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"Implementation of TPM in Manufacturing Organizations, A Case Study of A Paper Mill, Measuring Performance Through OEE."

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Abstract:
In the contemporary manufacturing sector, equipment effectiveness and efficiency are key factors in determining how successfully an organisation performs its production function and how successful it is overall. The industrial sector has been developing at an excellent rate for over ten years, drawing significant foreign capital investments to this nation. The producers now have a significant competitive edge in the worldwide market, particularly with regard to price and quality, thanks to their outstanding performances. But as time has gone on and highly sophisticated and automated machinery has been used more and more widely in the industry, the importance of equipment efficiency has grown. Thus, the upkeep of these intricate machinery and equipment. For manufacturers, maintaining these intricate machines and equipment became extremely important and expensive. Many organisations started to understand that a solid foundation of effective and efficient equipment was necessary to sustain this high level of performance. Thus, putting Total Productive Maintenance (TPM) into practice in the manufacturing sector has become a crucial operational approach to combat output losses brought on by inefficient equipment.
TPM is a technique that adds value to an organisation by assisting with the maintenance and improvement of the production system through the use of employees, machines, and processes. This paper discusses the so-called "big six losses" in any sector, along with the calculation of the overall equipment effectiveness in a paper manufacturing company (quality, availability and speed). The primary goal of a case study conducted in the paper mill is to examine the current TPM implementation and its effects on the manufacturing process, as well as to pinpoint any process flaws. Employee involvement, management commitment, etc., and identifies areas for improvement to reach world-class standards by maximising OEE and eliminating all losses.
Keywords - TPM, OEE

1. Introduction

To determine the root causes of inefficiencies in TPM implementation, namely in production performance, TA firm was chosen. The TPM technique is presently being used by the case study to address issues with the production process. There is still opportunity for continual improvement at this organization even though they have used the TPM approach to decrease losses and shorten cycle times because they have not yet fully utilised TPM. The business believes that there is potential to lower production-related losses brought on by issues such brief operational pauses or equipment failure. The responsibilities of adhering to the company's preventive maintenance schedule and fully implementing Total Productive Maintenance (TPM) were too much for the maintenance department that was already in place. In light of this circumstance, a technique to enhance the TPM process flow is required, which will raise the overall operations' efficiency. This paper aims to investigate the effectiveness of TPM implementation in the actual manufacturing industry, specific to Cases study industry. There are two main objectives in this project. These are:
To analyze current maintenance systems and TPM system and to Identify the areas needed to focus and eliminate the shortcomings to maximize the OEE.

2. LITERATURE REVIEW

Total Productive Maintenance (TPM) is a methodology to form a corporate culture focus on maximizing the efficiency of overall production system through cross-functional section (Venkataraman, 2007). According to Angeles (2009), TPM can be described as a plant improvement methodology which enables continuous and rapid improvement of the

manufacturing process through the use of employee involvement, employee empowerment and closed-loop measurement of results. It is a production driven improvement methodology that is designed to optimize equipment's reliability and ensure efficient management of plant assets. TPM also aims on building up a corporate culture that thoroughly pursues production systems efficiency improvement and Overall Equipment Efficiency (OEE). From both definition, it can be seen that they both describes a synergistic relationship among all organizational functions, but particularly between production and maintenance, for continuous improvement of product quality, operational efficiency, capacity assurance, safety and enhancement of the people who work within the company. It emphasizes maximizing Overall Equipment Effectiveness (OEE) through employee involvement. TPM activities involved all employees, starting from top management till ground floor operators. TPM program is marked to increase production while at the same time, increase employee morale and job satisfaction. In order to set up Total Productive Maintenance (TPM) framework, the understanding of it must be total. According to Nakajima (1989), the goal of Total Productive Maintenance (TPM) is continuously improve all operational conditions, within a production system by motivating the daily understanding of all employees.

2.1 TPM Implementation

For TPM implementation following 12 steps is followed as per the JIPM methodology**.**

Step 1. Announcement of TPM:

Top management needs to create an environment that will support the introduction of TPM.

Step 2. Launch a formal Education Program:

This program will inform and educate everyone in the organization.

Step 3. Create an Organizational support structure:

This group will promote and sustain TPM activities once they began and include members from every level of the organization.

Step 4. Establish basic TPM policies and quantifiable goals:

Analyze the existing conditions and set goals that are specific, measurable, Attainable, Realistic and Time-based.

Step 5. Outline a detailed master deployment plan:

This plan will identify what resources will be needed and when for training, equipment restoration and improvements, maintenance management system and new technologies.

Step 6.TPM kick-off:

Implementation will begin at this stage**.**

Step 7. Improve the effectiveness of each piece of equipment:

Project teams will analyze each piece of equipment and make necessary improvement.

Step 8. Develop an autonomous maintenance program for operators:

Operators routine cleaning and inspection will help stabilize conditions and stop accelerated deterioration.

