Technical Guide
"Overall Equipment Effectiveness (OEE)"

Small and Medium Enterprises Development Authority
Ministry of Industries & Production
Government of Pakistan

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1 Disclaimer:

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1.1 Introduction to SMEDA:

The Small and Medium Enterprises Development Authority (SMEDA) was established in October 1998 with an objective to provide fresh impetus to the economy through development of Small and Medium Enterprises (SMEs).

With a mission "to assist in Employment Generation and Value Addition to the national income, through development of SME sectors, by helping increase the number, scale and competitiveness of SMEs", SMEDA has carried out 'sectoral research' to identify Policy, Access to Finance, Business Development Services, strategic initiatives and institutional collaboration & networking initiatives.

Preparation and dissemination of prefeasibility studies in key areas of investment has been a successful hallmark of SME facilitation by SMEDA.

Concurrent to the prefeasibility studies, a broad spectrum of Business Development Services is also offered to the SMEs by SMEDA. These services include identification of experts and consultants and delivery of need-based capacity building programs of different types in addition to business guidance through help desk services.

For more information on services offered by SMEDA, please contact our website:
www.smeda.org

1.2 Industry Support Program

In order to enhance competitiveness of SMEs and achieve operational excellence, SMEDA established an Industry Support Cell (ISC) for provision of foreign technical support and knowledge transfer in collaboration with International Development Organizations. SMEDA's Industry Support Program (ISP) initially launched with Japan International Cooperation Agency (JICA) and actively engaged in reducing energy inefficiencies and improving production and quality of products with the support of Japanese Experts. Later on, similar activities with other international partner organizations like German Corporation for International Cooperation (GIZ), Training and Development Centers of the Bavarian Employers' Association (bfz), Germany, and United Nations Industrial Development Organization (UNIDO) were also successfully implemented.

2. What is Overall Equipment Effectiveness (OEE)?

Overall Equipment Effectiveness herein referred as "OEE" is a "best practice" metric for monitoring and improving the efficiency of your manufacturing processes (i.e. machines, cells, assembly lines, etc.). OEE is simple, practical and powerful tool to measure the true manufacturing efficiency. It helps us analyse the problems and make improvements.

3. Components of OEE:

Following are the three major components of OEE.

a. **Availability (A)** measures productivity losses from down time (events that stop planned production for an appreciable amount of time).

b. **Performance (P)** measures losses from slow cycles (factors that cause the process to operate at less than the maximum possible speed).

c. **Quality (Q)** measures losses from manufactured parts that do not meet quality requirements.

The above three factors combination result in OEE score. OEE provides a comprehensive measure of manufacturing efficiency and effectiveness.

OEE = Availability x Performance x Quality

OEE = A x P x Q

4. World Class OEE:

World Class OEE for discrete manufacturing plants is generally considered to be 85% or better.

OEE Factor	World Class
Availability	90.0%
Performance	95.0%
Quality	99.9%
OEE	85.0%

Table 1: Benchmarking World Class OEE

Average OEE score for **discrete manufacturing plants**[1] are approximately 60-70%. Clearly, there is significant room for improvement in most manufacturing plants. Imagine what a 30-40% improvement (increasing OEE from average 60% to 85%) in productivity could do for your competitiveness and profitability!

[1] Production of distinct items. Fabrication & Assembling Industries Like Automobiles, Furniture, Smartphones Etc.

5. Eight Major Equipment Related Losses:

Following are eight major equipment related losses that reduces equipment efficiency.

1. Failure Losses – Breakdown Loss
2. Setup & Adjustments Loss
3. Cutting Tool Replacement Loss
4. Start-up Loss
5. Minor Stop and Idling Loss
6. Speed Loss – Operating at Low Speeds
7. Quality Defect & Rework Loss
8. Schedule Downtime Loss (Planned Breaks)

Overall Equipment Effectiveness (OEE) only considers total time that equipment is scheduled for production. This is the starting point for OEE analysis. It ignores all **planned/scheduled downtime losses** like for example planned breaks (cleaning, maintenance and lunch and tea time) etc. and thus eliminates the schedule downtime loss.

