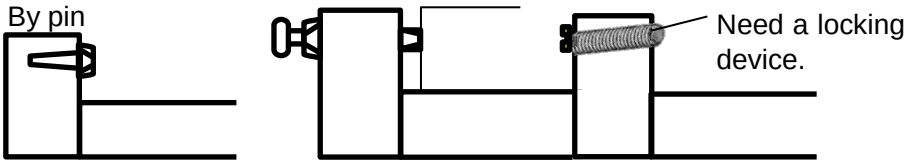


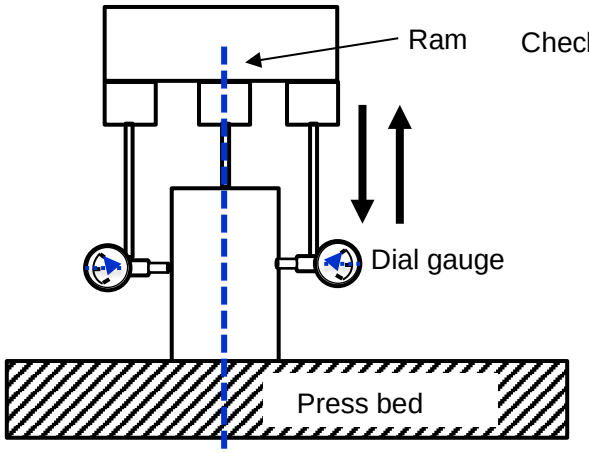
i. Adjustment of Ram guide

Ram's Guide

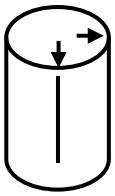


A structure that adjusts the clearance with a shim or bolt from the side.

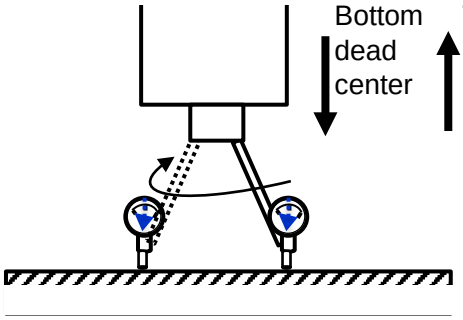




Check at least the 90 ° direction



②After confirming that the ram moves vertically,



Check the bed and bolster

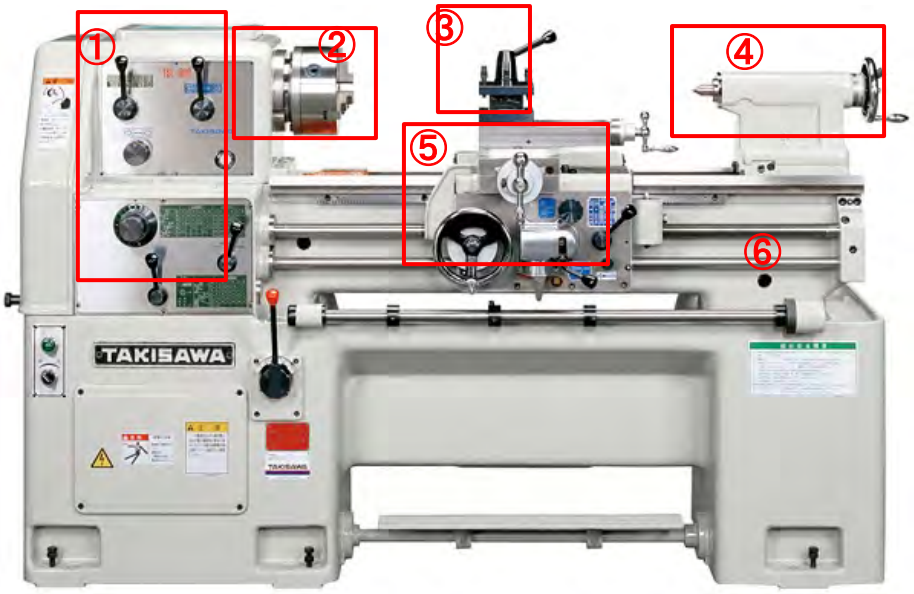
☆ The center of the bolster is concave.

③**Make the bolster hole as small as possible** even when the press die uses a load center and the clamp SP.

5.11 Machining

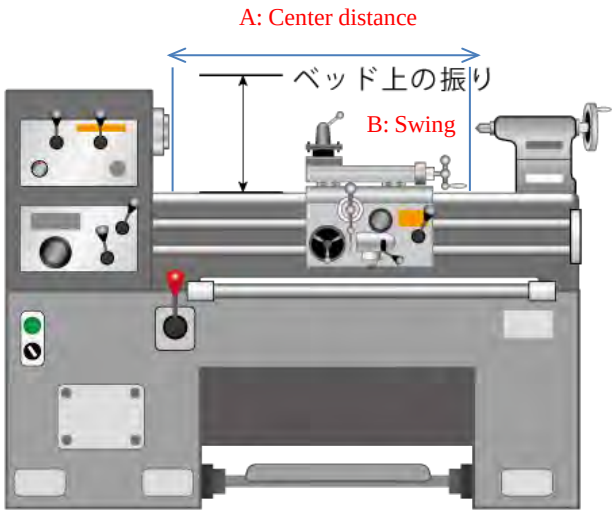
① Lathe, milling

No	Contents	A	B	C
①	(1) Explanation of contents; As there are lots of processing by level (such as production quantity and quality), coverage (such as the parameter of parts used) and cost requirements, it seems not easy to explain comprehensive explanation on Machining processing, so the items herewith limited to ones which Team explained during the regular circuit teaching/coaching to the target suppliers in Auto-parts PT, and the rules and the principles are describes as important factor. (2) Table of contents; 1) Types and the basic of machining (major parts of processing performed in Pakistan) 1.lathe, 2.milling 3.drilling/reaming 4.thread processing(tapping, rolling) 5.grinding(centerless grinding/surface grinding 6.broaching 7.gear cutting 2) Measuring instruments and its use 3) Drawing requirements and the selection of processing methods ・types and definitions of drawing requirements in machining process ・measurement methods and management methods 4) Quality control in mass production(MP) processing ・measuring instruments and measuring methods ・sampling inspection and all parts(100%) inspection ・on-site quality control (X-R control chart, process capability) ・set-up changes, tool changes 5) Items related to equipment maintenance 1.selection of coolant(cutting oil)and its management 2.treatment of chips 3.maintenance of equipment 6) Production control of machining(lot production, mixed production of other models) 7) Defect cases in the past in Pakistan and the counter measures (3) Individual contents (please refer table of contents in II) 1) Types and the basic of machining process lathe processing →Lathe structure（Normal lathe） Below figure：Elements of a normal lathe	○		



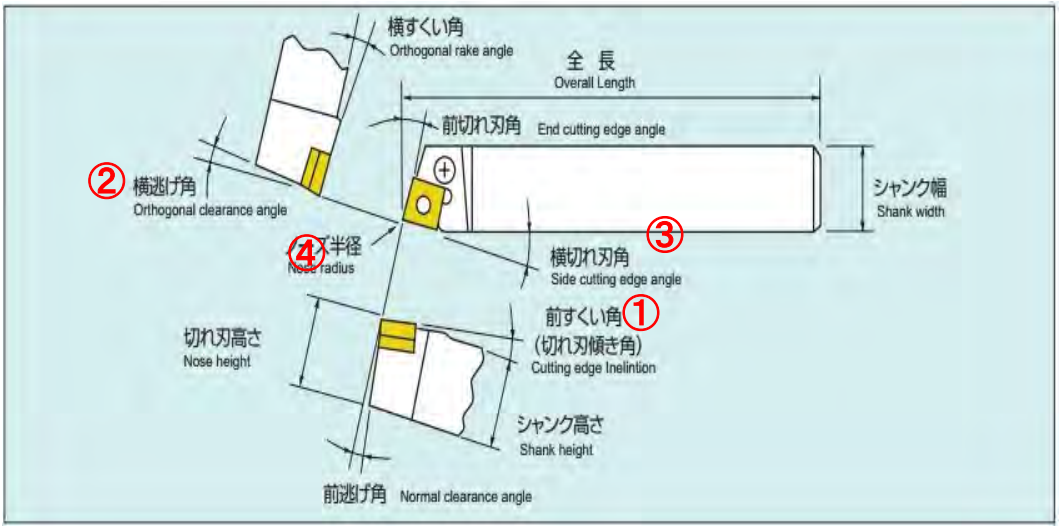
① : Main Spindle
② : Chuck
③ : Tool Post
④ : Tail Stock
⑤ : Saddle/Apron
⑥ : Bed

2)Size of lathe
Showing at below figure A & B and expressed by processing maximum size.



3) Cutting tool (bytes)
There are many types of cutting tool bytes according to the processing of outer diameter, inner diameter and the threading.
a. Cutting edge shapes

Cutting edge angle of cutting tool



name	Cutting angle	sharpness	chips	cutting	Edge strength	Blade life
① Front rake angle	Small	insane	Thick	Large cutting resistance	High	
	Big	crisp	Thin	Small cutting resistance	Low	
② Orthogonal clearance angle	Small			Wear of flank face is large	High	Short
	Big			Wear of flank face is small		Long
③ Side cutting edge angle	Small		Large width	Large vibration of cutting edge		Long
	Big		Small width	Small vibration		Short
④Nose Radius	Big	Finished surface roughness -small		Large resistance	High	Cutting conditions are up with same life
	Small	Roughness-big		Small resistance	Low	

Standard value (unit：Degree)：

Material	Hardness (HB)	High speed steel（HSS）				Super steel（WC）		
		Upper rake angle	Orthogonal rake angle	Front clearance angle	Orthogonal clearance angle	Upper rake angle	Orthogonal rake angle	Clearance angle
Carbon steel	85-225	10	12	5	5	0	6	7

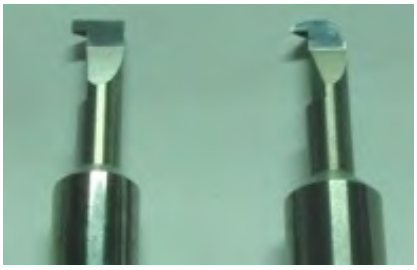
MG alloy	40-90	20	15	12	10	3	15	7
AL alloy	30-150	20	15	12	10	3	15	7

b. Types of byte

Types of bytes

- TA (slow-away type) : it is possible to replace the tip of the byte and this type of byte is common. Due to clamp mechanism, there may be processing error in the inside diameter or installation error of the tip. Solid type described later for the precision finishing use recommended. (In the case of precision finishing by TA type, there is also a byte called Micro Bore that can adjust the tip position.)

- Solid type : the tip is integrated with the byte, fixed by brazing. This type is used for smaller diameter machining and the precision finishing holes.



- Boring bar : when applied toΦ10 or more, boring bar, slow-away type described right figure also possible to apply, however, if overhang size is large, the rigidity of the arbor (shaft) is insufficient, processing accuracy may be further reduced.

- Center drill : used for the processing when center-hole processing in lathe processing.

c. Tool material and the processing conditions.

As tool materials, under-said ones are used.

i) HSS(High Speed Steel):it is high speed processed steel and made by SKH materials, there are 2 types: W(tungsten type,(W+V)and Mo(molybdenum type （Mo＋V or Co）.

Hardness is Hrc55‐60.

ii) Cemented Carbide: WC, TiC, TaC which are carbides of W, Ti, and Ta bound with Co. and made sintered alloy. Hardness is around Hrc 90.

iii) coating carbide : multilayer coating of TiC,TiN,Al2O3 etc. on a base material of carbide. With improved wear resistance without lowering toughness, it is almost commercially available TA tips in the market.

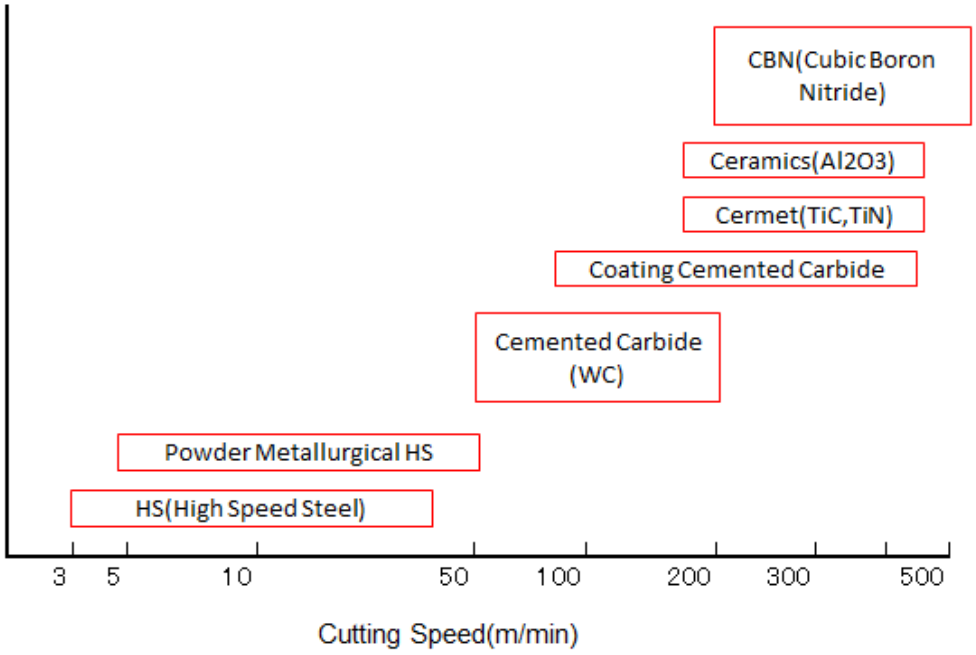
iv) Cermet: tool metal which are Tic, TiN as main component and sintered with Ni. Hardness is Hrc 93 or higher. It has both the tenacity of cemented carbide and the hardness of ceramic.

v) Ceramics: Tool steel made by sintering metal such as Tic to Al2O3.

Though hardness is Hrc94 but brittle(low deflective strength） Coping with heat and used for high speed cutting.

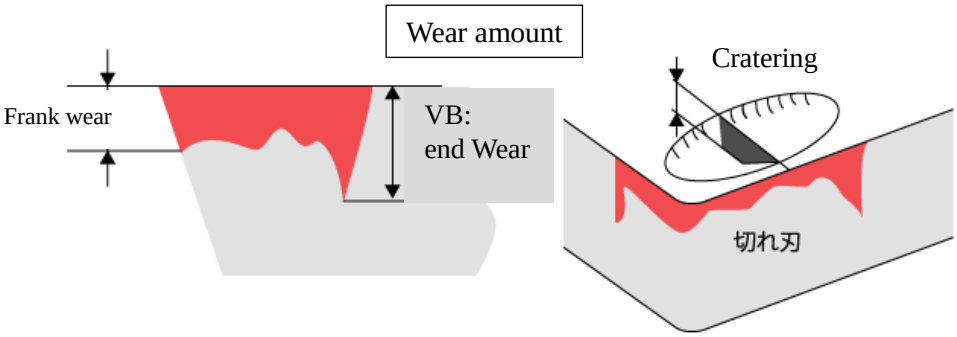
vi) CBN (Cubic Boron Nitride): B and N compounds (boron nitride) sintered with ceramic or Co as binder. Hardness is Hv4000 or higher and possible to use heat treated steel finishing processing.

Cutting speed of various tool materials in case outer diameter machining



d. Tool life

Most suppliers determine the life in terms of machined dimensions and surface finishing, but it should be aware of the tip wearing limits.



It is usual to define the wear limit value of the Cratering (rake face) and the side flank face (VB: End Wear) of figure 3.

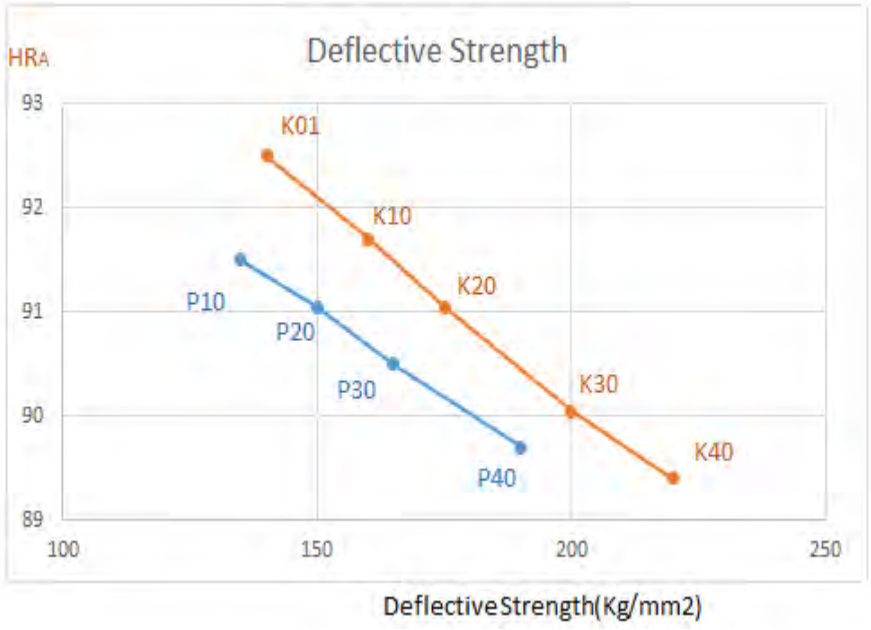
e. Classification of use of cemented carbide;

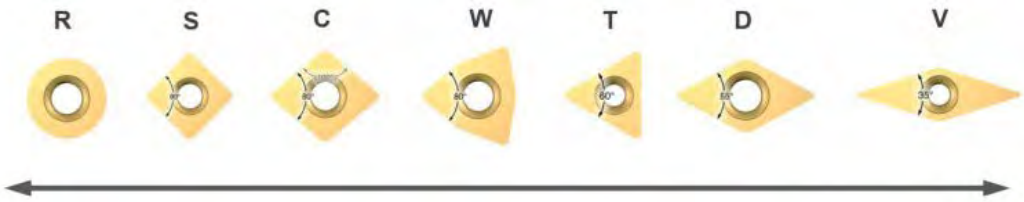
The cemented carbides defined in JIS are classified as follows:

K: Join WC with Co, suitable for cast iron and aluminum turning.

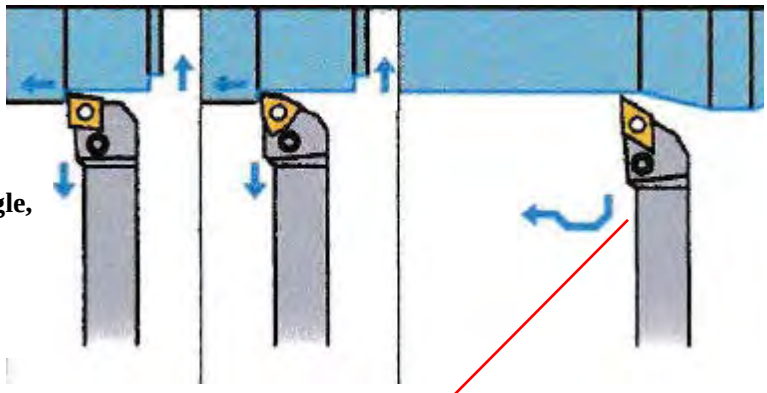
P:Bonded with WC, TaC and TiC and Co, suitable for cutting steel (Steel)

M: Intermediate between K and P.

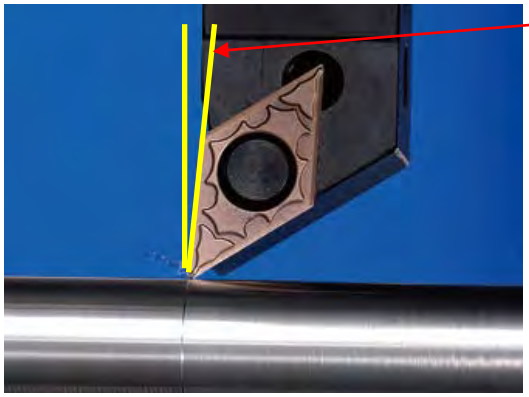
②	Deflective strength and hardness of Material: K and P  f. Types and selection of bytes; The types and the methods of use of the cutting tool depend on the material of the part, equipment and the method, and there are many tool makers with many variations. Here, only the basic example is shown. Actual application requires the technical advices from tool makers. Types of tip:  Round tip：Maximum cutting angle, For heavy cutting and roughing, The rigidity of the equipment is necessary. Square tip：Eight faces with zero front clearance angle can be used. The tip angle is large (90°) and the tip has rigidity. For roughing, if the equipment not rigid, it may break off. Diamond-shaped tip：Available up to 4 faces. Cutting edge angle is small and the machinability is good, For finishing of high precision cutting. Cutting edge angle and usage:		○	



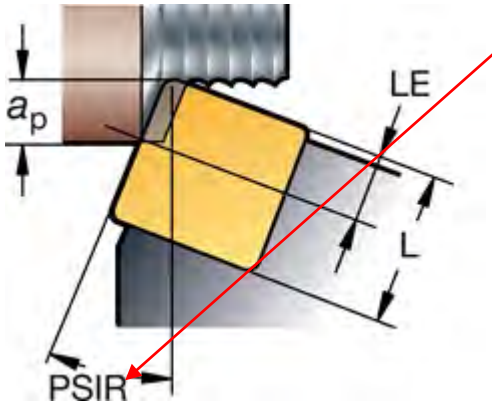
Large Cutting edge angle, medium accuracy, heavy cutting



Small cutting edge angle, high accuracy, light cutting

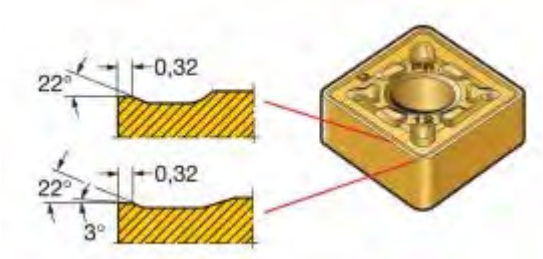


When the front clearance angle is positive, cutting resistance is small.
But heavy cutting not possible due to disadvantageous for the rigidity of cutting tool.



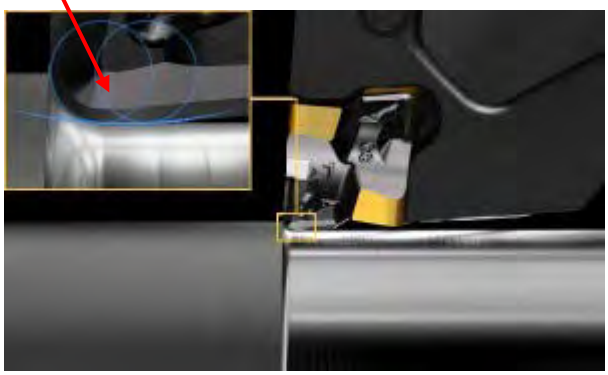
Square tip has negative front clearance angle and the opposite effect. Tip dimension setting by cutting depth.
aP：depth of cut
PSIR：front clearance angle
LE: length of cut depth
⇒selection of tip

setup of Tip breaker:



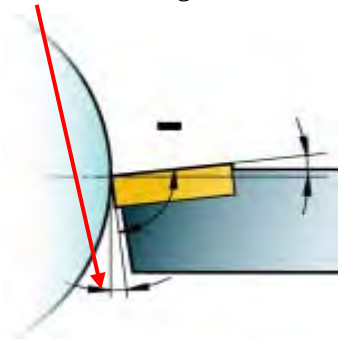
The figure shows the Tip breaker during roughing processing. Reduce the angle and width closer to the finishing processing.

wiper tip:

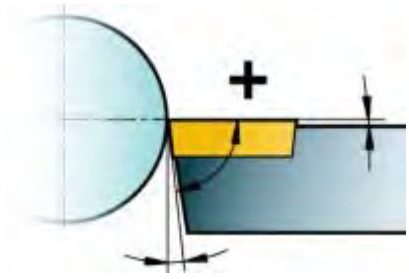


It is also effective to use a wiper tip to improve the processing surface quality or maintain the processing surface quality at a high feed rate.

front clearance angle:



If tip itself has no clearance angle and the rake angle is negative, the rigidity of the cutting edge increases and the it corresponds to heavy cutting, but the rigidity of parts and the equipment is required.(no thin parts possible)



Tip which has a clearance angle is less cutting resistance and high precision.it is for finishing, however, the back of tip is used.

4) Examples of improvement

a. Gear holes（Φ20+0.01+0.02）boring accuracy

The defect rate is high for tolerance of 10μ and 100% reworking required. TA tip which is considered to make it brazed, breaker shape and reamer however not succeeded. Finally by dropping the feed, it solved.

Gear hole case:

In Japan, such small diameter high-precision machining requires high-rigidity mounting which tip being fixed and use soldered bytes that do not show errors.

【Potential root-cause】

By dropping cutting resistance feed, reducing the deformation of the cutting tool, securing the holding rigidity of tip were estimated.

Reference : formula of cutting force(resistance)

F=ap×f×Kc

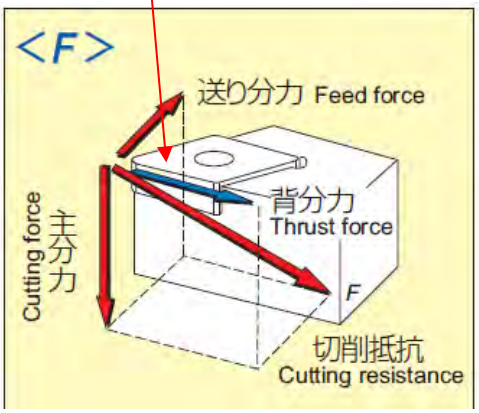
F:cutting force(resistance)(N)

Ap: cut depth（mm）

‘f: feed(mm/rev)

Kc: specific cutting force(N/mm2)

［in case of SCM steel 3600-4500］



b. Milling

Type of machine：Milling Machine

Milling machine-vertical

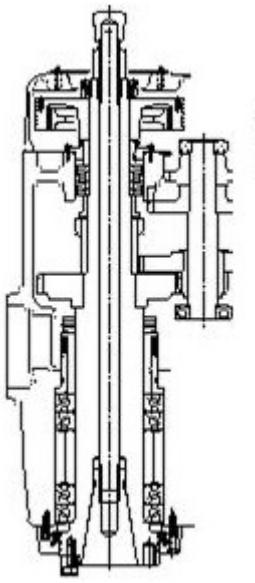
Horizontal milling with horizontal cutter-head

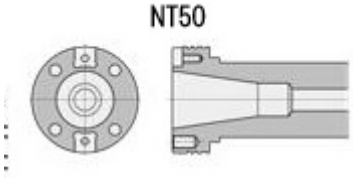
a. Size

・Describes per processing stroke as under-stated

NO	Longitudinal direction X		Horizontal direction Y		Vertical direction Z	
	horizontal	vertical	horizontal	Vertical	horizontal	vertical
0	450	450	150	150	300	300
1	550	550	200	200	400	300
2	700	700	250	250	400	300
3	850	850	300	300	450	350
4	1050	1050	325	350	450	400
5	1250	1250	350	400	500	450

・Spindle size (describes per size of National taper [NT])





Main spindle taper size (NT)：NT30, NT40, NT50, NT60

b. Type of tools

・Front Milling Cutter

A basic milling cutter that performs face milling with a vertical milling machine, also called a face mill. The slow-away type, which consists of the body of the milling cutter and the cutting edge (tip) is the mainstream, and if the cutting ability deteriorates, it can be used repeatedly by changing the cutting tip.

・Side cutter

Disc-shaped, bore-type cutting tool with cutting edges on the outer periphery and on both sides. Depending on the shape of the blade, there are types such as regular blade, rough blade, and staggered blade. It is used for grooving, step milling, side milling and particularly in the case of deep grooves, the use of a side cutter is most suitable for horizontal milling.

・End-mill

An end mill with a hemispherical bottom blade is a ball end mill, which is attached to a machining center or a spindle of an NC milling machine, and is used in 3 dimensional processing such as mold cutting. End mills become more rigid as the number of blades increases and tool deflection is less likely to occur, making them suitable for precision cutting and finishing. The disadvantage is that if the number of cutting edges is large, the clearance for chipping is small, so the discharge performance is not good, and the heavy cutting causes chip clogging. For roughing, it is common to use a small number offend mills and to use a multi-edge end mill for finishing.

b. Cutting method

・Down cut and Up cut

Down Cut：Tool wear is less, and chattering is also less. The feed mechanism of Machining Center is ball type, and play is minimized, and it is used for the general metal processing.

UP Cut ： In the case of general-purpose milling machines, the feed mechanism is a square or trapezoidal screw. And the backlash of the feeder increases, and the combination with the work material, there is a risk that the work material may slip during the material feeding.

Up Cut is used to protect above-stated risk, or the following case.

・To clean the cutting cross section by finishing

・when the surface finish of the work material is rough and the load is applied to the cutting tool

・in the case of a large work material(stainless, aluminum) with work hardening(strain hardening)

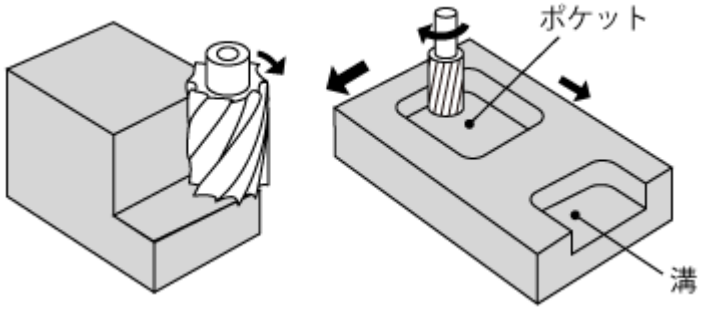
・Face milling cutter

The face milling cutter is a cutting tool that cuts a plane perpendicular to the rotation axis of the tool. A plurality of tips are attached at equal intervals along the circumference, and when the Z axis is fixed, it cuts the XY plane. The larger the outer diameter and the more the number of tips, the more the processing efficiency increases because the area that hits the material increases. Generally, a cutter with a diameter 20 to 50% larger than that of the material is used.

In order to attach a large milling cutter, the rigidity of the machine tool side is also required, so a large milling cutter and machining center are also used. On the other hand, in the case of a small milling machine or

machining center, it is necessary to consider that cutting resistance is not easily applied to the main shaft, and a milling machine is selected such that the approach angle, which is the angle of the blade to the material, becomes large. In addition, the greater the number of milling cutters, the better the chip removal efficiency.

・End mill

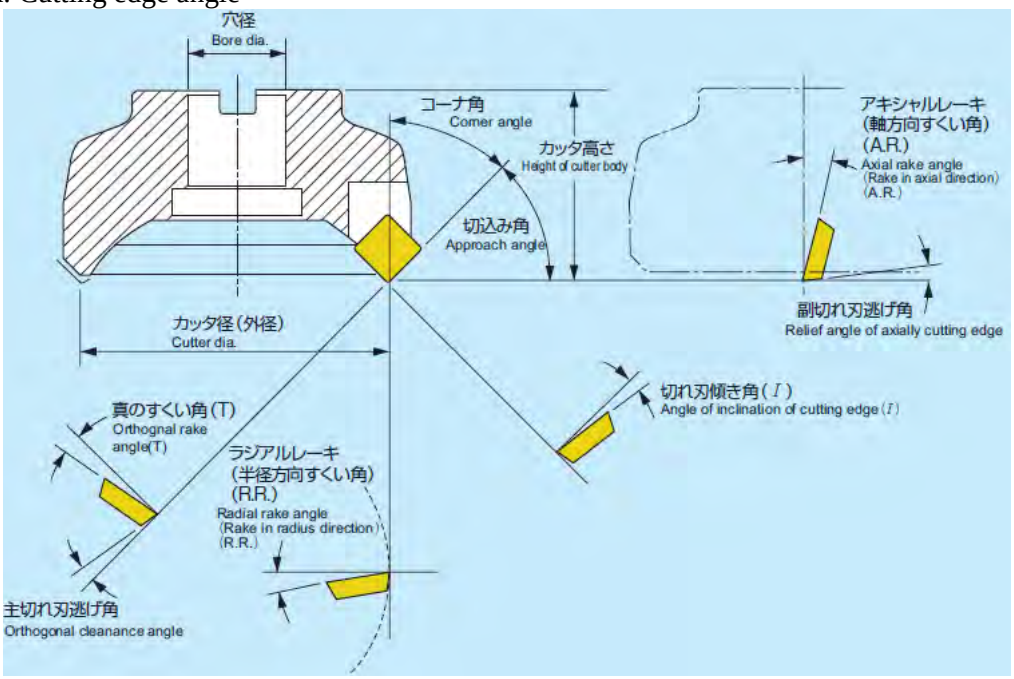


End mill is a tool that cuts the material like a drill, and differs in thickness, length, number of blades, twist angle, bottom shape. The blade also has T shape, inverted triangle and taper shape etc. The blade on the sides is in contact with the material for cutting, peripheral cutting, curved surface cutting, hole processing, planning and grooving, etc. The larger the number of blades, the thicker the diameter of the mill and the harder to bend, but the distance between the blades and blades is short and chip discharge capacity degrades. By rotating at high speed, cutting hard materials, longer mills may bend or break. Choose shorter ones as many as possible.

Setting of milling cutter

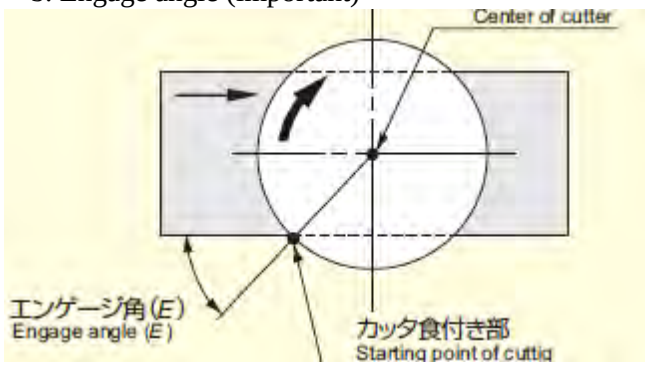
There are many types of cutters and various settings. Here is a typical face milling setting.

a. Cutting edge angle



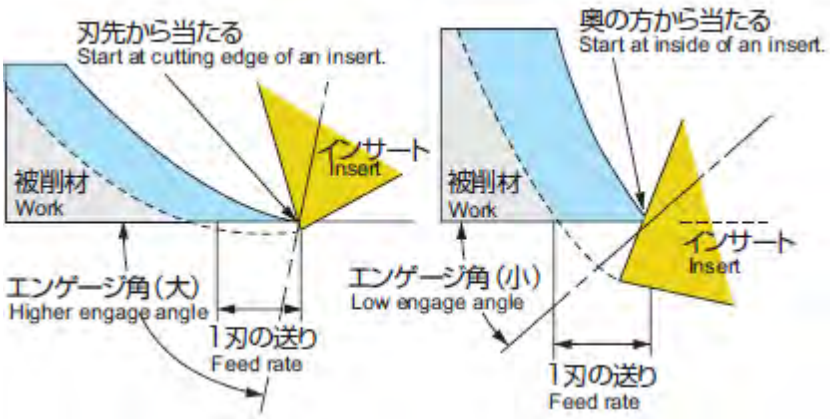
A:Rake angle	Sharpness	Cutting power	Cutting edge toughness	Chips ejecting	Bonding resistance
Positive: large	good	small	Small	poor	good
Negative: small	poor	large	Large	good	poor
Rake angle is generally designed depended on orthogonal clearance angle, Rake angle is already designed in proportion to orthogonal clearance angle.					

b. Engage angle (important)



The engage angle€ is determined by the cutter diameter and the width of the work material, and if it being too large ,the tool life will be short due to hitting from the cutting edge of the insert when biting the work material.

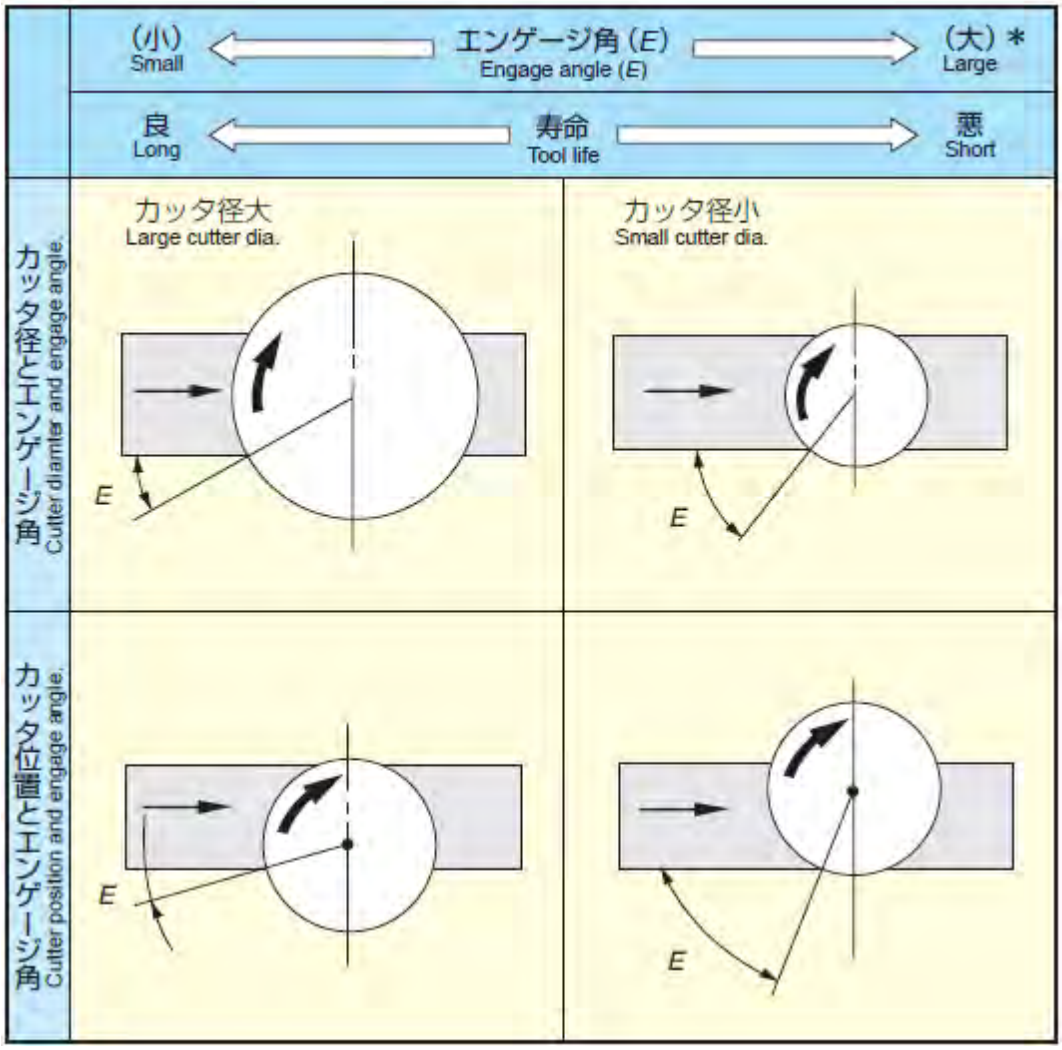
When engage angle is large when engage angle is short



The standard for engage angle recommends that 18to -10 for steel, 53 or less for cast iron and 37 to 42 for aluminum.

c. Cutter diameter

To use one which is 30～50% larger than the width of work material.

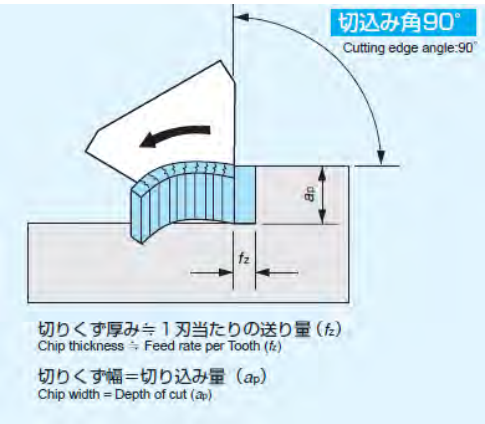


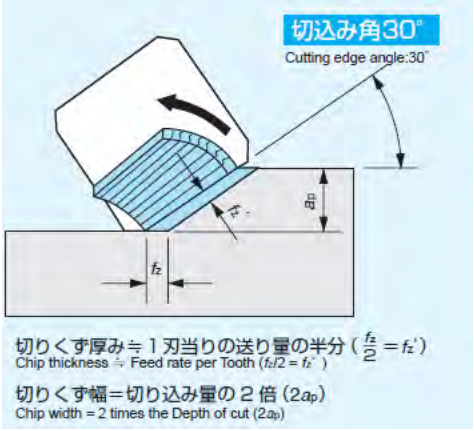
If the diameter of the cutter is too large, the distance until the cutter bites the work material and comes out becoming long, and the efficiency lowered.
Milling cutter diameter;
The width of the work material are as follows;
Steel 3:2
Cast iron 5:4
Aluminum 3:2~5:3

d. Cutting angle

Also called corner angle. When it is large, less cutting resistance and cutting depth (fz) is also large. The efficiency is good but the axis resistance increases and vibration occurs if there is no equipment rigidity. Cutting is no good.

It is standard that general steels are 30°and others are 45°.



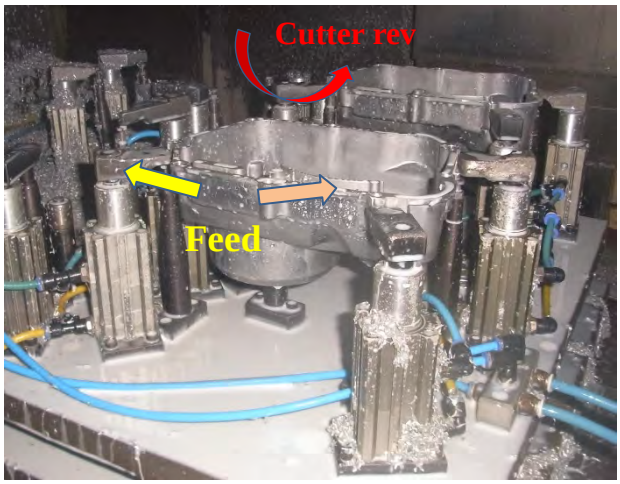


Standard parameter of milling cutter（quoted from Mitsubishi Metal）

material	hardness	Super steel symbol	Less than 1 ㎜		Less than 5mm	
			Cutting speed(m/min)	Feed (mm/blade)	Cutting speed(m/min)	Feed (mm/blade)
Steel	≦HB150	P20 P30			125-200	0.1-0.3
	～HB150				100-150	
Alloy steel	≦HB150				125-200	
	150～350				100-160	
	～HRc50				50-100	0.2-0.4
Cast iron	≦HB220	K10	100-150	0.1-0.15	80-125	0.1-0.3
FCD	τ≦50	K10 K20	60-120	0.1-0.15	60-100	0.1-0.3
	τ≧50					
FCMP	HB150-250	P20 P30			100-160	0.1-0.3
SUS	≧HB250	P20	60-100	0.1-0.15		
Al	HB90-120	K10	400-1000	0.05-0.10	300-500	0.1-0.3

Examples of improvement

(1) Improvement on milling feed direction (Case, Crank RH)



Up Cut

Down Cut

There is chattering at the time of cutting. As part of measures against flatness defects, by changing Down Cut to Up Cut method, and also change engage angle up to 40° (change also NC data) and improved the flatness as well as the chattering.

