Total Productive Maintenance (TPM)

The crux is: 

\[ T \] – Involvement of Total employee
\[ P \] – Linking of Productivity with maintenance
\[ M \] – Autonomous Maintenance activity

Quality and Reliability Engg. (171906)

Prof. K. M. Joshi
Assi. Professor, MED,
S.S.A.S Insti. of Tech., Surat
Origin of TPM

TPM Work out from TQM, which evolved as a direct result of Dr. W. Edwards Deming's influence on Japanese industry.

The initial statistical procedures and the resulting quality control concepts are accepted by the Japanese industry. This new manufacturing concept became popular as Total Quality Management or TQM. But some elements of maintenance did not agreeable or fit to maintenance scheme.

Though the TPM is Japanese philosophy, some roots of TPM are lies in the concept of Preventive Maintenance of USA. Preventive Maintenance technique often resulted in machines being over-serviced in making effort for improving production.

Oct 14, 1900 - Dec 20, 1993
Common Types of Maintenance

**PM** Preventive Maintenance
- Physical check up and preventive medicine for equipment to prolong the equipment service life
- System is to improve equipment so that equipment failure can be eliminated and equipment can be easily maintained.

**BM** Breakdown Maintenance
- Waits for maintenance until equipment fails and repair equipment. (failure does not have any significantly effect)

**CM** Corrective Maintenance
- Weakness of current machines are sufficiently studied to improve design and are incorporated before commissioning a new equipment.

**MP** Maintenance Prevention
- Production efficiency improvement to its maximum extent incorporate with quality.

**TPM** Total Productive Maintenance

www.joshikandarp.webs.com
Nippondenso was the first company to introduce plant wide Preventive Maintenance in 1960. However with the automation of Nippondenso, maintenance became a problem as more maintenance personnel were required. And thus a new maintenance philosophy Total Productive / Preventive Maintenance came into existence.
So the management decided that the routine maintenance of equipment would be carried out by the operators. By this Nippondenso which already followed Preventive Maintenance also added *Autonomous Maintenance*. And thus a new maintenance philosophy **Total Productive / Preventive Maintenance** came into existence.
The maintenance crew went in the equipment modification for improving reliability. The modifications were made or incorporated in new equipment. This lead to Maintenance Prevention.

And thus a new maintenance philosophy Total Productive / Preventive Maintenance came into existence.
Thus Preventive Maintenance along with Maintenance prevention and Maintainability Improvement gave birth to Productive maintenance. The aim of productive maintenance was to maximize Equipment Effectiveness to achieve optimum life cycle cost of production equipment. And thus a new maintenance philosophy Total Productive / Preventive Maintenance came into existence.
Before TPM Implementation

- Total Cost Increases
- Other Costs
- Material Cost
- Power Cost
- Wages
- Rejection
- Production

Cost vs. Year
It may be noted the **product, machines, employees, and the materials are the same.** The updated concept when implemented made the difference.
A Japanese approach called Total Productive Maintenance or Management is: *Maximize* Overall Equipment Effectiveness (OEE); Establish a total system for preventive and productive maintenance for the *entire life* of equipment; Involve *all* personnel, including top management personnel to the first line operator and Promote preventive maintenance by motivation management, namely, autonomous *small-group* activity. TPM brings maintenance into focus as a necessary and vitally important part of the business. It is *no* longer regarded as a *non-profit* activity.

The basic elements of Total Productive Maintenance known as “*Pillars*” are minted in next slide.
Basic element of TPM

Total Productive Maintenance

Eight Pillars of Total Productive Maintenance

(Source: Critical Success Elements of Total Productive Maintenance, By: Mr. K. M. Joshi et al., 2008)
TPM is a maintenance program which deifies concept for maintaining plants and equipment, with the goal of markedly increase production while, at the same time, increasing employee morale and job satisfaction. It put into service the machinery for optimal use by daily and time base maintenance.
A complete definition of TPM includes:

1. TPM aims to maximize equipment effectiveness
2. TPM establishes a through system of productive maintenance for the equipments entire life spam.
3. TPM is implemented by various departments (engineering, operations, and maintenance).
4. TPM involves every single employee, from top management to workers on the floor.
5. TPM autonomous maintenance by developing ownership.

The word “Total” in “Total Productive Maintenance” has three meanings that describe the principle features of TPM

1. Total effectiveness
2. Total Maintenance
3. Total participation of all employees.
Total all aspects and associate everybody

Productive activity by optimum equipment efficiency

Daily and time based autonomous maintenance by developing ownership
TPM brings a conceptual change in transforming the age-old maintenance responsibility restricted to section/department into a companywide culture of autonomous maintenance by everyone. This not only aims at prevention of breakdowns, but also utilizing the machinery to its full potential.

