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A Methodology for Implementing Total Productive Maintenance in Manufacturing Industries–A Case Study

Prof Pradeep Kumar[1], Dr. K. V. M. Varambally[2], Dr. Lewlyn L.R. Rodrigues[3]
[1]Manipal Institute of Technology, Manipal University, Associate Professor, Department of Mechanical Engineering, MANIPAL-576104, Karnataka state,INDIA.
[2]Manipal Institute of Management, Manipaluniversity, Professor, MANIPAL-576104
[3]Head of Department,Department of Humanities & Social Sciences,ProfessorDept. Of Mechanical & Manufacturing Engineering,Manipal Institute of Technology, Manipal university, MANIPAL -576104.

Abstract:-Total productive maintenance is practical technique aimed at maximizing the effectiveness of facility that we use within our organization .Total productive maintenance establishes a system of productive maintenance, covering the entire life cycle of equipment, covers all department, involves participation of all employees from top to bottom and promotes small group autonomous activities. During high growth era companies are making technical progress in automation and centralization of the plants, which needs large amount of manual work to maintain the automation systems. The strategy of maintaining the equipment of a plant is crucial for the effectiveness of manufacturing. And, as the competitive environment in the world continues to increase the pace, our project work intends to help companies to look for new strategies to save on costs, develop employees to face future challenges and bring about a new culture at work place.
To carry out successful implementation of our work, firstly, literature review was done thoroughly to understand the underlying concepts of TPM. Further, empirical study was conducted about the high end Printing press machines &Packaging machines based on real time data and analysis was done to obtain achievable results. Finally questionnaires were distributed to assess information on successful implementation of TPM in the industry. Results obtained through the empirical study reveals the varying trends in the Overall Equipment Effectiveness (OEE) and Total Productivity of the machines taken up for the study. The average values of OEE were found to lay between the ranges of 15% to 60% against world class standards of 85% and Total productivity(TP) varies between 0.09 to 0.34. The results highlight the major causes resulting in the downtime and decrease in the productivity. A comparative study between World Class industries where TPM has been implemented and industries which do not follow TPM identifies the various problems leading to decrease in the overall efficiency of the industry and provides valuable suggestions focussing on the benefits and methodology for implementing TPM in industries.

Keywords:-Total Productive maintenance (TPM), Overall Equipment efficiency (OEE), Partial Productivity (PP) and Total Productivity (TP).

I. INTRODUCTION

Total productive maintenance is practical technique aimed at maximizing the effectiveness of facility that we use within our organization .Total productive maintenance establishes a system of productive maintenance, covering the entire life cycle of equipment, covers all department, involves participation of all employees from top to bottom and promotes small group autonomous activities. During high growth era companies are making technical progress in automation and centralization of the plants, which needs large amount of manual work to maintain the automation systems. The strategy of maintaining the equipment of a plant is crucial for the effectiveness of manufacturing. And, as the competitive environment in the world continues to increase the pace, our project work intends to help companies to look for new strategies to save on costs, develop employees to face future challenges and bring about a new culture at work place..
Framework of total productive maintenance TPM seeks to maximize equipment effectiveness throughout the lifetime of the equipment. It strives to maintain the equipment in optimum condition in order to prevent unexpected breakdown, speed losses, and quality defects occurring from process activities. There are three ultimate goals of TPM: zero defects, zero accident, and zero breakdowns. Nakajima suggests that equipments should be operated at 100 percent capacity 100 percent of the time [6, 7]. Benchmarking on overall equipment effectiveness (OEE), productivity (P), quality (Q), cost (C), delivery (D), safety (S) and morale (M) etc. can facilitate an organization to realization of zero breakdown, zero defect, zero machine stoppage, zero accidents, zero pollution, primarily to achieve high reliability/flexibility of equipment and reduce costs through minimizing wastage of man hours, raw material, power, tools etc [7], [4], [13] &[11] which serve as the ultimate objective of TPM. TPM has been envisioned as a comprehensive manufacturing strategy to improve equipment productivity. The strategy elements include cross-functional teams to eliminate barriers to machine uptime, rigorous preventive maintenance programs, improved maintenance operations management efficiency, equipment maintenance training to the lowest level, and information systems to support the development of imported equipment with lower cost and higher reliability.