Step 9. Develop a preventive maintenance program:

Create a schedule for preventive maintenance on each piece of equipment.

Step 10. Conduct training to improve operation and maintenance skills The maintenance department will take on the role of teachers and guides to provide training, advice and equipment information to the teams.

Step 11.Develop an early equipment management program:

Apply preventive maintenance principles during the design process of equipment.

Step 12. Continuous improvement:

As in any lean initiative, the organization needs to develop a continuous improvement mind-set.

3.0 Case study

The ABC Paper manufacturing Company is considered and production data was also collected to analyze the Overall Equipment Effectiveness (OEE) for one of the Paper Machine, as this machine is the most critical in the production of this product i.e News Print paper.

In this company has two Paper machines are in operation since 1985 with installed capacity of 150 000 TPA. This mill rawmaterial is Waste paper. The products of this company are writing and Printing a nd Copier paper. One paper machine is didicated for manufacturing of Copier paper and

other one is for bouth Copier and writing Printing. This company has its own Capative power pant to meet uninteraputed Power supply.

In a paper manufacturing industry, the bottle neck equipment is Paper machine, the plant performance is measure bases on the quality production output. ABC paper mill has TPM policy is to achieve, Zero accident, zero breakdown and Zero Customer complaints. The TPM policy of this company is,

ABC Paper Company identified following major losses, these losses is related to overall company losses; the aim is to reduce these losses from the process.

Losses identified by ABC Paper Mills

Sl No	**Equipment relates major losses**	**Definition of Loss**
1.	*Planned Shut Loss*	*Loss generated due to less production on account of scheduled plant shut for periodic maintenance, development work or statutory inspection.*
2.	*Production Adjustment Loss*	*Loss generated due to less production for Lower rate due to low demand.*
3.	*Management Loss*	*Loss generated due to less production for shortage of inputs and shortage of space.*
4.	*Equipment Failure Loss*	*Loss generated due to less production for breakdown on account of mechanical, electrical or instrument nature and equipment failure resulting in stoppage of production for more than 10 mins.*
5.	*Process Failure Loss*	*Loss generated due to equipment stoppage for more than 10 Mins for operation failure.*
6.	*Set up / change Loss*	*Loss generated for setting right the machine for desirable quality product after the tool / knife change.*
7.	*Start up Loss*	*Loss generated due to time taken to start production.*
8.	*Speed Loss*	*Loss generated due to lower rate of production for equipment or Process deficiency*
9.	*Minor Stoppage / Idling Loss*	*Loss for less than 10 minutes for any minor stoppage or machine idle running.*
10	*Defect and Rework Loss*	*Loss generated due to defective production or due to reprocessing.*

Table 3.1 Definitions of Losses

The company listed above said standard losses applicable for the organization level for all the equipments. Following are the specific losses of the Paper Machine under each major losses.

- Plant shutdown loss : Annual shout down, Scheduled Felt change, Wire change, Roll change

- Management Losses : Stoppage for want of Water, Steam, Power, Pulp shortage.
- Minor stoppages : Stopage of equipment for dandy cleaning, Paper breaks etc.
- Equipment failure losses: Mechanical, Electrical, Instrumentation.
- Process failure losses : Stoppage for felt cleaning or wire cleaning, dendy cleaning, Head box flushing, Lead roll cleaning, Career rope slippage, / Breakage, Dandy changing, Paper jamming, Jamming of equipments, Carrier rope Slippage/ breakage, starch supply failure.

Startup Losses : Quality change time loss, Gramage change / adjustment time loss

For this case study, data for the ten months is collected from the paper machine, to analyze its performance. This paper machine operates all 3 shifts, with 8 hours working per shift. This is continuous process industry. The machine stops only during Annual maintenance.

Table: 3.2, shows the paper machine detailed time loss on various headings, like equipment failure, Process failure, minor stoppages, set-up loss, management loss etc. Month wise OEE is calculated.

