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Integrating Lean Implementation and Relayout Design for Efficiency Improvement

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Abstract. *Eliminating non-value-added (NVA) activities is a comprehensive solution to achieve efficiency in manufacturing industry production processes. Inefficiency arises whether the production facility and equipment are recent or timeworn. Division. Soybean Production PT. YZ seeks to evaluate the inefficiencies in the relatively new soybean production and packaging plan. The incompatibility of the layout of the production floor facilities was identified as the leading cause of the inability of the Soybean Production Division to meet consumer demands. This study aims to make the production floor layout based on material handling costs, provide good layout alternatives, minimize lead times, and increase cycle efficiency in production processes. The research method integrates Systematic Layout Planning (SLP) and the Lean Manufacturing approach. Value Stream Map (VSM) as a study result distinguishing waste, namely motion and waiting for the material transfer process, which leads to non-value added activity. The best alternative layout proposal was obtained, namely the second Alternative, with the results of minimizing material handling costs by 26% and time-wasting by 19%. VSM and Relayout design provide significant improvement in eliminating losses as well as efficiency improvement.*

Keywords: *lean, re-layout, SLP, VSM, waste*

I. INTRODUCTION

Efficiency based on non-value added elimination in man, machine, material, method, and money which is familiarly abbreviated as 5M production activity, is a vital activities a manufacturing and service business (Musfita & Mahbubah, 2021; Pujiyanto et al., 2021; Romadhani et al. al., 2021). Mapping the flow of information and the flow of goods is a preliminary helicopter view that can detect activities that are not yet efficient (Jakfar et al., 2014; Utama et al., 2016). The integration of efficiency methods is empirically proven to provide an effective solution of 5M efficiency compared to a single method (Cantini et al., 2020; Prasetya & Sunday Alexander Theophilus Noya, 2015). Facility layout design is the basis for organizing a production area so that operations become more efficient (Pérez-Gosende et al., 2021). The facilities and elements in question include raw materials, equipment, operators, and material changes from raw materials to the delivery of finished goods. An unsuitable layout can decrease productivity and operating expenses (Tarigan et al., 2020).

PT. YZ is a national-scale wheat flour manufacturing company. In addition to producing wheat flour, the company developed a soybean processing business based on soybean seeds. Processed local or imported soybeans, then packed using 50 kg sacks. The demand for the goods is approximately 200 tons daily. However, the firm could only deliver 150 tons, resulting in a deficit of 50 tons per day. The production division has been evaluating the inability to fulfill consumer demand.

Furthermore, The Soybean Division is a new Production Plan established in 2018. As an international-scale enterprise, the company has conducted sufficient studies and built the Soybean Division using international standards regarding equipment, machines, and human resources with good skills. The production facilities of machines and types of equipment have been running smoothly with regular maintenance.

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The Production Division Team has been conducting evaluations and assessments to solve the problem. The results of the initial evaluation revealed that there were inefficiencies in the production area.

The comprehensive approach used to identify waste and increase the efficiency of the production process is to use the VSM method, which is integrated with the layout design using the SLP method. The integration of VSM and SLP has been empirically proven to minimize material handling costs, reduce the wasted distance between stations, and increase productivity (Cantini et al., 2020; Febriandini & Yuniaristanto, 2019).

The VSM method has been used to analyze the waste that occurs in all production process activities with the help of the PAM tool in cast concrete production activities (Trisna et al., 2022). The results show that three types of waste activities occur: transportation, material transfer, and delay. In addition, VSM has also been used to identify value-added (VA) and non-value-added (NVA) scores in the garment production process (Prasetya & Sunday Alexander Theophilus Noya, 2015). The study result shows that capturing VSM is good in visualizing to identify non-value-added activities so they can reduce waste. Then, with VSM considerations, macro layouts in the production process can be made. The VSM method was also used to identify waste in the etiquette production process (Jakfar et al., 2014). This research shows that the leading causes of waste in production are overproduction, delay, transportation, excess processing, inventories, motion, and defects. Lean practices are also implemented in chemical production processes and water refining production processes to eliminate non-value-added activities (Musfita & Mahbubah, 2021; Romadhani et al., 2021).

Even though the lean method has been successfully implemented empirically based, there was a lack of practical cases due to the proposed efficiency scenario based on qualitative–based information (Sundar et al., 2014). Factors such as working method and human motion, as well as the equipment age, have not been considered. Layout facility design is considered a suitable approach to fill the gap in the lean method. There are several methods for designing facility layouts, one of which is the Systematic Layout planning (SLP) method. The SLP method was used to minimize material handling costs by propositioning a modified re-layout design in Malaysian multinational enterprises based in Malaysia (Febriandini & Yuniaristanto, 2019). Redesign layouts that aim to increase productivity and costs in the production process have also been empirically conducted in a variety of enterprise sizes, from medium to multinational firms (AB Kadir et al., 2018; Ali Naqvi et al., 2016; Kovács & Kot, 2017; Lins et al., 2021; Sojka & Lepšík, 2019; Suhardi et al., 2019). This research has been conducted in developed and developing countries worldwide.

