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Total Productive Maintenance (TPM) Implementation in Automobile Industry: A Case Study of Toyota Kirloskar Motor, Bangalore

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ABSTRACT

The study focuses on effective implementation of Total Productive Maintenance (TPM) and its outcomes. To understand the historical background, stages of TPM and strategies adopted in the TPM process to improve the equipment efficiency towards achieving zero defects in the production process. Further, to analyze the reasons and to assess benefits rendering from the implementation of TPM in the Toyota Kirloskar Motor, Bangalore. Therefore, to analyze the TPM implementation in the Toyota Kirloskar Motor, Bangalore structured questionnaire are constructed using a Likert scale. Through a cross-sectional survey design, 100 sample were drawn to carry out the analysis. Further, a normality test applied for the data to decide whether the data are normally distributed or not. For the study these are the following statistical tools are applied Chi-Square test, Mean, Standard Deviation, One-Way ANOVA and One-Sample t-test. The test revealed that majority of the respondents have strongly agreed, TPM implementation leads to attain zero defects in the production process which in turn will help the organization to reduce the wastage, breakdowns, reworks and to manage the resources efficiently towards attaining organizational goal.

Keywords: Benefits, Efficiency, Equipment, Reasons, Strategies, Stages.

INTRODUCTION:

In today's scenario, world-class manufacturing sectors are facing huge losses/wastage in the shop floor, due to operators, maintenance personnel, process, tooling problems and non-availability of components in time, idle machines, idle manpower, break down, rejected parts etc. are all examples of waste and quality related waste impact on the time, material and goodwill of the company. The other invisible wastes like operating the machines below the rated speed, start-up losses, breakdown of the machines and bottlenecks in the process are examples. Henceforth, to overcome the above wastes, a revolutionary concept of TPM has been adopted in many industries across the world. To address the above-said problems through achieving zero oriented concepts such as zero tolerance for waste, zero defects, zero breakdowns and zero accidents in the automobile industry.
Further, TPM maintenance program involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to increase production while, at the same time, increasing employee morale and job satisfaction. In order to bring maintenance into focus as a necessary and vitally important part of the business. Downtime for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. The goal is to reduce emergency and unscheduled maintenance to zero level. Therefore, TPM focus on streamlining the manufacturing and other business functions towards strengthening the manufacturing business performance for achieving a world-class high performance in industries. (Shah and Ward, 2013)

Historical Background of TPM:

TPM is an innovative Japanese concept. The origin of TPM can be traced back to 1951 when preventive maintenance was introduced in Japan. However, the concept of preventive maintenance is taken from the USA.

Nippondenso is the first company to introduce plant wide preventive maintenance in 1960. Preventive maintenance is the concept wherein, operators produce goods using machines and the maintenance group is dedicated with work of maintaining those machines, however, with the automation of Nippondenso, maintenance became a problem, as more maintenance personnel were required. So, the management decided that the operators would carry out the routine maintenance of equipment. (This is Autonomous maintenance, one of the features of TPM).

Therefore, the maintenance group takes up only essential maintenance works. Thus, Nippondenso added autonomous maintenance along with existing preventive maintenance to be taken care by production operators during the process. Further, the maintenance group starts to focus on equipment modification for improving reliability. The modification incorporated in new equipment leads to maintenance prevention. Thus, preventive maintenance along with Maintenance prevention and Maintainability Improvement gives birth to Productive Maintenance. The aim of productive maintenance is to maximize plant and equipment effectiveness in the industry. By then Nippondenso develops quality circles, involving the employees' participation in implementing productive maintenance. Based on these developments Nippondenso gets awarded for the distinguished plant prize for developing and implementing TPM, by the Japanese Institute of Plant Engineers (JIPE). Thus, Nippondenso of the Toyota group becomes the first company to obtain the TPM certification. Currently, the goal of productive maintenance is to maximize plant and equipment effectiveness to achieve optimum life cycle cost of production equipment in Automobile Industries.

