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Total Productive Maintenance
Section 8

Uptime
Strategies for Excellence in
Maintenance Management
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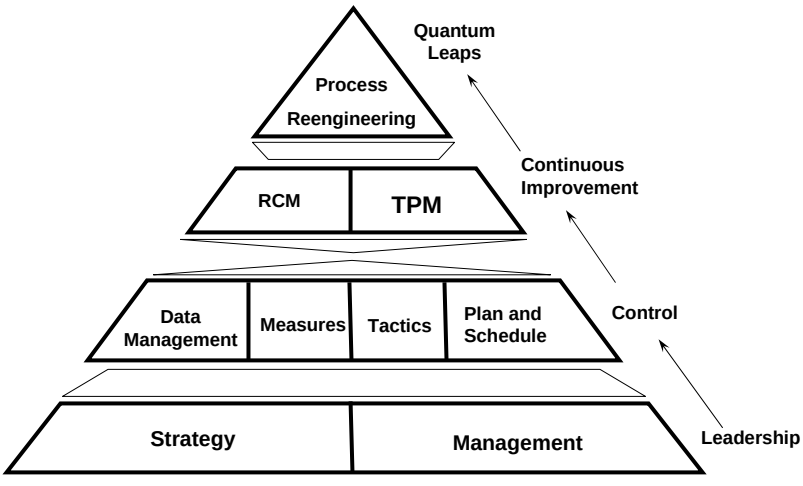

World Class Maintenance

2

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OUTLINE

- INTRODUCTION
- OBJECTIVES AND THEMS OF TPM
  - ASSET STRATEGY
  - EMOWERMENT
  - RESOURCE PLANNING AND SCHEDULING
  - SYSTEM AND PROCEDURES
  - MEASUREMENT
  - CONTINOUS IMPROVEMENT
  - PROCESSES
- IMPLEMENTING TPM: THE ELEMENTS
  - AWARENESS, EDUCATION, AND TRAINING
- KEY SUCCESS FACTORS

3

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INTRODUCTION

- Total Productive Maintenance (TPM) is an approach to managing physical assets that emphasizes the importance of operator involvement in making equipment reliable
- Management has always held an operator accountable for production output. More than ever, that person is also responsible now for product quality
- Many factors affect how well that can be achieved, including the way in which the workplace is organized as well as the equipment's effectiveness. When several people are involved, producing quality depends on teamwork

4

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TPM PRINCIPLES - 1/4

- **In its broadest sense, TPM is based on three sets of principles**
  1. ***Maintenance Engineering*; Seeks to manage the equipment life cycle, from strategic asset planning, through design and construction, to operation, maintenance, and disposal. Several techniques characterize the proactive nature of maintenance engineering including:**
     - ***Preventive (or planned) maintenance:* Planned and scheduled maintenance activities to find and correct problems that could lead to failure**
     - ***Predictive and condition-based maintenance:* Reducing fixed-time maintenance and relying on the condition of equipment to determine maintenance activity**

5

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TPM PRINCIPLES - 2/4

1. ***Maintenance Engineering*; Cont.**

- **Productive (or proactive) maintenance and cost reduction: Maximizing equipment performance through reliability and maintainability improvement and failure analysis**
- **Equipment data management: Equipment configuration, bills of material, as-built engineering drawings and maintenance histories**
- **Life cycle costing: The complete cost of equipment, from design and specification through construction and procurement to operations, maintenance, and disposal**

6

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TPM PRINCIPLES - 3/4

2. Total Quality Management (TQM)

- **TQM concepts were developed after WWII and adopted by Japanese manufacturing to improve the global image and acceptance of their products**
- **Incremental improvements in product quality at each stage of the process. Therefore small groups of employee use problem identification and problem solving tools and techniques to provide a higher quality service or product to their customer**
- **The ultimate goal of TQM is zero defects. Management style in a TQM culture is participative, trusting, and focused on fixing problems and defects, not on apportioning blame**
- **Information is widely shared, and TQM people let the data lead them**

7

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TPM PRINCIPLES - 4/4

3. Just-in-time (JIT)

- **JIT has as its goal the elimination of all waste: wasted time, space, labor, materials, inventory, movement. Any thing that does not add value in the eyes of the customer adds waste.**
- **The core concept for JIT is the reduction of the cycle time. Focusing on time to process and reducing this time has the effect of reducing inventory, delays, labor and space**
- **Producers are optimized, standardized, and taught**
- **Lot sizes are reduced**
- **Flexibility are dramatically increased**