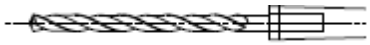
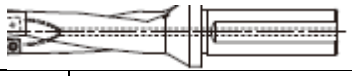
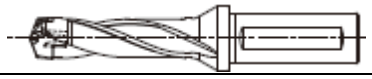
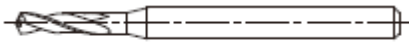
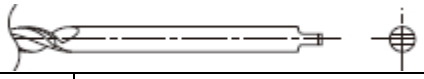
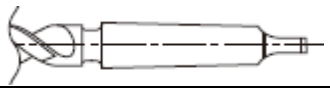
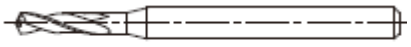
(2) Cutting performance improvement by the number of teeth of milling cutter (arm, trailing)

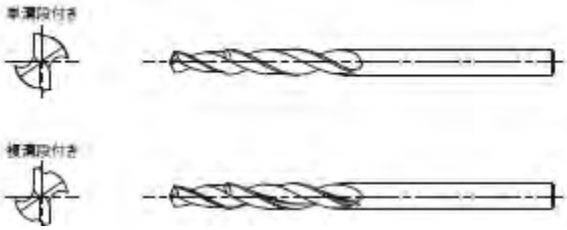
Poor surface roughness due to the chattering .Milling cutter change from 2 blades to 4 blades and improved.

【Cause】As the number of cutter blades increases, the resistance per blade decreases and the machinability improves. (However, equipment capacity is required).

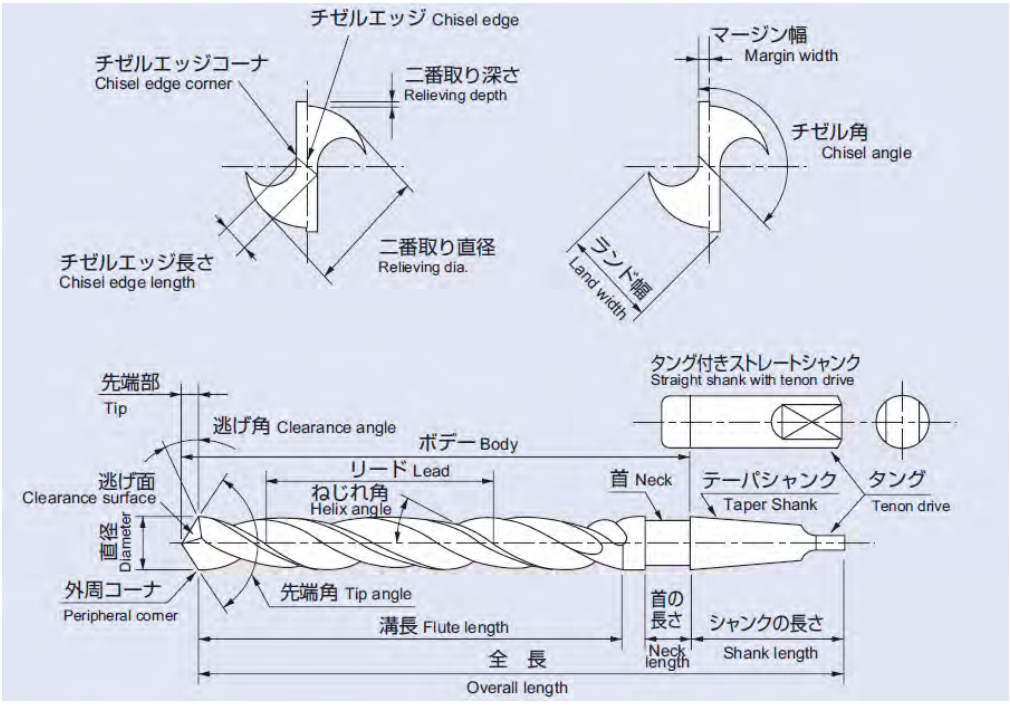
②Drilling

<table>
<tr><th>No</th><th>Contents</th><th>A</th><th>B</th><th>C</th></tr>
<tr><td>①</td><td>
<u>Drilling</u>
Many Drill processes are adopted in Pakistan. However, there are many examples not based on the principle of tools and construction methods. Please fully understand this manual and promote improvement of drilling process.

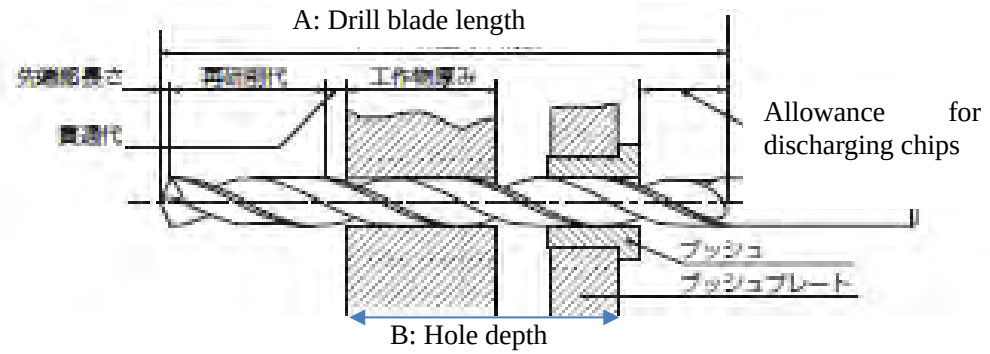
(1) Types of Drill
1) Classification by structure
<table>
<tr><td>Type</td><td>Description</td></tr>
<tr><td>Solid drill</td><td>Body and Shank together</td></tr>
<tr><td colspan="2">  </td></tr>
<tr><td>Blade tip drill</td><td>The cutting edge of another material stuck on the shank</td></tr>
<tr><td colspan="2">  </td></tr>
<tr><td>Insert drill</td><td>Insert the body into the shank and braze</td></tr>
<tr><td colspan="2">  </td></tr>
<tr><td>Indexable drill</td><td>Replaceable the cutting edge tip</td></tr>
<tr><td colspan="2">  </td></tr>
<tr><td>Detachable drill</td><td>The blade is mechanically attached to the body</td></tr>
<tr><td colspan="2">  </td></tr>
</table>
2) Shank shape
<table>
<tr><td>Type</td><td>Description</td></tr>
<tr><td>Straight Shank</td><td>Shank is cylindrical</td></tr>
<tr><td colspan="2">  </td></tr>
<tr><td>Straight Shank with tongue</td><td>In addition to the above, there is a tenon drive for anti-stick</td></tr>
<tr><td colspan="2">  </td></tr>
<tr><td>Taper shank</td><td>Tapered shank (generally used)</td></tr>
<tr><td colspan="2">  </td></tr>
</table>
3) Classification by application (Table 3)
<table>
<tr><td>Type</td><td>Description</td></tr>
<tr><td>Pivot drill</td><td>The diameter of cutting blade and shank is different</td></tr>
<tr><td colspan="2">  </td></tr>
<tr><td>Core drill</td><td>There is no cutting edge in the drill center and it is used to expand the hole. (3 or 4 blades)</td></tr>
</table>
</td><td>○</td><td></td><td></td></tr>
</table>

	
Center drill	Used for center hole processing
	
Starting drill	Used for preliminary drilling to increase hole location accuracy, and chamfering.
	
step drill	Two-step drill used for two-step holes and holes + chamfers
	Single groove stepped Double grooved stepped

(2) Names of parts of the drill



Drill setting



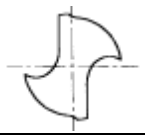
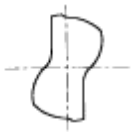
Drill blade length (A) = (B) hole depth (including bush work distance and bush length) + 1.5 x D (diameter of drill) + regrind and penetration allowance.

(3) Each part shape and specifications

a. groove

The groove forms the rake angle of the cutting edge by the twist angle and the tip angle, and is an important factor that determines the drill performance. The chips generated by the cutting edge are discharged along the groove of the tip. On the other hand, the cutting oil is supplied from the inlet of the hole toward the cutting edge contrary to the chips. It is the groove that fulfills this series of functions, and the deeper the hole to be machined, the greater the influence of the groove shape on the drill performance.

Groove shape

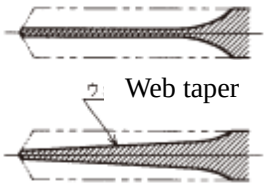
Name	Shape	Web	Application
General form		0.1 ~ 0.25D	There is a large chip capacity. ・For general use
High rigidity foam		0.2 ~ 0.35D	High rigidity, high feed Low thrust thinning such as R thinning is necessary. ・For heavy cutting
Flat grooved foam (Parabolic type)		0.3 ~ 0.45D	A foam that takes into account the rigidity as well as the width of the groove. ·Used for deep holes

b. Web

Web refers to the thickness of the web at the tip. The thicker the web, the higher the strength of the drill, but conversely the shallower the groove. If the hole to be processed is deep, the groove length of the drill will be long, so it is necessary to make the web thickness thick to avoid bending and breakage.

Further, it is necessary to secure the width of the groove for discharging chips, and the thickness of the tip is made thin, and a web taper is provided so as to increase in thickness toward the shank side. Also, as the web gets thicker, thinning is required to reduce resistance.

- Web taper



——Flat Grooved Type
----- General Type

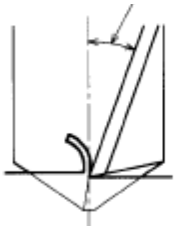
c. Helix angle

The twist angle of the drill is synonymous with the rake angle of the cutting edge. When the twist angle is increased, the cutting resistance is reduced. However, when the torsion angle is excessively increased, the drill rigidity is also reduced. (The carbide drill has a low toughness and is up to 6° for steel). A weak twist (hard edge strength UP) for hard materials, a strong twist (favorable sharpness) for soft materials, and a weak twist as the diameter decreases.

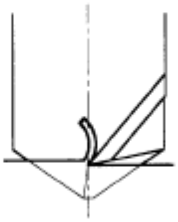
Helix Angle

Tip angle and substantial cut amount

Twist angle (= Rake angle)



Weak twist angle

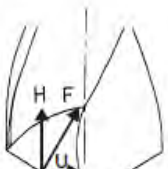


Strong twist angle

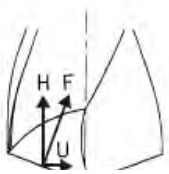
d. Tip angle:

The tip angle is most commonly 118°. If it is increased, thrust resistance will increase. The contact length with the work material (cutting edge length) and the actual cutting depth (chip thickness) also change, and affecting the cutting performance.

- Tip angle and thrust resistance



Tip angle 118°



Tip angle> 118°

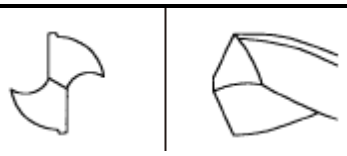
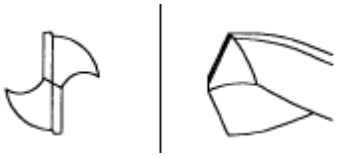
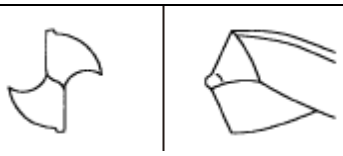
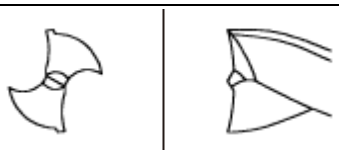
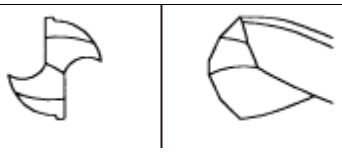
F: Cutting resistance
H: Thrust resistance
U: Centric force

e. Clearance surface

The cutting edge is formed by providing a flank on the end of the groove. The shapes are as shown in the table below and can be used depending on the application. Since the regrinding of the drill only involves the tip, the ease of regrinding is also important.

Clearance surface

Name	Shape	Application

Conical grinding		General drill grinding
Two-stage flat		It is used for small diameter drills because of its excellent centripetal and bladed precision.
Spiral		The clearance of the chisel edge is wide and suitable for soft materials.
Flat		Although the centripetally is bad, it is possible to take measures against burrs and counter boring.
Radial lip		It is effective in improving surface roughness, suppressing burrs and slap during penetration. Used for cast iron and Al castings.
Candle sharpening		It has the effect of suppressing burrs and vibrations when penetrating thin plates and the like.
Two-step grinding		The shoulder edge has high strength and is effective for drilling hard materials.

f. Thinning

If there is a chisel edge at the tip of the drill, the rake angle will be very small and the tip pocket (clearance) will also be a small wedge shape, so a very large thrust load will be generated compared to the cutting edge part. Biting property and centripetal also gets worse. Therefore, a method of shortening the chisel edge and attaching a scoop to improve chip discharge ability from the central part is called thinning (thinning the web thickness).

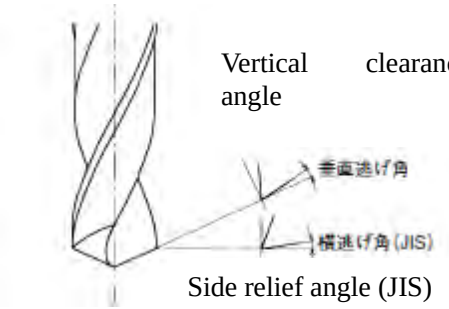
Thinning

Name	Shape	Application
No thinning		General purpose
R type		・Heavy cutting ・Good bite property・Chip cutting ・Reduction of thrust resistance

X type		・Good bite property ・Effective for drills of relatively thick web ・Reduction of thrust resistance
N type		・For drills with low web thickness and small tip angle ・Wide tip pocket ・The tip strength is large
S type		・For drills with low web thickness and small tip angle ・The tip strength is large ・Easy regrinding
W type		・For heavy cutting ・For high hardness material ・Chipping measures for cutting edges ・High cutting edge strength ・Reduction of thrust resistance
Three rake type		・The cutting edge accuracy is good ・Improvement of hole accuracy ・Not suitable for high web thickness drills and high feeds
Special thinning for high hardness (W+R type)		・High cutting edge strength ・Reduction of thrust resistance ・Suppress chipping in high hardness material processing

g. Clearance angle

Generally, it is set in the range of 6° to 15°, and is set small in the case of a carbide drill or a drill having a large tip angle or a large diameter, and conversely, in the case of a high speed drill or a drill having a small tip angle, a small diameter drill. The relief angle determines the escape with the work material, and if it is too small, seizure occurs due to heat generation, and if too large, chipping occur due to lack of edge strength, or chattering occurs.



Vertical clearance angle

Side relief angle (JIS)

It is necessary to be careful because incorrect setting of the relief angle at the time of regrinding causes trouble.

Recommended machining standard conditions (HSS drill)

Material	Tip angle	clearance angle	Helix angle	Chisel angle
Cast iron (HB 150)	90-118	12-15	20-32	125-135
(HB175)		12		
(HB250)	118-135	7-12	20-30	115-125
FCD	118	12-15	20-32	125-135
Forged steel (Normalizing)	118-125	10-15	20-32	
SCM	125-145	7-12	20-32	115-125
SUS	118-140		30-40	
Aluminum (Short hole)	90-120	12-15	17-40	125-135
(Deep hole)	118-130		32-35	

(4) Material of drill

Generally, materials of the same series as lathe tools are used, but drills require tool rigidity, so generally high speed steel (SK, SKS) and cemented carbide are used. Equipment rigidity is important, so use of a high hardness material (Cemented carbide) for equipment without rigidity (e.g. Drilling machine) will cause breakage easily, so care must be taken.

(5) Processing conditions

The processing conditions of the drill differ greatly depending on the rigidity of the equipment, the method of drilling, the type of tool (drill), and the variation of the material of the material to be cut.

The cutting condition reference table and tool manufacturer's recommended values are selected for each work material to be described later, and processing is actually performed, and the quality of processing is judged from the accuracy of hole and the state of chip discharge.

Standard condition in case of SK, SKS

Material	Tensile strength or hardness	Cutting speed [m/min]	Feed [mm/rev]
Carbon steel	50kg/mm2≧	20-27	0.7d-1.0d
	50-70kg/mm2	16-25	
	70-100kg/m2	12-18	0.7d-0.9d
Alloy steel	120kg/mm2≧	10-16	0.7d-0.9d
	120kg/mm2 <	5-12	
Cast iron	HB170≧	20-30	1.0d-2.0d
	HB170-220	15-25	0.8d-1.5d
	HB220<	10-20	0.7d-1.0d
Aluminum	HB40-120	30-150	1.0d-2.0d
Cupper	HB50-120	15-80	
SUS		10-16	0.7d-1.0d

‘d: Diameter of drill(mm)

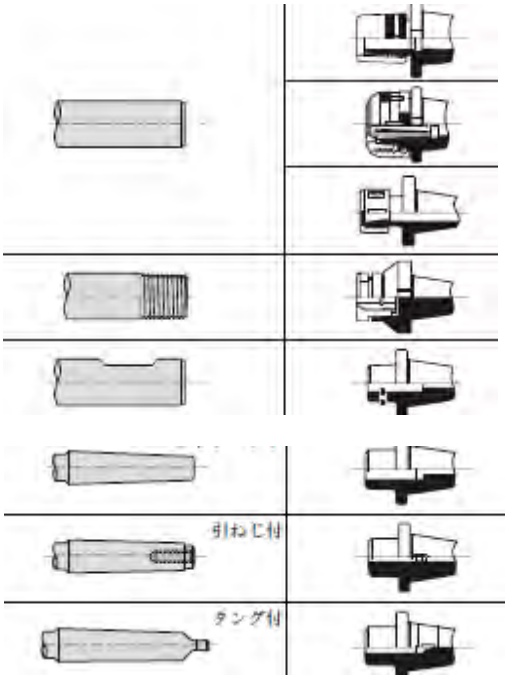
Standard conditions for carbide drills. (Table 8)

Material	HB	Cutting speed[m/min]			Feed [mm/rev]		
		Φ3-5.3	Φ5.3-8.5	Φ8.5-10.6	Φ3-5.3	Φ5.3-8.5	Φ8.5-10.6
FC	-	30-60	40-70	50-80	0.1-0.25	0.15-0.35	0.2-0.5
FCD	-	25-30	30-60	40-70	0.1-0.2	0.1-0.3	0.15-0.45
-S15C	200≧	40-70			0.15-0.4		
S45C, SCM	200-300	30-60			0.2-0.35		
SUS		15-35			0.1-0.25		

(6) Chuck

There are the following types, which are selected according to equipment and purpose.

a. Straight Shank
b. Taper shank



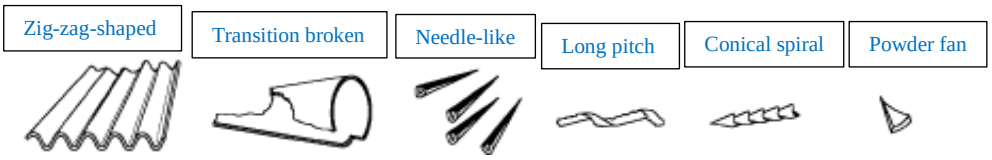
(7) Surface treatment of drill (Table 9)

Processing method	**Purpose**	**Feature**	**Application**
Steam treatment (Homo processing)	Anti-adhesion improvement	・Modified surface with 1 to 3 μm oxide film of Fe3O4 ・Porous and hold cutting fluid ・ Decrease of friction coefficient ・Adhesion prevention ・ Not suitable for non-ferrous metals	・Applicable to general-purpose stainless steel and mild steel such as SS41 and S15C. ・ Not suitable for Al.
Nitride treatment	Wear resistance improvement	・Treatment layer 30 to 50 μm ・ Surface hardness 1000 to 1300 HV ・ Abrasion resistance improvement ・Reform the surface by the infiltration into the inside of the substrate	・ Highly abrasive material ・Cast iron ・ Thermosetting resin ・ Possible to combine with homo processing

Coating	Wear resistance improvement	・Film thickness of 2 to 6 μm ・Surface hardness 2000 HV or more ・Abrasion resistance improvement ・Decrease of friction coefficient ・Adhesion prevention	・Hard-to-cut materials ・Hard alloy steel ・Stainless steel ・Heat resistant steel ・Titanium alloy
Electrodeposition	Wear resistance improvement	・Adhesive bonding of diamond and CBN super abrasive grains by electroplating ・Abrasion resistance improvement	・Grinding of hard and brittle materials such as ceramic

(8) Chips processing

The form of the chip is very important for the cutting performance of the drill, since the drilling process cuts in the hole and discharges the swarf through the grooves. Chips are roughly classified as follows.



Inappropriate form of chip causes the following obstacles.

(a) The fine chip is clogged, which lowers the life and the hole accuracy, and also causes drill breakage. (Powder shaped fan)

(b) It becomes a long chip, wraps around the drill and interferes with the work and causes the drill breakage. (Conical spiral, long pitch type)

(c) Long chips inhibit penetration of cutting fluid (Conical spiral, Long pitch)

Chips are divided appropriately by various methods to eliminate chipping and improve the processability. With metal materials, as the feed rate per blade increases, the thickness of chips increases and the form of chips tends to change, and the chips shape also changes depending on the work material and cutting fluid. Therefore, the cutting conditions are adjusted and stable drilling is performed so as to obtain a transition broken shape with good chip treatability.

Measures against chips

Measures	**Remarks**
Increase the feed	Use rigid drills and machines
Intermittent feed	Cycle time increases
Attach the chip breaker	How to put a breaker is difficult
Apply thinning	Requires dedicated regrinding machine

(8) Measures against precision defects

a) Hole accuracy

With regard to hole accuracy, machining hole enlargement, hole position accuracy, hole bending, roundness and surface roughness can be mentioned. In addition, burrs generated on the outlet side in drilling with a drill often cause problems in post-processing operations. In machining, it is clear that high rigidity and accuracy of tools, workpieces and processing machines are effective for stable high-precision machining, but in drilling

- Drill installation runout, processing conditions (holder, cutting speed, feed amount, cutting fluid)
- Drill shape (length, tip shape, web shape)
- Shape of processed work (inlet side processed surface condition, shape of inlet and outlet, thickness, holding condition)

These affect the accuracy of the hole.

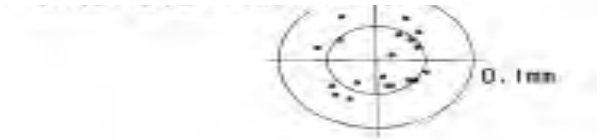
b) Hole enlargement

It is generated by swinging or vibration of the tool during processing. Shows the influence of runout on mounting on hole diameter and hole position (from OSG technical data). For general purpose drills with low rigidity, this tendency is further increased.

Center offset and hole diameter

Runout when installing = 0.034mm

Runout when installing = 0.112mm



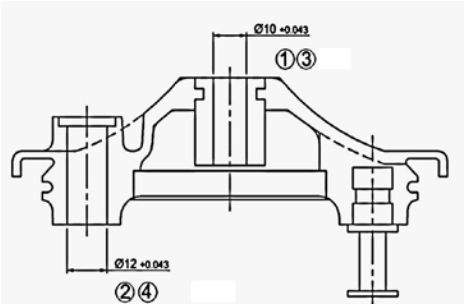
c) Rifling

The fact that the hole is polygonal is called rifling.

This is a phenomenon in which the hole is distorted into a polygon due to the vibration of the drill. In most cases, it is a triangle or a pentagon. The two points on the cutting edge of the drill vibrate as a turning center and draw an equal-diameter strain circle each time it rotates about 60 °. This is caused by the imbalance of cutting resistance, and the drill makes one rotation and the distorted hole produces the imbalance of cutting resistance in the second rotation, the phase of vibration shifts one after another, and the top of the triangular hole has three streaks. It is a kind of regenerative chatter that appears as a streak. In most cases, as the hole gets deeper, the friction between the drill margin and the wall of the drill dampens the vibration, the rifle mark disappears and the roundness also improves. However, the hole at this time is a wide funnel-like hole in the mouth. In order to eliminate this phenomenon, it is possible to suppress run-out during installation, lip height, and irregularities in point shape, etc.

a. Increase the rigidity of the drill
b. Increase the feed per rotation (roundness improves as feed amount increases)
c. Reduce the clearance angle
d. Thinning shape change

【Pakistan case】 Figure 9: Cover Brake



The accuracy of the hole diameter of Φ10 hole and the pitch of Φ12-Φ10 are poor. Also, the machined surface is bad.

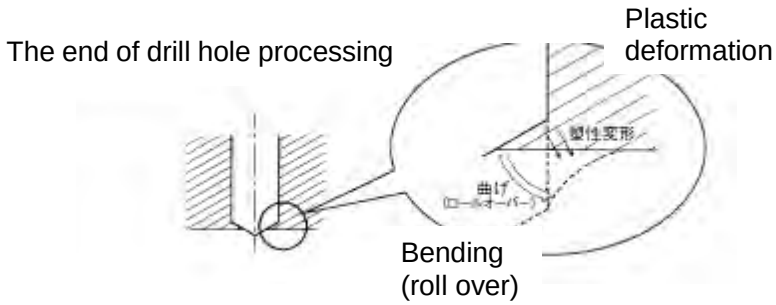
i. Cause: The drill is dislocated and chattered because the normal drill is used for the pilot hole (a normal drill cannot be bored). Since there is no drill rigidity and no bush is used, the rigidity of drilling is insufficient and the hole is in a rifling state.

ii. Measures: A change in the tool (Change from drill to boring or core drill) has been proposed but it is not accepted in terms of cost. Temporary measures are currently made by increase the machining allowance for finish reamers and lowering the machining allowance for drills.

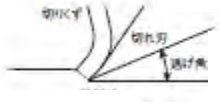
d) Burrs

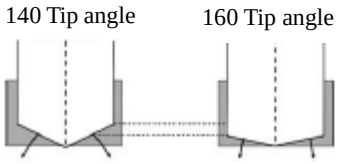
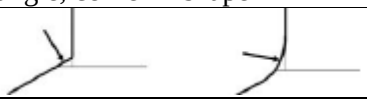
During drilling, burrs may come out at the hole outlet and hole inlet sides of the workpiece. It occurs particularly when drilling ductile materials and thin plates.

Figure: Mechanism of burrs



Countermeasure for burrs

Increase the relief angle Cutting chips Cutting edge  Large relief angle Work material	Suppress burrs by sharpening the cutting edge and reducing cutting resistance.

Increase tip angle 	By increasing the tip angle, it is possible to shorten the plastic deformation distance so that the force acts in the direction to suppress the rollover.
W angle, corner R shape 	Suppress burrs by changing the cutting thickness and changing the direction of cutting force.
Decrease feed amount	Reduce burrs by reducing the amount of cutting and cutting resistance.

【Pakistan case】
This is an example in which the penetration of the drill is uneven and burrs are generated because the biting surface of the drill and the drilled side are not horizontal and are curved surfaces. At present the burrs are removed manually.

The method for improving the hole position accuracy is described below. I hope you will try it in the future.

(a) Centering (starting drill)
(b) Counterbore processing
(c) Increase the rigidity of the drill (stub type, higher core thickness,)
(d) Make point shape and thinning with emphasis on biteability
(e) Lower the feed

(10) Regrind
When the drill has reached the end of life and the need to regrind, the following is taken into consideration.
(a) Wear amount of cutting edge corner, chisel, margin, etc. (JIS B 0171 excerpt)

Flunk wear　Peripheral wear　Rake face wear　Corner wear　Chisel edge wear

(b) Machined hole size, accuracy, surface finish
(c) Chip color and shape
(d) Cutting resistance (spindle current value, sound, vibration will be substituted)
(e) Processing quantity

It is necessary to decide the judgment standard which is easy to manage from these according to the contents of work. According to the wear judgment, regrind is only for the flank surface of the tip and thinning, so if it is used until the wear is considerably advanced, the regrind itself takes time and the tool life may be shortened even if it can be regrind.
It is important to determine the economical amount of tool wear taking into account the total life of one drill = regrind life × number of regrindings.
The judgment criteria based on the machined hole shall be when the expansion

allowance of the hole, the bending or straightness of the hole, etc. exceed the control value as a result of confirmation by the limit gauge, cylinder gauge, etc. It is also an effective way to stop the equipment when torque, thrust or power requirements exceed certain limits. In constant management, the above items are comprehensively judged, and a fixed quantity is used as a judgment standard.

In drill regrinding, it is important to use a drill dedicated or universal type tool grinder to obtain stable life and hole accuracy. The shape of regrind is basically to be the shape of a new drill if it can be processed without problems with a new drill. However, if there is a problem with the shape of the new drill, select a suitable cutting edge shape and thinning depending on the processing purpose.

▸ **Notes on regrinding**

(a) Do not give the drill a heat that causes a decrease in hardness
(b) Eliminate all damage, especially damage to the outer margin
(c) Eliminate imbalance in point shape as shown in the figure
(d) Remove grinding burrs without giving chipping or chipping by grinding

Eccentricity of the chisel edge

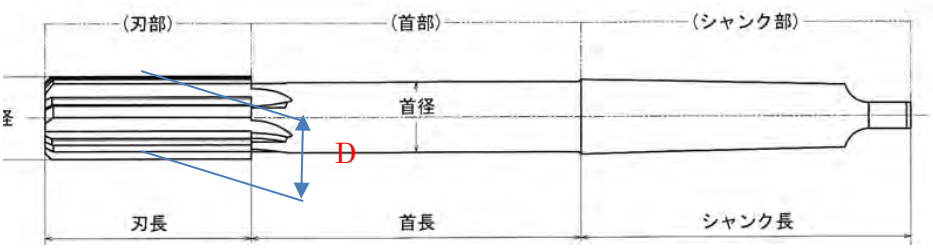
Lip height

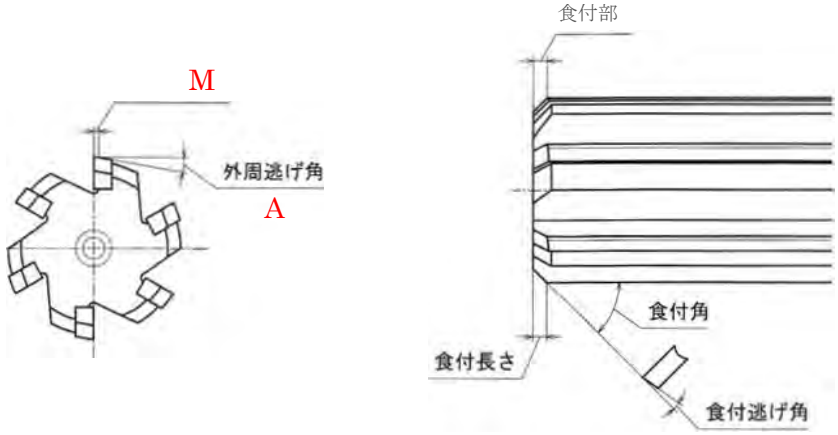
Half width error

Carbide drills are regrind to have the same shape as new drills, because the degree to which the quality of regrind affects the performance is high.

③ Reamer, Thread cutting

No	Contents	A	B	C
①	(1)Reamer processing 1)Reamer shape, specifications	○		





a. Diameter

The diameter（D）means the diameter of the cylindrical part immediately after the bite, and in machine reamer, in general, is the diameter of apportion 1.0~1.5D long from the tip. It is important to make the diameter of this part correctly aligned with the processing dimension.

b. Back taper

The reamer is tapered from the length of the diameter towards the shank. This is called a back taper, and 0.02 to 0.03mm/100mm is the standard. If it being too large, the burnishing effect will be reduced and if it being too small, the reamer due to tightening by inner diameter of the hole, the burnishing torque becomes excessive, causing chattering or burn-in results.

c. Number of blades;

The number of reamer blades is even and one which has large number of blades becomes better finished surface, however the cutting resistance will increase.

Also, the strength of the cutting edge is reduced, and chip clogging tends to occur. Standard values show in Table 1.

Diameter(mm)	Number of blades
3.0-12.5	4-6
13.0-25.0	6-8
26.0-38.0	8-12
40.0-52.0	10-14
55.0-78.0	12-18
80.0-100.0	14-20

d. Land & margin

The dimensions to the cutting edge and the heel are (L)land and there are(M)Margin and Clearance surface between them. If land is narrow, cutting blade stiffness decreases and chatter occurs. Margin is a portion which determines the dimensional accuracy by burnishing the inner surface of the hole, cut by the major cutting edge with the minor cutting edge of the biting portion.

Material	Number of tooth
Cast iron	0.05-0.10
Alloy steel	
Heat resistant steel(SUH)	0.10-0.30
Cu	
Aluminum	0.50-1.50
Mg	0.20-0.60

If margin width is narrow, it causes wear and charring. If it is wide, the burnishing torque becomes large and tool life becomes short. Table 2 shows the margin width standard.

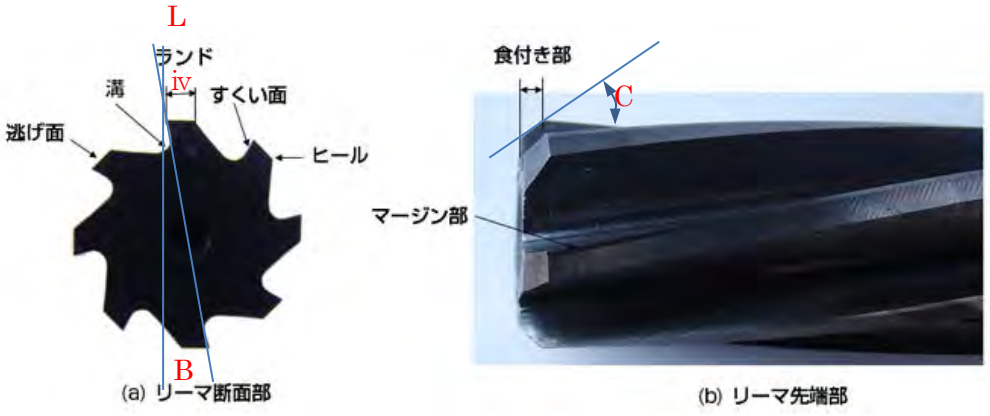
e. Bite part

A reamer bite (chamfer) has a bite portion for cutting and a guide portion for scribing, which forma cutting edge. The inclination of the major cutting edge with respect to the reamer axis © is a biting angle, and a machine reamer has a standard of 45°.The connection between the main cutting edge and the secondary cutting edge may leave a feed mark on the inner diameter, and the biting portion be in 2 stages. The 2 step cutting blade is only for a through hole and not applicable to a blind hole.

f. Rake angle

The standard cutting edge of the machine reamer is (A)rake angle 8°, (B)rake angle 0~5° (standard values are shown in Table).

Material	Rake angle: degree
Carbon steel	5
Alloy steel	7-10
SUS	
Cast iron	0-5
Aluminum	5-10
Mg	5-8



(2)Cutting allowance, processing conditions(HSS reamer);

The reaming allowance is 3% or less of the machined diameter, under hole diameter (Example: 0.3 allowance, 0.6 diameter in ⌀20). Processing standard values are shown in below table.

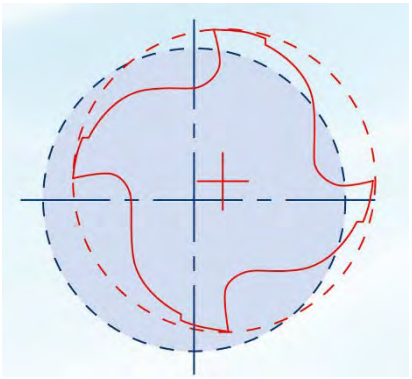
HSS Reamer-cutting parameter

Material	Cutting speed (m/min)		Feed (mm/rev)			
			ReamerΦ5 ≧	Φ5-20	Φ21-50	Φ50 <
Carbon Steel -	Soft Hard	3-6 2-4	0.2-0.3	0.3-0.5	0.5-0.6	0.6-1.2
SCM, SCr	Soft	3-4	0.1-0.2	0.2-0.4	0.4-0.5	0.5-0.8

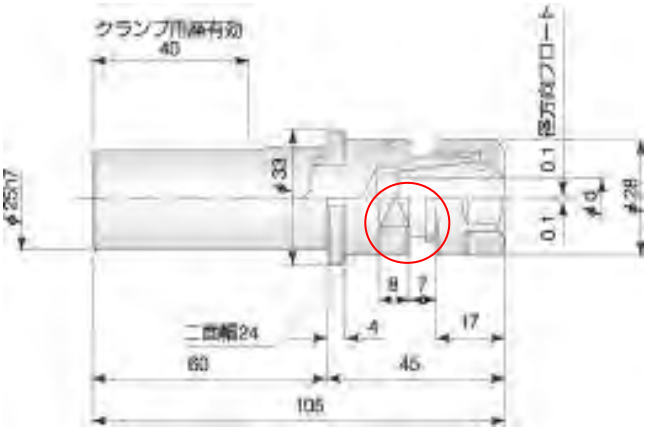
(Alloy steel)	Hard	2-3				
FC (Cast iron)	Soft Hard	4-6 3-4	0.3-0.5	0.5-1.0	1.0-1.5	1.5-3.0
FCD	Soft Hard	4-6 3-4	0.2-0.3	0.3-0.5	0.5-0.6	0.6-2.0
Aluminum	Soft Hard	12-2-3-12	0.3-0.5	0.5-1.0	1.0-1.5	1.5-3.0

The removal allowance of the reamer has a large effect on machined hole accuracy. In addition, the Coaxiality between the machined pilot hole and the reamed hole is also important, and if this is deviated, the reamer is vibrated due to the unbalance of the machining allowance, which causes the chattering and the hole accuracy defect.(see Figure)

< hole accuracy defect >

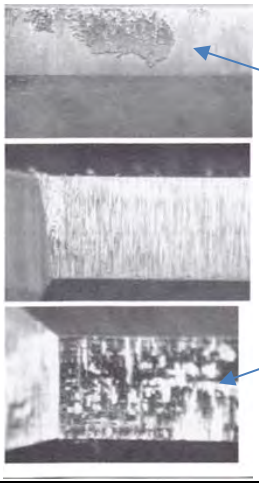


<Floating reamer holder>



There are also chucks of floating Reamer Holder (see the above figure) that can be machined by shifting the reamer axis during machining of the center hole of the pilot hole and the machining hole. However, the hole position follows the pilot hole (if the pilot hole position is misaligned, the reamer hole also effected to shift).

(3)trouble shooting

Defect	Root cause	Counter measure
hole diameter accuracy variation 	Fast cutting speed	Reduce its speed
	Fast feeding	Reduce feeding speed
	Weld to margin width	Margin optimization
	Chuck accuracy, runout	Equipment rigidity taper chuck
	Insufficient coolant	Internal fueling to deep hole
	Composition of cutting edge	Reduce cutting speed Coolant change Allowance optimization Reduce margin width
Imperfect surface finish	Less burnishing	Increase margin width Reduce bite angle/back taper

(4)Pakistan cases

Finishing surface of reamed hole is imperfect accuracy

[Cause]
too large of allowance and lack of burnish

[Counter-measure]
optimum of allowance and change of margin width
（0.05→0.10～0.12mm）

(5)Tap

Here, the machine tap for mass production is described.
（explanation of Hand Tap is omitted）

1)Types of tap

The taps are finished in 1 step using taps with 2.5ridgesfor bite part.
In the case of blind hole, there are 2.5 incomplete threads.

There are the following types of taps.

②

Spiral Tap : used for blind holes. The grooves are spiraled to facilitate the discharges of chips.

Point tap : used for through holes. Suitable for work pieces with continuous chips.

Roll tap : Finish the thread by rolling instead of cutting. Pre-hole (pilot hole) accuracy is required, but thread strength can be improved about 1.4 times that of the cutting tap. Suitable for ductile materials (aluminum, steel, copper) etc.

2)Cutting conditions

Tap speed is automatically determined by the number of tool rotations and the thread pitch. Here, only important cutting speeds are shown.

Tap cutting speed（m/min）

Material		Spiral	Point	Roll	Cemented carbide
Carbon steel	≧S15C	8-15	10-20	8-15	-
	S15-45C	6-12	8-14	7-12	-
	S45C<	5-10	8-12	5-10	-
Steel(Heat treatment)	<HRc45	3-5	4-7	-	-
FC		-	-	-	15-25
SCM		5-10	7-10	5-10	-
SUS		3-8	4-9	6-15	-
SKD		5-8	6-10	-	-
FCD		5-10	5-10	-	12-20
Cu		8-12	8-13	25-35	15-33
AL	-7000	15-25	20-25	25-35	23-40
	AC,ADC	11-22	12-24	15-25	15-25
Ti_Alloy		6-9	6-9	-	-

3) Pakistan cases

a. thread defect（Front Arm Setting Nut）

Thread shape defect occurs with thread gauge.

【Cause】
Improper processing speed
【Counter-measure】
Tool rotation speed optimization
1120rpm→460rpm
(21m/min→8.6m/min）:
Normally 6～12 m/min

【Results】
Defects improved to almost zero.

b. Insufficient thread strength (Crown Handle)

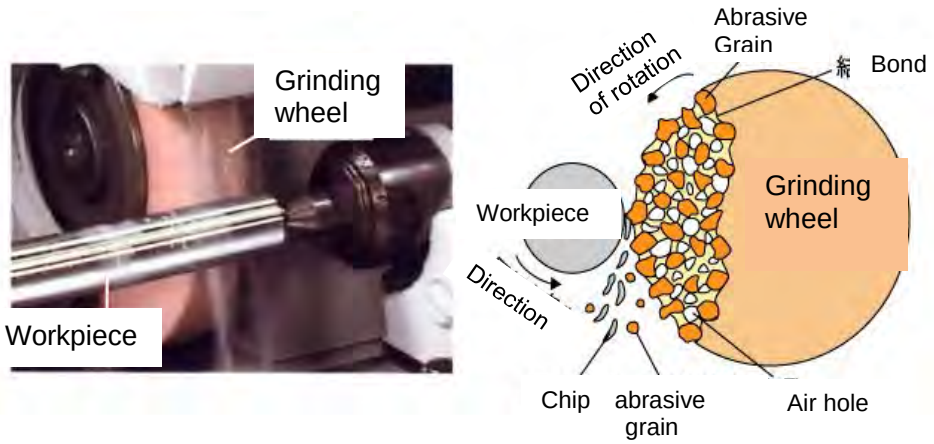
Strength test for M8 × 1.25 thread of Crown Handle

Improving with Roll tap

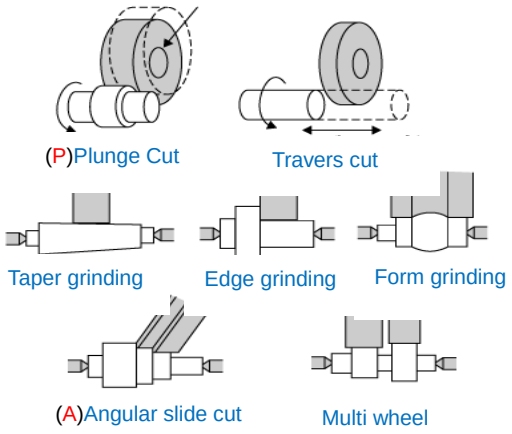
【Cause】
The number of effective threads in the cutting tap is small and the strength does not meet the OEM requirements.

【Counter-measure/Results】
Improved by changing from cutting tap to rolling tap.

