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Proposed Implementation of Lean Manufacturing to Reduce Waste in Plywood Production

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ABSTRACT: CV. Treewood Abadi Group is a manufacturing company engaged in producing plywood products. In the plywood production process from raw materials to finished products there are still obstacles in the form of activities that do not have added value or waste that cause decreased efficiency and effectiveness of production activities. This study aims to identify the correlation relationship between the type of waste and waste that has the greatest effect on the plywood production process. The steps of this research are mapping the flow of the production process using waste assessment model, selection of mapping tools with value stream analysis tools and then providing proposed improvements based on the failure mode that has the highest risk priority number value. with failure mode and effect analysis, it is found that the proposed improvements are in the form of implementing visual displays, improving material handling tools, re-layout and increasing the number of workers.

KEYWORDS: Failure Mode And Effect Analysis, Plywood, Production Process, Waste Assessment Model.

1. INTRODUCTION

CV. Treewood Abadi Group is a manufacturing company engaged in the production of plywood products. in the manufacture of products where the company needs to continue to improve its productivity performance so as to be able to produce quality products by minimizing the cost of production activities (cost production) to get the maximum profit for the company. to achieve these goals the company must know and identify what activities are value-added activities and identify waste that occurs during production activities so that it can be eliminated and able to cut the time of production process activities optimally.

From the results of preliminary observations, it is known that the main product of CV.Treewood Abadi Group is plywood, in the production process often experiencing obstacles or activities that have no added value, especially the frequent occurrence of defects in ongoing production activities. Defect that occur are defects caused by the presence of air or water from the hot press trapped in the plywood layer so that the surface layer of the plywood becomes uneven, which is called the blistar defect. This overprocessing occurs because of the rework on products that experience defects, so that it can indirectly increase production costs in terms of material, time, labor required and tools or machines used. waiting also occurs due to trouble on the machine caused by the use of machines that are not in accordance with the frequency of capacity so that the machine will tend to experience maintenance more quickly.

Based on the activities of waste problems that have been described by the author, it can ultimately reduce work productivity and waste of production process time. The form of waste should be eliminated so that the flow of the production process can run smoothly. This study aims to identify the relationship between types of waste in the production section based on value-added activity with lean manufacturing principles where waste contained in the production process flow can be minimized to help solve existing problems.

Based on research entitled "*Application of Lean Manufacturing to Minimize Waste Box Printing*." Explaining that waste is a work activity that does not provide any added value to an input to output process throughout the process of making, producing, and selling occurs or waste that must be disposed of or eliminated, especially in the process of production activities. The method used is the waste assessment model, selection of mapping tools with Value stream analysis tools and identifying the causes of detailed waste using fishbone diagrams, prioritizing failure modes and causes of failure using failure mode and effect analysis and providing improvement proposals based on failure modes that have the highest risk priority number value. the recommended improvements to the company to minimize waste are: Establishment of Standard Operating Procedures on the molding machine control process, re-layout of the production floor, and installation of visual displays.

2. RESEARCH METHODS

At this stage, the data needed for the research will be collected. The data collected is primary data. The data is collected through interviews or distributing questionnaires to related parties, observing the cycle time of each process, distributing this questionnaire aims to assess the waste on the production floor and to find out the relationship between one waste and another waste. In addition, secondary data is used to obtain information about everything that is done in the research, such as the number of workers, machines used, company layout and related journals to support in obtaining data on the amount of production waste, and company documents related to the research. Furthermore, the data obtained is processed, resulting in proposed improvements where existing waste can be eliminated.

2.1 Value Stream Analysis Tools (VALSAT)

Value stream analysis tool is used as a tool to map in detail the value stream that focuses on value-added processes. This detailed mapping can then be used to find the causes of waste that occur. In general, there are seven kinds of detail mapping tools used (Hines & Rich, 1997). Can be seen in table 2.1.

Table 2.1 Matrix Value Stream Analysis Tools

Waste	Mapping Tools						
	Process Activity Mapping	**Supply Chain Response Matrik**	**Production Variety Funnel**	**Quality Filter Mapping**	**Demand Amplification Mapping**	**Decision Point Analysis**	**Physical Structure**
Overproduction	L	M		L	M	M	
Waiting	H	H	L		M	M	
Excessive Transportation	H						L
Innappropiate Processing	H		M	L		L	
Unneccessary Inventory	M	H	M		H	M	L
Unneccessary Motion	L	L					
Defect	L			H			
Note :							
H = High Correlation and Usefullness							
M = Medium Correlation and Usefullness							
L = Low Correlation and Usefullness							

2.2 Waste Assessment Model (WAM)

Waste assessment model is a model developed to simplify the process of finding waste problems and identifying waste elimination. This method describes the relationship between waste types. The relationship between wastes is inter-dependent, and has an influence on other types of waste (Rawabdeh, 2005). The relationship between waste types can be seen in Figure 2.1.

