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Profit comparison analysis in production system simulation based on lean principles to achieve sustainable manufacturing

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Abstract: Companies can achieve effective and efficient process if they make continuous improvements to achieve sustainability. In general, companies are aware of waste in the production process, but do not carry out measurements and analyzes related to this waste, including unit cost and profit analysis. A production system is needed that is able to minimize the unit costs and maximize profits in the company, one of the concepts used is the lean concept. This study aims to analyze the cost unit and profit generated in production systems that apply lean principles. Production system simulation is carried out using the concepts of Heijunka, Jidouka, and Kanban System. These three concepts are applied to a production system simulation that uses miniature cars with unit cost and profit comparison outputs with traditional production systems, pull systems, heijunka, jidouka, and Kanban systems. The results show that the unit cost of simulations 1 to 6 is getting lower, while the profit is increasing. In simulations 1 and 2 no profit was obtained because of implementing the traditional system while in simulations 3 to 6 there was an increase in profit because they had applied lean principles to the production system. Simulations that have implemented the lean concept have low unit costs and increasing profits, but what distinguishes the work methods applied. Production systems that apply the lean concept can help a company achieve sustainability in the economic field.

1 Introduction

Competitionin the industrial world is becoming increasingly stringent with the existence of new innovative manufacturing technologies so that this makes companies able to continue to maintain and improve quality and production capacity [1].

Lean Manufacturing is a concept that is able to identify and eliminate waste through continuous improvement. This method is ideal for optimizing the performance of production systems and processes because it is able to identify, measure, analyze, and provide solutions for continuous improvement. Basically lean aims to eliminate or reduce waste [2].

Waste can affect the company's sustainability, especially in the economic field of the production system. A production system that is not lean will cause high unit costs and low profits for the company, making it difficult to achieve sustainability in the economic sector. Therefore, the concept of downsizing or lean is considered capable of overcoming this. With lean production, sustainability from an economic standpoint will be easily achieved in the form of unit cost efficiency with maximum profit achievement. Based on sustainable development, there are three pillars that are the focus in achieving sustainability, namely social, environmental and economic [3,4]. To achieve sustainability in the economic field, good productivity must be applied to the production system [5].

Manufacturing companies looking to increase profits can make continuous improvements in productivity and quality by reducing additional working time, labor, production time, and production costs by streamlining production processes. Some of the tools that can be used to achieve sustainability in the economic field are by implementing the Kanban, Kaizen, and 5S systems [6]. The Toyota Production System (TPS) has long implemented a lean or lean production system by implementing several concepts in its production system by making continuous improvements by finding methods that are able to minimize unit costs and increase profits from the production system side. Some of the methods applied are the Heijunka method, which is leveling production both in terms of volume and product mix [7], the Jidoka method in which there is an automation process that turns manual processes into automatic ones, and the Kanban method, which is a production order card that functions to control inventory [8].

Several studies have been conducted to maximize profit by referring to the lean concept for achieving sustainability in the economic field. [2] the concept of lean manufacturing is to maximize profit by reducing waste on the production floor and making improvements to any identified waste. [1] using the concept of lean manufacturing to increase production capacity that can maximize business profits, to identify waste that occurs use value stream mapping. [9] researching related to case studies in the automotive sector regarding the production of spare parts, the application of a combination of customized lean and green strategies resulted in a reduction of around 10.8% of the production costs of representative spare parts so that from reducing production costs, profit can be maximized. [10] in research conducted applying lean manufacturing to the furniture industry in Malaysia and the results show that deficiencies were found in lean implementation due to the challenges faced, namely in the form of technical knowledge, training, and financial resources during the initial phase of lean implementation. [11]conducted a study by applying lean manufacturing in a company to encourage an increase in the company's financial strength by making continuous improvements to the production system. [12] developing a methodology that can be applied by small and medium enterprises (SMEs), especially SMEs in the manufacturing sector, the results of research provide suggestions for the right lean tools for SMEs in maximizing profits. [13]presents a customized approach to low cost economic and ecological optimization of manufacturing processes, by identifying the relationship between ecological characteristics and Lean principles to develop an Eco Lean mindset.

Based on several previous studies, this research will develop a production system based on lean principles by adopting the method applied by the TPS, which has been proven capable of minimizing unit costs and maximizing profits by reducing waste on the production floor to achieve sustainable manufacturing in the economic field. Production system improvements can be seen through production system simulations that are run with several types of simulations that apply the TPS method, namely the heijunka, jidouka, and Kanban systems. In the production system simulation, miniature cars are used.

The purpose of this study is to obtain a production system that can minimize unit costs and maximize profits by adopting lean principles in it and referring to the method used in the Toyota Production System. The results of this study can overcome the problem of waste in production systems, especially in manufacturing. Thus the company is able to achieve its respective sustainability in the economic field, especially in the manufacturing sector by applying the best production system simulation results in minimizing unit costs and maximizing company profits after testing the production system simulation to several methods applied to TPS.