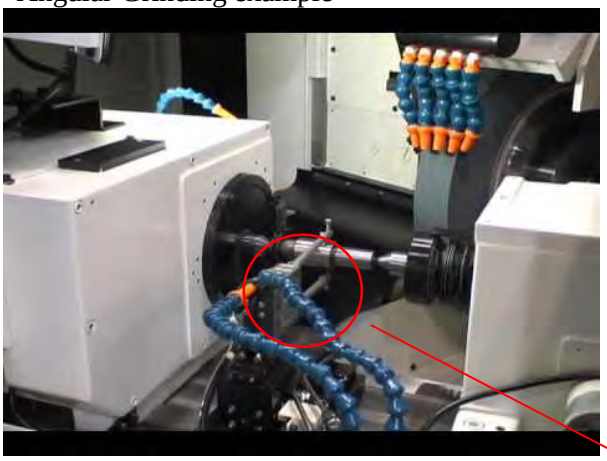
④ Grinding process

No	Contents	A	B	C
①	Grinding process There are Machine grinding using a grinder and Free Grinding performed by Hand Grinder etc., but only Machine grinding is explained here. (1) Mechanism of grinding This is a process in which a grindstone as a tool is rotated and a workpiece rotating in the opposite direction to the grindstone is cut with abrasive grains having a particle size (in the case of mechanical grinding: # 46 to # 220). The abrasive grains are sintered with a bond. Abrasive grain wears and falls off at the same time as processing of a workpiece by grinding. At this time, chips adhere between the abrasive grains and clogging occurs, and the machinability gradually decreases. Therefore, during processing, a "Dressing" process is required to scrape off the wheel surface.  Above figure: Outline of cutting (quoted: Grinding basics, Nikkan Kogyo Shimbun, 2006) The grinding speed is expressed by the peripheral speed, and is very fast at 30 to 100 m / sec (1800 m / min-6000 m / min). Therefore, the following matters are important. ・The grinding wheel and spindle are balanced. → Not only does the accuracy deteriorate due to vibration, but it also carries the risk of grinding stone breakage. ・ Selection of grinding conditions according to the specifications of equipment and grinding wheel → Do not exceed the maximum peripheral speed of the equipment and grinding wheel (2) Cylindrical grinding: Machining the outer diameter or end face of a cylindrical workpiece. Using a cylindrical grinder, one with a 90° angle to the part is called (P) Plunge cut, and one with an inclination is called (A) Angular Slide grinding.	○		

Types of outer diameter grinding

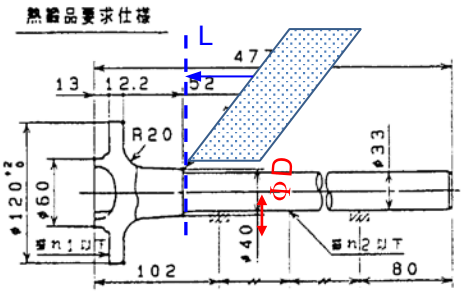


Angular Grinding example



In the case of Angular Grinding, it is necessary to determine the feed position of the grinding wheel at two points, diameter (D) and end face (L).

Automatic sizing apparatus:
Control the grinding wheel feed position by measurement of end face position (L) and outer diameter (ΦD)



Grinding conditions (It will be described as an example because it varies depending on equipment accuracy and rigidity)

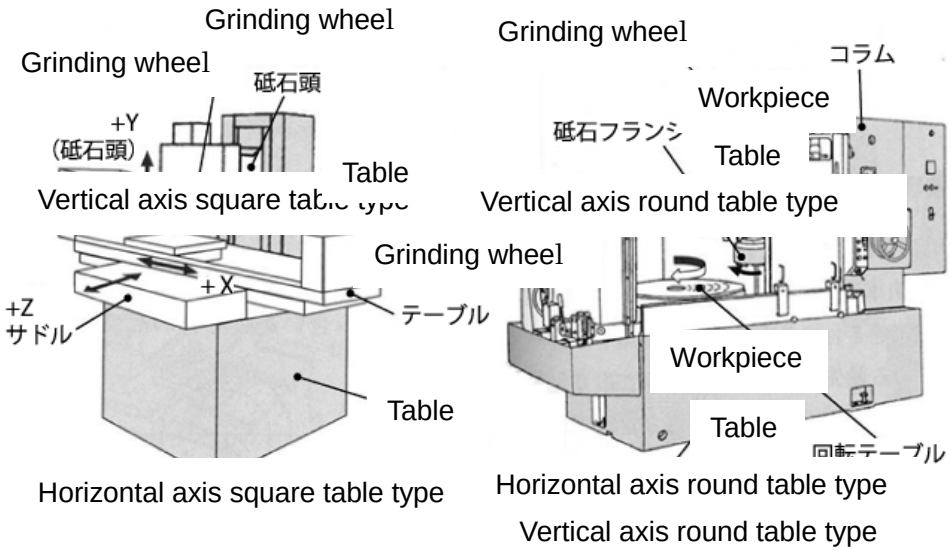
※ Data not disclosed for aluminum grinding

Material	Grinding wheel: Type (Grain size)	Circumferential speed (m / sec)	Feed (Coarse / Fine: μ / rev)	Allowance (mm)
Cast iron	A,WA(#32-80)	45-120	5-8/1-2	≦0.15
Steel, Alloy steel	WA,GC(40-100)	45-120	1.5-3.0/-.5-1.5	
Aluminum	GC,CBN	500-1200	※	≦0.10

(3) Surface grinding

Surface grinding machines are classified according to the orientation of the main spindle with respect to the table surface, and there are vertical axis types and horizontal axis types. Moreover, it divides into a square table shape and a round table shape according to the shape of a table. Reciprocating the table is in the form of a square table, often used for mold correction. It is a round table type that the table rotates.

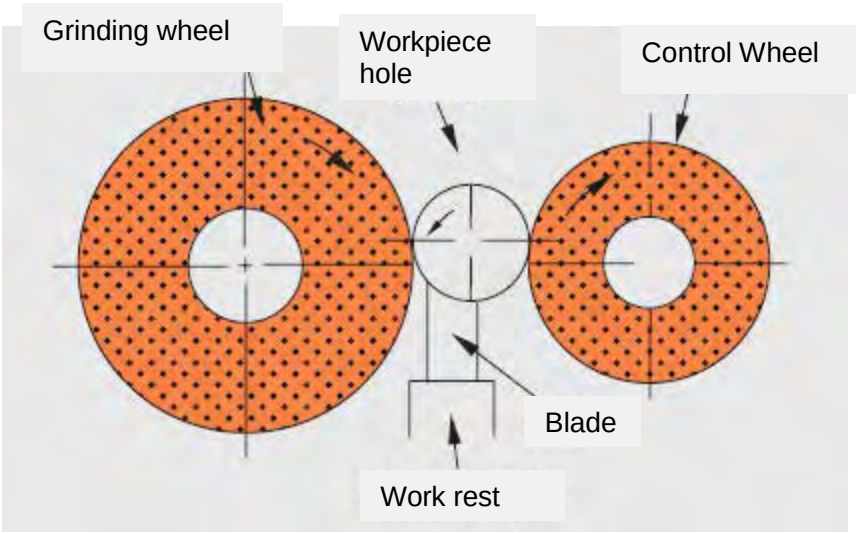
Figure: Surface grinding type



Vertical axis round table type

(4) Centerless grinding

As shown in below figure, on the Work rest (Blade), the workpiece is sandwiched between the grinding wheel and the adjusting wheel to carry out grinding. The adjusting wheel drives the workpiece so as to give a rotational difference compare with the grinding wheel.



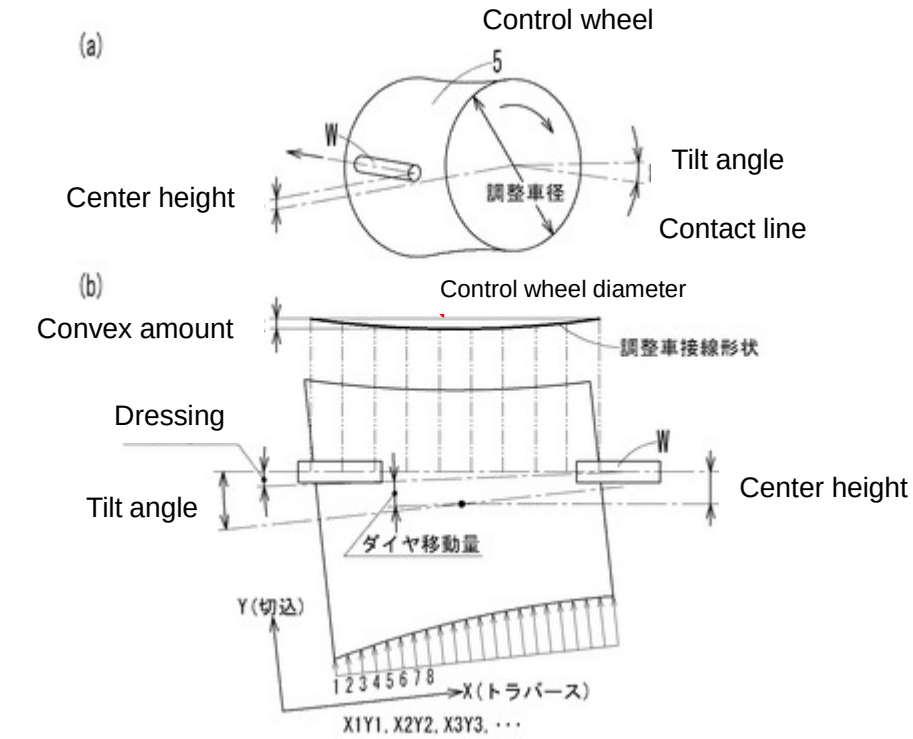
The grinding wheel speed (circumferential speed) is the same as cylindrical grinding, but the rotation speed of the adjusting wheel is selected so that the peripheral speed of the workpiece is 1/20 to 1/50 of the grinding wheel. The adjustment wheel and the workpiece are offset at the center position, and the workpiece is pressed against the work rest by the rotational difference between the grinding wheel and the workpiece, and grinding is performed.

(5) Through feed grinding

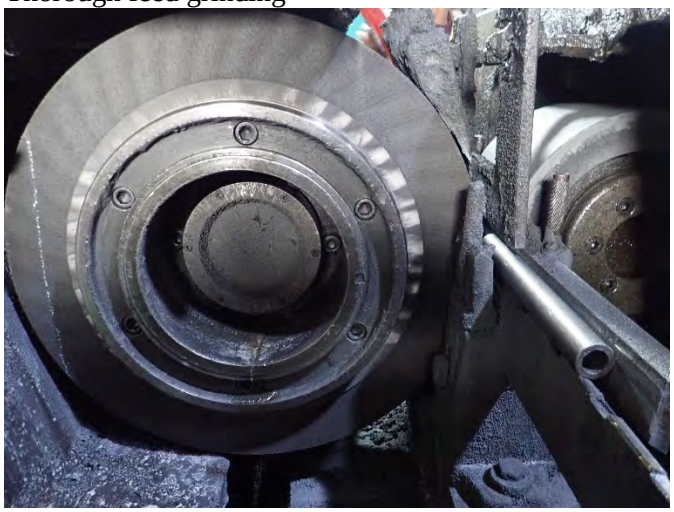
When grinding parts longer than the grinding wheel width by centerless grinding, the adjusting wheel is inclined and the grinding force of the grinding wheel is exerted

②

in the cross feed direction on the work rest to continuously grind the outer periphery of the shaft. In this case, the adjusting wheel is not straight but is slightly concave in shape, and the dressing is also concave in shape.



Thorough feed grinding



○

(6) Notes on centerless grinding

a. Work rest height

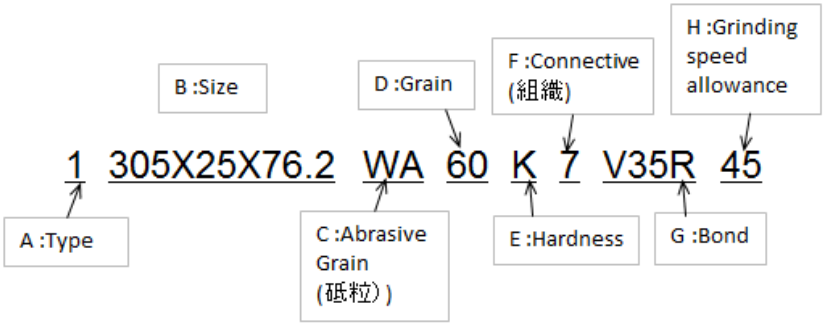
In centerless grinding, the grinding wheel, adjusting wheel and parts need to be held in balance on the work rest, so the Work Height becomes important. The position from the center of the grinding wheel and the adjusting wheel to the center of the processing part is (D / 2) + α (α = 2 to 4 mm: adjusted by the material and the grinding accuracy).

b. Adjustment wheel material

Abrasive grain	Basic grade use A abrasive grains and high grade (high durability and high frictional force) use AZ abrasive grains
Particle size	The standard is # 150. Grain size selection affects workpiece slip and accuracy.

Degree of coupling	The standard is R.

(7) Grinding wheel
Grinding wheel symbol



A: Shape
1: Flat type 2: Ring / disk 3: Taper on both sides 4: Taper on both sides
5: Recess on one side 6: Straight cup 7: Recess on both sides
8: Safety 11: Taper cup 27, 28: Offset type
B: Outer diameter x Thickness x Hole diameter
C: Abrasive grain — A,WA,PA,SA,CX,C,GC,CBN,Diamond
D: Grain size: 8-3000, For general mechanical grinding, use 46 ~ 220.
E: Hardness (Degree of bonding): A (soft) to Z (hard)
F: Structure: 0 (Soft) ~ 14 (Coarse)
G: Bonding material: V (Vitrified), B (Resinoid), R (Rubber), M (Metal),
P (Electrodeposition)
H: Maximum operating circumferential speed: 30, 33, 40, 45, 57, 50, 63,

serial	(C)Abrasive Grain	Usage	Remark
Al2O3 径	A	Carbon steel, Alloy steel	
	WA		≧HRc50
	PA	Carbon steel, Alloy steel, Cast iron	
	SA		
	CX	Carbon steel, alloy steel, Cast iron, stainless steel	
Carbon	C	Cast iron	
	GC	Carbid, Aluminum	
Special	CBN	Steel, Cast iron	Long life grinding
	Diamond	Carbide, Ceramic, Glass	

2, 80, 100 (m / SEC)

(8)Dressing
In the case of the grind wheel, when the number of operation increases, the abrasive grains wear, drop off and clog, the sharpness decreases, and the grinding burns and the processing accuracy deteriorate. For this reason, it is necessary to cut off the surface of the grinding wheel and the adjusting wheel with a diamond or the like. The conditions vary depending on the grinding conditions, but please set the following reference.

a. Grinding amount: A single infeed is 0.03 or less, and is selected according to the required surface finish.

Infeed (mm)	0.005-0.009	0.01-0.03	0.031≦
Grinding	High precision	Normal grinding	Roughing etc

	surface		
Requested finish	0.8S≧	1.6S-3.2S	6,4S≦

b. Feeding: The following formula is standard.

F＝(d×N)/(2.5×1000)

F: Dresser feed speed (mm/min)

D: Average grain size of abrasive grains (μm: see the following table)

N: Grinding wheel (or adjustment wheel) rotation speed (rpm)

Feed speed of general grinding wheel (particle size # 46-# 100) and grinding surface roughness reference standard.

Finished surface	0.006	0.003	0.002	0.001
Feed (mm/rev)	0.2	0.1	0.06	0.04

Grinding wheel grain size number and abrasive grain diameter

Number (D)	30	36	46	60	70	80
Diameter(μm)	590	500	350	297	210	177
Number (D)	90	100	120	150	180	220
Diameter (μm)	49	125	105	74	62	53

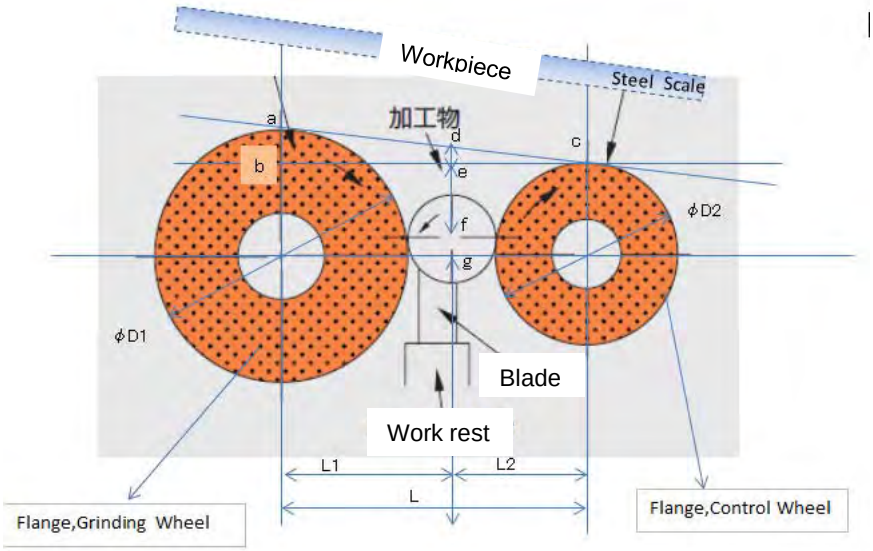
【Pakistan Case】

1. Finished surface and dimensional accuracy

Unable to satisfy required accuracy 1.6s, dimensional tolerance ± 0.005

Measures:

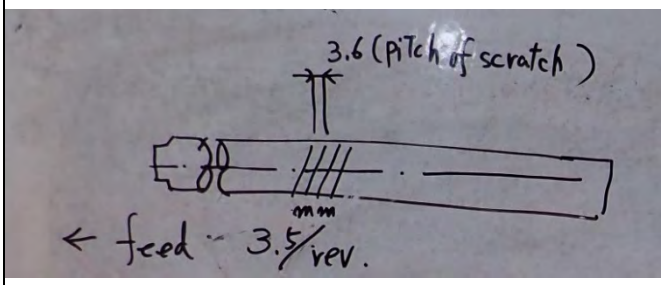
- Change the abrasive grain size to 46 from 32.
- Optimize the work height
  Correct to standard value (d / 2) + 4

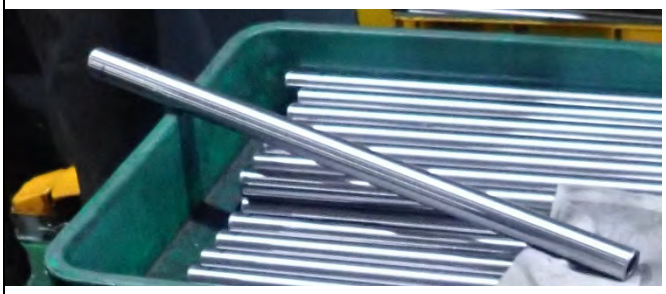


Formula used for improvement (Method to measure work height from equipment)

Work Height=gf=(D2/2)-ef
ef =df-de
df=Actual Measurement
de=ab×(L2/L)
ab=(D1/2)-(D2/2)

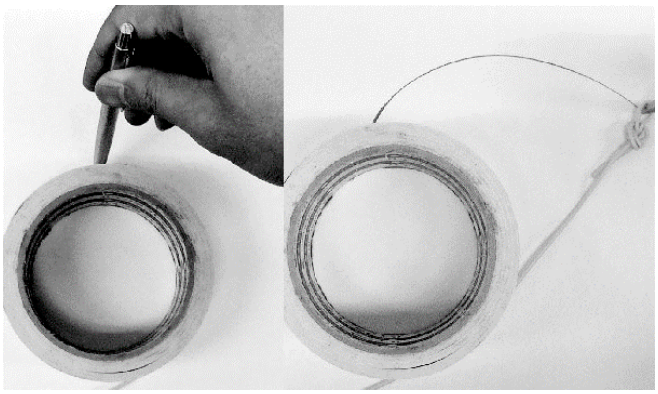
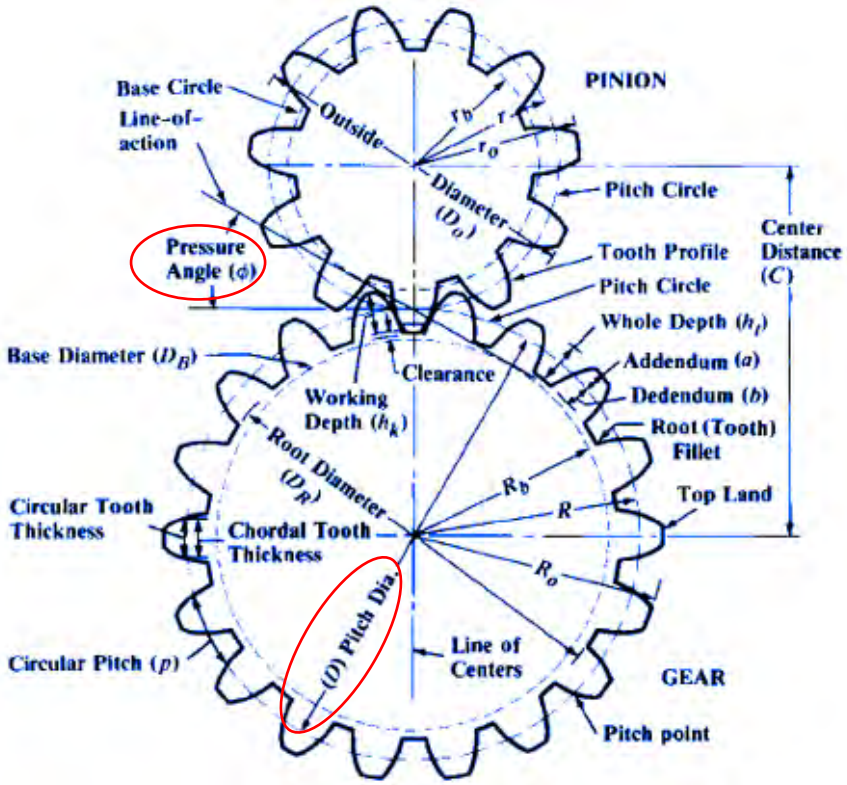
2. Feed mark
Through Feed
Feed mark flaw occurs in ”Through feed process”.



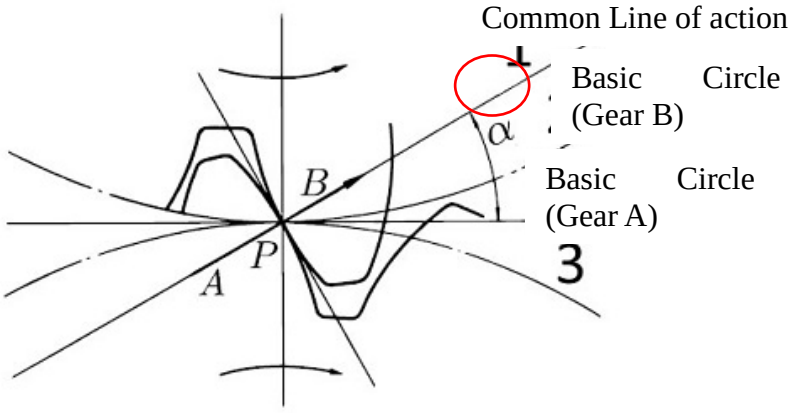


Correcting the wear of the work rest and the dressing shape of the adjusting wheel. (In progress)

⑤Gear machining

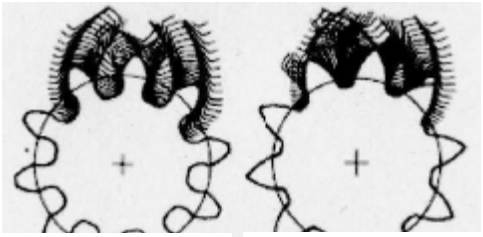
No	Contents	A	B	C
①	Gear machining Due to the difficult Gear machining, will explain herewith the basic design concept and its machining (processing) outline. Target is limited to spur gears. However, gears used in automobiles have higher requirements in terms of accuracy and strength such as helical, rack, pinion and hypoid, and actual machining/processing requires many other techniques and experience. (1)Gear tooth shape; Involute  When the yarn wound around a circle is unwound in the circumferential direction, the locus drawn by one point of the yarn is called involute. (2)Gear dimension a. specification Gear specification  b. Tooth size M: Module Module is the factor which represents the tooth size and expressed in the following formula. $M = \frac{D}{Z}$ D : Pitch Diameter Z: Number of tooth	○		

c. Pressure angle



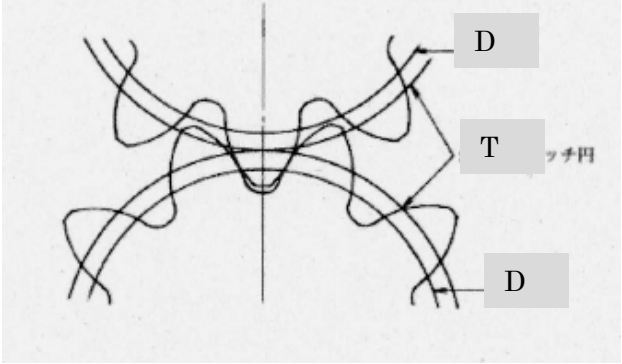
Normally there are many gears atα=20°

(3) Off set gear



Normal tooth form | Off set tooth form

In theory, if the number decreases the tooth base will be in a shape of scooped up (Under Cut) and strength falls. The tooth shape with the meshing pitch circle shifted to prevent this is called OFF set gear.



Off set gear is a gear whose meshing (T) pitch circle meshes outside of a regular tooth shape (D) reference pitch circle, and the pressure angle on the meshing pitch circle is called the meshing pressure angle, and is different from the calculated pressure angle.

There are plus transitions in which the tooth thickness is larger than that of the regular tooth shape and minus transitions in which the tooth thickness is smaller than that.

(4)Hob processing

a. tools and principles

Hob cutter

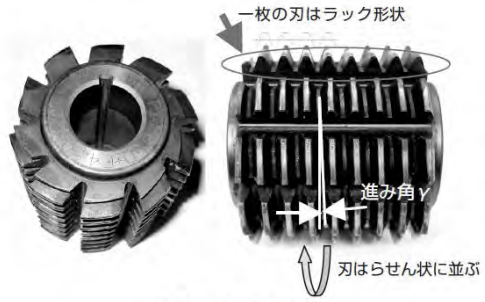
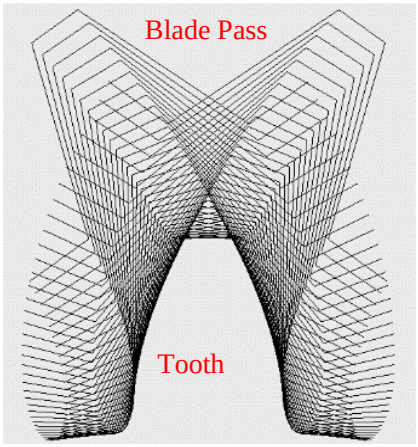
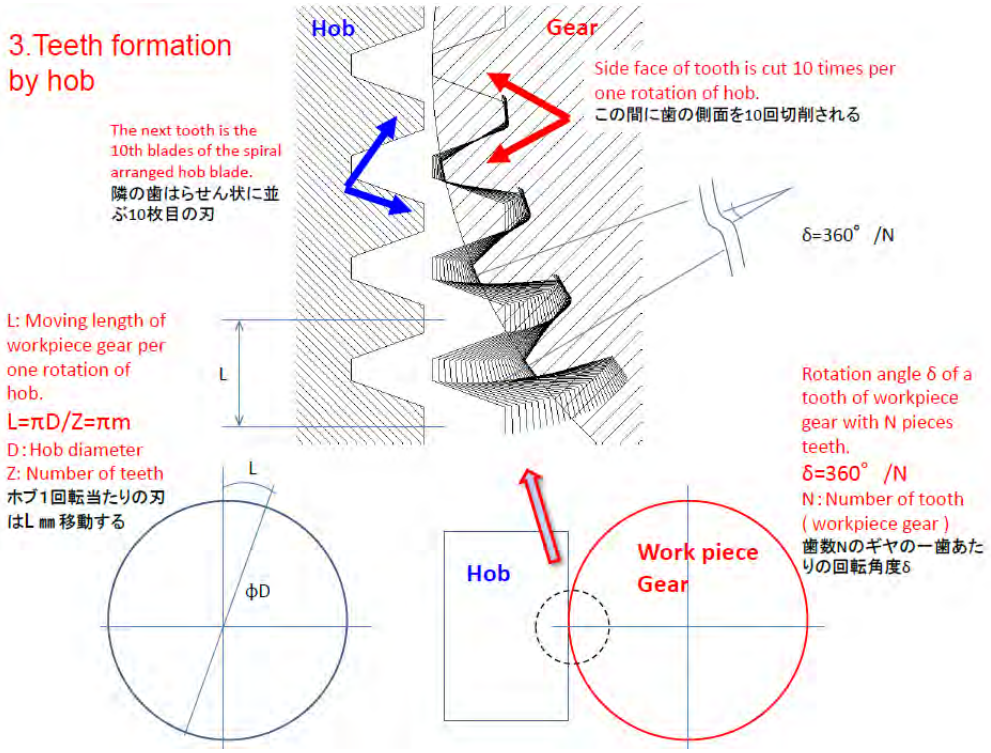


図 4　ホブの形状
（ホブの刃はらせん状に並び，正面から見ると進み角γをもつ）

The hob is a milling cutter with a cutting blade on the worm.
As the hob rotates, each cutting edge on the thread surface synchronizes with the rotation of the workpiece to create a tooth shape.

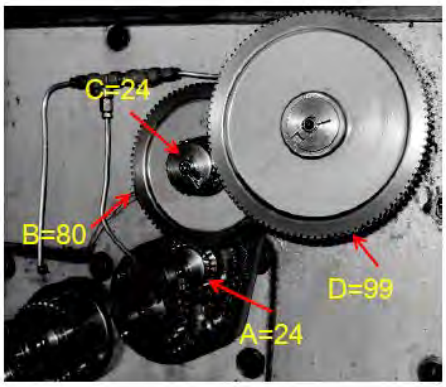
Hob processing principle

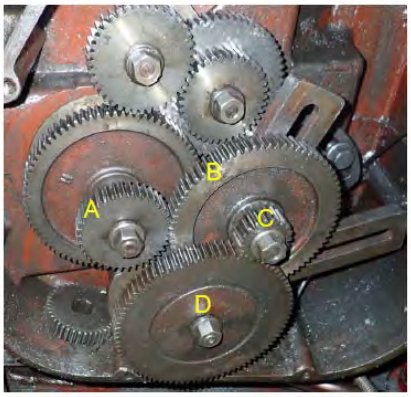




Module & pressure angle are constrained on hob blade specification. Gear train between hob and workpiece gear has to be changed depend on number of teeth of workpiece gear.
Ex: NJ-300(Japan machine) defined calculation formula is
12/N= (A/B) × (C/D) =>N=Number of teeth.
In case of cutting teeth 165 of gear,
A=99, B=80, C=24, D=99 are calculated and
12/165= (99/80) × (24/99) is selected.
With this machine, in case of N=12, rotation is determined D=A, so one revolution of hob spindle rotate 1/12 revolution of workpiece gear. Each hobbing machine has calculation formula or setting tables.

b. Cutting conditions;
i) cutting speed：50 (TiN coating) ~250 (PVD coating) m/min
ii) feed：greatly affects the finished surface,
standard value (figure quoted from Mitsubishi Material)





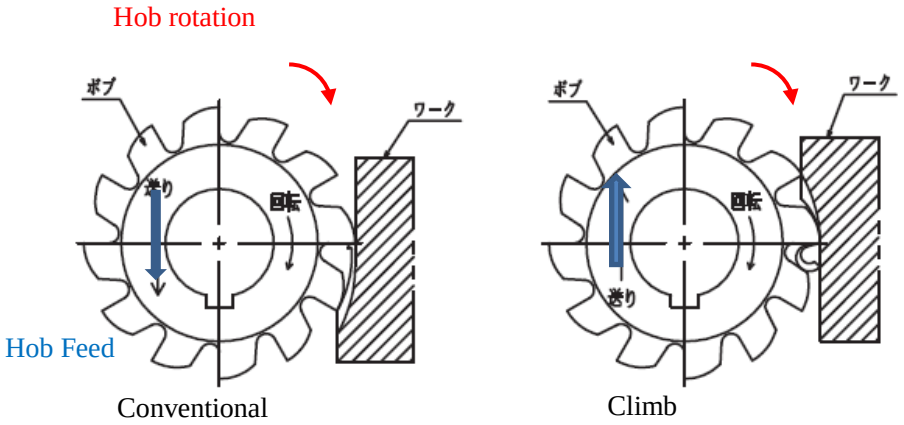
Hobbing	Feed(m/min)
finishing	0.8-2.0
Before shaving	2.0-4.5
Before cutting	2.0-6.5

iii) shift
The hob is determined by the amount of wear that causes maximum wear on the bite side (rough cutting area), and the regrind timing is determined. The hob cutting position is moved in the direction of the hob axis at a constant cutting length, and the maximum wear amount is dispersed to each blade. This is called Hob Shifting.
iv) Machining time
machining time is calculated in the following formula.

$$T = \frac{Z \cdot I \cdot N}{F \cdot n \cdot Zw} = \frac{Z \cdot N(l_1+b+l_2)}{F \cdot n \cdot Zw}$$

T: machining time (min)
Z: number of tooth
I: hob movement amount (mm)
‘n: hob rotation number (rpm)
N: number of cuts
Zw: hob row number
‘ l1: hob movement amount at start of cutting (mm)
‘ b: tooth width (mm)
‘ l2: hob movement amount at end of cutting (mm)

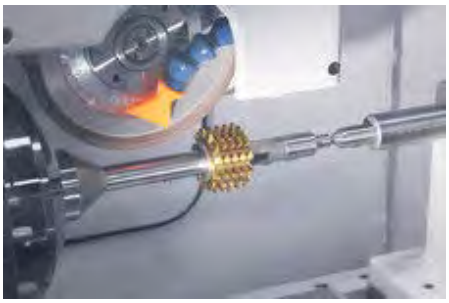
v) Climb Cut (Down Cut)/ Conventional Cut (Up Cut)
Cutting Method



	Conventional	Climb
	Large module	Medium/small module
Hob flank wear	×	○
Finish roughness	○	×
Cutting bite	×	○
Chips dischargeability	○	×

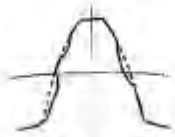
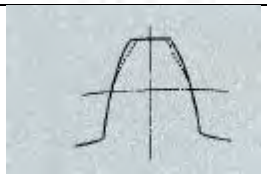
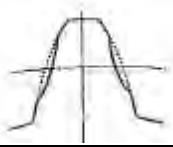
vi) Hob regrind

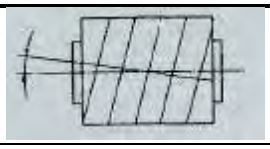
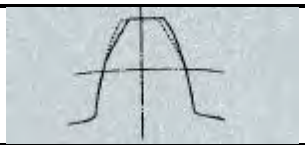
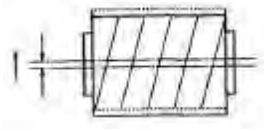
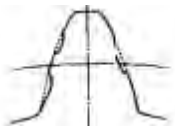
The hob is re-polished with a dedicated grinder on the rake face. The shape accuracy of each blade is important to ensure the accuracy of the table.



【standard condition：CBN wheel】
Grind speed：1800~2000m/min
feed：150~250m/min
incision：0.1~0.15mm/pass

Hob re-grind accuracy and gear accuracy

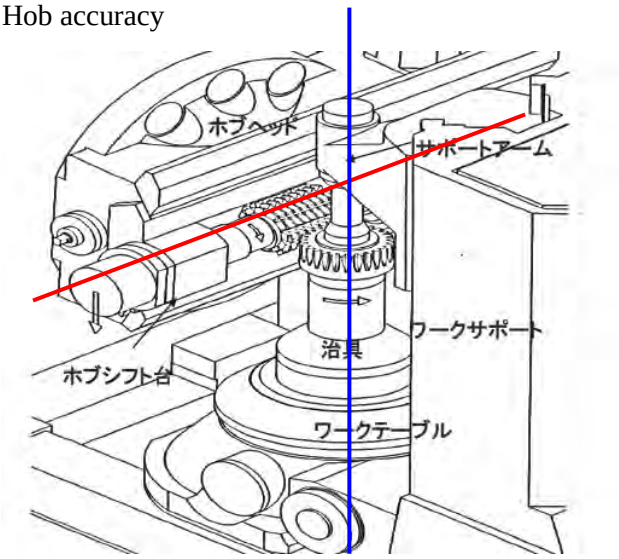
Error	Hob shape	Cutting gear tooth form	Impact to gear
Groove Division			Error 0.1mm=>tooth shape error 6μ
Rake angle			Rake angle error 1°→pressure angle 3°
Swell in scooping surface			Scooping surface 凸 0.1 ㎜ →tooth shape error 6μ

Groove lead			Lead error 1°→pressure angle 10°
Attach swing			Swing 0.025 ㎜ →undulate 9μ

vii) Hob axis accuracy

Runout management of the hob shaft and the processed product mounting shaft required. (Less than 0.02 for 2nd class Gears)

Hob accuracy



(4)PAKISTAN cases

Kaizen cases

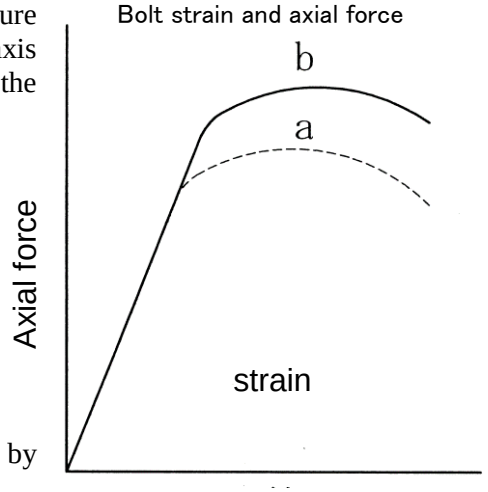
Gear Idler

Base tangent length is out of tolerance. As a result of the investigation, since the variation was little in the new hob, re-polishing accuracy was estimated to be insufficient.

Counter-measure-1)
Manual indexing the position of hob grinding machine→ Change to use Index Plate and implemented Kaizen.

Counter-measure-2)
Correct the runout of the cutter arbor of the hobbing machine（0.04→0.015mm）

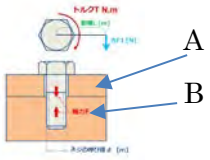
⑥Tightening

No	Contents	A	B	C
①	(1) Tightening In spite that tightening is important, it can be carried out with simple tools and are often handled easily, but there are many problems over time (problems occurring in the process of using for the products). So it can be detected at the time of the shipment and causes problem. Their effects can be fatal. As a result of conducting a survey on the thread tightening failures of the car which one OEM shows that the tightening failure is the main cause of the trouble and when loose fatigue destruction related to it added, it nearly shares 70% of the total problems related to the tightening. Since the initial tightening force directly affects the functional quality with fatigue destruction or loosening of the fastening body, the reliability of the fastening body largely depends on this tightening control. (2) Bolt tightening method; ① torque method, ② torque gradient method, ③ rotation angle method, ④ elongation measurement method; There are 4 methods and ②③④ are limitedly applied to the specialized parts such as engine of which details information are described in the general rules(JIS B 1083).In this manual, only① torque method which used widely in general are explained intensively. (3) Torque method; When the bolt is tightened, the torque is consumed 50% to the friction of the bearing surface, 40% consumed for the friction of the thread face, only the remaining 10% is converted to the axial force. Transmission efficiency is insufficient and axial force variation is likely to occur, however, it is widely used because that it is a simple method with excellent workability. (4) torque and axial force When bolt is tightened, in general, as figure "Bolt strain and axial force" shows, the axis surrenders to with value lower than b of the simple pulling and relatively decreases the axial force. This rate of decline is big as friction coefficient of the thread face and the bearing face, and friction coefficient is to be fixed in the material, lubrication state of the fastening body and the female thread. Aimed clamping axis force are usually fixed in the elasticity domain that maximizes 70% of standard Proof stress when they tighten a bolt by torque method. Bolt strain and axial force  (5) Calculation of torque; Relation between torque (Tf) and axis force (Ff) is expressed in the formula (1). Tf=k･d･Ff……(1) Formula (19) is replaced with (2) by the variation of k or tolerance set of Tf. In general, the tightening torque TfA is determined by formula (2). TfA＝0.35k(1+1/Q)σy･AS･d……(2) Where k is the friction coefficient of the thread surface (μS), the friction coefficient of	○		

the bearing surface. Typical values are determined by (μw), as shown in the below table "Torque factor".
⇒there is a difference in the value of k depending on the combination condition. It turns out to be a factor which generates variation in tightening axial force.

Q is called a tightening factor and can be expressed as Q=Ff max／Ff min ,which serves as a measure of variation. Q varies depending on the method of tightening and tools, etc. and standard values are shown in table "Tightening factor Q".

Torque factor

Bolt surface treatment	Torque factor(k)	A-B 
Steel bolt (black oxidation film) with oil	0.145	SCM-FC
	0.155	SCM-SCM
	0.215	Al-Al
Steel bolt (black oxidation film) no oil	0.25	SCM-FC
	0.35	SCM-SCM
	0.550	Al-Al

Tightening factor Q

Tightening factor :Q	Method of tightening	Surface condition		Lubrication
		Bolt	Nut	
1.25	Torque wrench	Phosphating	-	all
1.6	Impact wrench			MoS2 pasted
1.8	Torque wrench(with limited torque)			No lubricant
3.0	wrench			all

The point to be noted is that torque coefficient t (k) changes the coefficient of friction in the surface condition of the bearing surface and thread surface. As a result, the value of k fluctuates by nearly double. In other words, even if the same thread, by change of adhere to oil or not, the axial force is doubled at the same torque.
⇒oil adhesion to the thread surface cause thread breakage and torque slippage **(Slip), due to excessive axial force.**

(6) Standard torque;

Standard torque is defined in JIS by bolt strength grade（4T～12T）.Normal design standards are based on this rule.

Standard torque（N-m）

Bolt Size	Strength Grade			
	4.6(4T以下)	8.8(8T)	10.9(10T)	12.9(12T)
M8	8.4	22.5	31.6	37.9
M10	16.7	44.5	62.6	75.2
M12	29.1	77.6	109.0	131.0
M14	46.4	124.0	174.0	209.0
M16	72.3	194.0	271.0	325.0
M18	100.0	266.0	373.0	447.0
M20	141.0	376.0	529.0	635.0
M22	192.0	511.0	720.0	865.0
M24	244.0	650.0	915.0	1100.0
M27	358.0	951.0	1340.0	1610.0
M30	484.0	1290.0	1820.0	2180.0
M33	661.0	1760.0	2470.0	2970.0
M36	848.0	2260.0	3180.0	3810.0
M39	1100.0	2920.0	4110.0	4930.0
M42	1350.0	3610.0	5080.0	6080.0
M45	1700.0	4540.0	6370.0	7630.0
M48	2030.0	5440.0	7620.0	9120.0
M52	2640.0	7040.0	9880.0	11800.0
M56	3270.0	8710.0	12300.0	14800.0
M60	4080.0	10900.0	15300.0	18300.0
M64	4930.0	13100.0	18500.0	22300.0
M68	5970.0	16000.0	22500.0	27000.0
M72	7150.0	19100.0	26900.0	32300.0
M76	8540.0	22700.0	31900.0	38300.0
M80	10000.0	26600.0	37500.0	45000.0

(7) Notes on torque control and tightening works;

For torque operations which require torque control is torque wrench and to manage the tightening torque.

