Journal of Scientific Research and Development 2 (12): 95-100, 2015
Available online at www.jsrad.org
ISSN 1115-7569


# The analysis of lean manufacturing tools in Malaysia's manufacturing industry

Ng Tan Ching [1, 2, *], Tang Sai Hong [2], Lee Kok Hoe [1], Siti Azfanizam Ahmad [2], Mohd Idris Shah Ismail [2], Morteza Ghobakhloo [2]

[1]*Department of Mechanical and Material Engineering, University Tunku Abdul Rahman, Kuala Kajang, Malaysia*
[2]*Department of Engineering, University Putra Malaysia, Serdang, Malaysia*

**Abstract:** Lean manufacturing is a methodology to eliminate waste, which is an activity that creates no value for the customers. Customers always wish to obtain products that are not defective. Lean tools are implemented to the specific processes to reduce waste. Examples of lean tools are Just in Time, Total Productive Maintenance, Total Quality Management, Supply Chain Management, Customer Relationship Management and Human Resource Management. Lean tools can be applied simultaneously to eliminate waste, which eventually improve quality of the products and services, thus adding more value to the customers. This paper discusses the five mentioned lean tools in Malaysia's manufacturing industry and analyses them in ascending order according to their efficiency on production output through survey questionnaire. This paper generally helps manufacturers to determine the most affected factors in succeeding lean practices.

**Key words**: Lean manufacturing; Just in time; Total productive maintenance; Total quality management; Supply chain management; Customer relationship management; Human resource management

## 1. Introduction

Anvari [1] expresses "lean manufacturing" is an approach being practiced to eliminate waste in a production that consumes resources but creates no value to customers. In the book "Lean Thinking: Banish Waste And Create Wealth In Your Corporation" written by Womack and Jones [1], lean provides a system to identify value, arrange value-adding activities in the best manner, perform activities without waste and continuously improve them. To be more specifically, lean provides closer approach to customer demand with less human effort, less equipment, less time and space.

When it comes to define the value of a product, customers do not concern about the cost of inventories or overhead cost. Value is defined by customers when they see the end products on their hand. The wastes are hidden in different forms in all the manufacturing processes. According to Erfan [2], elimination of waste in order to achieve qualified system is to be done with the application of LM tools. LM has the potential to shorten the production lead time and reduce space for inventories in an industry. This allows overall cost reduction and promotes higher profit gain. In this manufacturing industry that involves different stages of processing raw material to final product, putting more capital investment does not improve the production. In a long run, this can only create waste that lowers the quality of products. Therefore LM is proposed to eliminate waste. LM has a comprehensive set of technique that maximizes customer value, allowing customers to obtain the best quality products.

## 2. Literature Review

Stated by Womack and Jones [1], waste, or known as "muda" in Japanese word, is referring to the activity that consumes resources but creates no value to the customers. TaichiiOhno identifies 7 types of waste in a physical production line, that are "overproduction", "waiting", "transport", "over processing", "inventories", "movement" and "defective parts". LM has three main aspects that make it a famous philosophy to be practiced, which are efficiency, quality and responsiveness. In the highly competitive market, an organization has to reduce production cost and other expenditures in order to increase profit margin. Besides, production goods have to be kept in acceptable quality as low quality products do not guarantee profit to an organization. Lastly, responsiveness to customers is important for the success of an organization. An organization has to continually undergo improvement in order to produce valuable and high quality products. LM provides the methodologies or methods to reduce non-value added activities in an organization. It emphasizes on the continuous flow of production that begin with customer demands, integrates all involving parties in a production, with proper tools handling and time management to provide an excellent outcome to customers.

* Corresponding Author.

According to Feld [3], Just in Time (JIT) is a technique that deals with inventory and materials handling. Based on a research by Alcaraz [4], the main concept of JIT initially is to control material flow. In a production line, JIT is used to monitor inventory level of a production and control amount of materials used in each workstation to prevent overproduction. In the traditional manufacturing, productions are being "pushed" to the customers and this causes higher production than demand. JIT emphasizes on the pull system, whereby production can only starts with the order of customers. As JIT is one of the pillars for TPS, it focuses on the waste elimination where non-value added activities also occur in the machine and workers capabilities.