2 Literature review

2.1 Lean manufacturing

Taiichi Ohno created the TPS, which is the basis of various lean production movements. The definition of lean manufacturing is that lean is a systematic approach to identify and eliminate waste through continuous and sustainable improvement and development [11,12].

Lean is a systematic approach that can identify and reduce the occurrence of waste based on value-added activities and non-value-added activities, basically in lean continuous improvement is carried out to gain excellence in the production system by flowing products (materials, work in process, output) and information with a pull system [14,15]. Lean is being able to produce products in high quantities, have lower overhead costs, and use production resources more efficiently [16]. A company that has seen that a lean production system will provide a good change to its business, will be compelled to try implementing this system in its company [14].

According to [17] to become lean manufacturing requires a way of thinking that focuses on making the product flow through stages that provide value without any obstacles (one piece flow), a pull system originating from customer demands to achieve short processing intervals and a culture of continuous improvement diligently.

2.2 Sustainable manufacturing

The application of sustainable manufacturing in any industry, including industry in Indonesia, requires not only planning a production system based on the three pillars of sustainability (economic, social and environmental), but also a holistic implementation method to support the application of the concept of continuous improvement. Measurement of sustainability performance is always based on the triple bottom line, which focuses on environment, economy and social (Figure 1). A company will be said to have a sustainable manufacturing system if the company has been able to achieve a level of sustainability in these three aspects. However, companies cannot separate sustainability improvements in each aspect because these aspects will continue to be related. In encouraging sustainability in the economic and environmental fields, companies need to implement lean manufacturing systems. To foster sustainability in the economic and social domains, companies should adopt both large-scale manufacturing and an efficient logistics system. From a production standpoint, logistics plays a crucial role in acquiring materials from suppliers for the company's production processes. Simultaneously, from a marketing perspective, logistics is instrumental in the distribution of goods from the company to consumers. To increase sustainability in the environmental and social fields, companies need to implement green manufacturing. Therefore, it can be concluded that in achieving a sustainable manufacturing system, companies must implement a lean, mass and green manufacturing system To increase sustainability in the environmental and social fields, companies need to implement green manufacturing. Therefore, it can be concluded that in achieving a sustainable manufacturing system, companies must implement a lean, mass and green manufacturing system [19].

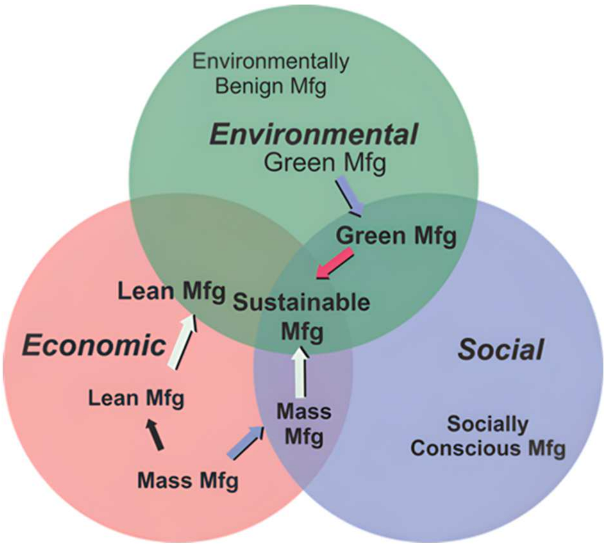

Figure 1 Sustainable manufacturing sources [18]

2.3 Toyota Production System

The application of the Toyota Production System (TPS) principle aims to expedite all production areas with various processes, achieve high quality output, reduce waste generated, achieve high quality output, and achieve low production costs in producing products. Economic benefits will be achieved by optimal inflows and outflows as well as a minimum area. The financial benefits will be enormous by applying this TPS principle in the production line. With a balance between stations in the production process, it will reduce stock in each process. This will lead to lower production costs. With effective stock management will be able to prevent the instability of a production process. In addition to balancing the process between stations, it will have implications for increasing overall production output. The process of balancing output between work stations is what will be the focus of this research [20].

According to Taiichi Ohno [21] the most basic waste is overproduction, because it accounts for most of the other waste. The TPS aims to achieve stable and lean production by expecting average production to be in balance with long-term demand forecasts which can also include variations in short-term demand. At Heijunka, reserve product inventories are carried out to deal with sudden peaks in demand so that customer orders are still fulfilled without changing production. In addition, Kanban is a scheduling approach that matches supplies with actual needs. Kanban is supported by a nameplate in the form of a card containing information on the parts that need to be provided in the production unit/facility or by outside suppliers. Visual cues such as kanbans can also be used to control overproduction and uneven production rates. Jidoka aims to design equipment in a production system capable of automatically detecting production problems and stopping when these problems occur. Examples of problems are equipment malfunctions, quality issues, or delays in worker response. The visual system is able to provide information to workers who operate machines [22]. In applying the lean concept to TPS to reduce costs, most of the production processes include the principles of Kaizen activities, flow analysis and Kanban systems [16].