Sl.No	LOSSES DESCRIPTION	UNIT	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Avg.
1	Calender hours	Hrs	720	744	720	720	744	720	744	720	744	730.67
2	Annual Shut	Hrs	0	0	0	0	0	0	0	0	0	0.00
3	Available hours	Hrs	720	744	720	720	744	720	744	720	744	730.67
5	Total stoppages	Hrs	63.42	46	186.74	59.66	65.5	129.25	54.42	49.17	58.01	79.13
4	Running Hrs.	Hrs	656.58	698	533.26	660.34	678.5	590.75	689.58	670.83	685.99	651.54
	EQUIPMENT FAILURE LOSS											
5	Mechanical break downs	Hrs	18.58	24.08	22.25	14.83	20.58	17.08	13.83	15.58	22	18.76
6	Electrical /Inst break downs	Hrs	1.25	0	1.5	0.33	1.25	1.58	0.83	1.5	0.5	0.97
7	Total downtime	Hrs	19.83	24.08	23.75	15.16	21.83	18.66	14.66	0	22.5	17.83
8	Mechanical break downs	Nos	4	2	1	1	5	2	2	2	1	2.22
9	Electrical break downs	Nos	2	0	1	0	1	2	1	1	1	1.00
	TOTAL	Nos	6	2	2	1	6	4	3	3	2	3.22
	PROCESS FAILURE LOSS:											
10	Wire change	Hrs	0	0	0	0	5	0	0	5	0	1.11
11	Felt Changing	Hrs	2	0	0	4	4	0	0	3	0	1.44
12	Felt washing	Hrs	1	0	1.42	0	0.75	0	0	0	0	0.35
13	System Washing	Hrs	8.25	1	4	6.67	3.5	2.75	9.33	1.25	0.5	4.14
14	Head Box cleaning	Hrs	1.83	1.67	1.33	1.5	7.83	7.25	14.17	8.92	9.42	5.99
15	Cleaning Other Equipments	Hrs	0	0.17	0.5	2.25	0.84	0	0	0	0	0.42
16	Dandy Changing	Hrs	4.5	6.5	4.25	8.42	3.75	1	1	0	0	3.27
17	Paper Jamming.	Hrs	0.25	0	0	0	0	0	0	0	0	0.03
18	Jamming of Equipments	Hrs	0	0	0	0	0	0	0	0	0	0.00
19	Carrier Rope Slippage / Brks	Hrs	0.75	0	1	0.5	0	0.67	0	0	0	0.32
20	Starch Supply Failure	Hrs	0	0	0	0	0	0.42	0.17	0	0	0.07
21	Start up	Hrs	1	0	0	1	1	0	0	0	0	0.33
22	Misc	Hrs	0.34	0	1.08	1.83	0	2	0	0	0	0.58
	TOTAL	Hrs	19.92	9.34	13.58	26.17	26.67	14.09	24.67	18.17	9.92	18.06
23	No of process failures	Nos	5	4	6	8	8	7	7	6	4	
	MINOR STOPAGE											
24	Dandy cleaning	Hrs	9.41	12	8.67	11.17	8.83	6.17	5.08	10.08	6.17	8.62
	No.of minor stopage	Nos	47	75	54	63	49	37	32	67	38	51.33
	no.of breaks	Nos	79	81	83	89	73	74	83	83	79	80.44
	SETUP LOSS:											
25	Quality Change Loss	Hrs	2	2.33	1.75	2.5	2.25	2.25	8	5.25	11.5	4.20
26	grammage change	Hrs	1.42	2.58	1.83	6.33	2.75	0.75	2.25	2.42	1.67	2.44
	TOTAL	Hrs	3.42	4.91	3.58	8.83	5	3	10.25	7.67	13.17	6.65
	MANAGEMENT LOSS											
27	Pulp Shortage	Hrs	0	0	0	0	0	18	0	0	0	2.00
28	Power shortage/Restriction	Hrs	0	3.5	143.5	9.5	3	7.75	1.5	0	5.92	19.41
29	Steam Restriction	Hrs	18.58	3.83	1.58	0	8.5	67.42	2.17	20.83	6.5	14.38
30	Develop	Hrs	0	0	0	0	0	0	0	2.5	0	0.28
31	Problem at stock		1.67	0.34	0.75	0	0.5	0.33	1.17	0	0	0.53
	TOTAL	Hrs	20.25	7.67	145.83	9.5	12	93.5	4.84	23.33	12.42	36.59
32	Actual Production	MT	756	852	741	855	894	787	1041	1020	928	874.89
33	Should be Production (Target)	MT	959	1019	779	964	991	862	1055	1026	1050	967
34	Production Rate	MT/hr	1.15	1.22	1.39	1.29	1.32	1.33	1.51	1.52	1.35	1.34
35	Target Production Rate	MT/hr	1.46	1.46	1.46	1.46	1.46	1.46	1.53	1.53	1.53	1.48
36	Rejection %	%	8.60	6.50	8.14	6.84	7.32	10.32	4.91	3.88	5.65	6.91
37	Speed loss	Hrs	138.77	114.44	25.73	74.72	66.17	51.71	9.19	4.16	79.45	62.70
38	Rejections	Tons	90.44	74.48	72.29	76.54	78.54	100.16	59.62	47.30	61.62	73.44

Table: 3.2. Paper Machine data for April 15 to December 15.

Table 3.2 shows the Paper machine data collected for 10 months period, the data indicates the time losses of different categories, which are the further groped in to broad categories for calculating OEE.

3.3 Improvement Proposal

All collection of data and data analysis from current and improved of TPM implementation will be proposed to the company to suggest new improved system The data analysis done can be a reference for the company to improve the production and maintenance operation to become more efficient.

3.4 Summary

This work has presented the approach in the research and how to identify the shortcomings in current TPM implementation in order to continue the improvement. The analysis of the data and its impact on OEE and its associated factors are discussed.

