Organizational Culture Influence On Total Productive Maintenance (TPM) and Operational Performance Using RASCH Model Analysis

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Abstract. *Market globalization, competitive product and services, high economic crises are the most critical factors that influence the success of the manufacturing companies in global market. Therefore it is critical to the manufacturing companies to be efficient in production and lean tool may used to achieve that. The most frequently used is the Total Preventive Maintenance (TPM), even though there are many studies have been conducted in relation to the TPM but there is limited research in investigating the effects of the TPM on operational performance. However, the result of the studies was not consistent, where TPM practice may have positive and negative impact on operational performance. Among the reason is the culture of the organization that influenced the implementation of TPM and operational performance. Due to that this study attempts to investigate the influence of organizational culture on the TPM implementation and operational performance. Rasch model is used in this study due to its ability in interpreting and analyzing the ability of respondents in performing the difficult items. The online questionnaires were distributed to 63 randomly selected automotive companies located at Northern Region of Malaysia. Results of the study revealed that the organizational culture has influenced on the successful implementation of TPM and operational performance. Therefore by the implementation of TPM in outstanding organizational culture can improve operational performance.*

Keyword: Total Preventive Maintenance (TPM), Lean manufacturing, Operational performance, Organizational culture, Rasch model

1. Introduction

Many businesses in Asia have tried to receive several new business initiatives to ensure that they remain in the market competitive at present. According to Holweg (2007) lean manufacturing is the best manufacturing practices in various industries.

Lean manufacturing consists of a number of lean tools such as Total Preventive Maintenance (TPM) (Greene, 2002). Total Productive Maintenance (TPM) plays an important role in effectively managing the machines and in improving the machine capability.

However poor organisational competencies in managing the maintenance function effectively can severely affect competitiveness by reducing throughput, increasing inventory, and leading to poor due date performance (Ashayeri, 2007). According to Georgios and Prodromos (2008) organizational performance can be divided into two parts: financial performance and non-financial performance. The operational performance is part of the non-financial performance and is defined as the measurement aspects organization output resulting from organizational processes (Voss, Ahlstrom, & Blackmon, 1997).

According to John (1999) many TPM implementation failed due to the culture of the organization. Organizational culture is defined as the values and beliefs that are practiced by all employees in an organization (Weese, 1996). According to Maddox (2009) the successful implementation of TPM, shall begin with the commitment and leadership of the management team to ensure the success of the program. Radnor and Walley (2008)

argues that a change in attitude not only to management but involve all employees in order to create lasting organizational change. Therefore, this study is intended to determine the influence of organizational culture on the relationship TPM with operational performance.

2. Research Framework

After explaining the problem statement, the next step is to build a conceptual framework to guide research. Hence the conceptual framework of major importance in identifying the concept, the relationship between the variables and the direction of the relationship. Figure 1: Research Framework shows the relationship between TPM, organizational culture and operational performance. The independent variable in this framework is TPM. On the other hand, the dependent variable is the performance of the operation. Organizational culture is a moderator variable between TPM and operational performance.
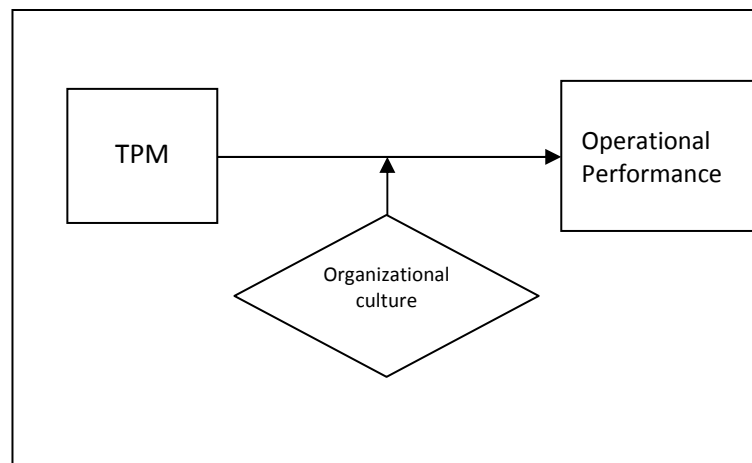

Figure 1. Research Framework

2.1. Research Methodology

Sample survey or population study is comprised of companies that manufacture products and automotive components adopting lean tools. These companies or the respondent are a supplier of components and products to

the automotive industry. This study only focused on the Northern Peninsular Malaysia only covering Perlis, Kedah, Penang and Perak. This is because most of the automotive companies operating in the area north of the peninsular and has the same type of manufacturing process. Respondents assigned

a six-digit code to facilitate analysis. The first two digits indicate the number of respondents or organization is the location of the third digit, fourth digit indicates the number of years of operation, the fifth digit indicates the number of employees and sixth digits indicate the total turnover.

