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Application of Lean Manufacturing System: a Case Study of Control Cable Manufacturing

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***Abstract*— This paper proposes the application of lean manufacturing system to improve the efficiency and reduce the wastes in the control cable process in the automotive industry. With the improvement of the bottleneck process and the balancing of the workflow of the process by considering the material flowchart, the process was improved and verified. The proposed workflow is developed based on the concept of lean manufacturing and the improvement in terms of more continuous flow can be achieved. As results indicated, the productivity of the studied process was increased by 33 percent and the waste was reduced to 0. In addition, the process inventory can be reduced to 0.**

***Index Terms*— Lean manufacturing management, waste, the control cable in automotive manufacturing**

I. Introduction

IN Thailand, the automobile industry is one of the most important clusters leading to more than 7 billion Baht per year of the export value, and the number of employees in this cluster is approximately 8 percent of the total employees in the country. The control cable for automobile is one of the most important parts in automotive manufacturing due to the values of the export are greater than one billion Baht per year. Generally, the manufacturing of this product is categorized as the mixing of the continuous process and job shop process. Most processes in this manufacturing still use many labors/operators leading to lower productivity and higher waste costs. There are many researchers attempted to develop and apply the lean manufacturing management system to improve the productivity and cost in the production line. In [1], Anand and Rambabu proposed the results of using Lean tool to improve the production process of the ABC Company, XYZ Section, which the product of this company is the PVC window and door. For their results, the production period of the process was improved from 360,864 to 41,764, and the value added time was improved from 1476 seconds to 740 seconds. As seen in their result, the process is significantly improved.

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Lorna [2] illustrated the study of process improvement of the pharmaceutical company, which the simulation of the process was based on the program simulation model, Siman based interface. This tool is useful for simulating the enhancements prior to actual implementation.Weixia and Jiwen [3] studied the improvement in pipe production process using the program I Grafix. As shown in their results, the process has been improved by 29.5% in terms of efficiency. Fabian and Marko [4] proposed the use of Lean management to improve the team management by collecting data into the software. Kamolrat and Natcha [5] proposed the waste reduction by lean six sigma approach for improving the micro cable manufacturing. The results showed the effectiveness of applying Lean in this manufacturing.

This research work focuses on the improvement in the control cable production line in the automotive parts manufacturing, Thai Steel Cable which is the largest company in the control cable manufacturing in Thailand. From the company's production report, the capability of the process is 48,000 pieces per month; however, the demand from the customer is 62,449 pieces per month, thus either the new production line or process improvement needs to be considered. Adding the new production line requires the investment cost and new operators leading to the higher product cost; thus, the process improvement is a more attractive way of the company's plan. In engineering aspect, the improvement by reducing waste, i.e. the fatigue of the operator, slow cycle time, etc. in the process will increase the productivity and reduce the production cost, and the lean management system can help to achieve these objectives by reducing the lead time of the production. Lean concept attempts to remove or shorten the process flows, organizations leading to the reduction of the production cost and reducing the lead time. Therefore, there are many researchers and industrial engineers in various industrials apply this concept for solving the manufacturing problem. In this paper, the application of lean for the control cable manufacturing process is demonstrated to solve the problem of low capability of the production line.

II. Literature review

Lean concept is a system tool for eliminating the wastes or non-value added in the business process and create a new business flow for the manufacturing/company. Through the lean method, the company can optimize their profit and achieve the lower resource leading to the minimum cycle time, lead time and inventory. In addition, the profit, morale, customer satisfaction and accident records in the company will then be improved. "Lean" has been defined as a systematic approach to identify and eliminate the waste through the concept of continuous improvement. Lean focuses on the value added flow of resources from the customer's point of view. To compete in today's economy, with lean, a company will be better than its competitors. Lean emphasizes on the elimination of waste that results in higher customer satisfaction, profitability, throughput, and efficiency. Jacobs and Chase [6] stated that "Lean production" is an integrated set of activities designed to achieve production using minimal inventories of raw materials, work-in-process, and finished goods. Parts arrive at the next workstation "just in time" and are completed and move through the process quickly. Lean philosophy is also based on the logic that nothing will be produced until it is needed.

The principle or philosophy of the lean concept is the ways to identify and eliminate waste to enhance the processes and products with the customer requirement and creating a system to pull in the process to ensure a continuous flow of processes, and improve continuously to enhance their processes and products regularly to eliminate waste in the production process. There are 8 types of waste that need to be considered in Lean concept.