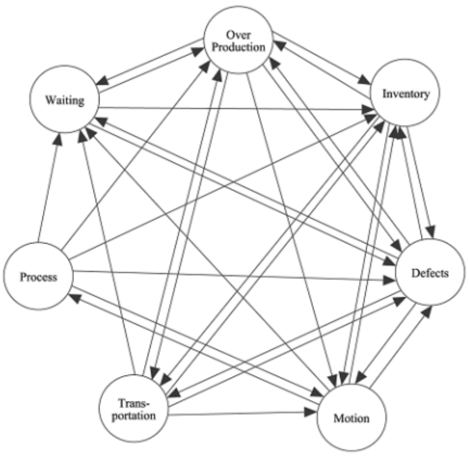


Figure 2.1 Seven Waste Relationship

The seven wastes can be grouped into three main categories that are associated with man, machine, and material. The man category contains the concepts of motion, waiting, and overproduction. The machine category includes overproduction waste, while the material category includes transportation, inventory, and defects. In the waste assessment model, there are two stages, the first is to identify the relationship between wastes using the Waste Relationship Matrix to determine the relationship between wastes that occur and the next step is to identify waste with a waste assessment questionnaire with the aim of knowing the most dominant waste and the level between waste.

2.3 Failure Mode And Effect Analysis (FMEA)

Failure mode and effect analiysis is a technique used to find, identify, and eliminate potential failures, errors, and known problems from systems, designs, processes, or services before they reach consumers (Puspitasari & Martanto, 2014). Failure mode and effect analiysis can be found by calculating the risk priority number value which is the product of the multiplication of severity, occurrence rate and detection rate.

3. RESULT AND DISSCUSION

After collecting some necessary data, such as the waste relationship questionnaire, production activities, and research data, the data will then be processed.

3.1 Waste Assessment Model (WAM)

Waste identification using the Waste assessment model is done by filling out a questionnaire which consists of two stages.

The first is to identify the relationship between wastes using the waste relationship matrix and the second is to find out the most dominant waste and the level between wastes using a waste assessment questionnaire.

3.1.1 Waste Assessment Model (WRM)

The weighting of the questionnaire was given to respondents consisting of 2 people, namely factory managers and accouinting. All relationship types are displayed using rows and columns. There are symbols converted into numbers with references (A:10, E:8, I:6, O:4, U:2, X:0). Can be seen in table 3

Table 3.1 Waste Relationship Matrix

F/T	O	I	D	M	T	P	W
O	A	E	I	E	U	X	O
I	I	A	I	U	O	X	X
D	I	A	A	O	I	X	E
M	X	I	O	A	X	U	E
T	U	U	I	A	A	X	O
P	I	I	E	I	X	A	I
W	O	E	I	X	X	X	A

After all letter symbols are converted into numbers, then the score value is calculated by summing the weight value of each waste. after knowing all waste scores, the presentation percentage of each waste is calculated. Can be seen in table 3.2.

Table 3.2 Waste Relationship Matrix Value

F/T	O	I	D	M	T	P	W	*Score*	%
O	10	8	6	8	2	0	4	38	15.57
I	6	10	6	2	4	0	0	28	11.48
D	6	10	10	4	6	0	8	44	18.03
M	0	6	4	10	0	2	8	30	12.30
T	2	2	6	10	10	0	4	34	13.93
P	6	6	8	6	0	10	6	42	17.21
W	4	8	6	0	0	0	10	28	11.48
Score	34	50	46	40	22	12	40	244	
%	13.93	20.49	18.85	16.39	9.02	4.92	16.39		100.00

From table 3.2 it is known that the value of the line from defect (D) has the largest score and percentage of 18.03%. This percentage shows that waste defects when they occur will have a considerable influence on the emergence of other waste. In the matrix column, it is also known that the value of to Inventory (I) has the largest score and percentage, which is 20.49%. This percentage shows that Inventory waste is the waste that is most influenced by other waste.