Based on the total sample, this study considers the results of tests on samples of this study may reflect the results of the overall study population. A total of 76 companies have been identified through the list of suppliers in the vehicle manufacturer. The sample size for population size 76 is 63 (Krejcie & Morgan, 1970; Sekaran, 2003). Thus a total of 63 were randomly selected and required to fill out an online questionnaire or online. Unit of analysis for this study is the organization and most of the respondents were CEOs, managers, engineers and executives.

This questionnaire is designed to assess the capacity of organizations in implementing TPM items to enhance operational performance and the influence of organizational culture on this relationship. It was developed based on extensive literature review and also expert opinion involving management representative in the organization. Before further research was conducted it is important to ensure the instrument used is valid and reliable. Due to the importance of reliable instrument, the instrument should represent what it is supposed to measure; hence the objective of this paper is to conduct an exercise to check the reliability of the instruments using Rasch Model.

These questions are divided into three variables, namely TPM as independent variables and the operational performance as the dependent variable and the culture of the organization as a moderator variable. The formation of this research question was to undergo two types of measurement validity, content validity and construct validity. Content validity is to ensure that the measurement includes a series of items that emphasize concepts. Construct validity to test all these questions the appropriateness of an item analysis to meet or fit the Rasch model. Reliability test was conducted to measure the extent to which the indicator without bias (error-free) and ensure consistent measurement over time and include various items in the instrument (Sekaran, 2003). In the Rasch model reliability of the instrument can be seen through the items and reliability of person.

Most of the questions were mostly taken from previous studies and modified to suit the purposes of some, such as TPM (McLachlin, 1992), organizational culture (Cameron, Kim, Quinn, & Robert, 1999; Knapp, 2010) and operational performance (Ahmad & Schroeder, 2003). TPM questions divided into two dimensions with B11.X code where the X indicates the number of dimensions Preventive Maintenance (1), and Equipment (2). While organizational culture questions divided into six dimensions with C.Y code where the value of Y indicates the number of dimensions of dominant feature (1), leadership organization (2) employee management (3), bonding organization (4), emphasis strategic (5) and success criteria (6). Similarly, the operating performance of questions it is divided into six dimensions with D.Z code where the Z indicates the number of dimensions of quality (1) cost (2), time (3), delivery (4), productivity (5) and flexibility (6). Six Likert scale measurement range (6 point Likert scales) used in this study. This is because the scale of measurement does not provide the range of 6 points midrange (midpoint) or neutral point (Tang, Shaw, & William, 1999).

2.2. Rasch Model

Current practice of measuring performance is only counting the responses of priorities from the organizations. The rating is only an order of preference; which is continuum in nature and it is not linear and also do not have equal intervals which contradict with the nature of numbers for statistical analysis (A. A. Aziz, 2008). In Traditional Test, the scatter plot is applied to establish the best regression. However prediction from ordinal response is

almost impossible due to absence of intervals scale. The normal solution in linear regression approach is to establish a line which fits the points as best as possible; which is then used to make the required predictions by inter-polation or extra-polation as necessary (A. A. Aziz, Mohamad, A., Arshad, N., Zakaria, S., & Masodi, M., 2007) as shown in Figure 2.
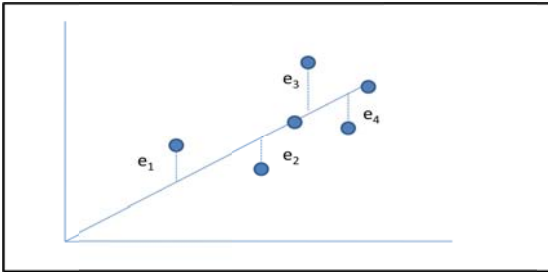

