TPM: Factors and Barrier Analysis Towards Maintenance efficiency in Manufacturing Industry

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***Abstract*— Previous studies indicated that the autonomous maintenance barrier factors are affected the maintenance efficiency. However, most of these studies were conducted in the service industry but not in the manufacturing industry. Therefore, the purpose of this research is to identify the most critical barrier factors towards maintenance efficiency and also to identify the relationship between autonomous maintenance barrier factors and maintenance efficiency in manufacturing industries. Five research hypotheses were examined while considering the autonomous maintenance barrier factors which including lack of top management commitment, lack of training, lack of maintenance knowledge, resistance by employees, and lack of tools and instrument. The findings of this study revealed that lack of tools and instrument is the most critical barrier factor. This quantitative case study is crucial to the manufacturing industry in Malaysia because it provides a broad insight into the correlation between the autonomous maintenance barrier factor and maintenance efficiency.**

***Keywords*—** *TPM, maintenance efficiency, manufacturing, autonomous maintenance*

1. Introduction

Total Productive Maintenance (TPM) is a highly structured approach, which uses several tools and techniques to achieve highly effective plant and machinery. With competition in the manufacturing industry recently, TPM has proven that a maintenance improvement philosophy prevents organizational failure [1].

The TPM is a source of emphasis on moving the maintenance paradigm by emphasizing the amount of employee involvement in maintenance activities. Autonomous maintenance (AM) is usually performed by operators, maintenance technicians, and others involved in maintenance activities. Autonomous maintenance enables machine operators to perform simple maintenance tasks such as lubrication, bolt tightening, cleaning and inspection to prevent damage and respond immediately if certain failures have been detected [2].

2. Literature Review

According to [2], TPM is an innovative system for equipment maintenance that optimizes efficiency, eliminates defects and promotes maintenance of autonomous operators through daily activities. To achieve quality in all stages of manufacturing operations, implementation of Total Productive Maintenance (TPM) is required as described by [3]. TPM strives to integrate best practices for continuous batch production process to improve equipment efficiency and materials productivity. TPM aims to maximize equipment effectiveness throughout the life of the equipment and strive to keep the equipment in optimal condition to prevent damage, loss of speed and unexpected defects from process activities [4].

3. Methodology

To conduct this quantitative methods, the survey is required focus to employees involved in maintenance activities in production line. According

[5] to design a survey, the researcher need to consider about the sample which is represented the respondents that will produce the most valuable data through the questionnaire survey. At least ten workers were selected from various manufacturing industries and they are consist of technicians, supervisors, maintenance guys and operators that involved in maintenance activities. The criteria of the respondents are:

i. People from manufacturing industries
ii. Have been working in that company for two years and above.
iii. Expertise in machinery.
iv. Have a knowledge about TPM

Data has been analysed using Statistical Package for Social Science (SPSS) 22.0 version software. The data analysed using descriptive statistic. While the descriptive data allow the data to be comprise into a graphical form such as tables and charts [6].

4. Data Analysis And Results

This section discussed analysis and results of the research.

4.1 Reliability Test

Reliability analysis was used to test the consistency of data collected. Cronbach's Alpha is a tool used for measuring the internal reliability. The value range of reliability is from 0.0 to 1.0. The closer the value of Cronbach's Alpha to 1.00 indicates that it is more desirable. For Cronbach's Alpha with a value higher or equal to 0.7, it is acceptable. However, if Cronbach's Alpha with a value lower than 0.7, improvements is required to do in order to get Cronbach's Alpha with 0.7 or above. This can be done by removing the problematic questions from that collection of questions. For the actual study, the number of respondents is 45 people. Results of the analysis is shown in Table 4.1.

Table 4.1: Reliability test for Actual Study

Section	Variable	Alpha Cronbach	No. of question	No. of respondents	Result
Section B	Lack of top management commitment	0.766	5	45	Acceptable
	Lack of training	0.914	5	45	Excellent
	Lack of maintenance knowledge	0.917	5	45	Excellent
	Resistance by employee	0.911	5	45	Excellent
	Lack of tools and instrument	0.755	5	45	Acceptable
Section C	Maintenance Efficiency	0.702	5	45	Acceptable

4.2 AM barrier factors

Descriptive analysis was represented in the form of mean after analysis of data using SPSS software to identify the most important barrier factor to implement AM.