Stages in TPM Implementation:

The main objective of TPM is to maximize the equipment utilization effectively with zero defects. Therefore, the following stages should apply for the implementation of TPM in the Automobile Industry:

SI.No	TPM Stages		Explanations
1.	Stage A	Preparation Stage	During the preparation stage, top management plays an important role in achieving the success in TPM implementation. Therefore, in the management hierarchy level proper understanding, communication, commitment and active involvement is very much in need to take proper decisions. The same decision will be communicated to another level of management. Later on, the decision made on TPM implementation is recorded in in-house magazines, display on the notice board as well as to suppliers and customers.
2.	Stage B	Introduction Stage	A small get-together is arranged by the industry includes suppliers and customers participation. To create awareness on the supply of quality based materials to sustain in the market. People from related companies and affiliated companies who can be our customers, sisters concerns etc. are also invited. Some may learn from us and some can help us and customers will get the message from us that we care about the quality output, cost, and keeping to delivery schedules.
3.	Stage C	Implementation Stage	In this stage, eight the pillars of TPM activity are carried out to attain zero defects in the production process. The eight pillars involve establishing the system for production efficiency, for the initial control system for new products and equipment, for improving the efficiency of administration, rest are for control of safety, sanitation as working environment and so on.
4.	Stage D	Institutionalizing Stage	In this stage, TPM implementation is going to reach the maturity stage and the time for receiving the PM awards.

Sources: Venkatesh Rai. B.J, International Journal of Technology and Engineering.

Henceforth, the present study focuses on TPM implementation in Toyota Kirloskar Motors. To have a better insight into how the Toyota Kirloskar Motors has adopted the TPM process through lean manufacturing as a management philosophy derived from the Toyota Production System (TPS). Further, in the study, one common factor on Lean manufacturing is identified that the expenditure of resources for any process doesn't add value to

the final customer and consider as a non-value-added process in the production process. Hence lean production encompasses a wide variety of practices or tools including just in time, total quality management, total productive management, kaizen etc. in an integrated system. Lean production is synonymous with the Toyota Production System (TPS), the aim of lean production is to reduce the seven cardinal wastes like defects, overproduction, transportation, waiting, inventory, motion, processing into the automobile parts in Toyota Kirloskar Motors.

REVIEW OF LITERATURE:

Many research works have been carried out on TPM implementation in aboard as well as India out of these few selected studies have been considered for the study, as follows:

P. Kumar. et al (2012), have analyzed in the study to have an insight more on productivity and competitiveness of the organization through TPM implementation for printing press industry. The results highlight 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 are 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. and the major causes resulting in the downtime and decrease in the productivity. Finally, the comparative study between world-class industries on TPM implementation has come across one important factor. Those companies implemented TPM in the production process showing overall efficiency in the production process than that of industries who are yet to implement TPM.

Paropate. et al (2013), has potratyed the improvement in the availability, performance efficiency and the quality rate, results in improvement of the overall equipment effectiveness of the equipment. At the Spinning plant, implementation of total Productive maintenance is suggested for the carding machine. Finally, the study reveals with the results on present condition values for availability, quality rates, performance efficiency, and overall equipment effectiveness are 89.6832%, & 68.9866% respectively and the values after TPM implementation are 91.96%, 79.758%, 97.177% & 71.465% respectively. These values show the improvement and successful implementation of TPM on a carding machine where in A, P, Q factors are minimum in the industry.

Jain, Bhatti, & Singh, (2014), have identified the critical key success factors of TPM implementation practices is based on the achieving organizational effectiveness and productivity. Unsuccessfully implement TPM philosophy leads to various barriers like lack of management commitment and understanding, lack of adequate training, failure to allow adequate time for TPM implementation. The study confirms all 5S principles affect TPM directly or indirectly to achieve continuous improvement.

Mwanza & Mbohwa, (2015), has analyzed the TPM model in a chemical manufacturing company in Zambia to evaluate the effective implementation of TPM for higher competitiveness in the dynamic business environment. Finally, the result indicates a long breakdown machine, a huge inventory of spare part, and the high cost of maintenance become the first priority of the maintenance team to achieve customer satisfaction. Hence the company should standardize the procedure, identify the critical spare part, reduce the time to purchase critical spare part, and increase lifetime the method of Quality Function Deployment (QFD) to translate the needs and wants of production management.

S. Kumar, Raj, & Shubham, (2017), has assesed TPM implementation is based on machine performance wise breakdown analysis. To improve the performance of maintenance activity, product and process quality, employee morale and job satisfaction. Finally, the study is carried out based on section wise breakdown analysis, breakdown types wise and equipment wise breakdown analysis to avoid delay in the manufacturing process in the industry.

OBJECTIVES OF THE STUDY:

The following are the major objectives of the study:

1. To examine the demographic profile of the employees in Toyota Kirloskar Motor, Bangalore.
2. To analyze the reasons for the organization implementation of TPM in Toyota Kirloskar Motor, Bangalore.
3. To identify the strategies that have been used for successful implementation of TPM in Toyota Kirloskar Motor, Bangalore.
4. To evaluate the benefits of TPM Implementation to the Toyota Kirloskar Motor, Bangalore.

RESEARCH METHODOLOGY:

- **Research design:** The research design is descriptive research.

