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Effective Implementation of Total Productive Maintenance and Impacts on Breakdown Time and Repair & Maintenance – A Case Study Of A Printing Industry In Bangladesh

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Abstract:- To sustain today's highly competitive market, every company must minimize its operating expenses. Total Productive Maintenance (TPM) can play an effective role in this aspect. The main purpose of this study is to find out a proper planning system for implementing TPM at the initial stage in the organization. This study discusses the important key performance indicators or KPIs of TPM, which are Machine Breakdown time, Mean Time between Failure (MTBF),Mean Time to Repair (MTTR) and Breakdown time percentage of available time. The case study of TPM implementation has taken from a manufacturing company in Bangladesh that has started implementing TPM since January 2011. Significant improvements of these KPIs are contrasted with previous year's values. This study explains how TPM transforms an industry's overall maintenance system to increase the productivity.

Keywords:-TPM, MTBF, MTTR, Break Down Time.

I. INTRODUCTION

Maintenance is one of the areas in modern management to increase machine productivity and to produce quality products. This obviously improves equipment efficiency rates and reduces costs (Lemma, 2008). Maintenance in a particular section could not provide much improvement. This insists to go for maintenance in all departments which eventually leads to Total Preventive Maintenance (TPM). TPM concept developed from Productive Maintenance (PM), which was originated in United States in the late 1940's and early 1950's. At that time, they developed productive maintenance schedule. After the Second World War, when Japanese companies were struggling with their costs, in 1953 twenty Japanese companies formed a PM research group; in 1962 they were sent to USA for doing research in PM system. They created the Japanese Institute of Plant Engineers (JIPE), later that became Japanese Institute for Plant Maintenance (JIPM) in 1969. Nippondenso, a Japanese automotive component manufacturer, one of the part of Toyota, first used the term Total Productive Maintenance in 1961 and later it won JIPM PM Prize for TPM implementation. Nissan and Mazda followed the tool TPM. In 1970, when Japanese economy faced macabre TPM began to flourish in all Japanese companies. In 1980's and 1990's TPM became popular in America and the Western World as a part of Total Quality Management. Dupont, Exxon, Kodak, Acoa, AT&T, Ford, Hewlett-Packard, Proctor and Gamble are some of the companies who believed in TPM and implemented TPM. The popularity and the effectiveness of TPM in recent time are beyond questions (Pomorski, 2004).

II. LITERATURE REVIEW

To ensure smooth running of production facility maintenance is an important aspect. Total productive maintenance is stepwise strategy that combines best features of productive and preventive maintenance with total employee engagement. TPM prevents losses before occurring to achieve zero defects, zero accidents and zero breakdowns (Suzuki, 1992). Companies around the world accept TPM to abate production losses caused by machine breakdowns, as they believe the concept of zero breakdowns is possible to achieve (Wllmott and McCarthy, 2001). TPM is an effective tool of converting traditional boss-subordinate management into a participative management style. It helps to create the ownership of the machine to the machine operators, which helps to enhance the skill label of operators with cooperation of maintenance personnel. It is a paradigm shift from the typical perceptions of who is responsible for maintenance. TPM has to be implemented by all departments' including operations, maintenance, environmental, purchasing, accounting, stores, safety and human resources; in a word, TPM involves every employee, from top management to shop floor employees

(McKone et al, 2001). TPM changes the mind set up of the people. It shifts the traditional attitude of the operators' *I operate-you fix to I operate-I fix style* (Thun, 2006). TPM involves maintenance persons and operators together, where maintenance department does general breakdown servicing and operators take the ownership of the machines (Taisir, 2010).

The losses that are experienced by each industry are different. In general, the losses can be categorized into 16 major types under 4 categories that elaborately describe all aspects of losses (Venkatesh, 2007). Those four main categories are Seven major losses that affect overall equipment efficiency, Losses that affect equipment loading time, Five major losses that affects human work efficiency and Three major losses that affects effective use of production resources.

In TPM, operators and maintenance personnel work together to attain fixing any abnormalities that are found in the equipments. TPM combines the best features of preventive maintenance, condition based maintenance and predictive maintenance. All of these actions are ensured through eight pillars that actually thrive the deployment of TPM (Lazim et al, 2008). The 8 pillars of TPM may be summarized as Focused Improvement & Process Improvement, Autonomous Maintenance, Planned Maintenance, Quality Maintenance, Early Equipment Management, Education and Training, Safety, Health and Environment and TPM in office (Rodrigues and Hatakeyama, 2006).

There are number of metrics for TPM. As per company strategy, KPIs are selected. The most important KPIs are MTBF (Mean Time between Failures), MTTR (Mean Time to Repair), and Overall Equipment Effectiveness (OEE) (Baluch et al, 2010). Sometimes, machine breakdown time status, setup time status are also considered as important KPIs of the plant which help to meet desired cycle time and on time delivery. Overall equipment effectiveness is a function of availability, performance and quality indexes. OEE can be increased by reducing the losses (Jeong and Phillips, 2001).

OEE = Availability * Performance * Quality.

