2. IMPROVING OVERALL EQUIPMENT EFFECTIVENESS

The object of production improvement activities is to increase productivity by minimizing input and maximizing output. More than sheer quantity, “output” includes improving quality, reducing costs, and meeting delivery dates while increasing morale and improving safety and health conditions, and the working environment in general.

The relationship between input and output in production activities can be illustrated in a matrix (in Fig. 2). Input consists of labor, machines, and materials, while output is composed of production (P), quality (Q), cost (C), delivery (D), safety, health and environment (S), and morale (M).

Correlating these factors in terms of equipment maintenance demonstrates clearly that all aspects of PQCDSM are related to output. With increasing robotization and automation, the more the production process shifts from workers to machines, the larger the role played by the equipment itself in controlling output, or PQCDSM. Productivity, quality, cost, and delivery, as well as safety and health, environment, and morale all depend on the condition of equipment.

TPM strives to maximize output (PQCDSM) by maintaining ideal operating conditions and running equipment effectively. A piece of equipment that suffers breakdown experiences periodic speed losses, or lacks precision and produces defects are not operating effectively.

The life cycle cost (LCC) (the cost incurred during the equipment’s life span) required maintaining equipment at its optimal level is limited. TPM strives to achieve overall equipment effectiveness by maximizing output while minimizing input, i.e. LCC.

To achieve overall equipment effectiveness, TPM works to eliminate the “six big losses” that are formidable obstacles to equipment effectiveness. They are as follows:

Down time:

1. Equipment failure – breakdowns
2. Setup and adjustment – from exchange of die in injection molding machines, etc.

Speed losses:

3. Idling and minor stoppages – due to abnormal operation of sensors, blockage of work on chutes, etc.
4. Reduced speed – due to discrepancies between designed and actual speed of equipment.

Defects:

5. Process defects – due to scraps and quality defects to be repaired.
6. Reduced yield – from machine startup to stable production.

Figure - 2

Relationship between Input and Output in Production Activities

Input / Output	MONEY			Management Method
	MAN	MACHINE	MATERIAL	
Production (P)				Production Control
Quality (Q)				Quality Control
Cost ©				Cost Control
Delivery (D)				Delivery Control
Safety (S)				Safety and Pollution
Morale (M)				Human Relations
	Manpower Allocation	Plant Engineering & Maintenance	Inventory Control	OUTPUT INPUT PRODUCTIVITY

MAXIMISING EQUIPMENT EFFECTIVENESS thro' TPM

EQUIPMENT EFFECTIVENESS IS A MEASURE OF THE VALUE ADDED TO THE PRODUCTION THROUGH EQUIPMENT

TPM MAXIMISES EQUIPMENT EFFECTIVENESS THROUGH TWO TYPES OF ACTIVITY:

QUANTITATIVE: **INCREASES TOTAL AVAILABILITY OF EQUIPMENT AND ITS PRODUCTIVITY WITHIN A GIVEN PERIOD OF OPERATING TIME**

QUALITATIVE: **REDUCING NUMBER OF DEFECTIVE PRODIUCTS AND STABILIZING AND IMPROVEMENT QUALITY.**

OVERALL EQUIPMENT EFFECTIVENESS

O.E.E = AVAILABILITY X PERFORMANCE RATE X QUALITY RATE

BREAK DOWN LOSS SET UP & ADJUSTMENT LOSS OTHERS	IDLING AND MINOR STOPPAGE LOSS REDUCED SPEED LOSS	QUALITY DEFECT REWORK LOSS START UP LOSS

CALCULATION OF O.E.E.

$$\text{Availability (operating rate)} = \frac{\text{loading time} - \text{down time}}{\text{loading time}}$$

$$\text{Performance rate} = \frac{\text{output} * \text{actual cycle time}}{\text{loading time} - \text{down time}} \times \frac{\text{ideal cycle time}}{\text{actual cycle time}}$$

⇩ *Net operating rate* reflects losses resulting from minor stoppages

⇩ *Operating speed rate* reflects reduced speed losses

$$\text{Quality rate} = \frac{\text{number of good products*}}{\text{output}}$$

** Number of good products = Input – (start up defects–process defects–trial products)*

Overall Equipment Effectiveness = Availability x Performance Rate x Quality Rate

Various factors influencing availability and their interdependencies are given in Figure - 3

