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# Applying Lean Principles, Tools and Techniques in Set Parts Supply Implementation

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***Abstract*****—**Lean, which was initially developed by Toyota, is widely implemented in other companies to improve competitiveness. This research is an attempt to identify the adoption of lean in the production system of Malaysian car manufacturer, Proton using case study approach. To gain the in-depth information regarding lean implementation, an activity on the assembly line called Set Parts Supply (SPS) was studied. The result indicates that by using lean principles, tools and techniques in the implementation of SPS enabled to achieve the goals on safety, quality, cost, delivery and morale. The implementation increased the size of the workspace, improved the quality of assembly and the delivery of parts supply, reduced the manpower, achieved cost savings on electricity and also increased the motivation of manpower in respect of attendance at work. A framework of SPS implementation is suggested as a contribution for lean practices in production system.

***Keywords*****—**Assembly line, lean manufacturing, production, parts supply.

## I. Introduction

LEAN has been successfully implemented in various companies of manufacturing and services [1]-[2] . It has been accepted as a multi-dimensional approach with a set of principles, tools and techniques to drive down the manufacturing cost through identifying and eliminating waste [3]-[4]. The implementation of lean is transferred across organizational boundaries from mature countries to developing countries [5]-[6]. However, the implementation is not a simple task as it is multi-facetted requiring the integration of principles, tools and techniques that can be visualized to deliver more value along the business process flow.

This study is concentrated on a new system in lean production system which is called Set Parts Supply (SPS). SPS was introduced by Toyota as a system to overcome the huge parts variants [7]. The main concept in SPS is to separate the task of assembling parts to the car body on the assembly line and the task of searching, reaching and picking parts from component racks on the line-side assembly line [8]. The set of parts were put on the SPS trolley and the trolley was pushed to the assembly line. In the conventional system, the assembly manpower will do all the tasks, but in SPS, other manpower will do the searching, reaching and picking task while the assembly manpower only concentrate on assembling parts to the car body.

Reports of SPS implementation in Toyota and several industries shows that SPS can be very beneficial to the industries in terms of space utilization, time reduction and improve quality [7], [9]-[11]. However, according to Nomura [8], SPS has its own demerit because more operators have to be hired for task of searching, reaching and picking. In addition, this system will create a non-multi-tasking manpower with less experienced on assembly line [12].

In order to fill the research gap on the debate around SPS implementation, it led us to explore on how SPS has been implemented in Malaysian automotive industry, Proton which adopted lean in the production system called Proton Production System (PPS). As a new system in lean, it must probably many areas to be concerned such as on the area of how the lean principles, tools and techniques are applied in the SPS implementation.

Therefore, this research is important to gain a greater understanding on the adoption of lean production system with the practiced of SPS implementation. In the remainder of the paper, first we choose to concentrate on how lean is implemented in the Proton Production System (PPS). Second, the study focuses on how lean principles, tools and techniques have been applied in the SPS implementation and at the end of this paper, a framework of SPS implementation is proposed to highlight the lean principles, tools and techniques in SPS.

## II. Methodology

This research used a case study method to allow researchers to gain the experience of empirical enquiry and intensive analysis of real-life situations. According to Yin [13], the case study is suitable to answer the ‘how’ and ‘why’ question to find the explanation of a business process and a specific phenomenon under investigation.

The case study was conducted in Proton Tanjong Malim assembly plant in the trim and final shop. The data collection was gathered through observation, interview and official document review. One of the researchers was attached to the Industrial Engineering Department to observe and gain in-depth information regarding the SPS implementation in PPS for a three months period.

Historically, Proton had a very close relationship in terms of technical partners and supplier from Mitsubishi Corporation and Mitsubishi Motors Corporation. This relationship

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facilitated the influences of Japanese values, terms and principles to the production system [14].

## III. Results and Discussion

### A. Proton Production System (PPS)

To cope with the volatile customer and competitive global market, the adoption of lean in PPS is important to remove or eliminate waste in daily activities to keep the production running efficiently. To transform the production system with lean adoption, there are four steps which are fundamental to PPS: (a) visual management and philosophy (b) stable and standardize process (c) Just In Time (JIT) and *Jidoka* (automation with a human touch) and (d) *Kaizen* or also known as continuous improvement.