MTBF (Mean Time between Failures) is an index that indicates mean time between two separate failures (Rodrigues and Hatakeyama, 2006).

$$MTBF = \frac{\sum duration\ of\ correct\ operation}{\text{No of breakdown}}$$

MTTR (Mean Time to Repairs) is an index that indicates mean time taken to repair the equipment (Rodrigues and Hatakeyama, 2006).

$$MTTR = \frac{\sum duration\ of\ Repairs}{\text{No of repairs}}$$

III. RESEARCH METHODOLOGY

Each research problem is in some way unique, and therefore requires a tailored research procedure. The first step in doing this research was the formulation of the problem and the creation of the research questions. Thereafter, identify the methodology which would best fit the problem under research. After that, gathered secondary data in the form of books and articles in order to improve understanding of the research problem. This study identifies unplanned machine breakdown time, MTBF, MTTR and Percentage of Breakdown time of Available time as most important attributes that not only improve machine OEE but also reduce maintenance and repairing costs as well as make quick response on the breakdown. This study is limited to Focused Improvement, Autonomous Maintenance, Planned Maintenance and Education & Training pillars. Previous year's historical data are used as baseline for selected attributes and current year's data are captured to compare the improvement in results.

IV. CASE STUDY

A printing industry in Bangladesh is considered for the case study of TPM implementation. This paper only focuses on the implementation procedure of Focused Improvement or Kobetsu Kaizen pillar, Autonomous Maintenance or Jishu Hozen pillar, Planned Maintenance Pillar and Education & Training Pillar. As TPM is a Top Management driven project, decision of implementing TPM was informed by the top management to all members from operation, supply chain, human resource departments. TPM implementation team has been formed at various levels and departments. An ABC analysis has been conducted on 6 categories: EHS, Quality, Production Effect, Breakdown Frequency, Repair Type and Maintenance Cost for every machine. For each category machines are ranked A, B or C where A indicates most important machines which need more attention for repair when breakdowns occur, B indicates important machine that need some attention for repair when breakdowns happen and C requires less or minimum attention for repair when breakdown occurs.

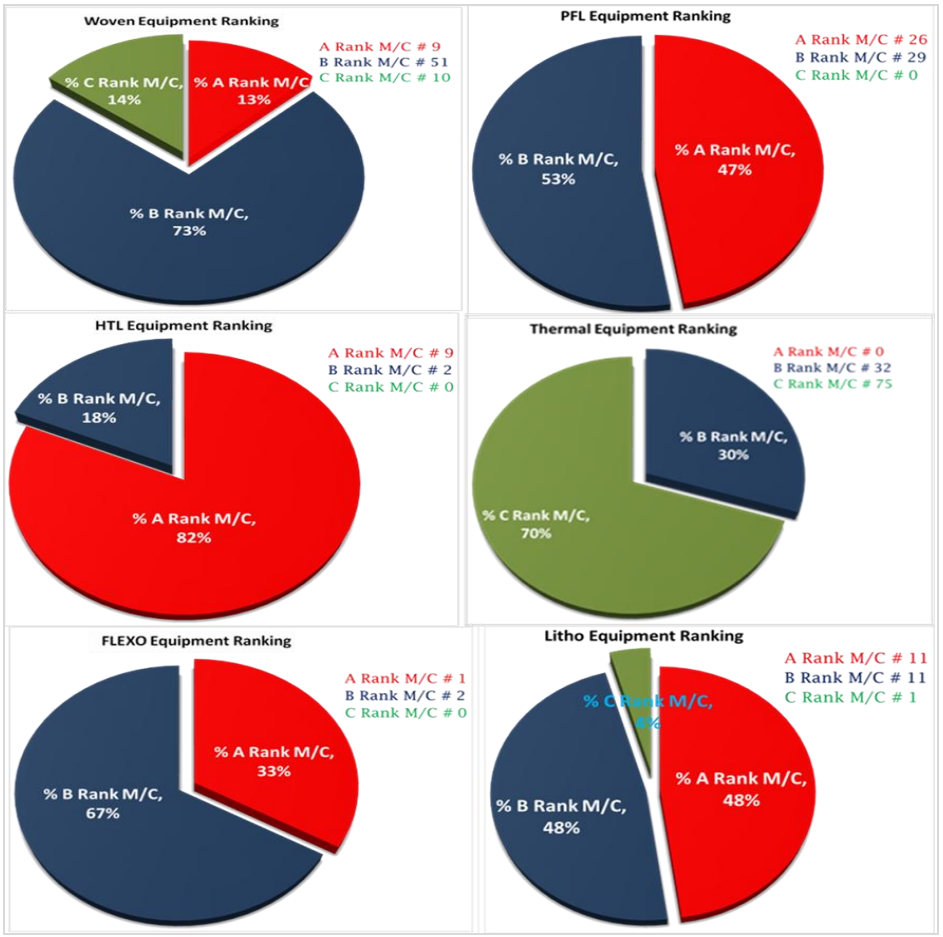


Fig. 1: Equipment Ranking

To select the prioritized department for implementation an analysis has been done in terms of 16 major losses and opportunity lost (in terms of thousand dollar production) due to these losses. Among the losses, initially the breakdown time loss is considered. Figure 2 shows the percentage of all losses.

