IMPROVEMENT OF DOORFRAME PRODUCTION PROCESS IN WOOD FACTORY USING LEAN TECHNIQUE

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Introduction

In the manufacturing industry, competition is high in terms of price, quality, product delivery time, and customer satisfaction. It is necessary to improve the performance and to reduce waste in the process. Lean techniques are important techniques that are used to improve processes to increase productivity in small, medium and large industries, to reduce waste, to respond customer requirements and to increase competitiveness advantage. This research studied the working production process in wood factory. Main products are doorframes divided into standard and customized according to customers' orders. The demand for standard doorframes is 66.46%. There are 7 sizes of all sizes all in the same length but with different widths. The highest demand for standard doorframes is 0.80 x 2.00 meters. The demand for standard doorframes are an average of 3,018 pieces per month, with an average of 116 pieces per day from 16 employees. But they can produce only 80 pieces per day. When the demand for a product exceeds the capacity of the process. Therefore, employees need to work overtime. Including hiring more workers. The cost of labor increased. In the year 2018, this plant was planned to increase production to accommodate the increasing demand of customers. If the production process does not meet the needs of the customer. The production will need to recruit more staff or more machines. As a result, the cost of production increased. In the process of manufacturing labor from people with machines. There are no clear operational steps within the production process and time limits for production. It is not defined as a large industry. There are delays in the production process. The production line is not balanced. Each stage of the survey found that the unemployment of people and machines did not work. Affect the delivery of the product to delay the customer. The objectives of this study are to reduce the time and unnecessary steps, to balance the production line in the production process and to reduce the problem of delayed delivery which identifies the actual process improvement using lean technique.

Literature Review

This independent study concepts, theories, and research related to improving the efficiency and effectiveness of business processes. Variety of types and sizes, which brings a variety of tools are also applied such as Lean Techniques.

Analysis of waste in the process.

In the production process, there is often a hidden waste, which is the efficiency and effectiveness of the process is lower than it should be. Therefore, it is necessary to constantly explore and analyse the process so as not to overlook the waste that occurs. This is an important first step in seeing the current state of the process so that visibility and identification of wastes can lead to many ways to eliminate or reduce these losses. (Oliveira, et al., 2017), analysed the current status of the overall the production process with value stream mapping (VSM) to detect several wastes and to appropriately select lean tools for improvement. This VSM showed a high level of stock and several workplaces which may have emerged because there are a large number of unplanned breakdowns due to malfunctions, which could be reduced through the implementation of the total productive maintenance. (Coffey Jr., et al., 2018), used process maps to identify outpatient pre-operative holding area processes before and after implementation of lean interventions. Waste and root causes were categorized and workgroups

were created using the 5 Why's, and future state design, to redesign the existing workflow for first cases of the day. (Sutari, 2015), Production did not meet customer specification that rework defect. The 7QC Tools include the Pareto Chart to identify defects that need to be addressed. Then analyse the cause of the defect with the Ishikawa Diagrams. And the tools to improve the production time and reduce the loss of repetition, resulting in inadequate product value. Kaizen is primarily used to help reduce repetitive problems. Reduce work time. Reduce waste due to non-compliance with customer requirements. This results in improved production processes in terms of time. Including cost effective production.

So, the researcher studied the process of doorframe producing then used VSM, flow process chart and flow diagrams to analyse the current waste in the factory case study. This is used as a guideline to select lean tools and methods to eliminate wastes appropriately to increase productivity in the process.

Using of lean techniques in industrial plants.