Figure 2. Best fit line concept

$$y = \beta_0 + \beta_1 m \quad (1)$$

In obtaining the best fit line, however, there exist differences between the actual point; yi, and predicted point; that is on best fit line. The difference is referred as error, e

$$y_i - \acute{y}_i = e_i \quad (2)$$

Since there is always errors involve in the prediction model, the deterministic model of equation (1) renders itself less reliable. This can be overcome by transforming it into a probabilistic model by including the prediction error into the equation;

$$y = \beta_0 + \beta_1 m + e \quad (3)$$

Under the Rasch philosophy the data collected have to fit the Rasch model's specification (Aziz et al., 2007; Bond & Fox, 2007) rather than establishing "best fit line". Rasch moves the concept of reliability from establishing "best fit line" of the data into producing a reliable repeatable measurement instrument Wright & Mok et al, (2004) extracted from Aziz et al. (2008). Rasch focuses on constructing the measurement data to suit a measurement model with of errors. By focusing on the reproducibility of the latent trait measurement instead of forcing the expected generation of the same raw score, i.e the common expectation on repeatability of results being a reliable test, the concept of reliability takes its rightful place in supporting validity rather than being in contentions. In Rasch it is required to test whether the data allow for measurement on linear interval scale specifically in a cumulative response process i.e. a positive response to an item stochastically implies a positive response to all items being easy or otherwise. Rasch Model is expressed as the ratio of an event being successful as;

$$P(\theta) = \frac{e^{(\beta_n - \delta_i)}}{1 + e^{(\beta_n - \delta_i)}} \quad (4)$$

where:

e = base of natural logarithm or Euler's number; 2.7183

β_n = person's ability keupayaan *person*

δ_i = item or task difficulty

This study used the Rasch model for further analysis because it is very appropriate in the analysis of quantitative data, especially in the social sciences and also it is able to measure the ability of each respondent in the performance of difficult items (Bond & Fox, 2007; Saifudin et al., 2010).

3. Finding and Discussion

The majority of respondents are in the state of Kedah (65%), followed by Penang (26%) and Perak (9%). The data obtained reflect the population in which most of the automotive industry in the state of Kedah, Penang and Perak as that shown in the Figure 3 Number of respondents by state. These places have a lot of manufacturing activities and some industries are located in vendor village areas.
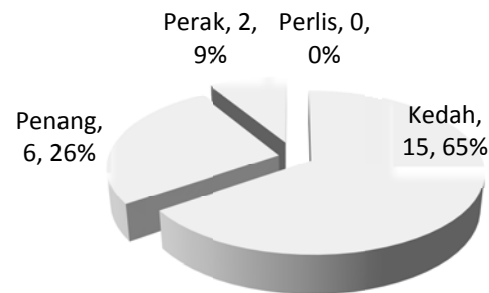

Figure 3. Number of respondents by state

There are 12 organizations that have been operating between 11-20 years followed by four organizations (1-10 years), 4 organizations (21-30 years) and 3 organizations (30 years and above). The data obtained reflect the 52% of the automotive industry has been operating between 11-20 years, while 13% say it has been operating for more than 30 years as shown in Figure 4 Number of years in operation.
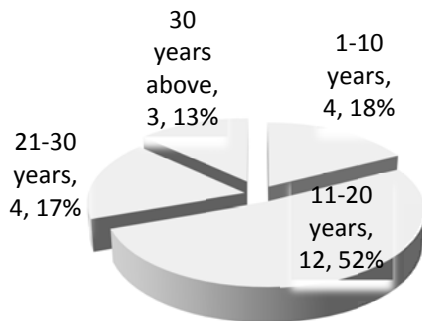

Figure 4. Number of years in operation

Figure 5 Number of Employees, showed that the majority of companies involved in this study had more than 150 employees (48%). Five companies (22%) have an employee between 51 to 150 people and only seven companies (30%) who have employees ranging from 5 to 50 people.
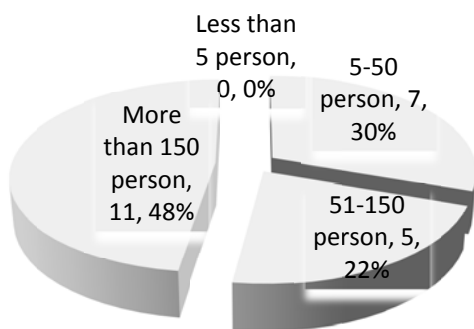