3 Methodology

3.1 Data collection

Production system research based on TPS was carried out in two stages of data collection :

1. The research was carried out with experimental activities in the Manufacturing System Lab with step 1-6 simulations on the TPS for miniature car products of the Pick Up <P/U>, Double Cabin <D-Cab>, and Multi Purpose Vehicle <MPV> types.
2. Literature research, namely literature studies related to the issues, will be discussed in this study such as lean manufacturing, sustainable manufacturing, and the TPS.

3.2 Processing and analysis of data

Processing the data is done by calculating the unit cost and profit generated in each simulation that is carried out starting from step 1 to step 6. The cost components that are calculated to determine the unit cost and profit are depreciation costs, labor costs, and production costs at each product unit workstation. In this study, a comparative analysis of the unit cost and profit generated in each simulation based on the TPS was carried out.

3.3 Distribution of work stations

1. Work Station <WS> #1
   Perform the assembly of the lower part of the car by combining the chassis, front & rear axle and axle holder
2. Work Station <WS> #2
   Assembling the bottom of the car by combining the results of WS #1 and wheel products
3. Work Station <WS> #3

Performing the assembly of the top of the car by combining the results of the WS #2 product and the body according to the model being worked on

4. Work Station <WS> #4
   Conduct quality checks and record defects found from WS #3 products

3.4 *TPS simulation steps and conditions*

The TPS simulation (Figure 2) is carried out with 2 cycle times with a takt time of 90 minutes. Cycle Time (CT) is how long it takes to produce an output, including non-value added activities and value added or the time it takes an operator to complete 1 cycle of work including to do manual work and walk. Takt time is not a tool, it is a concept used to design a job and measure the tempo of customer demands. Takt Time (TT) is the time available to produce an item or service divided by the amount of products or services demanded by the customer in that period [23]. Each cycle time is fulfilling 5 demands out of 10 total demands.

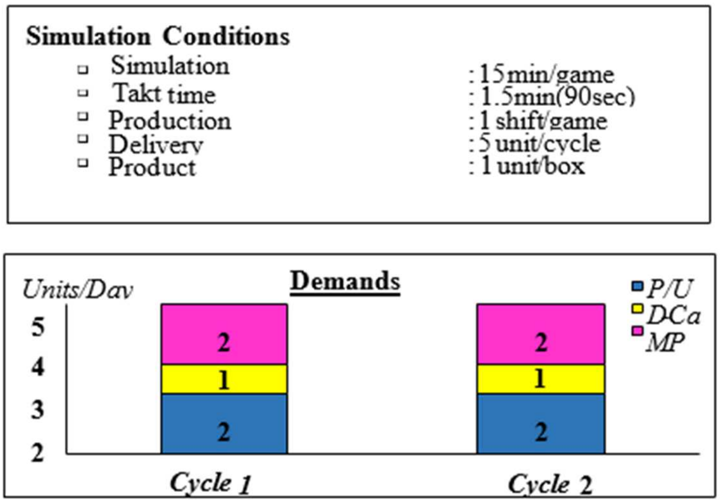

Figure 2 Simulation conditions

Simulation #1 (Figure 3):

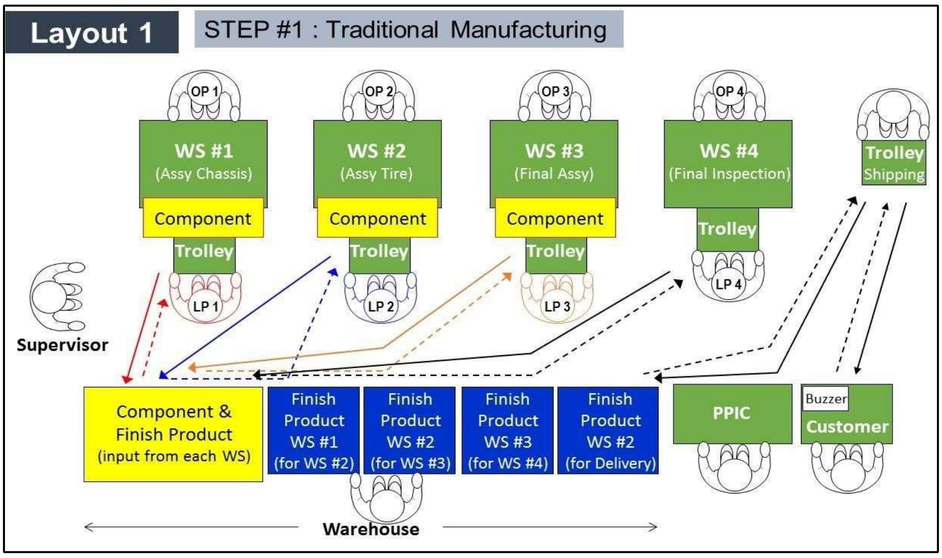

Figure 3 Traditional manufacturing
Source [24]

In simulation #1 the company implements a production system that is still traditional where it uses a warehouse as a centralized place for both material stocks as well as finished goods stocks and semi-stock stocks and those ready to be sent to customers.