Combining Lean Approach and Facility Design Method has been used due to complexity of the production floor needs to be resolved to provide production efficiency (AB Kadir et al., 2018; Cantini et al., 2020; Jia et al., 2013; Kommula et al., al., 2015; Kovács, 2019; Nagi & Altarazi, 2017; Prasetya & Sunday Alexander Theophilus Noya, 2015; Putri & Dona, 2019). Implementing Lean and facility Layout is based on the case study with objects on three continents: Europe, Asia, and Africa. The business scale of the study object is one medium-scale business and seven large and multinational business scales. The combination of the Lean VSM method is carried out in a refinement equipment maintenance company on gas and oil engines that experience inefficiency due to waste in the workshop area (AB Kadir et al., 2018). A Lean-based Simulation approach and facility Layout were also carried out on large-scale companies in China, Botswana, and Italy to eliminate inefficiencies along the production flow (Cantini et al., 2020; Kommula et al., 2015; Kovács, 2019). Implementing a Lean and facility Layout was also carried out to improve process capability in a carpet company in Jordan (Nagi & Altarazi, 2017). While in Indonesia, the integration of the two methods is implemented in large-scale garment manufacturers and medium-scale processed food home businesses in Sumatra

(Prasetya & Sunday Alexander Theophilus Noya, 2015; Putri & Dona, 2019).

Although research based on Lean integration and facility design based on empirical evidence has been carried out on various continents, the previous study has a number of limitations. Simulation-based research has limitations on model validation and is challenging to implement in the real world case. In the empirical evidence of previous studies, that cases-based were applied to businesses that have been stable and established. In the case of empirical studies, previous research did not consider the age factor of machines and equipment, so the proposed framework was inadequate. This research fulfills the gap in previous research. The significance of this research is to use an actual world case study, and the author is involved in the project team at PT XZ Enterprise.

Furthermore, the author was part of the team that founded Plan soybean three years ago. This study combines two methods, VSM with SLP, where waste reduction is not only in cycle time but also distance reduction in moving goods, material handling costs, and an efficient and practical layout of proposals in the production process. This study also presents an alternative solution for improving transportation waste using the SLP method. In addition, this research also presents the calculation of cycle time and the cycle efficiency process after the layout improvement has been carried out to provide a facility layout recommendation and increase the productivity process. This research aims to streamline the production process to minimize material handling costs, provide the best layout alternative, minimize lead time, and improve cycle efficiency in soybean packaging production at PT. YZ.

II. RESEARCH METHOD

Research Models and data collection

The project has been piloted from January 2022 to the present in the Commodity Division at PT. YZ. Descriptive and quantitative were used as research approaches to improve a previous situation. Walk thorough survey was used as an observation instrument on the production line. Moreover, observation was conducted on station plans. The production stages begin with raw materials for Hopper, Separator, Destoner, Packing, Weigher, and finishing, labeling, and palleting to finish well. Qualitative and quantitative data were used in this study. Qualitative data was collected using questionnaire instrument. This instrument then used to brainstorm with thirteen respondents: a Production Head, Production Supervisor. Three Producton Leader, and seven production operators. Walk through observation was conducted to determine the production process and the layout of facilities and workstations on the production line. Quantitative data was obtained from the company's record. This data include production flow data for each product, cycle time, and machine facility data. In addition, the production process, current production layout, and material handling costs were presented as quantitative data.

Data processing

This study procedure consists of nine stages are described as follows. The first stage was Non-value-added activities identification, followed by the initial production layout identification stage. The initial stage result was used to map the current state using the Process Activity mapping (PAM) tool to analyze each process that has value added. The third stage was improving the initial facility layout using the Systematic Layout Planning (SLP) method with the From to Chart Outflow approach, determining priority scale, making ARC, and designing ARD. The proposed layout design from the results of the ARD method is the fourth stage and was continued by calculating the cycle time using a stopwatch and for material movement using the distance formula divided by the speed of the material handling tool.

The sixth stage is to calculate the average Time and the standard Time for the initial layout and proposal with the formula:

$$Wn = Ws\,(1 + RF) \quad (1)$$

$$\mathrm{Wb} = \mathrm{Wn} + 100\%\ (100\% - \mathrm{Allowance}) \quad (2)$$

The seventh stage was to calculate the cycle efficiency process between the initial layout and the proposed layout, which was calculated using the formula:

$$Process\ cycle\ efficiency = \frac{value\ added\ TimeTime}{manufacturing\ lead\ time} \quad (3)$$

The eighth stage was capturing a map of future VSM from the results of improving the proposed layout and Current VSM. Comparing the initial layout with the proposed layout is the last stage of the research.

III. RESULTS AND DISCUSSION

Process Activity Mapping

Process Activity Map (MAP) provides an overview of the physical flow and information, which will later be identified to calculate the VA

Table 1. Process Activity Map of Soybean Production

No	Activity	O	D	T	S	I	NVA/VA	Description
1	Transfer raw materials to hopper machine using a loader			T			NVA	Long product transfer distance
2	Mix raw material in hopper machine	O					VA	No Wasting
3	Product transfer from hopper to a separator			T			NVA	Repeated material accumulation
4	Soybean shell separation process	O					VA	No Wasting
5	Product transfer from the separator to destoner			T			NVA	Long product transfer distance
6	The stone separation process in destoner	O					VA	No Wasting
7	Product transfer from destoner to packing			T			NVA	Long product transfer distance
8	Packing process		D				NVA	Waiting for material to process packing
9	Product transfer from packing to the weigher			T			NVA	Long product transfer distance
10	Weighing process	O					VA	No Wasting
11	Product transfer from weigher to finishing			T			NVA	Long product transfer distance
12	First sewing process	O					VA	No Wasting
13	Product transfer from finishing to labeling		D				NVA	Waiting for material to process sewing
14	Labeling process	O					VA	No Wasting
15	Product transfer from labeling to finishing			T			NVA	Repeated material accumulation
16	Final sewing process					I	VA	2nd inspection and sewing
17	Product transfer from finishing to palleting			T			NVA	Long product transfer distance
18	Palleting process	O					NVA	Long product transfer distance
19	Product transfer from palleting to Warehouse			T			NVA	Long product transfer distance

