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THE ANALYSIS OF WASTE ACTIVITIES IN SUPRAMAK BED PRODUCTION BY USING VALUE STREAM MAPPING AND VALSAT APPROACHES

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ABSTRACT

X Ltd. is a company which is producing hospital equipment with one of its products is supramak bed (patient's bed). From the observation at the production floor of X Ltd, several non-value added activities are identified, which are components accumulation, reworking a number of products which do not meet the standards, idling operators, and waiting in working process. Based on the results of VSM Current State Map is obtained that total time for value added activities are 96816 seconds and for non-value added activities are 80869 seconds. Based on WAM analysis, the highest waste occurs during waiting time with an index of 19.09%. Based on VALSAT analysis, the proposed input from researchers are as follows: giving the mandates to the warehouse department, monitoring product flow, creating and enforcing SOP, increasing the number of forklifts, and analyzing transportation effectiveness.

Keywords: waste analysis, lean manufacturing, Value Stream Analysis Tools, Value Stream Mapping.

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I.INTRODUCTION

Manufacturing industry has experienced rapid development, now shifted from the viewpoint of optimizing low-cost mass production to the era of lean manufacturing, which prioritizes added value and minimizes waste (Masuti, P.M., & Dabade, U.A., 2019), mass customization that prioritizes flexibility (Jack Hu, 2013), even ready to enter the era of smart manufacturing (Morteza, 2018). Lean manufacturing system is preferred because it's considered as capable in minimizing time, supplies, capital, even resources (Dighe, B., & Kakirde, A., 2014). The keynote of this approach is to focus on increasing activities with as few resources as possible and eliminating non-valuable activities while preventing waste (Womack et al., 1990). We should know that the value to waste ratio of Japanese companies is around 50%, USA is 30%, while one of the advanced companies in Indonesia is only able to reach around 10%, (Gazpers, 2012). It becomes the proof for the importance of lean thinking in manufacturing systems in our country.

X Ltd. is a company that is producing hospital equipment, particularly supramak bed (patient bed). From the first stage of this research were identified several non-value added activities, such as accumulation of work in process components, the number of reworked products, idle operators, and delays (waiting) in work processing.

Production process of supramak bed are divided into two stages of divisions, they are WP (Welding-Painting) and FA (Final Assembly). Activities in WP are wielding and painting. There are 3 warehouses in WP division, for MS (mild steel), SS (stainless steel), and Standard part. The warehouses are used as storage room for production-ready components obtained from suppliers. Continuous repetition of waiting had been found. The parts needed for production are sent two days before the day of production in gradual scheme. The matter becomes more intricate by the application of 1 lot parts provision policy in starting the production process, as set by the company. In other words, sub-assembly part that come first will lie idle (waiting) in warehouse for two days. The policy also applied for painting stage, resulted in accumulation of components which being worked on (work in process). Moreover, standard part warehouse receives the items once in a month based on the sum of monthly production, to meet the needs of final assembly (FA). In other words, sub-assembly parts are in waiting phase for quite a long time before joining the assembly stage, so that the risk of shortages or excessive sub assembly parts is getting higher. As for the activities of FA division are: 1) sub-assembly, 2) final assembly, 3) final inspection, 4) packing, which then will be analysed by using waste analysis model.

Based on the observations, the researchers are going to find out and analyse the waste on supramak bed production floor of X Ltd. with Value Stream Mapping and VALSAT, as well as giving suggestions and input for improvements.

II. METODE PENELITIAN

A. Research Design

Brief research flow can be seen in Figure 1.