Lean technique is a systematic process improvement tool by identifying and eliminating the waste. It has been used extensively in various businesses to increase the ability to produce quality products and more effective. (Lam, et al., 2016), used the line balancing tool to reduce imbalances workers and workloads and to solve bottleneck problems on production lines using Takt time vs. work cycle times of each assembly station. The line balancing analyses the ability to respond to customer needs of each station. The electronic assembly line can meet the needs of customers. But, there are also losses due to the unemployment of employees. ECRS has been used to combine work stations from 4 to 3 as a result, the ratio of balance and efficiency increase the balance. (Antosz & Stadnicka, 2017), showed that small and medium enterprises (SMEs) in Poland are keen on adopting lean manufacturing philosophy to use in the organization in order to improve the operation, 81% of them are aware of the need to eliminate waste. The major wastes were waiting for materials, 49% of unnecessary movements, 41% of damaged goods and 39% of damaged machines, which also increased the competitiveness. Lean companies use the basic principles of 5s. (Garnea, et al., 2016), the improvement of the productivity about the pressure vessel manufacturing unit which reduced the motions and waits and also provided a better working environment. They remove the scrap and other unnecessary raw materials. An additional worker was employed at the full welding station to perform the pre-weld jobs. The re-layout reduced the transport time and promoted the continuous flow. The generalized fixture was replaced by a modular fixture which reduced the time spent on indexing and clamping. Work standards were defined to improve the efficiency of the manufacturing process by creating a standard operating procedure. All these implementations led to the increase in productivity of full welding process and child parts assembly station and also decreased its total operating cycle time. (Nguyen & Do, 2016), applied lean techniques in reengineering an electronics assembly line. Reengineering focuses on some aspects such as reducing wastes, standardizing works, internal logistics, workplace designing and changing layout. After improvement in throughput time from 7.5 days from 3 days for the same order. The number of operators decrease 40%. Average cycle time decreases 40% and saves 30% space.

In doorframe production process is a person's work with the machine. It consists of several steps. When seeing the process that produces waste, there is no need for production. The researcher will eliminate or consider what steps can be combined without increasing the workload for people and machines and the sequence of production steps to reduce unnecessary movement, production is faster. And improve the work easier and more convenient to reduce the time and process of production more efficiently.

Using of lean techniques in wood and furniture factory.

(Sujová & Marcinková, 2015), said that in view of business processes the fierce competition in the timber and furniture market in Slovakia. In addition to the quality of the product. Also consider the quality and efficiency of internal business processes. Focus on improving production processes to add value to products and organizations. By exploring different wood processing plants that management tools have been adopted to the organization to promote business processes in terms of optimization. Increase productivity and quality, reduce hidden costs in the process. Most of the wood processing plants in Slovakia are small with 11-20 employees. Produce a few times. It does not give importance to

improving internal processes. Lean management, TPM, and Kaizen have resulted in a number of operational wastes. But Zimbabwe's furniture factories have adopted lean techniques to improve the production of wooden beds for export. (Nyembaa & Mohawk, 2017), started from a work study to explore non-value-added activities, the plant layout is complex. The process was analysed by process chart and flow diagrams this plant layout is complex. There are the cross flow of process routes and old machinery often results in product quality and delays in fulfilling customer orders. As well as the location of the machine is exposed to dust, resulting in some lost products. The spray station is also located near other work stations which are not properly controlled. Affect the safety of work. Lean techniques have been used to improve the distance between stations that need to interact. Reduce waste from transportation and improve production time efficiently. A furniture manufacturing company in Southern Brazil (Guimarães, et al., 2015), improved both ergonomic and production outcomes by a cellular teamwork model. Work enlargement and enrichment, and the improvements in workstation design and process flow increased worker satisfaction and reduced postural risk, fatigue, body pain and production waste. Workload was reduced by 42% and productivity increased by 46%.

This research will observe the positioning of work stations or machines in accordance with the production plan. Starting from the survey, the station alignment of the factory is currently in line with the workflow which high frequencies of interaction are nearby or combine work stations by a cellular teamwork model to improve ergonomic and reduce transportation distances, which reduce waste from non-value-added activities for improvement production time efficiently.

Research Methodology

The research focused on the improvement of doorframe production process and product delivery. Researchers have made a framework for research approach that it is divided into 4 steps to the following steps as show in

Study Production process and related research

Study process and current problems by studying the method and collecting data from the actual location. Then write and analyse the process as a whole, using the current stream of values that provides an overview of the process from a customer perspective. This makes it possible to identify the activities needed to eliminate waste. Study papers and theories related to process improvement include 7 wastes, Lean, and Line Balancing.