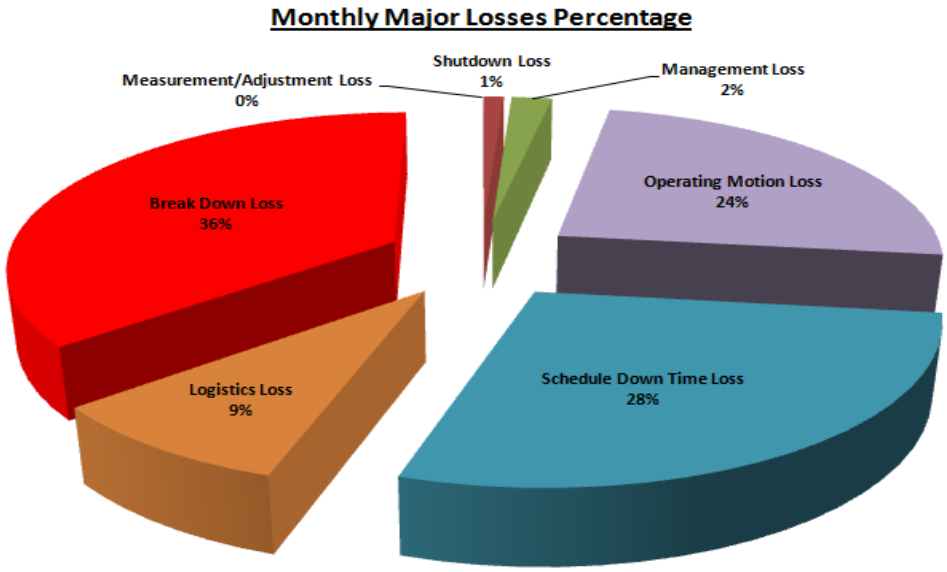


Fig. 2: Percentages of major losses

It has been found that break down time loss has more contribution to the total loss time and that is 36%. Figure 3 shows the Pareto analysis for breakdown time and opportunity loss due to breakdown time loss for all six departments to select the pilot department.

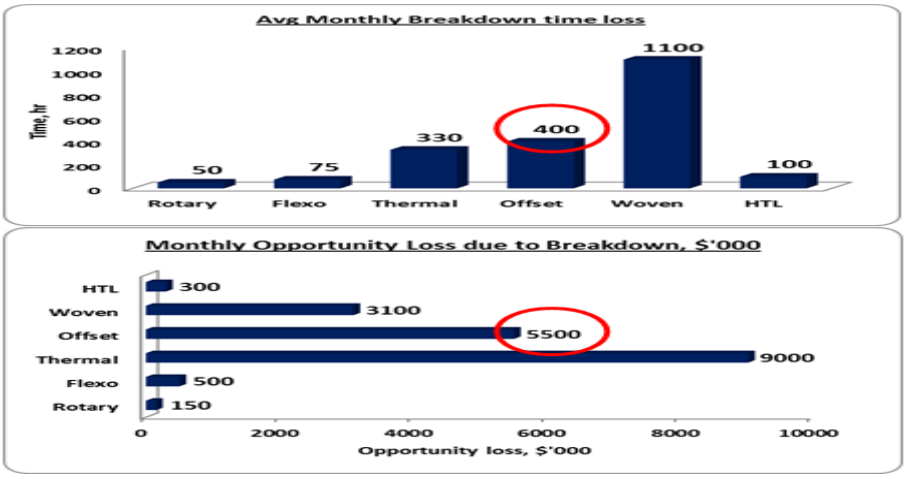
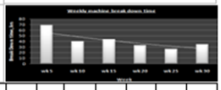


Fig. 3: Breakdown loss amount and its impacts

The ABC analysis identifies 3 most important departments for TPM implementation: HTL, Offset & PFL having 82%, 48% and 47% 'A' ranked machine that indicates these departments having machines that have no alternative and any breakdown of these machines can cause tremendous production loss. From Pie chart, it's obvious to take breakdown time loss as it has highest impact among other losses. From Pareto analysis Offset department is taken as the model department for implementing TPM as it is relatively high both in breakdown time and opportunity loss due to breakdown.

After selecting Offset as the model department, a one-year master plan, named A3 project of Offset TPM implementation is prepared. The Gantt chart is the blue print of TPM implementation for the year. Actual KPIs are matched with the planned KPIs every week and take corrective actions where it requires. The selected KPIs for the initial stages are machine breakdown status, MTBF, MTTR and percentage of breakdown of available time. Figure 4 shows the project A3 developed by the selected industry for TPM implementation master plan.