Sl.No	DESCRIPTION	UNIT	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Avg.
1	**AVAILABILITY**	%	91.2	93.8	74.1	91.7	91.2	82.0	92.7	93.2	92.2	89.1
2	**PERFORMANCE**	%	78.9	83.6	95.2	88.7	90.2	91.2	98.7	99.4	88.4	90.5
3	**QUALITY**	%	91.4	93.5	91.9	93.2	92.7	89.7	95.1	96.1	94.4	93.1
4	**OEE**	%	65.7	73.3	64.8	75.8	76.3	67.1	87.0	89.0	76.9	75.1

Table: 3.3. Summary of factors of OEE

This summary is outcome of complied ten months data of a Paper machine. The OEE trend which gives an indication of Paper machine performance and helps to find areas and route causes for the problems and weakness points.

4.0 Results and discussion:

The result and analysis of the information and data collected is discussed in this chapter. From this chapter, more focus is given on the problem identification and ways on how to solve them to maximizing TPM benefits. The analysis attempts to identify which losses in the system needed to be focused on and treated first. The results from actions and improvements of the activities are one of the main objectives in this Paper.

An observational research technique is an observation that will give many positive aspects in return. Validity is known as a great approximation of the truth in given inference, conclusion, or proposition. By using the observational research techniques, the findings will be strong in validity because a depth of information about a particular behaviour can be collected.

However, there are negative aspects to this technique which is reliability. Reliability is the extent that observations can be replicated. To observe the growth of any situation will take some considerable time. External validity is the extent that the study's findings would also be true for other people, in other places, and at other times. With this project, observation has been conducted during operating times at the company. This data can be used as the basis for further analysis and suggestion improvements.

4.1 Data Findings

Collecting data from the company is essential for this project as it is used to determine the factors which prevent the company from improving the existing TPM system. Data on paper machine breakdown frequencies, losses, production, quality defects were collected for this. All of these data gathered were compiled and are presented in the table 3.2. Further the data is analyses in to find the treads of Paper machine availability, Performance rate , Quality rate and OEE.

4.1.1. Availability:

The availability trend of the Paper machine is as depicted in the Fig 4.1.

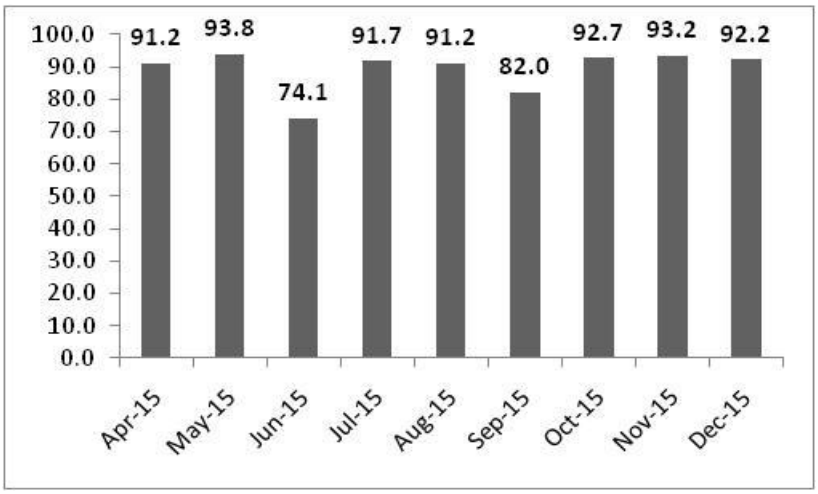

Figure 4.1: Availability of Paper machine.

This indicates the loss accrued due to unplanned production machine downtime events. This is calculated as downtime during which the planned production was interrupted for various reasons, downtime or downtime causes are associated to this data. The most typical machine downtimes to take into account are those that involve malfunctioning, insufficient material, and output accumulation and machine format changeovers. Even though the latter downtime causes are not to be eliminated they can nevertheless be reduced in most situations.

4.1.2. Performance rate:

The Performance trend of the Paper machine is as depicted in the Fig 4.2.

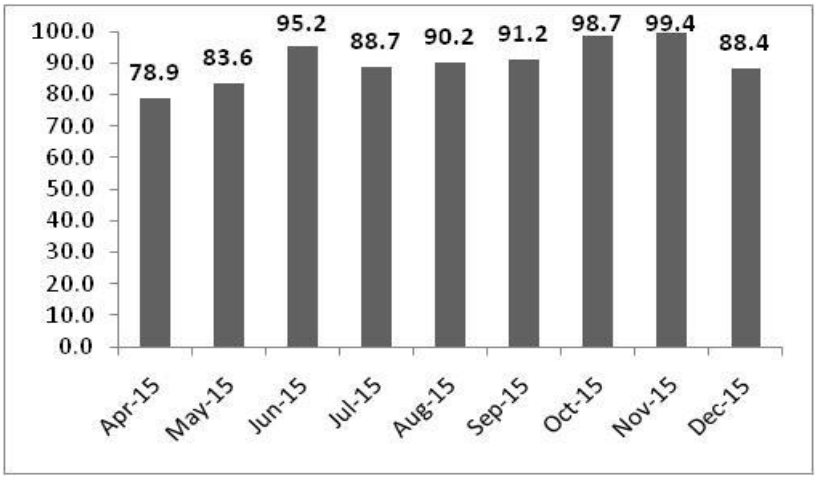

Figure 4.2: Performance rate Of Paper machine.