1. Over Production: Overproduction occurs when the goods have been produced more than the demand from the customers. One common practice that leads to this waste ("muda") is the large batch production. Overproduction is considered as the worst waste because it hides and/or generates all the other wastes. Overproduction leads to the excess inventory and the large storage space and preservation those are the most disadvantages.

2. Waiting: When the goods are not transferred or being struck at the production process.

3. Transportation: When the product is moved, it leads to the risk of damage, lost, delay, etc. Thus, the transportation is one type of the wastes in lean concept.

4. Over-Processing: Over-processing is defined as the time more work is carried out while the customer does not require.

5. Inventory: There are many forms of inventory such as raw materials, work-in-progress (WIP), or finished goods. These three items not being actively processed is accounted as waste.

6. In contrary, with the transportation, waste, "*motion*" refers to the waste that caused from either over time (wear and tear of the equipment and for workers) or during discrete events (accidents that caused damage to the equipment).

7. Defects: This causes the extra costs, rescheduling production, labor costs, etc.

8. Losses from the full potential of the personnel is not carried out to provide the organizations with maximum efficiency.

Based on the waste mentioned above, the principle of the lean concept to deal with the minimizing waste can be summarized as follows:

1. Specify the value from the customer need by product family.

2. Identify all steps in the value stream of each product family, eliminating the values which do not create the value.

3. Add the value-creating steps in tight sequence so that the product will flow smoothly toward the customer.

4. As the new flow is introduced, he customers can provide to put the value from the next upstream activity.

5. If the value and the value streams are identified, wasted steps are removed, go to the step 1 again and continue analyze them until the perfect flow/process is achieved.

III. Research Methodology and Implementation

To perform the lean analysis, the following steps were carried out.

1. Survey the current state of the production line, identify and put the value of each step.

2. Analyze the process.

3. Try to improve the process using the software analysis.

4. Summarize the results.

The following issues describe the details of each step including the result and simulation software.

A. Survey the current state of the production line

The preliminary survey starts from the study of the sources of 8 wastes in the interesting process, the control cable car. The interesting parameters are the flow chart to know the entire process, including the bottleneck, defects, and machine performance to reduce waste from the manufacturing process. Based on the survey data, the control cable production process has the lead time of 14.86 days, this long lead time is caused by the preproduction process 2.5 days, assembly process 0.5 days and the unbalanced of the process cycle time which has a percent difference of 76.4% between its maximum and minimum value. The current process efficiency is 85%; however, the standard of car maker process efficiency is specified as 95% minimum. Defect from process is 100 ppm Fig. 1 shows the studied process flow, which composes of Hilex cutting machine, Inner cutting machine, Outer cutting machine, Assembly station, Post waiting and Shipping Area. The material and cycle time, including the total lead time have been analyzed and calculated as shown in Fig. 1.

B. Process analysis and Improvement

Based on the survey information, the reducing waste, especially in the inventory bottleneck was investigated. As shown in the diagram in Figs. 1 and 2, the inventory process spends the 2.5working days, which can be improved by balancing the process. Based on the survey data and the proposed analysis, firstly, some of the process steps those are assembly process and preparing parts process were combined. Secondly, the 10 pieces batch-material loading was considered to be changed to a single piece-material loading. Finally, the all process steps were focused on more continuously and balanced. The new process was proposed as shown in Fig. 3. As seen in this figure, the processes were combined as 8^{th} steps and the 10 pieces loading system was proposed.