Simulation #2 (Figure 4):

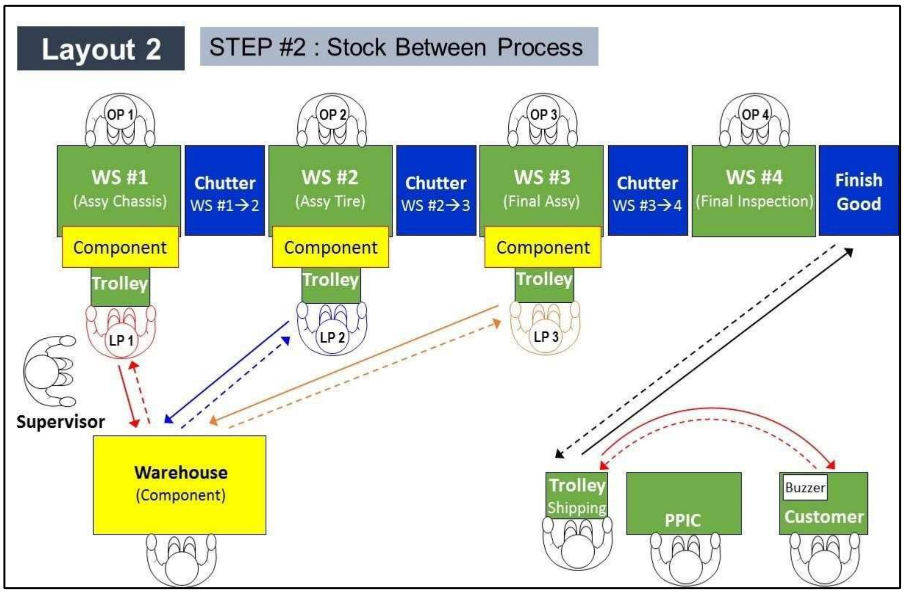

Figure 4 Stock Between Processes
Source [24]

In simulation # 2 the company implements a production systemwho have implemented a store at each work station and warehouse only as a place to store materials and still use production orders in the form of a schedule.

Simulations #3 and #4 (Figure 5):

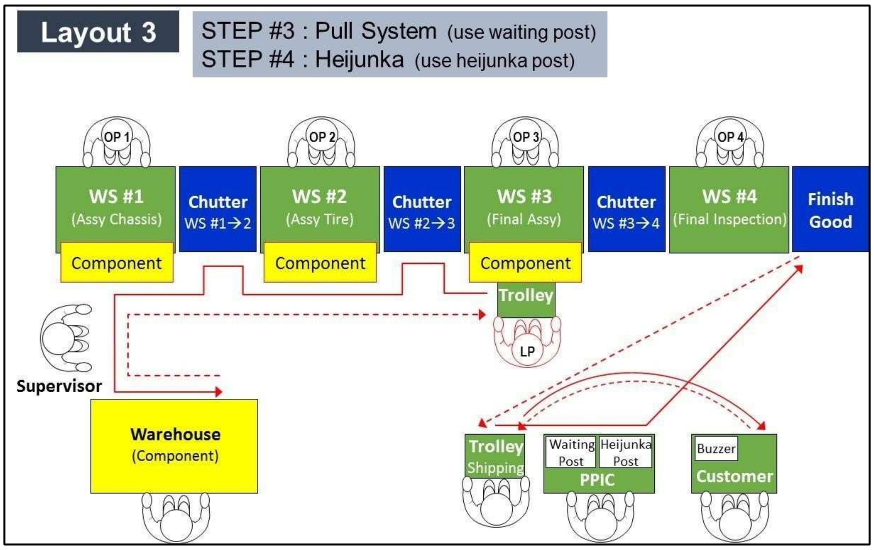

Figure 5 Pull System and Heijunka
Source [24]

In simulation # 3 the production system implemented by the company is a pull system at each work station, in this simulation Kanban and waiting post are used, the Kanban function is a card for production orders while the waiting post function is a tool to obtain information from visualized customer.

In simulation #4 the production system applied is a pull system and heijunka post which are tools with the aim of equalizing the operator's workload.

Simulation #5 (Figure 6):