Out of the above 8 major equipment related losses, the following 7 losses are used to calculate the OEE.

Type of Loss	Definition	Units
1. Breakdown Loss	A breakdown is a loss of or reduction in machine's capacity to function. Breakdown loss is the time losses (reduction in output) and physical losses (increase in defectives and rework) arising from sporadic and chronic failures	Time (minutes)
2. Setup and Adjustment Loss	The time losses incurred from when the last good product of the previous run comes off the line until changeover, adjustment and test processing are completed and the first good product of the next run emerges, together with the physical losses created by test processing	Time (minutes)
3. Cutting-tool replacement loss	The loss incurred by stopping a machine in order to change cutting tool such as a grindstone, saw blade, cutter wire or lathe tool when it has become worn out or damaged	Time (minutes)
4. Startup Loss	The loss incurred when production starts, throughout the run-up to steady-state operation until processing conditions have stabilized	Time (minutes)
5. Minor stops and Idling Loss	Unlike breakdown losses, these are the losses resulting from stopping and starting and transient problems which requires a machine to be paused or idled for short periods	Time (minutes), number
6. Speed Loss	The loss arising from the difference between the equipment's design speed and the speed at which it actually operates	Speed, ratio
7. Quality defect and re-work loss	The physical losses and time losses created by defective and re-work	Time, quantity

Table 2: Seven Equipment Related Losses Used in OEE Calculations

5a. Loss Categorization:

The top 7 machine related losses that are used to calculate the OEE are further categorized as shown in the below picture. It is pertinent to mention that SD Loss represents Scheduled/Planned Downtime losses and it is Excluded from OEE calculation.