This indicator measures the speed loss and actually produced and subtracts the product loss caused by slowed down production runs. There are many factors that reduce the effective production speed rate to that of the machine's normal capacity. These factors include substandard materials, machine wear and tear, machine defects or operator inefficiency. These inefficiencies slow the production process down causing substandard production performances in respect to those planned.

4.1.3. Quality rate:

The quality rate of the Paper machine is as depicted in the Fig 4.3.

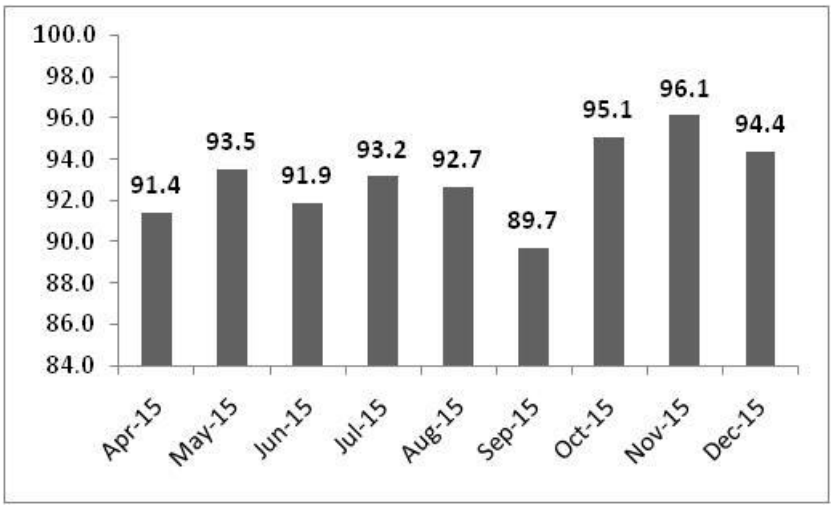

Figure 4.3: Quality rate of Paper Machine.

This indicator measures production loss caused by rejects which are produced below the minimum standard quality required. This also includes the production that need to be reworked. The less the quality indicate there is rejections and reworking, this may be due to equipments problem, input material problem and skill level of the operators.

4.1.4. OEE:

Overall equipment effectiveness is used to identify and categorize major losses or reasons for poor performance. From the OEE factors (availability, efficiency, and quality/yield) to capture asset performance information as a basis for specific improvements at the plant-floor, operations, maintenance, and departmental decision-maker levels. The OEE of the Paper machine is as depicted in the Fig 4.4.

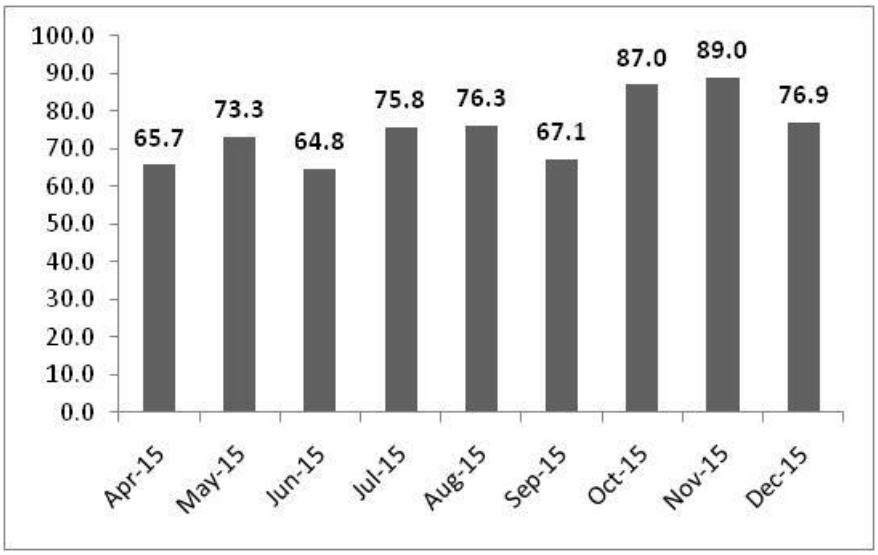

Figure 4.4: OEE of Paper machine.