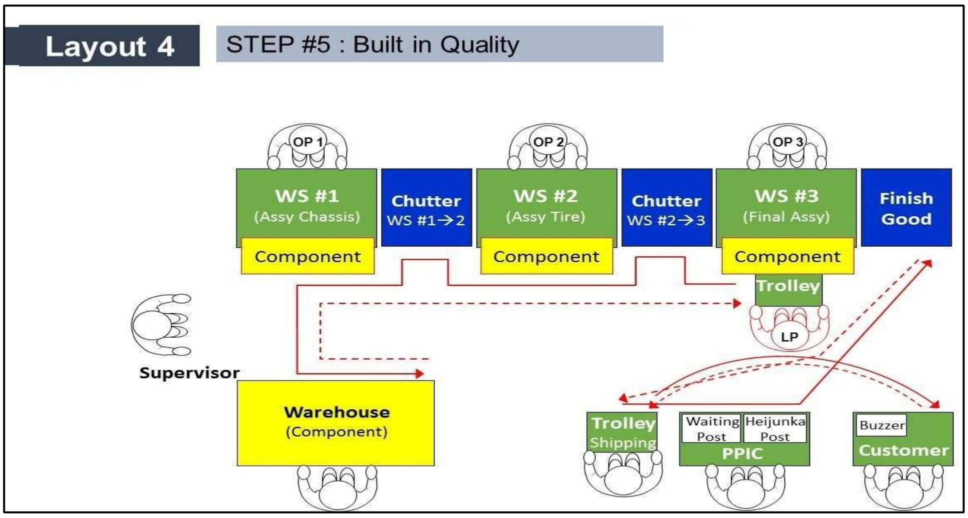

Figure 6 Built-in Quality
Source [24]

In simulation # 5 the company implements a production system with Built-in Quality (does not receive, manufacture and forward NG goods) in simulation 5 each work station operator must check product quality and ensure the point quality of his work.

Simulation #6 (Figure 7):

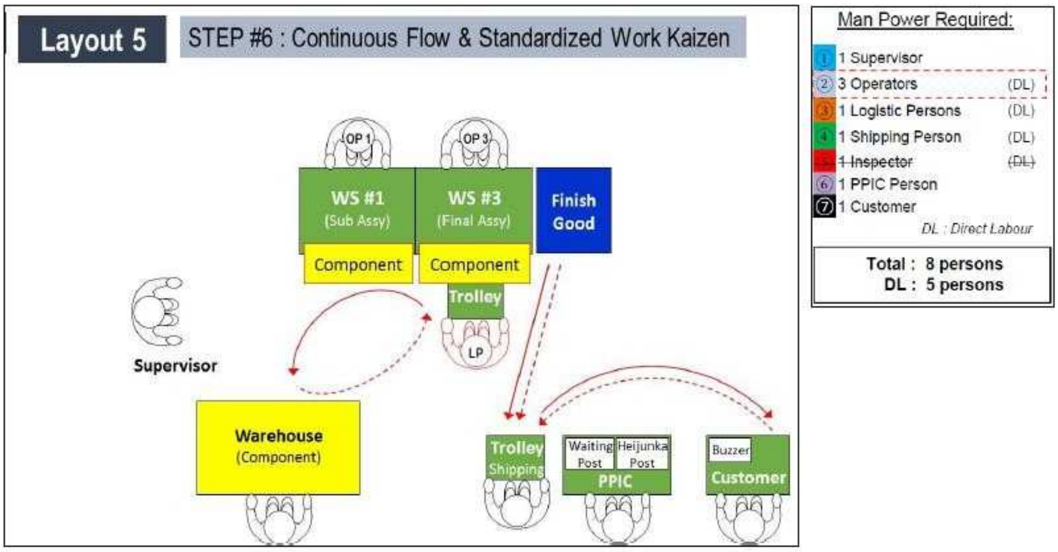

Figure 7 Continuous Flow & Standardized Work Kaizen
Source [24]

In simulation # 6 the company implements a production system which implements TPS by flowing each one part and reviewing work standardization based on Takt Time [24].

4 Results and discussions

To process the data, the reserachers calculate the total cost at each workstation for each simulation. The total cost is calculated to find out the unit cost, profit, and no good rate in each simulation. Profit and unit costs generated in each simulation will be analyzed to get the best simulation. Each simulation uses a different method. Simulation 1 uses traditional manufacturing, simulation 2 uses stock between process, simulation 3 uses a pull system, simulation 4 uses heijunka, simulation 5 uses build-in quality, and simulation 6 uses continuous flow and standardized work kaizen. The following calculation is a description for simulation 1 (traditional manufacturing), which consists of calculating the total cost based on the cost of good production and no good production at each workstation. The number of orders for each simulation is the same, namely 10 units of cars consisting of Pick Up <P/U>, Double Cabin <D-Cab>, and Multi Purpose Vehicle <MPV> types in each simulation.