Notes in this case are the following.

a. The most common errors are to forget tightening. Checkmarks must be made at the same time as the torque wrench operation (Collective marking later would be NG) It is also necessary Pokayoke such as a counter type torque wrench which can monitor the number of tightening.

b. For confirmation of QL type torque wrench(type in which the neck part is bent and make sound at specified torque. Be sure to turn nut with torque wrench (to confirm

tightening margin), and confirm the tightening sound (to confirm tightening rotation), if no rotation, there is the possibility of over torque.

c. Stop tightening when a confirmation sound is heard.

d. When confirming torque of the completely tightened parts again at the shipping inspection etc., confirm that the tightening rotation can be performed with 15% or less of the specified torque (retightening torque).

e. Type F should not be used in MP lines, as there are many human errors with over tightening.

f. Check the torque of important fastening part after 24 hours passed after the complete tightening.(The bearing surface may conform with the passage of time and, axial force may decrease in particular, tightening at the sheet metal surface.

g. No adhesion of oil on tightening surface unless there is a draw instruction（possibility of too high Axial force）

h. Ensure flatness and parallelism of the tightening bearing surface(the axial force decreases over time)

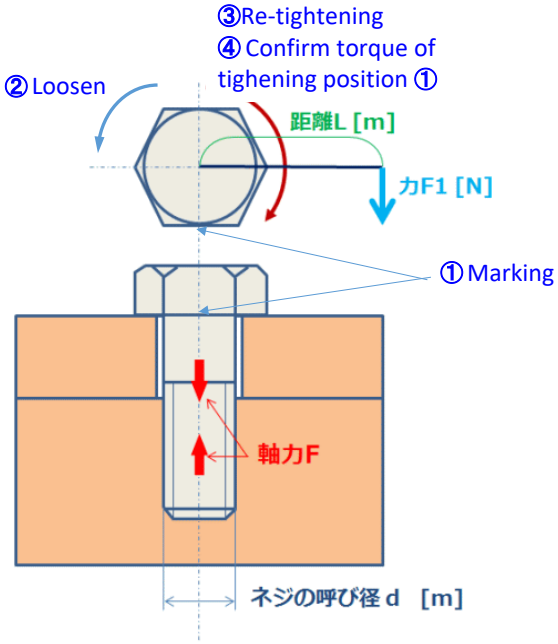
QL type Torque Wrench

F type Torque Wrench

i. Torque check is basically on the nut side.

j. Check torque of bolt and nut with small torque tolerance. If there is a risk of over torque in case of retightening torque, check the tightening torque by the angle method.

Angle tightening



①Make marking on nut or bolt in the tightening state.

②Loosen around 45 degrees

③ Again, tighten it with torque wrench(F type) to the marking position of①.

④ Confirm the torque at the position of marking.

(7) Tolca bolt;

Bolt which applied a friction regulator and to lower coefficient of friction of thread surface, giving high axial force used in the chassis of the car which requires high axial force is called tolca bolt.

The method of tightening is subject to OEM instruction, however, notes in the following points.

a. Axial force, depending on the tightening speed, controls tightening speed with AC servos（Be careful at the time of manual operation）.

Reference: A parameter “joint Coefficient” to prescribe tightening speed and torque curve in the case of torque bolt.

b. Reuse is impossible.（not possible to retighten）

Electric wrench

(9)Impact wrench;

Usually drive with air, and often results in over torque by a shock at the time of the tightening. Form air pressure control with using regulator.

(10)Electric wrench with torque detecting function recommended (please refer to the figure “electric wrench”).

(11)Locknut

a. Reuse is impossible, use a new part always.

b. Prevention Torque added (idle tightening torque which do not adhere to the bearing surface) to set management tightening torque.

(12) Thread locker

a. Use one conforming 100% with drawing requirement.

b. Adhere to usage expiration date.

(13) Pakistan cases

Figure “seat assembly” shows the situation of thread hole repair at the time of Seat assembly, which is important safety part.

Since welding accuracy insufficient, almost all thread are re-tapped (Re-Tapping) and then bolts of the adjuster and the seat body tightened. In this case, there is a possibility that thread may be damaged and it may be loosened in the process even if the torque is apparent.

It is necessary to check the torque after 24Hr after the tightening as well as single part accuracy improvement.

Seat assembly

5.12 Other Individual Technical Skills

① Parts Paint Process

No	Contents	A	B	C
①	**Major Principle** According to the OEM Parts Drawing & Required Quality Specs.	○		
②	**Selection of Paint** Basically, follow the OEM required quality specifications and decided paint maker brand. 1) Solvent Paint Properties : Short Delivery time (less tinting time), Maximum possible small lot size (tinting only the required quantity), easy color change (Possibly only Thinner Washing) 2) Powder Coating Properties : High paint film thickness possible (one coat 50~80μ), Excellent Environment performance (Non Organic Solvent), reusable (recoverable overspray), difficult color change (hard to manage at site, good to use for mono color). 3) Water base paint properties : High safety (Non inflammable), environment friendly (Non organic solvent)	○		
③	**Main Paint Procedure** An overview is given below; 1) Sheet Metal Exterior body parts : 1-1. Pre-Treatment → ED → Top Coat (Body Color & color matching) 1-2. Pre-Treatment → Top Coat → spray top coat 2) Sheet Metal Chassis Inner Sheet Parts : 2-1. Pre-Treatment → ED → (Spray top coat) 2-2. Pre-Treatment → Spray Powder Coating 3) Plastic Exterior Skin Parts : 3-1. Pre-Treatment → Spray Powder Undercoat → Spray top coat 4) Aluminum Outer Panel Parts : 4-1. Pre-Treatment → ED → Spray top coat 4-2. Pre-Treatment → Spray Powder Undercoat → Spray top coat 5) Major warnings : 5-1. Pre-Treatment : Painting items are Sheet Metal, Plastic, Aluminum, each has different processes and chemical agents. 5-2. ED : Paint items are Sheet Metal Exterior Skin & Chassis Inner, paint will be different for each of them. 5-3. Spray Undercoat : Paint items are Sheet Metal, Plastic, Aluminum and paint is different for each of them. 5-4. Spray Top coat : Paint items are Sheet Metal, Plastic, Aluminum, and paint material is different for each of them.	○		
④	**Paint Plan** As per OEM's drawing & required specs, plan paint as per following sequence. Major points are required process, machine capacity, and secure paint environment. 1) Pre-treatment / Paint Process Plan 2) Pre-treatment / Paint equipment & Layout Plan 3) Chemicals / Paint Selection 4) Exhaust & Waste Water treatment plan (Exhaust & waste water treatment plan which qualifies the environmental regulation of the area)	○		

⑤	**Pre-treatment / Paint Process：** Sheet Metal ED Case 1) Hanging on Hangers 2) Hot water bath 3) Pre-degreasing 4) Degreasing 5) 1st water bath 6) 2nd water bath 7) Surface Conditioning 8) Phosphating 9) 3rd water bath 10) 4th water bath 11) D.I. water bath 12) Electro Deposit (ED) 13) UF water bath 14) D.I. water bath 15) Air Blow 16) Dry Oven (160～210℃ ×15～20 minutes) 17) Setting 18) Spray top coat 19) Setting 20) Clear Coat 21) Bake Dry (140～180℃ ×20～30 minutes) 22) Unloading **Benefits of Electro Deposit**： ED Paint is lead-free Epoxy Resin Pain. Therefore, it is excellent for rust prevention, adhesion, and to ensure uniform film thickness. Its expected resistance is more than 700 Hours in Salt Spray Test (SST). **Passivation Treatment not required**： Unless the part to be painted is not temporarily kept as stock between the pre-treatment and ED (in order to carry out continuous production), passivation treatment in between is not required. It is not only for ED but it will also bet the same for under coat (Spray, Powder).		○	
⑥	**Pre-Treatment/Paint Process：** Exterior Plastic Panels Paint Case (BS, PP parts) 1) Loading 2) Air Blow 3) Degreasing 4) Under Coat (Spray, Powder) 5) Setting 6) Spray Inter Coat 7) Setting 8) Spray Top coat 9) Setting 10) Low Temperature Dray Bake (70～110℃ × 20～40 minutes) 11) Unloading **Paint Process Key point**： In case of 3C (3 coats) of body, inter coat will be painted in such a case but inter coat will be eliminated in case of vehicle body 2C (2 coats). In this case OEM consensus is required.		○	

⑦ **Pre-Treatment/Paint Process：** Exterior Aluminum Panel case ○

1) Loading
2) Hot water rinse
3) Degreasing
4) 1st water bath
5) Neutralization (Oxidation)
6) 2nd water bath
7) Chromate Coating
8) 3rd water bath
9) 4th water bath
10) DI water
11) Dry
12) Setting
13) Under coat (Spray, Powder)
14) Setting
15) Inter Coat (Spray)
16) Setting
17) Top Coat (Spray, Color)
18) Setting
19) Dry Bake Oven (130～150℃ ×20min.)
20) Unloading

＊Paint Process Key point：

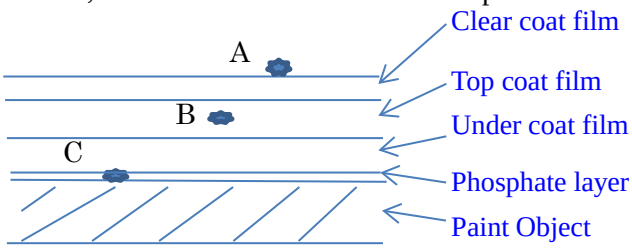
In case of 3C (3 coats) of body, inter coat will be painted in such a case but inter coat will be eliminated in case of vehicle body 2C (2 coats). In this case OEM consensus is required.

⑧ **Paint Defects and their Root Causes**： ○

1) Dust：In air, paint, Paint Equipment, Paint Booth, Worker
2) Flotation：Paint Viscosity, Worker, Worker posture
3) Gloss：Paint Tinting, Dry Bake Oven Parameter (Temp., Time, Humidity)
4) Orange Peel：Paint Tinting, Dry Bake Oven Parameter (Temp., Time, Humidity)
5) Uneven Color：Paint Tinting, Paint Equipment, Worker
6) Scratch：Worker (Handling), Paint Jig Design
7) Uneven Paint Film：Worker, Worker Posture (wrist paint is NG), Paint Equip. ○

⑨ **Dust Countermeasures**：

(1) In order to find the root cause, check the dust area using magnifying glass and also check in which layer of paint surface it exists. Then focus for root cause only that specific area, consider countermeasure and implement.



Dust A：The top painted surface, deposit after paint due to setting or baking.
Dust B：Inside the top coat, it exists in the paint or booth or in spray equipment.
Dust C：On the object surface to be painted. It deposits before or during pre-treatment process.

	Counter measure for Root Cause： **Dust A**：①Maintain positive pressure inside the Paint Booth. Prevent from air circulation from outside. The only possible through the Air Filters. ②Air Filter cleaning, replacement (Paint Booth & Inside Oven). ③Dust, abnormal particle Dust & dust particles (such as application of grease layer to paint booth) **Dust B**：①Filter cleaning and replacement when paint tinting. ②Paint piping, Paint hose, Spray Gun cleaning **Dust C**：①Pre-treatment tank cleaning, pre-treatment liquids refreshing, work place cleaning. ②Enhancement of pre-treatment implementation, especially, degreasing, water bath, and final water bath.			
⑩	**Counter measures for un-even paint film thickness：** (1) ED Film：①Review the position of electrodes. Equal distance between painting object and electrodes. ②Revision of electrodes shape. ③Try with dipping of coating parts in paint bath at different angles, and vibration during energizing process. (2) Spray Paint Film Thickness： ①Main root cause is derived from operator's skill. Especially, pay attention to the following in spray paint. ②Operator's posture, spray gun holding style, spray movement speed. ③Spray gun with shaking wrist is NG. In principle paint at right angle position to the coating object and constant spray painting. ④For longer size painting objects operator will bend downward and paint as mentioned in 3).For longer size painting objects operator will bend downward and paint as mentioned in 3).		○	
⑪	**Paint Tests：** Mainly paint film efficiency is important. Basic tests (JIS K 5600) are given below, but follow the OEM requirements for production parts. 1) Appearance, hardness, film thickness 2) Adhesion 3) Wear resistance 4) Weather resistance 5) Chemical resistance			○

② Aluminum Material

No	Contents	A	B	C
①	**(1) Characteristic of Aluminum material** 1) Characteristic⇒Apply auto parts (Example) Light weight ⇒body panel/structure parts Anti rust ⇒paint less (Motor cycle parts) :high texture Low electric conductivity ⇒ Battery case, electrode High thermal conductivity ⇒ Engine parts(C/H,C/B)	○		

Specification of metal materials

material	tensile N/mm2	Elongation %	sharing strength N/mm2	Density	melting ℃	conductivity IACS%	Heat conduct(20℃) μm/m℃
Cu:hard	343	6	192	8.9	1065-1082	100	390
:forg	233	45	158				
Iron:Cast	206	0.5	302	7.1	1305	2	50
:Plate	350	21	288	7,65	1530	16	70
Steel:Cast	515	24	412	7.86	1466-1510	11	50
:Forg	412	30	309	7.85		12	60
SUS:Soft	618	55	460	7.9	1427-1471	2.4	20
:Hard	1059	15	769			2.1	
Ti :soft	392	42	245	4.5	1660	3.1	17
③ AL:-H18	166	5	89	2.71	657	57	230
:7000T6	566	11	338	2.80	476-638	33	130

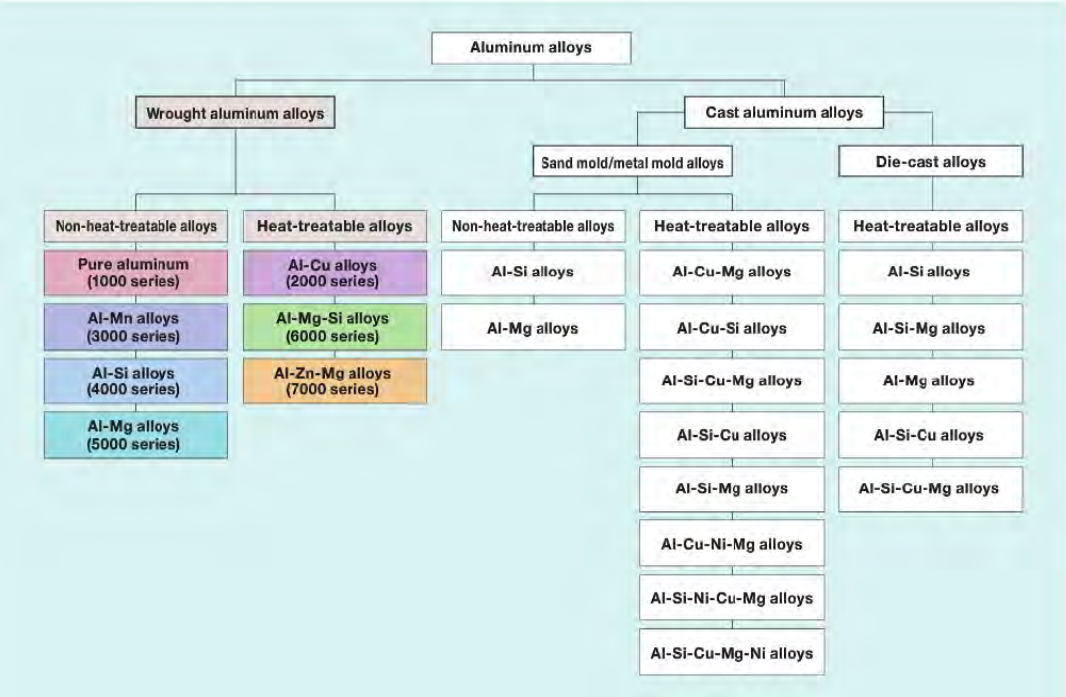
2)Classification of material
Usually, Auto parts of aluminum are using as Aluminum Alloy which contained of Si, Mg, Cu and other materials.

1. Classification of wrought method
①Wrought aluminum alloy(Rolling, Extraction material）: 1000－7000series
②Casting（Die casting, sand molding）:ADC, AC, Al-Si casting aluminum alloy

2. Classification of Aluminum alloy
Heat treatable Alloy：2000,6000,7000,[Casting]Al-Cu-Mg-Si-Ni
Non Heat treatable ：1000,3000,4000,5000,[Casting] Al-Si ,Al-Mg

Refer the classification at figure “Serial of Aluminum Alloy”

Serial of Aluminum Alloy



(2) For casting material (Material for Die Cast & Sand casting)

1)Die Casting material

(ADC: Described of 1, 3, 5..are showed as ADC1, ADC3, ADC5..)

category	range	Composition									
		Cu	Si	Mg	Zn	Fe	Mn	Ni	Ti	Pb	Sn
1	Max	-	11.0	-	-	-	-	-	-	-	-
	Min	1.0	13.0	0.3	0.5	1.3	0.3	0.5	0.3	0.1	0.1
3	Max	-	9.0	0.4	-	-	-	-	-	-	-
	Min	0.6	11.0	0.6	0.5	1.3	0.3	0.5	0.3	0.15	0.1
5	Max	-	-	4.0	-	-	-	-	-	-	-
	Min	0.2	0.3	8.5	0.1	1.8	0.3	0.1	0.20	0.10	0.1
6	Max	-	-	2.5	-	-	0.4	-	-	-	-
	Min	0.1	1.0	4.0	0.4	0.8	0.6	0.1	0.20	0.10	0.1
10	Max	2.0	7.5	-	-	-	-	-	-	-	-
	Min	4.0	9.5	0.3	1.0	1.3	0.5	0.5	0.30	0.2	0.2
12	Max	1.5	9.6	-	-	-	-	-	-	-	-
	Min	3.5	12.0	0.3	1.0	1.3	0.5	0.5	0.30	0.2	0.2
14	Max	4.0	16.0	0.45	-	-	-	-	-	-	-
	Min	5.0	18.0	0.65	1.5	1.3	0.5	0.3	0.3	0.2	0.3
Al	Max	-	8.0	-	-	-	-	-	-	-	-
S9	Min	0.1	11.0	0.10	0.15	0.65	0.50	0.05	0.15	0.05	0.05

2)Material for sand molding

(AC: Description of 1B,2A, …are showed as AC1B, AC2A…)

Upper value: Min limit, Lower value: Max limit

Ver	Composition										
	Cu	Si	Mg	Zn	Fe	Mn	Ni	Ti	Pb	Sn	Cr
1B	4.2	-	0.15	-	-	-	-	0.05	-	-	-
	5.0	0.30	0.35	0.10	0.35	0.10	0.05	0.35	0.05	0.1	0.05
2A	3.0	4.0	-	-	-	-	-	-	-	-	-
	4.5	6.0	0.25	0.55	0.8	0.55	0.30	0.20	0.15	0.05	0.15
2B	2.0	5.0	-	-	-	-	-	-	-	-	-
	4.0	7.0	0.50	1.0	1.0	0.50	0.35	0.20	0.20	0.10	0.20
3A	-	10.0	-	-	-	-	-	-	-	-	-
	0.25	13.0	0.15	0.30	0.8	0.35	0.10	0.20	0.10	0.10	0.15
4A	-	8.0	0.30	-	-	0.30	-	-	-	-	-

	0.25	10.0	0.60	0.25	0.55	0.60	0.10	0.20	0.10	0.05	0.15
4B	2.0 4.0	7.0 10.0	- 0.50	- 1.0	- 1.0	- 0.50	- 0.35	- 0.20	- 0.20	- 0.10	- 0.20
4C	- 0.20	6.5 7.5	0.20 0.40	- 0.30	- 0.5	- 0.60	- 0.05	- 0.20	- 0.05	- 0.05	- 0.05
4C H	- 0.10	6.5 7.5	0.25 0.45	- 0.10	- 0.20	- 0.10	- 0.05	- 0.20	- 0.05	- 0.05	- 0.05
4D	1.0 1.5	4.5 5.5	0.4 0.6	- 0.5	- 0.6	- 0.50	- 0.30	- 0.20	- 0.10	- 0.10	- 0.05
5A	3.5 4.5	- 0.7	1.2 1.8	- 0.1	- 0.7	- 0.6	1.7 2.3	- 0.20	- 0.05	- 0.05	- 0.20
7A	- 0.10	- 0.20	3.5 5.5	- 0.15	- 0.30	- 0.6	- 0.05	- 0.20	- 0.05	- 0.05	- 0.15
8A	0.8 1.3	11.0 13.0	0.7 1.3	- 0.15	- 0.8	- 0.15	0.8 1.5	- 0.20	- 0.05	- 0.05	- 0.10
8B	2.0 4.0	8.5 10.5	0.50 1.50	- 0.50	- 1.0	- 0.50	0.10 1.0	- 0.20	- 0.10	- 0.10	- 0.10
8C	2.0 4.0	8.5 10.5	0.50 1.50	- 0.50	- 1.0	- 0.50	- 0.50	- 0.20	- 0.10	- 0.10	- 0.10
9A	0.50 1.50	22.0 24.0	0.50 1.50	- 0.20	- 0.80	- 0.50	0.50 1.50	- 0.20	- 0.10	- 0.10	- 0.10
9B	0.50 1.50	18.0 20.0	0.50 1.50	- 0.20	- 0.80	- 0.50	0.50 1.50	- 0.20	- 0.10	- 0.10	- 0.10

3)Effect of elements in Aluminum Alloy material

Metal	Effect	Defect	remark
Cu	･hardness increasing ･Matrix enhancement ･free cutting(macining) ･High temperature strength	･loses anti corrosion	
Si	･metal flow sitimulation ･Function of Rizer ･reducing heat expamsion ･wear resistance	･Al-Mg Alloy (loses elongation, deterioration of shock resistance	
Mg	･Al-Mg Alloy:Improving anti corrosion,sterength and free cutting ability ･Ai-Si Alloy:age hardening	･increasing viscosity of molten metal	
Zn	･improving liquidity ･(Al-Zn-Mg alloy:improving strength with Mg	･loses anti corrosion	
Fe	･die cast alloy: Prevention for heat sticking	･FeAl3,Al-Fe-Si deposited: loses toughness ･Sludge⇒hard spot ･Al-Mg alloy: loses anti corrosion	
Mn	･Prevention of loses toughness and anti corrosion	･deposited sludge	
Ni	･High strength, capacity increasing for heat resistance	･anti corrosion	
Ti	･Grain refining ･macineability(*1) increasing ･Al-Cu alloy: prevention for shrinkage crack	･increasing viscosity of molten metal in excessive	*1: elongation,toughness

(3) Molten metal treatment

1) Al-Si State Diagram & Fine Grain Treatment

Shown Fig-1 as “State Diagram of Al-Si Alloy” which using for casting generally. Same as state diagram of carbon steel, Alloy which has Si less than

12.6% is called “eutectic Si-Al Alloy, has Si over than 12.6% is called hyper eutectic Si-Al Alloy.

1. Hyper eutectic Alloy

Such as AC9A which contents Si over than eutectic amount , Primary eutectic Si miniaturization process .In case of hyper eutectic Al - Si alloys, coarsening of primary crystal Si occurs and adversely affects abrasion resistance, machinability .need to prevent occurrence of the phenomenon.

revent growth of eutectic Si : In case of untreated Si eutectic, it grows in a needle shape, it can be improved to a fine granular shape which has more aantageous strength by the treatment.

Eutectic Point

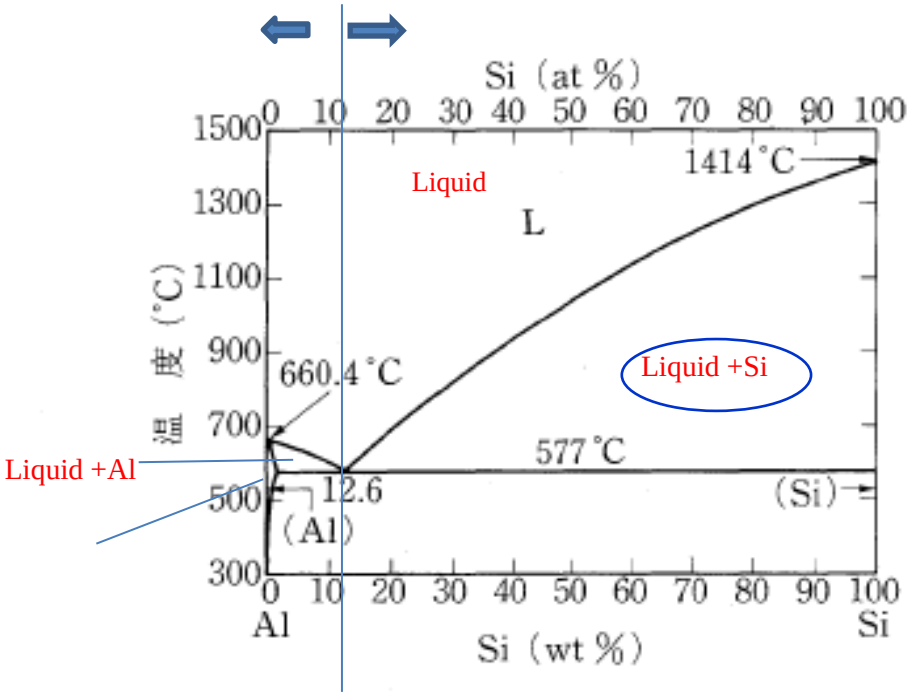


図 1 State Diagram

For improvement of eutectic Si, Basically,base elements which contained Na, Sr and Sb are used. Generally, contained NaF, NaCl flux , based on Na, areused into the molten metal using Phosphorizer . If Si is high and the cooling rate is slow, increase the amount of Na added. 50 to 150 ppm for sand mold castings and 30 to 100 ppm for die castings. Na oxidizes and consumes quickly, therefore tablet type flux used floating on the surface of molten metal is used recently.

2. Eutectic alloy

AC1A -AC7A which contents Si less than eutectic amount, Alpha crystal appears as primary crystal upon solidification. If it becomes coarse, becomes a factor of short and low toughness.

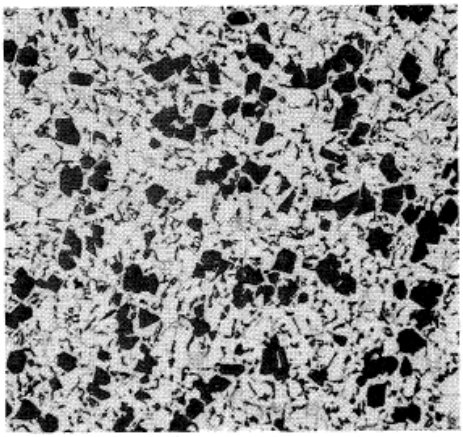
※1 : αCrystal: In case of eutectic alloy, crystal of solidification in cooling grows to large size due to dendrite solidification of aluminum alloy. It causes crack or shrinkage of casting. Crystal in dendrite is called alfa crystal.

Prevent growth of eutectic Si. In case of untreated Si eutectic, it grows in a needle shape, it can be improved to a fine granular shape which has more advantageous strength by the treatment.

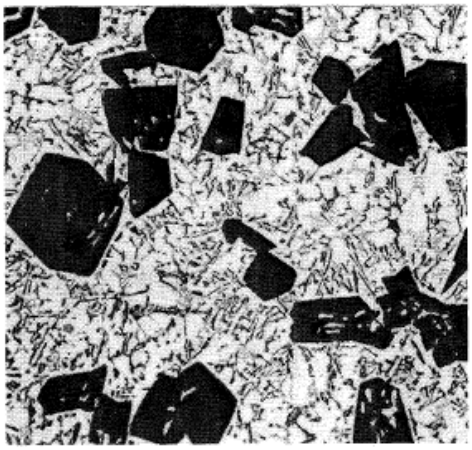
For improvement of eutectic Si, basically, base elements which contained Na, Sr and Sb are used. Generally, contained NaF, NaCl flux, based on Na, are used into the molten metal

using Phosphorizer. If Si is high and the cooling rate is slow, increase the amount of Na added. 50 to 150 ppm for sand mold castings and 30 to 100 ppm for die castings. Na oxidizes and consumes quickly, therefore tablet type flux used floating on the surface of molten metal is used recently

With Miniaturization of primary crystal Si.

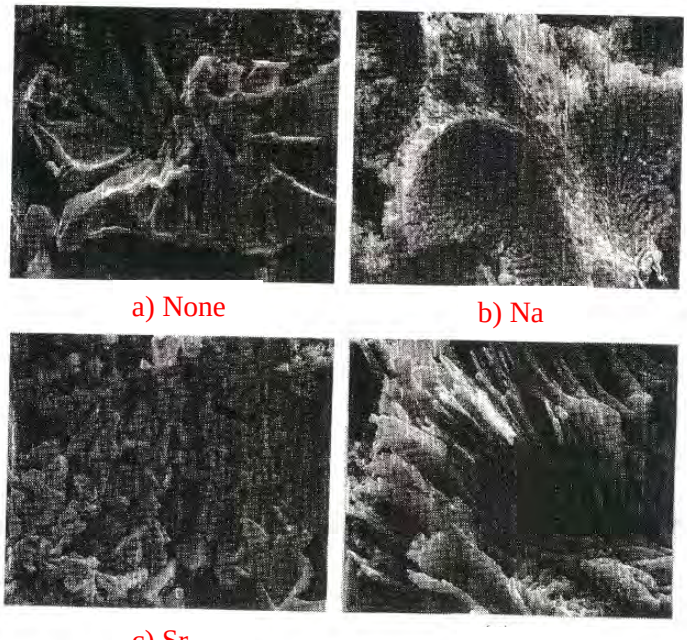


Without Miniaturization of primary crystal Si.



Effective of Grain refining with extra element adding（AC4CH)

.



a) None

b) Na

c) Sr

d) Sb

図14　AC4C 合金の共晶 Si の形態。(a)無処理，(b) Na 処理，(c) Sr 処理，(d) Sb 処理。F 材，SEM 像。（×600×1/2）

2)De-gassing treatment

(1) Explanation for improvement of Aluminum casting molten material regarding Grain refining/strength improving and reducing porosity.

①. Treatment of molten metal

5 kinds of treatment needed: NO4).5) has been explained in above section.

i) De gassing treatment(Hydrogen gas removing）

ii) Sludge cohesion, filtration of molten metal

iii) Grain refining of macro crystal grain.

iv) Improvement of Eutectic （Grain refining of micro crystal of Al-Si alloy)

v) Grain refining for Primary crystal of Silicon.

①-i). De gassing treatment

Moisture in the air reacts with molten aluminum, hydrogen is generated and melts in the molten metal.

This hydrogen becomes H2 gas porosity when aluminum coagulates.

The method of degassing treatments are as follows.

1] Inject an inert gas as Ar, N 2 directly into the melt through a pipe (lance).

2]. Blow Ar and N 2 into the molten metal through rotating nozzle.

3].Add the flux of halide (ethane hexachroride: C2Cl6) into the molten metal. (Add 0.2 wt% of the molten metal to the phosphorizer and wait for completion of reaction)

4]. Combine NO 1 and 3 are used , Ar and N 2 are used as carriers and NO 3] is blown into the molten metal

Formerly, 1] was the mainstream, but NO 2] has become widespread lately.

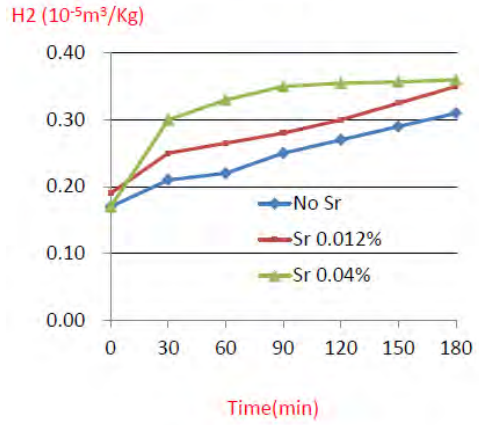
This merit is effected in the short time (within 5 minutes) than 1 (30 minutes) and also has low contents of H2 gas (0.1 - 0.15 ml / 100 g), high purity gas with low dew point is used to avoid water contamination in the gas.

When high temperature and high humidity in the summer season or the holding temperature of molten metal is high, the molten metal again absorbs H 2 in the air after degassing treatment. This tendency is especially high for molten metal improved with Sr. Accordingly, it is necessary to control the use time after the processing or to repeat the processing.

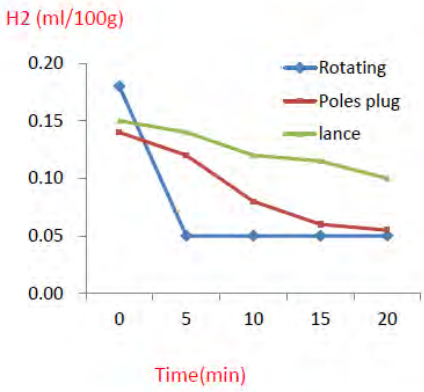
[Example of PAKISTAN]

(1) Tablet is used in supplier, however most of supplier is using the tablet before 2-4 hours of casing (need to use within 60min before casting.) and also using amount are not clear.

Graph :H2 gas in Molten metal



Graph :H2 gas of de-gassing treatment



(1)—2 Treatment for Sludge removing

The oxide film and the nitride in the molten metal are adhered to remove the inclusions of the molten metal.

1]. Inert gas or halogen gas blowing

2] Flux treatment

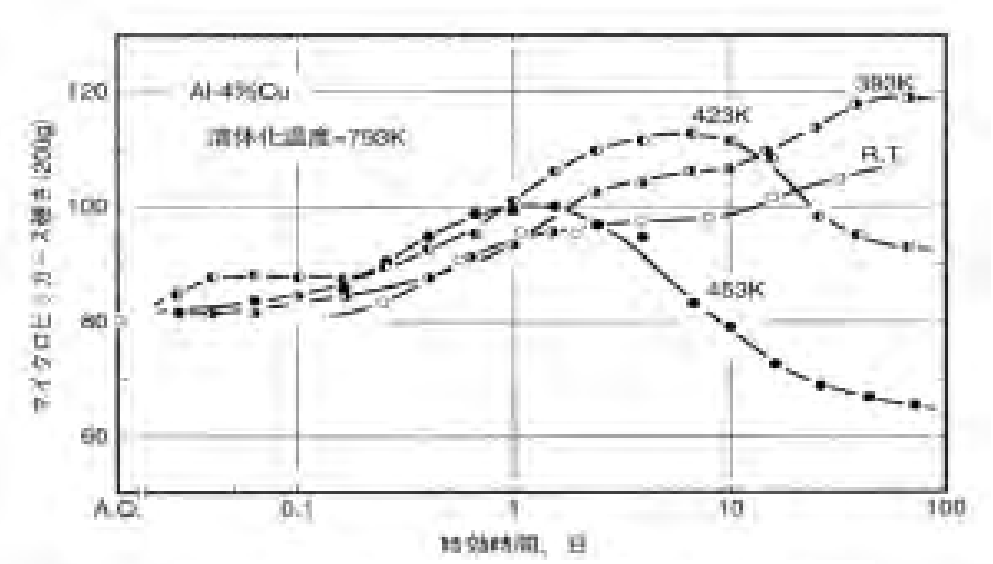
NaCl, KCl, NaF, and flux with Na2SiF6 and Na2SO4 added as main

components. The addition amount is standard 0.2% of the molten metal.
Reaction temperature is used at 700 ~ 760 ℃.
(Use on surface of molten metal in order to help oxide burning)
3]. Filter Filtration
Reticular filter, spongy filter (ceramic)
4] The combination of above

4. Heat treatment for Aluminum Alloy

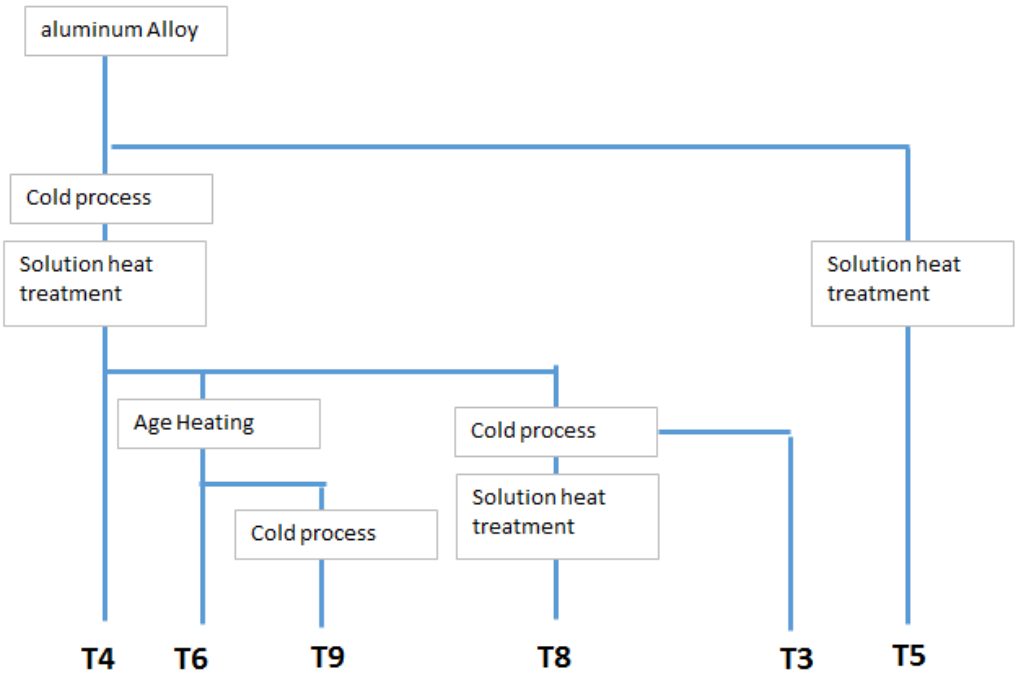
1) When the Aluminum alloy is kept at a high temperature right below the Freezing Point, atoms of alloy elements such as Cu, Mg and Si in the crystalline structure of Al are uniformly dissolved forming a "Solid Solution" state.
This state is called "Solution Treatment". When not completely melted alloy elements from this state, stable large crystals such as CuAl2 and Mg2Si are formed, and these crystals will be dispersed in some area of crystal structure of Al structure (the "Precipitation" state). In this state, the precipitates are large and the alloy is not strengthened.
Without performing slow cooling, the high-temperature solid solution state is carried over (maintained) at room temperature at a high temperature by means such as quenching into water (quenching).

The material in this state is called a **Super Saturated Solid Solution**. After this, as shown in FIG. 2, the element dissolved in the aluminum alloy is finely precipitated by maintaining the temperature at room temperature to approx., 200 ° C. for several hours to several days (in industrial terms, several hours). This precipitate stops the movement of dislocation of metal atoms, therefore strength is increased.
This phenomenon of alloy hardening is called the "Aging Hardening", and such treatment is called "Artificial Aging Treatment". This phenomenon is used to strengthen aluminum alloy by Heat Treatment。



Aging Curve of hardening for AL-Cu Alloy

1) Kinds of treatment and condition are described in following (Fig-3)



Aluminum alloy		Metal mold casting				Sand Mold casting			
		Solution heat treatment		age heating		Solution heat treatment		age heating	
Material	HT	℃	Hr	℃	Hr	℃	Hr	℃	Hr
AC1B-T4	T4	515	10	-	-	515	10	-	-
	T6	515	10	160	4	515	10	160	4
AC2A	T6	510	8	160	9	510	8	160	10
AC2B	T6	500	10	160	5	500	10	160	5
AC4A	T6	525	10	160	9	525	10	160	9
AC4B	T6	500	10	160	7	500	10	160	7
AC4C	T5	-	-	225	5	-	-	225	5
	T6	525	8	160	6	525	8	160	6
	T61	525	8	170	7	525	8	170	7
AC4H	T5	-	-	225	5	-	-	225	5
	T6	535	8	155	6	535	8	155	6
	T61	535	8	170	7	535	8	170	7
AC4D	T5	-	-	225	5	-	-	225	5
	T6	525	10	160	10	525	10	160	10
AC5A	T6	520	7	200	5	520	7	200	5
AC8A	T5	-	-	200	4	-	-	-	-
	T6	510	4	170	10	-	-	-	-

[Example of Pakistan]

(1) Improvement of T6 treatment

Supplier has implemented T6 treatment at constant temp of 525 *C for 8 hours of AC4CH. and change the stacking alignment of wheels from tower to pyramid like shape. As a result hardness improved up to desired level 65 ~ 70 HB (Previous 40-45HB) after heat treatment. After painting wheel rims are again baked in which hardness improved further up to ~ 90 HB.

(Supplier explained that heat treatment for 10 hours is costly & not cost efficient.)

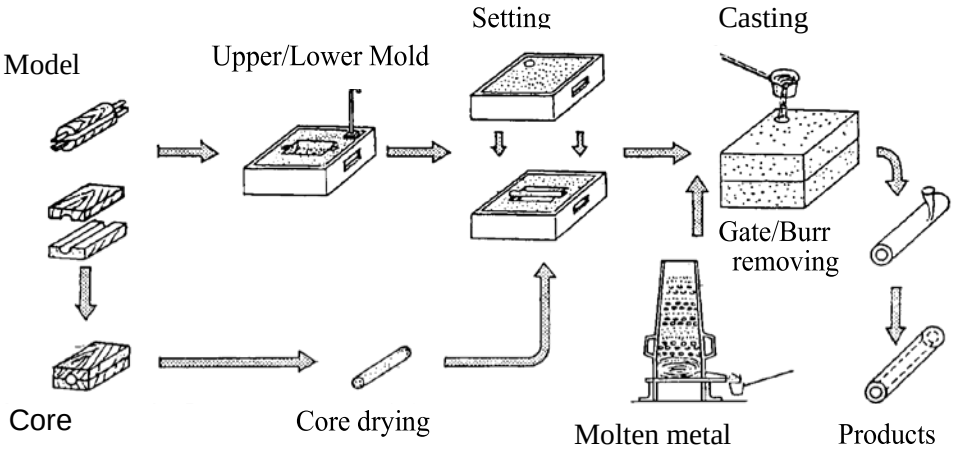
⇒Heat treatment condition of aluminum has to be controlled in tighten tolerance due to solution treatment effects in severe condition of aluminum.

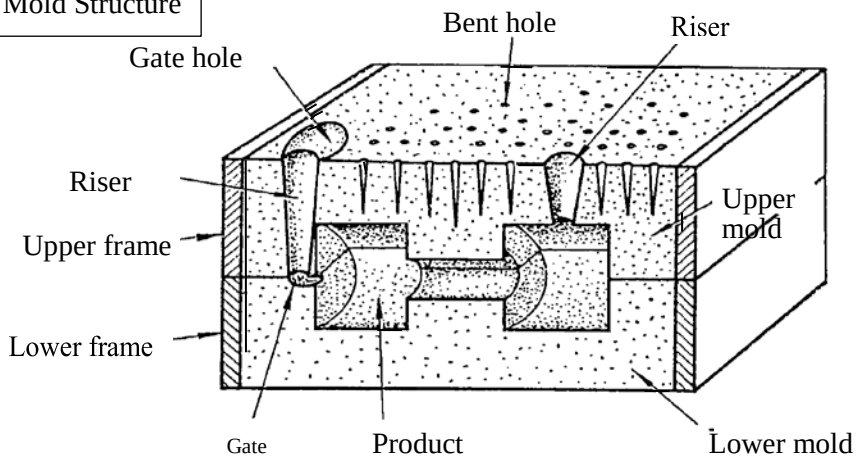
(Ex: Treatment Temp.525±5℃)

Aluminum Wheel (AC4CH-T6)

Crown Handle (AC4CH-T6)

③Aluminum Casting

<table>
<tr><th>No</th><th>Contents</th><th>A</th><th>B</th><th>C</th></tr>
<tr><td>①</td><td>
1. Alloy Classification
1) Material difference between Aluminum Casting and Die Casting
(Refer to details of each material for "Aluminum material")
Table1：Material difference between Aluminum Casting and Die Casting
<table>
<tr><th></th><th>Casting Properties (Warnings)</th><th>Material Requirements</th><th>Recycle Material</th></tr>
<tr><td>Aluminum Casting (AC)</td><td>Pressure & cooling speed are low, and roughness & blowholes occur during solidification</td><td>Allowable value of impurities including Fe is small. Add additives for miniaturization.</td><td>0~50% (less tolerance for impurities)</td></tr>
<tr><td>Die Casting (ADC)</td><td>Because of high melting speed & pressure, cooling speed is also high, makes fine structure but seizure & sink marks occur on mold surface.</td><td>To prevent from seizure marks on mould, Fe contents has to be less than 1.0%. Impurities tolerance is high than casting material.</td><td>Below 90%</td></tr>
</table>
2.Casting Concept
1) Mold Casting
(1) Basic Concept（Please see below figure）


Mold Structure


</td><td>○
○</td><td>○</td><td></td></tr>
</table>

(2) Mold Classification & Properties

(a) Sand Mold

Concept of mold design using Binder agent and thermosetting resins with Silica Sand or Phenolic Resin. Classification and properties are shown in below table.