Title : TPM Implementation in Offset Department

Bangladesh has been identified as a key growth site. The objective is to improve machine condition, reduce machine breakdown time, trained operators, reduce maintenance and servicing costs.	**Steering Team** : Operation Manager, ELS Manager, Project Champion. **Core Team :** Group head, Department head, Maintenance head, Other members.	Overall Status Project Champion : Iftekhar Aziz Last Update: 25 August, 2011
Current Condition Machine Break Down Time, hrs/week : 90 No of operators Trained : 67	**Target Condition** Machine Break Down Time, hrs/week : 68 No of operators Trained : 100	

Schedule													
Major milestone/Deliverables	Owner	Status	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2010 m/c breakdown time,MTBF,MTTR calculation	Team													
Yearly TPM calander preparation	Team													
Circulate Fuguai/Abnormality tags	Team													
Start initial cleaning and servicing	Team													
Prepare PM1: Daily-Weekly-Monthly maintenance schedule	Team													
Training on TPM,Know your m/c,PM1 checklist,KPIs,SMED	Team													
Setup time reduction and Kaizen event	Team													
Prepare PM2: Technician stage maintenance schedule	Team													
Problem analysis using 5why,PDCA,FMEA techniques	Team													

*Status: 1= On Target, 3= Behind schedule, significant concerns, BLUE=Complete

Top deliverables/Key tasks complete last 30 days	**Key learnings and issued surfaced**
CD 74 machine initial cleaning and servicing ang abnormality tag solutions	All tags can not be solved: parts high purchase ate, need to prepare locally

Up coming deliverables/Next 30 days tasks						
Action Items	Due Date	Responsible Person	Accountable	Consult	Inform	Status
CD 74 PM1 checklist in local language	30-Aug	Manager, Maintenance	Dept. Head	Champion	Mentor	On Going

Current Issues	**Cause**	**Counter Measure**	**Who**	**By When**
Set up time reduction of 2 color and 4 color machine	Materials not ready	Super Market	Dept. Head	20-Aug

		Meeting Schedule			Frequency	Day	Time
Department/Function	**Name**	**21-Jul**	**28-Jul**	**4-Aug**	Weekly **11-Aug**	Thursday **18-Aug**	12:00pm-1:00pm **25-Aug**
Operation Manager	Balachandra						
Lean Sigma Manager	Biswas						
GOLD	Aziz						

Color Code 1-Red Absent 2- Green Present 3- V Vacation or Holiday

Fig. 4: TPM Implementation Project A3

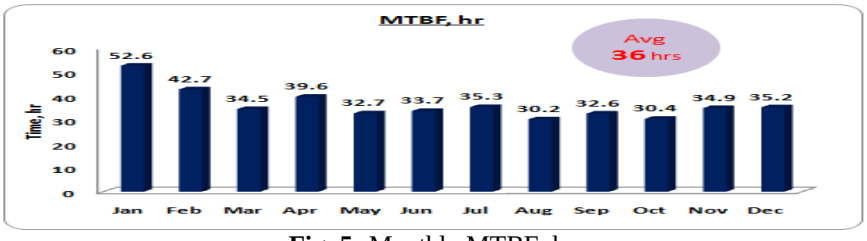


Fig. 5: Monthly MTBF, hr

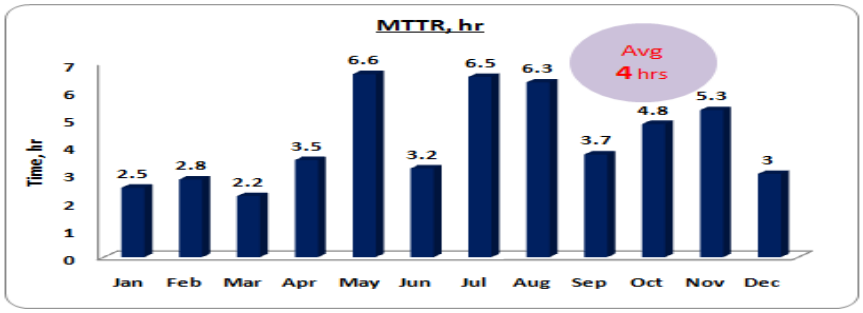


Fig. 6: Monthly MTTR, hr

After all required calculation a calendar is prepared that shows whole year machine cleaning and servicing plan. Estimated start and finish dates are showed in the calendar according to which maintenance program carried out for.