The OEE data provides defined and quantifiable reasons for poor equipment performance. These can then be prioritized, used for root cause analysis, and problem elimination progress. The OEE percentage can be used as a relative indicator of asset performance for individual equipment, engineering, operations, and maintenance to evaluate equipment stability and the availability of untapped or “hidden” capacity for the purposes of production scheduling and capital investment justification. Tracking and tending OEE percentages for the machine shows rates of

improvement and/or degradation over time.

4.1.5. Comparison of OEE with world class.

It can be seen from the table 4.1 that the performance of Paper Machine as overall Equipment effectiveness is 75.1% , where as the availability is 89.1% of production time and the performance is 90.5% while quality rate is 93.1%. Table below shows the comparison between World Class Company and ABC Paper mills.

Factors	OEE of ABC Paper mills	OEE of world class
Availability	89.1%	90%
Performance	90.5%	95%
Quality	93.1%	99%
OEE	75.1%	85%

Table: 4.1 World Class Company and ABC Paper mills.

In order to gather more information on how the TPM implementation was done in this company, a series of interviews were conducted. Employees from various sections was interviewed to investigate the TPM implementation since its kick-off to till date and issues, role of top management to shop floor people and linkage in their line of work. This is because in order for TPM to work, communication and intraction between all sections are important as it is to enforce the Autonomous Maintenance (AM) practice which is one of the TPM pillars. The interview questions were also constructed to investigate whether they were aware of their responsibility in implementing TPM. Sometimes it is noticed most of the employees are not have enough enthusiasm and knowledge of implement TPM system level of awareness is too low. This situation commonly exists within operator's maintenance crew. Therefore all the staff are not participating in any improvements initiatives driven by the company. The questioner used to assess the awareness and involvement of employees is as shown in Fig: 4.5

Sl	Questions	YES	NO	CANT SAY
1.	TPM is additional job not part of my job responsibility.	✓		
2	Lack of Quality and Productivity culture			✓
3	Training programs are of too High level			✓
4	Compartmental working of departments	✓		
5	Do you have your product cost and its components		✓	
6	Do you have adequate training on TPM Pillars Concepts		✓	
7	I feel AM activity is not followed in true spirit.		✓	
8	TPM teams lack of necessary mix of skills and experience.	✓		
9	Do Top management visits shop floor and review TPM or 5 S activities.	✓		
10	Do you have clarity of company objective of TPM			✓

Figure 4.5: Questioner for assessing employee's involvement in TPM

This questioner is administered for 85 operating and maintenance crew, out of which 69% of the respondents said they are not considering TPM as their routine job and they are not having Concept knowledge of Autonomous maintenance.

4.2 Problems Identification

There were several problems identified during data collection for this study. This includes equipment breakdown, production rate, lack of communication between production and maintenance, lack of training for operator, and insufficient skilled manpower. Although there are more problems in this company, these identified problems were the main things that need to be sorted out by the company in order to increase their efficiency in production, hence achieve the TPM goals and objectives.

Equipment breakdown was stated first because from the data collected , there is a certain parts of the Paper machine that keeps on getting faulty and this might have cost the company dearly as the corrective maintenance will cost about three times than preventive maintenance (Mobley, 1990). Table: 3.2 shows average 25 times of breakdown per month for paper machine equal to 9.5 Hrs of breakdown period and these findings were taken from April 2015 to Dec 2015. If this situation persists throughout the year, the accumulated breakdown time will be excessive.

Unplanned down time is hard to determine but it is crucial to know on how much time will it take for each breakdown and it is also important to know what is the source or reason for the breakdown to happen in the first place. Reason for this incident is just because not following preventative maintenance as per scheduled. Breakdown data should be tabulated charted and tabulated to apply the Root Cause Analysis, preferably starting with the most severe loss categories.

Negligence of this practice will cause random The main problem now is there is lack of training available for the workers and if there is, the levelof participation is too low. For example, a worker attends a training course and after that, they never practice the knowledge gained from the training course. This occurrence was identified through the interview and furthermore, some of the operators did not know what to do or who to service to the equipments. As a result, some of the equipments will be serviced in a hurry to catch up with the production. In Table: 3.2, the data for the paper machine equipment failures are recorded. This data will be used to determine which losses is the biggest contributor to the downfall of the production. However, a poor data management is one of the reasons why equipment breakdowns in the company cannot be resolved.

High demand in production is also identified as a reason why the maintenance team was burdened and they cannot cope with additional work load imposed by TPM, there were not enough skilled personnel to do the maintenance jobs and from the interaction it is noticed system of analysis the previous machine breakdown data to determine route cause of breakdown is not taken as serious.

Lack of interdepartmental coordination and accountability are the main problem which is holding the TPM back seat. The organizational interdepartmental cooperation is very important for all TPM activities and drives the people around to practice TPM. If the management did not commit to these activities, the production floor, maintenance team, and operators will feel that they are not obliged to do anything at all in enforcing TPM. Take aside the management staff, the interaction between maintenance team and production floor is also lacking.