- **Sources of data:**
- **Primary data:** The primary data is collected through a structured questionnaire by using survey method.
- **Research instrument:** Structured Questionnaire
- **Survey design:** Cross-sectional survey design used for collection of data.
- **Secondary data:** Secondary data are collected from books, websites, various research publications, journals, periodicals and company records.
- **Focus group:** Plant/Factory Managers, Operations Managers and Maintenance Managers of Toyota Kirloskar Motor, Bangalore.
- **Sampling procedure:**
- **Sampling method:** Non - probability sampling method
- **Sampling technique:** Convenience sampling technique
- **Sample size:** 100 Respondents
- **Tools for analysis:** To analyzing the data normality test is applied and found means and the sample distribution is not shaped like a normal curve ($p < 0.05$) and the sample size is small N=28. Henceforth, to test the normality of data Shapiro – Wilks W test (P=0.527). As the data is normally distributed for the study parametric test like Mean, Standard Deviation, One Way ANOVA, One-Sample t-test is applied.

HYPOTHESIS:

The study is based on the following hypothesis:

H1: There is a variation between demographic profiles of the employees.
H2: There is a significant difference between reasons for the organization implementation of TPM.
H3: There is a significant relationship between the strategies have been used for successful implementation of TPM.
H4: There is a significant relationship between the benefits of TPM Implementation to the Toyota organization.

ANALYSIS AND INTERPRETATION:

Demographic Profile of the Respondents:

Table No.1 represents the demographic profile of employees of Toyota Kirloskar Motor, Bangalore city. The overall respondents are 100 employees out of that 85 respondents belong to a male category and 15 respondents are belongs to a female category. This reveals male employees are actively involved in the survey than that of female employees. In the context of age pattern, the majority of the respondents numbering, 47 employees belong to between 30 to 39 years and 24 employees belong the between 40 to 49 years respectively. Further, in the educational background group, the majority of the respondents numbering 65 employees are of professionals and 20 employees are of postgraduates respectively. In the context of the annual income level of the employees, Majority numbering, 38 and 27 respondents belongs to the income level of between 2.5 lakh to 5 lakh and below 2.5 lakh respectively. In the context of occupation, majority numbering, 35 and 33 employees belong to operations managers and maintenance managers respectively. Further, the duration of TPM implementation numbering, 48 and 28 employees belongs to 1 year to 2 years and 6 months to 1 year respectively.

Table No 1: showing the demographic profile of the Employees of Toyota (Descriptive statistics)

SI. No	Factors	Classification	F	%	Mean	S. D	SEM	Chi-Square
1.	Gender	Male	**85**	**85**	1.20	.402	.040	**$\chi2$=2.31 P=0.000 (Ho Rejected)**
		Female	15	15				
2.	Age Pattern	Between 21-29Years	19	19	3.35	783	.078	**$\chi2$=1.999 P=0.001 (Ho Rejected)**
		Between 30-39 Years	**47**	**47**				
		Between 40-49years	24	24				
		Above 50 Years	10	10				
3.	Educational Background	Graduate	15	15	1.34	.607	.061	**$\chi2$=2.701 P=0.067 (Ho Accepted)**
		Post Graduate	20	20				
		Professionals	**65**	**65**				
4.	Occupation	Plant/Factory Managers	32	30	1.03	.171	.017	**$\chi2$=4.11**

SI. No	Factors	Classification	F	%	Mean	S. D	SEM	Chi-Square
		Operations Managers	**35**	**35**				**P=0.078**
		Maintenance Managers	33	35				**(Ho Accepted)**
5.	Annual Income	Below Rs.2,50,000	27	27	2.20	.995	.099	**$\chi 2$=1.999**
		Rs 2,50,000 to 5,00,000	**38**	**38**				**P=0.003**
		Rs 5,00,000 to 7,50,000	25	25				**(Ho Rejected)**
6.	Duration of TPM Implementation	Less than 6 Months	24	24	3.41	.570	.057	**$\chi 2$=4.11**
		6 Months to 1 year	28	28				**P=0.081**
		1 year to 2 year	**48**	**48**				**(Ho Accepted)**

Sources: Field Survey.
Note: Level of Significance = 0.05

To calculate, chi-square test for gender, age pattern and an annual income of the respondents is applied. The table value of $\chi 2$ for degrees of freedom at 5% level of significance, the calculated P-value is 0.000, 0.001, and 0.003 is less than the Alpha Value of 0.05 are found to be significant. Therefore, the results indicate that the stated null hypothesis to be rejected and the alternative hypothesis to be accepted. In the other part of the calculation, chi-square test for the data of educational background, occupation and duration of TPM implementation of respondents, the table value of $\chi 2$ for degrees of freedom at 5% level of significance, the calculated P-value is 0.067 0.078, and 0.081 is more than the Alpha Value of 0.05. Hence find to be Not significant. Therefore, the results indicate stated null hypothesis to be accepted and the alternative hypothesis to be rejected.

