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Evolution of Various Losses in Total Productivity Maintenance

KEYWORDS: Six big losses, Thirteen Big losses, Overall equipment effectiveness, World Class Manufacturing, sporadic losses and chronic losses, Kobetsu Kaizen steps

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ABSTRACT *Total Productive Maintenance or TPM is a maintenance program which involves concept for maintaining plant and equipments effectively so that various losses are minimized and give higher productivity and efficiency for any organization.*

The intent of the present paper is to highlight the evolution TPM with special reference to the TPM pillar of focused Improvement, which focuses on various losses, beginning with the Nakajima Model and evolving to the JIPM Model. These losses when eliminated give significant improvement in terms of higher productivity reduction of quality defects, on-time delivery of product or services reduction of cost, less inventory & accidents etc.

1. Introduction:

In any modern manufacturing organization, efficiency and effectiveness plays a dominant role to determine the performance of the organization. In today`s high growth era and global competition most of the companies are progressing by changing its large amount of manual work to automation. It requires a high level of maintenance program which can keep the equipments of the plant effectively. Total Productive Maintenance or TPM is a newly defined concept for maintaining plant and equipment so that overall equipment/system effectiveness of any industry can be increased.TPM has been recognized as one of the significant operation strategy to regain the production losses due to equipment inefficiency. TPM is a unique Japanese system of maintenance, which has been developed by Japan Institute of Plant Maintenance (JIPM). It has been very important tool for equipment intensive manufacturing sector; it is a key means for increasing machine availability. The value of deploying TPM is widely recognized, particularly in current market scenario where economy is in recession, installed capacity is greater than demand, quality is basic, growing competition, and selling price is dictated by market, diverse equipment, centralized control and few operators in the plant.

The basic practices of TPM are often called pillars of TPM. TPM has eight pillars: 1. Autonomous Maintenance, 2. Focused improvement, 3.Planned maintenance, 4.Quality maintenance, 5. Education & Training, 6. Office TPM, 7. Safety, Health & Environment, 8. Initial flow control.

2. Six Big Losses :

Seichi NakaJima of Japan who is rightly called the father of TPM, initially found six big losses in any organization which when eliminated would result in improved equipment utilization and lead to world class manufacturing. These six losses are:

	Six major losses that impede overall equipment effectiveness	
(1)	Failure losses	Losses due to failures. Types of failures include sporadic function-stopping failures, and function-reduction failures in which the function of equipment drops below normal levels.
(2)	Setup and adjustment losses	Stoppage losses that accompany setup changeovers
(3)	Start-up losses	When starting production, the losses that arise until equipment start-up, running-in and production processing conditions stabilize.
(4)	Minor stoppage and Idling losses	Losses that occur when the equipment temporarily stops or idles due to sensor actuation or jamming of the work. The equipment will operate normally through simple measures (removal of the work and resetting).
(5)	Speed losses	Losses due to actual operation speed falling below the designed speed of the equipment.
(6)	Defect and rework losses	Losses due to defects and networking.

3. Identification of additional losses:

Further work in this area by various researchers found that there are more losses which are also very important to discuss. Benefits of listing more losses will give finer analysis to achieve higher overall equipment effectiveness (OEE) to world class manufacturing (WCM). These losses are:

(1)	Cutting blade and jig change losses	When losses due to changing the cutting blade due to breakage. Changing of blade consumes time and results in speed loss which reduces the capacity of the equipment and the production time exceeds normal cycle time. This affects OEE
(2)	Management losses	In any work situation there are waiting time which are treated as loss due to inability of management for proper line balancing of equipment, waiting of materials, tools, instructions repairs etc. These losses increase if the proper communication fails within the organization. This also results in increased production time compared with normal cycle time. is affects OEE
3)	Motion losses	Researcher has derived these losses from method study. When proper integration of three main resources men, machine and materials are not in the best possible way this losses may increase. Application of method study provides specification of work method to eliminate waste in motion, which are unproductive and which do not have value to the task performed. These losses further increase from differences in skills involved in setup and adjustment work, cutting blade change work. This also results in increased production time and reduces OEE Method study application are very useful to reduce or eliminate these type of losses where the problem are recorded systematically with the help of various charts & symbols and new and effective method, are design, to achieve a process result, with effective use of human capabilities as well as equipment capabilities