II. LITERATURE REVIEW

In this competitive age, firms are striving to improve customer's satisfaction and minimize production costs [8]. Traditionally, production costs are minimized by increasing the meantime between failures of the production equipment on the one hand and minimizing maintenance costs on the other [9]. Cutting maintenance costs alone will not help to minimize the production cost, but may lead to ineffectiveness of the production equipment. As such the basic underlying approach of TPM is to maximize production equipment effectiveness, which is typically measured by the OEE [10]. An OEE rating may be used to compare different sites within an individual business group, and may influence strategic investment and other important decisions [5]. If a company has an OEE of 85% or above, then it is considered to be a world-class company. The commonly used maintenance performance indicators [2] are measures of:

• Equipment performance, such as availability, reliability and OEE.
• Process performance, such as the ratio of achieved to planned work, as well as of schedule compliance.
• Cost performance, such as labor and material costs of maintenance

2.1 Overall Equipment Effectiviness (OEE)

TPM initiatives in production help in streamlining the manufacturing and other business functions, and garnering sustained profits. The strategic outcome of TPM implementations is the reduced occurrence of unexpected machine breakdowns that disrupt production and lead to losses, which can exceed millions of dollars annually. Overall equipment effectiveness (OEE) methodology incorporates metrics from all equipment manufacturing states guidelines into a measurement system that helps manufacturing and operations teams improve equipment performance and, therefore, reduce equipment cost of ownership (COO).

TPM initiatives are focused upon addressing major losses, and wastes associated with the production systems by affecting continuous and systematic evaluations of production system, thereby affecting significant improvements in production facilities. The evaluation of TPM efficiency can facilitate significantly enhanced organizational capabilities across a variety of dimensions. TPM employs OEE as a quantitative metric for measuring the performance of a productive system. OEE is the core metric for measuring the success of TPM implementation program. The overall goal of TPM is to raise the overall equipment effectiveness. OEE is calculated by obtaining the product of availability of the equipment, performance efficiency of the process and rate of quality products[3]. OEE provides a way to measure the effectiveness of manufacturing operations from a single piece of equipment to an entire manufacturing plant or several manufacturing plants in a group. In doing so OEE provides a complete picture of where productive manufacturing time and money is being lost and uncovers the true, hidden capability of the factory. It becomes the key decision support tool for continuous improvement programmes [12]. TPM focuses on optimizing planning and scheduling. Availability, performance and yield (i.e. acceptable quality-rate) are other factors that affect productivity [1]. Availability losses result from breakdowns and change-over, i.e. the situation in which the line is not running when it should be. Performance deteriorations arise from speed losses and small stops or idling or empty positions. In this case, the line may be running, but it is not producing the quantity it should.

2.3 OEE Calculation

Availability: Availability takes into account Down Time Loss, and is calculated as:Availability = Operating Time / Planned Production Time

Performance: Performance takes into account Speed Loss, and is calculated as: Performance = Ideal Cycle Time / (Operating Time / Total Pieces)

Ideal Cycle Time is the minimum cycle time that your process can be expected to achieve in optimal circumstances. It is sometimes called Design Cycle Time or Theoretical CycleTime. Since Run Rate is the reciprocal of Cycle Time, Performance can also be calculated as:Performance = (Total Pieces / Operating Time) / Ideal Run Rate

Quality:Quality takes into account Quality Loss, and is calculated as: Quality = Good Pieces / Total Pieces

OEE measurement is made up of three underlying elements, each one expressed as a percentage and accounting for a different kind of waste in the manufacturing process.

OEE = Availability x Performance x Quality.

$OEE = A \times PE \times Q$

2.2 Productivity

Productivity is a measure of the effective use of resources, usually expressed as the ratio of output to input. Productivity ratio can be calculated for a single operation, department, an organization or an entire country. For profit based organizations, productivity is an important factor determining how competitive a company is.