The philosophy of TPM can be understood easily by its structure shown in figure “House of TPM”
| **Voluntary maintenance system:** Responsibility for upkeep of equipment |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| **Not big spectacular innovations but Small continual improvement** |
| **Defect free Manu.: Full proof system:** Quality Control to Quality Assurance |
| **Maintenance improvement initiative:** Minimal problem and Running in time on equipment |
| **Upgrading the skills of the workforce:** Opportunistic approach Multi skilling employee |
| **Improve synergy between various business functions:** Safe and Appropriate work environment |

<table>
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<tr>
<th><strong>Autonomous Maintenance</strong></th>
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<tr>
<td>Kobetsu Kaizen</td>
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<td>Safety, Health &amp; Environment</td>
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Milestones in Road Map of TPM

1. Analysis of the Difference between Basic Conditions and Current conditions
2. Informing everyone of the Management decision to introduce TPM
3. Training and Campaign on TPM
4. Creating a TPM Promotion Organization
5. Establishing basic TPM policies and objectives
6. Formulating a master plan for the introduction
7. Develop best practices & routine standard
8. Elimination of losses & Improving Equipment Efficiency
9. Initial control system & Quality Maintenance
10. Safety, Hygiene & Pollution Control
11. Wider Application for Completion of TPM

(Source: Critical Success Elements of Total Productive Maintenance, By: Mr. K. M. Joshi et al, 2008)
Overall Efficiency of Equipment

PLANT

CALANDER TIME (A)
RUNNING HOUR (B)  
Loss by Stoppage  
Suspension
OPERATION HOUR (C)  
Loss by Stoppage  
Loss by Capacity
NET OPERATION HOUR (D)  
Loss by Capacity  
Loss by Deficiency
VALUABLE OPERATION HOUR (E)  
Loss by Deficiency

8 MAJOR LOSSES
1. Planned Maintenance  
2. Production Control
3. Equipment B/D  
4. Process B/D
5. Regular Production  
6. Irregular production
7. Production deficiency  
8. Reprocessing

CALCULATION OF OVERALL EQUIPMENT EFFECTIVENESS

Availability = \frac{\text{Calendar Time (A)} - (1+2+3+4)}{\text{Calendar Time}} \times 100

Performance = \frac{\text{Actual Avg. Production}}{\text{Standard Production}} \times 100 = \frac{C}{D} \times 100\%

Rate of Quality = \frac{\text{Production}}{\text{Quality}} \times 100 = \frac{E}{D} \times 100\%

OEE = \text{Availability} \times \text{Performance Efficiency} \times \text{Rate Of Quality}

(Source: Apollo tyres, case study, 2005.)
Overall equipment effectiveness

OEE breaks the performance of a manufacturing unit into three separate but measurable components: **Availability, Performance, and Quality**. Each component points to an aspect of the process that can be targeted for improvement.

OEE may be applied to any individual Work Center, or rolled up to Department or Plant levels.

**Calculation:** \( \text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality} \)

**Example:**
A given Work Center experiences...
Availability of 86.7%
The Work Center Performance is 93.0%.
Work Center Quality is 95.0%.

\[
\text{OEE} = 86.7\% \times 93.0\% \times 95.0\% = 76.6\%
\]
Total Effective Equipment Performance

Where OEE measures effectiveness based on scheduled hours, TEEP measures effectiveness against calendar hours, i.e.: 24 hours per day, 365 days per year. TEEP, therefore, reports the 'bottom line' utilization of assets.

Calculation: TEEP = Loading x OEE

Example: A given Work Center experiences...OEE of 34.0%
Work Center Loading is 71.4%
TEEP = 71.4% Loading x 34.0% OEE = 24.3%

Stated another way, TEEP adds a fourth metric 'Loading', Therefore
TEEP = Loading x [Availability x Performance x Quality]

Loading The Loading portion of the TEEP Metric represents the percentage of time that an operation is scheduled to operate compared to the total Calendar Time that is available.

Calculation: Loading = Scheduled Time / Calendar Time

Example: A given Work Center is scheduled to run 5 Days per Week, 24 Hours per Day. For a given week, the Total Calendar Time is 7 Days at 24 Hours. Loading = (5 days x 24 hours) / (7 days x 24 hours) = 71.4%
**Availability**
The Availability portion of the OEE Metric represents the percentage of scheduled time that the operation is available to operate. The Availability Metric is a pure measurement of Uptime that is designed to exclude the effects of Quality, Performance, and Scheduled Downtime Events.