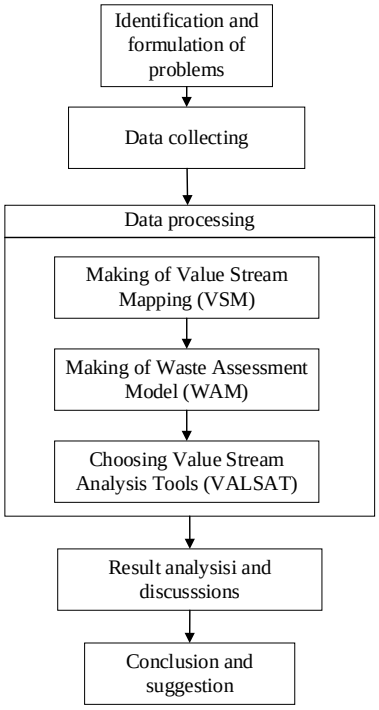

Figure 1 Research flow

The research flow can be seen in figure 1. Observation was done to map and obtain information related to production floor, because waste problems on production floor could be more clearly seen by observing. Then, the data related to the making of Value Stream Mapping (VSM), Waste Assessment Model (WAM), and Value Stream Analysis Tools (VALSAT) were collected. After processing the data, result analysis and discussion were conducted, which then resulted in improvements input for supramak bed production floor of X Ltd.

B. Research Object and Subject

The object of this research is X Ltd. particularly company's supramak bed production floor consisted of two divisions, which are Welding-Painting and Final Assembly divisions

C. Data Collection and Subject

There were three methods in collecting data used in this research: observing, interview, and literature review. Interviews were held towards company's management, initiated by observation process. Furthermore, literature reviews were used to analyse and utilize the data from existing literatures.

D. Research Instruments

There was 1 instrument used in the making of Waste Assessment Questionnaire (WAQ), in form of questionnaire sheet which used to find out the weight in Waste Assessment Model (WAM) making process.

III. RESULT AND DISCUSSION

A. Welding-Painting Division (WP)

The first stage on supramak bed production process was welding. The process in this stage was spot welding, robot welding and stainless steel welding. The number of operator in each process shown in table 1.

The welding process took 930 minutes. The issue in this stage was the time waste when operator stops 20 minutes before the specified break. Since the total working process took two days, meant that the total of time waste because of this vice were 40 minutes. Welding process also stopped when the production floor flooded with rainwater, where the duration varied from 20 minutes or more, depended on the duration of rain along working time. After deducting the waste time, total time for welding process left were 870 minutes.

Table 1 Number of Operators in Welding Process

Num	Process	Number of Op
1	Welding	12 People
2	Metal Finish	2 People
3	Treatment	3 People
4	Cleaning	4 People
5	Chromium and Polishing	11 People
6	Quality Control	1 People
7	Transferring	1 People
	Total Operators	34 People

The second stage was painting process. Each lot of sub-assembly consisted of 20 units. The details of operators in painting process shown in table 2.

Table 2 Number of Operators in Painting Process

Num	Process	Number of Op
1	Loading	3 People
2	Washing	1 People
3	Drying	-
4	Sanding and dust cleaning	2 People
5	Spraying	2 People
6	Oven	-
7	Quality Control	1 People
8	Unloading	2 People
9	Wet Painting	1 People
10	Transferring	1 People
	Total Operators	13 People

The painting process used one conveyor which equipped with 80 hangers. Based on observations, it used only 63 out of 80 hangers. Bed product needed 4 hangers in painting process. The process in each hangers took 2.5 hours with change-over time were 2 minutes, thus the conveyor rotated for 308 minutes in one period. Since there were 17 malfunctioned

hangers, the calculation of time waste were 2 x 17 minutes. The issue didn't stop at that point because malfunctioned hanger also reduced daily optimum output. Daily optimum working time were 7 hours and 45 minutes. The conveyor rotated 1.9 in daily working time. It meant that with the total of 80 working hangers, the accumulation for hanger utilization for 1.9 times of rotations were equal to 158 hangers per day. However, the number of functioning hangers only 63, so that the optimum accumulation only 124 hangers per day. Besides, painting process for each sub-assembly were performed with random arrangement so that semi-finished goods were piled up around painting area. Total time for painting process were 7.45 hours or 465 minutes per day minus 342 minutes or 20520 seconds of working time for 20 units of patient beds, therefore the differences were 123 minutes.

B. Final Assembly Division (FA)

The process in FA division were divided into several stage consisted of sub assembly, final assembly, final inspection, and packing. In sub assembly process, the assembly was performed in panel part, backrest crank, knee rest crank, IV pole, and side guard. The number of operators in sub-assembly process shown in table 3

Table 3 Number of Operators in Sub Assembly Process

Num	Process	Number of Op
1	Panel frame	7 People
2	Side Guard holder	4 People
3	Crank and IV pole	2 People
	Total operators	13 People

Time calculation for sub-assembly process was carried out only on three items consisted of the IV pole, backrest crank, and knee rest crank, because the other items were processed at the beginning of the welding process. In other words, the parts were idle (waiting) in the sub-assembly area and waiting for the final assembly process with other parts. The calculation time of each sub-assembly process can be seen in table 4

.