Activity can be identified with production and consumption. Production is a process of combining various immaterial and material inputs of production so as to produce tools for consumption. The methods of combining the inputs of production in the process of making output are called technology. Technology can be depicted mathematically by the production function which describes the function between input and output. The production function depicts production performance and productivity is the metric for it. Measures may be applied with, for example, different technology to improve productivity and to raise output.

2.4 Productivity Calculation

TPF: Total Productivity of a Firm, TPi: Total productivity of product I, PPij : Partial productivity of product i with respect to input factor j

j: {H, M, C, E, X}, H: Human input, M: Material and purchased parts input, C: Capital input, E: Energy input and X: other expenses input

I: 1, 2, N

N: Total number of products manufactured in the firm
Oi : Current period output of product i in value terms
OFi : Total current output of the firm in value terms
Ii: Current period input of product i in value terms
Iij: Current period input of type j for product i in value terms, IFi: Total current input of the firm in value terms
INR: Indian Rupee.

Total Productivity of Product i in terms of its Partial Productivities.The Total productivity of product as the ratio of the total output value of product i to the total input cost that is incurred in producing this output[14]. Thus,

$TP=Oi/Ii = Oi/\sum j\ Iij$

The partial productivity of product i with respect to any input factor j as the ratio of the total output value of product i to the input cost of factor j. Thus,

$PPij = Oi/Iij$

$Oi=TPi\ X\ \sum j\ Iij$ and $Oi=PPij\ X\ Iij$

$TPi\ X\ \sum j\ Iij = PPij\ X\ Iij$ and $Wij = Iij\ /\ \sum j\ Iij$

Wij represents the weight corresponding to the input factor. In other words, Wij represents the fraction of input factor j with respect to the sum of all the inputs used to produce product i, TPi = Wij X PPij for all j.

This metric has become widely accepted as a quantitative tool essential for measurement of productivity in manufacturing operations. The OEE and Productivity measures are central to the formulation and execution of a TPM improvement strategy. TPM has the standards of 90 per cent availability, 95 per cent performance efficiency and 99 per cent rate of quality. An overall 85 per cent benchmark OEE is considered as world-class performance [16]. OEE measure provides a strong impetus for introducing a pilot and subsequently companywide TPM program.

III. PROBLEM STATEMENT

Many organizations fail to achieve expected performance results when implementing TPM techniques. A possible reason for the failure to achieve performance results is that such organizations supports from top management, lack the knowledge, skill and appropriate planning practices for generating systemic and congruent approaches for implementing improvements.

The case study was carried out to check for the Overall Equipment Efficiency (OEE), Productivity and Total productive maintenance (TPM) factors of the different Machines in packaging Industries checked .Manipal Packaging Solutions (MPS) is one of the many important and lucrative organisations under the Manipal group. Located in the Shivally Industrial Area, MPS majorly focuses on making Cartons, covers, printed, sheets, Trays, etc. The preparation of the Cartons and sheets goes through a number of steps before a final product is made.

Major machines taken up for analytical study in Manipal Packaging & Solutions are: Offset printing machine, Punching machine, Elton lamination machine & HB Gluer Machine.

3.1Offset Printing machine :

is a six coloured UV printing machine which uses cardboard and sheets as input raw materials. These sheets are provided by ITC and JK industries.

3.2 Punching machine

This machine, which is of two types are used for several purposes. The first one is used to make the demarcations in the printed sheet so that individual cartons get separates and can be sent to the folding and gluing machine. This machine utilises a dye which is designed in order to cut the cartons in their required shape and size as they pass through this machine. The second machine is mostly used to give the embossing features to the cartons using the dyes provided by the customer company. Some pharmaceutical companies also demand for brail embossing.

3.3 Lamination Machine (Elton)

This machine is used to spread glue on the cardboard behind every printed sheet depending on the customer demands and requirements. The sheets are loaded manually on the bench at the rear side of the machine and are sucked into the machine using a push mechanism. The cardboard is fed into the machine from below as the sheet and the board come close the drum containing glue rolls in between them and the sheet and the board get glued together. Further using a pressing and heating mechanism they are glued properly and are sent as output.