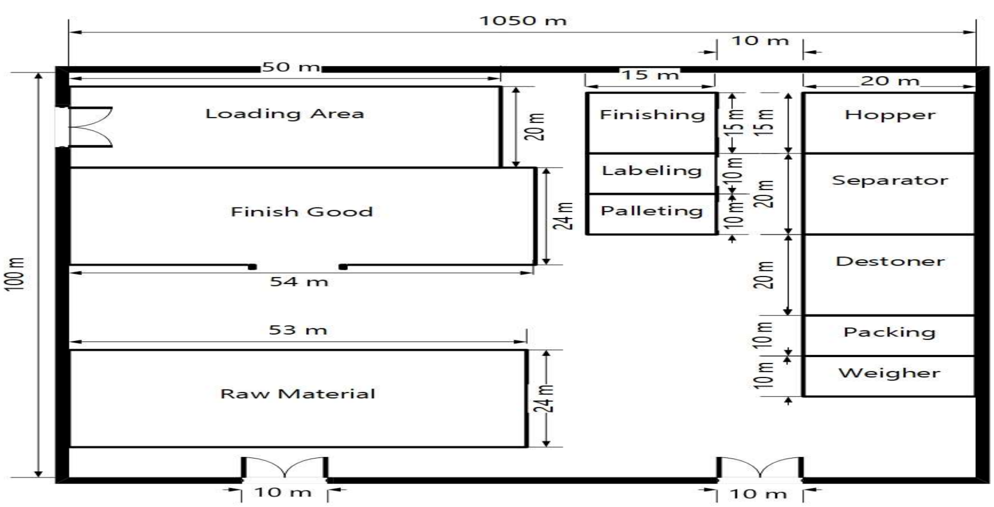

Figure 1. Initial facility Layout

and NVA time, lead time, cycle time, and cycle process. Process activity mapping is presented in Table 1. In addition, the NVA activities were backtracking movement from the raw material warehouse to the hooper. The second NVA was distanced during the material transfer process.

Table 2. Available Area

Code	Available Area	Dimension		Area (m2)
		Length (m)	width (m)	
RM	Raw Material	53	24	1272
H	Hopper	20	15	300
S	Separator	20	20	400
D	Destoner	20	20	400
P	Packing	20	10	200
W	Weigher	20	10	200
F	Finishing	15	15	225
PL	Palleting	15	10	150
F1	Finish Good	54	24	1296
LO	Loading	50	20	1000
Total				5593

Table 3. Distance between Facility

From	To	Distance (m)
RM	H	130,5
H	S	17,5
S	D	20
D	P	15
P	W	10
W	F	65
F	L	12,5
L	F	12,5
F	PL	22,5
PL	F1	44
Total		349,5

Table 4. Material handling Cost

From	To	MH	MH/meter	MH Cost
RM	H	Loader	Rp 450	Rp 58.725
H	S	Loader	Rp 450	Rp 7.875
S	D	Screw Conveyor	Rp 3.600	Rp 72.000
D	P	Screw Conveyor	Rp 3.600	Rp 54.000
P	W	Conveyor	Rp 4.000	Rp 40.000
W	F	Forklift	Rp 660	Rp 42.900
F	L	Conveyor	Rp 4.000	Rp 50.000
L	F	Conveyor	Rp 4.000	Rp 50.000
F	PL	Conveyor	Rp 4.000	Rp 90.000
PL	F1	Forklift	Rp 660	Rp 29.040
Total				Rp 494.540

Identify Initial Layout

The layout size of the commodity division is 1050 meters long and 100 meters wide. For the size of each floor in production, it can be seen in table 2. The description of the initial layout and code for each facility can be seen in Figure 1. Codes facilitate reading when mapping stations, such as RM (Raw material) and H (Hopper) codes. S (Separator), D (Destoner), P (Packing), W (Weigher), F (Finishing), L (Labelling), PL (Palleting), F1 (Finish Good), LO (Loading).

It can be seen in Table 1. that seven activities with code O = operation process, two activities with symbol D = delay, nine activities include symbol T = Transportation, and an activity part of S = Storage, I = Inspection. Furthermore, the identification of the initial layout availability area in the production process is presented in Table 2. Furthermore, the distance between stations can be seen in Table 3.

It can be seen from Tabke 3. The remotest distance in the first sequence was moving from the raw material warehouse to the hopper of 130.5 meters. The second rank was the distance from the palleting process to the hopper—finish goods by 44 meters. The fourth rank was material handling tools for transportation equipment moving from station to station: Loader, Forklift, Screw Conveyor, and Conveyor. Material handling costs were obtained from the MH cost per meter results multiplied by the distance traveled. From the data obtained, the material handling costs per meter and total can be seen in Table 4.

From To Chart Outflow

From To Chart (FTC) is a variation of the mileage chart regularly found on motion activity. The results of the FTC outflow calculation can be seen in Table 5. This table provides information on loading and unloading process movement. Costs were generated based on the cost of consumables for transportation. In addition, the FTC table was calculated as a result of material handling costs. The outflow FTC was the cost coefficient based on the graph calculating the costs arising from the machine. The result of the highlighted values was based on FTC Outlow due to backtracking activity in the production process.

Table 5. From To Chart Outflow

To / From	RM	H	S	D	P	W	F	L	PL	F1
RM		7,457								
H			0,109							
S				1,333						
D					1,350					
P						0,932				
W							0,306			
F								1,00	3,099	
L							0,357			
PL										
F1										

Priority Scale

The results from the FTC outflow table were then made into a priority scale. This process was ranked from the prevalent to the minimum number, namely raw material with hopper, hopper with separator, separator with destoner, destoner with packing, packing with weigher, weigher with finishing, finishing, with palleting, labeling with finishing.