AM is very important and if this practice is left out, TPM will probably fail. It is always recognized that AM is the backbone of TPM. AM is an activity where everyone participates in improving and maintaining the equipment's reliability and efficiency. Operator improvement is also important to increase the knowledge of all the workers and enhancing the machine life. If the operators know how to determine the machine conditions, it will be easier for the maintenance team to service the machine before it breaks down.

call if there is a machine breakdown.

Production	Maintenance
• Startup losses	• Checking and inspection
• Inspecting and lubricating	• Preventative maintenance
• Detection of abnormal signs	• Condition monitoring and machine diagnosis
• Minor Stoppages	• Establish planned maintenance
1. Establishing the basic condition of the equipment	
2. Adhere to the usage conditions of the equipment	
3. Inspection and restoration of defective parts	
4. Correct design weaknesses	
5. Enhance operator and maintenance skills	

Figure 4.6: Five Remedies to Achieve Zero Breakdowns according to (Halfrohreich, 2011).

4.3 Discussion

The main thing to discuss is how this data analysis can be used to improve the level of TPM implementation in this company. Earlier in the literature review, eight TPM pillars was mentioned by Ahuja and Kamba (2008) and by putting these eight TPM pillars in place will ensure the effectiveness of TPM. Attacking the Six Big Losses is another way to ascend the TPM implementation to another level. There are three main problems in the production floor and there are all comprised in the Six Big Losses. They are idling / minor stoppages, setup and adjustment, and equipment failure.

First of all, equipment failure must be dealt with because there is no use in solving other problem if the main problem still left unsolved. So a step by step approach should be practiced during the

process of Six Big Losses elimination. Then only the equipment will be in the optimum performance and the work to maintain its performance can be done easily either by the maintenance team or the operator for minor fault. Equipment breakdown and lack of AM practice are the main problem that was holding TPM progress. The target is to achieve a world class OEE which is at 85%. With the current breakdown frequency, the availability for the machine proves that there are a lot of improvements needed to achieve the world class OEE percentage.

With reduced breakdown frequencies, the production team will have a smoother operation and efficiency will probably increase. Another downside to high frequency of breakdown is the increment of maintenance cost. Cost for maintenance will increase due to replacement and repair cost some times the faulty machine will probably need a part to be replaced in order to get it working at satisfactory level.

How can the equipment failure be eliminated so that OEE will increase? OEE is the product of availability, efficiency and quality. By attacking all this criteria one by one , the OEE can be increased. The availability is the readiness of the equipment and by practicing good preventative maintenance system, availability can be increased. Then for quality, 10 steps in quality maintenance could be carried out and this will normally target zero defects and zero failures in practice. Lastly for efficiency, the minor stoppages, process troubles, setup and adjustment controlling results optimum performance. Figure 4.6 show the five remedies to achieve zero breakdowns.

There are two areas that needed to be focused on to keep the OEE sustainable. Firstly, the management should play an effective role in the company, and secondly the data computing, analysis of data and benchmarking. There is another observation in the company, functioning of the maintenance department, the attitude of some maintenance staff. During the interview staff claimed that they do not have enough time to enforce preventive maintenance of all the machine and they feel that they are overloaded with additional job and suggests the management to additional manpower in order to do all the works within the specific schedule.

Training must be provided to all the employees and this is to enhance their knowledge and more importantly is to create awareness of AM and basically about TPM. For instance, the training for handling an equipment or machine will train the operator on what to do when there is a problem with the machine or how to preserve and maintain the life of a machine. All the employees in the company should feel they are a part of the company's plan as the AM involves everyone in the company. For example, machine operators should feel that they contribute to the company by maintaining the equipment without equipment failure.

Daily work performed by the maintenance crew on production floor should be taught to all employees of production and maintenance. This way, maintenance can always focus on preventive maintenance .This responsibility transfer from Maintenance to Production will form a partnership and enforce the AM. AM is one of the TPM pillars and by promoting the pillars of TPM with thorough elimination of losses that cause failures, quality problems, and unstable conditions such as minor stoppages, are effective in preventing equipment breakdown.

Another area is, safety hazards inside the factory are the issue. Why do accidents occur in work places when TPM is implemented? .Usually an accident happens due to the unsafe mechanical and/or environmental factor, poor managerial factor, and personal factor.

All of these factors can be viewed in Figure 4.7.