Simulation #1

1. *Total Cost*WAS #1
   cost = \$10
   goodproduction = *Quantity*x Cost = 1 x \$10 = \$10
   No good production = *Quantity*x Cost = 0 x \$10 = 0
   total cost = *good Product*+ No good Product = \$10 + 0 = \$10
2. *Total Cost*WAS #2
   cost = \$20
   goodproduction = *Quantity* x Cost = 4 x \$20 = \$80
   No good production = *Quantity* x Cost = 0 x \$20 = 0
   total cost = *good Product* + No good Product = \$80 + 0 = \$80
3. *Total Cost*WAS #3
   cost = \$30
   goodproduction = *Quantity* x Cost = 3 x \$30 = \$90
   No good production = *Quantity* x Cost = 0 x \$30 = 0
   total cost = *good Product* + No good Product = \$90 + 0 = \$90
4. *Total Cost*WS #1 #2 #3
   total cost = WS#1 + WS#2 + WS#3 = \$10 + \$80 + \$90 = \$180
   So, the total cost obtained in WS #1 #2 #3 Simulation 1 is \$ 180.
5. *Total Cost*WAS #4
   cost = \$40
   goodproduction = *Quantity* x Cost = 4 x \$40 = \$160
   No good production = *Quantity* x Cost = 6 x \$40 = \$240
   total cost = *good Product* + No good Product = \$160 + \$240 = \$400
6. *Shipping*
   Number Of Orders = 10 Pcs
   Cost Delivery (On Time) = \$100 x Quantity = \$100 x 7 = \$700
   Cost Delivery (Delayed) = \$80 x Quantity = \$80 x 0 = \$0
   Total Delivery(d) = 9
   Cost Undelivered
   /Reject Product = \$30 x Quantity = \$30 x 3 = \$90
   Total Income = *Cost Delivery* - *Cost Undelivered* = \$700 - \$90 = \$610

   So, the total income earned on shipping Simulation 1 is \$610.

   Unit cost = (Fixed Cost + Total Cost WS #1#2 #3 + Total Cost WS #4) / Total Delivery
   = (\$200 + \$180 + \$400) / 7 = \$111
   Profit = *Total Income*– (Fixed Cost + Total Cost WS #1 #2 #3 + Total Cost WS #4 + Labor Cost)
   = \$610 – (\$200 + \$180+ \$400+ \$180) = -\$350

   Quality(NG Rate) $= \frac{Total\ \text{NG WS\#4}}{Total\ Order\ Customer}\ x\ 100\% = \frac{6}{10}\ x\ 100\% = 60\%$

   To calculate the unit cost and profit in each simulation, Ms. Excel, the following are the calculation results in simulation 1 shown in Table 1.

Table 1 Lean Manufacturing Simulation 1 Evaluation Sheet

Lean Manufacturing Simulation Evaluation Sheet Round #1 — fill in the blue column

The cost of depreciation is fixed:						$ 200	---> A
Labour			No. of Labour:	12		$ 15	---> F
Cost of Labour						$ 180	
WS	**Area**	**Status**	**Quantity (Q)**		**Cost©**	**Total Cost (Q x C)**	
#1	In Process product	Good Product		Pcs	$ 10	$ -	
		No Good Product		Pcs	$ 10	$ -	
	In Warehouse	Good Product	1	Pcs	$ 10	$ 10	
			Sub Total 1			$ 10	---> 1
#2	In Process product	Good Product		Pcs	$ 20	$ -	
		No Good Product		Pcs	$ 20	$ -	
	In Warehouse	Good Product	4	Pcs	$ 20	$ 80	
			Sub Total 2			$ 80	---> 2
#3	In Process product	Good Product		Pcs	$ 30	$ -	
		No Good Product		Pcs	$ 30	$ -	
	In Warehouse	Good Product	3	Pcs	$ 30	$ 90	
			Sub Total 3			$ 90	---> 3
			Total 1 + 2 + 3			$ 180	---> B
#4	Final Inspection	Good Product	4	Pcs	$ 40	$ 160	
		No Good Product	6	Pcs	$ 40	$ 240	
			Total			$ 400	---> C
SHIPPING	Number of Order		10	Pcs			
	Delivery	On time	7	Pcs	$ 100	$ 700	
		Delayed		Pcs	$ 80	$ -	
		Total Delivery (D)	7,00	Pcs			
	Undelivered /Reject Product		3	Pcs	$ -30	$ (90)	
					Total Income	$ 610	---> E
	Unit Cost	(A + B + C) / D				$ 111	---> G
	Profit	E - (A + B + C + F)				$ (350)	
	Customer Satisfaction	On time delivery	7	Pcs			---> H
		Late delivery	0	Pcs			---> I
		Undelivered	3	Pcs			---> J
		Total delivery = ((H/(I+J))x 100%)				70%	
	Quality	NG rate	60%	%	(NG A + NG B + NG C + NG FI) / (Production total in all processes)		

The results of the comparison of company profits from each simulation can be seen in the table below (Table 2).

Table 2 Comparison of simulation results

Simulation	*WS #1*	*WS #2*	*WS #3*	*WS #4*	*Total income*	*Unit cost*	*Profit*	*Quality (No Good Rate)*	*Man Power*
1	$10	$80	$90	$400	$610	$111	-$350	60%	12
2	$10	$80	$180	$400	$870	$97	-$165	10%	11
3	$10	$20	$150	$440	$1000	$82	$45	20%	9
4	$10	$40	$150	$240	$1000	$64	$225	0%	9
5	$10	$0	$240	-	$870	$50	$300	0%	8
6	-	$20	$120	-	$1000	$34	$540	0%	7