DAY	JANUARY	FEBRUARY	APRIL	MAY	JUNE	DAY
THU		3			2 L 01 GT052-4C	THU
FRI		4	1		3	FRI
SAT	1	5	2		4 L 01 GT052-4C	SAT
SUN	2	6	3	1	5 L 01 GT052-4C	SUN
MON	3	7	4	2 L 23 GT052-2C	6 L 01 GT052-4C	MON
TUE	4	8	5	3	7 L 01 & L 02 GT052-4C	TUE
WED	5	9	6	4 SM 52	8 L 01 & L 02 GT052-4C	WED
THU	6	10	7	5 SM 52	9 L 01 & L 02 GT052-4C	THU
FRI	7	11	8	6	10	FRI
SAT	8	12	9	7 SM 52	11 L 01 & L 02 GT052-4C	SAT
SUN	9 TPM L31 GT052-2	13	10	8 SM 52	12 L 02 GT052-4C	SUN
MON	10 TPM L31 GT052-2	14	11	9 SM 52	13 L 02 GT052-4C	MON
TUE	11 TPM L31 GT052-2	15	12	10 SM 52	14 L 02 GT052-4C	TUE
WED	12 TPM L31 GT052-2	16	13	11 SM 52	15 L 02 GT052-4C	WED
THU	13 TPM L31 GT052-2	17 TPM L02 GT052-4C	14	12 SM 52	16	THU
FRI	14	18	15	13	17	FRI
SAT	15 TPM L31 GT052-2	19 TPM L02 GT052-4C	16	14 SM 52	18 L 31 GT052-2C	SAT
SUN	16 TPM L31 GT052-2	20 TPM L02 GT052-4C	17	15 SM 52	19 L 31 GT052-2C	SUN
MON	17	21	18	16	20 L 31 GT052-2C	MON
TUE	18 TPM L03 GT052-2C	22 TPM L02 GT052-4C	19	17	21 L 31 GT052-2C	TUE
WED	19 TPM L03 GT052-2C	23 TPM L02 GT052-4C	20	18 CD 74	22 L 31 GT052-2C	WED
THU	20 TPM L03 GT052-2C	24 TPM L02 GT052-4C	21	19 CD 74	23	THU
FRI	21	25	22	20	24	FRI
SAT	22 TPM L03 GT052-2C	26 TPM L02 GT052-4C	23 L 04 GT052-2C	21 CD 74	25 L 03 GT052-2C	SAT
SUN	23 TPM L03 GT052-2C	27 TPM L02 GT052-4C	24 L 04 GT052-2C	22 CD 74	26 L 03 GT052-2C	SUN
MON	24	28 TPM L02 GT052-4C	25 L 04 GT052-2C	23 CD 74	27 L 03 GT052-2C	MON
TUE	25 TPM L48 GT052-4		26 L 04 & L 23 GT052-2C	24 CD 74	28 L 03 GT052-2C L 25 GT0-1C	TUE
WED	26 TPM L48 GT052-4		27 L 04 & L 23 GT052-2C	25 CD 74	29 L 03 GT052-2C & L 25 GT0-1C	WED
THU	27 TPM L48 GT052-4		28 L 23 GT052-2C	26 CD 74	30 L 25 GT0-1C	THU
FRI	28		29	27		FRI
SAT	29 TPM L48 GT052-4		30 L 23 GT052-2C	28 CD 74		SAT
SUN	30 TPM L48 GT052-4			29 CD 74		SUN
MON	31 TPM L48 GT052-4			30 CD 74		MON
TUE				31 CD 74		TUE
DAY	JANUARY	FEBRUARY	APRIL	MAY	JUNE	DAY

Fig. 7: Yearly TPM calendar

According to the dates showed in the calendar of figure 7, initial cleaning and servicing of the machines are executed. While cleaning all the abnormalities of the machines, even the simplest abnormalities are recorded in abnormality tags. There are two kinds of tags: white and red. The white tags show operators themselves identify and fix the problems while the red tags display technical persons need to fix the problems as the problems are out of operators' skill. As soon as cleaning is done PM1 schedule: daily, weekly and monthly maintenance checklist is prepared. For operators convenience the checklists are converted in the local language. The details image of the parts is consolidated and maintenance books are made, which are given to the operators for reference. Figure 8, 9 and 10 show the daily, weekly & monthly maintenance checklist.

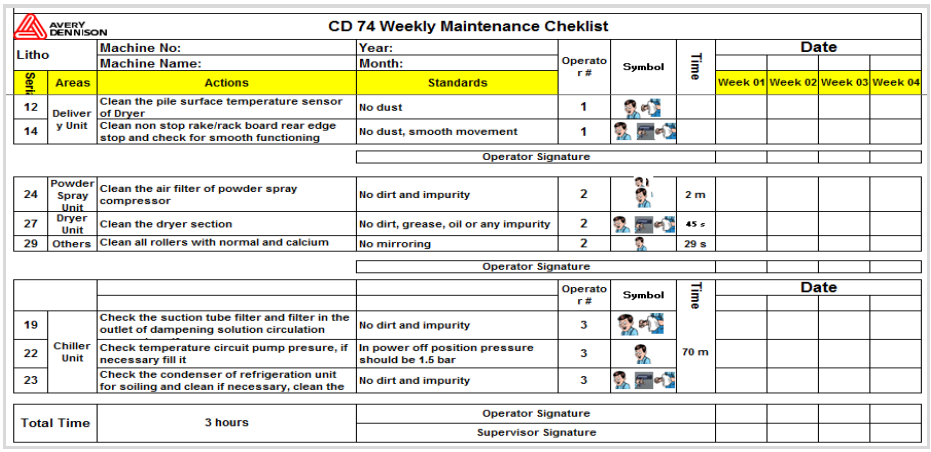
AVERY DENNISON — **CD 74 Daily Maintenance Cheklist**

Litho	Machine No:	Year:	Symbol	Time	Date							
	Machine Name:	Month:			1	2	3	4	5	6	7	8
Serial	Areas	5S Actions										
1	Workplace	Staff wear the personal protective equipment correctly?										
2		Chemicals has safety label and coverage, and keep in second category container?										
3		Any oil stain, scrap and miscellany on the floor?										