3.4 Gluer Machine (HB):

The HB Gluer gives the final and finishing touch to the cartons. In this machine the cut pieces of the sheets are fed after full inspection. The sheet gets folded and glued inside the machine taking the right shape and fold it requires before going to the customer. This being the last stage the chances of the sheets getting spoiled is reduced to the minimum as it will spoil the efforts put up by the previous machines. Hence there are total of three inspections done and if any error is found it is rectified then and there.

The methodology employed to carry out the project uniquely identifies the existing operations in the facilities with the help of empirical study and questionnaires. The average values of Overall Equipment efficiency and Total Productivity is calculated and compared against world class standards. Further valuable suggestions are given so as to increase the efficiency of the existing system.

IV. RESEARCH METHODOLOGY

Manipal Packaging Solutions runs either in two shifts or in three shifts depending upon the work load. Usually the shifts are of 8 hours which includes a 30 minutes break for lunch or dinner. Our primary study involved tabulation of all factors leading to the calculation of the Overall Equipment Efficiency and Productivity of the system and its direct influence in determining the efficiency of the existing system

The key assumption is that the literature study, combined with the results of the empirical study, will provide insight into the impact of TPM on the performance of the selected section of the industries, thereby improving the Overall Equipment Efficiency.It is assumed that the management of industries in Manipal wishes to adopt the total productive maintenance philosophy as part of their future strategic objectives. The study comprises of: Literature study, Empirical study and Questionnaires.

4.1 Literature Study

The Literature Study was done in order to establish key concepts, which relate to TPM. The results of the literature survey were used as a guideline to determine the impact and effectiveness of TPM on manufacturing performance at the facilities.The existing theory relating to TPM was analyzed from secondary sources and related sources such as: Internet sites and web pages of different companies and organizations Text books and other published material directly and indirectly related to the problem area. Academic as well organizational journals and newsletters relevant to the problems, daily reports of companies under study [15].

Our study involves an extensive study of the existing systems in two of the major industries in Manipal, Manipal Packaging Solutions.

4.2 Empirical Study

Empirical Study implies measurements, and measurements are rules for assigning numbers to empirical properties. The empirical study consists of observations and calculations of highly visible measures of performance such as: Overall Equipment Efficiency (OEE), Total Productivity (TP), Downtime reasons and its frequency of occurrence, variation of OEE over a period of thirty shifts.

The Empirical study was conducted in the Manipal Packaging Solutions. Manipal Packaging Solutions runs either in two shifts or in three shifts depending upon the work load. Usually the shifts are of 8 hours which includes a 30 minutes break for lunch or dinner. Our primary study involved tabulation of all factors leading to the calculation of the Overall Equipment Efficiency and Productivity of the system and its direct influence in determining the efficiency of the existing system

V. ANALYSIS AND DISCUSSION

On the basis of collected data and we calculated OEE of the four machines for ten shifts (as shown in Table1,2,3,&4,)and graph for thirty shifts (Fig.1). We find out Availability, Performance efficiency, Quality rate by using this data we calculated average OEE and Total Productivity (TP) of the four machines (as shown in Fig .2 and 3) and compared. The Overall Equipment Effectiveness (OEE) of Machines of Manipal Packaging Solutions, the average values of OEE (Fig.3) and Total productivity (TP)(Table 5, 6,7&8). The average OEE of Printing machine is 16.67%, Punching machine is 45.5 %, Gluer Machine 25 % and Lamination Machine 58.77% and Total productivity (TP) of Printing machine is 0.1234, Punching machine is 0.0933, Gluer Machine 0.3416 and Lamination Machine 0.34711. By improving availability and performance, OEE can be increased, but world class OEE 85%, availability 90%, performance 95% and quality 99% [16].