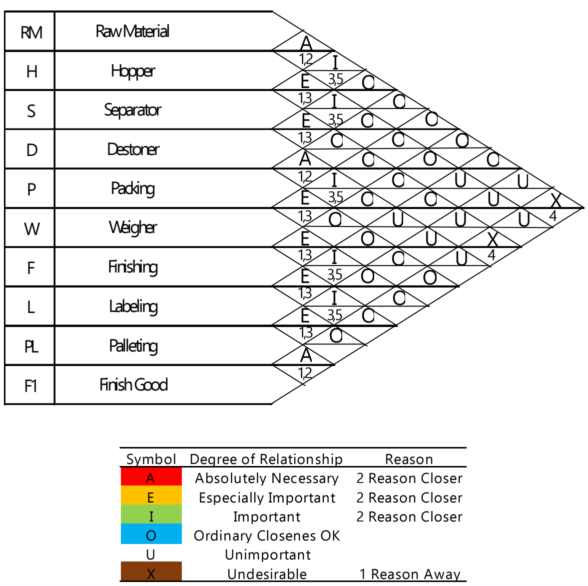

Figure 2. Activity Relationship Chart

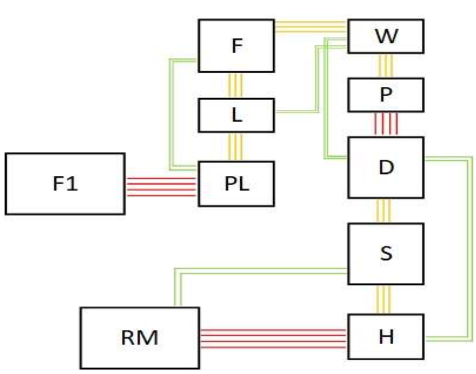

Figure 3. Activity Relationship Diagram

Activity Relationship Chart

The activity Relationship Chart (ARC) can be seen in figure 2. It was drawn to determine the degree of relationship between workstations for the following reasons:

1. Workflow processes
2. Use the same personnel
3. Easy to move goods
4. Noise, dust, and vibration
5. Easy monitoring

For these reasons, the ARC is generated as Figure 2.

Activity Relationship Diagram

The ARC illustrated in Figure 3. was used as a feeder on Figure 3, namely Activity Relationship Diagram (ARD).

It can be seen in Figure 3. that the red line indicates that it was necessary to transport it nearer. , The yellow mark was significant to convey it. The green one was necessary to bring it closer. Once the ARC and ARD are done, layout improvements can be formulated to increase cost efficiency and the distance between stations.

1st Alternative L

The first alternative layout design is based on the results of the priority scale presented in Table 4. The 1st alternative layout delivered a change in the layout of the Hopper station, which was closer to the raw material area.

Consequently, there was a modification in terms of the distance of each station, as seen in Table 6. Illustrate adjustment of material handling cost. It can be seen in Table. 7 that there was a significant reduction in the distance. In addition, the following Table 7. The total material handling costs incurred using 1st alternative layout was Rp. 398,835.00 with a total distance of 160.5m, with fewer costs than the original layout.

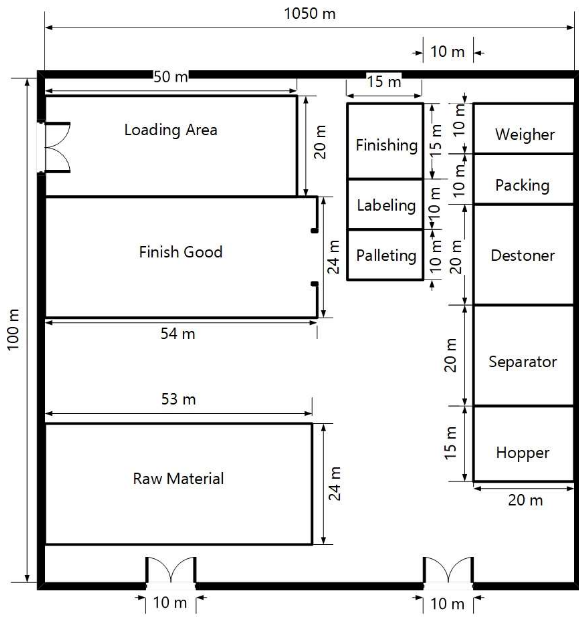

Figure 4. Layout 1st Alternative

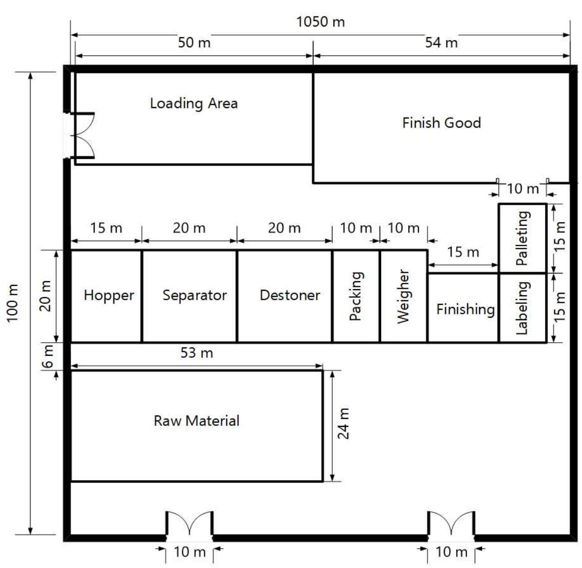

Figure 5. Relayout 2nd Alternative

2nd Alternative layout

The second alternative layout can be seen in Figure 5. The second alternative scenario was generated because the production area was focused in the middle to be closer to the raw material and finished goods area.