In the study conducted by Stamm [5], Total Productive Maintenance (TPM) utilizes continuous improvement processes to optimize production efficiency by reducing equipment downtime. It is mainly used to monitor and prevent machine breakdown. Machine reliability is very important as machine breakdown can affect the entire manufacturing line. Feld [6] identifies and simplifies properties of TPM into 3 elements: preventative maintenance, corrective maintenance and maintenance prevention. Preventative maintenance highlights the efforts of preventing machine from breakdown. It deals with the necessary steps being taken to perform scheduled machine checking, identify unusual machine performance, daily maintenance on tools and equipment in workplace. Corrective maintenance focuses on the sustainability of repaired tools and equipment. Maintenance prevention deals with the proper function of equipment in certain processes. Every machinery and equipment has to be function in a user-friendly manner.

Total Quality Management (TQM) is a management philosophy that requires continuous improvement, social and technical approach, and teamwork of whole organization as a practice to improve the quality of production as suggested by Cornelison [7]. According to Anvari [8], TQM pinpoints the important of the employee involvement in an organization, through continuous improvement, strong teamwork spirit with long range thinking to improve the quality of products, meet customer requirements as well as suppliers' satisfaction. TQM focuses on customers demand and ensure the highest quality being delivered. The value of quality will be defined solely by customers themselves depending on goods or services. Management has to determine the customers' requirement and study the culture at the current location before the organization identifies the core values and applies the correct principles.

## 3. Methodology

This study is conducted to analyze the application of LM among the manufacturing companies in Penang and Klang Valley. This research is targeting both mass production companies and small medium enterprise. The questionnaire is answered by managerial positioned officers as they are familiar with the companies' practices and information. The questionnaire is formed through many findings from the literature review about the lean tools. Those topics are discussed and analyzed to become the questions of this study. Once preparation is finished, the survey forms are printed out and passed to the manufacturing companies in certain area. After collecting all forms from the manufacturing companies that willing to complete the survey, the data is recorded into SPSS software, which will be used to analyze the results. It is used to determine the reliability analysis, normality, descriptive analysis, linear regression, correlation and factor analysis of this study.

## 4. Results and discussion

There are 5 types of analysis being done in this research. The reason is to find out the most efficient lean tool (according to the answered questionnaire received) as discussed above.

### 4.1. Reliability analysis

Reliability analysis examines whether the survey questions are reliable and trustworthy in this study. As a rule of thumb, any variables that obtain indicate they are reliable in such study. Table 1 shows the reliability statistics analyzed by SPSS software. The value of the survey data is found to be 0.812. Hence, the data is reliable. When each of the questions is removed from this study subsequently, the data remains reliable as the Cronbach's Alpha is higher than 0.7.

**Table 1:** Reliability of Survey Questions

| Reliability of Survey Data | | | 0.812 | |
|---|---|---|---|---|
| | Scale Mean | Scale Variance | Total Correlation | Cronbach's Alpha if Item Deleted |
| JIT1 | 58.4080 | 43.319 | 0.350 | 0.806 |
| JIT2 | 57.9902 | 43.716 | 0.367 | 0.804 |
| JIT3 | 57.9175 | 43.615 | 0.441 | 0.801 |
| TPM1 | 58.4993 | 41.853 | 0.481 | 0.797 |
| TPM2 | 58.5902 | 42.393 | 0.424 | 0.801 |
| TPM3 | 58.5356 | 42.602 | 0.497 | 0.797 |
| TQM1 | 58.8447 | 40.058 | 0.508 | 0.795 |
| TQM2 | 58.5720 | 40.734 | 0.537 | 0.792 |

| | | | | |
|---|---|---|---|---|
| TQM3 | 58.4811 | 40.374 | 0.562 | 0.790 |
| SCM1 | 58.6993 | 43.716 | 0.231 | 0.817 |
| SCM2 | 58.5356 | 43.125 | 0.344 | 0.806 |
| HRM1 | 58.8640 | 43.876 | 0.332 | 0.807 |
| HRM2 | 58.8356 | 42.173 | 0.516 | 0.795 |
| CRM1 | 58.1175 | 44.365 | 0.338 | 0.806 |
| CRM2 | 58.0811 | 44.152 | 0.369 | 0.804 |
| CRM3 | 58.0629 | 44.465 | 0.388 | 0.804 |

### 4.2. Normality analysis

This study is proposed that sustainability of LM depends on the lean tools implemented by the organizations. The common lean tools that can be found in organizations are JIT, TPM, TQM, SCM, HRM and CRM. Fig. 1 illustrates the hypothesis of this study. In general, normality test can compute the significance value of the hypothesis. For any significance value, the hypothesis is true and it proves the relation is significant.


