A COMPARISON OF PROCESS IMPROVEMENT BETWEEN LEAN AND LEAN-SIX SIGMA APPROACH IN OUTBOARD PLANT

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Abstract

This paper describes approaches which are popular in manufacturing include Lean approach and Six Sigma approach. Lean approach can reduce wastes on process and develop continuous flow process. Furthermore, Six Sigma approach can reduce variability in process and reduce defects to a minimum. In the other hand, the combination of Lean and Six Sigma approach is interested in a few industries. Therefore, a comparison between Lean and Lean-Six Sigma in process improvement via an outboard motor plant which is continuous process is necessary to study for identity appropriate approach in organizations. In case study of outboard motor, the first approach to process improvement is Lean. An implementation Six Sigma to Lean had done for process improvement after that. Through the improvement, production efficiency, standard time and defect rate after process improvement by Lean approach were 92.56%, 106.29 seconds, 0.88% respectively and by Lean-Six Sigma approach were 93.55%, 102.74 seconds, 0.43% respectively.

Keywords: Process improvement, Continuous flow, Lean, Lean-Six Sigma

1. INTRODUCTION

In the present, there are high competitions in reducing production costs for the survival, such as reducing labor cost or raw material cost. The development is brought in organizations due to the sustainability of organizations. Also, both manufacturing and service industries provide many approaches to improve working performance. There are two approaches which are popular in manufacturing. They are Lean approach and Six Sigma approach. Advantages of Lean approach are process which occur continuous flow and reduce wastes. In the other hand, Six Sigma approach has advantages of development and improvement in quality part. Almost manufacturing plants choose one of two approaches for development but there are a few manufacturing plants to choose the combination of Lean approach and Six Sigma approach. Therefore, it is interesting in the comparison between applying two popular approaches and appropriate choosing one of two popular approaches.

The similarities of Lean approach and Six Sigma approach are focus on process

improvement. In the other hand, the differences are Lean approach emphasizes simple working for all level, improves continuous flow process and uses for investigating difficult cause but easily management. Six Sigma approach emphasizes bringing statistical tools to solve problems and uses for investigating easily root cause but difficult management because of fixed five steps.

Nevertheless, the disadvantage of Lean approach does not support in information or statistical tools for decision. In the other hand, the disadvantage of Six Sigma approach does not emphasis on continuous flow process because Six Sigma is considered to an only interesting on specific problem not the whole process. Therefore, the combination of Lean approach and Six Sigma approach as Figure 1 probably are more efficiency.

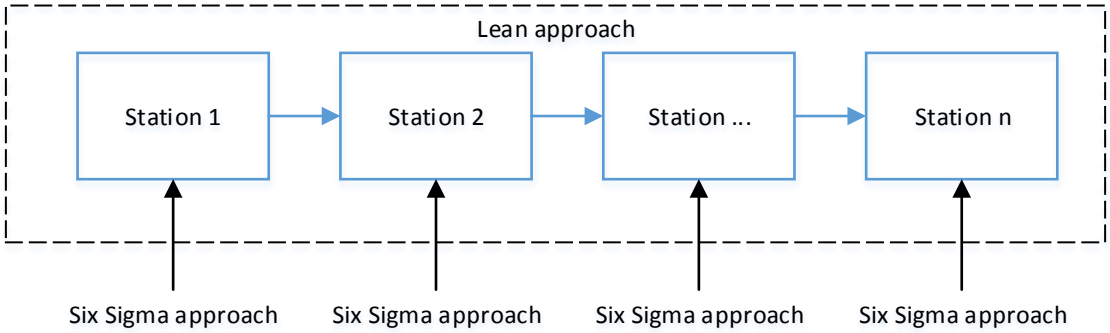

Figure 1: The combination of Lean and Six Sigma concept

1.1 Lean Approach

Lean approach focuses on investigation and eliminating 7 wastes (Hines et al., 2000) on throughout the whole process. In additional, it affects occurring continuous flow and smooth process in every department of plant such as designing department, purchasing department, manufacturing department, delivery, management during the day include communication between manufacturer and customer. As a result, it can reduce time, cost, increase profit and produce fit process for manufacturing and transportation, Moreover, an important on the implement of Lean approach does not use an instant tool but it is balance between concepts, activities and methods to improve the organization in the correct and appropriate direction.