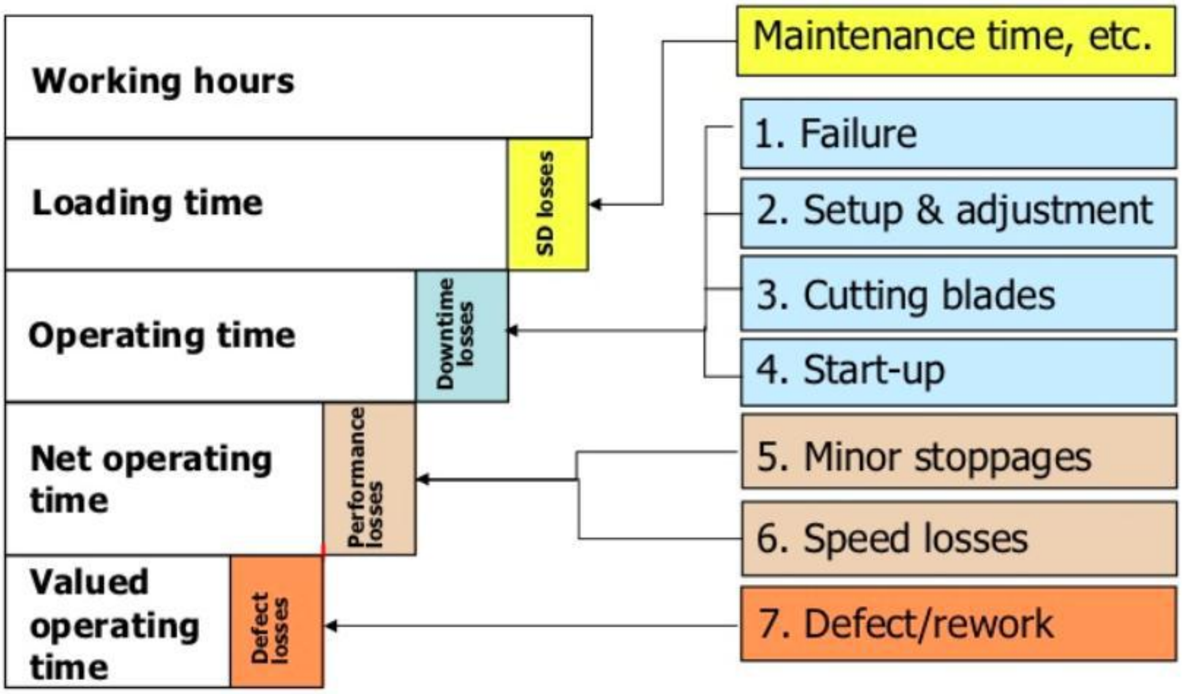

Table 3: OEE Loss Categorization

5b. Working Hours/ Plant Operating Time:

Refer to the table # 3, the working hours also known as **Plant Operating Time is the** amount of time the facility is open and available for production. Plant Operating Time/Working Hours consist of Productive Time plus all types of losses.

Components of Working Hours/ Plant Operating Time:

a. **Loading Time/ Planned Production Time:**

We start with plant operating time or working hours, we subtract all scheduled down times like (lunch/tea breaks, scheduled maintenance any other planned shutdown) and calculate the loading time. Loading time is also known as Planned Production Time.

b. **Operating Time:**

From Loading Time/ Planned Production Time we subtract all downtime losses (as shown in the table 3: OEE Loss Categories above). The remaining time is called the Operating Time. It is the time during which the equipment is actually in operation.

c. Net Operating Time:

From Operating Time, we subtract all Speed/Performance Losses. The remaining time is called the Net Operating Time. It is the time the equipment is operating at a stable or constant speed.

d. Valued Operating Time/ Fully Productive:

From Net Operating Time, we subtract all Quality/Defect Losses. The remaining time is called the Fully Productive/ Valued Operating Time. It is the time during which the quality product is manufactured.

6. How to Measure the OEE?

As we know that OEE is multiple of three factors Availability, Quality and Performance.

OEE = Availability (A) x Performance (P) x Quality (Q)

Below we present the details about the each of the three factors separately and how to calculate each of them.

a.) Availability:

Availability accounts for Down Time Losses (refer Table 2 & 3). Downtime Looses includes all events that stop planned production for several minutes like (equipment failure, material shortages & changeover time etc.).

Availability is the ratio of **Operating Time to Planned Production Time/ Loading Time** (See Components of Plant Operating Time Heading # 5). It represents the Percentage of scheduled time that the equipment is available to operate.

$$\textbf{Availability} = \frac{\textbf{Operating Time}}{\textbf{Loading Time/ Planned Production Time}}$$

b.) Performance:

Performance takes into account the Speed/Performance Losses (refer Table 2 & 3). Speed losses include all the problems that cause your process to operate at less than the maximum speed when running. Different situations which results in Speed/ Performance loss includes (machine wear, substandard materials, misfeeds and operator inefficiencies etc.)

Performance is the ratio of **Net Operating Time to Operating Time** (See Components of Plant Operating Time Heading # 5). It represents the speed at which the equipment runs due to Speed/Performance Losses as opposed to its designed speed.

Performance = **Net Operating Time** / **Operating Time**

Or

Performance = **Ideal Cycle Time * Total Count** / **Operating Time**

Or

Performance = **Actual Output** / **Theoretical Output as Per Time Study**

c.) Quality:

Quality takes into account the Quality/ Defect Losses (refer Table 2 & 3). Quality/ Defect Losses deals with problems of produced pieces that do not meet quality standards i.e. Rejected including rework.

Quality is the ratio of **Fully Productive Time/ Valued Operating Time to Net Operating Time** (See Components of Plant Operating Time Heading # 5). It represents the Good units produced as a percentage of the Total units produced.

Quality = **Fully Productive Time/ Valued Operating Time** / **Net Operating Time**

Or

Quality = **Goods Parts** / **Total Parts Produced**

d.) OEE Calculation by Factor Method:

OEE considers all three factors as shown below.