3.1.1 Waste Assessment Questionnaire (WAQ)

The waste assessment questionnaire approach consists of 68 different questions, which are introduced to allocate waste. Each question represents an activity, condition, or behavior that can cause waste. Some questions state "from", which means they represent the type of waste that can cause other waste with reference to the WRM. Some other questions state "to", which means they represent the type of waste that may be caused by other waste. The full results of the waste assessment questionnaire. Can be seen in Table 3.3.

Table 3.3 Tabulation of waste assessment questionnaire results

Information	O	I	D	M	T	P	W
Score (Yj)	0.282339	0.278751	0.264563	0.259355	0.238571	0.256250	0.263993
Pj factor	217.01	235.15	339.96	201.56	125.64	84.65	188.12
Yj final	61.27	65.55	89.94	52.28	29.97	21.69	49.66
Yj final (%)	16.54	17.70	24.28	14.11	8.09	5.86	13.41
Ranking	3	2	1	4	6	7	5

In Table 3.3, it can be seen that the biggest waste that occurs is defects with a percentage of 24.28%. In second place is inventory with a percentage of 17.70%. While Overprocessing is in third place with a percentage of 16.56%.

3.2 Value Stream Analysis Tools (VALSAT)

Followed by the selection of detailed mapping tools that are appropriate according to the type of waste that occurs. Therefore, the VALSAT matrix is used, which has value provisions, namely the value of one low correlation, the value of three medium correlation and the value of nine high correlation, and for the weight column obtained from the weight of the identification results with the waste assessment questionnaire method. Can be seen in Table 3.4.

Table 3.4 Matrix Value Stream Analysis Tools

Waste	***Wight***	**PAM**	**SCRM**	**PVF**	**QFM**	**DAM**	**DPA**	**PS**
O	16.54	16.54	16.54	49.62	0	16.54	49.62	49.62
I	17.7	17.7	53.1	159.3	53.1	0	159.3	53.1
D	24.28	24.28	24.28	0	0	218.52	0	0
M	14.11	14.11	126.99	14.11	0	0	0	0
T	8.09	8.09	72.81	0	0	0	0	0
P	5.86	5.84	52.56	0	17.52	5.84	0	5.84
W	13.41	13.14	118.26	118.26	13.14	0	39.42	39.42
Total score		464.54	341.29	83.76	240.9	248.34	147.98	25.79
Ranking		1	2	6	4	3	5	7

From table 3.4 it is known that the selected tool is process activity mapping because it has the first rank with a total score of 464.54. Process activity mapping is a tool used to understand the process flow and describe the order fulfillment process in detail step by step. This depiction is to identify what percentage of activities are value-added activities, non-value-added activities, non-value-added activities but still needed in the plywood production process. Can be seen in Table 3.5.

Table 3.5 Process Activity Mapping

Activity	**Total**	**Time (Second)**	**Presentase (%)**
Operation	11	5620.6	39%
Inspection	8	3524.9	24%
Transportation	8	235.3	2%
Delay	6	5131.8	35%
Total	33	14512.6	100%
VA	7	5222.1	36%
NVA	6	5131.8	35%
NNVA	20	4158.7	29%
Total	33	14512.6	100%

Based on the activity mapping process in table 3.5 it is known that the thirty-three plywood production process includes eleven operating activities, eight inspection activities, eight transportation activities and six are delay activities.

3.3 Failure Mode And Effect Analysis (FMEA)

From the identification of waste using the waste assessment model, the most dominant waste is obtained. next is to identify the root causes of the seven wastes using the fishbone diagram. After knowing the causes of waste using the fishbone diagram. The next step is to analyze potential failures based on the causes of failure, this analysis uses the failure mode and effect analysis method to determine the RPN (risk priority number) value.

