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Accounting Contribution to Total Productive Maintenance

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Accounting plays significant role in business. The increase of business competition increases the need to accounting that can be used as a tool to develop competitiveness. Increasing business's competition calls companies to more be concerned about quality. Quality is a key source of competitive advantage, and studies have shown that quality is positively related to increased market share and profitability (Evans & Lindsay, 1996). Customer satisfaction is a crucial goal of the entire quality process (Scott, 1998). Quality is based on value, that is, the relationship of usefulness or satisfaction to price (Evans & Lindsay, 1996). Quality includes on time delivery, defect free products, and satisfying customer services. Quality enhancement is under responsibility of all organizational members (Praptapa, 2009).

There are many methods and management tools to ensure and enhance quality. The term Total Quality Management (TQM) is commonly used to denote the system of managing for total quality. As companies, especially manufacturing companies, realise that quality can be provided if production systems are working efficiently and effectively, then people pay more attention to the best utilisation of equipment. An approach to optimalize the relationship between people and the equipment on which they rely is known as Total Productive Maintenance or TPM.

Keywords : accounting contribution, TPM, develop competiveness

1. Defining TPM

Total productive maintenance is a Japanese approach, which is pioneered by Seiici Nakajima in the late 1970s, "to maximise the effectiveness of equipment by setting and maintaining the optimum relationship between people and machines". (Willmott, 1994). In Japan, it is often defined as "productive maintenance involving total participation." It is considered as the latest and best in the series of modern manufacturing techniques (Hartmann, 1992).

Japan Institute of Plant Maintenance (1995) explains the meaning of "Total" in TPM as "total efficiency", "total maintenance", and "total participation" (shopfloor to top management). Hartmann (1992) also points out that the 'Total' in TPM stands for total economic effectiveness, includes total coverage, encompasses all aspects of maintenance system, means full participation by all involved employees and, in later phases, means not just equipment and production areas but is extended to all other departments involved with equipment. In some plants, TPM is extended to cover general offices.

TPM was originally defined by the Japan Institute of Plant Maintenance (JIPM) to include the five strategies as follows:

1. Maximise overall equipment effectiveness.
2. Establish a comprehensive Productive Maintenance (PM) system covering the life of equipment.
3. Involve all departments that plan, use, and maintain equipment.
4. Involve all employees from top management to front-line workers.
5. Promote PM through motivation management, ie. Autonomous small group activities.

(Suzuki,1994)

To reflect the trend that TPM is applied throughout many organisations, in 1989 JIPM introduced a new definition of TPM with the following strategic components:

1. Build a corporate constitution that will maximise the effectiveness of production systems.
2. Using a shop-floor approach, build an organisation that prevents every type of loss (by ensuring zero accidents, zero defects, and zero failures) for the life of the production system.
3. Involve all departments in implementing TPM, including development, sales, and administration.
4. Involve everyone, from top management to shop floor workers.
5. Conduct zero-loss activity through overlapping small-group activities.

(Suzuki, 1994)

TPM is a manufacturing-led initiative, which is a derivative of TQM (Geragluy, 1996). TPM draws heavily upon the philosophy of TQM (Carannante, 1996). TPM can be expected to contribute significantly in quality improvement when it is applied as a single quality management tool, but the best result will be reached when it is applied as a part of total quality production system. The relationship between TPM and total quality production system is described in the following figure:

TPM Attractions

TPM attracts many companies because of some reasons such as:

- It is measurable, visible, practical common sense
- Employees can understand and therefore value the concept
- The element of TPM have been tried and tested
- Much of TPM is about rediscovering old values
- It a grass roots process
- It also a world class process
- It is led by manufacturing and therefore driven by production and maintenance as equal partners.

(Willmott, 1994)