7 Wastes (Hines et al., 2000) which is often used in Lean approach eliminate wastes or decrease wastes to a minimum by eliminating non-value added activities in process such as labors, machines, methods and materials. 7 wastes are

1. Overproduction
2. Inventory
3. Transportation
4. Motion

5. Processing
6. Delay
7. Defect

1.2 Six Sigma Approach

An apparent characteristic of Six Sigma approach is statistical perspective to reduce process variability and defects to a minimum. Six Sigma approach has clear timeframe, management for improving profits, setting the goal and analyzing the cause of defects which all of them is responded to the needs of customer. Six Sigma approach provides and applies a collection of various statistical tools to classify and to choose systematic tools leading to the perfection of the product and the satisfaction of customer. The one of Six Sigma approach advantages is the changing variable unit to performance indicator which is able to measure the successful. In additional, Six Sigma approach assault to produce produces, according to the needs of customer. In the other hand, produces which do not relate to the requirements of customer call defects. Moreover, Six Sigma approach can identify and measure the needs of customer by calculating level of defects, productions and production rate. Six Sigma approach has 5 phases (Cavanaugh et al., 2005) to operate as Figure 2.

1. Define phases
2. Measure phase
3. Analyze phase
4. Improve phase
5. Control phase

The strength of Six Sigma approach is Six Sigma staff teams (Pyzdek, 2003) who work mainly on the Six Sigma project and has a skill of Six Sigma for process improvement. Moreover, Six Sigma staff teams can use almost time to manage problems of projects lead to a short time of completing project.

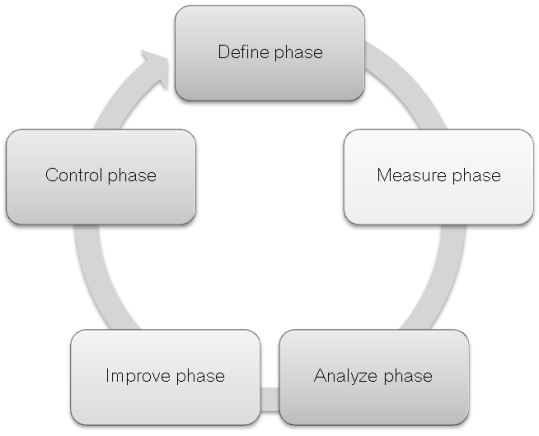

Figure 2: DMAIC phase

1.3 Lean-Six Sigma Approach

Lean-Six Sigma which is the combination of Lean approach and Six Sigma approach is approach which brings advantages of two approaches (Lean and Six Sigma) to improve process. The benefit of Lean approach can produce fit process of manufacturing and transportation. Furthermore, advantages of Six Sigma approach are the development and improvement in a part of quality and use statistical tools for investigating defects. Moreover, both Lean approach and Six Sigma approach emphasis on customers.

In a part of practice, Lean approach is brought to standard and Six Sigma approach is brought to solve the problem and to reduce variability in manufacturing process as Figure 1. Although Lean approach and Six Sigma approach have different concept and different method, using both Lean approach and Six Sigma approach can solve problems together and occur new approach to manage problems.

2. LITERATURE REVIEW

2.1 Literature Review of Lean Approach

Toni L. Doolen and Maria E. Hacker (2005) studied and explored tools for Lean approach which can be applied for organization which succeeded in applying Lean approach to many factories. The selection of correct tools was studied in a case study of an electronic factory at Northwest pacific. In this case studies, there were studying 7 tools which have differently to indicate the appropriate different conditions.

Jan Riezebos, Warse Klingenberg, Christian Hicks (2009) studied the theory of Lean approach which was able to apply for manufacturing and service industries. It helped organizations to compete manufacturing, quality and service. This case study is a combination of Lean approach and Information technology (IT) in many fields such as logistic topic, manufacturing management and advanced maintenance.

Tarcisio Abreu Saurin, Cle´ ber Fabricio Ferreira (2008) studied the effects of Lean approach under different condition in an agricultural machinery factory, Brazil. There were data, including qualitative data for lean manufacturing, the interview of safety specialists, safety engineers and safety operators. The implementing questionnaire for operator provide for analyzing current condition and comparing differentiation between old system and new Lean system. There were 4 working groups include manufacturing, the continuous development, healthy and safety.