Reasons for the organization implementation of TPM:
Table No.2 represents the reasons for the organization implementation of TPM. Majority of the respondents has strongly agreed and positive opinions about all reasons for implementation of TPM in the Toyota Kirloskar Motors Bangalore. According to the one-way ANOVA test is a category of parametric test. Describe testing the significant difference between reasons for TPM implementation in the organization. The highest mean and standard deviation are found in 'to reduce administrative costs and to reduce the man power' recorded the value of 28.43 and 5.94 respectively. As against the lowest mean and standard deviation are found in 'For involvement and productivity of people in support functions and providing awareness about office TPM to all support departments' recorded the value of 16.00 and 3.22 respectively.

Table No 2: showing reasons for the organization implementation of TPM
Descriptive and exploratory statistics (One-way ANOVA F –test)

Reasons	N	Mean	S. D	F- Test	(Sig 2-tailed) P-value	Hypothesis (H0)
Providing awareness about office TPM to all support departments	100	21.40	3.22	2.18	0.072	**H0** Accepted
Involvement and productivity of people in support functions	100	16.00	5.12	3.68	0.083	**H0** Accepted
To reduce administrative costs	100	28.34	4.34	2.43	0.000	**H0** Rejected
To reduce inventory carrying cost	100	25.60	5.89	1.38	0.091	**H0** Accepted
To reduce number of files	100	19.14	3.57	3.44	0.001	**H0** Rejected
To reduce the man power	100	23.89	5.94	2.14	0.003	**H0** Rejected

Sources: Field Survey.
Note: Level of Significance = 0.05

Strategies have been used for successful implementation of TPM:
Table No.3 highlights the strategies have been used for successful implementation of TPM. Majority of the respondents has strongly agreed and partially positive opinions about all strategies used for successful implementation of TPM in the Toyota Kirloskar Motor Bangalore. According to the one sample t-test, is a category of parametric test. Describe testing the significant difference between strategies used for successful implementation of TPM. The highest mean and standard deviation are found to be the 'training of production

staff on basic maintenance activities and problem-solving tools and techniques' are recorded the value of 29.75 and 3.231 respectively. As against the lowest mean and standard deviation are found to be 'resources availability esp. financial support and top management commitment and training of production staff on basic maintenance activities' are recorded the value of 10.11 and 0.434 respectively. Further, the test reveals significant difference between top management commitment, effective communication, training of production staff on basic maintenance activities, operator ownership, problem-solving tools and techniques and availability of reliable data are found to be significant and in another case there is no significant difference between age of equipment, union Staff (Shop floor) and support Resources availability esp. financial support is found to be non-significant.

Table No 3: showing the strategies for successful implementation of TPM
Descriptive and exploratory statistics (One sample t-test)

Strategies for TPM Implementation	N	Mean	Std Dev	SA	A	N	DA	SDA	Cronbach's Alpha if Item Deleted	T-Value	P-value
Top Management commitment	100	27.95	1.613	40	15	0	25	20	.927	4.873	.001
Effective communication	100	16.39	1.410	20	25	10	15	30	.923	3.942	.000
Training of production staff on basic maintenance activities	100	29.75	0.434	60	30	0	05	05	.928	7.012	.000
Age of equipment	100	14.73	0.445	75	10	0	05	10	.928	4.970	.079
Operator ownership	100	15.81	2.123	30	15	05	28	22	.927	6.565	.002
Problem solving tools and techniques	100	26.82	3.231	90	10	0	0	0	.929	8.725	.000
Union Staff (Shop floor) Support	100	11.72	1.784	10	15	10	30	35	.929	6.725	.052
Resources availability esp. Financial support	100	10.11	1.112	50	20	0	20	10	.918	5.309	.063
Availability of reliable data	100	13.95	1.892	35	15	10	25	15	.929	4.970	.004