Table 4 Duration of Each Sub Assembly Process

Num	Part	Total Part	Processing Time (mins)	Processing time/unit (secs)
1	IV pole	20	2,29	14,9
2	Knee rest	20	31,52	95
3	Backrest	20	31,52	95
4	Final Side Guard	20	60	180

Based on table 4, the longest processing time within sub-assembly process was in final side guard, while the shortest was on IV pole part. Because the processes were carried out simultaneously, the amount of time used to calculate the length of sub-assembly process was the same the final side guard processing time, which was by 180 seconds/unit or 60 minutes/20 units.

The outputs from welding-painting division and sub-assembly division were assembled into the final product in final assembly process. The number of assembly lines used in the final assembly process were 3, each was handled by 2 operators. For 1 unit of bed, it took 335 seconds of assembly time. There were waiting time from the sub assembly process by 3600 seconds, and from the warehouse to the assembly line by 600 seconds. Operator's awareness to immediately lead the outputs to the final inspection was still poor, thus waiting time for finished product was reoccurred.

Finished product then entered the inspection stage (final inspection). Finished products that passed this stage were marked as QC. Unqualified products entered the rework process. Unfortunately, data on the number of rework processes were not well documented. The operators in the inspection process were 2. The processing time for 1 lot were 5828 seconds/lot or equal to 291 seconds/unit. During the observation, the time difference from the final assembly to the inspection process was found, resulted in the operator being idle for 44 seconds.

If the number of times in 1 lot was calculated, operator's total idle time were 836 seconds.

The products that passed the inspection then packed and sent to the warehouse. The number of operators on each packing line were 4 people, for a total of 2 packing lines. From packing area to the warehouse area, finished goods were transported by using 2 forklifts. Thus, the total operators in this process were 10 people. The time for packing process was the same time with packing time for 1 lot of finished product, which were 11560 seconds, or equal to 578 seconds/unit. The time differences from inspection process to the packing process were 287 seconds, or in other words, the time differences for 1 lot were 5453 seconds.

C. Value Stream Mapping

The inputs of VSM production were the flows of material and information of patient bed production process. Cycle time (CT) data for each work station can be seen in table 6, the number of each operator in table 7, and waiting time for each process in table 8. Then, value stream mapping current state shown in Figure 2.