8

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MORE ABOUT TPM – 1/2

- TPM began in Japan as a vital and necessary response to business imperatives to reduce waste, product variation, and production cycle time
- It was a fresh approach to the new challenges of the marketplace, not a logical progression of systematic maintenance management
- Just-in-time technique, though, attacked all forms of waste-any thing that did not add value to the manufacturing process
- Under these circumstances, the success of the entire process relied on each machine working to a uniform plant load, drumbeat.
- To further complicate matters for maintenance, final quality control inspection was being moved upstream in process, to eliminate defects and yield fluctuation at their source. As a result, machine performance problems were being identified much earlier

9

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MORE ABOUT TPM – 2/2

- Demands for conformance and reliability were greatly increased, with more stringent variation checks
- Maintenance management- or, more correctly, the management of equipment effectiveness- had to adapt quickly the new directives
- The concept that evolved was TPM, sometimes known by its most prominent feature, autonomous (operator) maintenance

10

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OBJECTIVES AND THEMS OF TPM – 1/11

- **The prime objectives of TPM are to:**
  - **Maximize equipment effectiveness and productivity and eliminate all machine losses**
  - **Create a sense of ownership in equipment operators through a program of training and involvement**
  - **Promote continuous improvement through small-group activities involving production, engineering, and maintenance personnel**
- **Each enterprise has its own unique definition and vision for TPM, but in most cases there are common elements in any TPM program. These have been summarized in the TPM wheel in Figure 8-1**

11

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OBJECTIVES AND THEMS OF TPM – 2/11

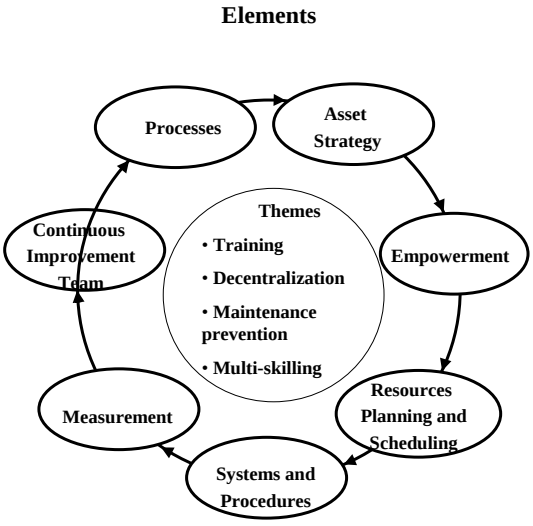

Figure 8-1 The TPM Wheel

12

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1. Asset Strategy – 3/11

- TPM is commonly used to support and enable the principles of TIJ and TQM
- This usually involves moving some equipment into a cell arrangement and removing anything that is redundant
- Setup modification and upgrading machine requirements are also commonly part of the plan
- Simplifying, streaming, and automating the manufacturing process have an impact on the way maintenance strategy with the neww asset structure

13

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1. Asset Strategy, cont. – 4/11

- When JIT is introduced, maintenance management normally should involved immediately:
  - *Layout evaluation* - including maintainability, operability, hydraulic/electrical/steam/plumbing services, environmental concerns, and floor loading consideration
  - *Equipment modification* – such as solving chronic problems before a cell startup. This could also mean providing enablers, for example, reducing excess motion to reduce wear and noise
  - *Post-move services* – to restore the equipment to satisfactory operating condition as a cell formed. Of key importance is the initiation or revision of a specific preventive maintenance program

14

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2. Empowerment - 5/11

- TPM puts the power in the employee's hand. It grants workers autonomy, along with responsibility
- At the same time TPM recognizes that employees in one area have much to teach and learn from others The entire organization gains strength and ideas from motivated continuous improvement teams
- A TPM environment encourages a skills between operators and maintenance, and multi-skill training in the various crafts
- It can provide increase job satisfaction for operations, trades, engineering, and supervision alike

15

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2. Empowerment, cont. - 6/11

- Most exciting about TPM is that it can fundamentally change organization culture. Centralized, command and control maintenance structure cannot support a JIT/TQM/TPM initiative
- Operator ownership is not about boundaries or barriers around equipment or sections of the process
- It's an expression of commitment and caring about condition, causes, and effects
- Building operator ownership is mostly a matter of removing impediments and providing correct training and tools to encourage a supportive relationship that is technically informed

