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Analysis of Production Process in Small Business Using Value Stream Mapping Approach

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ABSTRACT

This paper aims to identify waste and analyse production process activities using the Value Stream Mapping (VSM) in a small business as a case study. The waste was identified by a waste relationship matrix and waste assessment questionnaire to determine the percentage of waste that occurs. Furthermore, a detailed selection of waste mapping based on the value stream analysis tool was carried out. Based on the VSM analysis, it was found the value added activities of 71% of the total production time and 29% of other activity times (non value added). In the case study occurred the waste for the operator's work method at the station of printing and cutting station. The VSM was performed to reducing the waste. The result depicted reduction in lead time on the production floor was 2.3 hours. So, the company in the case study can eliminate the waste time in their production process activities.

KEY WORDS: *Production, Small business, VSM, Waste.*

1.0 INTRODUCTION

The production process can be effective and efficient by implementation of lean manufacturing tools such as Value Stream Mapping (VSM). The VSM is a method of mapping production flow and information flow in producing products. The VSM can identify all types of waste throughout the production process and eliminate waste by optimizing and improving the overall flow [1]. An implementation of the VSM can help companies for making of decisions to improve overall product production [2].

Based on [3,4], the Value Stream Mapping (VSM) is one method that can map waste or non-value added including materials and information from each work station of the production process of a product. The non-value-added activities can be delayed production processes. In addition, it may make the production process inefficient in form of the energy, cost and time. The companies can identify activities that can increase product value added, reduce waste and shorten lead times by using the VSM method and lean manufacturing system approach [5-7]. The VSM may increase efficiency productivity in companies engaged in industry, by identifying, evaluating and reducing non-value added or waste activities [8-11].

According to [5,12], the VSM is a visual mapping process of information and material flow, which aims to prepare better method and performance in the proposed future state map. In the value stream mapping there are two mappings that must be drawn, namely the creation of a current state map and a future state map. Making a current state map is done to map the actual condition of the production floor and all information contained in each process mapping, which is useful for identifying waste [2,8]. The future state map is a mapping of the company's condition in the future as a proposed improvement plan from the current state map. Therefore, in future mapping can be eliminated the non-value added activities and improve the manufacturing processes more efficiently and effectively.

Various authors agree that the VSM method has the potential approach to increase productivity in Small and Medium Enterprises [7,13-15]. Oliveira & Rocha, [13] developed a framework for the implementation of lean manufacturing tools such as the VSM in a medium-sized company. They employed the VSM at planning stage final of framework to discover the current state improvement to the future state VSM. They conducted the case study in medium-sized furniture industry, which was revealed the productivity improvement of 27% at drilling station of the case study company. Narke & Jayadeva [16] conducted study to implement the VSM method in medium scale business and it save of 336 hours per year. Therefore, the production system can improve by implementation of the VSM in labour-intensive small-medium businesses [17].

The VSM method can also be applied to increase the responsiveness of company managers to external and internal

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influences [18]. The management of small business can take advantage of the VSM method to reduce fluctuations and irregular production patterns, improve their production system and flexibility in order to increase their competitiveness and withstand sudden external threats. Whilst, the internal management can increase productivity to better operations, which in turn to determine waste or non value added activities in the system. Therefore, this paper objective is to identify and analyse the waste occurrence in production process for the small businesses. A case study was conducted at small scale enterprise in Pekanbaru, Indonesia.

2.0 METODOLOGI

In this paper were adopted qualitative and quantitative methods. The gathering data were employed: interviews, direct observation and documentations. The structured questionnaire was filled by involved the company own and management team. The obtaining data were the production process time, production process flow, Waste Relationship Matrix (WRM) questionnaire data, and Waste Assessment Questionnaire (WAQ) questionnaire data.

The Waste Relationship Matrix (WRM)

The WRM has a function to identify relationship of any waste on the production floor. According to [18-19], the WRM is a matrix used to analyze measurement criteria. The rows in the matrix show the effect of a particular waste on other wastes, while the columns in the matrix show the waste that is influenced by other wastes. In this paper, there were seven types of waste identified, namely: (1) Over production, (2) Waiting time, (3) Excessive transportation, (4) Inappropriate processing, (5) Excessive inventory, (6) Unnecessary motion and (7) Defect.

Waste Assessment Questionnaire

The waste assessment questionnaire can used to identify and allocate waste that occurs in the production line [18]. This assessment questionnaire consists of different questions, which each question represents an activity, a condition or a characteristic that may cause a certain type of waste. Some of the questions are grouped into the "from" type, which means the question refers to any kind of waste that occurs that can trigger or produce different types of waste. Meanwhile, the other question represents the type of "To", which means all kinds of waste generated by other wastes.