Figure 5. Number of Employees

Sales turnover for these companies showed 48% earning more than MYR25 million, 35% earning between MYR250, 000 to the 10th million and 17% earned between MYR10 million to MYR25 million. The above information is explained in Figure 6 Sales incomes.
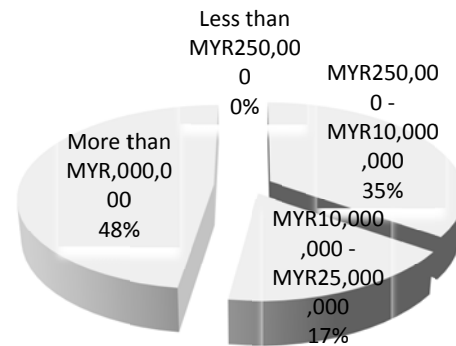

Figure 6. Sales incomes

In classical test theory reliability and validity measures are from Cronbach-α and Factor analysis. However Rasch Model which is in line with the concept of modern test theory known Item Response Theory (IRT) goes beyond this measurement by focusing on the reproducibility of measures rather than expressing the reproducibility of raw scores (Aziz et al., 2007).

The data from the survey was analyzed using Rasch Model statistical computer software program, Winstep 3.68.2 (Bond et al., 2007). In order to analyze how good the data collected fit the Rasch model, Summary Statistic Table as per Table 1 provides the overall summary statistic.

Table 1. Summary Statistics for TPM, Organizational Culture and Operational Performance

	MEASURE (Logit)	OUT. MNSQ	OUT. ZSTD
Mean	-0.13	0.82	-0.6
SD	0.55	0.26	0.9
Max	1.08	1.42	1.4
Min	-1.02	0.50	-1.9
Item Reliability:	0.78		
Person Reliability:	0.94		

In Rasch the reliability issues are discussed further in term of person reliability and item reliability. The person reliability and item reliability index provided in the above Table 1 indicates the reliability of person ordering and item placements respectively along the *logit* scale (Bond et al., 2007). The person reliability index is given at 0.94 which is deemed 'Excellent' reliability (Fisher, 2007), showing the stability of the person response validity. Item reliability index is at 0.78 which is of 'Fair' reliability (Fisher, 2007), inferring that the assessment tool can discriminate the person ability and the difficult item. This is the very crucial test as it determines the construct validity of the instrument hence valid data (Andrich, 1988; Bond et al., 2007). The mean item is at -0.13 logit. This indicates that the organization involved in this study in general have the ability to reach the items prescribed in the study. The most difficult item is located at 1.08 logit and the easiest item is located at -1.02 logit with the standard deviation of 0.55 logit which inferring to the small spread within the data. The mean person is at 0.77 logit. While the maximum logit for person is 2.43 logit and the minimum logit for person is -0.48 logit and the range is 3.97 logit which indicate a bigger spread among the respondents. The data also shows that there are respondents above the maximum item logit which indicates respondent's excellent ability in performing the items. Rasch analysis generates useful information in ensuring the data fit the model, the measures are Point Measure correlation (PtMea Corr), Outfit Mean Square (MNSQ) and z-Standard Test. These measures are used as 'quality control' to ensure the data can be used for further analysis. The guidelines given by Fisher, (2007) the quality control value for Pt-Mea Corr should lies between 0.40 and 0.80, MNSQ should be within 0.5 and 1.5 and the z-standard should be between -2 and 2. Figure 7 Expected Score ICC TPM, Organizational Culture and Performance showed that the data are in between two lines or confidence interval Confidence Interval Curve. Data showed that the value is in the trusted level of reliability. All items are 95% confident interval between data shows the fit to the model and can be used.
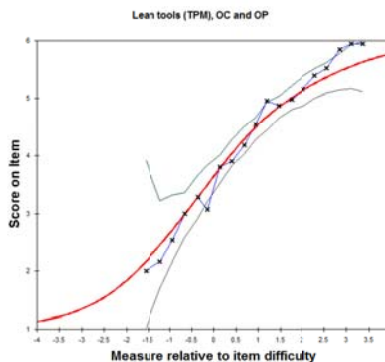