From alternative layout 2, illustrated in Table 2, the raw material area was far from the finished goods area because the finished material area must be clean and must not be contaminated with dust and other materials in the raw material area. In the alternative second re-layout, there was space saving next to raw materials, which can be used for production expansion or raw material storage. For distance and material handling costs in an alternative layout Two shown in Table 8.

It can be seen in Table 8. that the distance

Table 6. Facility Distance 1st Alternative

From	To	1st Alternative Distance (m)
RM	H	32
H	S	17,5
S	D	20
D	P	15
P	W	10
W	F	10
F	L	17,5
L	F	10
F	PL	22,5
PL	F1	6
Total		160,5

Table 7. Material handling cost 1st alternative

From	To	Material Handling	MH/meter	MH Cost
RM	H	Loader	Rp 450	Rp 14.400
H	S	Loader	Rp 450	Rp 7.875
S	D	Screw Conveyor	Rp 3.600	Rp 72.000
D	P	Screw Conveyor	Rp 3.600	Rp 54.000
P	W	Conveyor	Rp 4.000	Rp 40.000
W	F	Forklift	Rp 660	Rp 6.600
F	L	Conveyor	Rp 4.000	Rp 70.000
L	F	Conveyor	Rp 4.000	Rp 40.000
F	PL	Conveyor	Rp 4.000	Rp 90.000
PL	F1	Forklift	Rp 660	Rp 3.960
Total				Rp 398.835

from the alternative second distance table is less in comparison with the alternative layout 1. Table 9 shows the calculation of material handling cost in alternative layout 2. Material handling costs incurred by using alternative layout 2 were lower than alternative layout 1, with a total distance of 130.5m and less cost of Rp. 367,795.00

Furthermore, each layout result is calculated process lead time and process cycle efficiency.

Cycle Time

Table 10. Illustrate Cycle Time. The cycle time of each activity is calculated with the help of a stopwatch. In contrast, moving from one station to another uses the distance formula divided by the material handling speed. For Loader speed = 15 m/min, Screw Conveyor = 5 m/min, Conveyor = 5 m/min, Forklift = 10 m/min. the following result was based on the cycle time of each activity in the layout results.

Tabel 8. Facility Distance of 2nd Alternative

From	To	2nd Alternative Distance (m)
RM	H	6
H	S	17,5
S	D	20
D	P	15
P	W	10
W	F	12,5
F	L	12,5
L	F	12,5
F	PL	20
PL	F1	4,5
Total		130,5

Table 9. Material handling cost 2nd alternative

From	To	Material Handling	MH/meter	Total MH Cost
RM	H	Loader	Rp 450	Rp 2.700
H	S	Loader	Rp 450	Rp 7.875
S	D	Screw Conveyor	Rp 3.600	Rp 72.000
D	P	Screw Conveyor	Rp 3.600	Rp 54.000
P	W	Conveyor	Rp 4.000	Rp 40.000
W	F	Forklift	Rp 660	Rp 8.250
F	L	Conveyor	Rp 4.000	Rp 50.000
L	F	Conveyor	Rp 4.000	Rp 50.000
F	PL	Conveyor	Rp 4.000	Rp 80.000
PL	F1	Forklift	Rp 660	Rp 2.970
Total				Rp 367.795

Standard Time

Before calculating the standard TimeTime, it takes the average TimeTime for each activity Formula 1. There are nine classified operators in the production process, namely operators (1) heavy equipment loader operators, (2) separator operators, (3) destoner operators, (4) packing operators, (5) weigher operators, (6) labeling operators, (7) finishing operators, (8) operators Palleting, (9) Forklift operator. The rating factor

Table 10. Cycle Time

Activity	Cycle Time (second)		
	Initial Layout	1st SLP	2nd SLP
1	522	128	24
2	300	300	300
3	70,2	70	70
4	300	300	300
5	240	240	240
6	360	360	360
7	180	180	180
8	720	720	720
9	120	120	120
10	360	360	360
11	390	60	75
12	300	300	300
13	150	210	150
14	240	240	240
15	150	120	150
16	300	300	300
17	270	270	240
18	630	630	630
19	264	36	27

Table 11. Rating Factor Operator

OP	Factor				Total
	Skill	Effort	Work	Suitable	
1	+0,09	+0,03	0,00	0,00	0,12
2	+0,09	+0,03	0,00	0,00	0,12
3	+0,03	+0,01	0,00	+0,01	0,05
4	+0,04	+0,09	0,00	0,00	0,13
5	0,00	+0,03	0,00	+0,04	0,07
6	+0,03	+0,02	0,00	+0,05	0,10
7	+0,08	+0,04	+0,01	+0,02	0,15
8	+0,05	+0,09	+0,05	0,00	0,19
9	+0,09	+0,03	0,00	0,00	0,12

can be seen in Table 11. Once the rating factor data was obtained, the standard TimeTime for each activity was calculated, as presented in Table 12.

Furthermore, Table 13. illustrates the determination of the allowance for each operator. Such as eye fatigue, work movements, energy expended, temperature, and work environment.

Once the allowance data was obtained, the standard TimeTime for each activity was calculated using Formula 2, as shown in Table 14.