The first step is to visualize the production activities through *Genba Kanri* (GK) which means shop floor management. GK is used to educate the manpower to manage and find the 'real situation' on the shop floor. It also encourages a *Gemba* (actual place) walk to identify the non-value-added while walking through the plant. In PPS, GK contains eight key areas with 17 lean tools and techniques used to maintain, control and improved the shop floor management. The first area is *Hoshin Kanri* which means policy management used to set goals and targets to align the company for a better level of performance through continuous improvement. GK also contains 5S for safety workplace, standard operation, job allocation, skill training, continuous improvement, Total Quality Management (TQM) and Total Productive Maintenance (TPM).

The second step is to create a stable and standardized process using lean tools and techniques such as time study, motion study, *Yamazumi* Chart, line balancing, First In First Out (FIFO), Value Stream Mapping (VSM) and production levelling. This step is important to establish the process and organized work to become the baseline for continuous improvement.

The next step is the implementation of JIT and *Jidoka*. JIT with the *kanban* system is used to pull the inventory through production based on customer demand. *Kanban* which means visual card is used as a signal control to replenish the required quantity. *Jidoka* is the term that used to aware the manpower of the abnormal situation on the shop floor. It used the *andon* device at every assembly line as a visual control indicator to show the line, machine or process status such as *andon* light, *andon* board and *andon* cord.

Lastly, the kaizen activities are implemented continuously with never ending process includes the *Genchi Genbutsu* activity which means go and see the actual problem. To solve the problem occurred while kaizen activities, the 5-Why Analysis, Plan-Do-Check-Act (PDCA) cycle and Ishikawa (fishbone) diagram are practiced in teamwork.

### B. Set Parts Supply Implementation

The SPS implementation in Proton is an activity of avoiding the unsystematic shop floor management which fulfills the desired goals of best safety, high quality, lowest cost, shortest lead time, and high morale which have been adopted from lean production system. It was done with the application of lean principles, tools and techniques as practiced in PPS.

From this case study, the *Gemba* walk was the first activity to visualize the waste that occurred on the production line. It is an activity on the real place which creates value in the production system through focusing on eliminating waste and determine on how the production process can be improved. After that, the activity of *Genchi Genbutsu* was done where the project members go and see the problem at the ground to find the facts and real information. The technique of 5-Why Analysis was used to find the root cause of the problems.

From the analysis, the SPS was implemented to solve the failure of reaching the exact parts within the cycle time due to the huge variants of parts on the component racks. The PDCA cycle was used to implement the solutions and ideas to solve the problems.

In order to improve the throughput of assembly line, the line balancing was done with the activities of time study, motion study and the *Yamazumi* chart. The *Yamazumi* chart showed the balance of cycle time within the work process with the comparison of the required takt time and the number of operators.

In the SPS implementation, the parts on the component racks were sorted and categorized for regular use, rarely use and the parts are removed if not used by using 5S concept which consists five steps; Sort, Set, Shine, Standardize and Sustain. The visual control cards or part tags were used to place everything in order. The parts and the equipments must be cleaned. Therefore, the good quality parts can easily be reached by the manpower. The shine step was also applied to manpower with the safety and good quality of tools and corrects clothing.

The development and fabrication of lean racking were done as a kaizen effort to improve the performance of assembly line. The types of lean racking are

1) Component racks for parts replenishment.
2) SPS trolleys for supplying a set of parts to assembly line.
3) Small parts racks for placed the screws, nuts, clips and caps.

The lean principles, tools and techniques were applied during this stage such as *poka-yoke*, FIFO and synchronization to get a slim, compact and flexible design for space utilization and proper ergonomic. The concept of 'parts only' as a visual control also used to get better result in preparing the parts on the lean racking which resulted on the reduction of container usage.

To achieve the JIT production, pull system was applied to manage the parts flow on the component racks. The system started when the manpower of searching, reaching and picking task which is called the shopping man achieve an instruction to prepare parts for the upcoming car body. Every part that used for assemble to the car body along the assembly line is put together in the SPS trolley. The sets of parts on the SPS trolley are synchronized with the car body on the assembly line.