The steps to analyse the waste assessment questionnaire as following [19]:

- Count the number of questions "from" and "to" of the same type of waste and compute the weight of each question based on the waste relationship matrix.
- Eliminates the effect of varying the number of questions for each type questions by dividing each weight in a row by number of questions grouped (Ni).

$$Sj = \sum_{K=1}^{K} \frac{W_{j.k}}{N_i} \quad (1)$$

- Calculating the total score (Sj) based on equation 1 and the frequency (Fj) of the appearance of the value in each waste column, ignoring the value of zero.
- Calculating the value of the final waste factor (Yj final) by entering the probability factor of influence between types of waste (Pj) based on the total "from" and "to" in WRM. The Yj final can be generated using the following equation:

$$Y_{jfinal} = Y_j \text{ x } P_j = \left(\frac{s_j}{S_j} \text{ x } \frac{f_j}{F_j}\right) \text{ x (\%fromj x \%Toj)} \quad (2)$$

From the results of weighting using WAQ is obtained the percentage of each waste that occurs.

3.0 RESULTS

A case study was conducted at small business, which produce wet noodle. The manufacture of wet noodles includes preparation of raw materials, mixing of dough, moulding and cutting, boiling, cooling and packaging. The company production was 80 kg noodles/day and production standard time of 570 minutes. The raw material requirement was 40 kg-50 kg of wheat flour/day. The Value Stream Mapping (VSM) method was adopted to analyse productivity wet noodle in the case study company. The waste identification was used the Waste Relationship Matrix (WRM) and the Waste Assessment Questionnaire (WAQ).

The current value stream mapping is useful for identifying value-added activities, non-value added activities and necessary non-value added activities in the production process flow of wet noodle. It can also be used to find out the time to complete the production process of wet noodle. The process mapping data can be seen in Table 1.

From observations and research directly in the field, it can be identified waste that occurs in the company such as over production (O), waiting time (W), excessive transportation (T), inappropriate processing (P), excessive inventory (I), unnecessary motion (M), defect (D). The calculation of the relationship between wastes was carried out through discussions with the company and distributing questionnaires using the weighting criteria developed by [19]. The total relationship of this affect is 21 types of waste i affect the type of waste j (i_j). The scores were obtained from the six questions for each relationship between wastes. The total value was converted into a symbol of the strength of the relationship (A, I, U, E, O, and X). The conversion results were used to calculate the level of influence from each type of waste to other types of waste, with conversion values A = 10, E = 8, I = 6, O = 4, U = 2 and X = 0. The results of this calculation summed and the value of the level of influence was known in percent (%). Based on the calculation of the results of the waste linkage, a waste relationship matrix was created for the production process. The result of score waste relationship matrix in the case study company is depicted in Table 2.

Table 2: The score result of waste relationship matrix

F/T	O	I	D	M	T	P	W	*Score*	%
O	10	6	6	10	8	0	2	42	15.8
I	10	10	8	8	8	0	0	44	16.5
D	8	2	10	6	4	0	8	38	14.3
M	0	10	4	10	0	8	4	36	13.5
T	4	2	8	8	10	0	8	40	15.0
P	6	8	8	8	0	10	8	48	18.1
W	4	2	2	0	0	0	10	18	6.8
Score	42	40	46	50	30	18	40	266	
%	15.8	15.0	17.3	18.8	11.3	6.8	15.0		100

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The waste score was obtained from WRM, which used for the initial WAQ based on the type of question. Some questions were marked with the words "From", meaning that the question explains the current types of waste that can trigger the emergence of other types of waste based on WRM. Other questions were marked with the words "TO", which means that the question explains that each type of waste that was influenced by other types of waste.