Figure 7. Expected Score ICC TPM, Organizational Culture and Performance

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TABLE 1.0 Lean tools (TPM), OC and OP        ZOU880WS.TXT  Sep 23 15:27 2013
INPUT: 23 Person  269 Item  MEASURED: 22 Person  29 Item  6 CATS WINSTEPS 3.69.1.16
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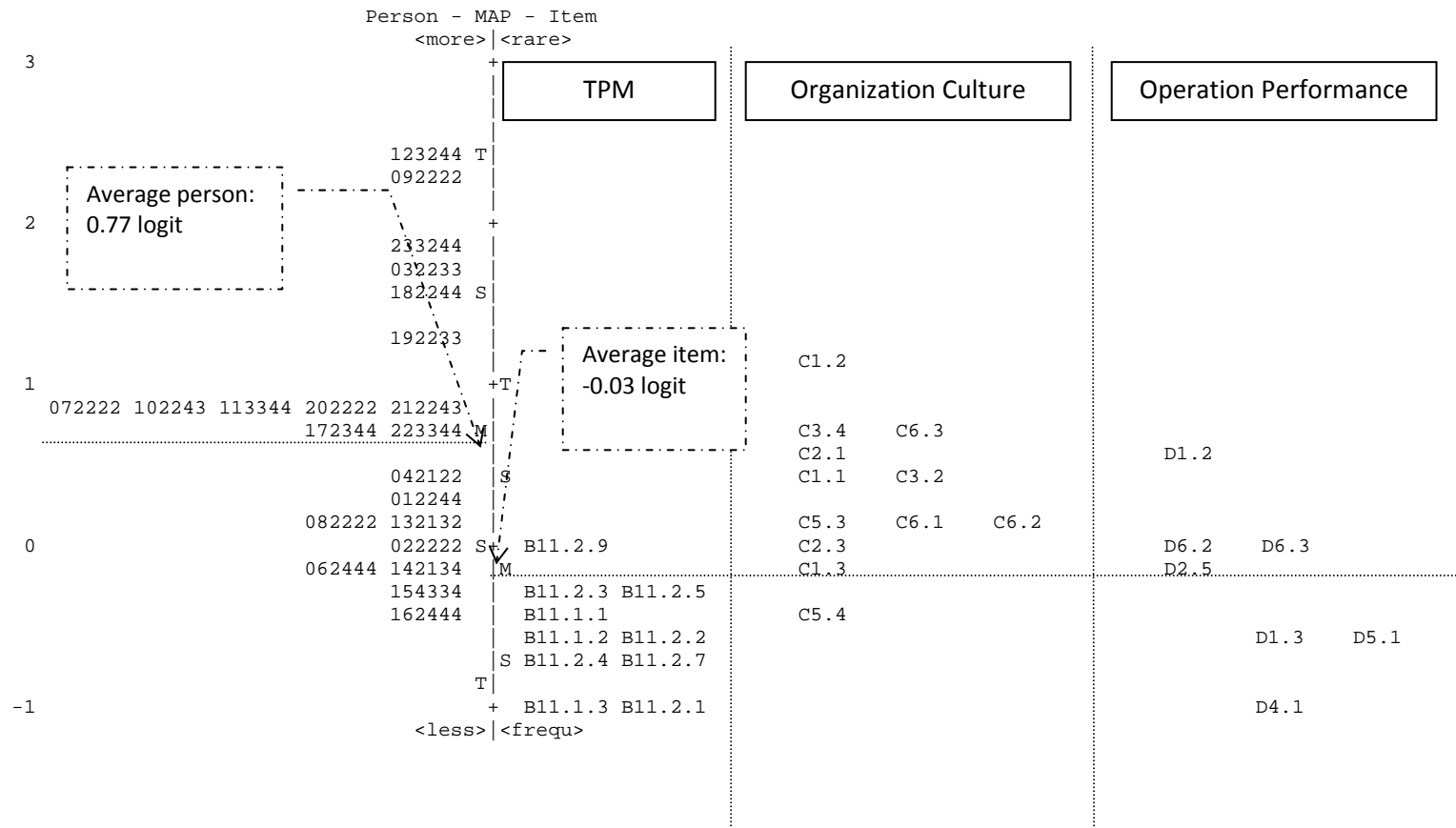

Figure 8: Map Variables TPM, Organizational Culture and Operational Performance

Figure 8 Map Variables TPM, Organizational Culture and Operational Performance shows the relationship between the person (respondent) with items (questions). Person position is on the left in map variable while item position on the other hand on the right. Person position arranged from average levels (mean) where highest position shows the person the ability to answer those items. Top position show person can answer many items while the bottom person position can managed to answer a little item. The item on the right side of the variable map shows the level of difficulty of items. The item on the bottom left side of variable map shows the items easily to answer or to be implemented. To facilitate the analysis made, these items are rearranged according to TPM, organizational culture and performance of operations.

