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An application of a Lean Six Sigma Methodology in an Agricultural Machinery Industry: A Case Study on a Production of Sugar Cane grapples

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Abstract

This research is an application of the Lean six sigma methodology in an agricultural machinery industry for the study of the production of sugar cane grapples**.** The objectives are to improve production through the application of Lean six sigma and to assess performance and cost performance**.** The study process started from studying the current production process of sugarcane Grapples, then, creating a production scenario model with the plant simulation program, developing the production process with Lean six sigma methodology using value stream mapping and developing the route of the manufacturing process following the six sigma guidelines using the model DMAIC. It was developed by designing and constructing the jigs, with the idea that the equipment must be rotated in all directions and can be stopped as required. The given procedures were assigned to workers for welding. The yield can be increased from 70**%** to 95**%.** In terms of the performance, it was found that the production efficiency of sugar cane grapples increased to 47**.**85**%**, the production cost decreased by 5**%**, resulting in the efficiency and the cost of production of sugar cane grapples was in the set goals**.**

Keywords: Lean Six Sigma, Agricultural Machinery Industry, Sugar Cane Grapple.

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INTRODUCTION

Lean manufacturing focuses on the need for continuous elimination of non-value-added activities and for maximizing value-added activities through cost reduction and quality enhancement of organizational processes. Lean production can be termed as a waste reduction of non-value-added activities, the activities that do not add value to the process. Non-value activities can be divided into seven areas, such as being from overproduction, unnecessary waiting, unnecessary transport, product processing, inventory, product movement and defects. Process waste elimination significantly improves operations, resulting in lower cost and more efficiency with the use of a number of Lean manufacturing tools and techniques such as, visual control, 5S, wire making value and Kaizen. A popular tool for Lean manufacturing methods is called Kaizen. Kaizen generally means continuous improvement by engaging all employees from the top level to the assembly line as part process [1]. Discrete manufacturing companies often require flexible production systems that can improve quality and time according to product requirements as per specification. A regular analysis in the manufacturing process is to generate cost-related improvements or operating practices that may result in modifications to the company model that chooses to implement change [2]. A rigorous competition is one of the challenges that manufacturers face due to globalization. As a result, manufacturers need to do something to ensure they remain competitive in the marketplace. One of the strategies many companies adopt to improve their competitiveness is to implement the Kaizen concept to be used continuously in their organization. Therefore, the best way to respond to this increasing global competitiveness is to have companies undertake continuous improvement activities aimed at reducing waste [3-4]. Using Six Sigma in employee training is one of the best ways to improve quality and implement DMAIC models to improve the quality of each process, a key concept of Lean management for the improvement of quality and maximum efficiency [5-7]. One of the most frequently used methods in this context is the value stream method (VSM). According to a study of Fraunhofer Institute for Industrial Engineering, the IAO found that 60% of VSMs were used in the analysis and design of manufacturing systems in the automotive sector and in large companies. The advantages of this method, considering the production control perspective, are the principles of the integrated material considerations and data flow. These methods are production systems and guarantee sustained increased efficiency over the long term [8-10].

Figure 1. Sugarcane Grapple Agricultural Machine

This research aims to improve the efficiency and reduce the production cost of the agricultural machinery industry by applying the Lean Six Sigma production approach. The sugarcane grapple products being shown in Figure 1 was selected due to the high price of the sugar cane machine products and the farmers' high demand for sugar cane grapples. Adopting the Lean Six Sigma production approach to the production of this sugar cane gripper will be a model for the production of other products. For the implementation, the program Plant Simulation was used to model situation and analyze the production before and after the operation. Therefore, the main objective of the research is to develop production by applying the Lean Six Sigma method to assess the efficiency and cost of production in the agricultural machinery industry for the study on the production of sugar cane grapples.