Analysis of current production process

The flow process chart of doorframe production process is drawn to realize as-is process. The value added (VA), non-value added (NVA) and necessary but non-value added (NNVA) activities could be identified from this stage. The flow diagram shows the flow direction and the distance of production from the first stage to the final stage of process. And analysis balance of production lines was calculated from productivity per day Eq (1), Line Balance Ratio from Eq (2), Target manpower from Eq (3) and Line Balance Efficiency from Eq (4), as in:

Productivity per day	= OT / CT	(1)
Line Balance Ratio	= Tw/ N* CT	(2)
Target manpower	= Tw / TT	(3)
Line Balance Efficiency	= Tw/ Target manpower*TT	(4)

Where those variables are defined as follows:

OT = production time per day
CT = the most time-consuming workstation.
Tw = total time of workstations
N = total number of workstations
TT = Takt time

Data collection on process & product delivery

Collects information about current work processes, manpower, machinery used, transport distance between work stations position and placement of machines or stations. Transport time, components, and waiting time between work stations.

Improve production process & product delivery

The improvement started with the use of the ECRS principles to eliminate NVA and NNVA activities that occurred in each of the investigated work steps. Then use the line balancing tool to minimize imbalance between workloads in order to achieve required the continuous flow under the conditions of customer requirements. And use the fishbone diagram identifies many possible causes for an effect or problem about delayed delivery of products using brainstorming, Interviews with relevant staff. Results are analysed by comparing number of processes, times, line balance efficiency and problem of delayed delivery before and after improvement.

Results

Analysis of current production process

1. The doorframe production process was studied using VSM by examining the working process. The primary data was collected to draw the overview of doorframe production process in current state VSM. It consisted of 11 workstations which the lead time at 1378.68 sec. NVA activities were found waiting work in process until 100 pieces before to be taken out from planing and grooving, NNVA activities were found transport and inspection. VA activities were found, which equivalent to 72.60 % of the total time as in Figure 1.

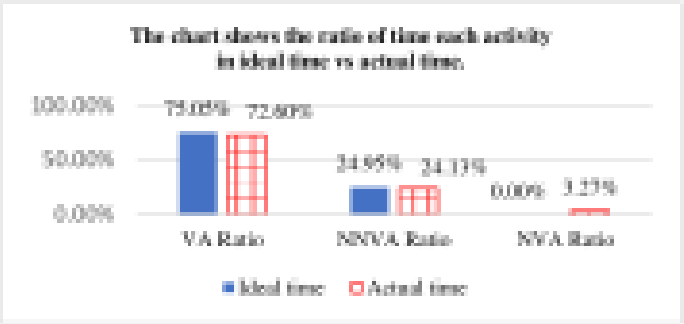

Figure 1: The chart shows the ratio of time each activity in ideal time vs actual time

2. After the current state VSM was sketched, overall doorframe production processes are more comprehensible. The wastes can be detected from each stage. The flow process chart identified 12 VA were carried out, 2 NVA and 4 NNVA.
3. Flow diagram from the planing stage to the assembly stage showing the distance to move from the planing station to the cutting station is 12 meters, and from the grooving station to the punching station is 7.80 meters. As a result, transportations take a long time.
4. Problem Delivery to the Customer, the factory and the researcher collect the product delivery information. As shown in Table 1.

Month 2017-2018	The ratio of deliveries	
	On time	*Delay*
October	38.52%	61.48%
November	23.29%	76.71%
December	37.76%	62.24%
January	31.98%	68.02%
February	29.04%	70.96%

Average	32.12%	67.88%

Table 1: The problem of product delivery

The average delivery delay of 67.88% reflects the problems of production processes that cannot respond to customer requirements. Therefore, use a fishbone diagram to identify several possible causes for delayed delivery results or problems. There are 3 main reasons:
a) The wastes in the production process.
b) No ongoing order tracking.
c) Lack of continuous communication and information sharing among departments.

Improve production process & product delivery

1. Improvement processes using of ECRS principles

- Reduce the number of work in process before moving from planing B station and grooving B station. Can reduce the waiting time before removing from the work station. It also makes transportation easy and shorter time.
- Combination of work stations: planing A and planing B. Reduce time down to 32.25 seconds or equivalent to 13.52% show in Fig 2.

Figure 2: Planning station after improvement

- Integrate operation and inspection together in grooving A station. Reduce time down to 5.23 seconds or equivalent to 8.35% show in Fig 3.