16

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3. Resource Planning and Scheduling - 7/11

- During the introduction of TPM, there will be significantly increased demand on the maintenance department, especially as operator train to be more equipment conscious
- As they discover the causes of chronic equipment losses of malfunctions, they will want to have them corrected quickly
- If these operators are to be enthusiastic partners in equipment care, the maintenance department must have planning and scheduling procedures in place. They must have the capacity and skills available to assign priorities and carry out the work quickly and professionally
- As many organizations have found, it help to dedicate specific tradespersons to particular areas
- In this way, they become familiar with the equipment and form closer ties with the operators and supervisors

17

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4 Systems and Procedures - 8/11

- As continuous improvement teams begin to focus on equipment performance, standards best practice operating and maintenance procedures will evolve
- It will quickly become daily routine to track information such as equipment histories, part and materials, individual training progression, and costs
- Systematic maintenance management requires the most effective way to reduce or mitigate the risk of failure
- First, the nature of failure in a specific case must be understood
- Then the remedy can be chosen, whether it be based on time, use or condition factors, or some other tactic

18

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5. Measurement - 9/11

- **With continuous improvement, the current reality is judged against a future vision. In maintenance management, the prime objective is asset productivity: asset output divided by all inputs**
- **FOR TPM, it is also useful to measure continuous improvement success, including the number of active teams and their individual and collective progress**
- **The future vision is best tempered with an understanding of what the competition, industry at large, or best-in-class have achieved. Benchmarking is useful in this regard**

19

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6. Continuous Improvement Team - 10/11

- **Continuous improvement, based on Kaizen principles in Japan, is central to TQM and JIT**
- **Organizations that have begun implementing TQM, JIT, or Continuous Improvement (CI) processes will have CI team in place**
- **TPM team tends to base their agenda on effective maintenance management information system (for example, equipment histories for failure analysis). This begins with a Pareto review of failure of the equipment or processes that govern bottlenecking or add the most value to the product flow**
- **Operators in TPM build a strong relationship with their equipment. They drive an understanding within teams of failure causes, effects and impacts, and the resulting actions to eliminate these failure**

20

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7. Processes – 11/11

- TPM is often a radical change in the way asset maintenance is managed
- Some of the traditional processes for preventive, corrective, or breakdown maintenance and for stores inventory control are simply no longer appropriate
- In the new climate of responsiveness, flexibility, and empowerment, the existing processes must be revisited. They must be clearly understood, analyzed, and then redesigned to support the TPM objectives
- Each step along the way must add value and minimize any waste in cost, time, service, quality, or other resources

21

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IMPLEMENTING TPM: THE ELEMENTS – 1/12

- What TPM means, and what it will accomplish, is different for each application. The implementation plan, too, needs to be specific to the situation and plant environment
- A small wood-working firm with a tradition of production-maintenance integration could take a more informal approach than a large integrated steel mile
- A basic methodology that has proved successfully as a guide in many diverse applications is presented in Figure 8-2
- Following an implementation plan adapted from the Japan Institute of Plant Maintenance, the enterprise should progress through four phases in charting in its new course

22

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IMPLEMENTING TPM: THE ELEMENTS , cont. – 2/12

	I. Stabilize Mean Time Between Failure	II Lengthen Equipt. Life	III. Periodically Restore Deterioration	IV. Predict Equipment Life
Equipment Improvement	Restore accelerated deterioration by cleaning, lubricating, and tightening, and correcting visible defects	Learn more about equipment mechanisms and functions: develop inspection skills	Conduct autonomous inspections and adjustments: organize and visually manage work area	Manage operations and daily equipment care and inspections autonomously: carry out simple repairs and replacement
Equipment Improvement	Prevent accelerated deterioration with improvement to: • Control contamination sources •Enhance accessibility for cleaning, lube, and inspection Address chronic equipment losses and prevent recurrence	• Correct design and fabrication weaknesses • Prevent operating and repair errors • Eliminate sporadic failures • Improve maintainability and operability		• Further extend life using new materials and technologies • Learn and apply advanced failure analysis techniques
Planned Maintenance	• Prepare equipment logs • Help operators establish daily inspection and • Introduce visual control • Clarify operating conditions; comply with conditions of use	• Rank failures prioritize PM work • Standardize routine maintenance activities • Create data management systems to monitor failures, equipment, spares, costs	• Estimate life spans and learn early signs of internal deteriorating • Set standards fro periodic inspection and parts replacement • Improve efficiency of planned inspection and maintenance work and improve control of data and spares	• Apply condition-based monitoring technique to predict life • Conduct periodic restoration based on periodic life