OEE = Availability (A) x Performance (P) x Quality (Q)

$$\text{Availability} = \frac{\text{Operating Time}}{\text{Loading Time/ Planned Production Time}}$$

$$\text{Performance} = \frac{\text{Ideal Cycle Time * Total Count}}{\text{Operating Time}}$$

$$\text{Quality} = \frac{\text{Goods Parts}}{\text{Total Parts Produced}}$$

e.) Example Sample Data for OEE:

Following is the sample data from the manufacturing facility. Calculate OEE

Plant Operating Time/ Working Time Per Day = 8 hours

Scheduled/ Planned Downtime Loss Details:

Machine Cleaning Time = 15 Min, Tea Break = 15 * 2 = 30 Min

Equipment Stoppage Details:

Failure Loss = 35 Min, Setup & Adjustments = 45 Min,

Production Details:

Standard Cycle Time = 0.5 Min/ Unit, Processing Quantity = 440 units/day

Defective Pieces = 23 Units

Solution:

First we calculate the Loading Time/ Planned Production Time.

From Plant Operating Time/ Working Time Per Day = 8 hours = 8 *60 = 480 Min

We subtract Scheduled Downtime Loss = SD Loss = Machine Cleaning + Tea

Breaks = 15 + 30 = 45 Min

Loading Time/ Planned Production Time = Plant Operating Time – SD Losses

=480–45

Loading Time/ Planned Production Time = 435 Min.

$$\textbf{Availability} = \frac{\textbf{Operating Time}}{\textbf{Loading Time/ Planned Production Time}}$$

Operating Time = Loading Time/Planned Production Time – Downtime Losses

$$\textbf{Availability} = \frac{\textbf{Loading Time/Planned Production Time – Downtime Losses}}{\textbf{Loading Time/ Planned Production Time}}$$

Operating Time = Loading Time/Planned Production Time – Downtime Losses

Operating Time = 435-80 => 355

$$\text{Availability} = \frac{435 - (35+45)}{435}$$

$$= \frac{435 - 80}{435} = \frac{355}{435}$$

Availability = 0.81609 = 81.6%

Based on the available data we use the following formula for Performance Calculations.

$$\textbf{Performance} = \frac{\textbf{Ideal Cycle Time * Total Count}}{\textbf{Operating Time}}$$

$$= \frac{0.5 * 440}{355} \Rightarrow \frac{220}{355}$$

Performance = 0.6197 => 62%

Based on the available data we use the following formula for Performance Calculations.

Quality = $\frac{\textbf{Goods Parts}}{\textbf{Total Parts Produced}}$

= $\frac{440-23}{440} \Rightarrow \frac{417}{440}$

Quality = 0.9477 => 94.77%

Overall Equipment Effectiveness:

OEE = Availability * Performance * Quality

= **(0.8106 * .6197 * .9477) *100**

OEE = 47.6% **For Sample Data Activity**

7. Implementing OEE at Workplace:

In order to the start the implementation process for the Overall Equipment Effectiveness (OEE) at the workplace following steps are proposed.

1. **Decide OEE Project (i.e. Critical Facility/Machine/Line etc.)**
2. **Collect the Loss Data & Quantify**
3. **Classify the losses in the right category**
4. **Measure and Baseline the current OEE**
5. **Set the Target for the Future OEE**
6. **Prioritize the major losses**
7. **Analyze the root cause of the problems**
8. **Generate Countermeasures**
9. **Implement the solution**
10. **Follow-up and Monitor the Trend of the OEE**
11. **Raise the target of the OEE in the future**

8. Overall Equipment Effectiveness (OEE) KPI in Action:

In order to address and attack the major machine related losses (as shown in Table # 2 & 3) that affect the machine OEE. Data collection is the first step against each loss as categorized in Table # 2. Based on the collected analysis to be conducted using following root cause analysis tools and improvement methodologies as listed below. Countermeasures needs to be implemented in order to improve the OEE.