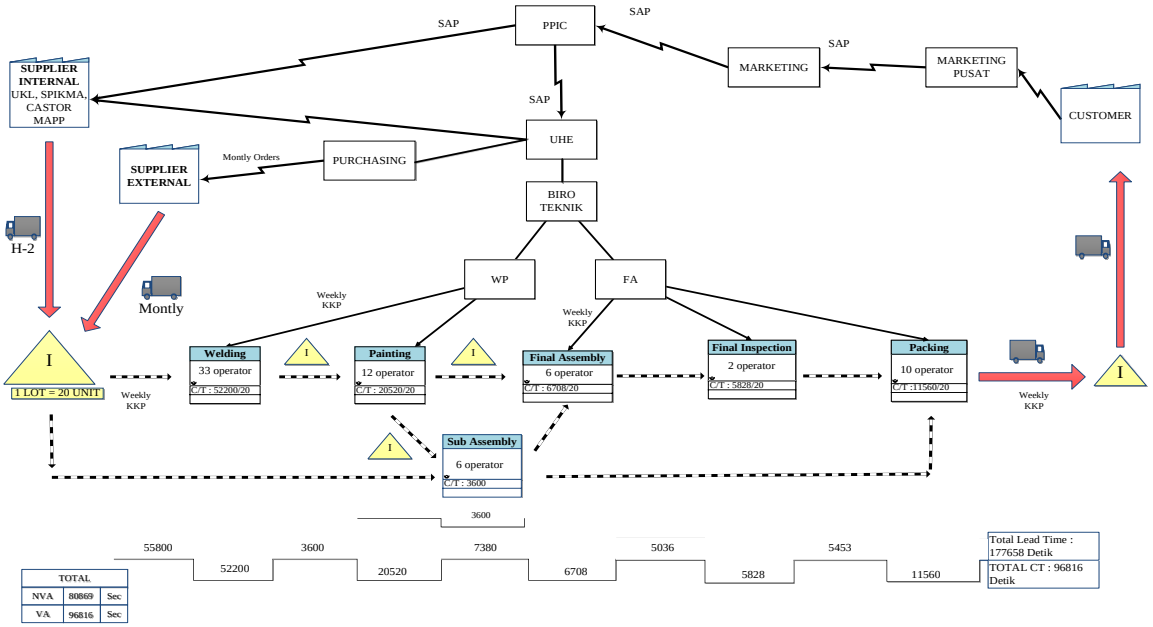

Figure 2 *Value stream mapping current state*

Table 5 Cycle Time of Each Working Station

Num	Work Station	CT (secs)
1	Welding	2610
2	Painting	1026
3	Sub assembly	180
4	Final assembly	335
5	Final inspection	291
6	Packing	578

Table 6 Number of Operators in Each Working Station

Num	Work center	Number of Op
1	Welding	33
2	Painting	12
3	Sub assembly	6
4	Final assembly	6
5	Final inspection	2
6	Packing	10

Table 7 Waiting Time for Each Operator

Num	Location	Waiting Time
1	Warehouse – welding	2 days
2	Welding – painting	60 minutes
3	Painting – final assembly	123 minutes
4	Final assembly – inspection	83,93 minutes
5	Inspection – packing	90,88 minutes

D. Waste Relationship Matrix (WRM)

Waste Relationship Matrix is a tool to determine the relationship between wastes by weighting the tabulations. The result of WRM is in table 8.

Table 8 Waste Relationship Matrix

F/T	O	I	D	M	T	P	W	Score	%
O	10	6	6	6	6	0	10	44	15.28
I	6	10	6	6	8	0	10	36	12.50
D	4	4	10	6	6	0	10	40	13.89
M	0	6	6	10	0	8	8	38	13.19
T	6	6	8	8	10	0	6	44	15.28
P	6	6	6	8	0	10	10	46	15.97
W	10	10	10	0	0	0	10	40	13.89
Score	42	48	52	44	30	18	54	288	100
%	14.58	16.67	18.06	15.28	10.42	6.25	18.75	100	

Description of the waste symbols are: overproduction (O); inventory (I); defect (D); motion (M); transportation (T); process (P); and waiting (W).

E. The Making of Waste Assessment Questionnaire (WAQ)

The recapitulation results of WAQ making to the whole product can be seen in table 9 below.

Table 9 Waste Assessment Questionnaire Matrix

	O	**I**	**D**	**M**	**T**	**P**	**W**
Skor	0.660	0.668	0.665	0.651	0.635	0.681	0.683
Faktor	222.80	208.33	250.77	201.58	159.14	99.83	260.42
Hasil Akhir	146.96	139.11	166.85	131.28	101.07	68.02	177.75
Hasil akhir (%)	15.78 %	14.49 %	17.92 %	14.20 %	10.86 %	7.31 %	19.09 %
Peringkat	3	4	2	5	6	7	1

Based on the result, dominant waste on production floor from the whole waste activities was W by 19.09%.

F. Value Strea Analysis Tools (VALSAT)

After the values of WRM and WAQ were obtained, the next step was to make the details on types of waste by using VALSAT. The results of VALSAT is in Table 10.

Table 10 Calculation Result of VALSAT

Pemborosan	**Bobot**	**PAM**	**SCRM**	**PVF**	**QFM**	**DAM**	**DPA**	**PS**
Over production	15.78	15.78	47.35		15.78	47.35	47.35	
Excessive transportation	10.86	97.70	97.70	10.86		32.57	32.57	
Waiting/Idle	19.09	171.8						19.09
Inappropriate processing	7.31	65.75		21.92	7.31		7.31	
Unneccessary inventory	14.94	44.82	134.47	44.82		134.47	44.82	14.94
Unnecessary motion	14.10	126.9	14.10					
Defect	17.92	17.9			161.29			
Total		540.71	293.63	77.60	184.38	214.39	132.05	34.03
Rating		1	2	3	4	5	6	7

Based on VALSAT analysis, the selected detail mapping tools was *process activity mapping*. PAM results were then divided into groups according to the activities. Activities grouping based on PAM can be seen in table 11.