Table 12. Normal Time

Activity	Average TimeTime (second)		
	Initial Layout	1st SLP	2nd SLP
1	584,64	143,36	26,88
2	336,00	336,00	336,00
3	78,62	78,40	78,40
4	315,00	315,00	315,00
5	252,00	252,00	252,00
6	378,00	378,00	378,00
7	189,00	189,00	189,00
8	813,60	813,60	813,60
9	135,60	135,60	135,60
10	385,20	385,20	385,20
11	417,30	64,20	80,25
12	330,00	330,00	330,00
13	165,00	231,00	165,00
14	276,00	276,00	276,00
15	172,50	138,00	172,50
16	330,00	330,00	330,00
17	297,00	297,00	264,00
18	749,70	749,70	749,70
19	295,68	40,32	30,24

Table 13. Operator Allowance

Operator	Allowance
Operator 1	17%
Operator 2	20%
Operator 3	20%
Operator 4	5%
Operator 5	10%
Operator 6	15%
Operator 7	15%
Operator 8	10%
Operator 9	17%

Manufacturing Lead Time

Calculating the manufacturing lead time of the production process is done by adding all the standard TimeTime for each activity. In the initial layout, the total production lead time is 7549.15 sec. Then for the proposed layout, the production lead time is 6354.28 sec; in the second proposed layout, it is 6143.74 sec. From the comparison of the layouts above, the least lead TimeTime of the production process is in the 2nd proposed layout. This result indicates that there will be an increase in productivity in the soybean packaging production process if the company chooses the 2nd proposed layout.

Process Cycle Efficiency

Furthermore, the percentage of process cycle efficiency for each layout was calculated using the formula 3. The process cycle efficiency of the initial layout was 48%. In the proposed layout, one process cycle efficiency is 58%, while the process cycle efficiency is 60% for the second proposed layout. In addition, the total value added TimeTime in the initial layout and proposed layouts 1 and 2 are 3,656.67 sec.

Table 14. Standard Time

Activity	Standard TimeTime (second)			Allowance
	Initial Layout	1st SLP	2nd SLP	(%)
1	704,39	172,72	32,39	17
2	404,82	404,82	404,82	17
3	94,73	94,46	94,46	17
4	393,75	393,75	393,75	20
5	315,00	315,00	315,00	20
6	472,50	472,50	472,50	20
7	236,25	236,25	236,25	20
8	856,42	856,42	856,42	5
9	142,74	142,74	142,74	5
10	428,00	428,00	428,00	10
11	463,67	71,33	89,17	10
12	388,24	388,24	388,24	15
13	194,12	271,76	194,12	15
14	324,71	324,71	324,71	15
15	202,94	162,35	202,94	15
16	388,24	388,24	388,24	15
17	349,41	349,41	310,59	15
18	833,00	833,00	833,00	10
19	356,24	48,58	36,43	17

The comparison results of the above layouts show that the process cycle efficiency that has experienced an adequate improvement is the second alternative layout with 60%. In comparison, the initial layout is only 48%, and the alternative layout is 58%. In this case, the company needs to rearrange the production process layout with the proposed layout design. The second alternative option so that the production process can run effectively and efficiently.

Value Stream Map

The initial layout results and two alternative layout design scenarios were then constructed into a value stream map. Figure 6. Illustrated current state map, while Figure7 and 8 illustrate future state maps based on the first alternative layout and the second alternative layout for the latter.

The following figure shows current and future value stream maps. The current value