The SPS trolley then moves to each workstation at the same time the car body arrives at the workstation. The sets of parts are supplied to the assembly line Just In Time. The assembly manpower takes the needed parts and concentrates on assembling parts to the car body. This situation resulted in a decrease of rejected quantities due to assembly process. It is also increased the quality of assemble and reduced the cycle time for assemble parts.

Table I shows the results before and after SPS implementation.

TABLE I
RESULTS BEFORE AND AFTER SPS IMPLEMENTATION

| Item | Before SPS | After SPS |
|---|---|---|
| Workstation<br>LHS (left hand side) :<br>RHS (right hand side) | 19:19 | 11:11 |
| Length of assembly line | 55 m | 38 m |
| Distance of components racks to conveyor hanger | 1.5 m | 3 m |
| Manpower | 32 | 30 |
| Lead Time | 1217.88 s | 1089.12 s |
| Downtime - Maintenance of turning device (LHS & RHS) | 180 s x 2 = 360 s | 0 s |

The results above show that sixteen workstations on the assembly line were closed (eight workstations at the left hand side (LHS) and eight workstations at the right hand side (RHS)) which saved the cost of electricity for 40 lamps and the blower fan, which totals about 22.3 kW. After implementation of SPS, the results indicate that the distance of the component racks to the conveyor hanger was increased which made the workplace wider and safer. The lead time of assemble process also decreased after the assembly manpower only concentrated on assembling parts to the car body.

The SPS implementation also built up the morale and motivation of the manpower by increasing the attendance by 3.7 per cent in the four-month period. The turning device on the assembly line which involved in SPS implementation was eliminated. As a result, the downtime due to maintenance of the mechanical failure was decrease from 360 s to 0 s.

Based on the case study of SPS implementation in PPS with the support from the literature review on lean principles, tools and techniques, the framework of SPS implementation has been proposed in the next section.

## IV. FRAMEWORK FOR APPLICATION OF LEAN PRINCIPLES, TOOLS AND TECHNIQUES IN SPS IMPLEMENTATION

The framework is suggested as a guideline to support the ideas and practices of lean principles, tools and techniques in implementing SPS system. It is a conceptual structure to explain the approach or method of doing a research study based on the research issue, experience and practical of the issue [15]. The framework also is proposed as a way of communication to explain a set of concepts and ideas that can be used as a guideline to others [16].

The proposed framework as shown in Fig. 1 contains six criteria which are goals and foundation as the basis of lean production system, and the four stage of SPS implementation process; problem finding, problem solving, data gathering and equipment/fabrication which come along with the foundation to achieve the goals.

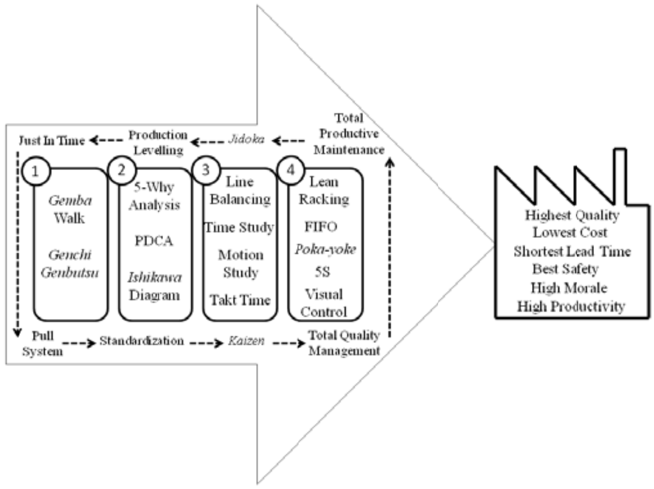


Fig. 1 Framework of SPS implementation in lean production system

### A. Goals

Each manufacturer should have their goals and objectives to drive the organizational success. In measuring the manufacturing performance, the most common dimensions to be measured are quality, cost, delivery (lead time), safety, morale and productivity [17]-[19]. The lean production system has been adopted by many manufacturers to facilitate for highest quality, lowest cost, best safety, high morale, shortest lead time and improve productivity. The adoption of lean in the production system is a way of creating more value with less resources such as people, capital, cost, space and time on each task and activity by eliminating waste systematically along the process of implementation.