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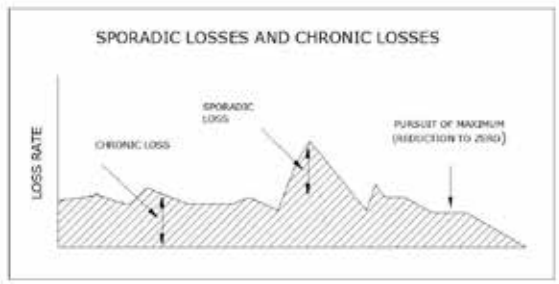
(4)	Distribution losses	These man hour losses are actually due to mismanagement in supply chain such as delays in transport of material, products, equipments and delays at the vendors and these losses can be minimized by making an effective supply chain management with vendor & supplier. This affects On time delivery which is an important tenet of World Class Manufacturing abbreviated as WCM
(5)	Energy losses	Losses due to ineffective utilization of input energy (electric, gas, fuel oil, etc) in processing. This affects Output of the plant and the OEE
(6)	Die, jig and tool losses	Financial losses (expenses incurred in production, regarding, renitriding, etc) which occur with production or repairs of dies, Jigs and tolls due to aging beyond service life or breakage. This adversely affects Cost which is an important factor of WCM goal
(7)	Yield losses	In any organization, several times, it is observed that qualities of weight of the material are different than required. Some time it is found that size & shape of the material received are not as per specification/ requirement. In such situation there are loss of time to replacing and getting new materials. Quantity loss is one of the metrics of Overall Equipment Effectiveness

The losses described above may be sporadic losses and chronic losses. Sporadic losses are those losses which has entirely new phenomenon, suddenly occurs after exceeding a certain dispersion range. It is recognized as loss compared with present level. Causes can be identified by past experience or intuition in many cases. To solve these type of losses generally Why-Why & cause & effect analysis are used.

Chronic losses : -

Phenomenon always occurs within a certain a dispersion range. It is repeated in short cycle and is always occurs with certain quantitative dispersion. Hence past experience and intuition for the cause do not work. It cannot be solved even if various actions are taken. Renovating countermeasures are needed. To solve this problem generally PM analysis is used.

Figure 1. Shows sporadic losses and chronic losses.

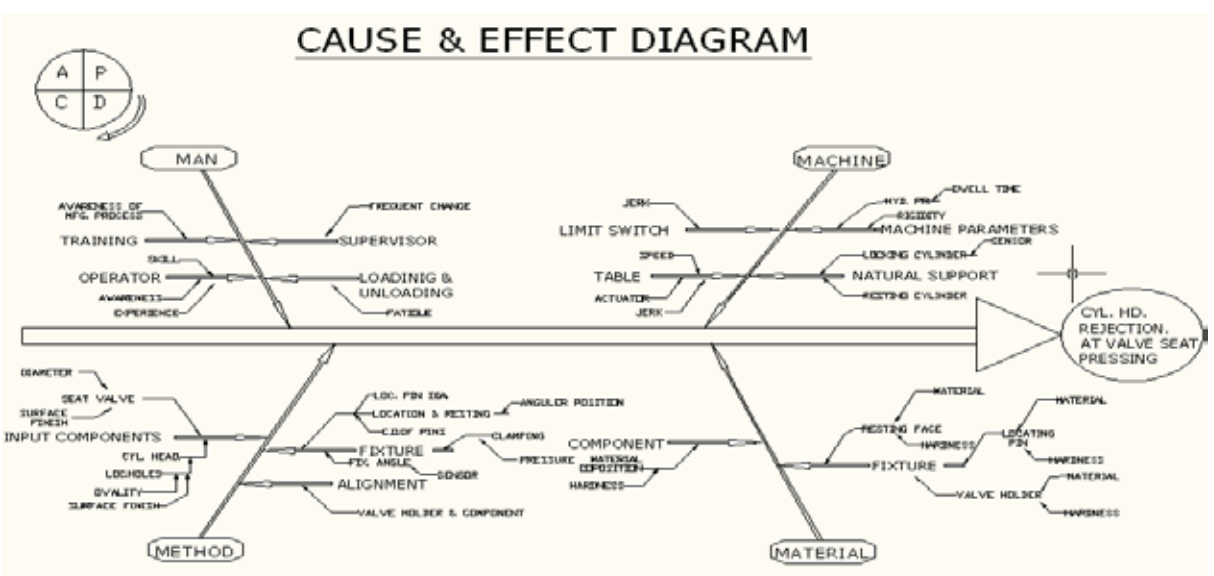


Why-Why analysis

Why-Why analysis is a powerful tool for analyzing problems. By asking 5 why's one would be able to arrive at the root cause of the problem. In most cases, 5 why's is maximum. In some cases 3 why's would also suffice. An example below shows how the why-why analysis is used.

Problem	Head lamp damage
Why	Headlamp damage during storage
Why	Overlapping of headlamp during storage after sub assembly
Why	Headlamp storage in bin
Why	No separate location for headlamp to avoid fouling with each other
Action	Location to be modify for headlamp storage

Cause and effect Diagram :Cause and effect Diagram is a representation of the systematic relationship between the "event" under investigation and all the possible "causes" influencing it. Causes and Effect Diagram is also a documentation of group thinking process to investigate the root cause(s) of the "event". It is also called as Fish bone Diagram as it looks like a skeleton of a fish. This is invented by Dr. K. Ishikawa who describes it as "any defect in a component, a product or service could be due to one or more causes. To find out the relationship between the causes and effect, a diagram is drawn systematically by mapping out all the probable causes influencing the effect". Fig below shows a cause & effect diagram used for a problem.