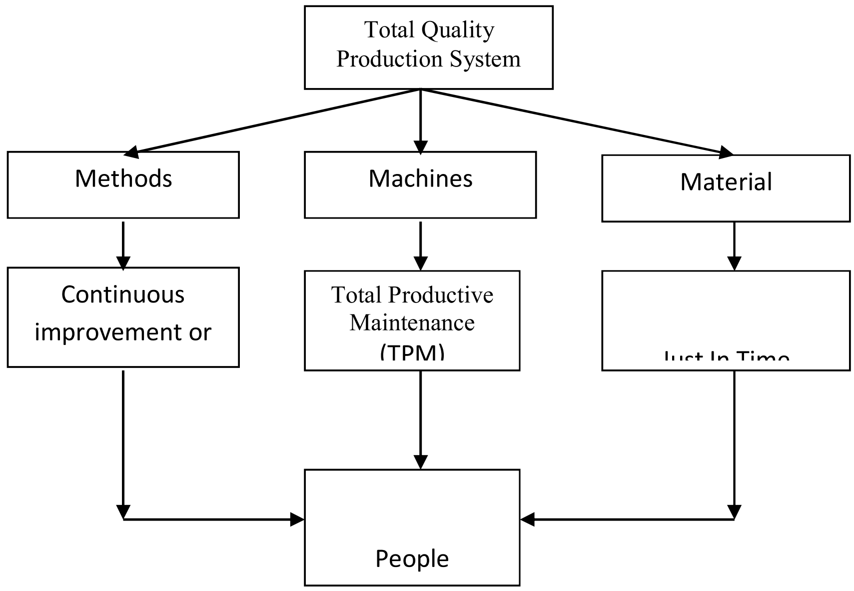

Figure 1: Total Quality Production System

Source: Willmott (1994) Figure 1.2. p.7

Benefits of implementing TPM are:

1. Maximised efficiency of equipment through participation of all employees.
2. Improved reliability of equipment leading to improved product quality and equipment productivity
3. Economical use of equipment throughout its total service life.
4. Operators trained and equipped to perform minor but essential asset care of their machines.
5. Increased utilisation of skilled trades in higher technical areas and more diagnostic work.
6. Practical and effective total quality team working example aimed at equipment improvement and maintenance prevention.
7. Improvement in overall equipment effectiveness as a measurable route to increased profitability.

(Willmott, 1994)

Success with TPM

Successful TPM implementation requires top management support and commitment. Management must promote and establish a team culture and use these teams to implement the TPM system. TPM is a system (culture) that takes advantage of the abilities and skills of all individuals in an organisation (Patterson, 1995).

There are many success stories of TPM that make TPM more attractive. World-class companies like Ford Motor, Motorola, Eastman Kodak, DuPont, Texas Instruments, Procter & Gamble, IBM, AT&T, and many others have successfully implemented TPM (Hartmann, 1992).

Result examples of TPM are:

- Value added ratio: increased
- Overall equipment efficiency: increased
- Process defect rate: decreased
- Number of customer complaints: decreased
- Manufacturing cost rate: decreased
- Delivery delay = 0 (zero)
- Inventory: halved
- Number of accident: decreased
- Number of suggestion for improvement: increased (JIPM, 1995)

The firms, which won the Productive Maintenance Prize in Japan from-1984 - 1986, achieved the following:

- Monthly equipment failures were reduced from 1,000 to 20
- Quality defects were reduced from 1% to 0.1%
- Warranty claims from clients were reduced by 25%
- Maintenance costs were reduced by 30%
- Inventory on hand was reduced by 50%
- Productivity was increased by 50% (Patterson, 1995)

TPM program fits with other quality development program. Asten, Inc. for example, reported that it gains satisfying results after instituted TPM in conjunction with TQM (so that in this case all of its gains are not attribute to TPM itself). Its success including:

- Average product cycle time, the time between order entry and shipping, has been reduced from 67.8 days to less then 10 days.
- The reject rate for finished goods has plunged 20%
- Asten's "meet all targets" rate has risen from 78% in 1989 to 94.8% at the end of 1995.
- Productivity has risen from 1.73 pounds per man-hour in 1989 to 1.91 per man-hour at the end of 1995.
- Work in process has been reduced by almost 15%
- Annual sales increase by approximately 61.6%
- Number of breakdown decrease from average 158 per month (accounting for 4,043 man-hour of down time) to on average 95 breakdowns in 1995 for less then 342 man-hours of down time. (Patterson, 1996)

Stage to TPM
There are four developmental stages of TPM:

- *Breakdown maintenance*: Fixing only when equipment breakdown (prior to 1950s)
- *Preventive maintenance*: time-based maintenance (1950s)
- *Productive maintenance*: condition monitoring, reliability engineering, maintainability improvement (1960s)
- *TPM*: proactive maintenance and behavioural sciences or total personal involvement (1970s)
  (Mc.Adam, 1996)

TPM Improvement Plan Sequences

There are three phases of TPM improvement plan. Those are:

- The *condition cycle*, which establishes the present condition of the equipment and identifies the area for improvement and future care.
- The *measurement cycle*, which assesses the present effectiveness of the equipment and provide a baseline for the measurement of future improvements.
- The *improvement cycle*, which moves equipment effectiveness forward along the road to world class performance.
  (Willmott, 1994)

Willmott (1994) points out that those three cycles include nine steps of improvement plan. It can be summarised in the following figure:

The followings are explanations of each step.