Fawaz A. Abdulmalek, Jayant Rajgopal (2006) studied about Lean approach on the working process of a metal process plant implemented value steam mapping to indicate what value added activities, non-value added activities and non-value added activities but necessary are. Furthermore, this journal explained simulations for comparisons between before

improvement and after improvement in many key performance indicators such as reducing lead time and reducing waiting time.

2.2 Literature Review of Lean-Six Sigma Approach

D. Eberts, R. Rottnick et al. (2012) studied the continuous flow process of raw material in semiconductor industries and managed the productive flow of organizations. Applying a Lean approach and a Six Sigma approach implemented to identified root causes, classified problems, investigated problems, increased the reliability of transportation, reduced and eliminated problems in product time, inventory.

Abdul Talib Bon, Norhayati Abdul Rahman (2005) studied about companies which emphasized on manufacturing and provided Lean-Six Sigma approach to managed wastes on production area. Moreover, they improved quality of products for a delivery to customers which without defects and increased productivity by using control chart for comparison.

Siddhartan Ramamoorthy (2007) studied an assembly line of upper main door of jet aircraft for business class in an aircraft industry. This case study is showed about an applying of a Lean and a Six Sigma in analyzing value steam mapping and identifying problems to solved a problems. In additional, process improvement used DMAIC step and objectives of this review were supplying raw material to assembled and prepared time scheduling in working.

3. CASE STUDY

Under investigation was an example to assembly line of outboard motor plant in part of final assembly process. This process is continuous labor-intensive assembly line. Final assembly process had 11 stations and 14 operators. Furthermore, problems of manufacturing process and plant layout affected to loss time for transportation during production led to transportation wastes, motion wastes and waiting. Moreover, the defects in process would be totally reworked not rejected due to high sale price. Consequently, rework activities caused non-value added activities and loss times.

Process improvement via Lean approach used indentifying and eliminating 7 wastes. After that, measurements after improvement of Lean which compared with before improvement had done for three months. In additional, Lean-Six Sigma approach which it added Six Sigma in process used 5 methods (DMAIC method) and chose the Six Sigma staff team for improvement. After that, measurements after improvement of Lean-Six Sigma which compared with before improvement and after improvement of Lean had done for three months. Methodology method of case study followed by

1. To study current condition and to set the objectives and scope of case study.
2. To study literature reviews and related theories.

3. To study assembly line of outboard motor plant and to collect information for analyzing.
4. To analyze root causes of the problem and to find process improvement method.
5. To improve process by Lean approach and to measure data.
6. To improve process by Lean-Six Sigma approach and to measure data.
7. To compare results of Lean approach and Lean-Six Sigma approach.

Therefore, process improvement by Lean approach had done about reducing 7 wastes to a minimum. As a result, production efficiency, standard time and defect rate after process improvement by Lean approach were 92.56%, 106.29 seconds and 0.88% respectively as Table 1. In the second approach analysis, process improvement by Lean-Six Sigma approach which had done from Lean approach plus Six Sigma approach. As a result, production efficiency, standard time and defect rate after process improvement were 93.55%, 102.74 seconds and 0.43% respectively as Table 1. In the other hand, before improvement had production efficiency, standard time and defect rate were 72.88%, 144.96 seconds and 1.64% respectively as Table 1.

Table 1: results of each approach

	Before	After Lean	After Lean-Six Sigma	unit
Total time	1437.09	1375.15	1344.68	seconds
Standard time	144.96	106.29	102.74	seconds
Station	11	11	11	Station
Total activity	82	76	74	Activities
Value added activity	33	35	34	Activities
Productivity	198	270	280	Machines/day
Production efficiency	72.88%	92.56%	93.55%	percent
Defect rate	1.64%	0.88%	0.43%	percent

4. DISCUSSION

Duration of this case study had been 11 months. At the beginning of the time, there were studies a condition of outboard motor and literature reviews. Then, at the end of fifth month, a researcher planned methods to process improvement of Lean approach and Lean-Six Sigma approach. After that, process improvement of Lean approach implemented to the plant and had measured for three months. At ninth month, process improvement of Lean-Six Sigma approach implemented to the plant and had measured for three months.