Sand Mold Classification

Normal Mold	Sand Mold		Silica Sand + Bentonite (Binder)	Low cost, easy to dismantle	Not suitable for high precision castings
Special Mold	Thermo-setting		Oil sand Phenol Furan Based	Clean Casting surface Short molding time High precision	Mold preheating at 250 ° C is required, mold thermal deformation. Binder cost is high
	Self - Hardening	inorganic	Cement Water Glass	Easy to mold High mold strength and high-pressure resistance.	Difficult to maintain mold accuracy in repeated casting (Binder effect)
		Organic	Furan Urethane		
	Gas Curing mold	inorganic	Water Glass	The forming is faster. Good mold accuracy without thermal deformation	Difficult to re-use mold sand
		Organic	Furan Urethane Phenol		
	Precision casting		LOST-WAX Plaster Mold Ceramic Mold	Small Precision Casting	Mold cost high

(b) Mold

Use metal for mold. It is classified as below as per molten pouring method.

① Gravity Casting

Same concept as mentioned sand mold except that mold material is metallic.

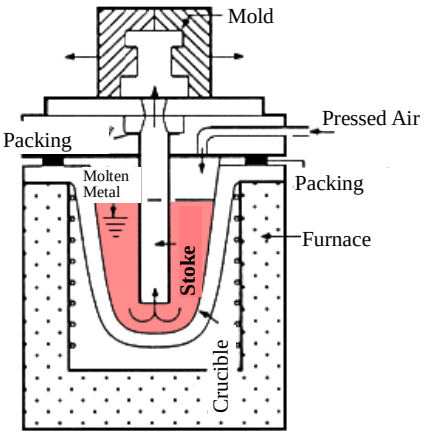
Mold is durable and mass production is possible by same mold.

② Inclined Casting : As an application of gravity casting, a concept to tilt the mold and hold molten material in a pan temporarily and pour it indirectly. ○

By controlling the pouring speed, high quality products with less defects can be produced. (Implemented for Engine Parts etc.)

③ Low Pressure Casting

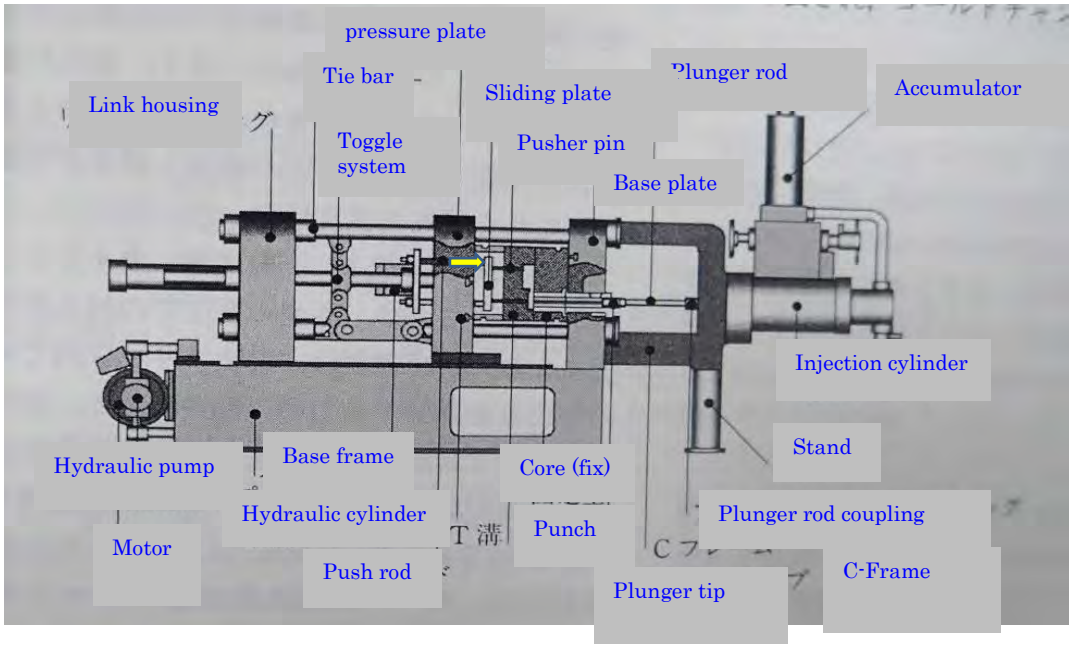
In a closed crucible 0.1to 0.8 barometric pressure (Bar) is applied and fill mold with molten metal from Stoke inside the molten metal. Since pressure is applied from molten metal outlet therefore no pressing for molten metal is required, so yield is better and because casting is done inside the inert gas therefore good casting with less blow holes or sink marks can be achieved. (Implemented for Alloy Wheel, etc.)



2) Die Casting

(1)Basic Concept

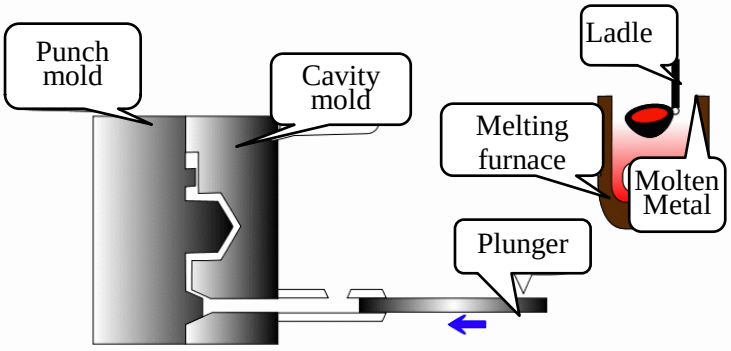
Mainly a horizontal Cold Chamber Die Casting machine is used as shown in below figure.



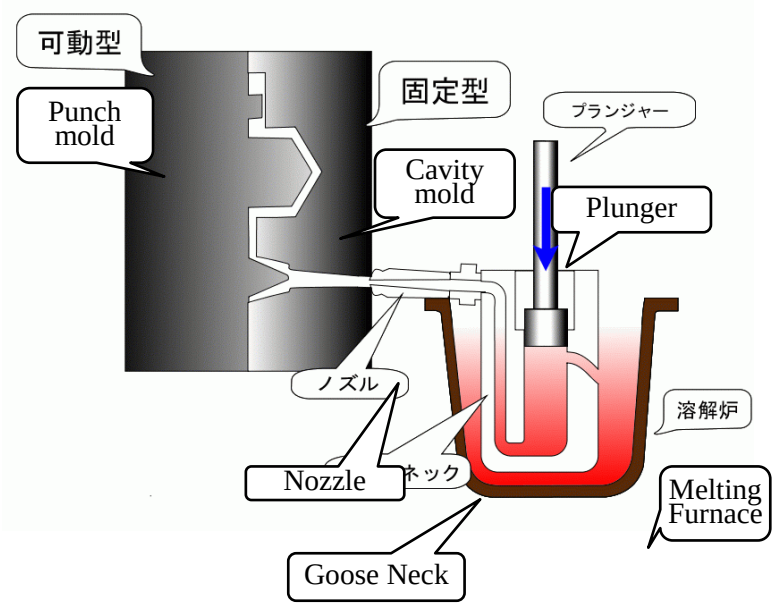
Cold Chamber & Hot Chamber

	Characteristic	remark
Cold Chamber	1.available for large size casting 2.Can be made in high pressure casting 3.Available for computer control casting 4.Cycle time is longer than hot chamber due to pouring movement needed	
Hot Chamber	1.for small parts casting 2.Short casting time than cold chamber 3.Stability of molten metal temperature 4.small load to mold die due to low injection pressure 5. Not for large size casting	

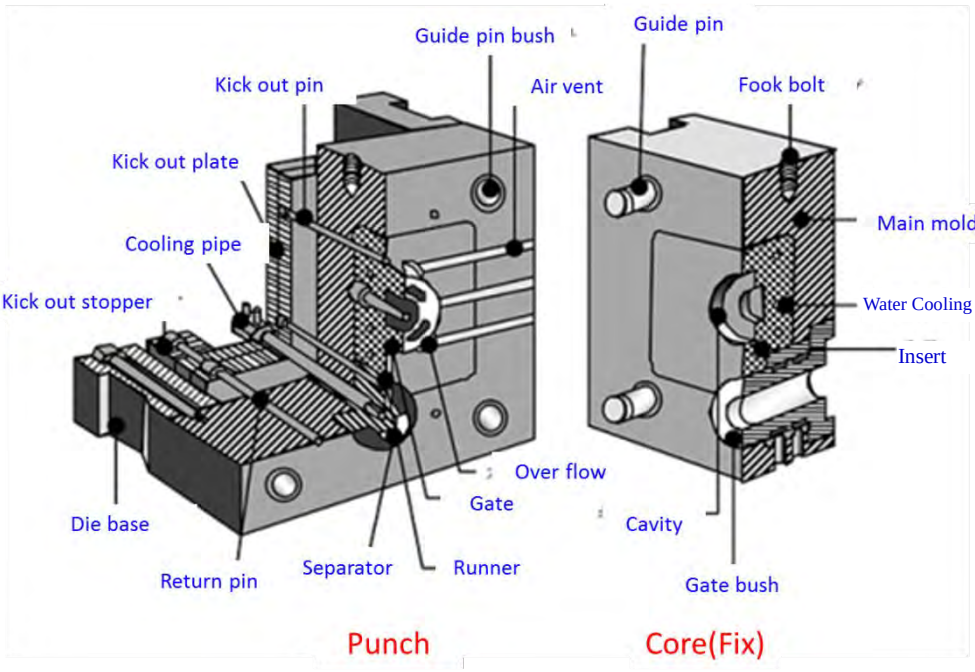
Cold chamber



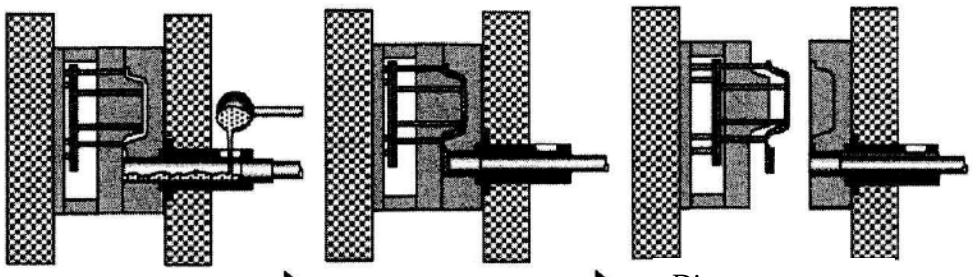
Hot chamber



(2)Mold Structure



(3)Die Casting Process



Setting Parameters (For Ref.: Example of less than 800t machine)

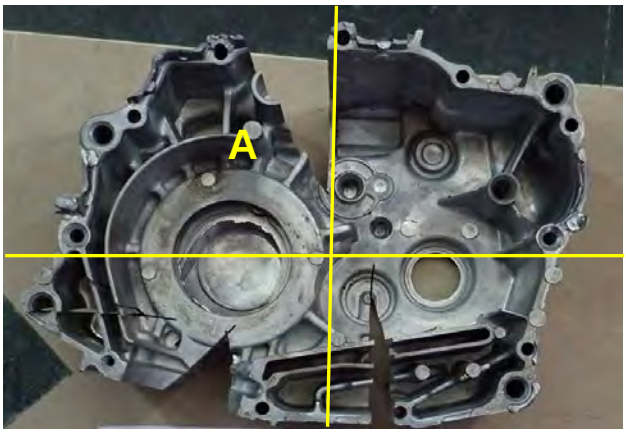
Operation			Machine & mold	
Mold life	500-800K_pcs		Mold temp.	220-250℃
Die coat water	Rite_Lube		Primary speed	0.3-0.5m/s
	Mixing ratio	1:50-80	Secondary speed	3-5m/s
	Spray time	depend on parts	Ejector pressure	10-15Mp
Anti-solder wax	#127: Apply after 5pcs Apply after 5pcs		Injection pressure	30-100Mp

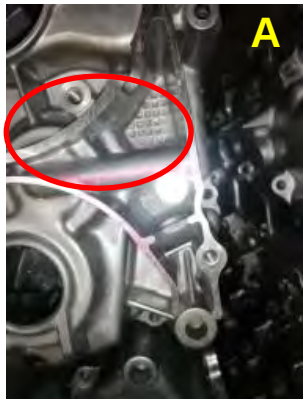
Generally in die casting, to fill the molten metal in thin cavity, high speed & high pressure injection parameters are required. To prevent the air entrapment in injection sleeve, at the start injection speed is kept slow and then material is filled in mold at once with high speed.

【Actual Situation in Pakistan】

1. Leakage due to sinking

Due to effect of mold temperature and delay Molten metal filling in mold causes thin areas or complex shapes (ribs) etc.





【Countermeasures】

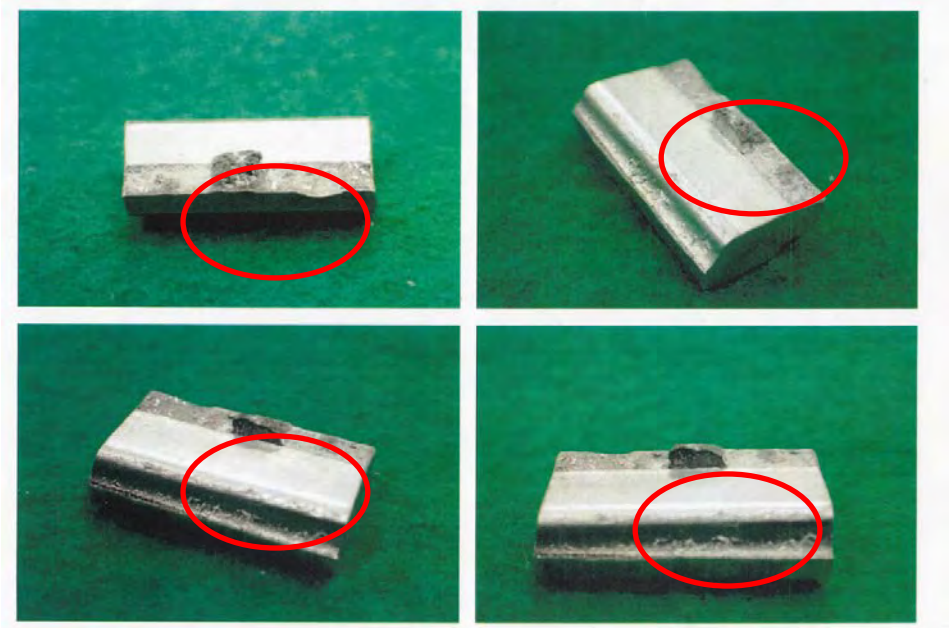
- **Optimization of mold temperature（225±10°）⇔ Actually it is difficult to control due to variation at different areas therefore, practically it is done by mold maintenance & application control of releasing agent.**
  - **a. Control of Releasing Agent Application (Automatic application is desirable**
  - **b. Injection Pressure & Speed optimization (Adjust by PLC)**
  - **c. Molten metal temperature control (670～700℃)**
  - **d. Mold water cooling pipe maintenance**
  - **e. Molten metal degassing: Usage of appropriate flux (for details please see Aluminum material section)**

* Although there are multiple elements of short molding counter measures and actual root cause, it cannot be covered all by above mentioned only but it is important to set standard parameters as given in Table 4 and to maintain them set the maintenance & operation standards.

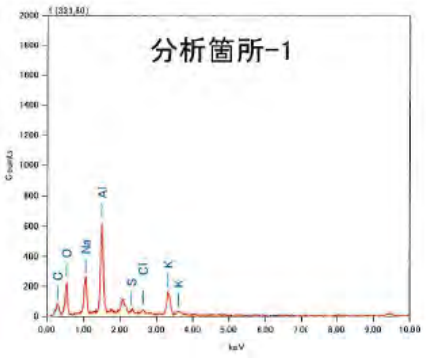
（There are a lot of examples showing, injection parameters are entrusted to machine manufacturer at the time of machine installation and later no control when doing mass production.）

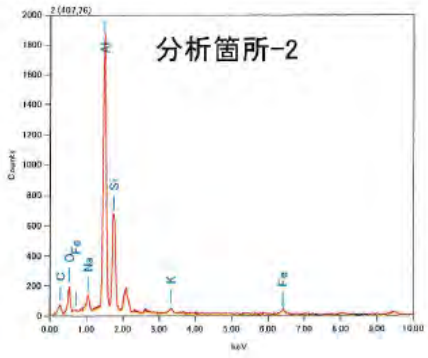
2.Hard particle (High hardness foreign particles)

It was observed in high pressure die casting, highly hardened substances deposited inside and cause breakage of tools in machining process.



Results of analysis with SEM (Scanning Electron Microscope) and EDX (Energy dispersive X-ray spectrometry)：Conducted in Japan





Analysis Point 1, 2 components Na and K do not exist in ADC12. Therefore, possibly it is because of contamination of plated parts.
Point 2 is close to the abnormal particles but Si contents are abnormally high (30%) means **Si eutectic crystal is assumed at this area** (please see "Aluminum material" for Si eutectic)

【Countermeasures】

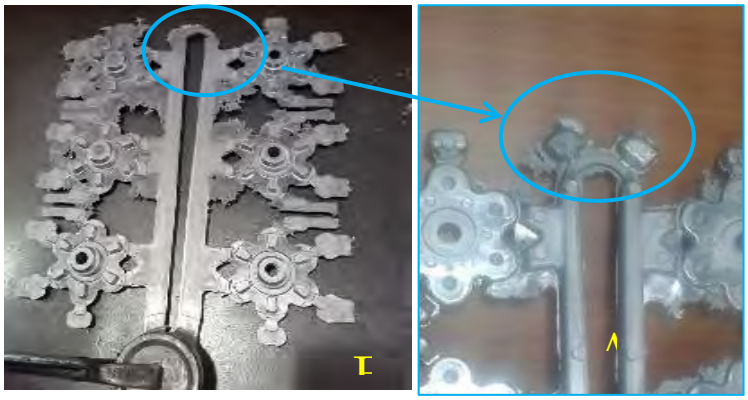
a. Molten metal crucible was changed from Cast Iron to Graphite (black lead) in order to prevent deposit of crucible components.
b. Increased cooling speed (by controlling mold & molten metal temperature)
c. Plated parts were excluded from the Return Material, and only virgin material and recycled material were used. Also set the usage ratio for each.

3.Other Examples and Countermeasures

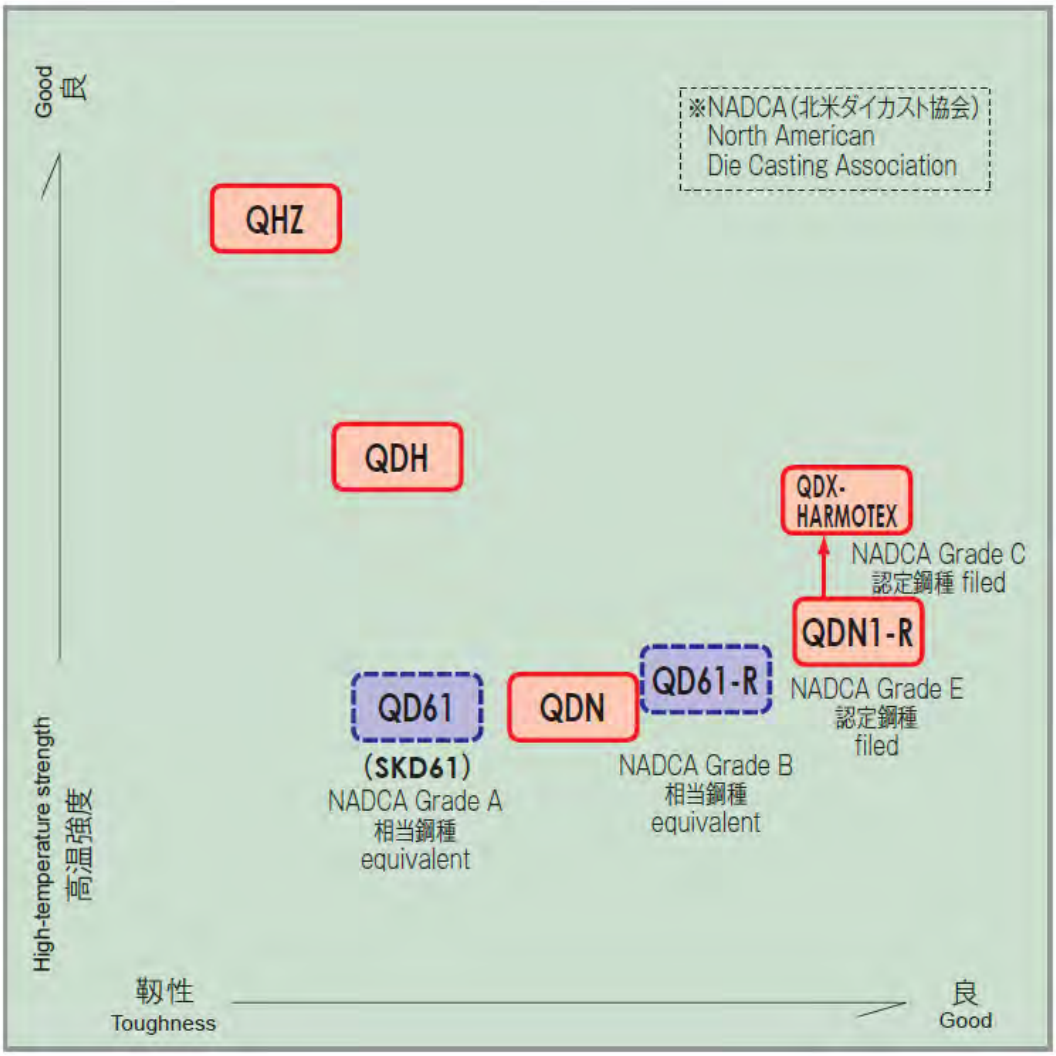
1) Blow Holes

Mold Overflow Improvements

As for countermeasure of short molding add Overflow at gate edge.

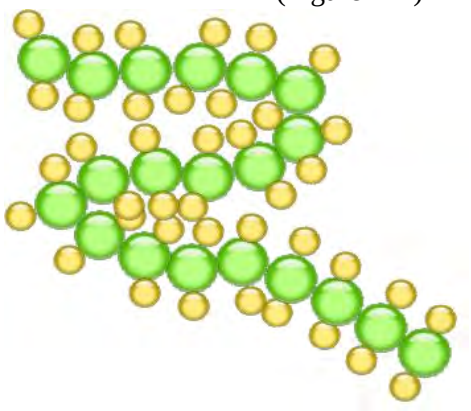
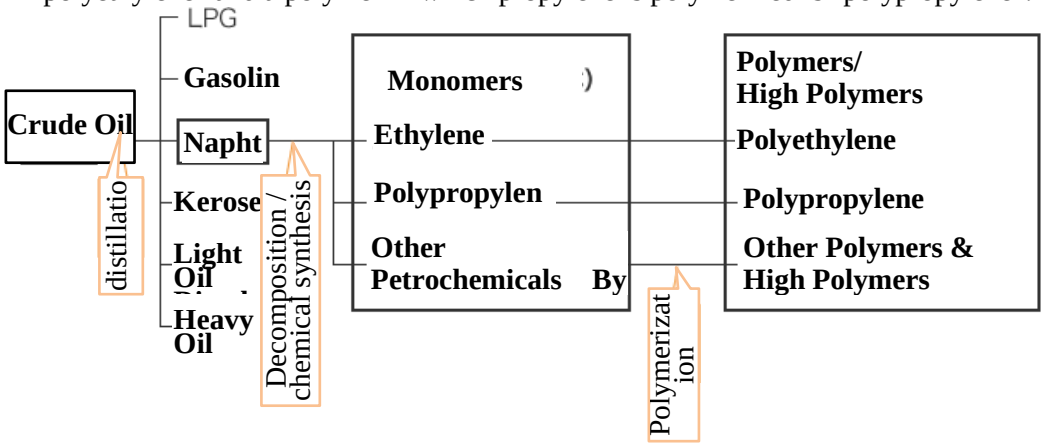


4. Mold Material for Die Casting (For reference：SANYO Catalogue)



symbol	application	features
QDN	Large, Squeeze dies	Superior nitriding property
QDN1-R		High toughness & greater high temperature strength
QDX-HARMOTEX	High performance dies, precision dies, squeeze dies	High toughness & softening resistance, Excellent heat-check resistance
QDH	Precision dies, High silicon type	toughness & high strength in high temperature
QHZ	High silicon type, For Pin & Sleeve	Matrix type high speed steel combining high toughness with high temperature
PCM30	Prototype, Small lots holder plate	Pre-hardened(30-33HRC) with superior machinability & toughness

	Types of damage and countermeasures ·Heat checking → Higher strength at high-temperature ·Cracking and chipping → Higher toughness ·Melting erosion → Surface coating or application of semi-high speed steel Steel grades shown in the figure on the right are classified in terms of their high-temperature strength and toughness. The most suitable steel grade for a particular requirement can be chosen from those listed in this figure.		○	

No	Contents	A	B	C
①	**【Ⅰ.Plastic Moulding】** 1. Resin material Overview 1)Resin means (1) Micro and Macro-Molecules A substance is consists of several atoms like water and carbon dioxide (see Fig. A-1) but sometimes more than 1000 atoms gather to form a molecules (See Figure A-2). This type of huge molecules is called macro-molecules and the others are called micro-molecules. (Fig. A-1) (Figure A-2)  Water molecule Carbon Dioxide molecule  The temperature is directly related to the movement of the molecule and molecule start to move actively when the temperature rises while distance to molecule becomes wider and it can move freely. (The reason why the polymer expands as the temperature rises) As shown in Fig. 2, polymer moves freely as the temperature rises because it is in the form of a string but molecules become entangled and they become difficult to move when it cools and becomes separated by a distance. Using this theory, the plastic can be heated to a make desired shape and allowed to cool and maintain its shape. (2) Monomers and polymers In the case of resin molding materials using petroleum raw materials "Polymeric substances" and "high polymeric substances" are generated (polymerized) from "Monomeric substance" in the following manner. Plastic molding is carried out by raw materials of "pellets" and "powders". a) Monomer Formation "Monomers" are produced by decomposing and chemically synthesizing "Naphtha" obtained in the process of distilling crude oil, which is a small molecule (micro molecular weight substance). These include ethylene and propylene, which are called petrochemical based products. b) Polymer / High Polymer (high polymer) formation The monomers are combined with one another to form large molecules (polymerize) (polymer substances), by becoming "polymers" or highly polymerized "high polymers ". For example, a polymer in which ethylene molecules are polymerized is "polyethylene" and a polymer in which propylene is polymerized is "polypropylene".  	○ ○		

(3) Material Form

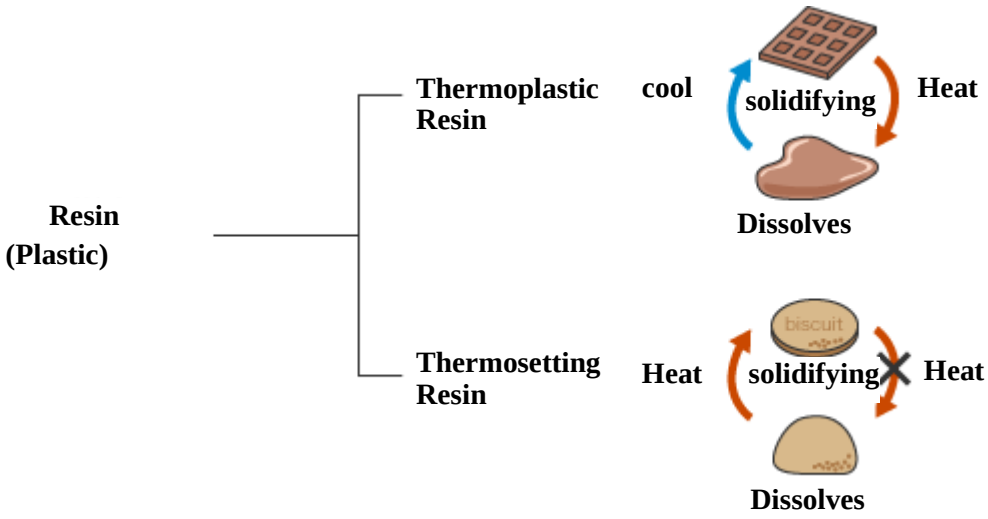
Processed into Pellets or Powder which is a suitable condition as a plastic molding material (pellets or powder), then additives and colorants are mixed with the resin and after passing through a process called "compounding", pellets and powders are formed. The “thermoplastic resin” uses pellets in which the resin is in the form of rice grains, and the “thermosetting resin” uses a powdered resin.

(4) Classification by nature of resin

Resin (plastic) melts (decomposes) and becomes soft when heat is applied, and can be deformed (formed) and solidifies in the deformed shape when cooled (Solidification). The resin is mainly divided into two types depending on the properties after solidification (after molding) by cooling.

a“Thermoplastic resin” deforms again with plasticity even if it is heated after molding.

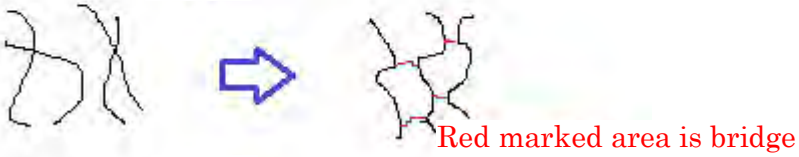
B “Thermosetting resin” do not deform even if heated after molding.



This occurs because the resin molecules are in the form of strings. Thermoplastic resins return to their original form when heat is applied, because the way of becoming a solid is intertwining each other's molecules. (Fig. 1) Thermosetting resins cannot be softened again because they cause a chemical reaction to bridge each other's molecules and form a bridge when solidified. (Figure 2: This is called a crosslinking reaction)

Accordingly, thermosetting resins have the property of being "heat resistant" and are used for kettle handles and the like.

(Fig. 1)



(Fig. 2)

(5) Types of Thermoplastic Resin

When resin molecules cool and solidify while forming string-like molecules (crystals) while solidifying (crystalline resin) and various defects in the string

(in case of uneven size of the yellow spheres shown in Fig. A-2), the molecules

separate into those (non-crystalline resin or non-crystalline resin) that solidify without aligning (without making crystals). (Figure 3)

a) Characteristics of Crystalline Resin

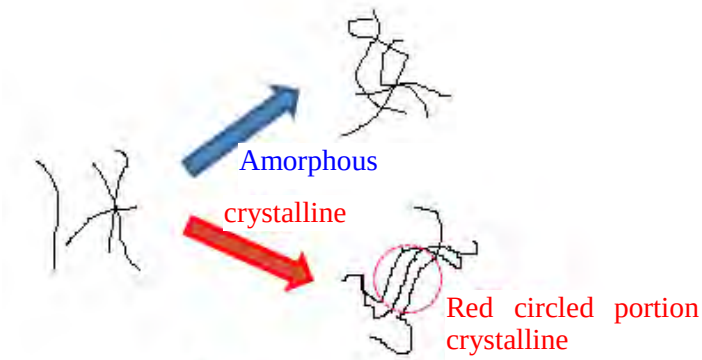


Fig.3

Compared with Amorphous by having crystal

i Its not Transparent

Because the refractive index of the crystal part and the amorphous part is different

ii High Chemical resistance

Because the surface of the plastic is covered with a strong crystal

iii High Shrinkage Ratio

This property appears because the crystal part has more molecules per volume than the amorphous part.

(6) Amorphous Resin

The thicker the plastic molecules, which are in the form of a string, the harder it is to vibrate by heat and the stronger it is against heat.

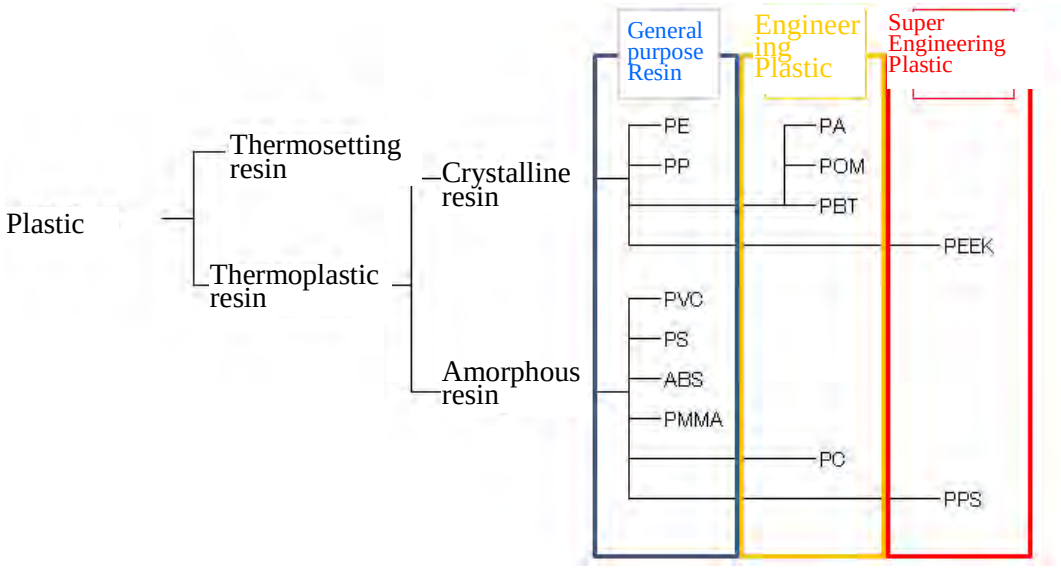
The molecular form of the resin is as shown in Figure A-2, where the green part is called the main chain and the yellow part is called the side chain.

The main chain which makes this string is

i. For carbon only: Relatively heat-sensitive (heat distortion temperature less than 100 degrees) General purpose Resin

ii. When elements other than carbon are contained: Heat resistant (heat distortion temperature over 100 degrees) Engineering Plastic (Functional Resin Functional Reinforced Resin Engineering Plastic)

iii. When Benzene is contained in addition to carbon: It is highly heat resistant (heat distortion temperature is over 150°) It becomes Super Engineering Plastic.



(7) General Purpose Plastic

"General-purpose resin" has low deformation temperature and is easy to mold Because polypropylene and polystyrene are relatively inexpensive, they are used for mass production of various products such as general goods, packaging, and agricultural applications.

Major types of general purpose plastics and application examples

Polyethylene (PE)	Low Density Polyethylene (LDPE)	Film, Laminate, Wire Coating
	High Density Polyethylene (HDPE)	Film, Food Content, Shampoo and Rinse Container, Bucket, Gasoline Tank, Pipe
	Ethylene / Vinyl Acetate Alcohol Copolymer (EVA)	Agricultural Film, Stretch Film, Toy
Polypropylene (PP)		Auto Parts, Home Electric Parts, Packaging Films, Food Containers
Polystyrene / Styrol Resin (Ps)		Oa. TV Housing Cd Case, Food Container, Toy
Vinyl Chloride Resin / Polyvinyl Chloride (Pvc)		Water and Sewage Pipes, Hoses, Pipes, Fittings, Gutters, Corrugated Sheets, Sash
Abs Resin (ABS)		Oa Equipment, Auto Parts (Internal And External Parts), Electrical Products, Game Consoles
As Resin (SAN)		Tableware, Disposable Lighters, Electrical Products
Polyethylene Terephthalate (PET)		Pet Bottle, Container, Insulation Material, Functional Film for Optics, Magnetic Tape
Methacrylic Resin (PMMA)		Car Tail Lamp Lens, Contact Lens, Dining Table, Light Plate, Water Tank Plate

Engineering plastic

"Engineering Plastic" as compared to General Purpose Resin is a resin (plastic) that has higher heat resistance and mechanical strength and is highly reliable as a material, so it is also used for high value-added products such as industrial parts and automobile parts.

Main types of Engineering Plastics and application examples

<General Purpose Engineering Plastic>

Polyamide (PA)	Automotive Parts (Intake Pipe, Radiator Tank, Cooling Fan, Etc.), Food Film
Poly Carbonate (PC)	DVD · CD Disc, Electronic Parts Housing (Mobile Phones and Others)
Polyacetal（POM）	Various Gears (DVD Etc.), Auto Parts (Fuel Pump Etc.), Various Fasteners and Clips
Polybutylene Terephthalate (PBT)	Electric Products, Electronic Parts, Automobile Electrical Parts
Polyphenylene Ether (PPE)	Pumps, Fittings, Hot Water Supply Ports, Auto Parts

<Super Engineering Plastic>

Fluorine Resin	Frying Pan Inner Surface Coating, Insulation Material, Bearing, Gasket, Packing
Polyimide (PI)	Semiconductor Parts, Communication Equipment, Insulation Materials, Adhesives
Polyether Sulfone (PES)	Precision Equipment, Auto Parts, Cooking Items
Polyether imide (PEI)	Printed circuit boards, IC sockets, automotive parts

○

(8) Types of Thermosetting Resin

Thermosetting resins are materials that cannot be dissolved and used again after molding once, and they do not melt even at high temperatures (heat resistance).

The thermosetting resin before heating is a low molecular weight compound (oligomer, prepolymer) either singly or in combination with a curing agent, initiator, catalyst, etc. When heated, it becomes a substance by crosslinking reaction proceeds to cure the three-dimensional structure, insoluble or infusible.

Thermosetting resins having high heat resistance as well as high insulation properties are used for tableware, heat insulation materials, electrical insulation parts, and semiconductors. Unlike thermoplastic resins, recycling is difficult.

Types of thermosetting resins and application examples

Urea Resin (UF)	Button, Cap, Electrical Product (Wiring Equipment) Plywood Adhesive
Melamine Resin (MF)	Tableware, Veneer, Plywood Adhesive, Paint
Unsaturated Polyester (UP)	Bathtub, Corrugated Sheet, Fishing Boat, Button, Helmet, Fishing Rod, Paint
Epoxy Resin (EP)	IC Sealing Materials, Printed Wiring Boards, Paints, Adhesives, Various Laminates
Silicone Resin (SI)	Food Appliances, Heat And Cold Resistant Containers, Seals And Joints, Coating Materials, Medical Parts
Polyurethane (PUR)	Foam: Cushion, Car Seat, Insulation Non-Foam: Industrial Roll, Packing, Belt, Paint, Waterproof Material, Spandex Fiber

(9) Hydrolysis (important)

Hydrolysis refers to the decomposition reaction that occurs when the resin reacts with water. Water molecules (H2O) are separated into H and OH on the resin and enter the decomposition products of the resin, and reactions occur in various cases along the reaction format.

When hydrolysis occurs, plastic and resin decrease in molecular weight and cause deterioration, which adversely affects the durability, rigidity and strength. Plastics and resins having ester bonds are susceptible to hydrolysis, and polybutylene terephthalate (PBT) polycarbonate (PC) is a resin that is susceptible to hydrolysis.

For example, in the flow where PC hydrolyses, the ester bond of PC is blocked by water molecule (H2O), carbon dioxide (CO2) is generated, low molecular weight and bisphenol A are formed, and hydrolysis occurs. It becomes a flow. It is necessary to take sufficient counter measures in the case of automobile exterior functional parts (door handles, door mirrors, etc.) for the hydrolysis of resin, and it is necessary to dry the material, coat it and carry out surface treatment to prevent water content and moisture absorption after use.

Forming Method

(1) Injection Molding

Heated melted resin (plastic) is poured or filled with an injection type system and it takes the shape, mainly used for molding of thermoplastic resin but It is also rarely used as a thermosetting resin. It is suitable for mass production because it can rapidly mold various resin products such as thin-walled products and complex shapes.

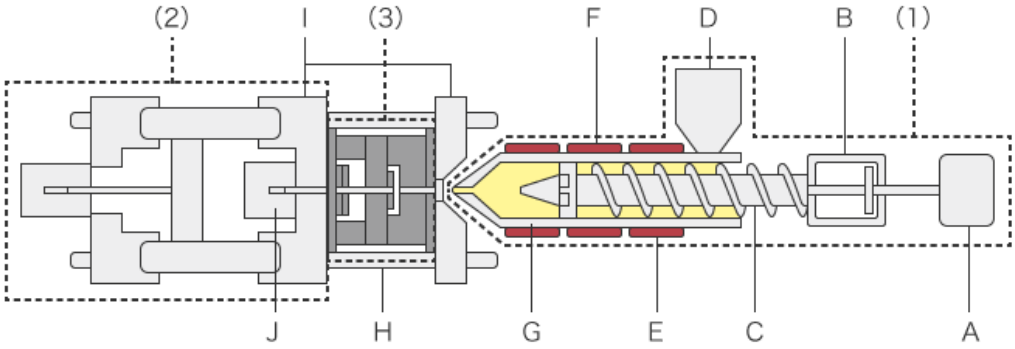
Injection molding is used for molding and mass production of a wide variety of resin products, ranging from small and medium-sized products such as casings and plastic models of electric products, toilet seats, for bath chairs and toilets, to large parts such as automobile bumpers It can be said that this is a typical resin molding method.

1) Injection molding types

Injection molding includes "insert molding" in which resin is integrally molded with metal parts and there are, "multicolor molding" and "different material molding" in which resins with different colors and materials are integrally molded, and these are called "composite molding".

Moreover, there are "film insert molding" or "film-in mold molding" as a method of "decorative molding" for giving a print or a high-class feeling on the surface of the injection molded item.