Table 1. OEE of a Printing Machine for ten shifts

Production Parameters ↓ / **Shifts** →	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total time (Minutes)	510	510	720	510	720	510	690	690	690	750
Production Breaks (minutes)	30	30	30	30	30	30	0	0	0	30
Machine Downtime(minutes)	255	270	390	345	345	300	450	405	405	420
Production Rate (Unit/minute)	266	266	266	266	266	266	266	266	266	266
Total Cartoons Produced	27000	19300	26700	14600	34500	30900	19000	29500	21600	49100
Total Cartoons Rejected	1079	771	1067	584	1379	1235	759	1179	863	1962
Total Good Cartoons Produced	25921	18529	25633	14016	33121	29665	18241	28321	20737	47138
Total planned production time	480	480	690	480	690	480	690	690	690	720
Total operating Time	225	210	300	135	345	180	240	285	285	300
Availability (%)	46.9	43.8	43.5	28.1	50	37.5	34.8	41.3	41.3	41.7
Performance (%)	45.1	34.6	33.5	40.7	37.6	64.5	29.8	38.9	28.5	61.5
Quality (%)	96	96	96	96	96	96	96	96	96	96
OEE (%)	**20.3**	**14.5**	**14**	**11**	**18**	**23.2**	**9.9**	**15.4**	**11.3**	**24.6**

Table 2. OEE of a Punching Machine for ten shifts

Production Parameters / **Shifts**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total time (Minutes)	480	480	510	510	510	510	510	510	510	510
Production Breaks (minutes)	30	30	30	30	30	30	30	30	30	30
Machine Downtime(minutes)	150	300	390	300	345	210	225	105	75	90
Production Rate(Unit/minute)	70	70	70	70	70	70	70	70	70	70
Total Sheets Produced	20165	10143	5043	3610	11531	20576	14415	23300	26415	20458
Total Sheets Rejected	104	52	26	19	59	106	74	120	136	105
Total Good Sheets Produced	20061	10091	5017	3591	11472	20470	14341	23180	26279	20353
Total planned production time	450	450	480	480	480	480	480	480	480	480
Total operating Time	300	150	90	180	135	270	255	375	405	390
Availability (%)	66.7	33.3	18.8	37.5	28.1	56.3	53.1	78.1	84.4	81.3
Performance (%)	96	96.6	80	28.7	122	108.9	80.8	88.8	93.2	74.9
Quality (%)	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5
OEE (%)	**63.7**	**32**	**14.9**	**10.7**	**34.1**	**60.9**	**42.7**	**69.0**	**78.2**	**60.6**

Table 3. OEE of a Gluer Machine for ten shifts

Production Parameters / **Shifts**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total time (Minutes)	510	510	720	510	510	750	840	510	510	630
Production Breaks (minutes)	30	30	30	30	30	30	60	30	30	30
Machine Downtime(minutes)	30	330	360	210	180	120	510	240	420	210
ProductionRate(Unit/minute)	350	350	350	350	350	350	350	350	350	350
Total Sheets Produced	49650	70038	45250	69320	61290	134950	143500	57150	27000	24597
Total Sheets Rejected	545	769	497	761	673	1481	1575	627	296	270
Total Good Sheets Produced	49105	69269	44753	68559	60617	133469	141925	56523	26704	24327
Total planned production time	480	480	690	480	480	720	780	480	480	600
Total operating Time	450	150	330	270	300	600	270	240	60	390
Availability (%)	93.8	31.3	47.8	56.3	62.5	83.3	34.6	50.0	12.5	65.0
Performance (%)	31.5	133.4	39.2	73.4	58.4	64.3	151.9	68.0	128.6	18.0
Quality (%)	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9
OEE (%)	**29.2**	**41.2**	**18.5**	**40.8**	**36.1**	**53.0**	**52.0**	**33.6**	**15.9**	**11.6**