Step one critically assesses the equipment condition. This is to review the production process so that all members of the team understand the mechanisms, controls, and material processing and operating methods in order to set up the priority of improvement.

Step two is the appraisal of condition. This is to assess the condition of equipment and to identify the refurbishment program necessary to restore the equipment to maximum effectiveness.

Step three is refurbishment. The objective of the refurbishment program is to set up a repair and replacement plan, based on the condition appraisal, and indicating the resource needed.

Step four is asset care. Once refurbishment of an item of equipment has been carried out, a future asset care program must be planned to ensure that the machine condition is maintained.

Step five is equipment history record. This is the essential prerequisite to the overall equipment effectiveness (OEE) calculation because it records the recent effectiveness of an equipment item.

Step six is overall equipment effectiveness. The OEE formula is at the heart of TPM process. It is based on measurable quantities and enables progress to be quantified as the organisation embraces TPM with all its implications. The OEE is products of availability of the assets, performance rate when running, and quality rate of product produced.

Step seven is assessment of the six big losses. The six big losses are:

- Breakdown losses
- Setup and adjustment losses
- Idling and minor stoppage losses
- Reduced speed losses
- Quality defect and rework losses
- Startup losses

Step eight is problem solving. In seeking to solve the problems, which lie behind the six big losses, TPM uses P-M analysis. This emphasises the machine/human interface: there are *phenomena, which* are *physical*, which cause *problems*, which can be *prevented*; these are to do with *materials, machines, mechanism*, and *manpower*. These problems may have a single cause, multiple causes or a complex combination of causes.

Step nine is best practice routines. This final step brings together all of the developed practices for operating, maintaining and supporting the equipment which are then standardised as the best practice routines.

Condition cycle:

Measurement cycle:

Improvement cycle:

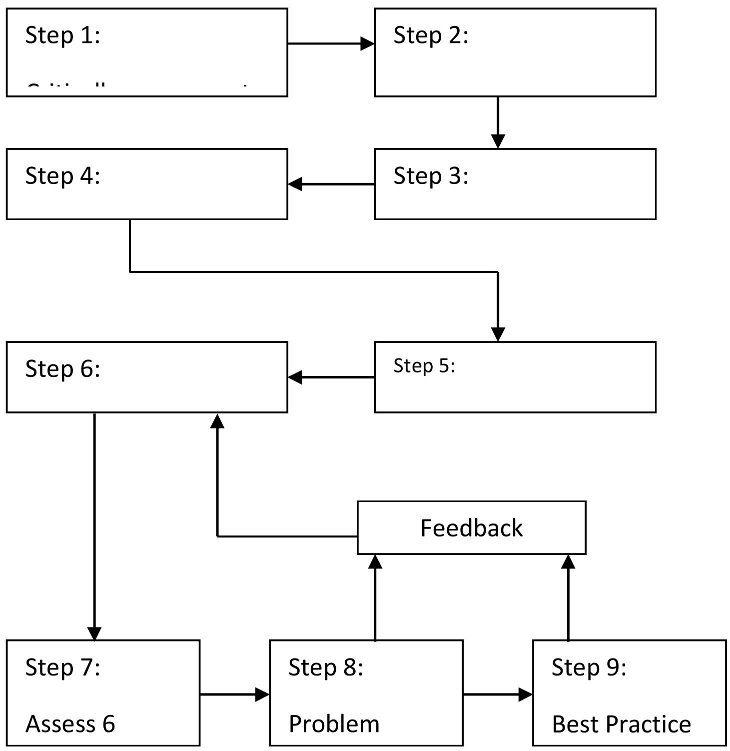

Figure 2: TPM improvement plan sequence

Source: Willmott, 1994.

Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) is a formula to measure equipment effectiveness. Suzuki (1994) calls Overall Plant Effectiveness for OEE. OEE formula is as follows:

OEE = availability x performance rate x quality rate

(Willmott, 1994)

Availability

Availability is the operating time expressed as a percentage of the calendar time. The formula to calculate availability is:

$$\text{Availability} = \frac{\text{Calender time - (shutdown loss + major stoppage loss)}}{\text{Calender time}} \times 100\ (\%)$$

Shutdown losses = shutdown maintenance loss + production adjustment loss

Major stoppage loss = equipment failure loss + process failure loss

(Suzuki, 1994)

Performance rate

A plant's performance rate expresses the actual production rate as a percentage of the standard production rate. The standard production rate is equivalent to a plant's design capacity of a particular plant. The formula to calculate performance rate is:

$$\text{Performance rate} = \frac{\text{Average actual production rate (example: ton/hour)}}{\text{Standard production rate (example: ton/hour)}} \times 100\ (\%)$$