METHOD OF OPERATION

The current process of sugarcane grapple production was studied first and a production scenario model with the Plant Simulation program was created. Then the Lean Six Sigma problem solving process using the problem solving process of DMAIC was implemented according to the Lean Six Sigma. Currently, the steps of the sugarcane gripper manufacturing process are as follows: steel cutting process, pole assembly, boom assembly, top-bottom tweezer assembly, pole assembly welding, boom assembly welding, Top-bottom tweezer assembly welding, sugar cane grapple assembly and paint spraying. The time and resources used for each process are shown in Figure 2. The steps are described in detail as follows (and shown in figure 2)

1) The steel cutting process is to prepare the workpiece of the pole set, boom set, upper and lower tweezers. The machines used are pipe cutting machines, laser cutting machines and Plusma cutting machines. It employs 2 people and takes 200 minutes to complete.
2) The process of assembling the pole assembly is to assemble the pre-cut steel into a pole assembly. The machine used is a welding machine. It employs 1 worker and takes 70 minutes.
3) The boom assembly process is to assemble the pre-cut steel into the boom assembly. The machine used is a welding machine. It employs 1 employee and takes 120 minutes.
4) The process of assembling the upper and lower jaws is to assemble the pre-cut steel into a set of upper and lower jaws. The machine used is a welding machine. It employs 1 employee and takes 130 minutes.
5) Column assembly welding process is to bring the pole assembly to be tightly welded at the specified point. The machine used is a welding machine. It employs one staff member nd takes 200 minutes.
6) Boom assembly welding process is the introduction of the boom assembly tightly to the specified point. The machine used is a welding machine. It employs 2 employees and takes 460 minutes.

7) The process of welding the upper and lower tweezers is the use of the upper and lower tweezers to be tightly welded at the specified point. The machine used is a welding machine. It employs 1 employee and takes 175 minutes.
8) The process of assembling the sugarcane grapple is the pole set, boom set, top and bottom tweezers, all together. The machine used is a welding machine. It employs 2 workers and takes 220 minutes.
9) The process of painting, the machine used is a paint spraying machine. It employs 1 employee and takes 210 minutes.