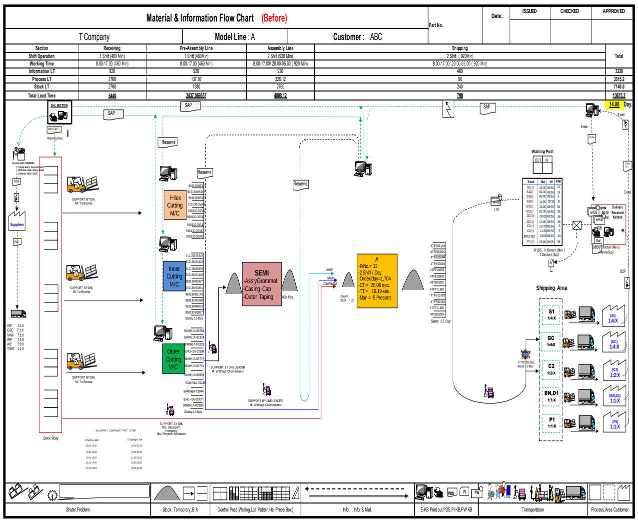
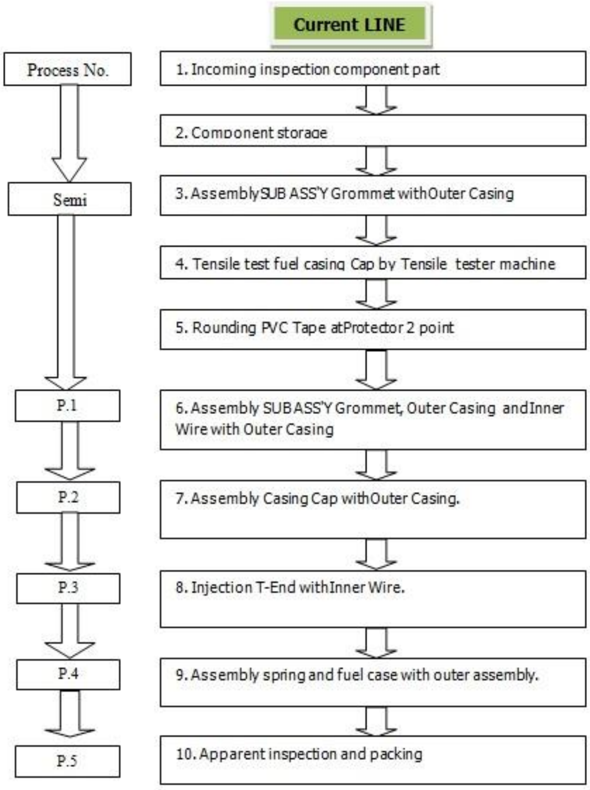


Fig.1 Current process flow



(a)

Component part detail:

1. Protector: Rubber tube for protection Outer
2. T-End: Zinc End of cable for joint to matching part.
3. Casing Cap: Cap of outer for connect to matching part.
4. SUB ASS'Y Grommet: Rubber seal for protect water leak in body.
5. Fuel Case: Component for lock cap fuel tank.
6. Inner Wire: For transfer force.
7. Outer Casing: Tube for protect inner.

(b)

Fig. 2 Details of the current process flow: (a) flow diagram (b) abbreviation.

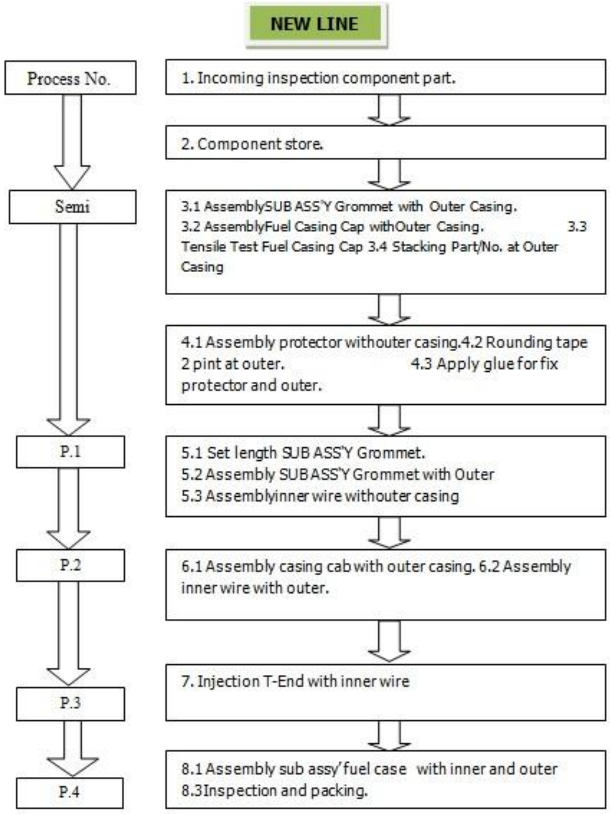


Fig. 3 Details of the proposed process flow

The process was improved not only the combination of the process steps, but also the rearranging of the process flow as shown in Fig. 4. The single piece flow reduces the inventory and idle lead times and number of operators. The wastes were clearly decreased and the process flow was compact. The number of operators was changed from 8 to 7 resulting in the reduction of the operating cost. The cycle time, as shown in Fig. 5, was reduced from 33.36 to 20.58, that means the productivity of the process is increased. The M3, Table tape rolling process, is significantly improved as it is the bottleneck of the entire process. The 12.58 sec. was expected to be gained in the process. In addition, based on the proposed concept, the lead-time of the inventory was reduced to 0 days. Fig. 6 shows the details of flow diagram including the lead-time analysis of the new process after improvement