Serial	Areas	Actions	Standards	Symbol	Time	1	2	3	4	5	6	7	8
1	Dampening System	Test the dampening solution	Meet stanard (fill record)		3 m								
2	Entire Machine	Check lubrication level and no foreign matter	Oil level in between min/max level		5 m								
3	All sensors	Clean feeder, front guide, varnish slot and paper receiving platform sensors	No dust		1 m								
6	Cylinder Bearers	Clean the bearer on all units	No lint and ink stain		24 s								

Total Time	30 mins	Operator Signature							
		Supervisor Signature							

Fig. 8: Daily maintenance checklist

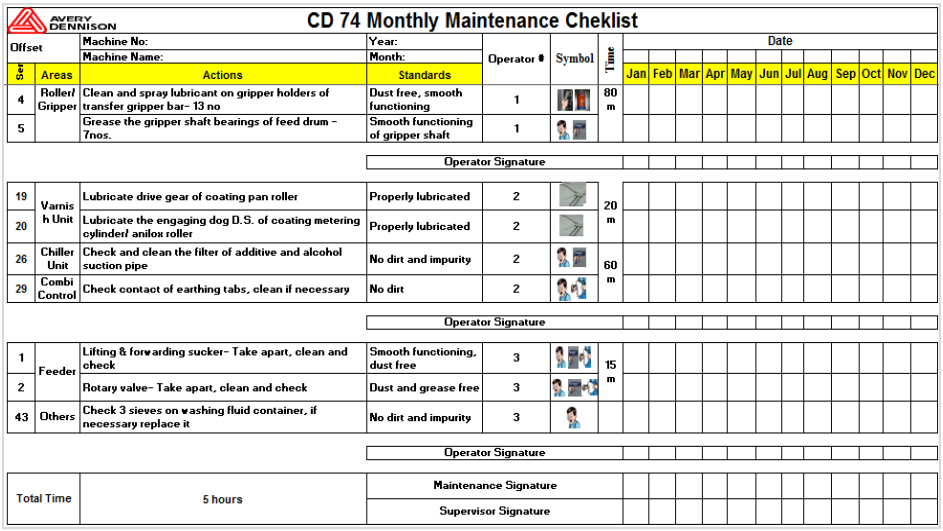


AVERY DENNISON

CD 74 Weekly Maintenance Cheklist

Litho		Machine No:	Year:	Operator #	Symbol	Time	Date			
		Machine Name:	Month:							
Serl	Areas	Actions	Standards				Week 01	Week 02	Week 03	Week 04
12	Delivery Unit	Clean the pile surface temperature sensor of Dryer	No dust	1						
14		Clean non stop rake/rack board rear edge stop and check for smooth functioning	No dust, smooth movement	1						
			Operator Signature							
24	Powder Spray Unit	Clean the air filter of powder spray compressor	No dirt and impurity	2		2 m				
27	Dryer Unit	Clean the dryer section	No dirt, grease, oil or any impurity	2		45 s				
29	Others	Clean all rollers with normal and calcium	No mirroring	2		29 s				
			Operator Signature							
				Operator #	Symbol	Time	Date			
19	Chiller Unit	Check the suction tube filter and filter in the outlet of dampening solution circulation	No dirt and impurity	3		70 m				
22		Check temperature circuit pump presure, if necessary fill it	In power off position pressure should be 1.5 bar	3						
23		Check the condenser of refrigeration unit for soiling and clean if necessary, clean the	No dirt and impurity	3						
Total Time	3 hours		Operator Signature							
			Supervisor Signature							