4.2.1 Lack of top management commitment factor

Table 4.2 Lack of top management commitment

No	Lack Of Top Management Commitment items	Mean	Level
1.	Top management does not encourage employees to do maintenance as priority.	2.71	Low
2.	Top management does not follow up and review the maintenance activities doing by employees.	2.16	Low
3.	Top management does encourage maintenance's peoples and production operators to work together on maintenance issues.	1.67	Low
4.	Top management does not care if maintenance's people doing proper maintenance job or not.	2.07	Low
5.	Top management does not monitor whether the maintenance's people help in launching the production work or not.	2.13	Low
	Average mean score	**2.15**	**Low**

Table 4.2 shows mean of lack of top management commitment items. From the observation, there are all five items have a low score mean with the mean value of 2.71, 2.16, 1.67, 2.07, and 2.13 respectively. The mean score shows that most of the respondents not agree with these 5 items. Based on the results,

the overall lack of top management commitment items achieve a low mean score.

4.2.2 Lack of training factor

Table 4.3 Lack of training factor

No	Lack Of Training items	Mean	Level
1.	Employees who operates machines not been trained to do maintenance job.	2.27	Low
2.	The employees who are responsible for maintaining new equipment are not trained well.	2.18	Low
3.	The employees does not receive training to help them doing maintenance job.	1.67	Low
4.	Maintenance peoples in organization does not have proper skills to do maintenance.	1.96	Low
5.	The employees who operate new machine and equipment are not trained well how to maintaining them.	2.16	Low
Average mean score		**2.05**	**Low**

Table 4.3 shows mean of lack of top management commitment items. From the observation, there are all five items have a low score mean with the mean value of 1.67, 1.96, 2.16, 2.18, and 2.27 respectively. The mean score shows that most of the respondents not agree with these 5 items. Based on the results, the overall lack of training items achieve a low mean score.

4.2.3 Lack of maintenance knowledge

Table 4.4 shows mean of lack of maintenance knowledge items. From the observation, there are four items have a moderate score mean with the mean value of 2.40, 2.40, 2.89, and 2.98, respectively.

Table 4.4 Lack of maintenance knowledge

No	Lack Of Management Knowledge items	Mean	Level
1.	Organization give less briefing about maintaining equipment and maintenance jobs.	1.69	Low
2.	Organization does not encourage workers to use work orders to do autonomous maintenance activities	1.87	Moderate
3.	Organization give less exposure about importance of maintaining activities to all employees.	2.40	Moderate
4.	Organization does not explain about maintenance issues to employees.	2.89	Moderate
5.	Does organization does not explain to employees about how much cost if production fail to maintain the machine equipment.	2.98	Moderate
Average mean score		**2.40**	**Moderate**

There also have one item that have low score mean. The mean score shows that most of the respondents not really agree with these 5 items. Based on the results, the overall lack of maintenance knowledge items achieve moderate mean score.

4.2.4 Resistance by employee

Table 4.5 Resistance by employee

No	Resistance By Employee items	Mean	Level
1.	Common comment among employees about maintenance job is “this is not my job”.	3.09	Moderate
2.	Employees feel that maintenance is resulted them have too many work other than operate equipment and machines.	3.00	Moderate
3.	Employees feel that maintenance cannot be avoided when the equipment ends their life cycle.	2.40	Moderate
4.	Production operators feel that they have no right to do maintenance other than technicians.	3.20	Moderate
5.	Employees feel that maintenance jobs are difficult to settle and challenges.	3.31	Moderate
Average mean score		**3.0**	**Moderate**

Table 4.5 shows mean of resistance by employee items. From the observation, there are all five items have a moderate score mean with the mean value of 2.40, 3.0, 3.09, 3.20, and 3.31 respectively. The mean score shows that most of the respondents agree with these 5 items. Based on the results, the overall resistance by employee items achieve moderate mean score.

4.2.5 Lack of tools and instrument factor

Table 4.6 Lack of tools and instrument factor

No	Lack Of Tools and Instrument items	Mean	Level
1.	Organization not provide enough tools and instruments for maintenance jobs.	3.18	Moderate
2.	Organization feel the cost for providing tools and instruments is high and wasteful.	3.07	Moderate
3.	Lack of tools and instruments cause maintenance jobs be slow.	4.38	High
4.	Lack of tools and less instruments contributes to maintenance activities.	4.09	High
5.	Lack of tools and instruments increase failure and breakdowns of equipment and machines.	4.27	High
Average mean score		**3.80**	**High**

Table 4.6 shows mean of lack of maintenance knowledge items. From the observation, there are three items have a high score mean with the mean value of 4.09, 4.27, and 4.38 respectively. There also have two item that have moderate score mean. The mean score shows that most of the respondents agree with these 5 items. Based on the results, the overall lack of tools and instrument items achieve high level mean score.