The TPS simulation involves several work sections consisting of four workstations, a warehouse section, a Production Planning and Inventory Control section. Each work station has its own workload which is carried out by the operator and limited by the supervisor. In simulation 1, namely traditional manufacturing involving 12 workers with 4 workstations, in simulation 2 involving 11 workers with 4 workstations, in simulations 3 and 4 involving 9 workers for 4 workstations, in simulation 5 involving 8 workers for 3 workstations, and in simulation 6 which involved 7 workers for 2 work stations. Based on the division of labor for each simulation, it can be seen that from simulations 1 to 6 there was a decrease in the number of workers, which was also followed by a reduction in the number of workstations. Except for simulations 3 and 4, they still use the same number of workers and workstations, this is because what was done was only changes to the production flow with the lean concept applied in simulation 3, namely the pull system and simulation 4, namely heijunka

Based on the results in table 1, a comparison of the simulation results can be seen. Setup simulation 1 (traditional manufacturing) consistsfrom 1 supervisor, 1 Production Planning Inventory Control (PPIC), 1 shipping person, 4 work station operators, 4 logistics persons, and 1 warehouse person. In this simulation, the company implements a traditional production system because it uses a warehouse as a place for stock centralization which consists of stock of finished goods, stock of semi-finished goods which are then sent to customers. The simulation results show that the unit cost value is $111, the profit value is - $ 350, and the quality (NG Rate) is 60%.

Setup simulation 2 (stock between process) consisting of 1 supervisor, 1 PPIC person, 1 shipping person, 4 operators, 3 logistics persons, and 1 warehouse person. In this case the logistics person for WS #4 is eliminated because in this simulation, the company implements a production system that has implemented a store at each work station and the warehouse is only a place for storing materials. From the simulation results, it is known that the unit cost value is $ 97, the profit value is - $ 165, and the quality (NG rate) is 10%.

Simulation setup 3 (pull system) consists of 1 supervisor, 1 PPIC person, 1 shipping person, 4 operators, 1 logistics person, and 1 warehouse person. In this case, the logistics person for WS 1 and 2 is omitted. So there is only 1 logistics person left to deliver materials to each work station. This is because the company's production system applies a pull system method at each work station. In this simulation, kanban and waiting post are used, the Kanban function is a card for production orders while the waiting post function is a tool to obtain information from visualized customers. The simulation results show that the unit cost value is $ 82, the profit value is $ 45, and the quality (NG rate) is 20%.

Simulation setup 4 (heijunka) consists of 1 supervisor, 1 PPIC person, 1 shipping person, 4 operators, 1 logistics person, and 1 warehouse person. In this simulation, the condition of the company implementing a production system is the pull system method at each work station and using heijunka posts as a tool to equalize the operator's workload. . From the simulation results, it is known that the unit cost value is $ 64, the profit value is $ 225, and the quality (NG rate) is 0%.

Simulation setup 5 (built-in quality) consists of 1 supervisor, 1 PPIC person, 1 shipping person, 3 operators, 1 logistics person, and 1 warehouse person. In this respect, work station 4 as the inspector is omitted. This is because the company implements a production system with built-in quality (does not receive, manufacture, and forward no good products) in a way that each work station ensures the quality of their respective work. Therefore, it is known that the unit cost value is $ 50, while the profit value is $ 300, and the quality (NG Rate) is 0%.

Simulation 6 setup consists of 1 supervisor, 1 PPIC person, 1 shipping person, 2 operators, 1 logistics person, and 1 warehouse person. In this case, the work station 2 operator is omitted because in this simulation, the company applies a process layout using 2 work stations and divides the work. As a result, it is known that the unit cost value is $ 34, the profit value is $ 540, and the quality (NG rate) is 0%.

In determining profit, a "profit planning approach" analysis is carried out which is based on the relationship between costs (cost) and income (income), the amount of income can be known based on the amount of demand [25]. In the simulations performed, it is known that the production costs calculated to determine profit are depreciation costs, labor costs, and production costs based on each workstation per unit product. The cost of producing a product per unit is divided into two types, namely the cost of good product and no good product. Good product means that the product produced is fit for sale in the market and meets quality control standards, while no good product means a product that does not meet quality standards and is not fit for sale in the market. In the production system simulation based on the TPS concept, the number of demands is assumed to be 10 units for three types of cars. The selling price to determine the amount of income is divided into three, namely the selling price of the product that is on time, the selling price of the product that is delayed, and the selling price of undelivered/rejected products. Total income is obtained based on three types of product selling prices. While the amount of profit is obtained based on the difference between the amount of income and depreciation costs, production costs incurred at each workstation for each simulation and labor costs. The total cost of production becomes one of the variables to calculate the unit cost. The unit cost is obtained by calculating the depreciation cost and the total production cost at each workstation then divided by the total product successfully delivered to the customer. production costs incurred on each workstation for each simulation and labor costs. The total cost of production becomes one of the variables to calculate the unit cost. It is obtained by calculating the depreciation cost and the total production cost at each workstation then divided by the total product successfully delivered to the customer. production costs incurred on each workstation for each simulation and labor costs. The total cost of production becomes one of the variables to calculate the unit cost. It is obtained by calculating the depreciation cost and the total production cost at each workstation then divided by the total product successfully delivered to the customer.