Sources: Field Survey.
Note: Level of Significance = 0.05

Benefits of TPM Implementation in the Toyota Kirloskar Motor Bangalore:
Table No.4 the benefits of TPM implementation to the Toyota Kirloskar Motor Bangalore reveals the majority of the respondents are agreed and partially positive opinions about all benefits of TPM implementation in the Toyota Kirloskar Motor Bangalore. According to the one sample t-test is a category of parametric test. Describe testing the significant difference between the benefits of TPM implementation in the Toyota Kirloskar Motor Bangalore. The highest mean and standard deviation are found in 'Reduces wastages and production of poor quality and reduces maintenance cost' are recorded the value of 28.21 and 4.21 respectively. As against the lowest mean and standard deviation are found to be 'Cost reduction by eliminating losses in PM and operators acquires a good understanding of equipment performance' are recorded the value of 15.52 and 1.10 respectively. Further, the test reveals a significant difference between 'optimizes equipment reliability, reduces wastages and production of poor quality, improves basic maintenance skills of operators, ensures efficient management of plant assets and reduction in the breakdown of equipment' are found to be significant. In the other case, there is no significant difference between 'reduces maintenance cost, improves/increases the rate of production, cost reduction by eliminating losses in PM, operators acquire a good understanding of equipment performance' are found to be non-significant.

Table No 4: showing the benefits of TPM implementation to the organization
Descriptive and exploratory statistics (One sample t-test)

Benefits of TPM Implementation	N	Mean	Std Dev	SA	A	N	DA	SDA	T-Value	P-value
Optimizes equipment reliability	100	23.15	2.98	40	10	10	25	15	2.781	.000
Reduces wastages and production of poor quality	100	28.21	3.47	90	10	0	0	0	1.052	.004
Reduces maintenance cost	100	22.45	4.21	60	30	0	5	5	2.473	.051
Improves/increases the rate of production	100	24.71	3.71	30	30	10	15	15	3.571	.062
Improves basic maintenance skills of operators	100	25.62	2.52	20	25	08	27	20	3.413	.003
Ensures efficient management of plant assets	100	27.42	3.81	25	25	10	20	20	4.073	.001
Cost reduction by eliminating losses in PM	100	15.52	4.05	80	20	0	0	0	3.752	.072
Operators acquires good understanding of equipment performance	100	26.16	1.10	55	20	0	10	10	2.862	.063
Reduction in breakdown of equipment	100	27.95	3.87	37	23	0	25	15	1.894	.005

Sources: Field Survey.
Note: Level of Significance = 0.05

FINDINGS:

The following are the major findings of the study:

- The overall respondents were numbering, 100 employees out of that 85 respondents belong to a male category and 15 respondents are belongs female category
- In the context of age pattern, the majority of the respondents numbering, 47 and 24 employees belong to the age group of above 30 to 39 years and between 40 to 49 years respectively.
- Further, in the educational background, the respondents' majority numbering, 65 and 20 respondents are postgraduates and professionals respectively.
- In the context of occupation, majority numbering, 35 and 33 respondents belong to operation managers and maintenance manager respectively.
- The highest mean and standard deviation are found to reduce administrative costs and to reduce inventory carrying a cost are recorded the value of 28.43 and 5.89 respectively.
- The highest mean and standard deviation were found to the training of production staff on basic maintenance activities and problem-solving tools and techniques are recorded the value of 29.75 and 3.231 respectively.
- The highest mean and standard deviation were found to Reduces wastages and production of poor quality and reduce maintenance cost has recorded the value of 28.21 and 4.21 respectively.

SUGGESTIONS:

The following are the suggestion for the study:

- Right now, only large and middle scale organizations implementing TPM. But TPM implementation should be made applicable and affordable to small-scale industry for that few changes can be made in TPM practices.
- Industries should focus more on safety, health, and environment in addition to the reduction in production cost applying TPM.
- To make sure an organization achieves excellence, the objectives and plan should focus on reaching the vision and mission. The organization should have a clear plan and objectives for TPM implementations.
- Industries Association should take initiative to create awareness in industries by organizing training programme, TPM awareness campaign, and Membership of TPM club of India etc.

- Evaluation of TPM should not only base on monetary benefits. Evaluation of criteria should focus on competitiveness, morale, reliability of the machine to the successful implementation of productive maintained in the organization.

CONCLUSION:

The study focuses only on total productive maintenance (TPM) implementation in Toyota Kirloskar Motor Bangalore. From the analysis majority of the respondents has strongly agreed and partially positive opinions about the strategies and benefits of TPM implementation in the Toyota Kirloskar Motor Bangalore. The study reveals a significant difference between top management commitment, effective communication, training of production staff on basic maintenance activities, operator ownership, problem-solving tools and techniques, availability of reliable data are found to be significant. In the context of benefits TPM helps in reducing wastes, maintenance cost improves/increases the rate of production, cost reduction by eliminating losses in PM, operators acquire a good understanding of equipment performance are found to be non-significant. Finally, the study reveals training of production staff on basic maintenance activities, the age of the machine and effective production maintenance are the proper strategies for implementing TPM successfully in Toyota Kirloskar Motor, Bangalore.

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