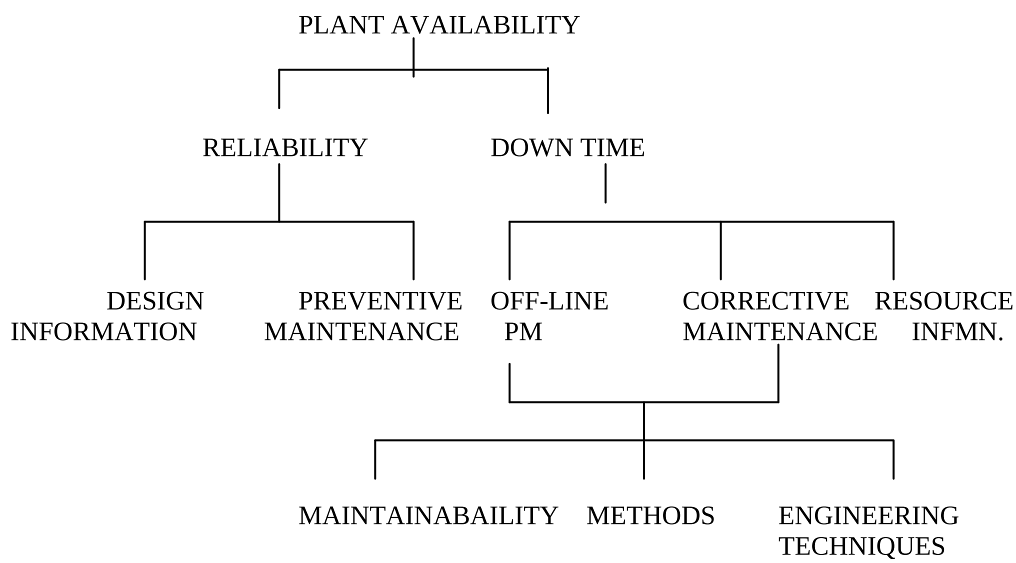

Figure-3

An Example

working hours per day 60 min. 8 hours= 480 min.
Loading time per day = 460 min.
Down time per day = 60 min.
Operating time per day = 400 min.
Output per day : 400 pieces

Types of downtime :

Setup	-	20 minutes
Breakdown	-	20 minutes
Adjustments	-	20 minutes

Defects – 3%
Availability(operating rate) =400/460) x 100 = 87%
Ideal Cycle time : 0.5 Minutes per product
Actual cycle time : 0.8 Minutes per product
Operating Speed rate = (0.5/0.8) x 100 = 62.5%
Net Operating Rate = 400 pcs x 0.8/400 Minutes x 100 = 80%
(100 – Net Operating rate) reflects losses caused by minor stoppages
Performance rate = 0.625 x 0.800 x 100 = 50%
Quality Rate = 98%
Overall Equipment Effectiveness = 0.87 x 0.5 x 0.98 x 100 = 42%

CASE STUDY ON MEASURING EQUIPMENT EFFECTIVENESS

In an Engineering industry, one of the machine centres is scheduled for two shifts operation at the rate of 8 hours per shift. The time allowed for changing tools, shift breaks, direct plant maintenance activities etc. is one hour per shift. Thus, the planned up time is 14 hours a day, and 336 hours per month. The maintenance manager has analysed the downtime data for last three months and found out that the machine centre has stopped for 262 hours due to various breakdown distributed on 89 occasions. The production manager reported a production of 4576 pieces during the above-mentioned period. The theoretical cycle time for producing each piece is 6 minutes and actual cycle time is 8 minutes. The quality control department rejected 456 pieces, as this did not confirm the prescribed standards.
It was also found that the failure causing the down time were distributed as follows:
Group 1 : 25% due to incorrect operation.
Group 2 : 55% due to were, incorrect lubrication, bad adjustment
Group 3 : 20% due to sudden failure like broken shafts, fuses etc.

The down time was found to have the following time components :

Time to find the failure	10%
Time to find spare parts, tools, drawings	20%
Time lost for want of spare parts	25%
Waiting for personnel	5%
Repair Time	40%

5% of all maintenance jobs were planned and 95% of the jobs were unplanned urgent repairs.

Calculate the overall equipment effectiveness (OEE) of the machine centre.
What is the Availability?
What is MTTF ?
What is MTTR + MTW?
What are the steps to be taken to improve the OEE?

FIVE REQUIREMENTS FOR ZERO BREAKDOWN

- ✓ MAINTAIN BASIC EQUIPMENT CONDITIONS
- ✓ ADHERE TO PROPER OPERATING CONDITIONS
- ✓ RESTORE DETERIORATION
- ✓ CORRECT DESIGN WEAKNESS
- ✓ IMPROVE OPERATING & MAINTENANCE SKILL

ZERO BREAKDOWNS – FOUR -PHASE PROGRAMME

STABILISE EQUIPMENT FAILURE INTERVALS (MTBF)

- RESTORE UNCHECKED DETERIORATION
- PREVENT ACCELERATED DETERIORATION

LENGTHEN EQUIPMENT LIFE

- CORRECT DESIGN WEAKNESS
- RESTORE VISIBLE DETERIORATION
- ELIMINATE CHANCE BREAKDOWNS

PERIODICALLY RESTORE DETERIORATION

- ESTIMATE EQUIPMENT LIFE
- LEARN SIGNS OF INTERNAL DETERIORATION

PREDICT EQUIPMENT LIFE

- USE MACHINE DIAGNOSTIC TECHNIQUES
- ANALYSE CATASTROPHIC BREAKDOWNS