2) General injection molding machine structure



A. Motor, B. Injection mechanism, C. Screw, D. Hopper, E. Heater, F. Plasticization mechanism, G. cylinder, H. tie bar, I. clamping mechanism, J. ejection mechanism, (1) injection device

a) Injection molding Process

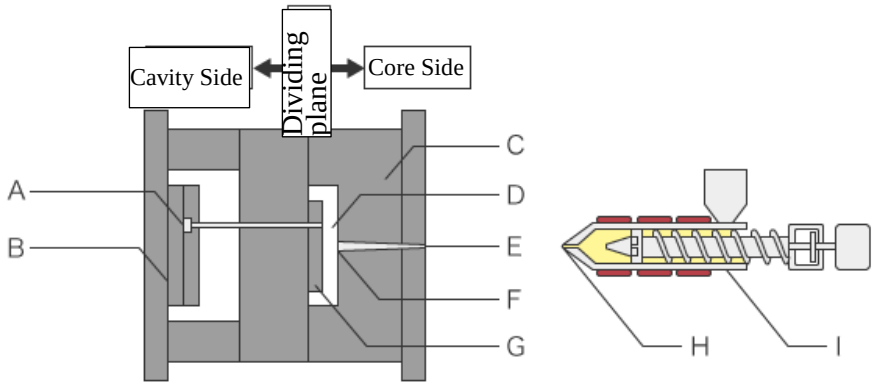
Plasticization mechanism	The molding material is heated and melted (plasticized) in a cylinder
Injection mechanism	The molten resin is extruded with a screw, weighed, and poured into a clamped closed mold. Control the screw speed and push out a fixed quantity of molten resin.

b) Clamp, Eject

○

Clamping mechanism	Close the mold (clamping). After injecting the material, it is cooled and solidified with cooling water from outside. At that time, since the resin shrinks and the volume decreases, the material is further supplied to maintain the pressure in the mold (hold pressure).
Ejection mechanism	After filling the material, open the mold and take out the molded product

3) Mold (Example of mold for injection molding)



A. Ejector pin, B. Ejector plate, C. Female mold, D. Cavity, E. Sprue F. Gate, G. Male mold, H. Nozzle, I. Ejector

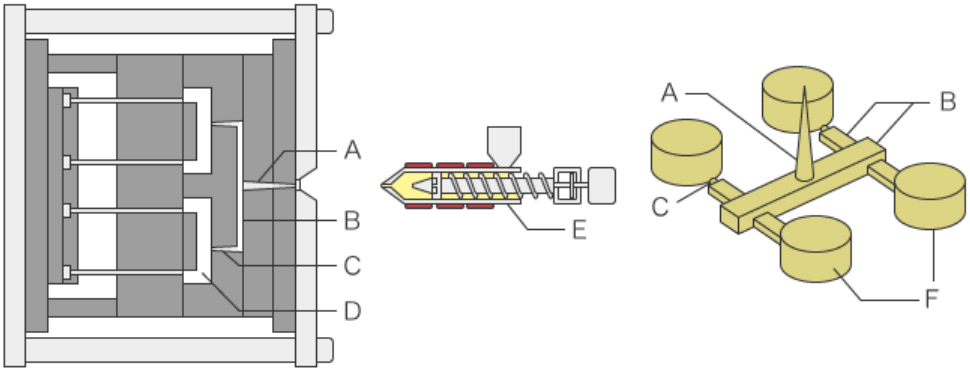
a) Molding process in mold

i. The molding process “female mold” in the mold is attached to the injection device side (Core side) and the “male mold” is mounted on the mold clamping mechanism side (movable side) and molten resin is injected in Cavity.

ii. The injected molten resin flows from the "sprue" in the mold through the "gate" into the "cavity".

iii. After the resin filled in the mold is cooled and solidified, the “ejector pin” fixed to the movable side “ejector plate” releases the molded product in the mold by releasing it.

b)"Multiple cavities" molds and injection molded parts



A. sprue, B. runner, C. gate, D. cavity, E. injection device, F. molded article

i. In case of "multi-cavities" where two or more molded products are made simultaneously, the injected molten resin first enters the mold from "sprue", passes through the "runner" and passes through the "gate" to each "cavity" Melted resin flows into cavity. By cooling and solidifying this, it becomes an injection molded product.
A part called sprue runner gate is also formed on the molded product side, and by cutting the gate, a large number of molded products can be obtained.

4) Defects and deficiencies caused by injection molding

In injection molding, it is necessary to be careful of following defects and errors.

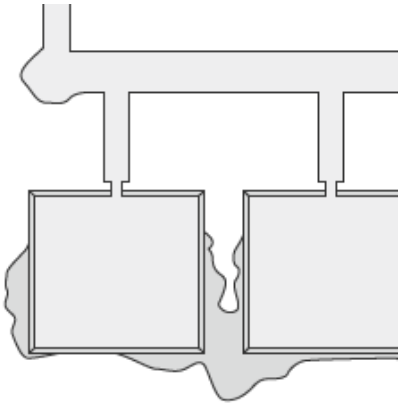
【Surface】

a) Burr

The resin projects out from the parting line of the molded product.

［Root Cause］

- The injection pressure is high
- Insufficient clamping force
- A large amount of resin
- Mold distortion



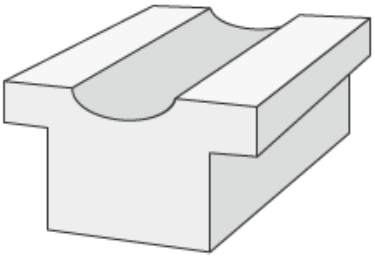
b) Sink Marks

The surface of the molded product is recessed.

②

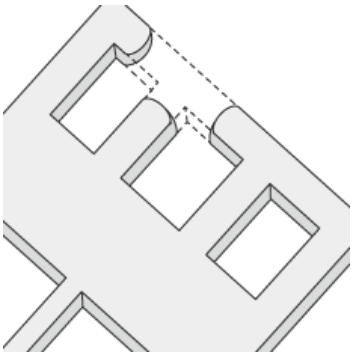
［Root Cause /Counter Measure］

-When molten resin shrinks, cools or solidies in the mold and the absolute amount of resin in the mold is insufficient. The phenomenon in which "sink marks" appear inside a molded article is called "air bubbles (voids)" or "inner mark". Cooling the material in the mold as a countermeasure adjustment of speed (cooling inside first) Optimization of cooling water pipe, adjustment of material quantity, etc.



c) Short Molding

A part of the molded article is missing forming an incomplete shape.



［Root Cause /Counter Measure］

- The resin reaches the end of the mold cavity

It was cooled and solidified before it was completed. The cause is

Insufficient amount of resin, injection pressure, inside of resin mold

Inflow into the water is not smooth. Measures

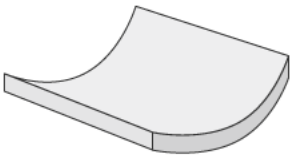
Increase injection pressure

Mold maintenance (shine),

Optimization of mold temperature

d) Deflection

The molded product is distorted in one direction.



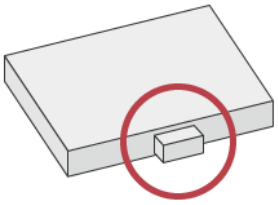
［Root Cause /Counter Measure］

- Excessive force applied when removing molded part from molds, etc. Deformation due to external force applied during mold release. The difference in the shrinkage of the molten resin depending on the flow direction can be another cause for this.

Countermeasure : adjustment of mold temperature (change temperature balance on Sink Mark side and change the temperature balance and control contraction speed, correction of ejector etc.

e) Gate remaining

After cutting, solidified resin remains in the gate part of the molded product

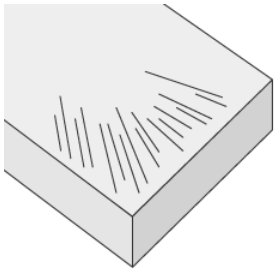


［Root Cause /Counter Measure］

When the gate portion is not solidified, the cut position of the gate becomes unstable, and the solidified resin remains in the gate portion of the molded article after cutting. As a countermeasure, adjust the injection time and mold opening speed.

f)Silver streak black streak

Silver white glittering in the flow direction of the resin
After streaks (striations) remain.
"Black streaks" are on the surface
There are black streaks.



［Root Cause /Counter Measure］

- "Silver streak" is caused by insufficient drying of molding material (pellet) and water droplets generated by temperature difference between mold and material.
- "Black streaks" are produced by mixing the carbonized resin heated in the cylinder at the time of injection. Measures include equipment maintenance (contamination removal in piping) mold and injection material temperature adjustment.

g)Weld Line or Parting Line

Welds in the mold appear on the surface as grooves or patterns.

○

［Root Cause /Counter Measure］

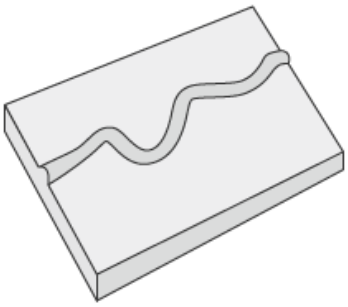
This occurs when the temperature or flowability of the molten resin is low, or the injection pressure and speed are insufficient, in "multi-cavity" or insert molding where there are multiple gates. Measures vary depending on parts and materials, and individual measures due to causes such as injection conditions, temperature conditions and mold structure are necessary.

h) Jetting

Marks like a butterfly remains on the surface.

［Root Cause /Counter Measure］

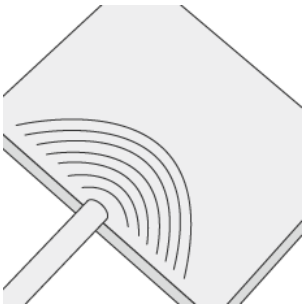
- Temperature of molten resin to be injected is low
- It occurs when the injection speed is too fast.
- The temperature was lowered in the mold early in the injection



Viscosity increases without melting the resin, and fusion with subsequently injected high temperature resin did not occur. As a countermeasure, lower the injection speed. Increase material temperature.

i) Flow Marks

Tree-ring-like wave pattern is generated in the center of the gate.



［Root Cause /Counter Measure］

・The temperature of injected resin is low

・It occurs when the injection speed is too slow.

・Cooled and cooled in the middle of flowing in the mold

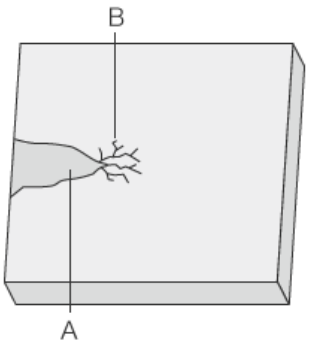
The cause is resin of the tip with high viscosity and the resin extruded later overlap. As a countermeasure, increase the injection speed. Review gate shape

j) Crack Crazing

Sinks marks and thin cracks occur

A.Crack

B.Crazing



［Root Cause /Counter Measure］

It is caused by external force and internal stress of molded parts. ⇒ When the molten resin is applied in the process of resin molding, the internal stress remains in the molded product due to the difference in molecular orientation and solidification ratio, which causes defects and issues such as “deflection” and “chipping”. Mold temperature adjustment and control as a countermeasure, review of injection parameters.

・**Blow Molding**

"Blow molding" is a technology that applies the old glass bottle manufacturing process, and is suitable for manufacturing hollow resin (plastic) moldings.

It is also called "blow molding" or "hollow molding" because gas is blown from the inside of the molten resin, expanded and molded.

Also, "multi-layer blow molding" has been developed, in which a plurality of molding materials containing different types of resins are molded in layers, and gasoline tanks and intake manifolds of automobiles are now made of Plastic.

1. Type of blow molding

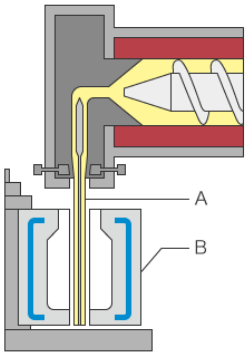
There has been great demand as a method for molding hollow-structured resin products such as containers, and with the evolution of plastic molded materials, the application range of blow molding has been expanded, and it has become possible to manufacture a wide variety of resin products.

Representative Blow Molding: The following two examples are described.

a) Extrusion blow molding (direct blow molding) The resin that has been heated and plasticized is extruded, a cylindrical "Parison (hot parison)" is molded with a die, and it is put into the mold directly without cooling and solidifying it, blow air into it and form the shape.）

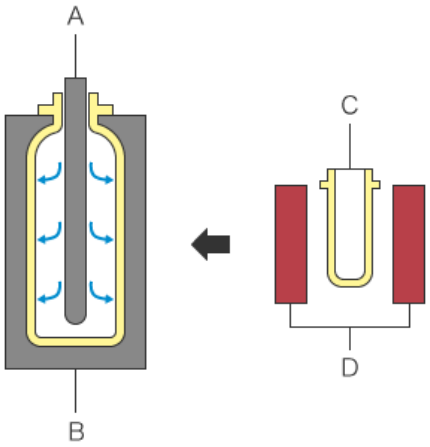
A. Parison (hot parison),

B. Mold



b) Injection blow molding (injection stretch / 2 axis stretch blow molding)

A thermoplastic resin is injection molded in advance as a test tubular “preform (cold parison)”. It is reheated in the next process, stretched into the mold with a "stretching rod" and blown with high pressure air to form. As typical products, plastic bottles made of polyethylene terephthalate (PET) can be given as examples.



A. Stretching rod, B. Mold, C. Preform (cold parison), D. Heater

In blow molding, temperature control of the material is particularly important.

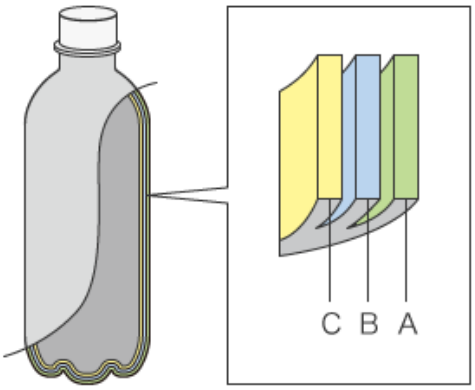
When extruding "parison (hot parison)", if the temperature is too high, "draw down" will lead to uneven thickness of the molded article. Even with "pre-foam (cold parison)", if it is not maintained at an appropriate temperature after reheating until it becomes soft, the thickness will be uneven and the blow process is performed to prevent such defects and problems, maintain precise control of resin temperature unique to blow molding.

【Draw Down】

In blow molding, when the viscosity of the molten resin is low, a phenomenon in which the preformed parison sags in the direction of gravity under its own weight. In the case of uneven thickness, the thickness of the upper and lower parts of molded articles such as containers will be uneven. On the other hand, in extrusion lamination etc., drawdown property of the resin will be higher in proportion with higher the productivity because high-speed take-up is possible.

c) Multilayer Blow Molding

Used in the manufacture of multi-layered resin containers. Two or more material resins are "jointly extruded" to form a multilayer "pre-foam (cold parison)". It is heated, air is blown into the resin in a mold and blow molded. This molding method using joint-extruded parisons is suitable for molding plastic containers such as gasoline tanks.



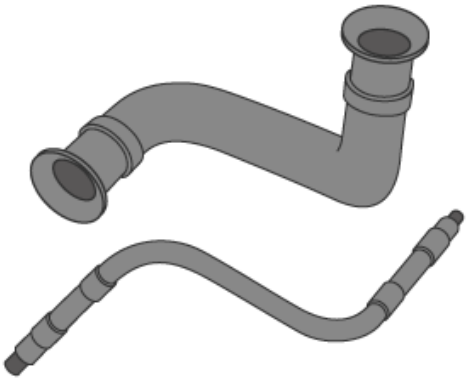
A. Polyethylene (pe), b. Adhesive layer, c. Ethylene / Vinyl Alcohol Copolymer (EVA)

d)3 Dimension blow molding

Using a computer control, the cylindrical parison is guided to lie down along with the complex mold shape.

Unlike "extrusion (direct) blow molding" where parisons are inserted in the longitudinal direction, it is possible to avoid material drawdown and flashes formation.

This molding method can produce high quality products of complicated shapes having curved portions and bellows, such as cooler hoses and heater hoses.



1) Blow Molding Machine

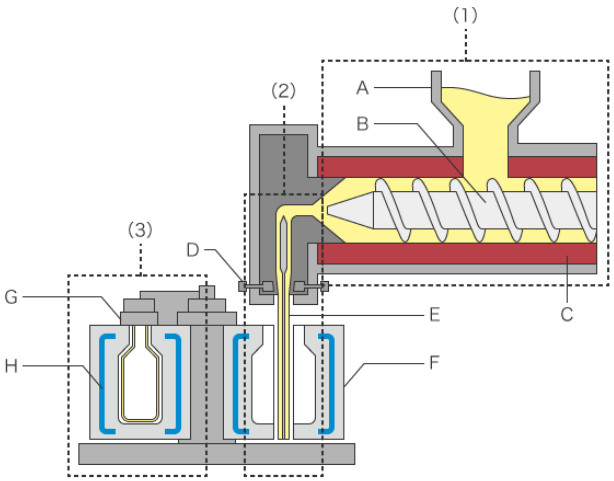
The blow molding machine mainly includes three mechanisms of (1) An Extruder (2) Parison Molding (3) Mold Clamping, Air Blow (Blow Process) and Cooling.

Structure of extrusion blow (direct blow) molding machine

A. Hopper, B. Extrusion screw, C. Heating cylinder, D. Die, E. Parison,
F. Mold, G. Air blow device, H. Cooling water hole

2) Plastic Press Machine

In the "extruder or plastic press machine", heated-mollt en resin (plastic) is extruded from a ring-shaped die. In some cases, the production efficiency is enhanced by continuously extruding the resin using a plurality of dies.



3) Parison Molding

"Parisons" that are preformed before the blowing step can be widely classified in 2 types.

Parison (Hot Parison)

In the case of "extrusion blow molding (direct blow molding)" shown in the figure, extrusion and blow processes of "parison (hot parison)" are performed continuously.

At first, it is also called "hot parison" because it is performed by extrusion molding a cylindrical (paronless) "parison", put into a mold with remaining heat, and blow molded.

Prefoam (cold parison)

In the case of “injection blow molding (injection stretch / double-axis stretch blow molding)”, injection molding of the “preform (cold parison)” as a material and blow molding are performed separately.

It is also called "cold parison" because it is injection molded in advance as a test tube (bottom) "preform" and allowed to cool and solidify a thermoplastic resin.

In the next process, it is reheated and blow molded. Because "preform (cold parison)" is small and highly portable, it may be purchased as an intermediate product from material producers.

(1) Clamping, Air Blow (Blowing Process), Cooling

When the container is formed by "extrusion blow molding (direct blow molding)" shown in the figure, the bottom portion of the cylindrical "parison (hot parison)" is formed by clamping.

By blowing compressed air into the parison, the resin is pressed against the inner wall of the cooled mold to cool and solidify the resin inside the mold, and then the mold is opened and the molded article is taken out.

(2) Defect, Failure Caused By Blow Molding

Various phenomena occurring in the blow molding process affect the quality of the molded article. For example, the drawdown that occurs in extrusion blow molding (direct blow molding) causes uneven thickness shape defect.

Moreover, “melt fracture” is a phenomenon in which the flow of molten resin is disturbed at the time of extrusion of a parison (hot parison), resulting in surface defects such as surface roughening of a molded product, and it occurs in all plastic moldings having an extrusion process.

Shape

Uneven thickness, flashes, dents, sink marks, bubbles in molded products, etc.

Vacuum Molding

A sheet / film of resin (plastic) extruded in advance is used as a molding material. The heated and plasticized resin is placed on a mold, and the space between the plastic and the mold is vacuumed, and then plastic is molded by suction into the mold. Vacuum suction and compressed air may be used in combination.

The mold is suitable for small lot production at relatively low cost since it can be molded on either side of the male or female mold.

Vacuum forming has various applications from thin-walled resin containers such as egg packs and food trays to big-size products such as automobile instrument panels and bumpers.

Small products can be molded continuously, but for large products such as automotive bumpers, one molded part is produced per molding.

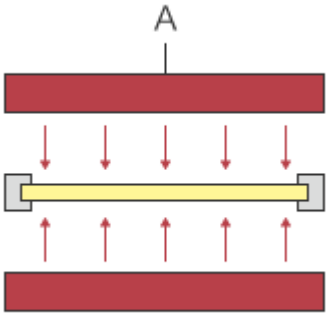
(1) Product example using vacuum forming

(2) Vacuum Forming Mechanism

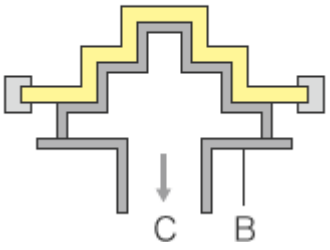
In vacuum forming, there are the mainly following three processes.

Equipment and process of vacuum forming

1) Material Heating And Plasticization



2) Forming & Cooling

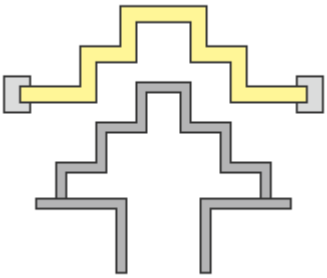


A. Heater, B. Mold, C. Vacuum suction

3) Release after solidification

The plastic sheet or plastic film of molding material is heated by a heater and plasticized.

Place the plasticized molding material on the mold and "vacuum suction" from inside the mold to mold and cool. After the resin solidifies, it is ejected.



4) Air Pressure Forming

A molding method in which resin (plastic) is pressurized with compressed air and the shape of the mold is copied. A plastic sheet or a plastic film is used as the material same as in case of vacuum molding.

Since the material can be brought into close contact with the mold at a pressure higher

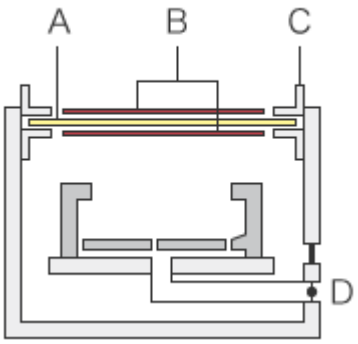
than vacuum forming therefore, a sharp shape is possible to be formed. This molding method is applied to the manufacture of automobile interiors and front covers for medical devices.

Pressure Molding Mechanism

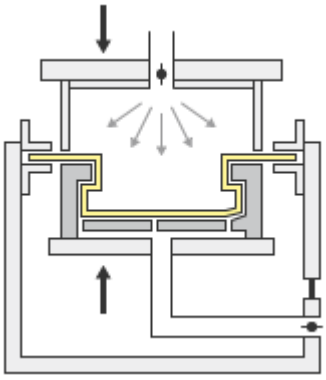
In air pressure forming, there are the following three major processes.

Equipment and process of pressure forming

1) Material Heating And Plasticization

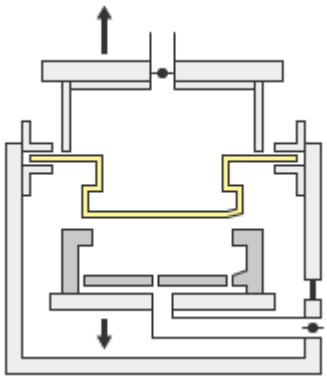


2) Forming & Cooling



3) Demold after solidification

A. sheet, B. heater, C. clamp frame, D. vacuum valve



The plastic sheet or plasticn film of molding material is heated by a heater to be plasticized. Place the plasticized molding material on the mold, press it with "compressed air" and shape and cool. After the resin has solidified, it is ejected.

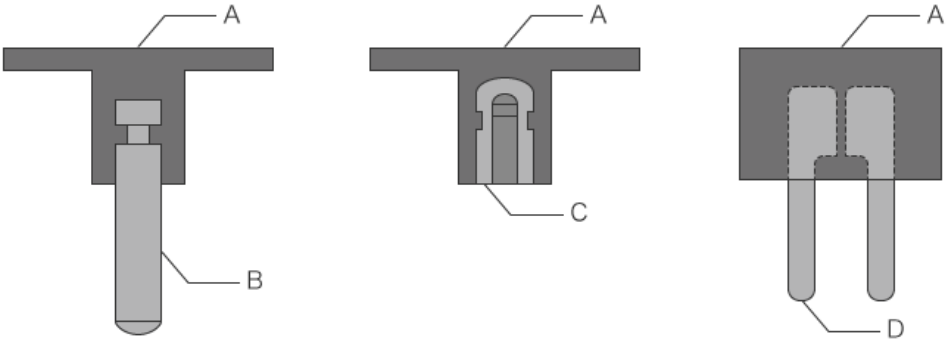
Defects and defects caused by vacuum forming and pressure forming In “vacuum forming” and “pressure forming”, it is necessary to be careful about following defects and failures.

Shape: uneven thickness, flashes, etc.

4) Insert Molding

A method in which metal screws and terminals (inserts) are placed in a mold before molding and resin (plastic) is injected around it, and it is integrally molded (composite molding). This molding method is often used in the manufacture of electronic parts such as connectors and switches utilizing the insulating property of resin, and tools such as drivers and pliers.

Example of Insert Molding



A. Molded resin (plastic), B. Metal rod, C. Metal screw, D. Metal Terminal

5) Multicolor Molding / Different Material Molding

A technology for combining and integrally molding plastics of different colors and

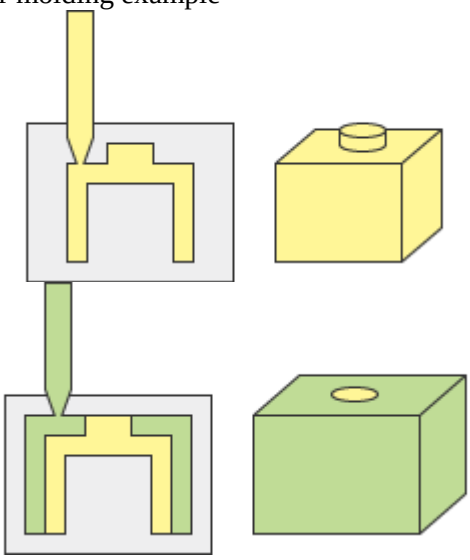
materials.

In case of "2-color molding", resins of respective colors are sequentially injected and heat-fused using two types of molds.

There is also a method of simultaneously injecting resin of different colors and materials for each part at the same time to the same mold, and integrally molding it.

It is widely used because molding with added design and functionality is possible.

2-color molding example

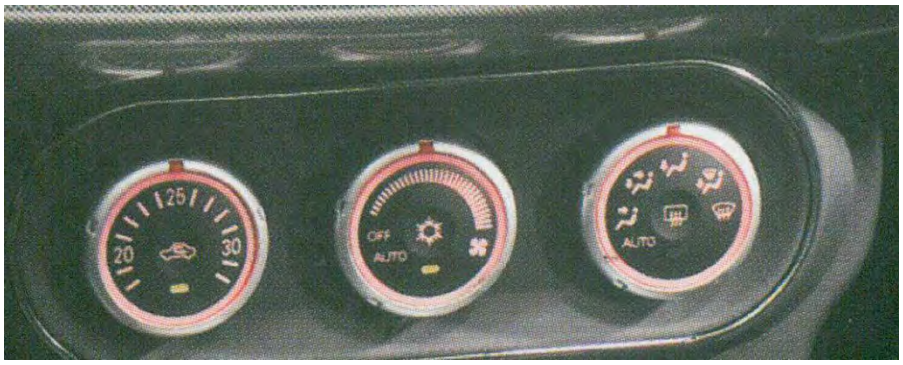


6) Decoration Molding (Film Insert Molding / Film in Mold Molding)

In film insert molding, characters, woodgrain, hairline tone, film for decoration with a carbon-like pattern, gloss, matte, etc. printed on the surface is set in the mold before molding, and plastic film in the mold are bonded together by heat and pressure at the time of injection molding, by forming in a single product.

In "film in-mold molding", a decorative film is set in a mold and "transfer" the film decoration to plastic during injection molding.

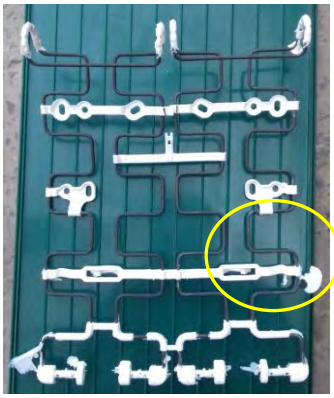
These "decorative molding" are used for logos and characters of resin products, membrane switches of electric products, and surface textures of automobile interior parts (plastic parts such as shift panels).



①

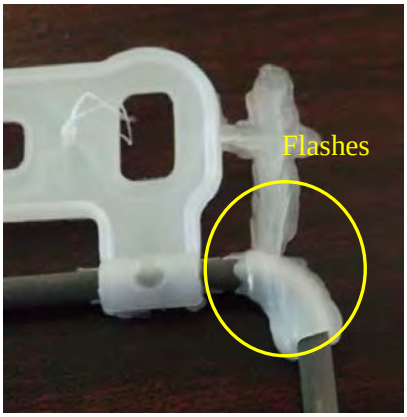
【Examples in Pakistan】

Spring



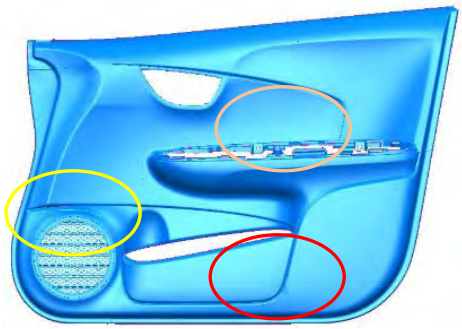
Flashes

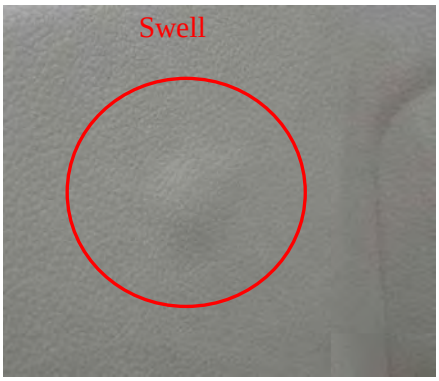
Crack

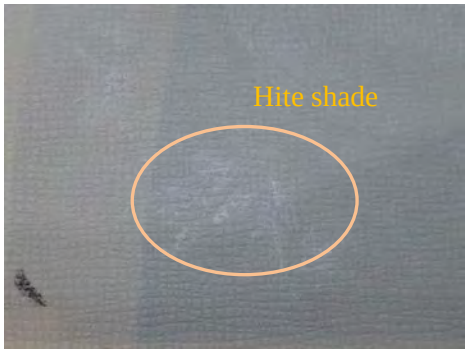


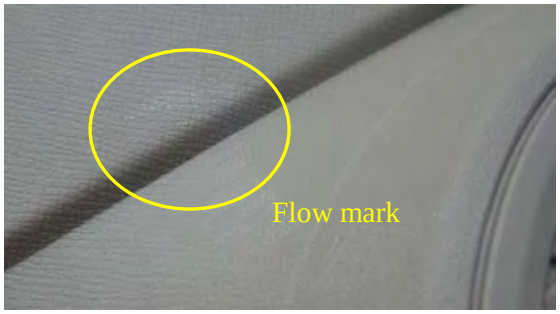
Removal is difficult when flashes come out, and cracks cannot be repaired (rejected). Reduced by mold repair and mold temperature control (5 => 3%). Considering a hot runner for further reduction.

Door trim



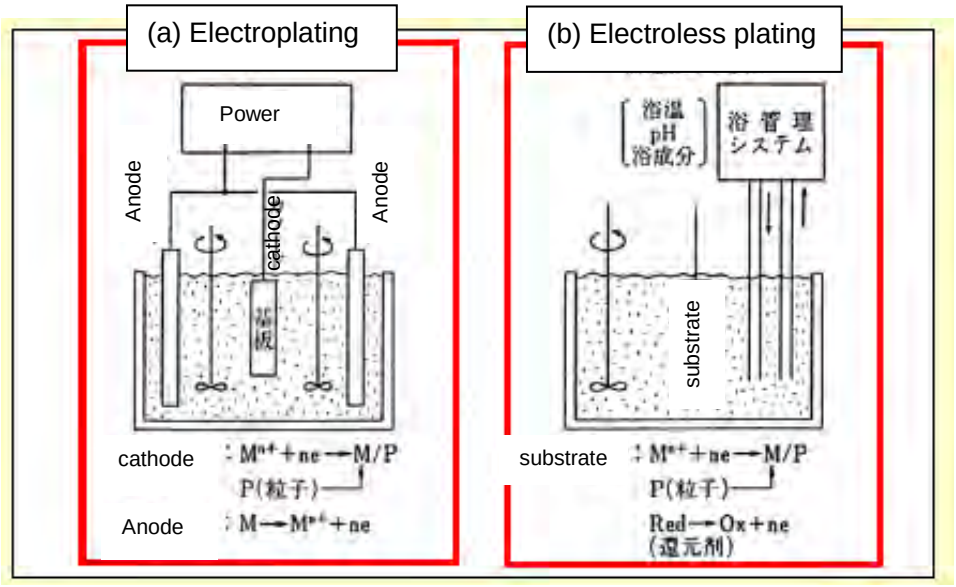






④Plating

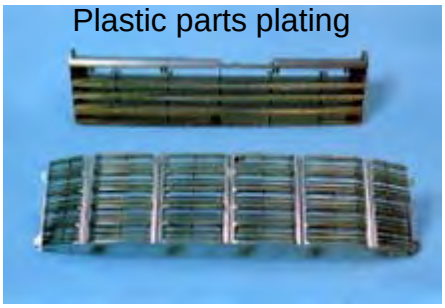
No	Contents	A	B	C
①	(1) Types of plating Plating is a method of reducing metal ions dissolved in the solution to the parts to be plated. There are two methods. One is (a) Electroplating method using a DC power source, and the other is (b) Electroless plating method (chemical plating method) use the reaction of metal ion and reducing agent (hypophosphorous acid, formalin, etc.) which presents in the solution.	○		



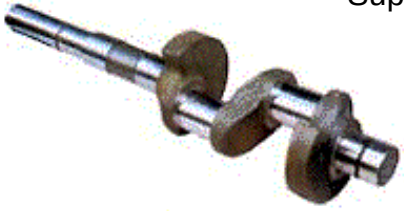
1) Metal electroplating

Electroplating is an electrolytic plating method performed with a direct current. The material to be plated (steel, resin, etc.) is immersed in a solution containing the metal cations to plate (Cr +, Ni +, Zn2 +, etc.). By applying voltage, the cations in the solution are adhered on the surface of the conductive object. The cations adhering to the metal surface are reduced to metal atoms to form a plating film.

Auto parts are used for decorative purposes, the improvement of corrosion resistance and surface hardness.



Super Hard Cr. plating



(2) Electroplating process and features

When manufacturing galvanized steel sheets and the like, generally, a continuous process of "steel strip → de_oiling → pickling → plating → chemical conversion treatment" is performed.

1) Degreasing process

Degreasing is an important process performed for the purpose of removing surface oil for the purpose of uniform adhesion of the plating solution.

1. Solvent cleaning method (Degreasing with organic solvent, immersion method, spray method and steam method)
2. Alkali cleaning method (Degreasing by chemical reaction with alkali, dipping method, spray method, electrolytic method, ultrasonic method)
3. Emulsion solvent cleaning method (Degreasing, immersing method, immersing / stirring method, spraying method with solvent dispersed in water)

2) Pickling process

The purpose is to remove adhered oxide film, rust, and inorganic dirt that cannot be removed in the degreasing process. A combination of an inorganic acid and a corrosion inhibitor is used for chemical removal.

Sometimes physical methods such as ultrasonic irradiation are combined.

3)Plating process

Cyanide bath has been widely used as a plating bath. Cyanide bath is aqueous solution containing ZnCN2 +, sodium cyanide and sodium hydroxide, also called a blue bath.

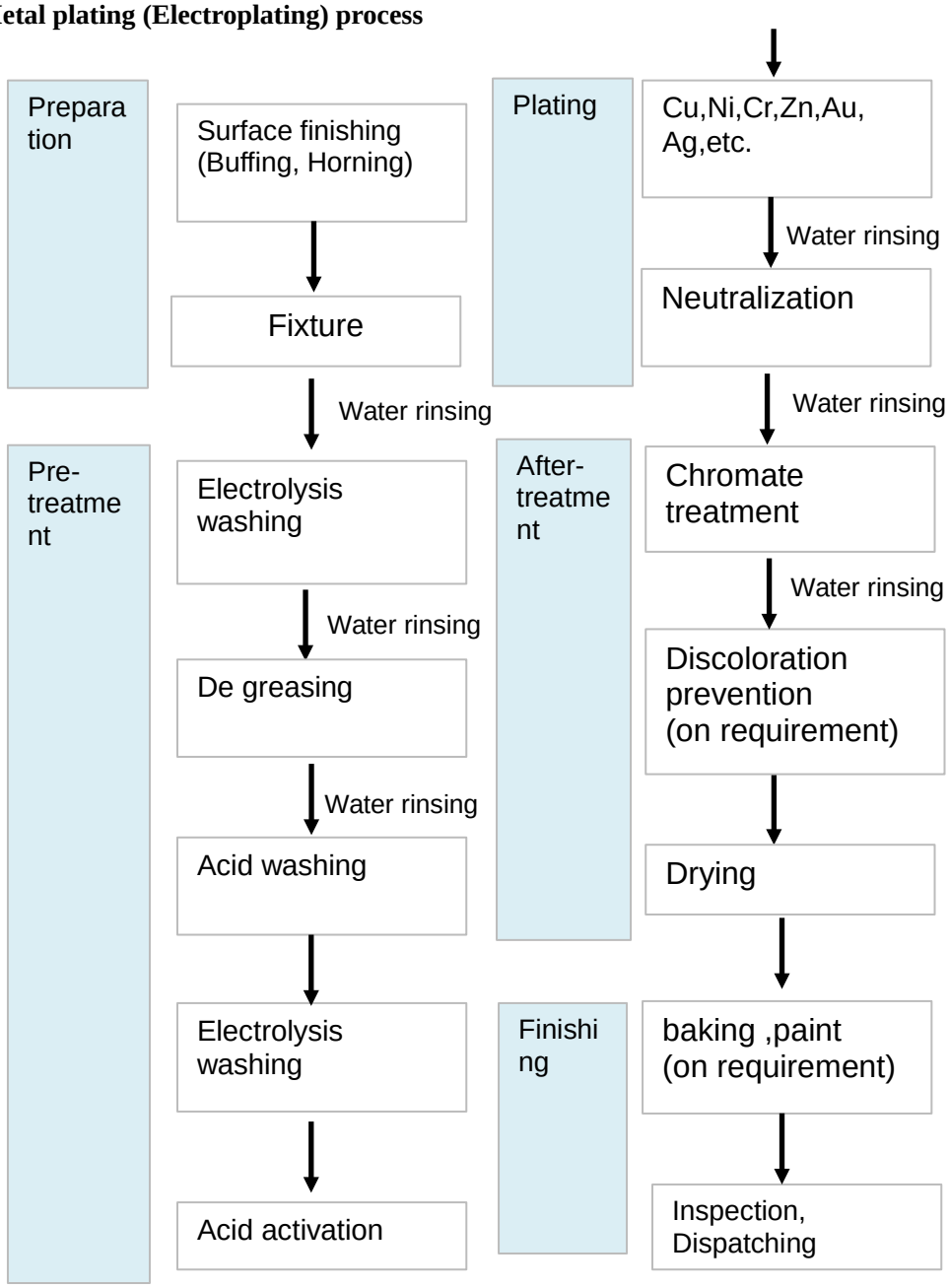
In recent years, examples of using baths that do not use cyanide (zincate bath, acid bath) are increasing due to the issue of wastewater treatment. The zincate bath is a bath mainly composed of zinc oxide and sodium hydroxide. The acidic bath is a bath mainly composed of zinc chloride, ammonium chloride or potassium chloride.

In these baths, brighteners and additives are used to adjust the finish. In general electro galvanizing, conditions are 20 to 35° C, DC voltage of 3 to 10V, and current density of 50 to 800A / m2 are adopted.

4) Post-process

To prevent discoloration and rust, perform treatment with chromate and discoloration prevention liquid (organic) as necessary. In Cr plating, baking is performed to prevent hydrogen embrittlement.

Metal plating (Electroplating) process



(3) Resin plating

1) Difference from metal plating

Since resin is a nonconductor, it is necessary to make the plated surface conductive. For this reason, etching, catalyzer, accelerator, and electroless Ni plating that are not found in metal plating are required. In addition, a strike nickel plating process for ensuring adhesion and a copper sulfate plating process are required for surface modification.

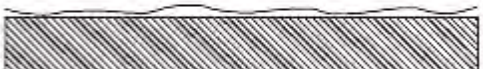
Compared to metal plating, there are many processes, and it is difficult to manage because it mainly consists of decorative parts and the appearance quality is severe. (In automobiles, Radiator grille, garnish, etc. have increased in size in recent years, and the suppliers that can be manufactured are limited.)

(4) Resin plating process (indicates example conditions)

a) De-Greasing

Ensure wettability (adhesion) in the next process (Etching).

Does not come into contact with liquid due to repelling.

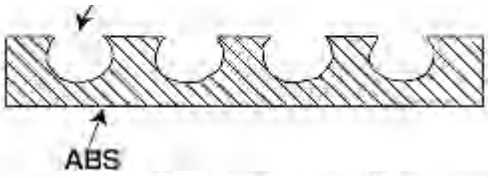


The wetness is good and the whole comes into contact with the liquid.

b) Etching

The butadiene in the resin is scientifically dissolved with Cr acid-sulfuric acid to form a micro crater on the surface to ensure adhesion.

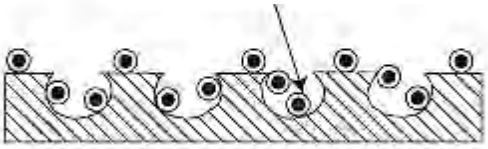
Holes are formed by dissolving the butadiene part.



c) Catalyzer (addition of catalyst)

When immersed in a solution, Pd and Sn colloids are adsorbed on the resin surface.

Colloid of palladium and tin.

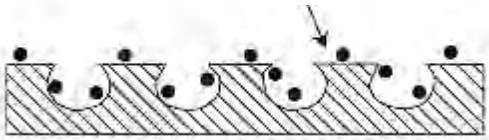


Catalyzer / Activator
PD Activator: 100ml/L, HCl: 200ml /L
Time: 4~5min, Room Temp.

d) Accelerator

By the reaction, Pd ions are metallized and become a catalyst for chemical plating.

Palladium

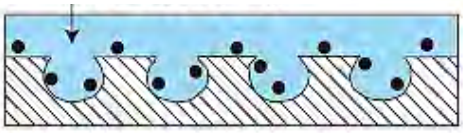


Accelerating
Sulfuric Acid: 10% of Volume
Room Temp.,
Time: 4~5min.

e) Chemical nickel

(Electroless Ni plating)
The resin surface is made conductive for electroplating.

Formation of chemical nickel film



Electroless Nickel
Nickel sulphate: 29g/l, Sodium Hypophosphate: 29g/l
Sodium Citrate:-29g/, Room Temp. Time: 8~12min

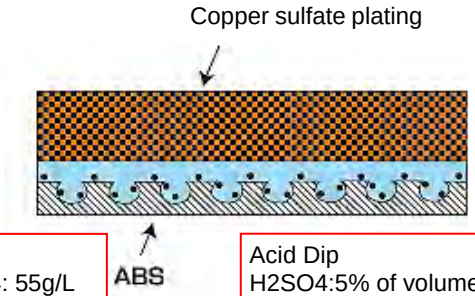
f) Strike plating

Strengthening the film thickness at the contact point between the hanger and the product
(Can be omitted depending on the product shape)

Since the film thickness is thin, when a high current is applied, the contact portion sparks and the plating film disappears.

g) Copper sulfate plating

Copper plating is thickened to meet the product's weather resistance (heat resistance, cold resistance) and surface accuracy.

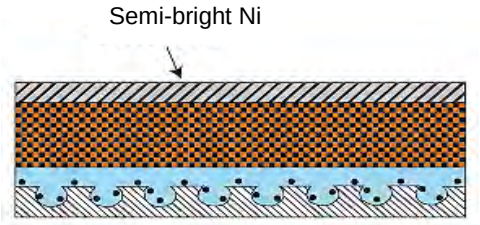


Acid Copper
CuSo4:160g/L, H2SO4: 55g/L
NaCl: 93mg/L,
Time: 40~50min
Room temp. 2~3Amps/dm2

Acid Dip
H2SO4:5% of volume
Room Temp.
2~5dip

h) Semi-bright Ni plating (S-Ni)

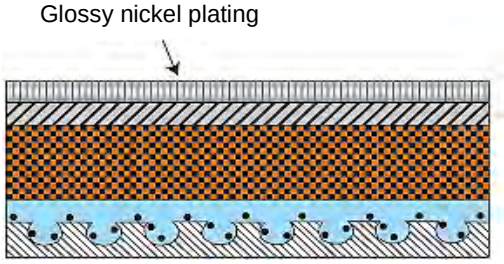
Protection of the base (Copper)
Improve rust prevention by adding a potential difference from the next process (Glossy Ni).