Customer satisfaction is the main goal for business actors. Customer (consumer) satisfaction is the ability of a product to meet or exceed consumer expectations and desires [26]. Customer satisfaction determines the success and failure of the company. Therefore, it is very important to know and understand whether the customer is satisfied with the services provided by the company. Calculation of customer satisfaction is based on the TPS concept by considering the number of products that are on time delivery, late delivery, and undelivered.

To see how much the level of product quality is produced, the TPS concept also calculates the Quality rate. The quality rate is determined based on the number of products that fall into no good product category at each workstation. The purpose of calculating the quality rate is to determine the level of production effectiveness in the production system that is run based on the quality of the resulting product [27].

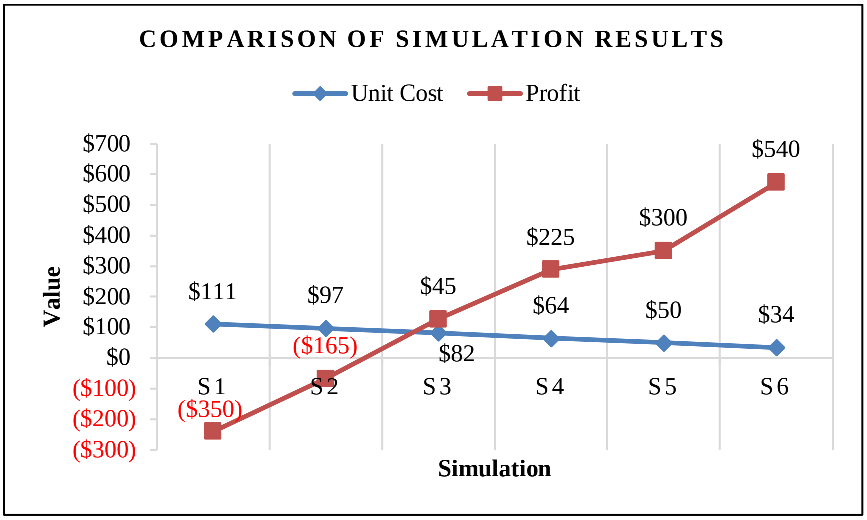

Figure 8 Comparison of simulation results

Based on the simulation results 1 to 6, the unit cost and profit values are different. Based on figure 8, it shows that the value for the unit cost starting from simulation 1 to 6 is getting smaller. This also happens to the profit value which shows that from simulations 1 to 6 it is increasing. With reference to the unit cost and profit values generated in the graphic images, it can be concluded that using the same number of orders with different work methods, it will affect how much the unit cost and profit values are obtained by the company. Simulation 1 which still uses the traditional method produces the largest unit cost and the lowest profit, however, in simulation 5, the workstation was streamlined, namely the quality control section. The role of quality control is held by each operator at workstations 1 to 3. Likewise with simulation 6 which applies the lean concept by applying kaizen in the process. From the unit cost results for simulations 5 and 6 there was a decrease and an increase in profit.

Referring to the work method for the car production system by running simulations 1 and 6, lower unit costs and higher profits are produced by adopting the lean concept in the production system. This can support the achievement of sustainability in the economic field by obtaining work methods that are able to produce low unit costs and maximum profits.

5 Conclusions

Based on the research results by running 6 simulations based on TPS obtained unit cost and profit results for each simulation. Simulation 1 shows the highest unit cost, which is $111 when compared to simulations 2 to 6 which have implemented lean principles in their production systems. Likewise, with the profit generated, simulation 1 produces the lowest profit, which is -$359 when compared to simulations 2 to 6. The profit generated by simulation 1 shows that the production system that is run in simulation 1 results in losses for the company with a minus profit value. From simulations 1 to 6, the unit cost results are getting lower, as well as the profit earned is increasing. Simulations using lean concept implemented by TPS show that the continuous improvement steps being carried out are increasing in simulations 2 to 6 by applying the lean concept. The results obtained show that the greater the lean steps taken by the company, the smaller the unit cost will be and the higher the profit will be. In addition to calculating unit cost and profits, each simulation also calculates the percentage of customer satisfaction and quality rate. If implementing the lean concept in the production system, the company has the potential to achieve maximum profits because the unit cost is also low. However, a potential drawback when implementing the lean concept is the increased workload for manpower, as the concept also involves reducing manpower. Therefore, it is necessary to measure the workload for manpower before deciding to implement the lean concept, which includes manpower reduction.

If the lean concept is applied to the production system, the company's sustainability, especially in the economic field, can be achieved by obtaining a small unit cost and maximum profit. The results of this study can be a suggestion for business actors, especially in the manufacturing sector, to apply the lean concept with reference to continuous improvement. Sustainable improvement steps with the lean concept can be undertaken by applying several concepts used in the TPS to its production system, such as Heijunka System, Jidouka, and Kanban. Furthermore, the lean concept can also be implemented in the production system by making technological improvements and leveraging digitization, which can streamline the production system.

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