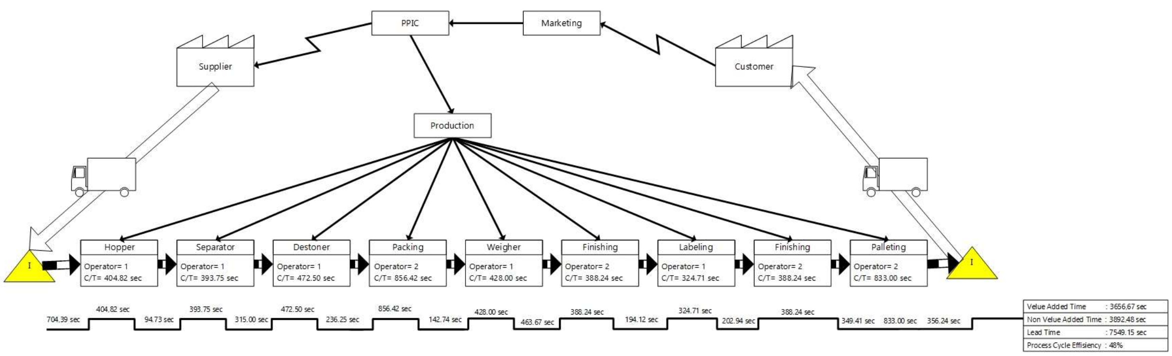

Figure 6. Current state map

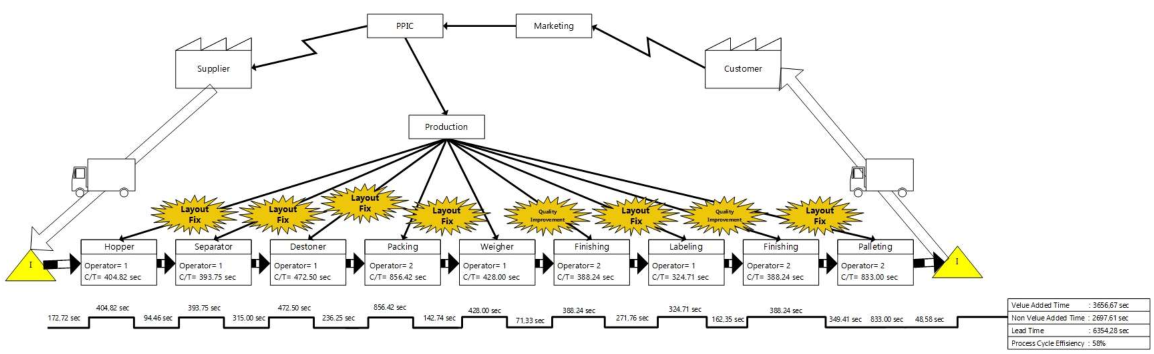

Figure 7. Future state map 1st SLP

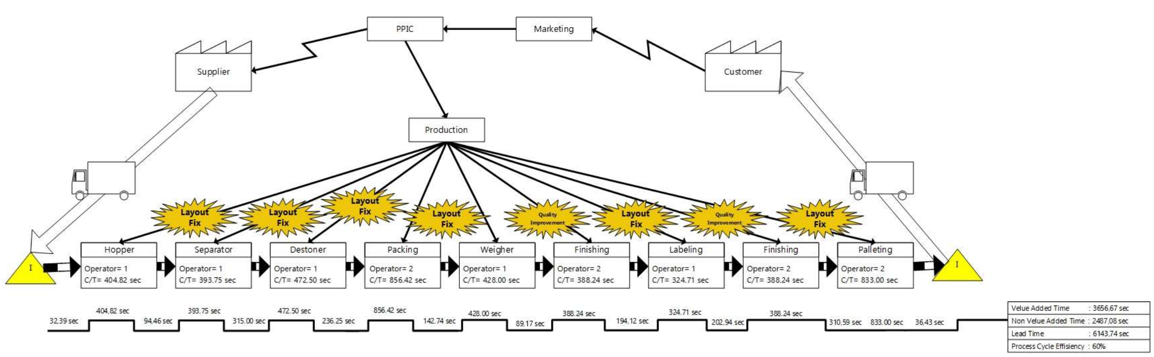

Figure 8. Future state map 2nd SLP

stream map informs that the production process's lead time is 7549.15 seconds, with VA 3656.67 seconds and NVA 3892.48 seconds. Then the process cycle efficiency time was obtained in the production of 48%. The higher NVA times resulting in waste in the production process. Therefore, it is necessary to make improvements in order to improve the process cycle efficiency and minimize the lead time in the production line. Future value stream mapping is designed based on the proposed waste reduction. Reducing waste occurs by improving the layout and distance at each station. In the Future VSM design in the proposed layout 1, the Value added time is 3656.67 seconds, and the non-value added time is 2697.61 seconds. As a result of these improvements, the cycle efficiency increased by 58%, with a lead time of 6354.28 seconds in the production process. From the results of the Future VSM design in the proposed layout 2, the VA time is 3656.67 seconds and the NVA time is 2487.08 sec. The NVA time in the second proposed layout is less than the initial and first proposed layout. The second proposed layout is more effective and efficient, with increase in cycle efficiency of 60% and lead time of 6143.74 sec.

Discussion

The combination of the Lean method and facility Layout is a comprehensive approach to solving inefficiency problems on the production floor. Although the implementation of VSM and Layout planning are theories that already exist and have been proven empirically, the results of this study have significant differences from previous studies. The results of this study indicate that non-value-added activity can occur in a new plan even though it has used international standards and a reliable workforce.

This study's results are similar to research conducted in developed and developing countries that the Lean method and facility design if applied in the service or manufacturing industries, can increase efficiency (Ali Naqvi et al., 2016; Cantini et al., 2020; Pérez-Gosende et al., 2021; Sojka & Lepšík, 2019; Tarigan et al., 2020). However, this study's results can add to empirical evidence of the implementation of the Lean method and facility design from the perspective of a developing country. Although case study-based research was applied in previous studies, the results of this study are based on real-world case studies (Pérez-Gosende et al., 2021). The implementation of the real-world case study of the integration of the method has not been widely carried out, so the results of this study can be used as a reference and empirical evidence in the lean approach and facility design scientific framework.

IV. CONCLUSION

The study finding can be summarize into two points as follow. The waste identification through process activity mapping distinguish the type of waste namely transportation and exsess motion. The two wasted lead to non-value added activity which lead to extensive material handling costs. This study finding also provide two alternative layout design in order to eliminate inneficiency on production flooer. The 2nd alternative layout has been proposed as the choicest layout. In addition, the 2nd alternative layout with a total distance of 130.5 meters with material handling costs of IDR 367,795. The manufacturing process lead time in the 2nd proposed layout is 6143.74 sec, with a process cycle efficiency of 60%. By choosing the proposed layout for the two companies, the company can minimize material handling costs by 26% and time-wasting by 19%.

Although this research can solve the problem of inefficiency based on a real case study, this research has limitations which is described as follows. Although the results of this study have been approved for implementation to improve inefficiencies on the production floor, the suitability of research findings with actual results on the production floor still requires further testing. The following limitation is that this research is only implemented in one case study in a large-scale company in a developing country. Research development with multiple case studies from companies in various countries will add to the empirical evidence of scientific studies on lean integration and facility design.

REFERENCES

AB Kadir, A. R., Zubir, B., Mohd Norzaimi, C. A., Sabri, M., Zaki, M., Faradiana, W., & Helinahani, N. (2018). Analysis of production layout model to improve production efficiency. *Advanced Structured Materials, 85*(September), 385–400. https://doi.org/10.1007/978-3-319-72697-7_31

Ali Naqvi, S. A., Fahad, M., Atir, M., Zubair, M., & Shehzad, M. M. (2016). Productivity improvement of a manufacturing facility using systematic layout planning. *Cogent Engineering, 3*(1). https://doi.org/10.1080/23311916.2016.1207296

Cantini, A., De Carlo, F., & Tucci, M. (2020). *Application of the lean layout planning system in a leather bags manufacturing plant and proposal of an approach to engage the company's staff in the research of the layout solution*. Proceedings of the Summer School Francesco Turco.