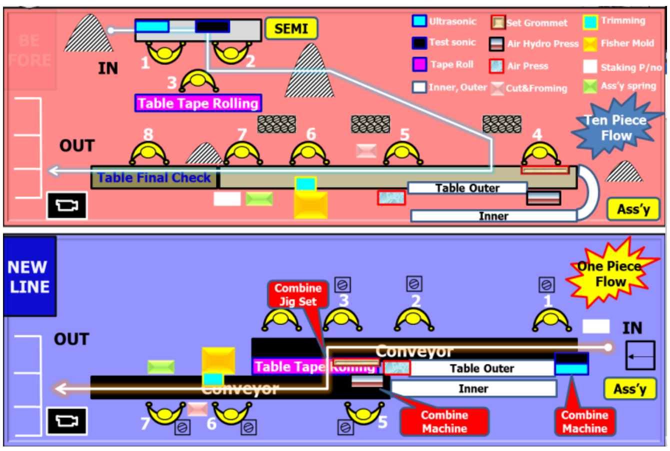


Fig. 4 Process layouts: (a) before and (b) after improvement

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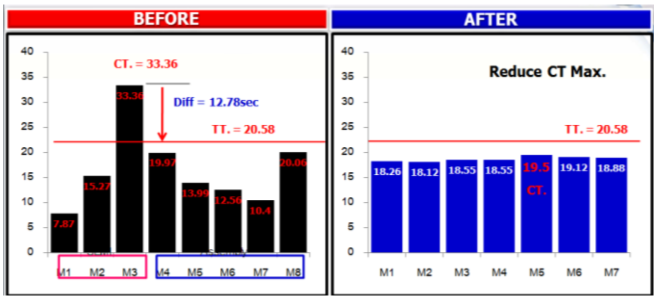

(a) (b)

Fig. 5 Cycle time (a) before and (b) after improvement

The result of the improvement by lean method made the changes in process flow chart which explained in Fig. 6. From the process flow, a significant change in the process is the change from batch 10 pieces per time to one piece flow. Some sub-processes those are the protector assembly and tapes rounding are separated in the current process; thus, they were considered as the wastes in terms of inventory. The combining of these processes produced the change in the inventory in the process to 0 (JIT: Just in Time).

C. Reducing the defects from the production process

Based on the survey data reported over the past 1year, it was found that the defect in the production process is 100 PPM (parts per million) mainly caused from the errors in the batch assembly process. Fig. 6 shows the diagram of the improved process and Fig. 7 shows the results of a study of the waste from defects, as seen in this graph, the main defects caused from the assembly process. The other causes are from the "not tape rolling" and "staking grommet shapeless". These sub-process were attempted to be focused.

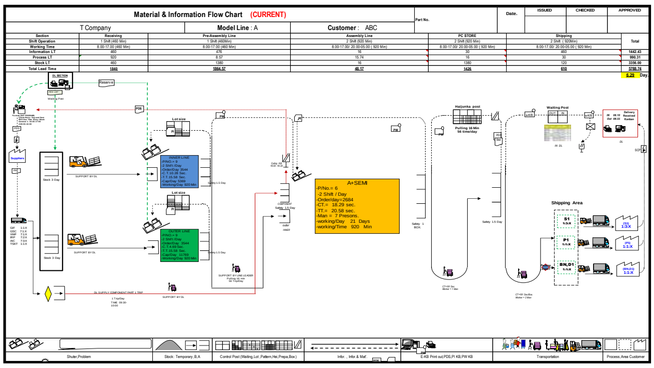

Fig. 6 The process flow after improvement.

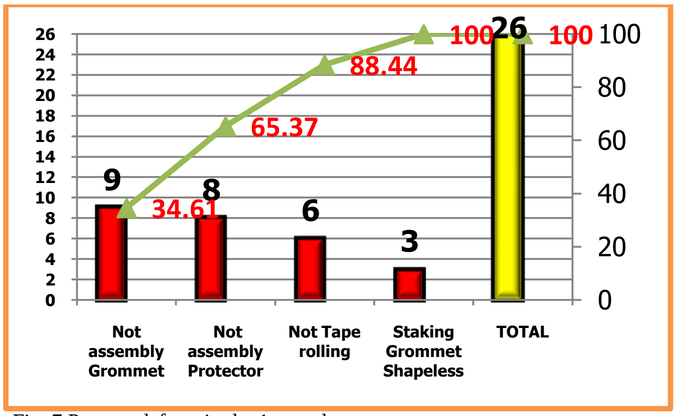

Fig. 7 Process defects in the 1 year data.