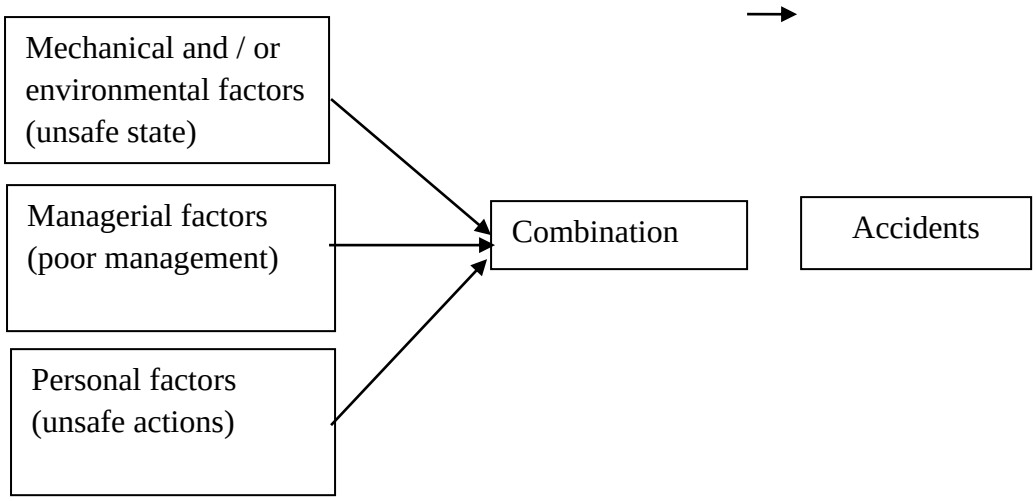

Figure 4.7: Mechanism of Accident Occurrence.

In most cases serious accidents occurred when there are malfunctions such as equipment breakdowns which disrupted the ordinary work flow. One of the keys on preventing accidents is to prevent equipment failures and quality defects from happening. The other thing is to provide a safe work environment for the workers to move around. This will avoid any possibilities for accidents.

Davis (1997) also had stated ten reasons on issues on TPM failure, and the problems that were stated are quite similar to the problems at hand. Some of the problems are not serious in changing, lack of relationship and structure, lack of education and training, poor structure and organisation in supporting TPM and its activities, and no motivation in the production section. With the elimination of the undesirable elements within the company, there should be no problem for success in the company by implementing TPM.

4.4 Summary

From this result and analysis, there are some key points identified. The data was gathered and after comparing it with before TPM implementation in the company and the results shown now are worth noting, companies that have shown in improvements in TPM implementation, the shortcomings of current practice were identified. It is essential for this study to identify these shortcomings as it will determine whether this study will reach its objectives or not.

Several equipments related running problems ware found. Other problems were also noticed throughout the observation in this project. The recurrence problems are such as equipment breakdowns, lack of coordination between the departments. The outstanding number of equipment breakdowns shows that there is space for the OEE to be improved for this company. The communication between the managerial department and production has been poor that it drives the company towards average level of success whereas the company actually can achieve greatness by implementing TPM.

The practice by the Quality Management should be carried out consistently in order to keep all equipment in mint condition. A guideline for Quality Maintenance can be refer in Figure 4.8. The figure will show the ten steps to deploy for Quality Maintenance.

Phase	Key activity	Tool	Steps	Action
	Present state analysis	Stratify Trend Data 1. Monthly 2. Daily data Collection	Step one	Confirm present status
Improvement	Selection machine (process)	QA matrix (wip)	Step two	Survey Process which generated the defects
	Organise defect pattern	Sporadic vs, chronic defects	Step three	Survey and Analyze 5M conditions
	Restore	Study	Step four	
	Analyze and improve reported quality defects	Why – why analysis PM Analysis	Step five	Analyze adverse and ideal conditions
	Review , implement	checks	Step six	5M conditions, defects, kaizen
Maintenance	Identify the relationship between product characteristics and process variables (conditions)	Q-M Matrix	Step seven	Set 5 M conditions
	Develop and implement trend control	Trend control	Step eight	Intensify checking methods and response
	standardize	Operational standards	Step nine	Select, check values
	Review		Step ten	Evolve standards

5.0 CONCLUSIONS

The objectives of this project were stated in the introduction chapter. The question now is, are all the objectives were fulfilled? The first objective is to analyse current maintenance systems present practices and identify the shortcomings. The second objective is to propose a new solution in the implementation of TPM to eliminate the shortcomings and maximize the OEE.

The current maintenance in the selected company did not utilize the use of TPM fully as they still practice reactive maintenance. TPM requires the practice of proactive maintenance or known as Planned Maintenance (PM) in TPM pillar. This objective also requested the identification of the shortcomings in the current implementation. A number of shortcomings or problems were discovered and elaborated on Chapter 4. The identified problems are equipment breakdown, lack of AM practice, high volume of production, lack of training and education, and still practicing the reactive maintenance instead of preventive maintenance.

In this Paper, proposals on how to solve and eliminate the shortcomings were given in detail. The problems were classified into five groups consisting of PM, Quality Maintenance (QM), Training and Education (T&E), Autonomous Maintenance (AM), and Safety, Health and Environment. In each group, a proposal or suggestion was included for each problem. As a solution, the company should make all of the proposals and suggestions as a reference and assimilate it to their company needs.

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