1. Brain Storming
2. 5 Why Analysis
3. Fish Bone Diagram

Improvement Methodologies:

1. Standardized Work
2. Quick Changeover
3. 5S/5T
4. Autonomous Maintenance
5. Preventive Maintenance
6. Error Proofing
7. Training of Operators & Maintenance Personnel

Let's check the OEE data (Table # 4 below) from one of the facilitated company in **"SMEDA-JICA Technical Support Project for Autoparts Sector in Pakistan"** through JICA's Automotive Experts. As part of the OEE study the average data for 3 months (January – March 2019) was observed to be 63%. The target for improvement was set at 75% OEE.

Further the root cause analysis done to improve the OEE data. It was observed during floor visit that the workers were not following the standard procedure as described in the work instruction sheet. The problem was discussed with the operator and it was found that the due to creation of gap in the Mold ejector plate each part was stuck and operator is taking longer time in order to remove the part from the Mold. The problem was observed as Speed loss issue that is affecting OEE, it was analysed and countermeasure was proposed as follows.

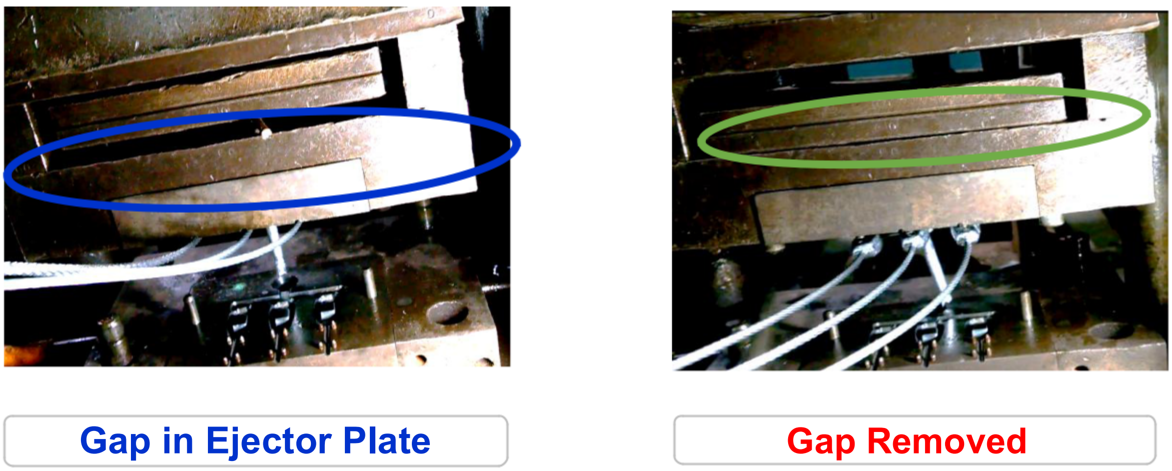

Figure 1: Facilitated Company Example of OEE Loss Analysis

Secondly there was a major problem of Gas load shedding in the area where the factory was situated. This resulted in impact on machine availability by increasing the downtime loss. To overcome this problem factory team arranged a gas cylinder to manage in case of gas load shedding.

As a result of the above Kaizen activity check the OEE data in the KPI graph below (Table # 4). The data started to improve from April 2019 onwards. Further the awareness of workers and maintenance staff was increased. The OEE data started achieving the target from May 2019 i.e. Target of 75%. It was advised to the team to continue monitoring the data trend and analyse in case of any problem in the data. Further it was suggested to revise and further tighten the target to 80% in future in order to improve further,