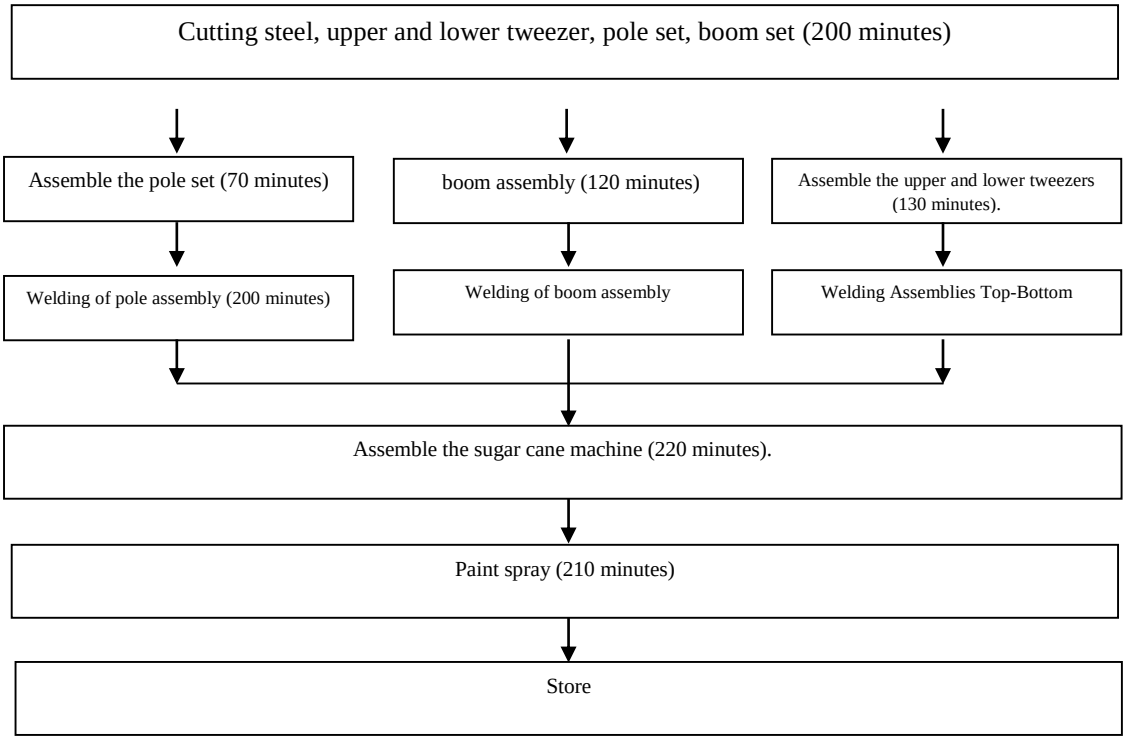

Figure 2. Production process of sugarcane grapple

The above production process steps were used to create a production scenario model with the Plant Simulation program The drawing of each production process was performed, starting from the steel cutting process, then, the upper and lower tweezers set process, the batch process, pole boom assembly process, pole assembly process, boom assembly process, upper and lower tweezer assembly process, boom assembly welding process, upper and lower tweezer assembly process, cane grapple assembly process and painting process, respectively. The result is shown in the figure 3 and the result of the critical station is displayed in figure 4.

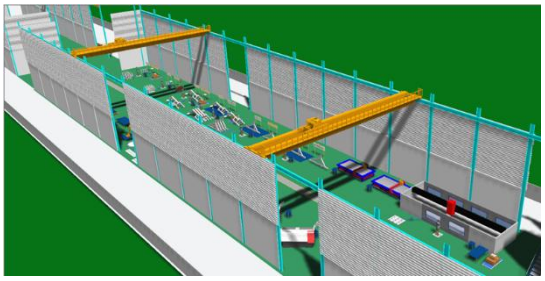

Figure 3. Production process model

Figure 4. The model shows the critical station.

When the modeling was completed, the program calculated the production capacity. The results are shown in Figure 5. The value is 1.04, showing that the current capacity of sugarcane grippers can produce 1.04 units / day, which the target set at 2 devices per day. Therefore, the production time of each batch of sugarcane machines must not exceed 240 minutes. It can be seen that the current production process is unbalanced, as the boom assembly welding station takes 460 minutes which exceeds the tact time that time is set. Therefore, the problem must be solved by developing operational methods and establishing by Kaizen to balance the production of sugarcane grippers, including delivering the total lead time and total production costs to meet the set goals.

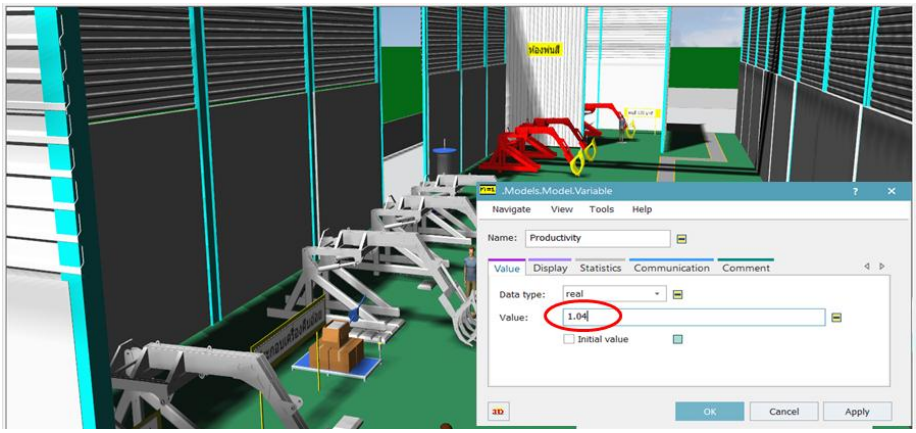

Figure 5. Current capacity of sugarcane grapple

Based on the above data, which were analyzed by Pareto diagram using principle by 80–20, it was found that the main cause of boom assembly problems was higher than tact time, lack of two crane grips. The approach edits would be given in the next update process. For determining solutions for boom assembly welding stations, designing and constructing JIG & FIXTURE workpiece jigs and standardizing welding methods were revised. The concept of the design and construction of the workpiece jig is that JIG & FIXTURE can stop at any position, control rotation with the remote control, be fast and convenient clamping, be able to bear the load, and be safety for the operator, as shown in figure 6.