Table 4. OEE of a Lamination Machine for ten shifts

Production Parameters / **Shifts**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total time (Minutes)	510	510	510	510	510	510	660	480	690	1020
Production Breaks (minutes)	30	30	30	30	30	30	30	30	30	60
Machine Downtime(minutes)	90	120	90	270	60	240	120	30	90	120
Production Rate(Unit/minute)	26	26	26	26	26	26	26	26	26	26
Total Cartoons Produced	6912	7776	8640	4300	8672	5400	9600	9150	12000	15600
Total Cartoons Rejected	77	86	96	48	96	60	106	101	133	173
Total Good CartoonsProduced	6835	7690	8544	4252	8576	5340	9494	9049	11867	15427
Total planned production time	480	480	480	480	480	480	630	450	660	960
Total operating Time	390	360	390	210	420	240	510	420	570	840
Availability (%)	81.3	75.0	81.3	43.8	87.5	50.0	81.0	93.3	86.4	87.5
Performance (%)	68.2	83.1	85.2	78.8	79.4	86.5	72.4	83.8	81.0	71.4
Quality (%)	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9	98.9
OEE (%)	**54.8**	**61.6**	**68.5**	**34.1**	**68.7**	**42.8**	**58.0**	**77.3**	**69.2**	**61.8**

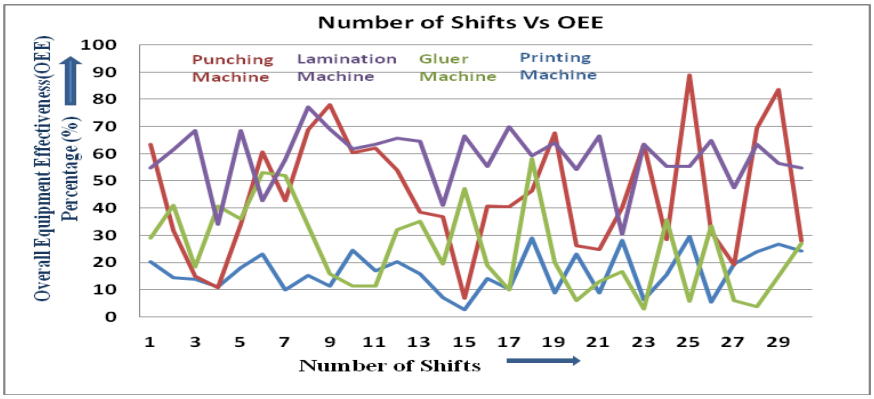

Figure 1. Graphical Representation of OEE of Machines in Percentage for 30 shifts

Table 5. Productivity of Printing Machine

RESOURCES	INR	PP	Wij
Output	10264920	Na	Na
Human	122000	84.14	0.0015
Materials	2680352	3.8	0.03316
Capital	75000000	0.13	0.9279
Energy	3024000	3.39	0.0374
Total Productivity(TP) = 0.123425			

Table 6. Productivity of Punching Machine

RESOURCES	INR	PP	Wij
Output	1645811	NA	NA
Human	9500	173.2	0.0001348
Material	272000	6.05	0.00386
Capital	7,00,00,000	0.0235	0.99362
Energy	167640	9.8175	0.00386
Total Productivity(TP) = 0.0933			

Table 7. Productivity of Gluer Machine

RESOURCES	INR I_{ij}	PP	W_{ij}
Output	1296428.2	NA	NA
Human	54000	24.007	0.00356
Material	54309	23.87	0.00358
Capital	1,50,00,000	0.086	0.99
Energy	30000	43.21	0.00198
Total Productivity(TP) = 0.3416			

Table 8. Productivity of Lamination Machine

RESOURCES	INR I_{ij}	PP	W_{ij}
Output	1167231	NA	NA
Human	9500	122.86	0.0069
Material	465678	2.5	0.33
Capital	9,00,000	1.29	0.65
Energy	960	1215.86	0.000697
Total Productivity(TP) = 0.33711			