4.3 Summary for the Autonomous Maintenance barrier factors

Table 4.7 shows the summary of the AM barrier factors based on total average mean scores.

Table 4.7 Summary for the Autonomous Maintenance barrier factors

No	Factor	Total average mean scores	Ranking
1.	Lack of top management commitment	2.15	4
2.	Lack of training	2.05	5
3.	Lack of maintenance knowledge	2.40	3
4.	Resistance by employees	3.00	2
5.	Lack of tools and instrument	3.80	1

4.4 Normality Test

Normality tests are used to determine whether the study population is distributed normally or not according to [7]. Non-parametric tests are used by Spearman correlation tests when data is not normally distributed. Because respondents did not exceed 50, the normal test was tested using the Shapiro-Wilk test as shown in Table 4.8. The table analysis shows that all the important factors of maintenance barriers to maintenance efficiency, P value <0.05. Therefore, this research is not normally distributed. Therefore, the Spearman correlation test was used to achieve the study objectives.

Table 4.8 Normality test result

TPM Barriers	Shapiro-Wilk		
	Statistic	df	Signif icant.
Lack of top management commitment	.850	45	.000
Lack of training	.747	45	.000
Lack of maintenance knowledge	.860	45	.000
Resistance by employees	.797	45	.000
Lack of tools and instrument	.824	45	.000
Maintenance Efficiency	.912	45	.002

The analysis of normality test in the above table is Shapiro- Wilk and normality test results show the value of p> 0.05, then it is not normally distributed.

4.5 Correlation test

Correlation analysis is a statistical method used to identify the extent to which two variables vary together which included the strength and direction of the relationship between two variables [8]. In this research, correlation test was used to determine the relationship between job stress dimensions and turnover intention. The test of Spearman correlation was used in the context of this study since the overall data was not normally distributed the previous section. For significance value below 0.05, the relationship between two variables exist. For significance value more than 0.05, there is no relationship between two variables.

4.5.1 Hypothesis 1

H_0 = There is no relationship between Lack Of top management commitment and maintenance efficiency.
H_1 = There is a relationship between lack of top management commitment and maintenance efficiency.

Table 4.9 Correlation between lack top management commitment and maintenance efficiency

			Maintenance Efficiency
Spearman's rho	Lack of top management commitment	Correlation coefficient	-0.536
		Sig.(2-tailed)	0.000

From Table 4.9, the significance value of the demand factor towards the acquisition intention is 0.000 <0.05. Therefore, H_0 is rejected. There is a significant correlation between these two variables. The Spearman's rho correlation coefficient value was -0.536 (53.6%). Correlation coefficients indicate that there is a moderate relationship between lack of top management commitment and maintenance efficiency.

4.5.2 Hypothesis 2

H_0 = There is no relationship between lack of training and maintenance efficiency.
H_1 = There is a relationship between lack of training and maintenance efficiency.

Table 4.10 Correlation between lack of training and maintenance efficiency

			Maintenance Efficiency
Spearman's rho	Lack of training	Correlation coefficient	-0.796
		Sig.(2-tailed)	0.000

From Table 4.10, the significance value of lack of top management commitment factor towards maintenance recorded was 0.000<0.05. Hence, H_0 was rejected. There is a significant correlation between these two variables. The value of Spearman's rho correlation coefficient is -0.796 (79.6%). The correlation coefficient shows that there is a strong between lack of training and maintenance efficiency.

4.5.3 Hypothesis 3

H_0 = There is no relationship between Lack of maintenance knowledge and maintenance efficiency.
H_1 = There is a relationship between lack of top maintenance knowledge and maintenance efficiency

Table 4.11 Correlation between lack of maintenance knowledge and maintenance efficiency

			Maintenance Efficiency
Spearman's rho	Lack of maintenance efficiency	Correlation coefficient	0.081
		Sig.(2-tailed)	0.599

From Table 4.11, the significance value of lack of maintenance knowledge factor towards maintenance efficiency recorded was 0.000>0.05. Hence, H_0 was accepted. There is no significant correlation between these two variables. The value of Spearman's rho correlation coefficient is 0.081 (8.1%). The correlation coefficient shows that there is a strong negative relationship between lack top management commitment and maintenance efficiency.