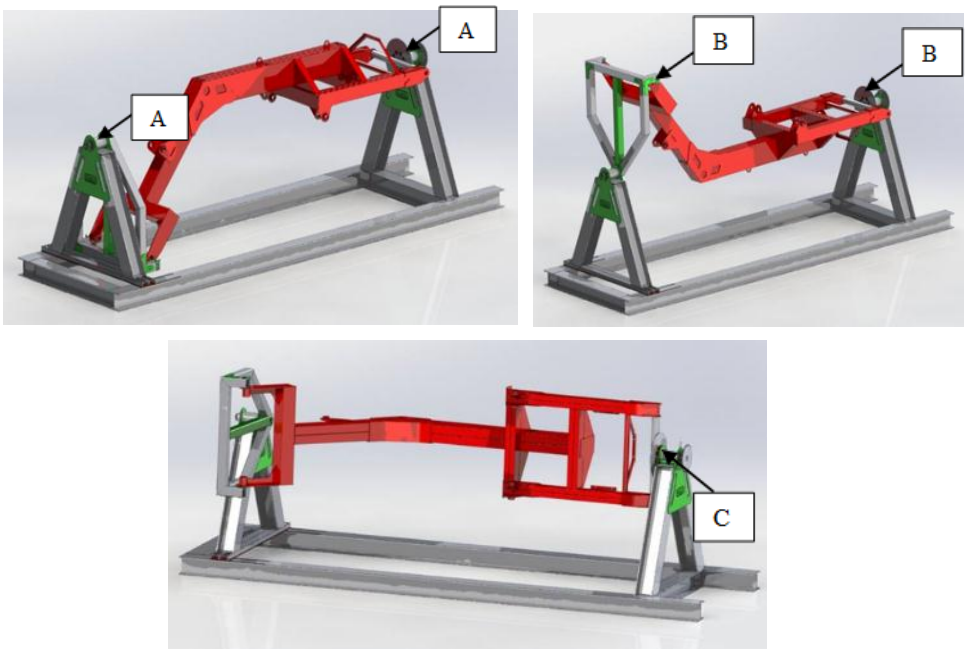

Figure 6. design of jigs

(A). Designed to be rotated with 2 pivot points.

(B). Designed to hold fast and convenient.
(C). Designed to stop at any position.

RESULTS

From the implementation of the Lean Six Sigma method in the agricultural machinery industry for the study on the production of sugarcane grippers, the results were as follows, namely the creation of the JIG & FIXTURE workpiece jig and the method. The welding was standard, by doing 12 experiments. The production time of each boom set was 245, 231, 252, 241, 251, 228, 233, 223, 241, 224, 256, 234 minutes. The results of the experiment can reduce the average operating time at the boom assembly welding station from 460 minutes to 238 minutes as shown in figure 7. From the above data, the production capacity can be calculated using the production scenario model using the

Plant Simulation program. The simulation can produce 2.01 machines per day, which was in line with the target set. Figure 8 shows the calculation of sugarcane grapple production capacity by computer program.