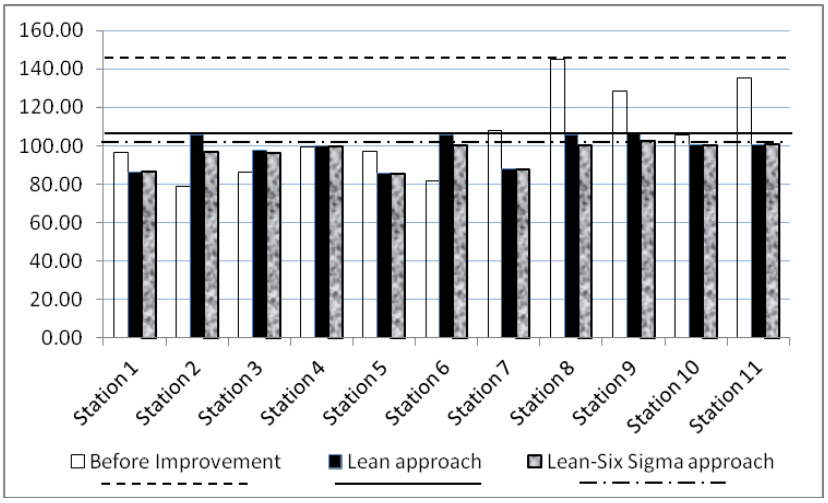

Figure 3: comparative of standard time (second)

This results need to be analyzed in key performance indicator, including production efficiency, standard time and defect rate of Lean approach and Lean-Six Sigma approach. The first of all, product efficiency before improvement was 72.88%, after Lean approach, product efficiency increases to 92.56% and after Lean-Sig Sigma approach increases to 93.55%. Moreover, process improvement in product efficiency index by Lean approach and Lean-Six Sigma approach compare before improvement increase significantly 27.00% and 28.36% respectively but process improvement in product efficiency index from Lean approach to Lean-Six Sigma approach increases slightly 1.07% as Table 2. Consequently, process improvement by Lean approach is significantly better than before improvement. In the other hand, Lean-Six Sigma approach is slightly better than Lean approach.

Table 2: Comparison between key performance indicators

	Lean	Lean-Six Sigma	Lean to Lean-Six Sigma
Total time	4.31%	6.72%	2.22%
Standard time	26.68%	39.72%	3.34%
Production efficiency	27.00%	28.36%	1.07%
Defect rate	46.34%	73.78%	51.14%

The second is standard time as Figure 3, before improvement was 144.96 seconds, after Lean approach, standard time decreases to 106.29 seconds and after Lean-Sig Sigma approach decreases to 102.74 seconds. Moreover, process improvement in standard time index by Lean approach and Lean-Six Sigma approach compare before improvement decrease significantly

26.68% and 39.72% respectively as Table 2 but process improvement in standard time index from Lean approach to Lean-Six Sigma approach decreases marginally 3.34% as Table 2. Consequently, process improvement by Lean approach is significantly better than before improvement. In the other hand, Lean-Six Sigma approach is slightly better than Lean approach in standard time index.

Lastly, defect rate before improvement was 1.64%, after a Lean approach, defect rate decreases to 0.88% and after a Lean-Sig Sigma approach decreases to 0.43%. Moreover, process improvement in standard time index by a Lean approach and a Lean-Six Sigma approach compare before improvement decrease significantly 46.34% and 73.78% respectively as Table 2. In additional, process improvement in defect rate index from a Lean approach to a Lean-Six Sigma approach also decreases substantially 51.14% as Table 2. Consequently, process improvement by a Lean approach and a Lean-Six Sigma approach are significantly better than before improvement in a term of defect rate. Nevertheless, defect rate calculate to volume of defect has low volume

5. CONCLUSION

Process improvement results by Lean approach which is implemented for continuous flow process can decrease substantially standard time and defect rate and increase significantly production efficiency. As a result, Lean approach can be confirmed for appropriate approach of continuous flow process improvement. In other hand, Lean-Six Sigma approach which compares with Lean approach results slightly more positive. The result of Lean-Six Sigma approach compared to Lean approach develops slightly because they are overlapped and Six Sigma approach mainly focuses on only specific problem not the whole process. Nevertheless, a benefit of Six Sigma approach is the Six Sigma staff team mainly responsible for improvement

Nevertheless, the main advantage of Six Sigma is full responsibility assigned to the team which should be a part of Lean Approach.

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