4.5.4 Hypothesis 4

H_0 = There is no relationship between resistance by employees and maintenance efficiency.
H_1 = There is a relationship between resistance by employees and maintenance efficiency

Table 4.12: Correlation between resistance by employees and maintenance efficiency

			Maintenance Efficiency
Spearman's rho	Resistance by employees	Correlation coefficient	-0.322
		Sig.(2-tailed)	0.031

From Table 4.12, the significance value resistance by employees factor towards maintenance recorded was 0.000<0.05. Hence, H_0 was rejected. There is a significant correlation between these two variables. The value of Spearman's rho correlation coefficient is -0.322 (32.2%). The correlation coefficient shows that there is a weak relationship between resistance by employees and maintenance efficiency.

4.6 Correlation between lack of tools and instrument and maintenance efficiency

H_0 = There is no relationship between lack of tools and instrument and maintenance efficiency.
H_1 = There is a relationship between lack of tools and instrument and maintenance efficiency

Table 4.13 Correlation between lack of tools and instrument and maintenance efficiency

			Maintenance Efficiency
Spearman's rho	Lack of tools and instrument	Correlation coefficient	-0.017
		Sig.(2-tailed)	0.912

From Table 4.13, the significance value of lack of top management commitment factor towards maintenance recorded was 0.000>0.05. Hence, H_0 was accepted. There is no significant correlation between these two variables. The value of Spearman's rho correlation coefficient is -0.017 (1.7%). The correlation coefficient shows that there is a very weak negative relationship between lack of tools and instrument and maintenance efficiency.

5. Conclusion

In this study, there are five factors has been chosen such as lack of top management commitment, lack of training, lack of maintenance knowledge, resistance by employees, and lack of tools and instrument. This study found that from the five factors listed, the lack of tools and instruments is the most influencing maintenance efficiency which represented mean analysis 3.80. These findings are similar to results of previous study that was done by [9][10]. This helped in considerably reducing failures and breakdowns of equipment and machines. So, it can be concluded that based on the feedback by respondents, the lack of tools and instruments are the most critical barrier factor that influenced the implementation of autonomous maintenance practices in manufacturing industries.

5.1 Summary for the Results of Hypothesis

This study conducted by stating some hypothesis testing to achieve the objectives of the study. The study has five hypothesis that should be tested using Spearman's rho correlation test. Summary for hypothesis testing are shown in the table below. Based on the table, it shows the relationship between factor of lack of top management commitment, lack of training, lack of maintenance knowledge, resistance by employees, and lack of tools and instrument towards maintenance efficiency.
The relationship between factors of lack of top management commitment, lack of training, resistance by employee are positive significant relationship ($p<0.05$) while factors of lack of maintenance knowledge and lack of tools and instrument there are negative relationship ($p>0.05$).

Table 5.1: Summary for the Results of Hypothesis

Hypothesis	**Spearman's rho correlation**	**Result**
Hypothesis 1 : There is a significant impact of lack of top management commitment toward maintenance efficiency	-0.536**	Accepted
Hypothesis 2 : There is a significant impact of lack of training toward maintenance efficiency	-0.796**	Accepted
Hypothesis 3: There is a significant impact of lack of knowledge about maintenance toward maintenance efficiency.	0.081	Rejected
Hypothesis 4: There is a significant impact of resistance by employees toward maintenance efficiency.	-0.322*	Accepted
Hypothesis 5: There is a significant impact of lack of tools and instrument toward maintenance efficiency	-0.017	Rejected

This study has been carried out to achieve the objectives as required by the researchers to identify the critical barrier factor that influences the performance of maintenance efficiency in manufacturing industries. The findings indicate that these factors affected the efficiency of maintenance in the manufacturing industry. Besides that, for the study to identify the relationship, five hypotheses were tested and three hypotheses were accepted. Table 5.1 shows that there was a significant relationship between factor of lack of top management commitment, lack of training, and resistance by employee factor with maintenance efficiency. However, the relationship between these factors with the efficiency of maintenance is a significant negative correlation ($p <0.05$).

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