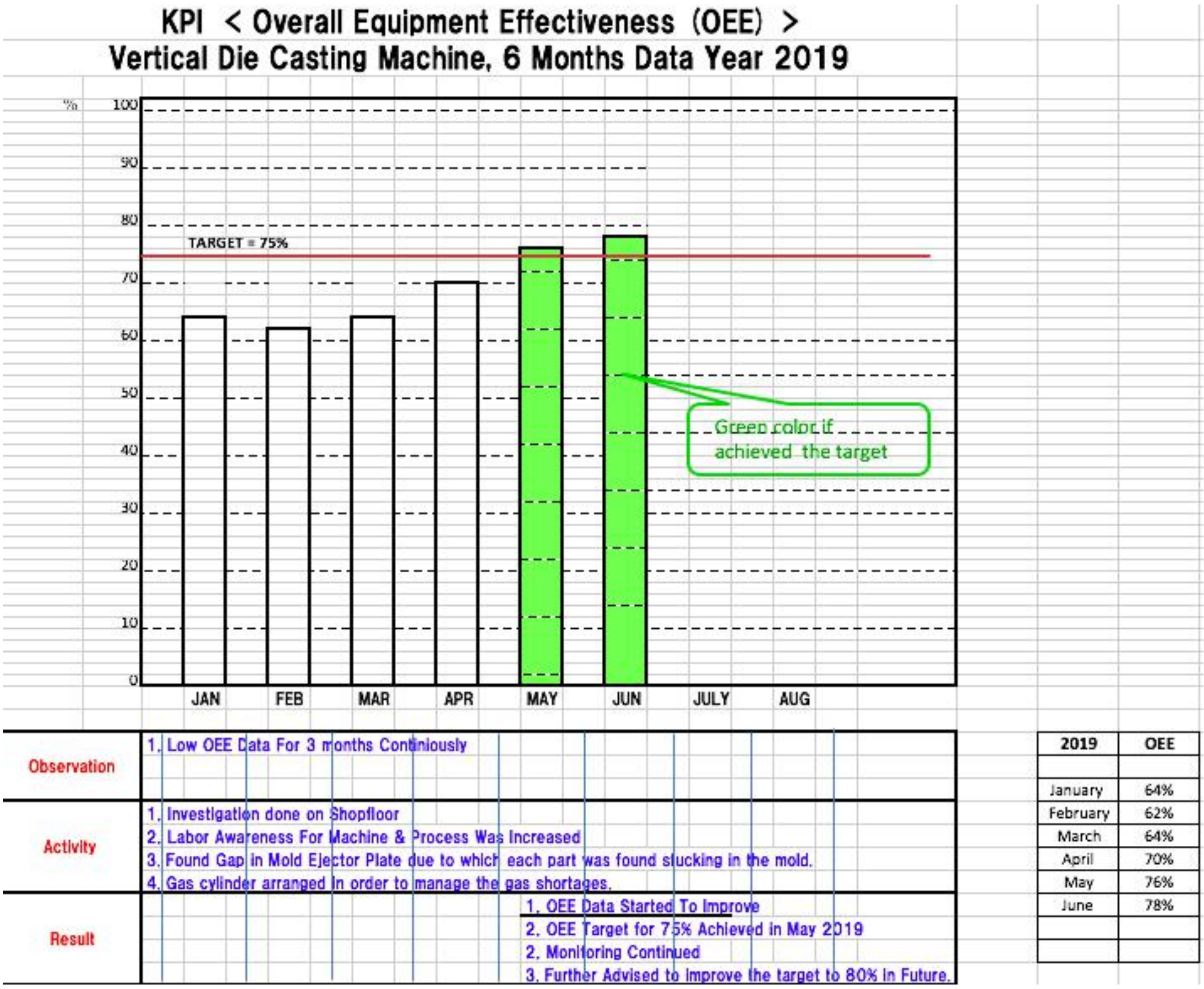

Table 4: Overall Equipment Effectiveness (OEE) Key Performance Indicator (KPI)

As observed from the graph that OEE value raise from **average 63% (before)** to **average 75% (after)** as visible from the OEE KPI data above. If we relate the before OEE (baseline) with losses it is linked directly with Speed/Performance losses i.e. Operating @ slow speeds and secondly with the availability of the machine due to gas load shedding problem. The overall Kaizen activities resulted in improvement in both availability and performance improvements (two important factors of OEE). Performance improved to 8-10% and machine was available to work for all future customer orders as and when required with no gas load shedding issue.