Table 3.6 Risk Priority Number Calculation

No	Type of failure	Effects of failure	S	Causes of failure	O	Current control	D	RPN
1	Defect blistar	The product can be repaired (rework) but requires additional costs such as materials, use of machinery and additional labor.	5	Operator is not careful when checking the veneer, operator is tired.	6	Re-checking, taking breaks in between work.	4	120
			5	The machine is not in optimal condition, the machine is broken during drying and pressing.	2	Perform daily maintenance.	3	30
			5	Incomplete press and drying process.	6	Classify products into rework categories.	9	270
2	Size defects are not up to standard.	The product cannot be repaired or falls into the reject category.	6	The operator was not careful when operating the double saw machine.	6	Take a break in between work.	3	108
			6	The machine is not in optimal condition, the saw blade is worn out.	3	Perform daily maintenance.	3	54
			6	Lack of supervision or negligence at work.	8	Not yet.	5	240
3	Waste inventory.	The production process is hampered.	7	The existence of rework on defect products stored in the warehouse.	9	Return to rework so that defect products do not accumulate in the warehouse.	4	252
			7	Produce without regard to demand.	3	Record customer requests and produce according to the number of needs ordered by the customer.	3	63
			7	The existence of defective products that are not neatly organized in the warehouse.	9	The operator arranges the products and sets the maximum limit correctly.	3	189
4	Waste overproduction.	The production process is hampered.	7	The existence of rework on defect products.	9	Return to rework so that defect products do not accumulate in the warehouse.	4	252
			7	Produce without regard to demand.	3	Record customer requests and produce according to the number of needs ordered by the customer.	3	63

No	Type of failure	Effects of failure	S	Causes of failure	O	Current control	D	RPN
5	Waste motion.	The production process is hampered.	7	Unnecessary movements performed by workers, processes that are done manually.	9	Not yet.	10	630
			7	Ineffective layout.	8	Not yet.	10	560
6	Waste waiting.	The production process is hampered.	7	Operator does not depart.	8	Not yet.	10	560
			7	Machine speeds are different, machines break down during production activities.	3	Perform daily maintenance.	3	63
			7	Ineffective layout.	8	Not yet.	10	560
7	Waste transportation.	Material movement is lengthy.	7	Limited transportation means, damaged.	4	Repair or buy new.	3	84
			7	Ineffective layout.	8	Not yet.	10	560
8	Waste overprocessing.	Material waste (raw materials, machine and labor usage).	7	Imperfect production process, rework on defect products.	9	Re-do the rework, implementing the existing Standard Operational Procedure (SOP).	6	378

After analyzing table 3.6, the most dominant waste is obtained to be resolved first. Therefore, it is necessary to prepare an improvement recommendation with the aim of reducing waste based on the root factors of the fishbone diagram and based on the highest RPN value.

Table 3.7 Improvement Based On Risk Priority Number

No	Type of failure	Element	RPN	Causes of failure	Improvement recommendations
1	Defect blistar.	- Methods	270	Incomplete press and drying process.	Application of visual display.
2	Size defects are not up to standard.	- Methods	240	Lack of supervision or negligence at work.	Application of visual display.
3	Waste inventory.	- Methods	252	The existence of rework on defect products.	Application of visual display.
4	Waste overproduction.	- Methods	252	The existence of rework on defect products.	Application of visual display.
5	Waste motion.	- Methods	630	Unnecessary movements performed by workers, processes that are done manually.	Proposed improvements to material handling equipment.
6	Waste waiting	- Man	560	Operator does not depart.	Employee addition.
		- Working environment	560	Ineffective layout.	Re- layout.
7	Waste transportation	Working environment	560	Ineffective layout.	Re- layout.

8	Waste overprocessing	- Methods	378	Imperfect production process, rework on defect products.	Application of visual display.

3.4 Make Suggestions For Improvement

Based on the results of the identification, it can be given or proposed improvement recommendations that are expected to help reduce waste as a design step with a lean manufacturing concept approach so as to create a more effective and efficient plywood production process.

a. Application of visual display

The application of visual displays aims to provide information and notifications in writing using color indicators so that workers are more attentive or alert. A good visual display is a visual display that can provide messages that can be understood and understood by the recipient of the information.