Actual production rate (example: ton/hour)

Average actual production rate =

Operating time

(Suzuki, 1994)

Quality rate

The quality rate expresses the amount of acceptable product (total production less downgraded product, scrap, and reprocessed product) as a percentage of total production. The formula to calculate quality rate is:

$$\text{Quality rate} = \frac{\text{Production quantity - (quality defect loss + reprocessing loss)}}{\text{Production quantity}} \times 100\ (\%)$$

(Suzuki, 1994)

The three factors of OEE (availability, performance rate, and quality rate) are affected by the six big losses. *Availability* will be affected by breakdown losses and by setup and adjustment losses. *Performance* will be affected by idling and minor stoppage losses and by reduced speed losses. *Quality* will be affected by quality defect and rework losses and by startup losses (Willmott, 1994).

Major Losses Affecting Production Effectiveness

The effectiveness of a plant's production depends on the effectiveness with which it uses equipment, materials, people, and methods. To maximise the effectiveness of plant, therefore, entails increasing the number of days the plant operates without a break and speeding up and improving its shutdown maintenance program.

A major feature of TPM is its "zero-orientation," which encourages teams systematically to reduce all kind of losses to zero (Suzuki, 1994). Although approaching zero is difficult, believing that zero defects can be achieved is an important prerequisite for the success of TPM (Nakajima, 1989). Those losses are identified as the six big losses (Nakajima, 1989; Willmott, 1994) that limit equipment effectiveness. As mention before, the six big losses include breakdown losses, setup and adjustment losses, idling and minor stoppage losses, reduced speed losses, quality defects and reworks, and startup losses.

Suzuki (1994) reclassified the six big losses into eight major losses that prevent any plant from achieving its maximum effectiveness. Those are:

1. *Shutdown loss*: time lost when production stops for planned annual shutdown maintenance or periodic servicing.
2. *Production adjustment loss*: time lost when changes in supply and demand require adjustment in production plans. They would never arise if all the product that a plant manufactures could be sold according to plan.

3. *Equipment failure loss*: time lost when a plant stops because equipment suddenly loses its specified functions. It includes *function-failure loss* and *function-reduction loss*.
4. *Process failure loss*: time lost when a plant shuts down as a result of factors external to the equipment, such as operating errors or changes in the physical or chemical properties of the substances being processed.
5. *Normal production loss*: rate losses that occur during normal production at plant startup, shutdown, and changeover.
6. *Abnormal production loss*: rate losses that occur when a plant performs inadequately as a result of malfunctions and other abnormal conditions that interfere with performance.
7. *Quality defect losses*: time lost in producing rejectable product, physical loss in scrap, and financial losses due to product downgrading.
8. *Reprocessing losses*: recycling losses that occur when rejected material must be returned to a previous process to make it acceptable.

To achieve maximum effectiveness, it is important to set out the improvement goals to eliminate or reduce the big losses, as described in the following table.

Type of Loss	**Goal**
1. Breakdown losses	0
2. Setup and adjustment losses	minimise
3. Speed losses	0
4. Idling and minor stoppage losses	0
5. Quality defect and rework losses	0
6. Stratup (yield) losses	minimise

Source: Nakajima, 1989.

People Involvement in TPM

As mentioned above, TPM maximised the relationship between people and the equipment on which they rely. It can be reached if people in the company from top level to shopfloor have strong commitment toward the success of TPM. As TPM is everybody's business in the company, everyone in the company should be actively concerned with the TPM activities. Training is the way to introduce and improve people's skill in work with TPM.

People's skills can be categorised based on the skill level. The skill levels are:

- *Level 1*: Lack both theoretical knowledge and practical ability (need to be taught)
- *Level 2*: Knows in theory but not in practice (needs practical training)

- *Level 3*: Has mastered practice but not theory (cannot teach others)
- *Level 4*: Has mastered both theory and practice (can teach others)

(Suzuki, 1994, p.263)

Total people's involvement implies all departments in the company should support TPM. Each department can support TPM in the various forms. For example:

- Marketing department can support TPM in the form of informing TPM Project Manager about the customer responses of the products' quality;
- Human Resource Department can arrange training or providing information about people's education and training backgrounds;
- Accounting and Finance Department can be involved in the planning stage of TPM by arranging the budget, giving review of cost and benefit of TPM activities, providing financial information tailored with the need of TPM activities, and designing accounting systems that fit with TPM activities.

In conclusion, TPM is not just about technical matters. It is not merely the work of production people and maintenance people. Involvement of all people in all departments is the important key success factor of the TPM.

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