23

Figure 8-2 TPM Implementation

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IMPLEMENTING TPM: THE ELEMENTS, cont. – 3/12

	I. Stabilize Mean Time Between Failure	II Lengthen Equipt. Life	III. Periodically Restore Deterioration	IV. Predict Equipment Life
Quality Maintenance	Clarify relationship between quality and equipment, people, materials, methods		Establish and maintain equipment control conditions	• Build in QM controls at the design stage
Maintenance Prevention	Define data system requirements and begin documenting equipment improvements	Incorporate data from current equipment improvement in new equipment design specifications		

24

Figure 8-2 TPM Implementation

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IMPLEMENTING TPM: THE ELEMENTS, cont. – 4/12

- This route progresses from stabilizing the mean time between failures and extending equipment life to predicting equipment life through condition monitoring
- The four phases of activities are conducted by team of production, maintenance, and engineering personnel working in concert
- The entire implementation process is supported throughout by comprehensive education and training (see Figure 8-3)

25

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IMPLEMENTING TPM: THE ELEMENTS, cont. – 5/12

	General Management	Maintenance Engineer	Operators	Maintenance
TPM objectives, elements, themes	✓	✓	✓	✓
General equipment cleaning, inspection, monitoring			✓	✓
Problem identification, analysis tools		✓	✓	✓
Basic equipment functioning, adjustment, optimization of skills			✓	✓
Focused technical skills				✓
Maintenance prevention and equipment redesign		✓	✓	✓

Figure 8-3 TPM Education and Training

26

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1. Awareness, Education, and Training – 6/12

- **Learning underscores each element of TPM. At Nachi Fujikoshi Corporation in Japan "Cultivating equipment-conscious workers is the base upon which every other feature of (TPM) rests. Education and training is not only one of the fundamental improvements activities of TPM, it is a central pillar that supports others"**
- **Managers, maintenance staff, team leaders, and equipment operators all must be extensively involved in the learning process**

27

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1. Awareness, Education, and Training, cont. – 7/12

- **Training supports:**
  - ***Decentralization*** **of decision-making and empowerment of employees. This will help them act autonomously, with knowledge and confidence, and as team players who know where and when to ask for help**
  - ***Maintenance prevention*****, or minimizing the amount of maintenance intervention without scarifying reliability. This is accomplished with standard operating procedures and systematic analysis and treatment of equipment failures and other abnormalities**

28

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1. Awareness, Education, and Training, cont. – 8/12

- The use of tools and techniques for problem identification, definition, solution, and team decision making are shown in Figure 8-4
- These aids are invaluable for the learning process
- Beyond understanding the theory behind TPM, you must have some practical knowledge before making sweeping changes to the system
- A pilot project in an area of the plant will work out any kinks and build experience and confidence in implementation team
- Of great help in a trial run is a detailed before-after study. One effective method is to have a staff photograph or videotape the area, looking for defects, disorders, and deterioration
- Such varied industries as aluminum rolling, primary steel, and discrete manufacturing level found that a series of pictures is worth countless words of description

29

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1. Awareness, Education, and Training, cont. – 9/12

For Problem Definition	For Solution Development	For Team Decision-making
• Process flowcharting	• Customer surveys	• Consequences seeking
• Histograms	•Cause and effect diagrams	• Brainstorming
• Plan charts	• Benchmarking	• Normal group technique
• Tree diagrams	• Force field analysis	• Multivoting
• Pareto diagrams	• FMECA	• Pairwise ranking
• Statistical process control	• Fault tree analysis	• Weighted factor evaluation
• Scatter plots	• P-M analysis	
	• Failure Analysis	

Automated Tools

- Computer aided design and drafting
- Computer aided manufacturing
- Computerize maintenance management system
- Material management system
- Materials equipment planning
- Computer integrated manufacturing
- Simulation
- Expert systems
- Geographic information management system

Figure 8-4 Tools and Techniques for TPM

30

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1. Awareness, Education, and Training, cont. – 10/12