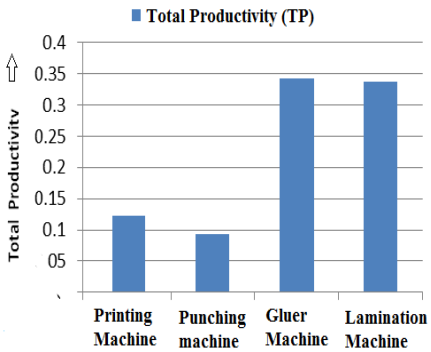

Fig.2 Total Productivity (TP) of Machines

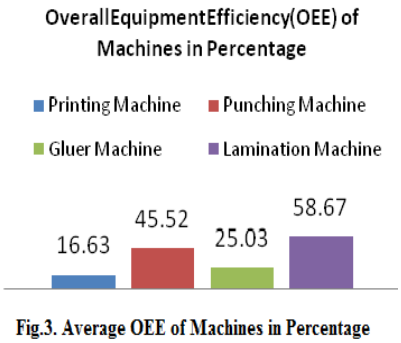

Fig.3. Average OEE of Machines in Percentage

VI. CONCLUSION

OEE is a Powerful Tool to identify previously hidden manufacturing losses and inefficiencies. Tracking OEE scores and using them to drive improvements in manufacturing processes is a vital step forward towards world-class lean manufacturing for organizations of all sizes and industries.OEE systems provide the rich functionality necessary to expose exactly what percentage of production time is truly productive and to dig deeper to reveal the causes of lost productivity. Even increasing the OEE score by 1% can lead to dramatic savings and turn-around lost production time into a positive contribution to profit. Fluctuation of OEE is seen, Value of OEE is observed to be maximum in Lamination Machine which is not frequently used. Printing Machine is the most frequently used machine owing to its high usage, downtime is more hence OEE is less. Calculating the OEE also give the company where they are and where is the weakness point and how to improve. As seen from the table the most common reason which leads to downtime in these machines are Cleaning which involves all kind of cleaning no job (except Printing machine)Make ready in which the machine is prepared for the new job coming up. The productivity of Machines are shown in the Fig.2, in that Total productivity (TP) of Punching and Printing machines are low , because the downtime is high, but TP of Gluer and Lamination machines are high, because downtime is low. In *Printing Machine*, the major downtime reasons (as shown in Fig.4) are all blanket cleaning, plate fix make ready and coat blanket fixing. These processes form a major part of the system and cannot be done away with, 16.61% value of OEE suggests that the equipment efficiency is quite low. The usage of the machine is very high and requires a lot of maintenance programs. Since this machine forms the initial part of the printing process the matching of the color as per the customer requirements takes a good amount of time thus leading to downtime.

In *Punching machine*, the major downtime (Fig.5) reason is due to the setting of the die. The die used for punching and embossing is provided by the customer to the printing company. Setting of the die is a time consuming process as precision is required in the output. Not all products require punching, due to which, for certain periods of time no job is done. This adds to the idle time of the machine. Make ready and cleaning processes also increases the downtime sufficiently. In *Gluer machine*, the main reason (Fig.6) for the downtime is setting of the final positioning of the carton. Since this process forms the final part of the output, inspection is carried out regularly to ensure precision in the output. In addition to it, block setting and cleaning leads to the increase in the downtime. In *Lamination machine*, OEE value suggests high efficiency. The major downtime (Fig.7) of the machine is gum cleaning as glue rolls have to be cleaned very often. Further, not many products are wasted during the process.

The various problems occurring in the press can be resolved or prevented from causing unwanted troubles leading to decrease in the overall efficiency of the system by the following methods suggested: The sequencing of jobs plays an important role in saving time. The sequencing of jobs depends not only on the assembly line of the industry but also on the customers. Sometimes, even if a particular sequencing decided upon by the experts saves a lot of time, the sequencing has to be dropped because of early customer demand. Thus the planned number of hours is not saved by the company which therefore leads to drop in the overall efficiency of the machine. Hence sequencing of jobs needs to be improved for better results.