**Calculation:** \( \text{Availability} = \frac{\text{Available Time}}{\text{Scheduled Time}} \)

**Example:**
A given Work Center is scheduled to run for an 8-hour (480 minute) shift. The normal shift includes a scheduled 30-minute break when the Work Center is expected to be down.

The Work Center experiences 60 minutes of unscheduled downtime.

**Scheduled Time** = 480 min – 30 min break = 450 Min  
**Available Time** = 450 min Scheduled – 60 min Unscheduled Downtime = 390 Min  
**Availability** = 390 Avail Min / 450 Scheduled Min = 87%
OEE = Availability x Performance x Quality

**Performance**
The Performance portion of the OEE Metric represents the speed at which the Work Center runs as a percentage of its designed speed. The Performance Metric is a pure measurement of speed that is designed to exclude the effects of Quality and Availability.

**Calculation:** Performance = (Parts Produced * Ideal Cycle Time) / Available Time

**Example:**
A given Work Center is scheduled to run for an 8-hour (480 minute) shift with a 30-minute scheduled break.
Available Time = 450 Min Sched – 60 Min Unsched Downtime = 390 Minutes
The Standard Rate for the part being produced is 40 Units/Hour or 1.5 Minutes/Unit
The Work Center produces 242 Total Units during the shift.

*Note: The basis is Total Units, not “Good” Units.*

Time to Produce Parts = 242 [Units] X 1.5 [Minutes/Unit] = 363 Minutes
**Performance** = 363 Minutes / 390 Minutes = 93.0%
OEE = Availability x Performance x Quality

Quality

The Quality portion of the OEE Metric represents the Good Units produced as a percentage of the Total Units Started. The Quality Metric is a pure measurement of Process Yield that is designed to exclude the effects of Availability and Performance.

Calculation: Quality = Good Units / Units Started

Example:
A given Work Center produces 230 Good Units during a shift. 242 Units were started in order to produce the 230 Good Units.

Quality = 230 Good Units / 242 Units Started = 95.0%
Autonomous Maintenance

... aims to enable the machine operators to carry out maintenance themselves, which would keep the machines producing and limit the number of defects produced.

Each employee prepares his own autonomous chart / schedule in consultation with supervisor.

Kobetsu Kaizen

... aim for reducing losses in the workplace that affect efficiencies. By using a detailed and thorough procedure one can eliminate losses in a systematic way.
<table>
<thead>
<tr>
<th>Loss</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Failure losses - Breakdown loss</td>
<td>Losses that impede equipment efficiency</td>
</tr>
<tr>
<td>2. Setup / adjustment losses</td>
<td></td>
</tr>
<tr>
<td>3. Cutting blade loss</td>
<td></td>
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<tr>
<td>4. Start up loss</td>
<td></td>
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<tr>
<td>5. Minor stoppage / Idling loss.</td>
<td></td>
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<tr>
<td>6. Speed loss - operating at low speeds.</td>
<td></td>
</tr>
<tr>
<td>7. Defect / rework loss</td>
<td></td>
</tr>
<tr>
<td>8. Scheduled downtime loss</td>
<td></td>
</tr>
<tr>
<td>9. Management loss</td>
<td>Losses that impede human work efficiency</td>
</tr>
<tr>
<td>10. Operating motion loss</td>
<td></td>
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<tr>
<td>11. Line organization loss</td>
<td></td>
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<tr>
<td>12. Logistic loss</td>
<td></td>
</tr>
<tr>
<td>13. Measurement and adjustment loss</td>
<td></td>
</tr>
<tr>
<td>14. Energy loss</td>
<td>Losses that impede effective use of production resources</td>
</tr>
<tr>
<td>15. Die, jig and tool breakage loss</td>
<td></td>
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</tbody>
</table>
Quality Maintenance

... aims to produce defect free parts by focusing improvements on the elements of the machine/equipment have an effect of product quality. It is aimed towards customer delight through highest quality through defect free manufacturing.

Planned Maintenance

This maintenance breaks down into 4 "families“.

- Preventive Maintenance
- Corrective Maintenance
- Breakdown Maintenance
- Maintenance Prevention
Office TPM

... aims to develop all back office functions to improve their productivity and eliminate losses. Office TPM should be started after activating four other pillars of TPM (AM, KK, QM, PM).