$H_1$: JIT is related to the sustainability of LM
$H_2$: TPM is related to the sustainability of LM
$H_3$: TQM is related to the sustainability of LM
$H_4$: SCM is related to the sustainability of LM
$H_5$: HRM is related to the sustainability of LM
$H_6$: CRM is related to the sustainability of LM

**Fig. 1:** Illustration of the hypothesis

Table 2 displays result for the normality test of all lean tools. Since this study is conducted in a population less than 2000, Shapira Wilk significance value is sufficient to explain the relations. Significance values of the lean tools are below 0.05. This proves the relations of JIT, TPM, TQM, SCM, HRM, CRM and the sustainability of LM are significant.

**Table 2:** Tests of Normality

| | Shapiro-Wilk | | |
|---|---|---|---|
| | Statistic | df | Sig. |
| JIT | 0.917 | 55 | 0.001 |
| TPM | 0.938 | 55 | 0.007 |
| TQM | 0.903 | 55 | 0.000 |
| SCM | 0.891 | 55 | 0.000 |
| HRM | 0.891 | 55 | 0.000 |
| CRM | 0.851 | 55 | 0.000 |

Normality analysis also gives information on the distribution of the survey data. Positive value of skewness indicates the graph is skewed to the left. In contrast, negatively skewed distribution is moved towards the right side. Kurtosis measurement scale examines the distribution of curve in terms of its peak. Survey data is said to be at normal height when the value of Kurtosis is within -2 to +2. Table 3 shows the value of skewness and Kurtosis for each question.

**Table 3:** Skewness, Kurtosis, Mean and Median of Each LM Tools

| | Skewness | Kurtosis | Mean | Median |
|---|---|---|---|---|
| JIT1 | -0.707 | 0.191 | 3.9276 | 4.000 |
| JIT2 | -1.192 | 1.352 | 4.3455 | 4.000 |
| JIT3 | -0.767 | -0.532 | 4.4182 | 5.000 |
| TPM1 | -0.524 | -0.225 | 3.8364 | 4.000 |
| TPM2 | -0.626 | 0.652 | 3.7455 | 4.000 |
| TPM3 | -0.182 | -0.232 | 3.8000 | 4.000 |
| TQM1 | -0.258 | -0.850 | 3.4909 | 4.000 |
| TQM2 | -0.604 | -0.392 | 3.7636 | 4.000 |
| TQM3 | -0.637 | -0.361 | 3.8545 | 4.000 |
| SCM1 | -0.662 | -0.113 | 3.6364 | 4.000 |
| SCM2 | -0.958 | 1.697 | 3.8000 | 4.000 |
| HRM1 | 0.424 | -0.279 | 3.4716 | 3.000 |
| HRM2 | 0.000 | -0.304 | 3.5000 | 3.500 |
| CRM1 | -0.665 | 0.445 | 4.2182 | 4.000 |
| CRM2 | -0.735 | 0.696 | 4.2545 | 4.000 |
| CRM3 | -0.257 | -0.568 | 4.2727 | 4.000 |

### 4.3. Descriptive analysis

Among 55 respondents in the survey, 52.7% of the respondents having less than 50 employees. 40% from the group are considered as medium size enterprise as they have 51 - 150 employees. 3.6% of the respondents consists 151 - 250 employees and another 3.6% are more than 250 employees. Besides, 20% of the respondents manufacture plastics, 30.9% are metal manufacturers, 9.1% produce electronic parts, 7.3% produce chemical products such as detergents and adhesive, 5.5% are paper manufacturers and 27.3% of the respondents manufacture other products such as furniture, food, labeling and coating. The mean and median for each question are also shown in Table 3.