Thirteen person (respondent) was well above the average person (0.77 logit), two are on average and while nine person below average as shown in Figure 8 Map Variables TPM, Organizational Culture and Operational Performance. The highest ranking person is 123244 and the lowest person is 162444. Based on the organization code shown person (162444) which is the lowest in the state of Kedah and has been in operation for 30 years, has more than 150 employees and achieved a turnover of over 25 million. Person (123244), which are at the top shows the organization's ability to perform the whole item. Based on that organization indicates this organization is in the state of Penang and has been operating between 21 to 30 years, has more than 150 employees and achieved a turnover of over 25 million.

One item TPM is on average (-0.03 logit) and nine items are below average. The lowest items are B11.1.3 and B11.2.1 but the highest is B11.2.9 items. Item below 162444 person shows a simple question answered by all organizations. In total all items TPM below the average line can be easily implemented by 20 organizations (from 142134 to 123244 person).

All organizational culture items are above average except C5,4 This shows that these items are difficult to answer This shows that these items are difficult to answer by the organization. The lowest item is C5.4 and the highest is C1.2 items. Only six person can answer to all the items (092 222, 123244, 233244, 032233, 183244 and 193233). Based on that, five person had operates between 21 and 30 years and three of them have more than 150 workers with earnings over 25 million. Although most organizations have different backgrounds, but it is easy to adopt the culture of the organization. To achieve the success that other organizations should strive to overcome.

There are four items operating performance was well above average and three items are below average. The easiest item to be addressed is related to the delivery DP4.1 while the most difficult item to be addressed is D1.2 to the quality. Most items are above average levels which showed operating performance items difficult to answer and illustrate the difficulty of achieving operational performance. However, 13 organizations (from 123 244 to 223344) easily answer all the operating performance questions and it show that all organizations are concerned to achieve outstanding operational performance.

On the other organization (person 162444) is only able to answer questions (item D1.3, D5.1 and D4.1) showed low operating performance. Based on the organization code shown person (162444) which is the lowest in the state of Kedah and has been in operation for 30 years, has more than 150 employees and achieved a turnover of over 25 million.

This shows that even if the organization has a good background, but it is not able to achieve good performance. This is likely caused obstruction in the culture of the organization. The operational performance is achieved by implementing all items TPM and operating performance and overcome obstacles that are present in the culture of the organization.

However, to achieve outstanding operational performance, organizations must be able to answer all items organizational culture and items operational performance. There are six organizations (from 123244 to 192233 person) are able to implement TPM and good organizational culture and achieve outstanding operational performance.

4. Conclusion

The study conducted showed clearly that the TPM are tool that can improve operational performance. The successful implementation of TPM is not entirely dependent on the number of years of operation, number of employees and sales turnover. Success or failure in the implementation of TPM to excel in operational performance much influenced by the culture of the organization.

This is in line with the view of some researchers TPM (Halim Mad & Ramayah, 2010; Johnson, 2001; Park & Han, 2001) and also other lean tools (Al Smadi, 2009; Charlene & Harold, 2002; John, 1999; Taleghani, 2010) as Charlene (2002) opined that organizational culture is a big obstacle in the implementation of cellular manufacturing. Organizational leadership is one of the most important factors in the lead role of organizational culture TPM implementation in the organization (Park & Han, 2001; Taleghani, 2010).

In addition to the bond between the employee and the employee and employee-management needs to be improved from time to time. It can be done by improving the relationship between the employee and also through training programs. Some researchers say one of the main obstacles is the willingness of people to change, especially unionized organization (Hutchins, 2007). However, if organizations implement good labor management, it will increase employee motivation (Mahal, 2009) and motivate employees with successful TPM activities. Researchers agree that the main obstacle to change is an issue that must be addressed by the organization in excellent shape organizational culture. However, with a strategic emphasis and understand the criteria for success of an organization is able to form a good organizational culture and achieve excellence in operational performance. This study focuses on TPM one of the lean tools, it can be expanded as future research to determine the influence of organizational culture on the relationship between the other lean tools and operational performance.