Figure 7. Test JIG & FIXTURE

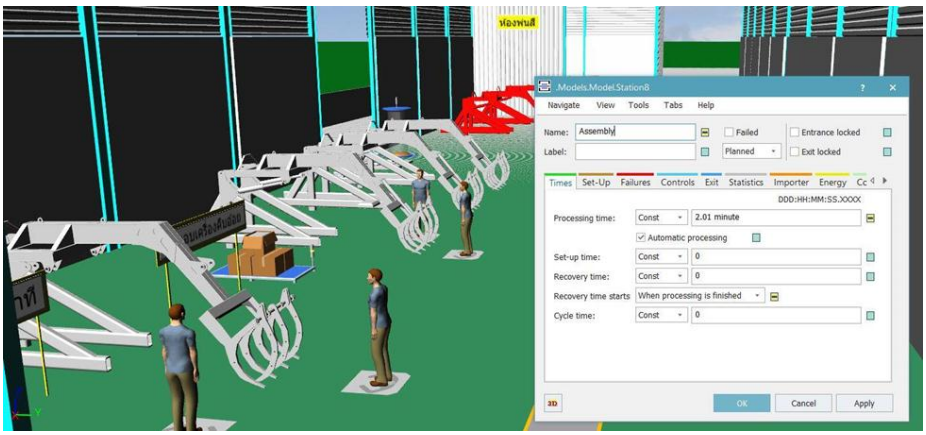

Figure 8. Calculation of capacity by computer program

For the results of a study on the development of a production system using the application of the Lean Six Sigma approach to assess the efficiency and cost of production in the agricultural machinery industry for the study on the production of sugarcane grapple, after adjusting the equipment of the production system, we can draw

a diagram of the sugarcane grapple production process in the form of a value stream mapping as shown in figure. 9. It is the current production process of sugarcane grapples.