- Processing loss
- Communication loss
- Cost loss including in areas such as procurement, accounts, marketing, sales leading to high inventories.
- Idle loss,
- Set-up loss,
- Accuracy loss
- Time spent on retrieval of information
- Non availability of correct on line stock status
- Customer complaints due to logistics
- Expenses on emergency dispatches/purchases
Training and Education

Critical To Communicate

Not Sufficient

EDUCATION & TRAINING

LEVEL 4 - CAN TEACH

LEVEL 3 - CAN DO CONFIDENTELY

LEVEL 2 – KNOW THEORY BUT CAN’T DO
Train the person so that he can do the job only little extent

LEVEL 1 - CAN’T DO
Teach basic things so that one is versed with knowledge
Top Management Leadership

• Full and continued support from top management,
• Allocation of adequate resources to quality improvement efforts
• Top management provides for new technology ...... are the elements those are very impotent for successful implementation of TPM.

Five S

<table>
<thead>
<tr>
<th>Japanese</th>
<th>Meaning</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seiri</td>
<td>Organization</td>
<td>Sort</td>
</tr>
<tr>
<td>Seiton</td>
<td>Tidiness</td>
<td>Systematize</td>
</tr>
<tr>
<td>Seiso</td>
<td>Cleaning</td>
<td>Sweep</td>
</tr>
<tr>
<td>Seiketsu</td>
<td>Standardization</td>
<td>Standardize</td>
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<tr>
<td>Shitsuke</td>
<td>Discipline</td>
<td>Self - Discipline</td>
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</table>
Housekeeping

- To improve morale by improving the physical surroundings of the worker.
- Clean up problems are categorized and contents of tag is transferred to a register.
- The frequency of cleanup and inspection is reduced based on experience.

Work Culture and Mind Set

- A culture in which there is interaction amongst the peers and support from supervisors.
- Agenda for changing initial resistance to adopting new methodology of maintenance into positive mind set.
Standardization

Generally the machinery or equipment are the concentrated regarding to standard but here the surroundings of machinery should also considered.

Visual Management

Visual management practices and color coding schemes demonstrate the status of working system.

- Valve normally kept closed
- Valve normally kept open in operation

(Source: IOCL, Gujarat refinery, case study, 2001.)
Health and Safety and the Environment

... aim to minimize the number of accidents, health problems and damage to the environment.

This element has goal to achieve: Zero accident, Zero health damage and Zero fires.

In this area focus is on to create a safe workplace and a surrounding area so that each employee feel safe during all process or procedures.
The goal of TPM are;
- Zero accidents
- Zero unplanned downtime
- Zero defects and
- Minimum life cycle cost
- Zero speed losses
- Zero waste

TPM encourages radical changes, such as;
- Flatter organizational structures
- Fewer managers and empowered teams,
- Multi-skilled workforce,

TPM gives better understanding of the performance of equipment by what they are achieving in OEE terms and what the reasons are for non-achievement.

TPM provides Optimum relationships between people and equipment/process by Involvement of everyone, from top leadership to shopfloor workers.
TPM – Advantages

- Improvements in operational efficiency and Lower operating cost
- Improvements in reliability and quality
- Maintenance partnership with production. - Better relationships with maintenance and production department.
- More emphasis on planning and preventative maintenance
- Improvements in production capacity / availability = increased productivity = increased ROI
- Increased equipment life span and effectiveness
- Its provides foundation for TQM, JIT, Lean Manufacturing etc
- Improvements in Health and Safety
- Higher morale from improved job satisfaction and job security
<table>
<thead>
<tr>
<th>Focus Area</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Focused Improvement</strong></td>
<td>Ensures that improvement became part of every one’s activity. Aims to eliminate production losses and cost reduction.</td>
</tr>
<tr>
<td><strong>Autonomous Maintenance</strong></td>
<td>Maintains basic conditions on the shop floor and in all the machines. Overall participation through TPM circles.</td>
</tr>
<tr>
<td><strong>Planned Maintenance</strong></td>
<td>A logical analysis of real causes for taking action on counter measures. Focuses on prevention.</td>
</tr>
<tr>
<td><strong>Quality Maintenance</strong></td>
<td>Develops the perfect machine for perfect quality. Eliminates in-process defects and customer complaints.</td>
</tr>
<tr>
<td><strong>Development Management</strong></td>
<td>Machines for high equipment effectiveness.</td>
</tr>
<tr>
<td><strong>Education &amp; Training</strong></td>
<td>Develops skills to ensure: • Uniformity at work • Practices on machines • Zero defects, zero breakdown and zero accidents. • The presence of multi skilled employees in all departments.</td>
</tr>
<tr>
<td><strong>Safety, Health &amp; Environment</strong></td>
<td>Achieving zero accidents and zero health hazards at work. Working toward the maintenance of a zero pollution plant and environment.</td>
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<td><strong>Office TPM</strong></td>
<td>Office becomes oriented to gamer excellent support for manufacturing. Improves man hour efficiency in offices.</td>
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