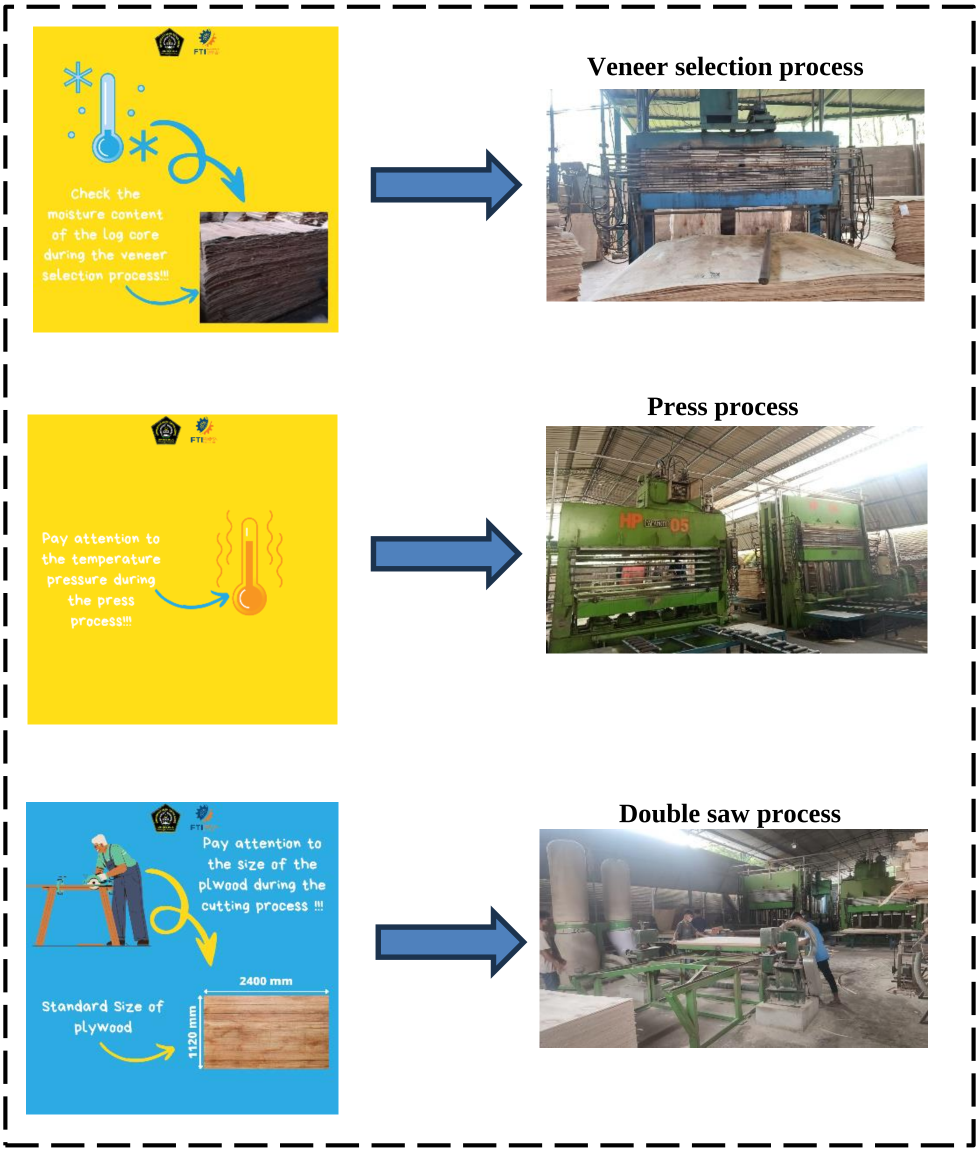


Figure 3.1 Application Of Visual Display

Based on the visual display in Figure 3.1, it can be implemented at the work station that has been determined, namely at veneer selection process, press process and double saw process while color can mean that yellow shows attention and blue shows insruction.

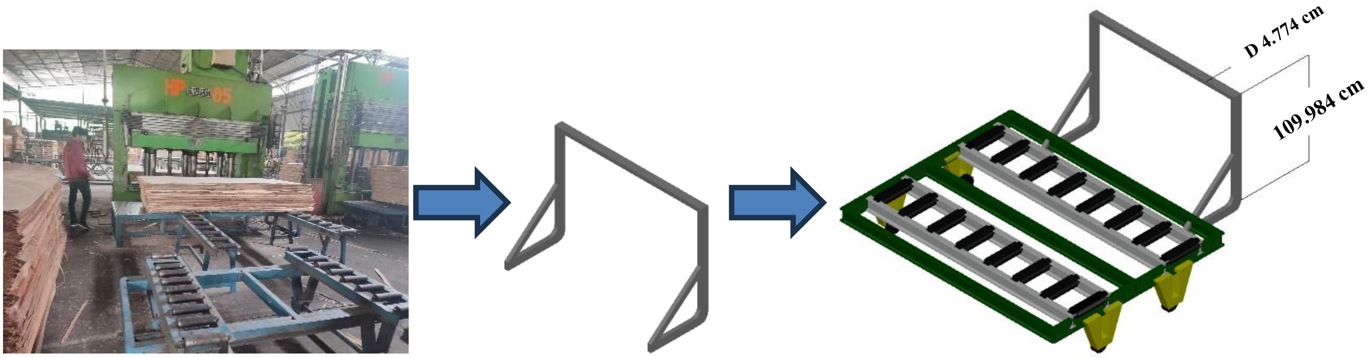
b. Proposed improvements to material handling equipment