Figure 3: Grooving A station after improvement

- Making jig for perforating station. Reduce time down to 13.25 seconds or equivalent to 18.07% show in Fig 4.

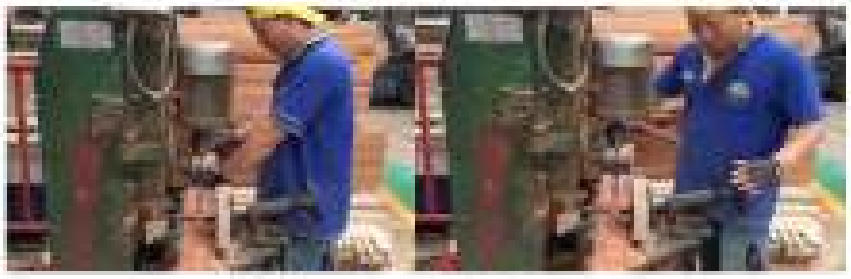

Figure 4: Perforating station after improvement

- Prepare equipment and assembly to be available. Reduce time down to 35.29 seconds or equivalent to 12.96% show in Fig 5.

Figure 5: Assembly station after improvement

From the results of the improvement of doorframe production process, the size of 0.80 x 2.00 meters can be reduced unnecessarily stage as shown in Figure 6.

Figure 6: The chart shows the number of each activity

Can reduce 1 inspection but transportation and delay cannot be reduced due to the obstacles in the process layout. Show the time changes for each activity from Figure 7.

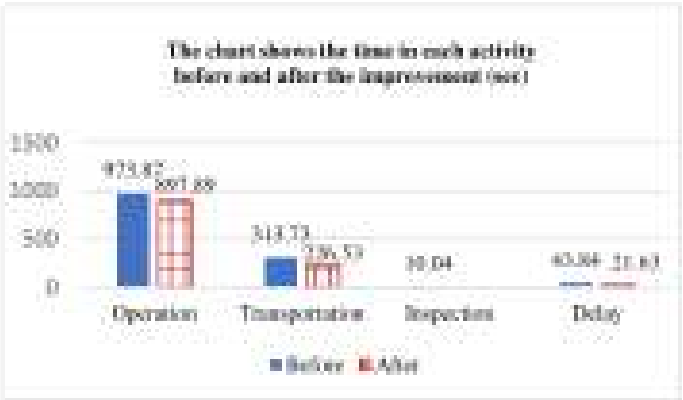

Figure 7: The chart shows the time in each activity.

The time in each activity after improvement was reduced, which corresponds to the ratio of time in each activity is based lean technique, as reflected in Figure 8.

The VA ratio is higher. This is consistent with the NNVA and the NVA have a reduced ratio because integrate operation and inspection together in grooving A station and reduce the number of work in process before moving, making transportation easy and shorter time.

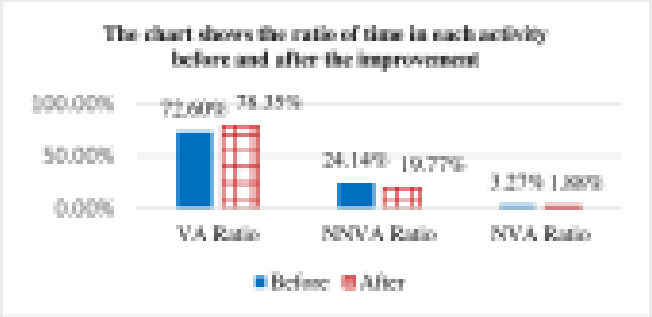

Figure 8: The chart shows the ratio of time each activity is based on lean technique.

2. Combine workstations using the line balancing.
Before the improvement, there are 11 workstations. Each workstation has a different production time which the balance ratio of the production line is 32.52% and line balance efficiency is 37.35%. Thus, combine workstations are 4 major workstations under customer requirements, include: planing, cutting, perforating and assembly. As show in Figure 9.