Table 9. Downtime of Machines

Printing Machine

Downtime Reasons	Frequency of Occurrence
Machine cleaning	18
Color approval	14
All blanket cleaning	105
Ink tap roll cleaning	21
Plate fix and makeready	42
Coating blanket fixing	24
Whole ink dockcleaning	12
Roller washing	19
All unit blanket fixing	20
Cylinder cleaning	9
Roller change	7
Water change and maintenance	3

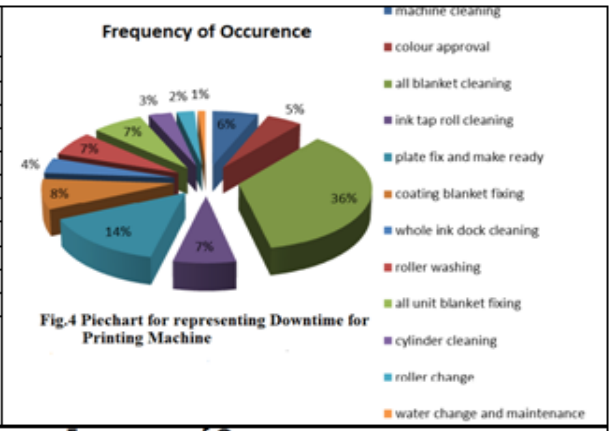

Fig.4 Piechart for representing Downtime for Printing Machine

Punching Machine

Downtime Reasons	Frequency of Occurrence
Sheet loading	7
Die setting	31
Cleaning	17
No job	18
Make ready	19
Cutting correction	2
Two play cutting	2
Oiling	1
Die rubbing	3

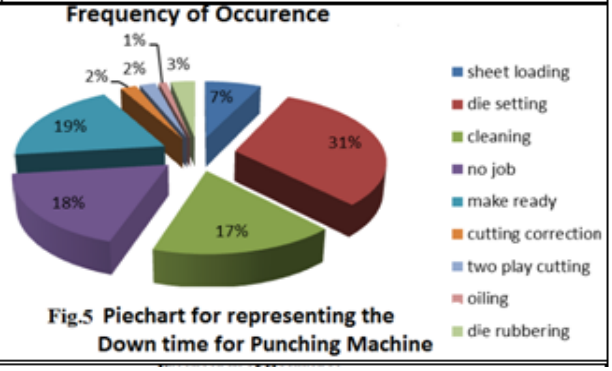

Fig.5 Piechart for representing the Down time for Punching Machine

Gluer Machine

Downtime Reasons	Frequency of Occurrence
Cleaning	4
Settings	42
No Job	14
Block Setting	5
Box Setting	2
Make Ready	1
File Loading	1
Gripper Problems	1

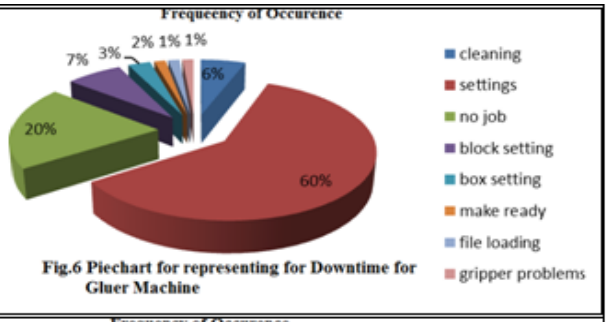

Fig.6 Piechart for representing for Downtime for Gluer Machine

Lamination Machine

Downtime Reasons	Frequency of Occurrence
Roll Cleaning	26
No Job	5
Box Cleaning	2
Gum Cleaning	90
Machine Cleaning	9
Job Change	7
Maintenance	1

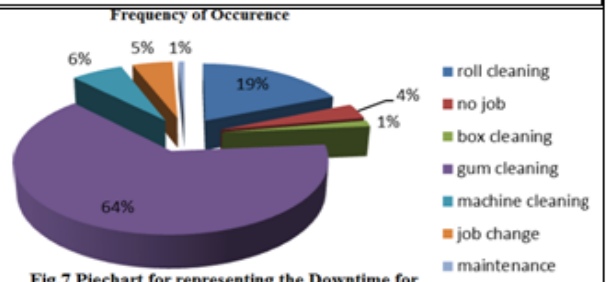

Fig.7 Piechart for representing the Downtime for Lamination Machine

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