- **Keeping a visual record is part of the following eight-step approach of piloting:**
  1. ***Education (basis)*** **– Companywide seminar on the elements, themes, and objectives of TPM, and how it relates to TQM, JIT, and CI programs that already in place**
  2. ***Survey*** **– Determine which area are likely to excel in a pilot program because of culture, attitude, preparation, or management style**
  3. ***Selection*** **– Select the pilot area based on its probability of success and on the productivity improvement potential. It should also be widely applicable to other areas of the *operation***
  4. ***Data collection*** **– Carry out Pareto analysis of the frequency and duration of losses caused by recorded failures, setups, idling, minor delays, quality, and yield losses**

31

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1. Awareness, Education, and Training, cont. – 11/12

5. ***Education (specific)*** **– Present a detailed seminar for pilot area personnel describing the selection process, data analysis for equipment loses, and TPM vision**
6. ***Photographic tour*** **– Have pilot's teams take "as-is" photographs or videos of equipment deterioration, defects, disorders, housekeeping, and so on, in their area**
7. ***Training*** **– Relate the Pareto analysis of losses to the result of the photographic tour. Also, provide training to minimize equipment deterioration and , therefore, equipment losses through the activities in Phase I Stabilize Reliability**
8. ***Kickoff*** **– Choose a formal kickoff date and location for Phase I. Categorize responsibilities for improvement for production, materials, maintenance, and engineering**

32

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1. Awareness, Education, and Training, cont. – 12/12

- **It is critical to measure the progress of the pilot program to gain momentum for plant wide success. Monitor such "outputs" as:**
  - ***Equipment effectiveness*** **– The product of availability, the process rate, and quality rate**
  - ***Reliability*** **– Mean time between failure**
  - ***Maintainability*****– Mean time to inspect, service, replace, or repair**
- **Also measure inputs such as**
  - ***Labor*** **– including degree of PM compliance, demonstrated proficiency in autonomous maintenance, crew size, and maintenance labor distribution**
  - ***Materials,*** **– including engineering stores inventory turns, inventory service level, vendor partnering, and obsolesces**
  - ***Cost effectiveness*** **– where cost are measured by function, area, equipment, job, and class of expense**

33

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KEY SUCCESSFUL FACTOR – 1/4

- **The single most important factor to implement TPM is true management commitment**
- **Organizations with this level of commitment are successful, even if they do not have the most comprehensive plan or a lavish budget**
- **What does honest commitment mean? You could say it's a little like bacon and eggs – the chicken was involved, but the pig was committed**
- **Management's commitment is certainly shown by what it's willing to put on the line**
- **The resources allocated are important, of course. But counts even more are the time and visible involvement of senior management, for however long it takes to put TPM in place**

34

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KEY SUCCESSFUL FACTOR – 2/4

- **Other key success factors include:**
  - **The team approach throughout the project cycle**
  - **The enthusiasm and team-team building skills of TPM leaders or project managers**
  - **A clearly defined methodology**
  - **The learning processes, particularly the communication between maintenance and operations in such vital areas as how the equipment does, what it does and how to keep it operating effectively**
  - **The mechanisms in place to reinforce positive behavior and results**

35

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KEY SUCCESSFUL FACTOR – 3/4

- **Many of North America's important manufacturers and processors are now fully immersed in TPM**
- **Dupont Fibers attributes major gains in productive capacity to TPM: having skilled people getting their equipment up to as-new condition and keeping it there, and eliminating failures through systematic improvement over th elong term**
- **Others include Timkin, Pepsi, Ford, Harley-Davidson, Wilson Sporting, MACI, Saturn Corp., Norton, John Deere, Unilever, Steelcase, and Toyota**
- **But as Mark O'Brein of Yamaha said, " As we looked around Japan and the U.S. for the perfect TPM recipe, we realized that no one has the cookbook"**
- **A successful implementation of TPM themes and elements certainly results in measurable benefits**

36

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KEY SUCCESSFUL FACTOR – 4/4

- Empwered, motivated employees will contribute in significant ways to help improve asset productivity
- The long-term benefit of caring about maintenance can be in another qute from Pirsig:
  - Each machine has its own personality, that is the real object of motorcycle maintenance, The new [nachines] start out as good-looking strangers and, depending on how they are treated, degenerate rapidly into bad-acting grouches or even cripples, or else turn into healthy, good-natured, long lasting friends. This one, despite the murderous treatment it got at the hands of those alleged mechanics, seems to have recovered and has been requiring fewer repairs as time goes on (Zen and the Art of Motorcycle Maintenance, P.39)

37

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Thank You

38