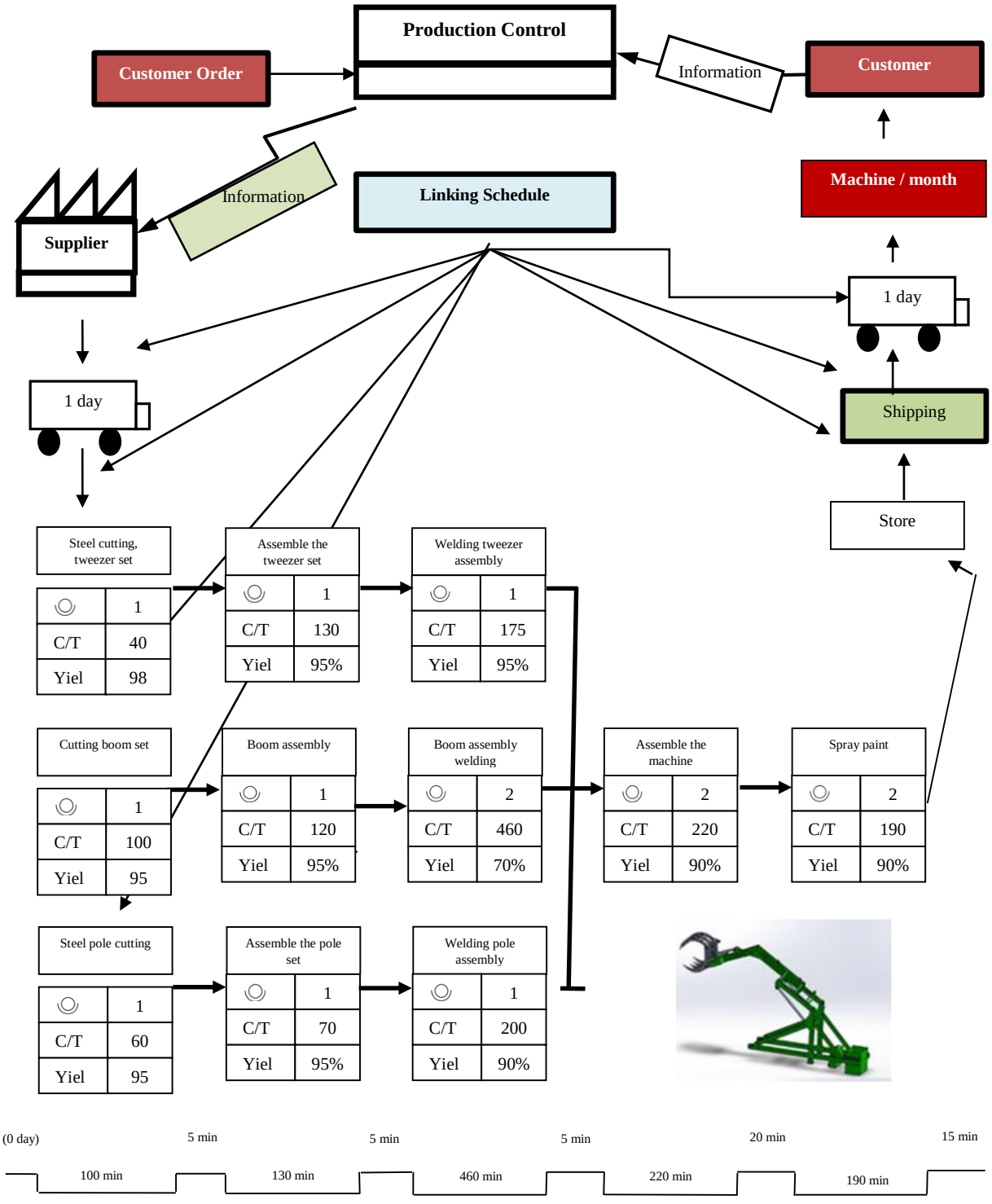

Figure 9. Value Stream mapping

DISCUSSION AND CONCLUSIONS

The main objective of this research is to develop production by applying the Lean Six Sigma method to assess the efficiency and cost of production in the agricultural machinery industry for the study of sugarcane grapple production. The aims were to increase production efficiency by at least 30% and reduce costs by at least 5%. From the implementation of the Lean Six Sigma method, it was found that the efficiency and cost reduction can be improved as follows. Before operation, the production efficiency was 52.15% and the production cost was 151,110 baht / unit. After operation, the productivity was increased by 47.85% and the production costs was reduced by 5%, which was in line with the set goals. Due to the Lean Six Sigma method, operators have been working step by step by adopting value stream mapping: VSM in the analysis to find the production station with the highest time and the lowest productivity, then follow the DMAIC process and production scenario modeling with plant program. The simulation in the analysis revealed that the boom assembly station was a low-yielding station. Therefore, the correction was performed by designing and constructing the jigs, with the idea that the equipment had to be rotated in all directions and could stop as specified. The workers were then assigned to the welding process, which can increase the yield from 70% to 95%, resulting in the efficiency and cost of production of the sugar cane crusher to meet the set goals.

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REFERENCES

[1] Juthamas Choomlucksanaa , Monsiri Ongsaranakorna ,Phrompong Suksabai. Improving the productivity of sheet metal stamping subassembly area using the application of Lean manufacturing principles. Procedia Manufacturing 2 (2015) 102 – 107.

[2] Victor Emmanuel de Oliveira Gomesa,b, Luis Gonzaga Trabasso. A Proposal Simulation Method towards Continuous Improvement in Discrete Manufacturing. Procedia CIRP 57 (2016) 270 – 275.

[3] Mohd Ghazali Maarof, Fatimah Mahmud. A Review of Contributing Factors and Challenges in Implementing Kaizen in Small and Medium Enterprises. Procedia Economics and Finance 35 (2016) 522 – 531.

[4] Sandrina Vilarinho, Isabel Lopes, Sérgio Sousa. Design procedure to develop dashboards aimed at improving the performance of productive equipment and processes. Procedia Manufacturing 11 (2017) 1634 – 1641.

[5] Eva Nedeliaková, Vladimíra Štefancová, Štefan Kudláč. Six Sigma and Dynamic

Models Application as an Important Quality Management Tool in Railway Companies. Procedia Engineering 187 (2017) 242 – 248.

[6] Pavol Gejdoš. Continuous Quality Improvement by Statistical Process Control. Procedia Economics and Finance 34 (2015) 565 – 572.

[7] Hiroshi Katayama, Legend and Future Horizon of Lean Concept and Technology. Procedia Manufacturing 11 (2017) 1093 – 1101.

[8] Lukas Hartmanna, Joachim Metternich. Waste in value streams caused by information flow: An analysis of information flow barriers and possible solutions. Procedia Manufacturing 52 (2020) 121–126.

[9] Federica Costa , Leonardo Lispi, Alberto Portioli Staudacher, Matteo Rossini, Kaustav Kundu, Fabiana Dafne Cifone. How to foster Sustainable Continuous Improvement: A cause-effect relations map of Lean soft practices. Operations Research PerspectivesVolume 6, 2019, 100091.

[10] Yuji Yamamotoa , Shumpei Iwao. Coordination in improvements at manufacturing plants and its effect on improvement capabilities. Procedia Manufacturing 38 (2019) 1566–1573.