From the process analysis, the assembly process has no the work instruction of the checking to verify the product before sending to the next station. One of the reasons is that the process is a 10 pieces batch flow so that the in process inspection is not feasible. Thus, to improve the process, one piece flow process and the design of the mistaken error proofing (called as "POKAYOKE") for detecting all errors from the operators were modified in the process so that the defects can be reduced to 0 PPM. In addition, The improvement of the process control by using the electrical sensors were implemented. Table I shows the results of the process before and after improvements with the use of lean techniques in the control cable manufacturing. As seen in this table, the significant improvements in terms of productivity, cycle time, lead time and defects were clearly shown, for example, 33% of the production rate was increased, etc.

TABLE I
RESULTS OF PRODUCTIVITY, CYCLE TIME, LEAD TIME AND PROCESS DEFECTS AFTER IMPROVEMENT BY LEAN CONCEPT.

	Before	After	% Change
Productivity (Pcs/ManHr)	18.75	24.82	33% ↑
Cycle Time (Sec)	33.36	19.5	71% ↑
Lead Time (Day)	14.86	6.29	58% ↓
Defect (PPM)	100	0	100% ↓

IV. CONCLUSION

From the proposed concept to improve by lean approach, the results of improvement in the production line of control cable were summarized in Table 1. Based on the results, the advantages of the improvement of 71% in cycle time, 33% in productivity, 58% in lead-time and 100% in defects are gained. Clearly, the significant improvement was proposed and it can be expanded to the similar products to make more competitive in the automobile manufacturing. In the future, the automatic machine such as an automatic cutting machine for outer cable, the new cutting and forming machine for inner cable that can reduce the number of operators and sub-processes and increase the cycle time will be considered as the next research topic.

REFERENCES

[1] Anand Gurumurthy, RambabuKodali. "Design of lean manufacturing systems using value stream mapping with simulation A case study," *Journal of Manufacturing Technology Management*, Vol 22, pp.444 - 473, 2011.

[2] Lorna R. Cintron, Sonia M. Bartolomei-Suárez. "SIM-Simulation: A Simulation tool to predict a lean production process," *Industrial Engineering Research Conference*, 2007.

[3] Wei Xia, JiwenSun, "Simulation guided value stream mapping and lean improvement: A case study of a tubular machining facility," *Journal of Industrial Engineering and Management*, pp.456 - 476, 2013.

[4] Fabian Fagerholm, MarkoIkonen, Petri Kettunen, "Performance Alignment Work: How software developers experience the continuous adaptation of team performance in Lean and Agile environments," *Information and Software Technology*, Vol. 64, pp.132 - 147 , 2015.

[5] Kamolrat Srisungsuk, NatchaThawesaengsakulthai. "Waste reduction by Lean Six Sigma approach in micro cable manufacturing," *Journal of engineering*, Vol. 2, 2013.

[6] Jacobs, F. R. & Chase, R. B. 2008. *Operations and supply management: the core*. Boston:McGraw Hill.

[7] Natchaphon Suphan, SuntichaiShevasuthisilp, "Productivity Improvement of Crystal Blank Production Using Lean Manufacturing System.", The Graduate Research Conference, Bangkok, Thailand, 2011.

[8] Sittiwat, Chaiwat, Precha"An Application of Lean Manufacturing System for Electronics Industry Case Study: Server Assembly Line," Conference on Industrial Network, Bangkok, Thailand, 2011.

[9] RasliMuslimen, Sha'riMohd Yusof, Ana Sakura Zainal Abidin. "Lean Manufacturing Implementation in Malaysian Automotive Components Manufacturer: a Case Study," World Congress on Engineering, London UK, 2011.

[10] Denish B. Modi, Hemant Thakkar, "Lean Thinking: Reduction of Waste, Lead Time, Cost through Lean Manufacturing Tools and Technique," *International Journal of Emerging Technology and Advanced Engineering*, Vol.4, pp. 339 - 344, 2014.

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