Table 1: The process activity mapping data in case study company

No	Activities	Unit (kg)	Operator	machine/ tools	Distance (m)	average time (minutes)	Activities					VA/ NVA/ NNVA
							O	T	I	S	D	
	Dough making											
1	Collecting raw materials for flour, eggs, ash water, food colouring and water from the storage warehouse	40	1	container	5	8.06		1				NNVA
2	Divide raw materials into 4 parts	40	1	scales		6.02	1					VA
3	Dough mixing process	10	1			12.13	1					VA
4	Divide the dough into 5 parts	10	1	knife		2.18	1					VA
5	Waiting for machining process (printing and cutting)		1			1.45					1	NVA
	Printing and cutting											
6	Picking up dough from the dough making table	2	2		1	1.00		1				NNVA
7	Rolling process for thinning	2	2	roller machine		30.14	1					VA
8	Putting the dough that is already thin on the cutting table	2	2		0.5	5.07		1				NNVA
9	The process of giving flour so it doesn't stick		2			4.01	1					VA
10	Installing the noodle cutting chisel on the roller machine		2	screwdriver		1.02					1	NVA
11	The process of cutting dough that has been thin and floured into a noodle shape.		2	roller machine and scissors	0.5	14.20	1					VA
12	Waiting for the boiling process		2			2.49					1	NVA
13	Remove the chisel, cut the noodles from the roller machine and go back to making a new dough		2	screwdriver		1.04					1	NVA
	Boiling											
14	Waiting for boiling water		2	boiling container		5.18					1	NVA
15	Taking the noodles to boil from the cutting table	2	2	container	1	0.75		1				NNVA
16	Boiling noodles	2	2			2.49	1					VA
17	Remove the noodles from the boiling container and drain the remaining water on the noodles		2	filter		2.16	1					VA
18	Placing the noodles on the cooling and packaging table		2	container		1.08		1				NNVA
19	Clean the remaining noodles left in the boiling container		2	filter dipper		1.13			1			VA
20	Adding water to the boiling pot		2	dipper		1.12		1				NNVA
21	Waiting for boiling water		2			3.21					1	NVA
22	Insert the noodles to be boiled next which is taken from the cutting table and repeat until the noodles are boiled	2		container	1	2.16					1	NVA
	Cooling and packaging											
23	Add cooking oil to prevent sticky	as applied	1			7.29	1					VA
24	Wait until the noodles are cold.		1			8.00					1	NVA
25	Cold noodles are packed in plastic with a weight of 2 kg per pack	2	1	scales		7.31			1			VA
26	Store noodles to warehouse		1			60.00				1		VA

Note: VA: Value Added; NVA: Non-Value Added; NNVA: Necessary Non Value-Added

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Table 3: The percentage of final result waste assessment and waste ranking

	O	I	D	M	T	P	W
Final result (%)	14.6	14.5	14.9	14.7	14.3	14.6	12.4
Waste rank	4	5	1	2	6	3	7

Furthermore, the final result of the waste assessment can be seen in Table 3. The higher percentage (14.9%) was occurred in term of waste of delay and awarded first ranking of the waste. The small percentage (14.4%) was occurred in term of waste of waiting (rank 7).

Process Activity Mapping in Case Study Company

The Process Activity Mapping (PAM) is able to describe the details of the stages of the production process. The process of making PAM used the actual company data and measurement of process time using direct measurements. The analysis of PAM in a case study company consists of 26 steps of work that run serially. The activities were operational, transportation, inspection, storage and delay. In detail of each type of activity can be seen in Table 1. The number of activities per activity type: operation, transportation, inspection, storage and delay have activities of 9 (34%); 6 (23%), 2 (8%), 1 (4%), 8 (31%) respectively.

Based the average time (minutes) each group of activities revealed the result of the PAM for total time production was 454.73 minutes, which was needed to make 80 kg of noodles. The detail proportion of time for each type of activity can be seen in Table 4.

Table 4: The results of total time for each group of the activities in case study company

Activities	Operational	Transportation	Inspection	Storage	Delay
Time (Minutes)	321.76	68.32	33.76	6.34	24.55
%	71 %	15 %	8 %	1 %	5 %

Based PAM analysis can be revealed the activity time, which was a value added of 321.76 minutes or 71% of the total time. Other activity time of 29% was the non-value added and necessary non value-added, which it can be minimized. The non value added activities that can be eliminated such as waiting for machining process (1.45 minutes), installing the noodle cutting chisel on the roller machine (1.02 minutes), waiting for the boiling process of 2.49 minutes, remove the chisel, cut the noodles from the roller machine and go back to making a new dough (1.04 minutes), waiting for boiling water (5.04 minutes), waiting for boiling water (3.21 minutes), insert the noodles to be boiled next, which is taken from the cutting table and repeat until the noodles are boiled (2.16), wait until the noodles are cold of 8 minutes. Total time for non-value-added activities can be eliminated 24.55 minutes. The total time for necessary non value-added was 20.03 minutes.

Based on the calculation of the initial stage of the improvement design, it is able to reduce the lead time on the current production floor from 570 minutes to 454.73 minutes. Then, by eliminate the non value added activities, the lead time for the future mapping can be reduced 24.55 minutes. Then, the total time production becomes 430.18 minutes. Therefore, future work in process time would be eliminated from 9.5 hours to be 7.2 hours (2.3 hours). So, the case study company can improve their productivity and reducing product delivery time.