4. Kobetsu Kaizan (focused improvement) is most important pillar of TPM. It deals with losses and prioritizing the most important losses, eliminating them and maximizing overall equipment effectiveness. This pillar itself may not deal with all losses but it is the driving force to carry-out the kaizen activity. This pillar particularly addresses reduction of loss due to (a) poor quality (b) reduced machine availability due to breakdowns (c) reduced yield due to slower production rate. This pillar is considered as mother of all pillars of TPM. This pillar indicates where we are? where we need to go? and by when? This pillar also predicts how much improvement (OEE) we need on annual basis to support our ever growing market and revenue.

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Cross functional project team including personnel from disciplines such as production, planned maintenance, quality maintenance and operators perform this activity to minimize and eliminate losses with respect to P(Productivity), Q(Quality), C(Cost), D(Delivery), S (Safety) & M(Morale).

5. These activities are carried out by the following 7 step methodology of JIPM.

Step	Details	Activity
Step 0	Select Improvement Topic	1. Select and register topic 2. Form project teams 3. Plan activities
Step 1	Understand Situation	1. Identity bottleneck process 2. Measure failures, defects and other losses 3. Use baselines (Bench Mark) to set targets
Step 2	Expose and Eliminate Abnormalities	1. Thoroughly study and expose abnormalities 2. Restore deterioration and correct minor flaws 3. Establish basic equipment condition
Step 3	Analyze Causes	1. Stratify and analyze causes 2. Apply analytical techniques (why-why analysis, why OK analysis etc.) 3. Conduct experiments, apply specific technology, fabricate prototypes
Step 4	Plan Improvement	1. Make improvement proposals and prepare drawings 2. Compare cost effectiveness of alternate proposals and make budget 3. Check for possible adverse effects and disadvantages
Step 5	Implement Improvement	1. Carryout improvement plan 2. Perform tests, trail runs 3. Provide instructions to work on improved equipment, operating conditions.
Step 6	Check Results	1. Evaluate results with time as improvement project goes on 2. Check whether targets have been achieved, if not, start from step 3 again
Step 7	Consolidate Gains	1. Prepare inspection and work standards 2. Make drawings and feed information to Development management Pillar 3. Train operators and or fitters to sustain the results

6. Each company who follow TPM has to make up their list & collect data. The highest losses will be the priority for KK pillar. And KK subcommittee will identify the priorities and assign project team is work on specific losses on different machines and areas. Remaining losses will have to be address by KK subcommittee in relation to after pillar of TPM.

Normally KK subcommittee addressees the following losses –
- Set-up Losses
- Tool change Losses
- Start-up loss
- Minor stoppages Losses
- Reduced speed Losses
- Management loss
- Tools, jigs and consumables loss
- Yield loss.

7. CollectIon of data on losses:
- Line and Machine wise data on all 16 losses are collected
- OEE related losses are collected from Production and Inspection records.
- Cost related losses such as spares, coolant, lubricants are collected from maintenance department.
- Tool losses and consumables are collected from relevant departments.
- Vendor related Quality defects, management loss and logistic loss form office TPM team reports.
- Operating motion loss and line organization loss by Industrial engineering team.

8. Organizing Kobetsu Kaizen sub-committee
A senior level person is nominated as chairman of this pillar. He should have exposure to plant process activities, equipment, etc. The members include persons from Production, Production engineering, Maintenance, system engineering. Quality assurance, Design & Development and form commercial department. This is a cross-functional team to achieve maximum benefits.

9. Overall equipment effectiveness:
OEE depends on the effectiveness with which it uses equipment, materials, peoples and methods. This is done by examining the input to the production process and identifying, eliminating the losses associated with each to maximize production. Eight major plant losses are identified. Shut down, Production adjustment, equipment failure, Process failure, normal production loss, abnormal production loss, quality defects, reprocessing.

OEE= Availability x Ratio of Quantity Output x Ratio of quality

$$\text{Availability} = \frac{\text{Actual Operating Time}}{\text{Planned production time}}$$

Planned production time =Plant operating hours-Planned shut down time

Ratio of quality = Actual Output/Normal Output under ideal conditions

$$\textbf{Ratio of quality} = \frac{\text{Good output}}{\text{Total output}}$$

10. How to fix targets for loss reduction/ elimination
Overall Equipment Effectiveness (OEE) targets are set based on prevailing conditions and taking into consideration of benchmarks. For Process/ individual machine, production quantity is calculated as per theoretical cycle time.

Collect data for previous one year (at least) before kick-off. KK committee looks at P(productivity), Q(quality), C(cost), D(delivery), S (safety) & M(morale) at the company level and selects areas under each category.

11. Benefit of Identifying additional losses in TPM:
Identification of additional losses in addition to the Six Big losses pointed by Nakajima will result in better and more realistic evaluation of Overall Equipment Effectiveness. The goal of WCM can be achieved more effectively by better identification of 7 additional losses.

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