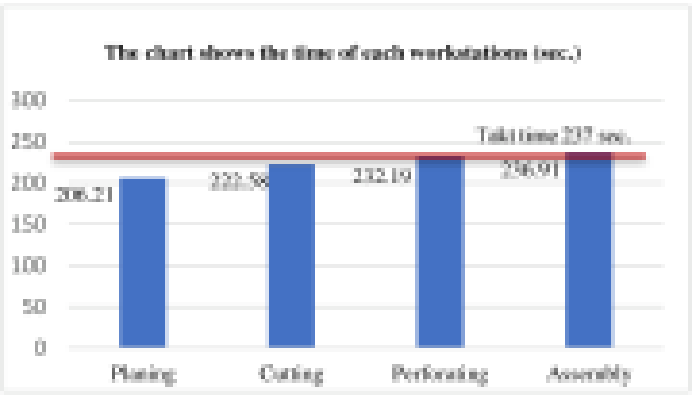

Figure 9: The chart shows the ratio of time each activity is based on lean technique.

3. Improvement of product delivery to customers.
From the fishbone diagram to the cause analysis. Lead to the following improvements.

- Improve the production process. As mentioned in section Improvement of production process.
- Increased tracking of order status on both the real and the system.
- Inter-departmental meetings "Delayed Delivery" to share information between each other. It shows the current production status regularly.

The delayed product delivery was 54.34%, as show in Figure 10.

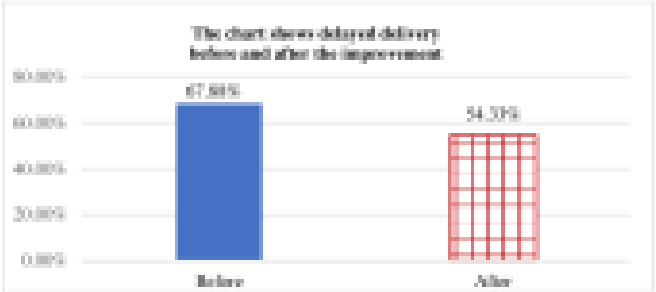

Figure 10: The chart shows the ratio of the delayed delivery.

Improvements from both production and delivery resulted in a 13.55% drop in deliveries.

Conclusion

This study investigates the doorframe production process. Lean techniques were used to reduce the waste which occurred in the production process.

Reduce unnecessary stage and time.

Using the ECRS principle to improve the sub-processes that have hidden wastes in the process, it is possible to reduce the production cycle time from 1,341.48 seconds per piece to 1,146.05 seconds per piece, or 14.57% of the total production cycle time. The three types of lean techniques can be classified as follows:

- NNVA, this reduces the inspection and reducing the number of work in process Reduce the number of work in process before moving from planing stage and grooving B stage from 100 to 50 pieces. The duration of the activity was reduced from 323.77 seconds per piece to 226.53 seconds per piece, which was reduced to 30.03% of necessary but non-value-added activities.
- NVA, reducing the number of work in process Reduce the number of work in process before moving from planing stage and grooving B stage from 100 to 50 pieces that reduced the waiting time from 43.48 seconds per piece to 21.63 seconds per piece down to 50.25% of non-value-added activities.
- VA, apply ECRS principles to eliminate latent wastes in the work process, such as planning A and planning B, grooving A, perforating and assembly. As mentioned above. The duration of the activity was reduced from 973.87 seconds per piece to 897.89 seconds per piece, which decreased to 7.80% of value-added activities.

Improvement of doorframe production process using ECRS can be summarized in Table 2.

Description	Before (sec)	After (sec)	Decrease (sec)	Percentage Reduction (%)
- VA	973.83	897.89	75.94	7.80%
- NVA	43.48	21.63	21.85	50.25%
- NNVA	323.77	226.53	97.24	30.03%
- Cycle Time	1,341.48	1,146.05	195.43	14.57%

Table 2: Value analysis of doorframe production process before and after improvement

Balance of production line.

Combine workstations from the 11 workstations to 4 major workstations under customer requirements, include: planing, cutting, perforating and assembly. Every work station can achieve required the continuous flow under the conditions of customer requirements. The balance ratio of the production line increased by 62.23% and line balance efficiency increased by 57.40%.

Reduce delays in delivery of products.

Improvements in production and delivery can reduce delays in delivery of products by 13.55%.

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