Semi-Bright Nickel
Nickel sulphate:-300g/L, Nickel Chloride:-35g/L
Boric Acid:-45g/L, Temp: 50~60C, Time: 18~24min
3~4Amps/dm2

i) Glossy nickel plating (B-Ni)

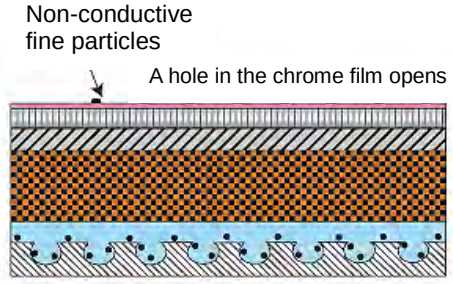
Prevents rust by creating a potential difference from the previous process.



High Sulphur Nickel
Nickel sulphate: 300g/L, Nickel Chloride: 60g/L
Boric Acid: 45g/L,
Temp: 50~60C, Time: 3~5min., 3~4Amps/dm2,
Temp: 50~60C, Time:10~15min.

j) Microporous plating (MP-Ni)

To ensure high corrosion resistance, non-conductive fine particles are co-deposited in the plated layer with fine holes.



Microporous Nickel
Nickel Sulphate: 300g/L, Nickel Chloride: 75g/L
Boric Acid: 45g/L
Temp: 50~60C, Time: 3~5min, 3~4Amps/dm2

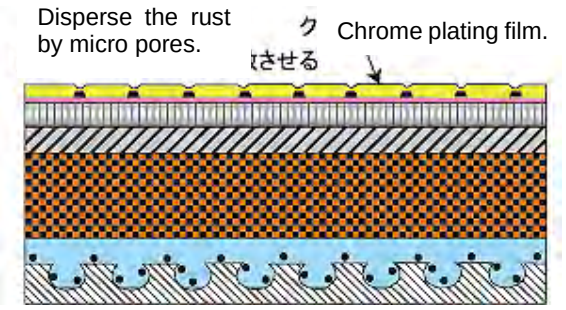
k) Chromate treatment

Immerse the plating surface in a thin chromic acid solution to prevent Ni oxidation.
Improve Cr adhesion in the final process.

l) Cr plating

Hard Cr plating film.

If the film thickness is too large, it will cause cracking.



Bright Chrome
Chromic Acid: 250g/L, Sulfuric Acid: 2.5ml/L
Time: 4~7min., Temp.35~45C, 8 ~10Amps/dm2

m) Water washing, pure water washing, drying

3) Galvanizing

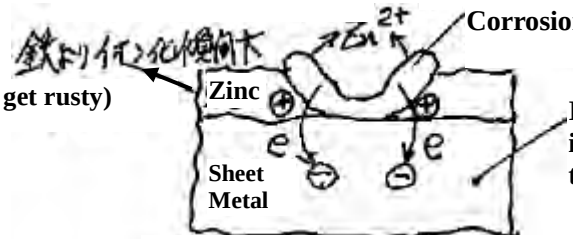
Galvanizing to protect iron from rust

Corrosion Protection Plating → Zinc Plating is frequently used.

Since Zn has higher ionization tendency than Fe (Base Metals) therefore it easily gets rusted. Therefore by galvanized iron metal Zinc corrosion starts first in order to delay iron rust. (Sacrificial Anticorrosive Effect)

Mechanism of Sacrificial Anticorrosive Effect
Zinc has high tendency of ionization than Iron

Dip in hexavalent chromium solution to form chromate film



(Easy to get rusty)

Corrosion generated Zinc Item

Iron has low tendency of ionization than Zinc (Difficult to get rusty)

In order to protect Zn from corrosion after plating → Chromate Treatment

In this case when pinholes are generated and rain droplets cover the surface, Zinc become ⊕ electrode of local battery and iron becomes Θ electrode and current flows from + to - whereas Zinc dissolves first. Moreover, corrosive particles of rusted Zinc cover the surface of iron and work to protect the iron.

MFZn8C

8 μ (Zinc plating film thickness) up to grade in indoor environment with high humidity (Cellar, Chamber)

Plating Process

Pre-Treatment Process ___ Remove the dirt of the base material surface and prepare the raw skin. (Degreasing, Acid treatment)

(Water Rinse)

Plating Process

(Water Rinse)

Post Processing

Prevent corrosion of Zinc plating by Chromate Treatment, in order to prevent easy discoloration, Anti-Discoloration, Pin Holes repair sealing and Drying.

Hydrogen Brittleness Elimination
(By Baking Treatment)

Appearance & Quality Inspection

Importance of Pre-Treatment: In order to achieve good adhesion, a surface which has many metal bonds at the outer surface between plating metal and the base material is produced.

70 to 80% of Plating defects are due to in adequate pre-treatment…. Plating adhesion interfering substances removal.

★ Prepare raw skin (Base Metal) before dipping in Plating solution

Interfering Substances:

1. Oil/fats and Oxides on the base material surface
2. Chemical compounds such as Oxides & Sulfides, etc., and inert substances
3. Re-formed compounds film on the surface.

Zinc sacrifices itself and get rusty first and delays the rust process of iron.
(Sacrificial Anticorrosive Effect)

After plating protect zinc to get rusty by Chromate Treatment (Hexavalent Chrome, Trivalent Chrome).

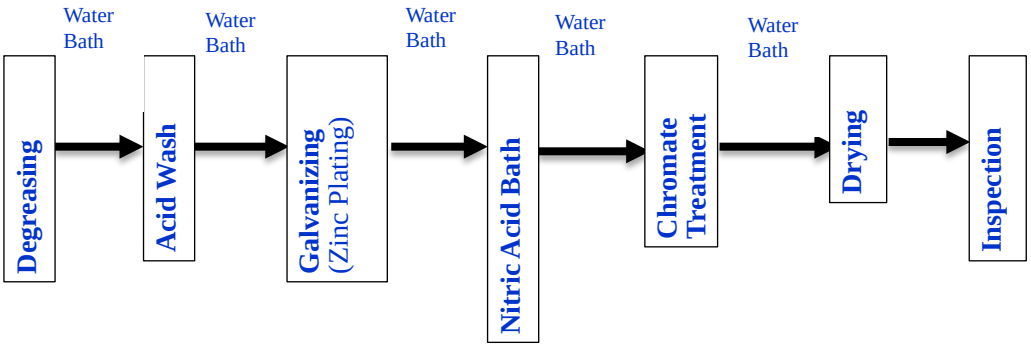
4 Types of Plating Bath Procedures:

Application: Bolts, Nuts and Screws, etc., after Heat Treatment

- Zinc Ammonium Chloride Bath
- Zinc Potassium Chloride Bath } Acidic Plating
- Cyanide Bath
- Zincate Bath (Without Cyanide) } Alkaline Plating

Zinc Plating temperature parameters are…… .

If the temperature is high, then plating reaction is accelerated and causing coarse plating.



No heating in Zinc Plating (Galvanizing)*!!*

Zinc Plating Baths Properties and Application

・Acidic Bath	- Ideal Electric Current ratio - Hydrogen Brittleness hardly occurs during Plating Process.	Heat Treated Parts Bolts, Nuts, Hardware, etc.
・Cyanide Bath		Press small parts, Complex Shape items

- Most common plating bath
- Good for secondary Processing -
Excellent uniform electro depositivity

• Zincate Batch	- CN^- extracted from Cyanide - Alkaline Bath Excellent uniform electro depositivity	Press parts, Bolts, Nuts, Hardware, etc.

Type and chemical composition of zinc plating solution

Solution	Chemical Component	Concentration
Cyanide Bath	Zinc Oxide Sodium Cyanide Sodium Hydroxide	19 ~ 28 g/l 30 ~ 45 g/l 75 ~90 g/l
Zincate Bath	Zinc Oxide Sodium Hydroxide	9 ~ 19 g/l 70 ~ 150 g/l
Ammonium Chloride Bath	Zinc Chloride Ammonium Chloride	31 ~ 104 g/l 150 ~ 200 g/l
Potassium Chloride Bath	Zinc Chloride Potassium Chloride Boric Acid	31 ~ 104 g/l 210 ~280 g/l30g/l g/l

②

Chromate treatment to protect zinc from corrosion

Chromate treatment …. Immerse the plated object in a hexavalent chromium solution to form a chromate film.

- Glossy Chromate
- Colored Chromate
- Black Chromate
- Green Chromate

Chromate Film Layer = Chromic acid Chromium (Conductive)

Heat resistance, corrosion resistance gets weaker at a temperature above 80 °C.

Major chemical components of Chromate solution used for Chromate Treatment.

Chromic Anhydride → Generates Hexavalent Chrome Ions

Sodium Dichromate

Dilute Nitric Acid / Sulfuric Acid

Hexavalent Chrome Film forming Components

Excellent self-repairing and improves corrosion resistance Galvanizing

Hence, Hexavalent Chrome is Harmful

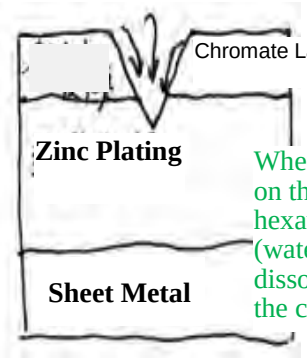
Therefore,

Trivalent chromium conversion treatment is good.

- Solution control range is comparatively strict.

Concentration, Solution PH, Temperature Control is important.

Self-Repairing of Chromate Film



When there is a scratch on the coated film, hexavalent chrome (water soluble) dissolves and repairs the coated fil.

Composition of chromate treatment solution and treatment conditions

Chemical Components g/l	Glossy Chromate	Colored Chromate	Black Chromate
Chromic Anhydride	0.1 ~ 2	4 ~ 10	10 ~ 40
Sulfuric Acid	0.3 ~ 5	0.5 ~ 5	2 ~ 30
Nitric Acid	0.5 ~ 10	1 ~ 5	--
Phosphoric Acid	0 ~ 2	--	0 ~ 20
Hydrofluoric Acid	0 ~ 2	-	--
Acetic Acid	--	-	0 ~ 100
Silver	-	--	0.2 ~ 0.4
Bath Temperature	Room Temperature	Room Temperature	Room Temperature
Soaking Time	0 ~ 30 sec.	10 ~ 30 sec.	30 ~ 120 sec.

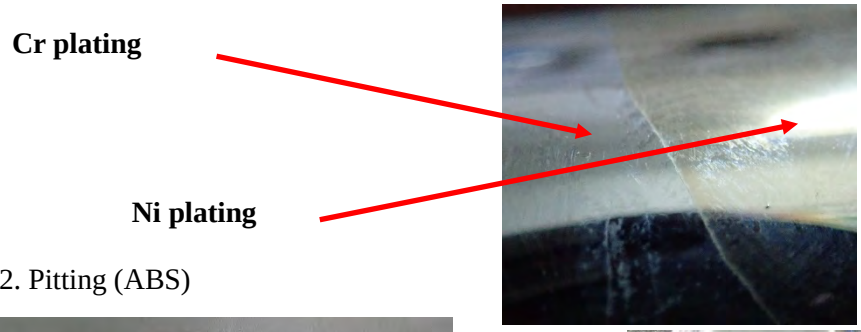
4) Problems and countermeasures

1. Plating peeling (Material: SPCD, t = 1.0)

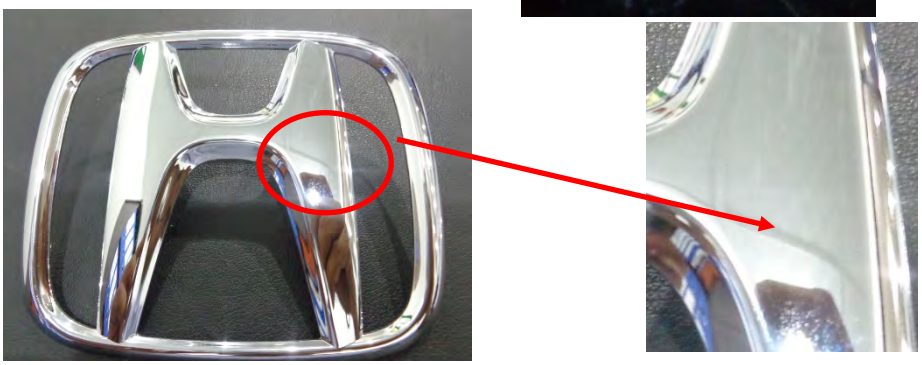
When Ni plating is divided into two layers according to OEM requirements, peeling occurs after Cr plating in the subsequent process. As a temporary measure, the conventional single layer plating was restored.

[Possible cause: Japanese supplier view]

It is considered that the conductivity is lowered due to insufficient pretreatment or the control of chromate treatment is insufficient. In the case of one layer, the adhesion can be ensured barely, but in the case of two layers, the electrical resistance increases and causes adhesion failure.



2. Pitting (ABS)



・Poor appearance（Pitting）

It is presumed to be caused by poor liquid control in the copper sulfate plating process (dirt of the processing liquid) and contamination after pickling and washing after plating. Currently, the chemical solution for copper sulfate plating has been improved by replacing it with a German one.

⑤ Heat treatment

No	Contents	A	B	C
①	**1. Heat treatment and Steel** 1) Classification of Steel Mainly classified into “Normal Steel” and “Special Steel” according to the JIS steel standard. Necessary heat treatment and usage is explained below: (1) Steel for Ordinary Structure: This material is manufactured as a product by cutting or welding and is not normally heat treated, it is a steel material with 0.3% or low C such as SS and SPC. (2) Carbon steel Manufactured by forging and rolling etc. C0.1%-0.6% steel (SC material), and its heat treatment is possible (It may be used as it is forged) (2) Cast iron Iron material with C2-4.5% Carbon and Si added. By heat treatment it is possible to do Quenching to form Martensite by heating and quick cooling like Steel but Chilled type using high carbon and Austemper treatment (both mentioned in detail later) is normally implemented. (3) Special Steel： Elements such as Cr and Ni, Mo, V etc., are added and heat treatment implemented. It is also called alloy steel because of the addition of multiple elements. ⇒ Classification of JIS steels is expressed in Table 1.	○ ○		

Table1

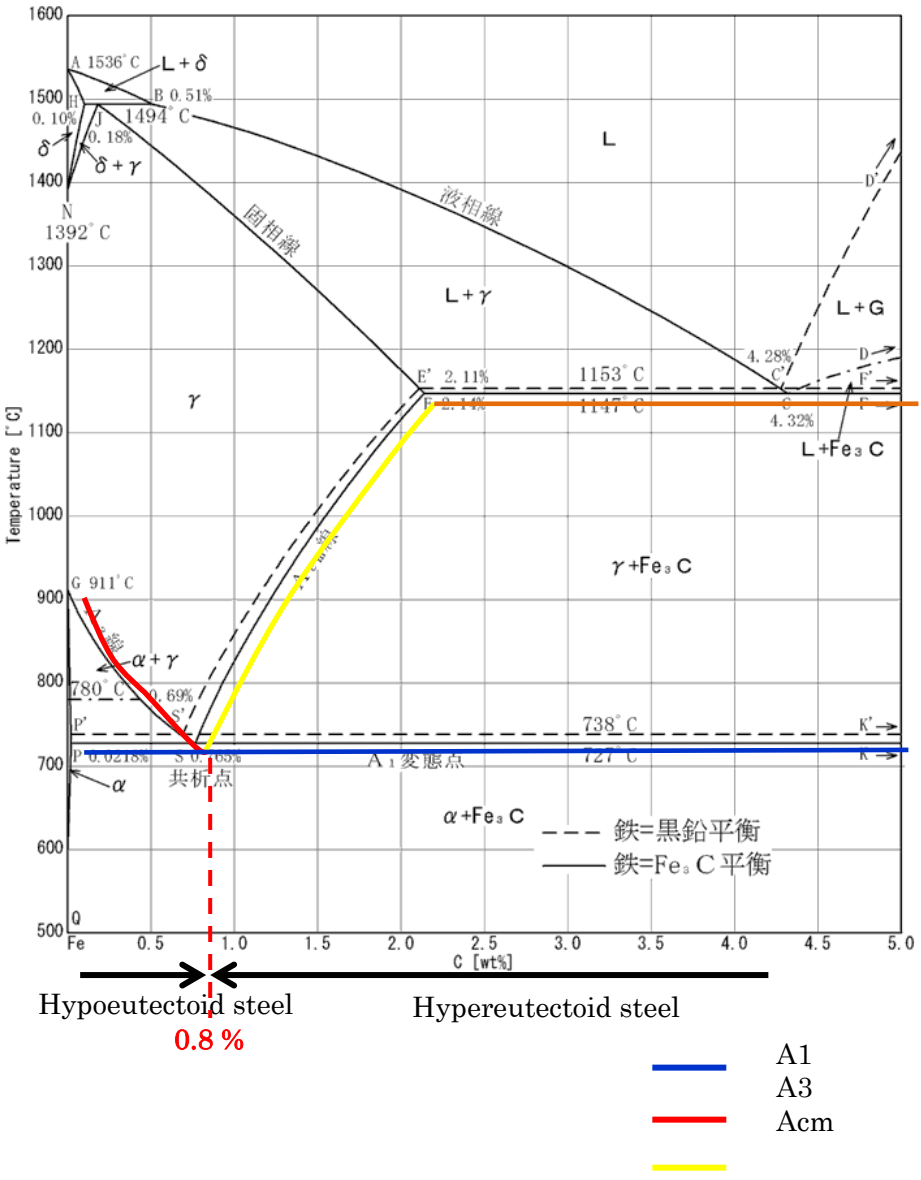
Concrete steel Normally no heat Treatment	SS	C0.1-0.2%	General structure rolled material
	SM	C0.1-0.3%	Rolled metal for welding structure
	SB	C0.1-0.3%, Si	Boiler Sheet Metal
	SPC	C0.03-0.25%	Cold Rolled Sheet metal
Carbon steel With heat treatment	S-C	C0.1-0.55%	Carbon Steel
	H	C0.4-0.55%	Forged hardened steel
Cast iron In case of application of heat treatment	FC	C2.5-4.5%	Normal cast iron
	MB	C2.7-3.0%	Meehanite cast iron
	FCMB	C2.5-3.2%	Black core malleable cast iron
	FCMW	C2.6-3.4	White core malleable cast iron
	FCD	C3.6-3.9, Si, Mn	Ductile iron
Special Steel With heat treatment	SCM	C0.13-0.48%+Ni, Cr, Mo	Cr-Mo Steel
	SK, SKS	C0.6-1.5%	Tool steel
	SKH	C0.4-0.8%, Cr, Mo, V, W	High speed steel
	SUJ	C0.95-1.1%, Mn, Si, Cr	Bearing Steel
	SUP	C0.-0.55%, Si, Mn, Cr, V	Spring Steel
	SUS	C0.1-0.4%, Cr, Ni (Mo)	Stainless Steel
	SUH	C 0.1-0.45%, Si, Cr, Ni, W	Heat resistant steel

2) Classification of Heat treatment

Complete Heat Treatment		Surface Heat treatment	
General Heat Treatment	Special Heat Treatment	Surface hardening treatment	Surface modification treatment
Quenching Tempering Annealing Normalizing	Solution treatment Subzero processing	Surface hardening • Oil, water hardening • Induction hardening • Carburizing	Nitriding Surface lubrication Surface improvement

2. Method for Heat Treatment

1)Relationship between Temperature and Treatment



(1). Quenching

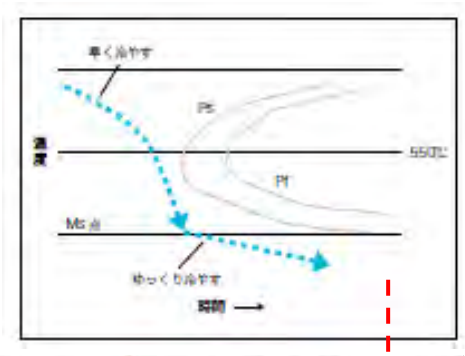
a. Heating

i) Hypo-eutectoid Steel (Steel below C0.8 %)

It changes from Ferrite(α) + Austenite(α+γ) to Austenite(γ) at the boundary of A3. To coarse iron, before quenching the iron it is necessary to carry out the heat treatment of A3 at the lowest temperature.

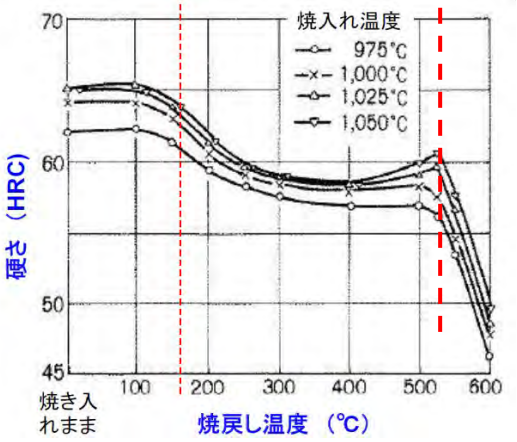
ii) Hyper eutectoid Steel (Steel above C0.8%)
Below A1 is Pearlite (α + cement (Fe3C)), Pearlite will become Austenite if it exceeds A1. All of it will become γ if it exceeds Acm. For this reason, in case of tempering, it is necessary for the treatment to be above A1 and below Acm.

b. Cooling
Choose a speed that does not touch the Ps curve, where Pearlite and Ferrite start separating. Instantly cool down to the top of the Ps curve to 550℃, after that slowly cool down such that the curve is not crossed. By doing this, Austenite is left over without precipitating, and after exceeding Ms point, it is pulled up by a cooling medium such as water or oil, and heat is removed by air. This is done to avoid sudden Martensite changes.



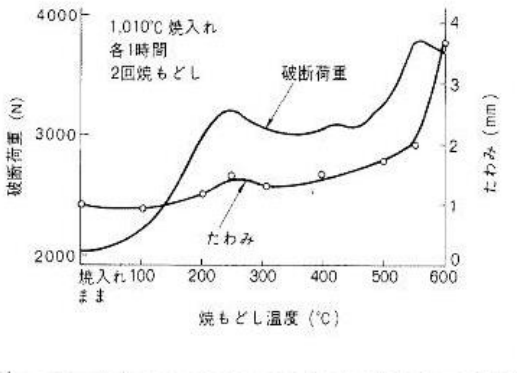
(2) Tempering, Annealing, Normalizing

a. Tempering
Steel gets hard and brittle only by quenching treatment. This is done to adjust the hardness and increase the toughness of the structure. The process includes high temperature tempering and low temperature tempering.



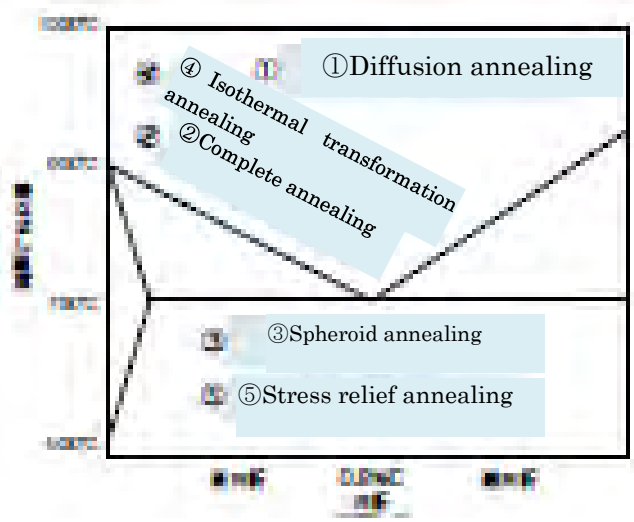
i) Low temperature tempering
By performing a process at 150-200C, Martensite structure becomes a toughened tempered Martensite. Resistance to abrasion and cracking can be prevented.

ii) High temperature tempering
Gears and tools that require high toughness are tempered at 550-650C, residual Austenite is decomposed and high elastic limit is achieved.



b. Annealing

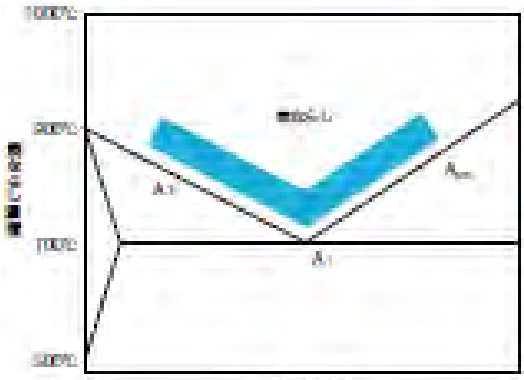
This is a heat treatment method in which the metal material is heated to an appropriate temperature, and after sufficiently holding the steel in the austenite structure, it is gradually cooled in a furnace. The internal residual distortion (residual stresses) is removed by work hardening, the structure is softened and improve the ductility. By Annealing process reduces lattice defects in the metallographic structure, and recrystallization is carried out to homogenize the structure and to soften due to decrease of residual stresses. Annealing can be divided into different types with different temperatures and cooling speeds depending on its purpose.



		Purpose
①	Diffusion Annealing	Homogenization
②	Complete Annealing	Internal Stress Removal
③	Spheroidizing Annealing	Workability Improvement
④	Isothermal Transformation Annealing	A process to change the structure internal Carbides into spherical form by quenching the austenite-structured steel, it will become difficult to quench and crack, toughness is achieved, and is implemented before tools steel processing.
⑤	Stress Relief Annealing	Residual Stress Relief

C. Normalizing

Normalizing is the process of heat treatment which removes internal deformation, restores structure to standard state, and refines it. After holding the steel in the austenitic state, sufficiently cool in atmospheric air.



Normalizing temperature

There are many steel materials produced by forging, casting and rolling, etc., those are partial aggregation of excessive heating and abnormal structure and Carbides, and most of which are coarse and non-uniform crystal grains. About such a steel material uniformly refine grains and improve mechanical properties. Moreover, by implementing heat treatment for the purpose of improving machinability etc., and it is a treatment to restore steel to its

standard condition.
i) Heated to a temperature about 50 ° C, A3 or Acm point and above to make austenite single phase and then leave it in the air (air cool) for cooling. At this time by increasing and decreasing transformation point fiber structure will disappear and along with refining of crystal grain will become hard & strong and fine pearlite will be achieved with good elongation and drawability, residual stresses will also be removed.
This is a heat treatment carried out for the purpose of improving mechanical properties and improvement of machinability. Moreover, increases strength and ductility, it is also implemented as pre-treatment of quenching.

3.Quenching Procedures

1) Water Quenching and Oil Quenching

Quench the steel from austenite region (A3, region above A1 transformation point) is used as the most common quenching procedure. Water has the highest cooling rate and the most effective transition to martensite but the structure becomes un-uniform and internal stress become higher causing cracks or distortion therefore to control cooling oil quenching (hot or cold) is used.

2) Carburizing

(1) Carburizing means

A procedure of permeating and diffusing Carbon on the surface of low carbon steel (generally called skin hardening steel) and then quenching it to harden the surface. There are three types of carburizing and quenching such as solid carburizing, liquid carburizing and gas carburizing, but from the productivity and quality point of view, gas carburizing and quenching is the mainstream currently. The surface is hard and the inside is soft, so it is excellent for wear resistance and fatigue resistance. The steel used is generally low carbon steel (or alloy steel), and it has to qualify the following conditions.

① Do not cause coarsening of crystal grains when heated at carburizing temperature
② Hardened layer with high hardness, wear resistance, fatigue resistance, and high toughness.
③ As for internal hardened portion also, crystal grains are not coarsened and have high toughness.
④ There are a few elements that inhibit carburization and does not contain any elements that make free carbide.

(2) Gas Carburizing

Other methods include vacuum carburizing using a vacuum furnace, plasma carburizing using plasma (also referred to as ion carburizing), and a dripping carburizing method in which liquid such as methanol is dropped into the carburizing furnace and carburization is performed using the decomposition gas.
It should be noted that most important point in Gas Carburizing is to prevent grain boundary oxidation as much as possible and it is important to suppress the formation of residual austenite.
In conventional carburization, the carbon concentration on the surface was made to be a eutectic composition (C 0.8%), and the wear resistance was improved by martensite obtained by quenching. But in this state temperature increased due to friction heat and high temperature when used at an atmosphere, etc., a softening phenomenon may occur and the life may be reduced. For preventing purpose from this problem, carbon concentration in the vicinity of surface is increased to about 3% carbide dispersion carburization in which the dispersion is spheroidized is also carried out.
This is used for parts which require high strength and wear resistance, such as automotive Drive Gears, to perform deep carburization (depth 1.0 mm [MAX]).

3) Surface Hardening Treatment other such as Nitriding

(1) Nitriding Treatment

	A method of hardening surfaces by infiltrating activated nitrogen (N) into the surface of steel. Quenching is not required in this case because very hard N nitride is made on the surface of steel. Since processing temperature is low in the α-Fe zone (510 to 570 ° C) below. A1 transformation point therefore there is no risk of seizure crack or seizure deformation. The nitrogen N penetrating into the steel needs a nascent N formed by thermal decomposition of ammonia therefore it is important that AL, Cr, Mo, etc., which have high affinity for this nitrogen has to be present in the steel. Especially Cr and Mo are essential components and there is a dedicated steel for Nitriding SACM 645 as specified in JIS. SCM, SKD, etc. also implement Nitriding treatment. There are two types of Nitrided hardened layer depth: Total hardened layer depth and Practically hardened layer depth, and since it is difficult to measure all hardened layers depth, practically hardened layer depth with high 50 HV than the hardness of the base material is applied. a. Gas Nitriding（HNTG） Ammonia decomposition gas heated to 500 to 550℃ and treated for 50 to 150 hours. Ammonia decomposition ratio in this case is about 30% and depth is 0.2 to 0.3 mm, while hardness achieved in this treatment is 1000 to 1200 HV. The disadvantage of this treatment is long processing time, since the properties achieved are excellent in wear resistance and corrosion resistance. b. Plasma Nitriding (Ion Nitriding) It is also called ion nitriding in nitriding developed for the purpose of shortening the nitriding time. This process is a type of gas nitriding that is carried out by discharging in reduced pressure vacuum. The treated material is cathode, and the vessel is anode, and discharge is conducted by applying a voltage of approx. 500 V in a vacuum of 0.5 to 10 Torr, and Nitriding is carried out if NH3 is inducted which ends within a few hours and gas can be saved with no pollution. The processing temperature is 450 to 570 ° C, and a mixed gas of N 2 and H 2 is often used for the processing atmosphere. c. Salt Bath Nitriding （HNTT） A typical treatment of salt bath soft Nitriding is Tuft ride, which is carried out by putting potassium cyanide or potassium carbonate or in a titanium crucible and melting it, then processed by blowing air into this. The treatment temperature is about 570 ° C., and time is about 30 to 240 minutes, and after heating, oil or water cooling is carried out. The steel used can be applicable to almost all materials, but cyanide pollution risk is possible however recently, a treatment with zero Cyanide pollution has been developed. The difference from gas nitriding or plasma nitriding is nitrogen and carbon infiltrate simultaneously to form carbonitrides. d. Gas Soft Nitriding There is no pollution in method of carrying out soft Nitriding of c by gas. There are cases using mixed NH3 gas and carburizing gas and where Urea is decomposed and used. Soft Nitriding is when NH3 gas and Carburizing gas is mixed with 1:1 ratio is the major Gas Soft Nitriding procedure. Other methods for Soft Nitriding are CO & N2 gas generated by N2 Nitrogen gas base and thermal decomposition of Urea. However, process temperature and time is same as other soft nitriding methods. e. Carbide Coating Treatment There are 2 types available such as, Dry Coating PVD (Physical Vapor Deposition) & CVD (Chemical Vapor Deposition) and wet coating such as TRD (VC carbide coating). In both cases, there are various methods for PVD and CVD for processing to form hard carbides or nitrides on the steel surface and hard coatings such as TiN, TiC, TiCN, TiALN,		○ ○	○
②				

etc., have already been practically in use. TRD generates hard VC carbide on the surface that is widely used for Dies and Molds. The characteristics of this treatment is high adhesion strength due to mutual diffusion of matrix and carbide layer and is difficult to cause peeling off but it requires good knowledge to manage large distortion due to high temperature. ○

f. Steam Treatment (Homogenized Treatment)

In Iron Oxides there is Iron Monoxide (FeO: white rust), Iron Trioxide (Fe2O3: red rust) and Iron Tetra oxide (Fe3O4: black rust). Fe3O4 is porous, hard and has high corrosion resistance therefore it is used for surface improvement and Steam Treatment is used to make form this coating. In order to prevent Red Rust, compressed steam is heated at 350 to 400 ° C and processing object is passed through 500 ° C superheated water which forms Fe304 coating Film. It should be noted that if temperature is too high or excessively long time may cause the change it to Fe203.

4) Induction Hardening

When quenching steel by high frequency induction heating, the current flowing through coil and object to be heated has a property of being concentrated on each surface as the frequency becomes higher, and this is called the Skin Effect. The currents flowing in coil and the object to be heated are opposite in direction to each other, and when the frequency

$$\delta = \sqrt{\frac{2\rho}{\omega\mu}} = \sqrt{\frac{2\rho}{2\pi f \times \mu_s \mu_0}}$$

is high, due to Skin Effect the current in opposite direction flows more close and electric resistance become lower and heat is generated at only surface of object to be heated.

The relationship between the surface depth (d) and the frequency (f) on which the current flows is as follow

δ: Current penetration depth(m)
ω : Angular frequency = 2π f (rad/s)
ρ : Resistance of conductor metals (Ωm)
μ : magnetic permeability Ratio = μsμ0 (H/m)
f : frequency (Hz)
μs : magnetic relative permeability ratio of conductor metals (-)
μo : vacuum magnetic permeability ratio = 4 π×10^(-7) (H/m)
(Magnetic field strength and μ s are in inverse proportion)
Frequency and depth of current penetration are inverse proportion
=> The higher the current frequency will be, the smaller will be heating depth. ○

Metal	Temp.	ρ ×10^{-8}Ωm	μs (－)	depth of current penetration δ(mm)			
				f=100Hz	f=1kHz	f=10kHz	f=100kHz
Cu	Normal Temp	1.7	1	6.6	2.1	0.66	0.21
AL		2.7	1	8.3	2.6	0.83	0.26
SUS304		70	1	42.1	13.3	4.21	1.33
Carbon Steel		15	150	1.59	0.5	0.16	0.05
	400℃	47	150	2.82	0.89	0.28	0.09
	700℃	90	150	3.90	1.23	0.39	0.12
	1000℃	120	1	55.1	17.42	5.51	1.74

Currently frequency range is wider and Thyristor-Inverter type Oscillators are widely used. The properties of Induction Hardening are,

①Thermal efficiency is better because of direct heating and operation time is shorter.
②Partial Hardening is possible and hardened layer selection is comparatively easy.
③There is very low oxidation, decarburization, and deformation due to short time heating

and sudden cooling treatment.

④Easy for operation standardization and automation.

⑤Not only wear resistance but also improves fatigue resistance due to large compression residual stresses generated on the surface by rapid heating and quick cooling.

Since Induction Hardening heating is carried out by a coil, therefore it is important to make a coil suitable for the size and shape of the workpiece. Coil types are available for different such as outer, inner, or flat surfaces, therefore selection is based on mostly experience factors.

For Induction Hardening, generally Carbon Steel for mechanical structure and low Alloy Steel is mostly used but due to quick heating, temperature increases while carbide do not form a solid solution sufficiently, and it is slightly higher as compared to Ac3 transformation point ferrous carbon type phase diagram and Induction Hardening hardness is highly effected by base structure before hardening. The hardness of Sorbite structure is high because Carbides dissolve sufficiently. Here are two indications of hardness: effective hardened layer depth and total hardened layer depth. Effective hardened layer depth matches to 50% Martensite (Half Marten) and the hardness limit is determined by C% of Steel. Moreover, the total hardened layer depth is adopted as hardness depth of base material.

The coolant is mostly a water-soluble coolant is used and the cooling method is often an injection type that can achieve high cooling speed, and is applied to parts such as crankshaft, gear, cam, roll, cylinder liner etc.

4.Examples and Common issues in Pakistan

1)**Molds & Dies Heat Treatment**

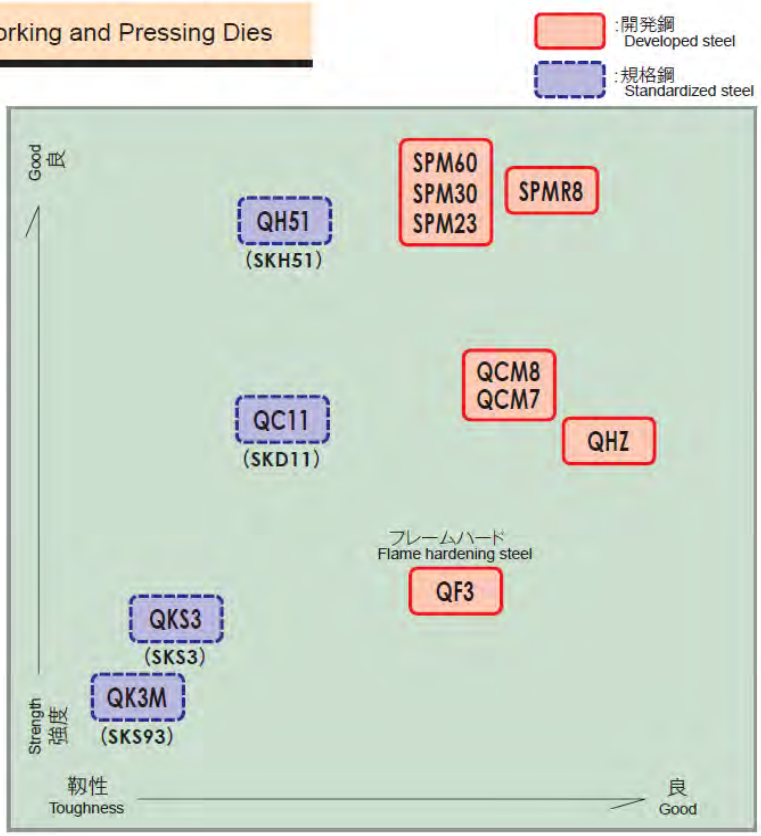
There are some cases occasionally observed where the mold material is not clearly known therefore proper heat treatment is not implemented.

By implementing following standards improvements have been observed in many companies. Please implement the process based on principle theory.

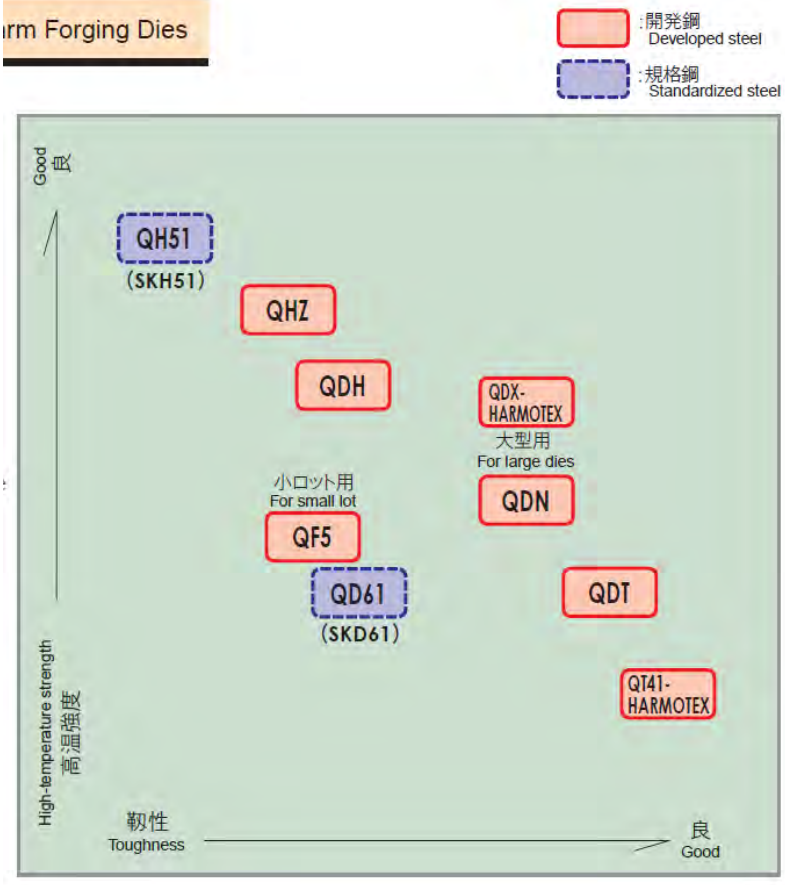
(1) Mold & Dies Material and Heat Treatment Parameters

a. Iron material for Cold Forming (Press) and Hot Forming (Forging) [from Catalog of Sanyo Special Steel]

Cold Working and Pressing Dies



rm Forging Dies



An increase of Hardness is very little by tempering at 500℃. The phenomenon is known as secondary hardening, when heating for quenching C, Cr, Mo, and V, etc., decompose from base material in a super saturated state, in tempering due to internal dispersion strengthening of composite material deposited by tempering. Moreover, decomposition of remaining Austenite to Martensitic also occurs. In order to maintain strength & hardness of material, Tempering temperature has to be set a little higher than peak of secondary hardening.

Especially in case of SKD11 is usually applied high Temp., tempering 500-530℃.
High tempering makes effect to avoid crack by reducing residual stresses. In case of required hardness, should be treated in low temperature tempering.

The reason for this is because of quenching and tempering in constant temperature kept in fixed time, prevents deformation of die due to strain caused by low thermo conductive of special carbide composition (Cr, W, Mo, & V). Heating hold time should be 40min/Φ25.

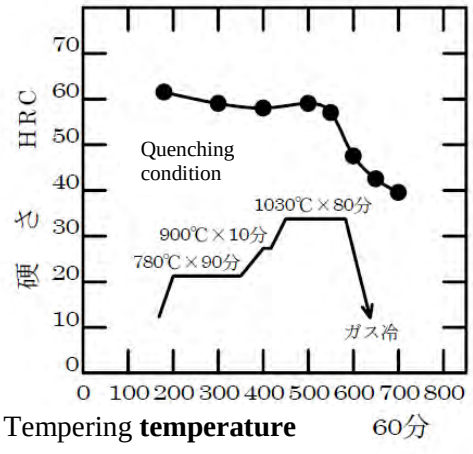
A slight increase in hardness appears at tempering temperature of 500 ° C. This is called Secondary Hardening, and is due to dispersion strengthening of composite Carbides precipitated by tempering and internal distortion generated in base to base solution, in which C, Cr, Mo & V, etc., are over saturated in solid solution during quenching and heating and simultaneously decomposition of residual Austenite martensite is accompanied by secondary hardening. In order to maintain the hardness and strength, temperature is set slightly higher than secondary hardening peak and in specially it is often utilized for SKD11 when high temperature hardening at 500～530℃. This is because low temperature hardening is based on the concept of hardness-based corrosion resistance, while in induction hardening is effective in preventing damage by reducing residual stresses. Doing quenching and tempering while maintaining constant temperature is for handling poor thermal conductivity of special carbides such as Cr, W, Mo & V and to minimize distortion due to rigidity or deformation of the mold material as much as possible. The standard time to hold is 40 minutes / φ25.