Reference

Al Smadi, S. (2009). Kaizen strategy and the drive for competitiveness: challenges and opportunities. *Competitiveness Review 19* (3): 203.

Ashayeri, J. (2007). Development of computer-aided maintenance resources planning (CAMRP): A case of multiple CNC machining centers. *Robotics and Computer-Integrated Manufacturing 23* (6).

Aziz, A. A. (2008). *Rasch Model fundalmentals: Scale construct and measurement structure*. Kuala Lumpur.

Aziz, A. A., Mohamad, A., Arshad, N., Zakaria, S., & Masodi, M. (2007). Appraisal of Course Learning Outcomes using Rasch Measurement: A Case Study In Information Technology Education. *International Journal of Systems Applications, Engineering & Development 4* (1).

Charlene, A. Y., & Harold, J. S. (2002). Cellular manufacturing for small businesses: Key cultural factors that impact the conversion process. *Journal of Operations Management 20* (5): 593.

Georgios, N. T., & Prodromos, D. C. (2008). Enhancing performance through best HRM practices, organizational learning and knowledge management. *European Business Review 20* (3): 185.

Greene, B. M. (2002). *A taxonomy of the adoption of lean production tools and techniques.* Ph.D., The University of

Tennessee, United States -- Tennessee. Retrieved from http://proquest.umi.com/pqdweb?did=765622 341&Fmt=7&clientId=28929&RQT=309&V Name=PQD

Halim Mad, L., & Ramayah, T. (2010). Maintenance strategy in Malaysian manufacturing companies: a total productive maintenance (TPM) approach. *Business Strategy Series, 11*(6), 387-396. doi: *http://dx.doi.org/10.1108/1751563101109309 8*

Holweg, M. (2007). The genealogy of lean production. *Journal of Operations Management 25* (2): 420-437.

Hutchins, C. B. (2007). *Five "S" improvement system: An assessment of employee attitudes and productivity improvements.* Ph.D., Capella University, United States -- Minnesota. Retrieved from *http://proquest.umi.com/pqdweb?did=122173 8901&Fmt=7&clientId=28929&RQT=309& VName=PQD*

John, J. L. (1999). Use mathematical modeling to give your TPM implementation effort an extra boost. *Journal of Quality in Maintenance Engineering 5* (1): 62.

Johnson, M. A. (2001). *Work group satisfaction as a predictor of total productive maintenance (TPM) performance outcomes.* Ph.D., Wayne State University, United States -- Michigan.

Krejcie, R., & Morgan, D. (1970). Determining sample size for research activities. *Educational and Psychological Measurement 30*, 607-610.

Mahal, P. K. (2009). Organizational culture and organizational climate as a determinant of

motivation. *IUP Journal of Management Research 8* (10): 38-51.

McLachlin, R. D. (1992). *Management initiatives and the implementation of Just-In-Time manufacturing by Canadian firms.* Ph.D., The University of Western Ontario (Canada), Canada.

Park, K. S., & Han, S. W. (2001). TPM--Total Productive Maintenance: Impact on competitiveness and a framework for successful implementation. *Human Factors and Ergonomics in Manufacturing, 11*(4), 321-338. doi: 10.1002/hfm.1017

Radnor, Z., & Walley, P. (2008). Learning to Walk Before We Try to Run: Adapting Lean for the Public Sector. *Public Money & Management 28* (1): 13-20.

Sekaran, U. (2003). *Research Methods for Business: a Skill Building Approach*. New York: John Wiley.

Taleghani, M. (2010). Success and failure issues to lead lean manufacturing implementation. *World Academy of Science, Engineering and Technology 62*, 618.

Tang, R., Shaw, J., & William, M. (1999). Towards the identification of the optimal number of relevance categories. [Article]. *Journal of the American Society for Information Science 50* (3): 254-264.

Voss, C. A., Ahlstrom, P., & Blackmon, K. (1997). Benchmarking and operational performance: Some empirical results. *International Journal of Operations & Production Management 17* (10).

Weese, W. J. (1996). Do leadership and organizational culture really matter? *Journal of Sport Management 10* (2): 197-206.