4.0 CONCLUSION

This paper objective is to identify and analyse the waste occurrence in production process for the small businesses. A case study was conducted at small business, which produce wet noodle. The result of identification of the biggest waste is defect of 14.9%. Based on the recommendations for future improvements, it is able to reduce the lead time on the production floor by 139.82 minutes. Based process activity mapping data is possible to add 1 roller machine with cutting chisels. In addition the roller can continue without having to wait for all the dough moulding to finish.

5.0 REFERENCE

1. Bait, S., Pietro A.D. and Schiraldi, M.M. (2020). Waste reduction in production processes through simulation and VSM, *Sustainability.* 12(8):3291. https://doi.org/10.3390/su12083291.
2. Chaple, A.P. and Narkhede, B.E. (2017). Value stream mapping in a discrete manufacturing: A case study, *International Journal of Supply Chain Management*, 6(1), 55-67.
3. Meudt, T., Metternich, J., Abele, E. (2017). Value stream mapping 4.0: holistic examination of value stream and information logistics in production, *CIRP Annals*, 66, 413-416.
4. Sunk, A., Kuhlang, P., Edtmayr, T. and Sihn, W. (2017). Developments of traditional value stream mapping to enhance personal and organisational system and methods competencies, International Journal of Production Research, 55, 3732-3746.
5. Martins, G.H. and Cleto, M.G. (2016). Value stream mapping and earned value analysis: A case study in the paper packaging industry in Brazil, *Brazil Journal Operation Production Management*, 13, 360.
6. Susilawati, A. (2021). Productivity enhancement: lean manufacturing performance measurement based multiple indicators of decision making, Production Engineering Research Development, OnlineFirst, 1-17.
7. Wanitwattanakosol, J. and Sopadang, A. (2011). A framework for implementing lean manufacturing system in small and medium enterprises, *Applied Mechanics and Materials*, 110-116, 3997-4003.
8. Chong, K. (2013). Elimination of waste through value add/non value add process analysis to improve cost productivity in manufacturing – a case study, *Conference: IEEE IEEM 2013*, Bangkok, Thailand.
9. Poornashree, V. and Ramakrishna, H. (2019). A study on reduction of non-value added activities in an assembly line of an automobile industry, International Journal of Engineering Research & Technology (IJERT), 8(6).
10. Ratlalan, R.M., Tama, I.P. and Sugiono. (2018). Implementation of lean manufacturing to minimize waste in the process of plastic box 60 using vsm and ahp method, *Journal of Engineering and Management in Industrial System*, 5(2), 67-76.

11. Schoeman, Y., Oberholster, P., Somerset, V. 2020. Value stream mapping as a supporting management tool to identify the flow of industrial waste: a case study, *Sustainability*, 13, 91.
12. Zahraee, S.M., Tolooie, A., Abrishami, S.J., Shiwakoti, N. and Stasinopoulos, P. (2020). Lean manufacturing analysis of a heater industry based on value stream mapping and computer simulation. Procedia Manufacturing, 51, 1379-1386.
13. Oliveira, A.L.G. and Rocha, W.R. (2019). Productivity improvement through the implementation of lean manufacturing in a medium-sized furniture industry: a case study, *South African Journal of Industrial Engineering*, 30(4), 172-188. Doi.org/10.7166/30-4-2112.
14. Vargas, A.R., Moltalvo, F.J.F., Fernandez, J.B., Quintanilla, J.D.S., Macias, E.J. and Alcaraz, J.L.G. (2019). Implementation of production process standardization-a case study of a publishing company from the SMEs sector, *Processes*, 7(646), 1-22.
15. Susilawati, A. and Tan, J. (2015). Lean manufacturing approach for improvement of SMEs in Indonesian industry, *Proceeding of Ocean, Mechanical and Aerospace -Science and Engineering-*, 2(1), 20-26.
16. Narke, M.M. and Jayadeva, C.T. (2020). Value stream mapping: effective lean tool for SMEs, *Materials Today: Proceedings*, 24(2), 1263-1272.
17. Faisal, A.M. and Singh, K.S. (2019). Implementing lean technique by using value stream mapping (vsm) in a labourintensive small and medium enterprise (sme): case study of goods manufacturing company, *International Journal of Research in Engineering, IT and Social Sciences*, 9, 567-672.
18. Lugert, A., Batz, A. and Winkler, H. (2018). Empirical assessment of the future adequacy of value stream mapping in manufacturing industries, *Journal of Manufacturing Technology Manag.*, 29(5), 886-906.
19. Rawabdeh, I.A. (2005). A model for the assessment of waste in job shop environments, *International Journal of Operations & Production Management*, 25(8), 800-822.

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