Febriandini, I. F., & Yuniaristanto. (2019). Re-design Facility Layout using Systematic Layout Planning Method: A Case Study : ro Cosmeceutical Sdn. Bhd. *IOP Conference Series: Materials Science and Engineering, 495*(1). https://doi.org/10.1088/1757-899X/495/1/012027

Jakfar, A., Setiawan, W. E., & Masudin, I. (2014). Pengurangan Waste Menggunakan Pendekatan Lean Manufacturing. *Jurnal Ilmiah Teknik Industri, 13*(1), 43–53.

Jia, Z., Lu, X., Wang, W., & Jia, D. (2013). Design and implimentation of lean facility layout system of a production line. *International Journal of Industrial Engineering : Theory Applications and Practice, 20*(7–8), 502–514.

Kommula, V. P., Mapfaira, H., Gandure, J., Mashaba, K., Monageng, R., & Samuel, O. (2015). Improving Productivity of a Machine Workshop through Facilities Planning. *International Journal of Mining, Metallurgy & Mechanical Engineering (IJMMME), 3*(3), 187–192.

Kovács, G. (2019). Layout design for efficiency improvement and cost reduction. *Bulletin of the Polish Academy of Sciences: Technical Sciences, 67*(3), 547–555. https://doi.org/10.24425/bpasts.2019.129653

Kovács, G., & Kot, S. (2017). Facility layout redesign for efficiency improvement and cost reduction. *Journal of Applied Mathematics and Computational Mechanics, 16*(1), 63–74. https://doi.org/10.17512/jamcm.2017.1.06

Lins, P. S., Kiperstok, A., Cunha, R. D. A., Rapôso, Á. L. Q. R. E. S., Merino, E. A. D., & César, S. F. (2021). (Re)layout as a strategy for implementing cleaner production: Proposal for a furniture industry company. *Sustainability, 13*(23). https://doi.org/10.3390/su132313109

Musfita, B. M., & Mahbubah, N. A. (2021). Implementasi Lean Manufacturing Guna Meminimalisasi Pemborosan Pada Proses Produksi AMDK Jenis Gelas Pada PT.XYZ. *Jurnal Serambi Engineering, 6*(2), 1683–1693. https://doi.org/10.32672/jse.v6i2.2864

Nagi, A., & Altarazi, S. (2017). Integration of value stream map and strategic layout planning into DMAIC approach to improve carpeting process. *Journal of Industrial Engineering and Management, 10*(1), 74–97. https://doi.org/10.3926/jiem.2040

Pérez-Gosende, P., Mula, J., & Díaz-Madroñero, M. (2021). Facility layout planning. An extended literature review. *International Journal of Production Research, 59*(12), 3777–3816. https://doi.org/10.1080/00207543.2021.1897176

Prasetya, A., & Sunday Alexander Theophilus Noya. (2015). Perancangan Ulang Tata letak Fasilitas Dengan Pendekatan Lean Manufacturing. *Jurnal Ilmiah Teknik Industri, 14*(2), 130–141.

Putri, N. T., & Dona, L. S. (2019). Application of lean manufacturing concept for redesigning facilities layout in Indonesian home-food industry: A case study. *TQM Journal, 31*(5), 815–830. https://doi.org/10.1108/TQM-02-2019-0033

Romadhani, F., Mahbubah, N. A., & Kurniawan, M. D. (2021). Implementasi Metode Lean Six Sigma Guna Mengeliminasi Defect Pada Proses Produksi Purified Gypsum Di PT. AAA. *Radial: Jurnal Peradaban Sains, Rekayasa dan Teknologi, 9*(2), 89–103. https://doi.org/https://doi.org/10.37971/radial.v9i2.224

Sojka, V., & Lepšík, P. (2019). *Re-Layout of Workshop Based on Material and People Flows*. 15th International Bata Conference for Ph.D. Students and Young Researchers, 955–961. https://doi.org/10.7441/dokbat.2019.093

Suhardi, B., Juwita, E., & Astuti, R. D. (2019). Facility layout improvement in sewing department with Systematic Layout planning and ergonomics approach. *Cogent Engineering, 6*(1). https://doi.org/10.1080/23311916.2019.1597412

Sundar, R., Balaji, A. N., & Satheesh Kumar, R. M. (2014). A review on lean manufacturing implementation techniques. *Procedia Engineering, 97*, 1875–1885. https://doi.org/10.1016/j.proeng.2014.12.341

Tarigan, U., Ishak, A., Simanjuntak, L. S., Rizkya, I., Putri, K. S., & Tarigan, U. P. P. (2020). *Facility Layout Redesign with Static Facility Layout Planning (SFLP) and Dynamic Facility Layout Planning (DFLP) at*

Convection and Computer Embroidery Industry. IOP Conference Series: Materials Science and Engineering, 1003(1). https://doi.org/10.1088/1757-899X/1003/1/012033

Trisna, Irwansyah, D., Zulhakim, R., & Saptari, M. A. (2022). Analisis Pemborosan Pada Produksi Beton Cor Dengan Pendekatan Lean Manufacturing. *Industral Engineering Journal, 11*(1), 1292–1303. https://doi.org/10.53912/iej.v10i2.735

Utama, D. M., Dewi, S. K., & Mawarti, V. I. (2016). Identifikasi Waste Pada Proses Produksi Key Set Clarinet Dengan Pendekatan Lean Manufacturing. *Jurnal Ilmiah Teknik Industri, 15*(1), 36–46.