### 4.4. Correlation analysis

Correlation Analysis is conducted to determine the strength of the relationships between the variables. Correlation between JIT1 and JIT2, JIT1 and JIT3, JIT2 and JIT3 are 0.348, 0.374 and 0.420 respectively. Correlation between TPM1 and TPM2, TPM1 and TPM3, TPM2 and TPM3 are 0.327, 0.397 and 0.697 respectively. There is a strong relation between TPM2 and TPM3 which can be due to safety

issues as maintenance tasks are safe to be conducted when the machines are not operating. Correlation between TQM1 and TQM2, TQM1 and TQM3, TQM2 and TQM3 are 0.871, 0.691 and 0.850 respectively. Correlations of TQM1 with TQM2 and TQM2 with TQM3 show a very strong relation. This phenomena can be due to the data of quality control is frequently recorded into statistical charts and used for improvement in the future. Correlation between SCM1 and SCM2 is 0.786. This strong relation can be explained by involvement of suppliers in the product designs may help to improve the quality of products. Correlation between HRM1 and HRM2 is 0.357. Correlation between CRM1 and CRM2, CRM1 and CRM3, CRM2 and CRM3 are 0.853, 0.574 and 0.646 respectively. The relation of CRM1 and CRM2 is very strong, the possible explanation is customers' feedback always include comments on product's quality, delivery and service performance.

### 4.5. Linear regression analysis

Linear regression analysis is used to determine the effects of all independent variables on the dependent variable. In general, significance value below 0.05 indicates an independent variable affects the dependent variable. Table 4 shows the relationship between dependent and independent variable with the respective significance value. SCM is related to JIT because the suppliers deliver materials based on JIT basis. The relation between TPM and TQM is significant, which can be explained by quality of products strongly depends on the condition of machine and tools in the production floor. SCM, HRM and TPM can affect sustainability of TQM as continuous improvement on the product's quality may require the involvement of supplier in the design stage as well as further research and development. Human resource also play important role for quality improvement as they can encourage employees to enhance knowledge in quality control and quality assurance. Significant relations can be seen in the linear regression of JIT and TQM to the implementation of SCM. The relation of TQM and HRM is significant, which can be explained by the duty of human resource in employee empowerment and provide additional training. CRM does not depend on any LM tools as the significance values are larger than 0.05.

**Table 4:** Results of linear regression

| Dependent Variable | Independent Variable | Significance Value |
|---|---|---|
| JIT | SCM | 0.003 |
| TPM | TQM | 0.002 |
| TQM | SCM | 0.046 |
| | HRM | 0.001 |
| | TPM | 0.002 |
| SCM | JIT | 0.003 |
| | TQM | 0.046 |
| HRM | TQM | 0.001 |
| CRM | - | - |

The possible explanation is whereby customers' feedback does not directly affected by other lean tools.

### 4.6. Factor analysis

Factor analysis is used to study the dimensionality of variables and classify them through data reduction method. As a general rule, numbers above 0.4 in the factor matrix is classified under one component. Table 5 shows the rotated factor matrix with 4 main factors for analysis. 4 components are related to the implementation of LM.

First component is "quality improvement". Top management should implement quality improvement on the products by identifying defective items, continuous monitoring and statistical charts to record data and develop better products. Quality improvement also requires the employees' knowledge to carry out quality control activities as well as enhancing the quality of products. Employee empowerment and additional training help to enhance quality improvement. Regular maintenance of machinery and tools in the production line ensures high quality products are produced all the time.

Second component can be known as "customer's management". From the point of view of customers, quality of the products can be defined in terms of reliability, durability and safety. Manufacturer can produce items that are more favorable in the market, which indirectly allow the manufacturer to stay competitive. Customers also concern about the serviceability of a product. On-time delivery, ease of getting repair and attitude of sales person contribute to the service performance of the products. Third component is known as "supplier management". Suppliers have to deliver good quality raw materials to the manufacturers. This is to ensure no rework and defective products in the production, which is the philosophy of LM. Involvement of supplier is highly recommended in the implementation of LM as supplier can provide opinions on product design and quality enhancement. Punctuality of material delivery is very important as manufacturers need to produce goods when there is customer order. Excess raw material in the storage is considered as waste in LM implementation.

Last component can be known as "maintenance". It explains the servicing of machinery and tools to control the quality of products. In LM implementation, TPM emphasize on preventative maintenance, corrective maintenance and maintenance prevention. Maintenance is encouraged to be carried out in daily basis and not only during machinery downtime. Machine availability is crucial for maximizing production of an organization. Besides, functionality of the machinery has to be user-friendly in order to ease servicing and maintenance.