Tabel 11 Pengelompkan aktifitas *final assembly*

Aktivitas	**Jumlah**	**Waktu (detik)**
Operation	52	2065
Transportation	34	445
Inspection	3	275
Storage	0	0
Delay	5	910
Total	94	3705

After the detailed activities were grouped and described, then the analysis process of value added and non-value added was performed. The index results for each type of activity based on PAM can be seen in table 12.

Table 12 Process Activity Mapping (PAM)

Klasifikasi	Sum	Time (secs)	Index
Value Added	55	2340	63.16 %
Non-value added	5	910	24.56 %
Necessary non value added	34	455	12.28 %
Total	94	3705	100 %

G. Improvement Input

The first suggestion for improvements based on previous results and discussion is fixing the flow of production process in welding process where W / idle always occurs. The input of production process flow in welding process shown in table 13.

Table 13 Proposed Process Sequences in Welding Process

Preceding	***Subsequent***
Pengelasan dudukan pendorong	
Pengeboran dudukan pendorong	Pengelasan kerangka menggunakan *Robot Welding*
Pengelasan dudukan rumahan lager	
Uji pipa pengungkit tempat tidur	Pengelasan Matras dengn *backrest*
Pengelasan *plat Frame Head and Foot dan foot end*	Pengelasan *sub assembly head and foot*menggunakan *robot welding*
Pengelasan dudukan tiang infus	Pengelasan alas matras
Pengelasan plat mur	Pengelasan *sub assembly* dudukan *side guard*

Second, it is important to prioritize hanger repairs and checks. Well controlled monthly maintenance information sheets are required. Then, due to the merging of painting process and the use of hanger, a measured suspension sequence is required to minimize waiting time. The input based on the results of this research are: every difference of 4 hangers should be replaced with another product so that the final assembly process line can be balanced. The arrangement of part sequences is converted from 20 orders into 5 orders, in other words, similar items divided by four in one arrangement. Thus, 20 patient beds will complete at the 114th hanger with total time 376 minutes. For the final assembly, the suggestion is based on PAM analysis. Details on NVA activities and improvements inputs shown in table 14.

Table 14 Proposed Hanger Utilization Sequences

No	NVA Activities	Cause	Input
1	Waiting for standard part from warehouse	Standard part were sent right before assembly process started, waiting for 1 lot.	Briefing the warehouse division to monitor product flow before the final assembly.

No	NVA Activities	Cause	Input
2	Waiting for the final inspection process.	Operators' negligence by did not directly deliver the finished products to the inspection station.	Creating and emphasizing SOPs. Giving rewards to the workers with certain target achievement conditions.
3	Waiting for product parts to be packed.	Operators' negligence by did not directly deliver the finished products to the packing station.	Creating and emphasizing SOPs. Giving rewards to the workers with certain target achievement conditions.
4	Products are waiting to be delivered to distribution warehouse.	The number and capabilities of forklift are limited.	Increasing the number of forklifts.
5	Products are waiting to be delivered to the finished goods warehouse.	The capability of trucks as main transportation is inadequate	Further transportation analysis

IV. CONCLUSIONS AND SUGGESTIONS

Based on WAM analysis, 5 types of waste on WD and FA production floor of PT. X are: a) over production, b) excessive transportation, c) waiting/idle, d) unnecessary inventory, and e) unnecessary motion. The highest number of waste is waiting time by the index of 19.09%. For further analysis, a more detailed mapping was carried out by using detail mapping tools, and the process activity mapping category was selected as the tool of waste elaboration on final assembly production floor. NVA of patient bed production based on detail mapping tools reached 24.56%. Therefore there are some suggestions for reducing the waiting time along the final assembly production floor, as follows: 1) briefing the warehousing division, 2) monitoring product flow, 3) creating and emphasizing SOPs, 4) increasing the number of forklifts, and 5) analysing transportation effectiveness.

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