Material handling tools that are less effective on the transport stroller, because previously the material handling tool did not have a handle that was used to push so that when workers wanted to push it would be a little difficult. The handle that will be proposed, of course, uses the size of the body dimensions of workers in the CV.Treewood Abadi Group, in this study the authors determine the size of the body dimensions of workers as many as five samples. body dimensions can be seen in table 3.8.

Table 3.8

Dody dimension	Function on tool parts	Average (cm)
Hand-held diameter	For handle diameter	4.774
Elbow height	For handrail height from floor	109.984

Initial condition

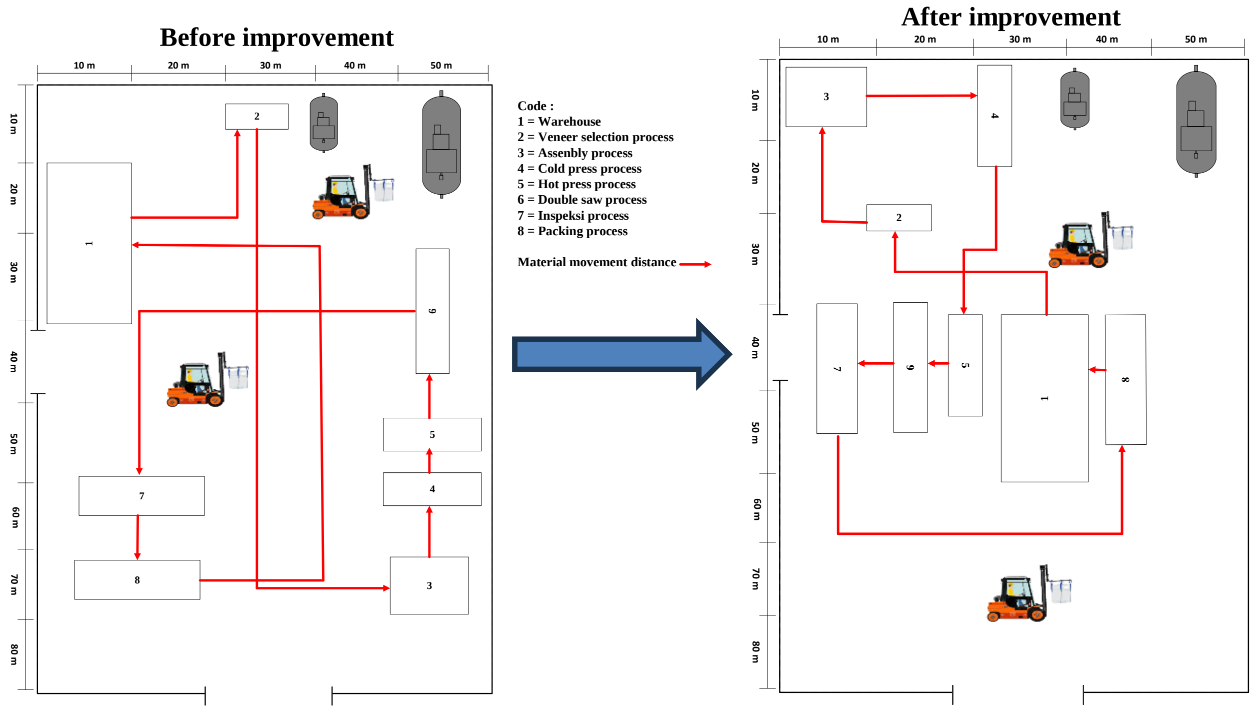


c. Re-layout

The current layout at CV.Treewood Abadi Group is not effective and efficient so it is necessary to re-layout in order to reduce transportation waiting time. Technically this happens because in the venner selection process to the assembly process where the length of the material transfer distance, besides that the cutting process to the inspection process has an opposite path between the venner selection process to the assembly process which results in the passing of forklifts from one another. Layout improvements are made using the BLOCPLAN method. obtained three alternative layouts then make a selection based on the shortest distance. Can be seen in figure 3.1