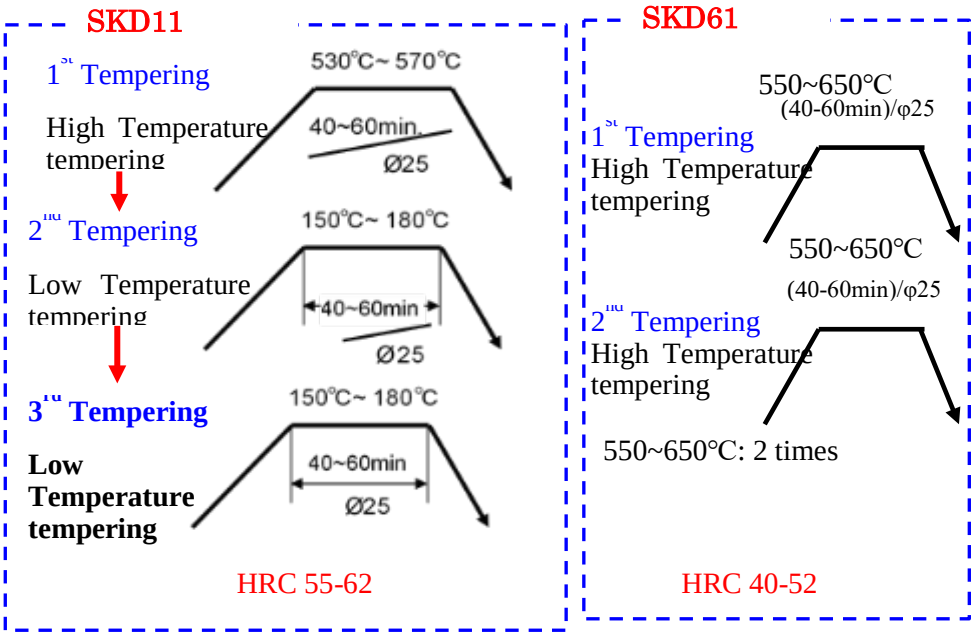
Achieve appropriate hardness and toughness makes better balance between anti crack and die life. Hardness standard （Hrc58 ~ 60）

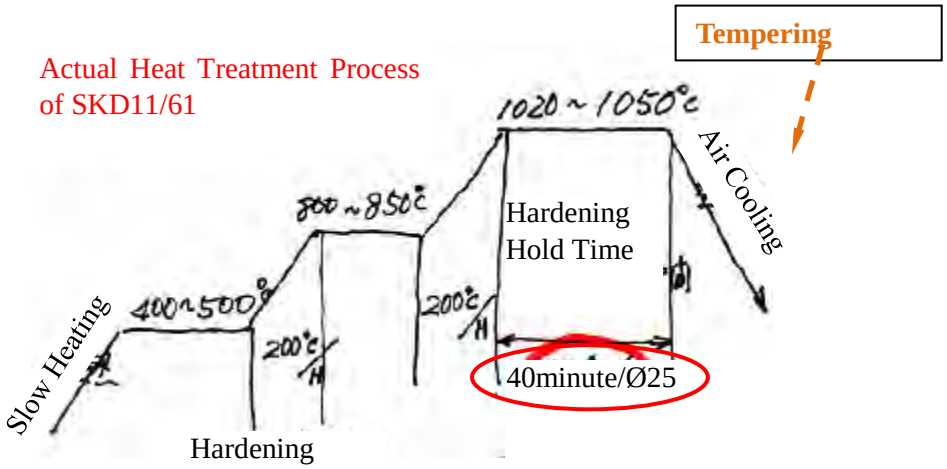
Recommended high temperature tempering (see details in graph).
(It helps to prevent cracks by reducing residual stresses). In case of targeting Hardness (durability), it is recommended to conduct low temperature tempering.

Achieve hardness (HRC 58 ~ 60) and toughness to achieve both crack and improved life.
==>Refer to Graph for recommended Parameters. High Temp, tempering is recommended. (it helps to prevent cracks by reducing residual stresses). In case of Hardness target (endurance) then low temperature tempering has to be implemented.

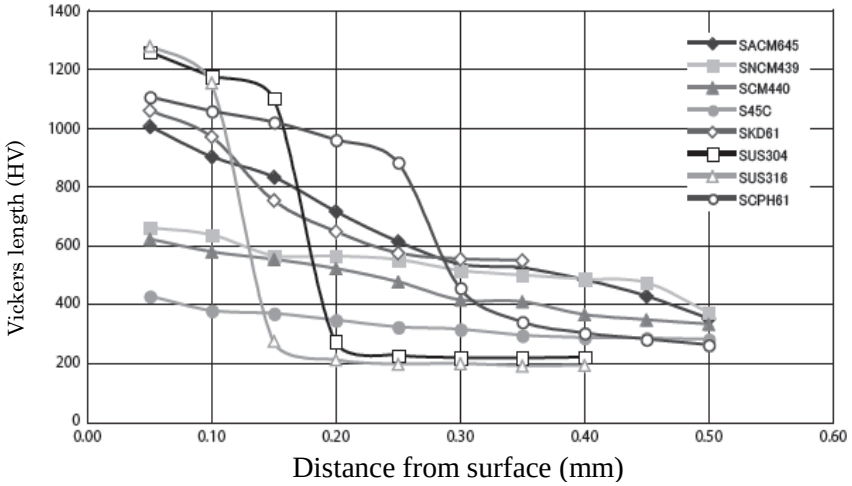
Tempering-hardness chart







Hardness distribution of all material surfaces (48hours processing)

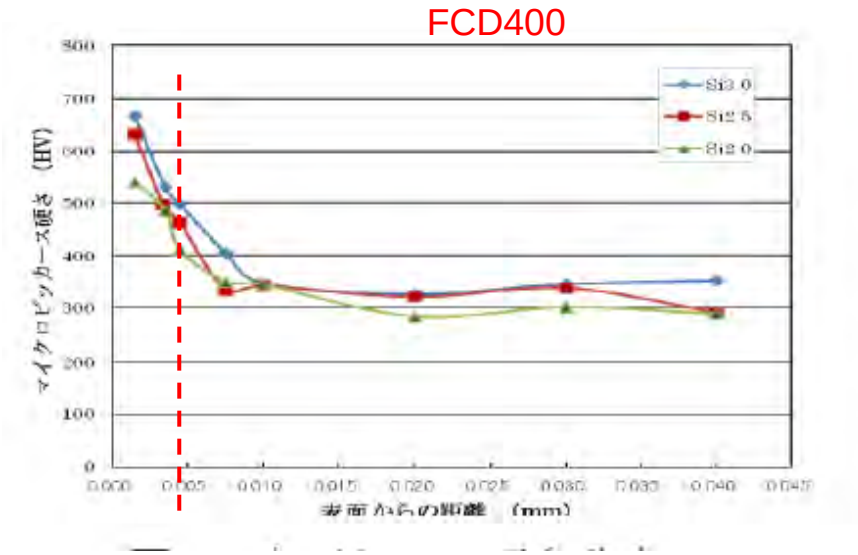


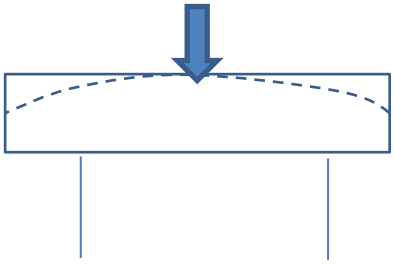
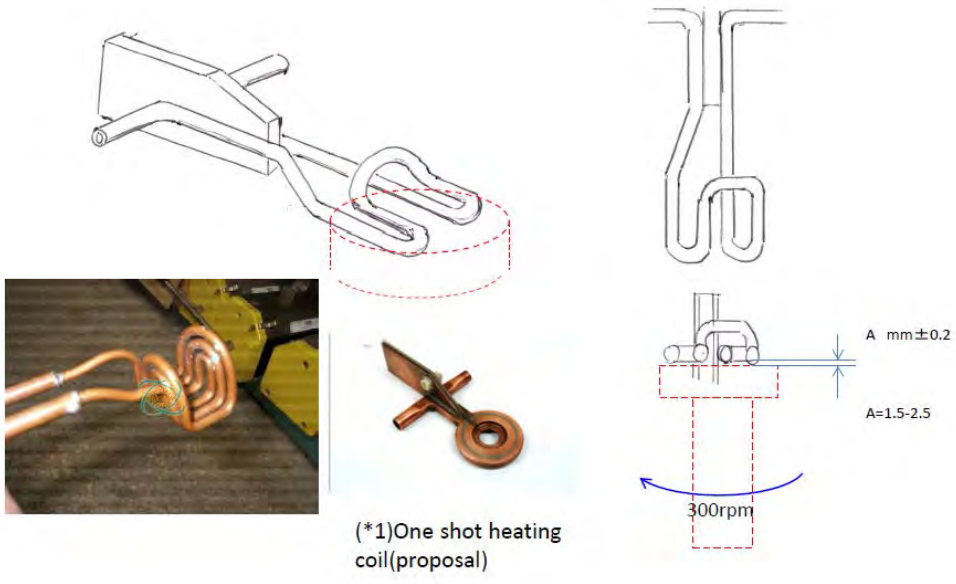
Distance from surface (mm)

Quenching of SKD11([ ]:SKD61)
Maintain temperature from 400℃ to 500℃ in fixed time to the core of whole material of Die (Φ25/40min). Then repeat the same process at 800℃ to 850℃, Air cooling when reaches at 1030℃.
Tempering: High temperature tempering 530℃～570℃, [550~650℃:2times] (To change decomposition of remaining Austenite to Martensitic), then second low temperature tempering: 150℃～180℃ 2times tempering (SKD11 only)
SKD11 hardening ([ ]: SKD61)
Hardening is carried out by maintaining same temperature 400 to 500℃ upto the core (40min=25Φ). Then repeat the same at 800 to 850℃ and start air cooling from 1030℃.
Later when Tempering, residual Austenite is changed to Martensite by tempering at a high temperature of 530 to 570℃[550～650℃× twice] and after that second time tempering at low temperature of 150℃～180℃ twice (SKD 11).

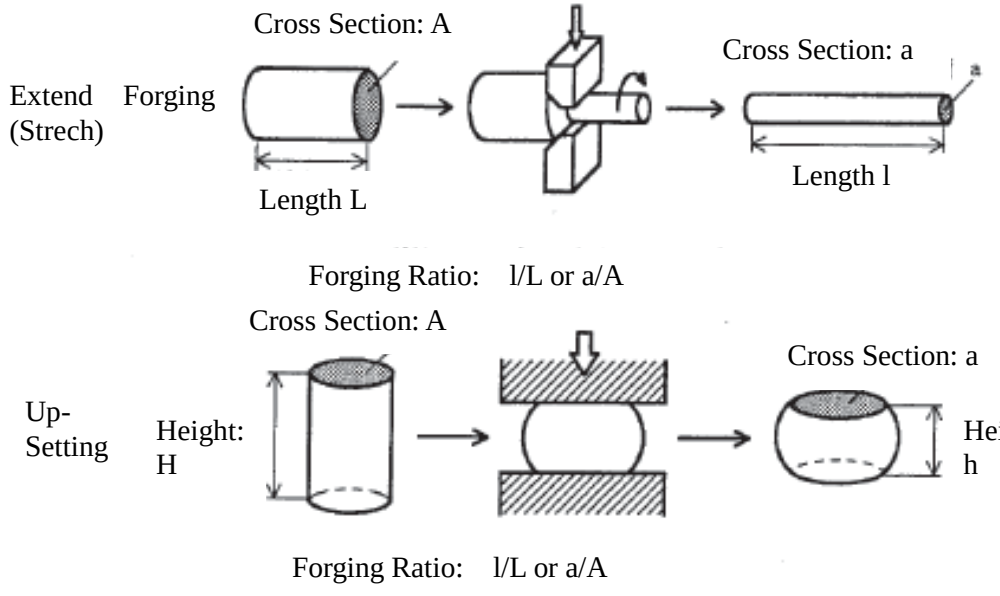
2) Nitriding of FCD

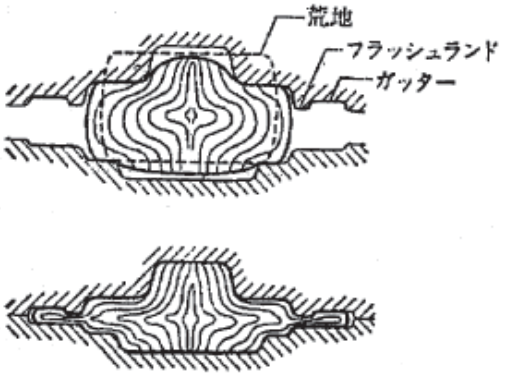
As mentioned above, the nitriding depth can hardly be achieved except by nitriding steel. In the example, design specification of nitriding depth in FCD400 is 0.3mm, but theoretically 0.05 is the maximum limit. Under the current circumstances reverse the appropriate value to 0.05mm and currently to improve depth some other procedure is under trial => regarding Nitriding there are a lot of hit & trial but it is necessary to learn manufacturing based on the correct theory.



①	3)Induction Hardening Since the induction heating to the outer surface is carried out by shaft coil and central portion where hardness is required is not heated causing hardening defect.   As a result of study with Japanese suppliers, following coil shape was proposed. (Actually, it was not implemented because high frequency was managed by Chill Casting.) Basically, in case of heating to fixed face, needs plane type (*1) as per attached picture, Proposed design When using current type coil to achieve heating.  (*1)One shot heating coil(proposal)		○	

⑥ Forging

No	Contents	A	B	C
①	**1. Forging types and features** **1) Classification by processing temperature** **(1) Hot forging** This refers to forging performed at or above the recrystallization temperature of a steel material. Processing of materials that cannot be processed at room temperature and large deformation at a time are possible, and products with complicated shapes can be manufactured. The amount of processing required for material improvement (forging) is expressed as a forging ratio. The forging ratio is shown in Figure 1. The forging ratio should be at least 4 and should be around 10 for tools and blade materials.  Fig 1: Forging Ratio	○		
②	 **(2) Cold Forging** Forged products (Forged flow lines along the shape are obtained, which is advantageous in terms of strength) Strong against repeated bending stress. Machined products (The metal flow line is cut at the processed part.) Casting products (No metal flow line and not strong against repeated stress.) This refers to a Forging without heating the material. Compared to the above hot forging, since the deformation resistance is high and the deformability is small, there is a risk of destruction of the forging die and product cracking, so the amount of deformation that can be applied at one time is small. The surface of the resulting product is clean and has good dimensional and shape accuracy, so there is no need for post finishing.	○		

③	The application of Cold Forging has been spreading in recent years. Hardness during molding enhances product increase. The die life is several thousand to several hundred thousand or more, longer than hot forging. Distortion occurs during strengthening by heat treatment after forging, and the accuracy obtained is deteriorated. Because of this, low heat treatment strained material and low strain heat treatment are required. **(3) Warm forging** This refers to a forging method performed at a temperature intermediate between the above for the purpose of combining the advantages of hot forging and cold forging. Care should be taken because the selection range of aptitude conditions is narrow. A high temperature is used when the main purpose is to reduce deformation resistance, and a low temperature is used to improve accuracy. **(4) Compound forging** A forging method in which a complicated shape is formed by hot or warm forging and then accuracy is improved by cold forging is called composite forging. In recent years, it has spread rapidly, and the accuracy in the final cold forging is improved by performing simple intermediate cutting after hot or warm forging. **(5) Constant temperature forging** When forging difficult-to-process materials that require heat resistance, this is a forging method in which the mold is heated to reduce temperature changes. **2) Classification by tool type or motion type** **(1) Free forging** This is a method of processing into a desired shape by applying pressure using a tool with a flat or curved surface called a hammer or an anvil instead of a forging die, and performing operations such as stretching, upsetting, drilling, staking, and cutting. It is suitable for production of large and medium-sized products in a variety of small quantities, but it depends on the skill of the operator. **(2) Die forging** As shown in Fig. 3, a material having a larger volume than the product is placed in a forging die with the shape of the product on the compression tool surface, heated or at room temperature (cold forging), and forging material into shape.  In order to fill the forging die with the material, a flash land (burr road) and a gutter (burr pool) are provided to control the material flowing out from the joints of the upper and lower dies (shown). The outflow resistance caused by friction in the flash land increases the internal pressure and fills the die with all the material, and finally drains the remaining material to the gutter.		○	

(3) Upset forging Forging that compresses the material in the axial direction. The head-forming process for screws, bolts, rivets, etc. is typical.

As shown in Fig. 4, if the material is held for a length L from the die hole and swung by tapping its head, it will buckle and fold if L is not less than about 2.5 times the material diameter D. If L / D is more than 3 times, double step as shown in (II). The application limit of multi-stage is as follows.

2 steps: L / D ≤ 4.5 (maximum 5.5)
3 steps: L / D ≤ 6.5 (Maximum 8.0)

(4) Rotary forging A processing method in which the entire shape is formed sequentially while pressing the material locally with a rotating tool. Although the machining time is long, it has a feature that it is quiet because there is little impact of pressurization, and the machining force and machining surface pressure can be lowered by sequential machining. It is disadvantageous in ensuring accuracy.

In addition, "Swing forging" in which the tool shaft is tilted to partially pressurize the material and swivel in the circumferential direction. "Ring Roll rolling", which forms a semi-finished ring product between several rolls, "Cross Rolling", where a wedge-shaped tool is bitten in order while rotating a round bar to make a stepped shaft by flowing the material in the axial direction.

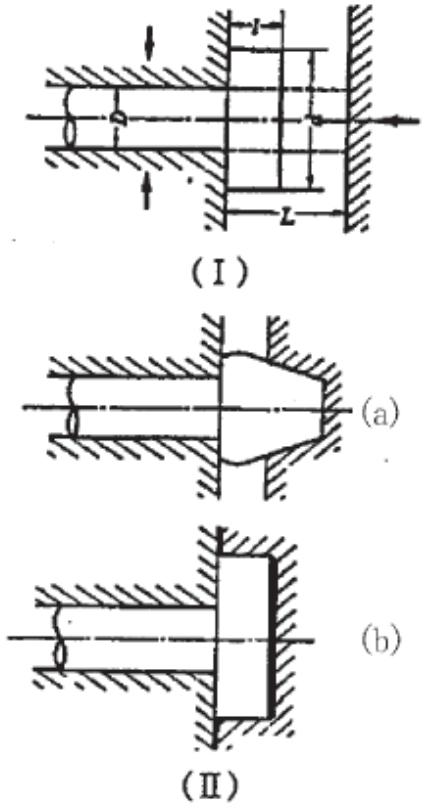


Fig 4. Head making upsetting

2. Forging material

1) Required properties of materials

		Requirement for material specification of forging
Character of Material		・ Strength：Tensile and fatigue, Anti-wearing, Impact, corrosion and heat resistance
PROCESS	material	・ Shape, dimension and tolerance ・ Surface quality：Scratch, Decarbonization ・ Inner defect：non-metal contamination, internal defect
	forging	・ hot forging：heat deformation resistance ・ cold forging, resistance of cold deformation, lubrication
	workability	・ machinability, welding performance
	Heat treatment	・ Hardenability, Surface treatment: Carburizing, Induction quenching, Nitriding

2) General forging materials and heat treatment

Sym.	Chemical contents (%)						Heat treatment	Application
	C	Si	Mn	C r	Ni	Mo		
S15C	.13- 0.18	0.15 ~ 0.35	0.30 ~ 0.60	< 0.2	< 0.2	-	N	Light duty parts
S25C	0.22 ~ 0.28	0.15 ~ 0.35	0.30 ~ 0.60	< 0.2	< 0.2	-	N	
S45C	0.42 ~ 0.48	0.15 ~ 0.35	0.60 ~ 0.90	< 0.2	< 0.2	-	N or QT	Crank arm
S53C	0.50 ~ 0.56	0.15 ~ 0.35	0.60 ~ 0.90	< 0.20	< 0.20	-	N or QT	ɔd, Nut
SCr420	0.18 ~ 0.23	0.15 ~ 0.35	0.60 ~ 0.85	0.90 ~ 1.20	< 0.25	-	C	Gear T/M Part, Piston
SCM415	0.13 ~ 0.18	0.15 ~ 0.35	0.60 ~ 0.85	0.90 ~ 1.20	< 0.25	0.15 ~ 0.30	C	
SCM420	0.18 ~ 0.23	0.15 ~ 0.35	0.60 ~ 0.85	0.90 ~ 1.20	< 0.25	0.15 ~ 0.30	C	
SNCM420	0.17 ~ 0.23	0.15 ~ 0.35	0.40 ~ 0.70	0.40 ~ 0.65	1.60 ~ 2.00	0.15 ~ 0.30	C	
SCr440	0.38 ~ 0.43	0.15 ~ 0.35	0.60 ~ 0.85	0.90 ~ 1.20	< 0.25	-	QT	Heavy Duty parts, Knuckle, Arm shaft
SCM435	0.33 ~ 0.38	0.15 ~ 0.35	0.60 ~ 0.85	0.90 ~ 1.20	< 0.25	0.15 ~ 0.30	QT	
SCM440	0.38 ~ 0.43	0.15 ~ 0.35	0.60 ~ 0.85	0.90 ~ 1.20	< 0.25	0.15 ~ 0.30	QT	
SNCM439	0.36 ~ 0.43	0.15 ~ 0.35	0.60 ~ 0.90	0.60 ~ 1.00	1.60 ~ 2.00	0.15 ~ 0.30	QT	
SNCM630	0.25 ~ 0.35	0.15 ~ 0.35	0.35 ~ 0.60	2.50 ~ 3.50	2.50 ~ 3.50	0.50 ~ 0.70	QT	

3. Forging die material

1) Types and heat treatment

Usage	Purpose	Sym.	hardness	Heat treatment	
			(HRC)	Quenching	Tempering
Hot forging	Hot working tool alloy steel	SKT4	32 ~ 49	820 ~ 880℃ OC	400 ~ 650℃空冷
		SKD6	33 ~ 54	1,000-1,050℃AC	550 ~ 650℃空冷
		SKD6	35 ~ 55	1,000-1,050℃ AC	550 ~ 650℃空冷
		SKD7	40 ~ 53	1,000-1,050℃ OC	550 ~ 650℃空冷
Cold forging	Cold working tool alloy steel	SKD8	40 ~ 56	1,070-1,170℃ OC	600 ~ 700℃空冷
		SKS3	57 ~ 61	800-850℃ OC	150 ~ 200℃空冷
		SKD11	58 ~ 61	1,000-1,050℃ AC	150 ~ 250℃空冷
			57 ~ 60	1,020-1,050℃ AC	500 ~ 530℃空冷
	High speed steel	SKH5	58 ~ 62	1,160-1,220℃ OC	550 ~ 570℃空冷
		SKH5	61 ~ 65	1,160-1,230℃ OC	550 ~ 580℃空冷
		SKH5	62 ~ 66	1,160-1,230℃ OC	550 ~ 580℃空冷

2) Detailed heat treatment conditions for SKD61 and SKD11

熱処理条件(℃) Heat treatment conditions			硬さ (HRC) Hardness	備　考 Remarks	互換記号 JIS Compatible JIS grade	山陽記号 Sanyo grade
焼なまし Annealing	焼入れ Quenching	焼戻し Tempering				
750~780 徐冷 Slow cooling	790~850 油冷 Oil quenching	150~200 空冷 Air cooling	55~60		SKS93	QK3M
750~800 徐冷 Slow cooling	800~850 油冷 Oil quenching	150~200 空冷 Air cooling	55~62		SKS3	QKS3
830~880 徐冷 Slow cooling	930~980 油冷 Oil quenching	150~200 空冷 Air cooling	55~62		SKD1	QC1
830~880 徐冷 Slow cooling	1000~1050 空冷 Air cooling	150~250 空冷×2回 500~530 Air cooling 2 times	55~62		SKD11	QC11
830~880 徐冷 Slow cooling	1020~1050 空冷 Air cooling	500~550 空冷×2回 Air cooling 2 times	55~62		–	QCM8
830~880 徐冷 Slow cooling	1020~1050 空冷 Air cooling	500~550 空冷×2回 Air cooling 2 times	55~62		–	QCM7
820~870 徐冷 Slow cooling	900~1000 空冷 Air cooling	–	(62~65)	フレームハード Flame hardenable	–	QF3
820~870 徐冷 Slow cooling	1000~1050 空冷 Air cooling	550~650 空冷×2回 Air cooling 2 times	40~52		SKD61	QD61

3) Required characteristics and countermeasures for die life

(1) Warm and hot forging dies

1. The die surface of the warm / hot forging die is subjected to repeated heat cycles of heat transferred from high-temperature parts, frictional heat with the die, and cooling by spraying lubrication / release agent application. As a result, heat cracks occur. Furthermore, the die surface layer is softened by heating to promote fluid wear. At the same time, the die is subjected to shock stress due to forging. Therefore, a die material having both high temperature strength and toughness is required.

Since the wear phenomenon varies depending on the shape of the forged product and the portion of the forging surface, it is necessary to determine what the wear phenomenon of the important part is. Table-1 shows each wear phenomenon and list the required properties of die materials.

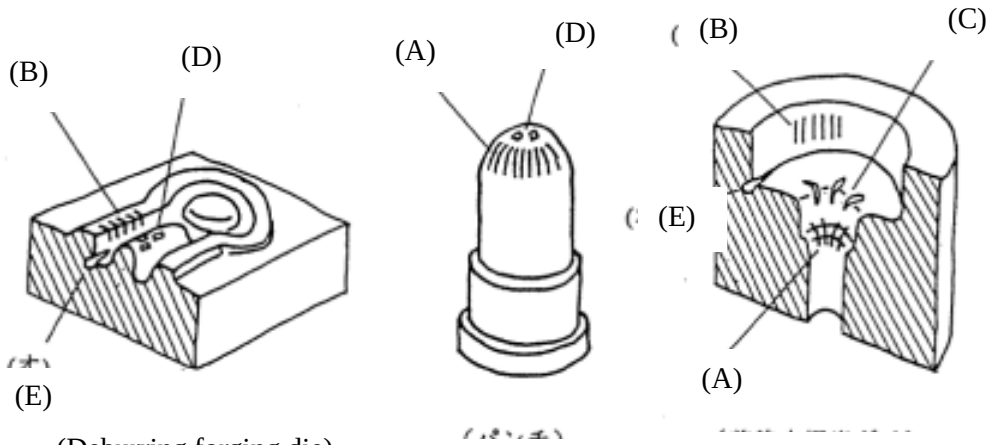
When the contact time with the workpiece is long and the thermal effect is large, such as the tip of a punch that digs into the workpiece, high temperature strength is required.

Hardness is required when the material flow is large but the contact time with the parts is short and the thermal effect is relatively small, as in a flash land. For setting the hardness high, the toughness and a large amount of carbide contained in the die material are required.

For heat cracks, high temperature strength and toughness are required.

The nitride layer peeling requires optimization of the nitriding characteristics of the die material and the high temperature strength of the base material supporting the nitride layer. Erosion occurs when forging is performed with the lubricant remaining at the corner R of the die. Since the lubricant vaporizes in an instant, a crater-like mark is formed on the die. This is difficult to deal with die materials and heat treatment, and it is necessary to take measures such as optimization of lubrication conditions and addition of vent holes in the die.

Fig-1



(Deburring forging die)

(Punch)

(Forward / backward extrusion die)

Die damage	Countermeasure	Heat treatment	Forging condition
(A) Worn out （Heat damage）	-Increase high temperature strength	- Nitriding, - High quenching temp.	- Die cooling - Lubrication
(B) Worn out (Without heat damage)	- Toughness - Carbon contents	- Surface treatment, - Hardness	- Die lubrication - High hardness
(C) Hear crack	-High temperature strength, - Toughness.	- Increase die cooling speed and hardness - Nitriding condition	- Die lubrication - Die cooling
(D) Peeling of nitriding layer	Nitriding condition	- Nitriding condition	-Die lubrication - Die cooling
(E) Erosion	—	—	- Die lubrication - Gas Purge hole
(F) Die brake	Toughness	- Increasing cooling speed of quenching - Reduce hardness - Nitriding condition	- Die pre-heating - Die surface improvement - Split design of die

2. Selection criteria for mold materials

SKD61 is mainly used for press dies, and SKT4 which is particularly excellent in toughness is mainly used for hammer dies. In order to prevent wear, a die material with higher high-temperature strength is required. High temperature strength increases in the order of SKT4-SKD61, SKD62-SKD7-SKD8. On the other hand, since the toughness is getting lower with higher temperature strength materials, there is a risk of die cracking when changing to a die material with higher high-temperature strength. Improvements to JIS steel grades with improved toughness and minimal high toughness have been developed and applied (Sanyo Special Steel: QDH materials, etc.).

Measures are vary depending on the degree of thermal effect on the die surface. If the die has a relatively small heat effect (as a guideline, the temperature rise of the surface layer is about 650 ° C or less), it is effective to increase the hardness. A die material having a small decrease in toughness even when the hardness is increased.

For die with a large heat effect (as a guide, the temperature rise is about 650 ° C or higher), it is effective to use die materials with high high-temperature strength. It is difficult to measure the temperature rise of the surface layer part. But by measuring the hardness of the surface layer part of the used die, It can be estimated.

Figure 2 shows examples of die material selection criteria divided into quenching and tempering materials (supplied in the annealed state) and pre-hardened materials (supplied by heat treatment). If the die has a relatively small heat effect (as a guideline, the temperature rise of the surface layer is about 650° C or less), it is effective to increase the set hardness. Choose a small die material.

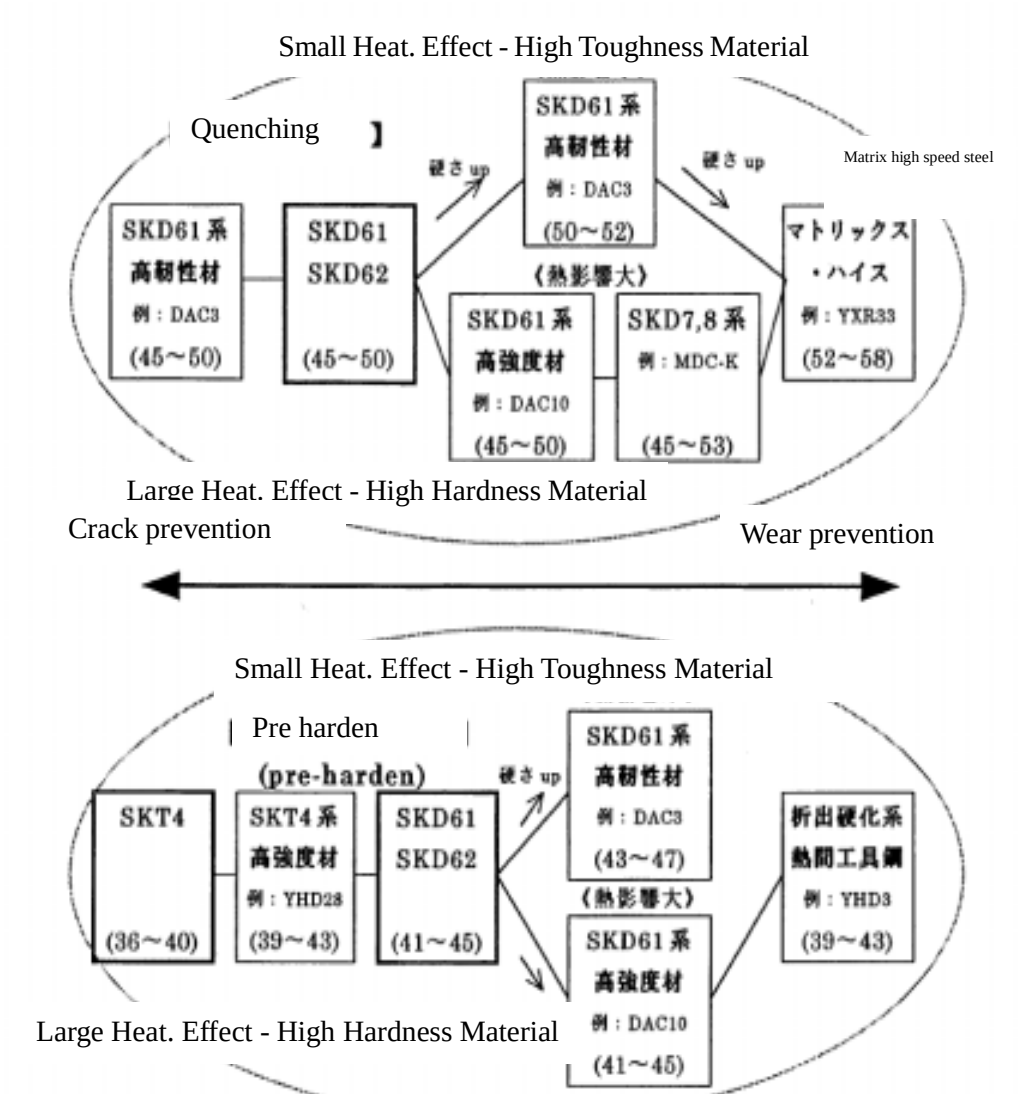


Fig 2. Selection criteria for hot and hot forging materials
(Note: Numbers in parentheses are guidelines for Rockwell C hardness)

Matrix Hi-speed steel is an excellent mold material for wear prevention, and is suitable for warm forging dies with high deformation resistance of parts and precision hot forging dies such as gears.

Precipitation hardening type hot work tool steel has the characteristic is pre-hardened material that only the die surface layer part becomes harder when the temperature rises during use, and has both machinability, internal toughness and high temperature strength of the surface layer part.

Quenching and tempering materials require heat treatment in the mold manufacturing process, but their characteristics change depending on the heat treatment conditions. The quenching temperature is set high if high temperature strength is important, and is set low if toughness is important.

The cooling method during quenching also affects the properties.

SKD61 and SKD62 can be cooled by air, but the toughness can be improved by adopting a cooling method (Salt bath, Gas high pressure vacuum quenching) that is faster than oil cooling or air cooling.

Over 70% of all hot and hot forging dies are surface treated).

Nitriding is a typical surface treatment. The nitriding characteristics differ depending on the die material, and the influence of chromium (Cr) contained in the die material is particularly large. SKD61 and SKD62 (both Cr = 5 wt %) have higher chromium content than SKD7 (Cr = 3 wt %) and SKD8 (Cr = 4 wt %), high nitriding hardness under the same nitriding conditions, and nitrided layer depth tend to be shallow. SKT4 (Cr = 1 wt %), which has a low chromium content, has almost no nitriding hardness.

4. Case of forging quality at PAKISTAN

1) Measures against burr (Gear,C1)

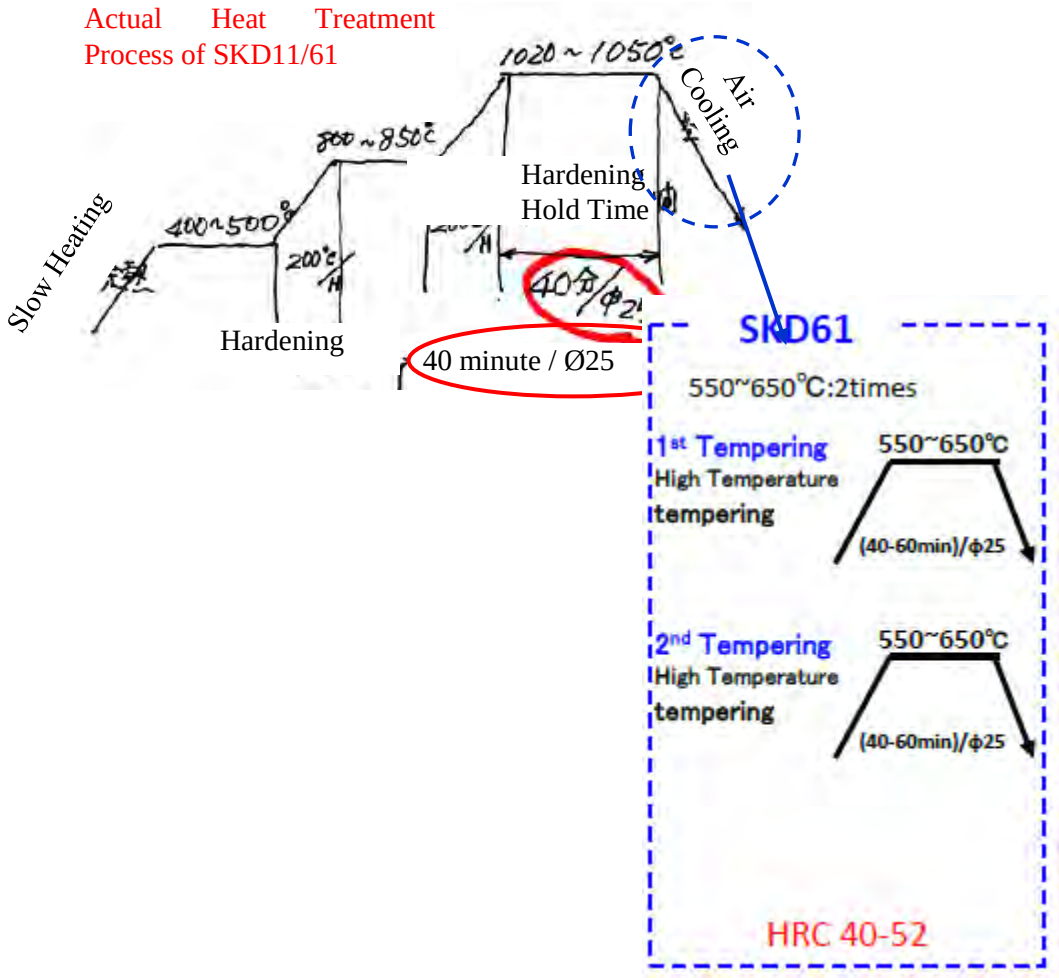
Burr occurring after machining.
Need 2-workers for de-burring.

Chamfer adding in counter wise in cutting direction. Not occurring burr after machining. 2-workers reduced.

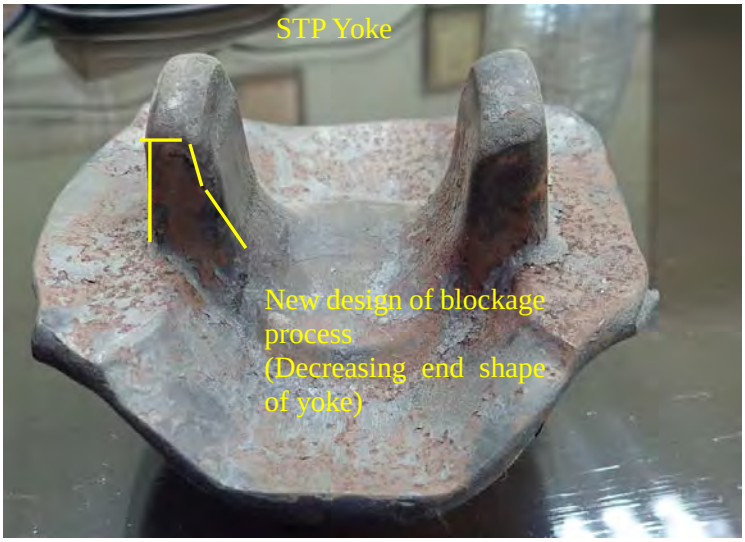
2) Die life (Gear, C1)

The heat treatment of the die (SKD61) has been optimized, and the mold life, which was 2000PC in the past, has been improved to 6000PC. (Refer to Table 3-2 above for optimization conditions)

Actual Heat Treatment Process of SKD11/61



3) Measures for lack of material



Making location chamfer of die and set the parts turning over in blockage to finisher.

Normally, the flow resistance is controlled by the type of Flash land and Gutter. However, since it is difficult to control the outflow resistance due to the structure of the die, the shape of the die modified and improved.

4) Forging failure due to defective shape of billet (bar material before forging)
(□: failure at Pakistan)

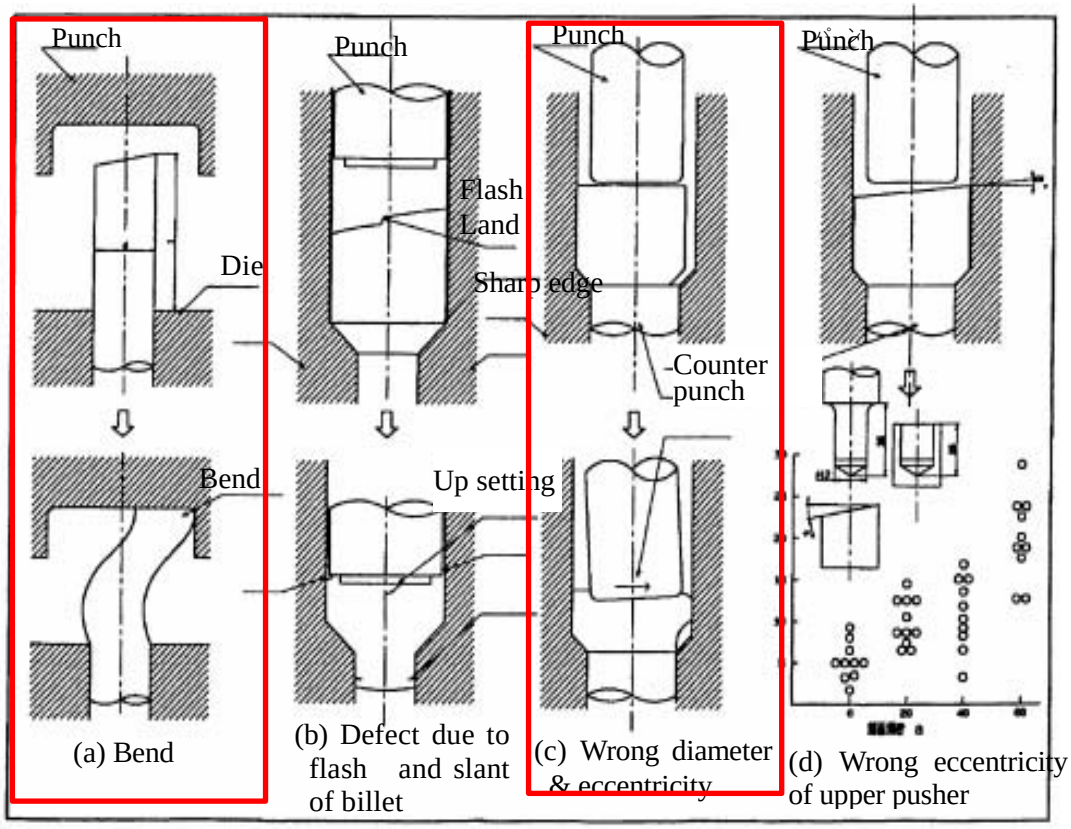


Fig. 1. Defects that occur in the product due to poor billet geometry

6. Reference Materials of Teaching / Coaching

Under-said materials are (1) Selection standards of target factories,(2) Supplier DATA & visiting records of teaching/coaching by JICA Experts, (3) Improvement Activity Progress control Sheet including picture records etc.

6-1; Selection standards of target factories ‥‥‥‥‥‥‥‥‥‥appendix 1

6-2; Evaluation sheet of target factories‥‥‥‥‥‥‥‥‥‥‥‥appendix 2

6-3; Selection standards of local consultants‥‥‥‥‥‥‥‥‥‥appendix 3

6-4; Evaluation of local consultants‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥appendix 4

6-5; Target supplier(factory) data sheet and visiting records by JICA Experts‥‥‥‥‥‥‥‥‥‥appendix 5

6-6; Improvement Activities progress Control Sheet‥‥‥‥‥‥‥‥appendix 6

6-7; Improvement Activities Progress Picture Records‥‥‥‥‥‥‥appendix 7

6-8; KPIs Monitoring sheet‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥appendix 8

6-9; KPIs legend sheet‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥‥appendix 9

7. Scheduling of Teaching / Coaching

7-1; New product development-case of SOP

7-2; Case on productivity and QA improvement of existing SOP parts

7-3; Case on process planning (process completion and ISQC)

7-4; Case on productivity and QA improvement of CO2 Welding

7-5; Case on improvement of Die and Molds maintenance

7-6; Case on productivity and quality improvement of machining process

7-7; Case on productivity and quality improvement of injection molding

8. Other Measures for Technical Improvement

8-1; Teaching school for vocational skills (Dojyo)

8-2; OJT

8-3; Vocational Skills competition (Olympic)

8-4; Training program in Japan/Third country

8-5; Technical collaboration as managerial option

End: