Total Productive Maintenance
TPM

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Lean Systems and Operations Modeling

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Agenda

- TPM History, Definition, Benefits and Roles
- Applying TPM, DMAIC & Metrics
- TPM Success (Benchmark Study in BioTech vs Food & Beverage Processing Industry)
- RCA Techniques
- Current Challenges
- TMP to Infinity and Beyond
- Q & A
TPM History

Dr. Deming 1900-1993  
1951 PM  
Nippon Denso PM in 1960  
Nippon Denso TPM Award
Total Productive Maintenance

- Promote the collaboration between all departments to focus on the durability of equipment
Definition

- **Total**: Total employee involvement
- **Productive**: Eliminate or minimize breakdown during production
- **Maintenance**: Complete a preventive maintenance program
Benefits of TPM

• Improves Teamwork

• Improves Equipment availability

• Reduces cost
Roles of TPM

- To target the major causes of poor performance (OEE)
- Involve operators in the routine maintenance of their equipment
- Improve maintenance efficiency
- Improving skills and knowledge
- To collaborate in partnership while having a common goal
Applying TPM

- Create a cross functional team
  - D-Define
  - M-Measure
  - A-Analyze
  - I-Improve
  - C-Control
Define DMAIC

D: Define the equipment, objectives, success indicators, customers, cost
Measure 7 Losses **DMAIC**

TPM identifies the 7 losses

OEE = Availability x Performance x Quality

| A | 1. Total time available – shutdowns/startup – scheduled maint. - calibration |
| A | 2. Set-Up |
| A | 3. Initial adjustment time |
| A | 4. Equipment Breakdown Time (TBF, TTR)- unscheduled maint. |
| P | 5. Idling |
| P | 6. Speed (cycle time) losses, |
| Q | 7. Quality losses: start-up and in process quality |
OEE

OEE = Availability x Performance x Quality

Availability (Downtime Loss) = Operating Time / Planned Production Time

Performance (Speed Loss) = Ideal Cycle Time / (Operating Time / Total Pieces)

Quality (Quality Loss) = Good Pieces / Total Pieces

<table>
<thead>
<tr>
<th>OEE Factor</th>
<th>Shift 1</th>
<th>Shift 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>90%</td>
<td>95%</td>
</tr>
<tr>
<td>Performance</td>
<td>95%</td>
<td>95%</td>
</tr>
<tr>
<td>Quality</td>
<td>99.5%</td>
<td>96%</td>
</tr>
<tr>
<td>OEE</td>
<td>85.1%</td>
<td>86.6%</td>
</tr>
</tbody>
</table>

Note: Availability (TBF and TTR)

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OEE “Pharmaceutical vs. Food & Beverage”

DMAIC

<table>
<thead>
<tr>
<th>OEE</th>
<th>Pharmaceutical</th>
<th>Food &amp; Beverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>39%</td>
<td>29%</td>
<td>63%</td>
</tr>
<tr>
<td>22%</td>
<td>44%</td>
<td>30%</td>
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Equipment Availability: TBF & TTR (Breakdown Time)

During production time, machine is producing (Uptime - green) or not producing (Downtime - red)

We define:

- MTBF = Mean time between failures
- MTTR = Mean time to repair
TTR - Unscheduled Down Time DMAIC

Unscheduled Down Time TTR for Line 1

Mean TTR Line 1 = 18 min

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Other Measurements  DMAIC

- Time to Maintain TTM (Schedule Downtime)
- Cost to repair CTR
- Cost to maintain CTM
- Cost of Loss
- Cost of Yield Loss
Applying TPM: Analyze DMAIC

A : Define the resources, C&E

Brainstorming and Fish Bone
Applying TPM: Improve DMAIC

- I: Establish current and future flow map, describe all responsibilities of operators and technicians.

Mean TBF Line 1 = 34 hr
Applying TPM: Control DMAIC

C: TPM Improvement Projects

<table>
<thead>
<tr>
<th>Projects</th>
<th>Effect</th>
<th>Due Date</th>
<th>Comp. Date</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIP cycle removed</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sight glass change</td>
<td>Leakage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training: Clamp Installation</td>
<td>Human Error</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add cooling step</td>
<td>Leakage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Aid Posted</td>
<td>Std Work</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Applying TPM  “Where to Start ?”

• Start with an equipment pilot

1. Choose the right machine

2. Choose the right person

3. Choose the good time
TPM and other Lean Tools

- Overall Equipment Effectiveness
- Mistake Proof
- 5S
- Standard work
- Set up reduction
- Self maintenance
Justice to Root Cause Analysis “RCA”

A systematic method that:
Investigates an incident, attempts to understand the underlying causes and generates corrective actions to prevent and mitigate incidents.

Common Recommendations:

- Training
- Procedure Revision
- Repair or Replacement of broken equipment
- Restart the system
- Fix and go!
Justice to Root Cause Analysis “RCA”

Analysis Techniques

- Brain Storming
- Fishbone
- 5 Why’s
- Method of Elimination
- Clue Generation
- Diagnostic Tree FTA
- Leveraging
- Stratification
- FMEA

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So what was the root cause of the failure?

- Failure
- Design & Installation
- Maintenance
- Operations
- Human Error
- Mgt. Control System
Management Control System “PDCA”

PLAN

- Proactive Analysis
- Management Control System

DO

- Operations
- OEE

ACT

- Reactive Analysis
- RCA

CHECK

- What could go wrong?
- What went wrong?
- How much can you afford to lose?

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COST of Non TPM

- “$30 Million Refinery Glitch Stalls Fuel Users – No Petrol for 2 Weeks”
- “Liquefied Natural Gas Project Back On Track after Production Train Repairs - $300 Million Lost”
- “Refuelling Problems Delay $250 Million Terminal Operation – Jet Fuel Pipes Contaminated”
- “330 Hospital Patients Suffer Cold Winter Showers for Two Days – Risk of Spreading Infection”
- More than 4 million barrels of crude oil spewed into the seas off the U.S. Gulf coast & 1.2 billion dollars in claims
TPM Implementation Challenges

- OEE measures
- RCA
- Leadership (Who Should Lead TPM ?)
- Employee training, development & compensation
- Employee Turn Over
- Collaboration
- Accountability
- Defined Responsibilities
- Spare parts and tools inventory mgt.
- 5S
- Visualize Standard Work and Maintenance Instructions
- Share best practices
TPM to infinity and beyond

- Asset Management and Spare Parts Inventory Management
- Predictive Maintenance
- Reliability Centered Maintenance, Ultra-Reliability and DFR
- Human Performance
- Information and Employee Communication
- Learning organization
- Management Control System

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Conclusion & Recommendation

- Decrease the firefighting!
- Increase Collaboration between departments
- Avoids stress in a breakdown
- Visual Maintenance
- Standard Work Maintenance
- Increase productivity
Questions?

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Resources:
TPM - Japan Institute of Plant Maintenance