### B. Foundation

The application of lean principles, tools and techniques such as JIT, pull system, production levelling or also called *heijunka*, standardization, *kaizen*, *Jidoka*, TQM and TPM are conceptually and practically well established in lean production system [20]-[26]. JIT and *Jidoka* are frequently modeled as two main principles in Toyota Production System which contribute to stockless production and to ensure the quality is maintained along the production process flow [3]. The pull system and production levelling are the pre-requisite for JIT principle as there used to control the inventory and level the customer demand at a constant rate. JIT is also supported with the *kanban* system as a signal of inventory level on the assembly line for parts replenishment. *Jidoka* is supported by *andon* as a visual control to avoid the abnormal situation in the production area.

The standardization becomes the best way to simplify and organized work for *kaizen* or continuous improvement. For equipment management and preventive maintenance, TPM is used as a system that gives the responsibility and awareness to avoid unnecessary equipment failures and eliminate losses in production activities with the total commitment among organizational functions and employee involvement. TQM is also considered as a main principle to achieve the customer satisfaction and production performance especially related on quality, cost, safety and delivery of the product.

All the lean principles, tools and techniques which considered as a foundation in the production system are come along with the four stages of SPS implementation to achieve the organizational goals and objectives.

### *C. Stage 1 – Problem Finding*

The SPS implementation begins with the *gemba* walk as a lean technique to find the problems or waste on the assembly line. *Genchi Genbutsu* or Go See is useful to identify the real problems on the shop floor especially for the management level to understand the real facts on the real place of work and help to improve the problems.

### *D. Stage 2 – Problem Solving*

In lean production system, the techniques of problem solving are used to identify the root cause of the problems and systematically solve the problem. The lean techniques that used in problem solving are 5-Why Analysis, PDCA cycle and *Ishikawa* diagram.

### *E. Stage 3 – Data Gathering*

The third stage of the SPS implementation framework is important to get the data on the cycle time, takt time, time study and motion study to balance the workload on the assembly line in *Yamazumi* chart.

### *F. Stage 4 – Equipment/Fabrication*

The concepts of FIFO, *poka-yoke*, visual control and 5S must be considered in the fabrication and the arrangement of lean racking for component racks, SPS trolleys and small parts racks.

## V. Conclusion

The implementation of SPS brings benefits for manufacturers to improve production performance. It is also used to increase the quality of assemble and reduce the cycle time for assemble parts. The delivery of parts became smooth because the set of parts were ready before it arriving at the workstation. The reduction of manpower, workstation, lead time and the improvement of workplace management will facilitate to the reduction of cost and increase the motivation of manpower. While implementation of SPS using lean principles, tools and techniques resulted improvement in the production system, this study also provide valuable facts regarding the adoption of lean from Japanese value in PPS. The proposed framework was suggested by using lean principles, tools and techniques as a guideline to implement SPS in lean production system.

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## References

[1] T. Melton, "The Benefits of Lean Manufacturing: What Lean Thinking has to Offer the Process Industries," Chemical Engineering Research and Design, vol. 83, no. 6, pp. 662-673, 2005.

[2] S. Bhim, S. K. Garg, S. K. Sharma, and G. Chandandeep, "Lean implementation and its benefits to production industry," International Journal of Lean Six Sigma, vol. 1, no. 2, pp. 157-168, 2010.

[3] J. K. Liker, The Toyota Way. New York: McGraw-Hill, 2004.

[4] R. Shah and P. T. Ward, "Defining and developing measures of lean production," Journal of Operations Management, vol. 25, no. 4, pp. 785-805, 2007.

[5] R. J. Schonberger, "Japanese production management: An evolution--With mixed success," Journal of Operations Management, vol. 25, no. 2, pp. 403-419, 2007.

[6] N. Nordin, B. M. Deros, and D. A. Wahab, "A Survey on Lean Manufacturing Implementation in Malaysian Automotive Industry," International Journal of Innovation, Management and Technology, vol. 1, no. 4, pp. 374-380, 2010.

[7] Y. Monden, Toyota Production System: An Integrated Approach to Just In Time, Fourth ed. New York: CRC Press, 2011, pp. 271-274.