Fig. 9: Weekly Maintenance Checklist



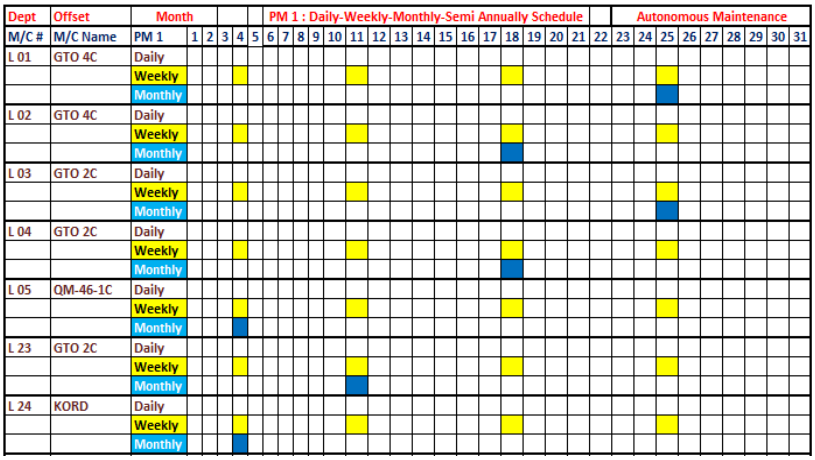
AVERY DENNISON

CD 74 Monthly Maintenance Cheklist

Offset		Machine No:	Year:	Operator #	Symbol	Time	Date															
		Machine Name:	Month:																			
Ser	Areas	Actions	Standards				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec				
4	Roller/ Gripper	Clean and spray lubricant on gripper holders of transfer gripper bar- 13 no	Dust free, smooth functioning	1		80 m																
5		Grease the gripper shaft bearings of feed drum - 7nos.	Smooth functioning of gripper shaft	1																		
			Operator Signature																			
19	Varnish Unit	Lubricate drive gear of coating pan roller	Properly lubricated	2		20 m																
20		Lubricate the engaging dog D.S. of coating metering cylinder/ anilox roller	Properly lubricated	2																		
26	Chiller Unit	Check and clean the filter of additive and alcohol suction pipe	No dirt and impurity	2		60 m																
29	Combi Control	Check contact of earthing tabs, clean if necessary	No dirt	2																		
			Operator Signature																			
1	Feeder	Lifting & forwarding sucker- Take apart, clean and check	Smooth functioning, dust free	3		15 m																
2		Rotary valve- Take apart, clean and check	Dust and grease free	3																		
43	Others	Check 3 sieves on washing fluid container, if necessary replace it	No dirt and impurity	3																		
			Operator Signature																			
Total Time	5 hours		Maintenance Signature																			
			Supervisor Signature																			

Fig. 10: Monthly Maintenance Checklist

A tracking system is also developed to keep the records of PM1 schedule, which displays in the department, so that department knows about each month's PM1 schedule. Figure 11 shows PM1 tracking system format.



Dept	Offset	Month	PM 1 : Daily-Weekly-Monthly-Semi Annually Schedule																			Autonomous Maintenance									
M/C #	M/C Name	PM 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
L 01	GTO 4C	Daily																															
		Weekly																															
		Monthly																															
L 02	GTO 4C	Daily																															
		Weekly																															
		Monthly																															
L 03	GTO 2C	Daily																															
		Weekly																															
		Monthly																															
L 04	GTO 2C	Daily																															
		Weekly																															
		Monthly																															
L 05	QM-46-1C	Daily																															
		Weekly																															
		Monthly																															
L 23	GTO 2C	Daily																															
		Weekly																															
		Monthly																															
L 24	KORD	Daily																															
		Weekly																															
		Monthly																															

Fig. 11: PM1 Tracking method

To ensure sound performance of PM1 by operators proper training module has been developed and a maintenance manual book with proper visualization of the machine parts and cleaning equipment is provided to every machine for operators' convenient. Figure 12 shows the maintenance manual for operators.

Fig. 12: Know Your Machine & Maintenance checklist visuals

Training calendar has been developed to provide necessary training to the operators before implementing maintenance checklist. The training consists both theoretical and practical session. All the operators in both shifts are considered for training. Figure 13 shows the training calendar for both shift operators.

Fig. 13: Operators Training record

PM1 is followed by PM2 i.e. technician level maintenance checklist, which focuses on critical equipment and their maintenance schedule. Table 1 shows one PM2 scheduling system.

Machine	Parts	Frequency	Up coming Dates of the current month Put tick mark beside dates if it is done			
GTO 4C GTO 2C	Operating side both bearing	after 15 days	2-Aug	16-Aug	30-Aug	
	Side Lay	after 10 days	2-Aug	11-Aug	20-Aug	29-Aug
	Delivery Jogger	after 30 days	2-Aug	31-Aug		
	Operating side both bearing	after 15 days	2-Aug	16-Aug	30-Aug	
	Side Lay	after 10 days	2-Aug	11-Aug	20-Aug	29-Aug
	Delivery Jogger	after 30 days	2-Aug	31-Aug		

Table 1: PM2 – Technician Maintenance Checklist

V. FINDINGS

After following above steps and action plans significant improvements have been found. The comparative analysis on Breakdown time, MTBF, MTTR and percentage of breakdown time of available time from year 2010 to 2011 has been determined. Figure 14 shows the comparison of breakdown time loss for year 2010 and 2011. It clearly shows almost 30% reductions in machine breakdown time.

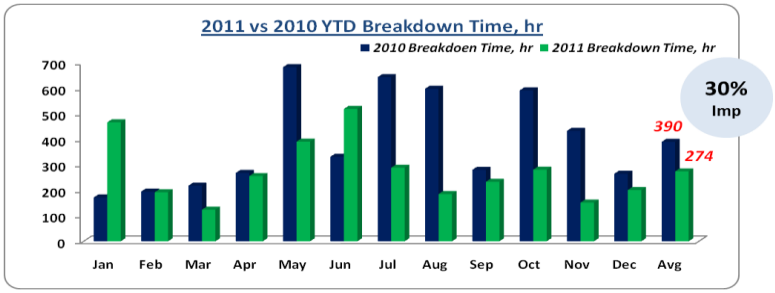


Fig. 14: Comparison of breakdown time loss for the year 2010 and 2011

Figure 15 shows the status of machine break down time in respect to available time. It indicates a positive improvement in the machine break down time status in respect to available time. In 2010 its value was 13% whereas in 2011 it goes down to 9%, which certainly shows positive outcome of TPM implementation in the department.