**Table 5:** Rotated Factor Matrix

| | Factor | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| TQM2 | 0.962 | | | |
| TQM1 | 0.851 | | | |
| TQM3 | 0.841 | | | |
| HRM2 | 0.473 | | | |
| TPM1 | 0.472 | | | |
| HRM1 | 0.435 | | | |
| CRM2 | | 0.947 | | |
| CRM1 | | 0.900 | | |
| CRM3 | | 0.626 | | |
| JIT3 | | 0.474 | | |
| SCM1 | | | 0.766 | |
| SCM2 | | | 0.748 | |
| JIT1 | | | 0.629 | |
| JIT2 | | | 0.473 | |
| TPM3 | | | | 0.729 |
| TPM2 | | | | 0.678 |

## 5. Conclusion

The objective of this study is to identify the common lean tools in the manufacturing industry, construct survey and determine the effectiveness of lean tools to the organizations. By conducting survey, respondents' opinion regarding lean tools is recorded and it is used for data analysis. This survey data is reliable, supported by Cronbach's Alpha = 0.812. Another test is conducted to ensure the reliability by removing each survey question individually from the test. Results shown in Table 4.1 confirmed that the survey data is reliable. Hypothesis of this study is confirmed by normality analysis, which proves the relations of JIT, TPM, TQM, SCM, HRM and CRM are significant to the sustainability of LM. Table 3 shows that LM tools are strongly implemented in the manufacturing industry as the mean values are very close to the median of data. Mean value of JIT, TPM, TQM, SCM and HRM are slightly below the median while mean value of CRM is slightly above the median. Effectiveness of these LM tools is favorable because most of the organizations implemented LM.

Correlations between these lean tools are in the range of moderately strong to very strong relation. In linear regression analysis, JIT depends on SCM with the significance value of 0.003. TPM depends on TQM with the significance value of 0.002. TQM depends on SCM, HRM and TPM with the significance value of 0.046, 0.001 and 0.002 respectively. SCM depends on JIT and TQM with the significance value of 0.003 and 0.046 respectively. HRM depends on TQM with the significance value of 0.001. CRM does not depend on any LM tools as the significance values are larger than 0.05.

Factor analysis also shows that the common lean tools in the manufacturing share the similar properties, which has been classified to quality improvement, customers' management, suppliers' management and maintenance. Some elements in the lean tools overlap with each other's in the implementation of LM. Therefore, factor analysis reduces and groups the lean tools into 4 components. Organizations can focus on these 4 main areas whenever they wish to improve companies' efficiency and increase value of the products to the customers.

It is concluded that sustainability of LM is strongly affected by JIT, TPM, TQM, SCM, HRM and CRM.

## 6. Research limitation and recommendation

A total of 120 survey forms were distributed to the manufacturing companies, due to short period of research, only 55 respondents returned the survey forms. It is recommended to extend the duration of study. Among the population of manufacturing industry in Klang Valley and Penang, there could be certain amount of companies do not implement LM. To prevent survey bias, it is advised to increase the sample size and target survey on large companies since most of the companies approached in this study are Small Medium Enterprises. To enhance the accuracy of survey data, it is recommended to conduct survey with different departments within an organization since one respondent representing whole organization may cause survey bias. Besides, sustainability of LM can be further studied by investigating its effect on business performance.

## References

Alcaraz, J. L. G., Maldonado, A. A., Iniesta, A. A., Robles, G. C., Hernández, G. A. 2014. A systematic review/survey for jit implementation: mexican maquiladoras as case study. Computers in Industry 65, pp. 761-773.

Anvari, A., Ismail, Y. and Mohammad, S. 2011. A study on total quality management and lean manufacturing: through lean thinking approach. World Applied Sciences Journal, 12(9), pp. 1585-1596

Cornelison, P. 2013. The effectiveness of total quality management principles in the printing industry. California Polytechnic State University. pp. 1-66.

Erfan, O. M. 2010. Application of lean manufacturing to improve the performance of health care sector in libya. International Journal of Engineering & Technology, 10(6), pp. 110-120.

Feld, W. M. 2001. Lean manufacturing tools, techniques, and how to use them. Florida: CRC press.

Kilpatrick, J. 2003. Lean principles. Utah Manufacturing Extension Partnership. pp1-5.

Stamm, M. L., Neitzert, T. R. and Singh, D. P. K. 2012. Evolution of manufacturing methodologies under the paradigm shift from taylorism/fordism to toyotism? 16th International Annual EurOMA Conference. Sweden, 14-17 June, 2009, Sweden: AUT University.

Womack, J. P. and Jones, D. T. 2003. Lean thinking: banish waste and create wealth in your corporation. New York: Free Press.