[8] T. Nomura, "Set Parts Supply System in Guangzhou Toyota [in Japanese]," Bulletin of the Kagoshima Prefectural Jr. College. Cultural and social science, vol. 59, no. pp. 17-29, 2008.

[9] Y.-c. Wang, L.-f. Wang, Z.-y. Xu, and G. Yang, "IE is the accelerator of economic growth mode transformation of autonomous vehicle," in 17Th International Conference Industrial Engineering and Engineering Management (IE&EM), 2010, pp. 759-765.

[10] S. Deechongkit and R. Srinon, "Three Alternatives Approaches of Material Supply in Assembly Line: A Comparative Study," presented at the Asia Pacific Industrial Engineering & Management System, Kitakyushu, Japan, 2009.

[11] H. Noguchi, "A new mixed flow production line for multiple automotive models at Tsutsumi plant (in Japanese)," Factory Management, vol. 51, no. 1, pp. 16-33, 2005.

[12] A. Smalley. (2009, 1 December). Toyota's New Material-Handling System Shows TPS's Flexibility. Available: http://www.leaninstituut.nl/publications/1106/ToyotaNewMaterialHandlingSystem.pdf

[13] R. K. Yin, Case Study Research: Design and Methods, 4th ed. Thousand Oaks, CA: Sage Publications, 2009, pp. 8-23.

[14] R. Abdullah, K. Jusoff, Z. Ahmad, and Y. Takahashi, "The Japanese Influence in Malaysian Automotive Industry: Human Resources Management and Development Practices," Management Science and Engineering, vol. 3, no. 4, pp. 59-70, 2009.

[15] S. Leshem and V. Trafford, "Overlooking the conceptual framework," Innovations in Education and Teaching International, vol. 44, no. 1, pp. 93-105, 2007.

[16] B. M. Deros, S. r. M. Yusof, and A. M. Salleh, "A benchmarking implementation framework for automotive manufacturing SMEs," Benchmarking: An International Journal, vol. 13, no. 4, pp. 396-430, 2006.

[17] S. Bhasin, "Lean and performance measurement," Journal of Manufacturing Technology Management, vol. 19, no. 5, pp. 670-684, 2008.

[18] V. Ramesh and R. Kodali, "A decision framework for maximising lean manufacturing performance," International Journal of Production Research, vol. 50, no. 8, pp. 2234-2251, 2011.

[19] R. Gapp, R. Fisher, and K. Kobayashi, "Implementing 5S within a Japanese context: an integrated management system," Management Decision, vol. 46, no. 4, pp. 565-579, 2008.

[20] D. Seth and D. Tripathi, "Relationship between TQM and TPM implementation factors and business performance of manufacturing industry in Indian context," International Journal of Quality & Reliability Management, vol. 22, no. 3, pp. 256-277, 2005.

[21] R. Shah and P. T. Ward, "Lean manufacturing: context, practice bundles, and performance," Journal of Operations Management, vol. 21, no. 2, pp. 129-149, 2003.

[22] I. P. S. Ahuja and J. S. Khamba, "Total productive maintenance: literature review and directions," International Journal of Quality & Reliability Management, vol. 25, no. 7, pp. 709-756, 2008.

[23] Y. Sugimori, K. Kusunoki, F. Cho, and S. Uchikawa, "Toyota production system and kanban system materialization of just-in-time and respect-for-human system," International Journal of Production Research, vol. 15, no. 6, pp. 553-564, 1977.
[24] S. Sakakibara, B. B. Flynn, R. G. Schroeder, and W. T. Morris, "The Impact of Just-in-Time Manufacturing and Its Infrastructure on Manufacturing Performance," Management Science, vol. 43, no. 9, pp. 1246-1257, 1997.
[25] A. Hüttmeir, S. de Treville, A. van Ackere, L. Monnier, and J. Prenninger, "Trading off between heijunka and just-in-sequence," International Journal of Production Economics, vol. 118, no. 2, pp. 501-507, 2009.
[26] P. G. Ranky, "Eighteen “monozukuri-focused” assembly line design and visual factory management principles with DENSO industrial examples," Assembly Automation, vol. 27, no. 1, pp. 12-16, 2007.

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