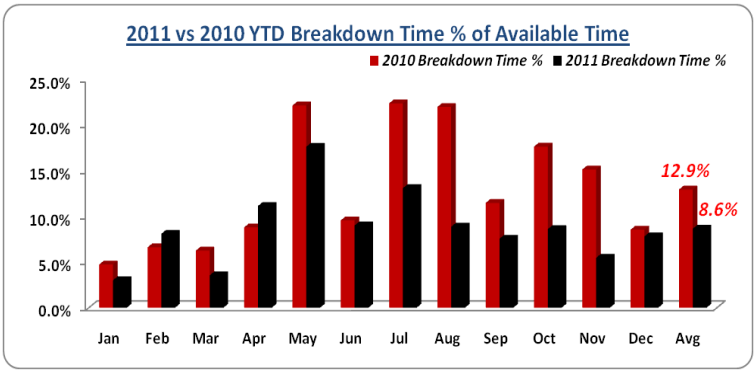


Fig. 15: Machine breakdown time in respect to Available time

Figure 16 indicates MTBF & MTTR; both the KPIs improve from previous year substantially.

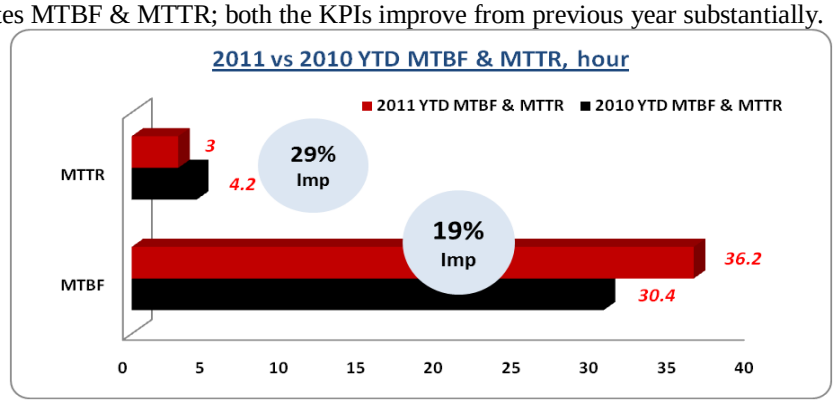


Fig. 16: Current & Previous year MTBF & MTTR

VI. CONCLUSIONS

By implementing TPM, this company achieves quick improvement in machine breakdown time, MTBF and MTTR. These are the direct benefits come out from the TPM. Apart from these KPIs, a transformation of work environment and employee mind set are also seen, in a word a change in culture is happening slowly. Initially operators consider TPM as a burden for them as during initial cleaning and servicing time, they have to work harder because cleaning is more laborious than operating the machine. After the positive impact on machines' condition motivates them to participate willingly in cleaning for several days that help to run their machine smoothly for a long period with better quality production in a shorter span of time. Now most important part for the company is to make sustainability in TPM. Frequent audit by top management and patronize the teamwork by appreciation and promoting TPM are few ways to make TPM more popular among the workforce. Displaying the success story in every corner of the factory surely makes TPM popular and acceptable to the workforce.

REFERENCES

[1]. Baluch N, Abdullah C S B and Mohtar S B 2010, "Maintenance Management Performance – An Overview towards Evaluating Malaysian Palm Oil Mill", *The Asian Journal of Technology Management*, vol. 3, issue 1, pp 1-5.

[2]. Jeong K Y and Phillips D T 2001, "Operational Efficiency and Effectiveness Measurement", *International Journal of Operations & Production Management*, vol. 21, issue 11, pp1404-1416.

[3]. Lazim H M, Ramayah T and Ahmad N 2008, "Total Productive Maintenance and Performance: A Malaysian SME Experience", *International Review of Business Research Papers*, vol. 4, issue 4, pp 237-250.

[4]. Lemma E 2008, 'Implementation of TPM (Total Productive Maintenance) in Ethiopian Textile Industries', Graduate Thesis, Addis Ababa University, Ethiopia.

[5]. McKone K E, Schroeder R G and Cua K O 2001, "The Impact of Total Productive Maintenance Practices on Manufacturing Performance, *Journal of Operations Management*, vol. 19, pp 39-58.
[6]. Pomorski T R 2004, "Total Productive Maintenance (TPM) Concepts and Literature Review", Brooks Automation, Inc. U.S.A.
[7]. Rodrigues, M. and Hatakeyama, K., 2006, "Analysis of the Fall of TPM in Companies",. *Journal of Materials Processing Technology*, vol. 179, issue 1-3, pp 276-279.
[8]. Suzuki T 1992, "TPM in Process Industry", Productivity Press, New York, U.S.A.
[9]. Taisir O T R 2010, "Total Productive Maintenance Review and Overall Equipment Effectiveness Measurement", *Jourdan Journal of Mechanical and Industrial Engineering*, vol. 4, issue 4, pp 517 – 522.
[10]. Thun J H 2006, "Maintaining Preventive Maintenance and Maintenance Prevention: Analyzing the Dynamic system", *System Dynamics Review*, vol. 22, issue 2, pp 163-179.
[11]. Venkatesh J 2007, "An Introduction to Total Productive Maintenance", *The Plant Maintenance Resource Center.*
[12]. Wllmott P and McCarthy D 2001, "TPM – A Route to World-Class Performance", Replika Press Pvt Ltd., Delhi, India.