Table 3.9 Output BLOCPLAN Method

Layout	R-score	Distance (meter)
1	0.59	97.37
2	0.54	93.65
3	0.69	112.55



To calculate the transportation time of material transfer after improving the layout, the transportation time before improvement and after improvement is used with the formula.

$$= \frac{Distance\ before\ improvement}{Distance\ after\ improvement} = \frac{Time\ before\ improvement}{Time\ after\ improvement}$$

equation:

$$\frac{24.29}{10.15} = \frac{27.3}{wP}$$

$$WP = \frac{27.3\ x\ 10.15}{14.32}$$

WP = 11.41 seconds

Table 3.10

No	Transportation	Before improvement		After improvement	
		Distance (meters)	Time (seconds)	Distance (meters)	Time (seconds)
1	Warehouse to veneer selection	24.29	27.3	10.15	11.41
2	Selection of veneer to assembly	76.42	80.4	8.00	8.42
3	Assembly to cold press	17	12.3	15.86	11.48
4	Cold press to hot press	8	14.6	16.33	29.80
5	Hot press to double saw	11.18	18.9	3.78	6.39
6	Double saw to inspeksi	35	52	5.51	8.19
7	Inspeksi to packing	12	17.1	25.23	35.95
8	Packing to warehouse	37.85	12.7	8.78	2.95
Total		**221.75**	**235.3**	**93.65**	**114.58**

d. Addition of workers

In the press process with the number of operators four people become five people. where in this press process the operator works at a pressurized temperature of 120^0C which causes the operator to quickly experience fatigue so that if one operator does not leave, the press process will be hampered.

3.5 Eliminate Non Value added Activity

Non value added activity occurs due to Work In Process (WIP), occurs when there is a certain amount of WIP in each process which results in waiting time. The amount itself is uncertain or does not have a set amount, so the amount of WIP is obtained by conducting observations and interviews. To reduce the duration of waiting time can be done by reducing the delivery of WIP in each plywood production process.

Table 3.11

Activity	Before improvement	After improvement	Difference	Percentage improvement
VA	5222.1 seconds	5222.1 seconds	0 seconds	0%
NVA	5131.8 seconds	2565.9 seconds	2565.9 seconds	50%
NNVA	4158.7 seconds	4044.12 seconds	114.58 seconds	3%

4. CONCLUSION

Based on the research that has been done, it is known that the most dominant waste in the plywood production process is defect 24.28%, inventory 17.70% and overprocessing 15.56%. Proposed improvements based on the highest Risk priority number are: application of visual display, tool repair, re-layout and additional labor and reducing the number of WIP shipments in each process can reduce Non Value Added Activity (NVA) 5131.8 seconds to 2565.9 seconds and Necessary Non Value Added Activity (NNVA) 4158 seconds to 4044.12 seconds.

REFERENCES

1. Goriwondo, W. M., Mhlanga, S., & Marecha, A. (2011). Use of the Value Stream Mapping Tool for Waste Reduction in Manufacturing.Case Study for Bread Manufacturing in Zimbabwe. *International Conference on Industrial Engineering and Operations Management Kuala Lumpur, Malaysia*, 236–241.
2. Hines, P., & Rich, N. (1997). Mapping Tools. *International Journal of Operations & Production Management*, *17*(1), 46–64.
3. Krisnanti, E. D., & Garside, A. K. (2022). Penerapan Lean Manufacturing untuk Meminimasi Waste Percetakan Box. *Jurnal INTECH Teknik Industri Universitas Serang Raya*, *8*(2), 99–108. https://doi.org/10.30656/intech.v8i2.4780.
4. Rahman, A. (2014). Analisis Pengendalian Kualitas Produk Roti Tawar Mr . Bread Dengan Metode FMEA (Di Bagian Produksi CV . Essen). *Jurnal Online Teknik Industri*, *1*(1), 1–8.
5. Rawabdeh, I. A. (2005). A model for the assessment of waste in job shop environments. *International Journal of Operations and Production Management*, *25*(8), 800–822.https://doi.org/10.1108/01443570510608619.
6. Soenaryo, H., Rispianda, & Yuniati, Y. (2015). Usulan Meminimasi Waste Pada Proses Produksi Dengan Konsep Lean Manufacturing di CV. X. *Jurnal Online Institut Teknologi Nasional*, *3*(2), 92–103