WASTE ELIMINATION ACTION EVALUATION USING MANUFACTURING SYSTEM VALUE ANALYSIS

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ABSTRACT

Implementing Lean Thinking in a certain manufacturing system give the recommendation of waste elimination. The recommendation that contains waste elimination action requires further analysis of its benefit, technical preparation, and financial consequences. The previous common approach such as severity, occurrence, and detection analysis has not yet convinced the company to directly follow the recommendation as further consideration need be taken. The proposed method in this paper, offer a further analysis to complete the recommendation based on each waste characteristic. First, benefits analysis provides the procedures of evaluation based on availability, performance, and quality as the element of overall equipment effectiveness. Benefit analysis matrix providing of how to describe the relationship between waste and availability, performance and quality variable. Next, technical preparation analysis consists of subsequent identification of man, machine, method and material. Technical preparation matrix requires information on how the resources should be identified to conduct the waste implementation action. Then, financial consequences consider both potential revenue and implementation cost. Financial matrixes have the relationship value between the revenue variable and implementation cost element. Finally, the matrixes will be summarized in the overall matrix in order to have the action rank or priority. The result of implementing this method in 3 types of companies vary in how to gather accurate data to fulfill the required value within each matrix. However, a complete set of analysis is suitable to be taken for a final decision.

Keywords: waste elimination action, manufacturing system, lean thinking.

1. INTRODUCTION

Continuous improvement in manufacturing system is a guarantee to be able to survive in an increasingly competitive industrial world (Mostafa & Dumrak, 2015). One method that can be used to carry out continuous improvement is to apply the concept of lean thinking, wherein this concept there are various recommendations related to waste elimination action. Waste elimination action is a way to eliminate waste in manufacturing systems so that the processes in the system can run effectively and efficiently (Mostafa & Dumrak, 2015).

Today, many companies have applied waste elimination action. Various methods can be used to eliminate waste. Suryoputro et al (2018) used a combination of Value Stream Mapping and Ergonomics methods to identify and reduce existing waste in an upright panel buffing process. The combination of the two methods is expected to reduce the waste that occurs without increasing the risk of injury and fatigue to the operator, and to increase productivity (Suryoputro, Sari, Burhanudin, & Sugarindra, 2017). The Waste Assessment Model (WAM) method was applied by Henny and Budiman (2017) to measure how much waste occurred in a shoe company. WAM works by identifying the effects of seven types of waste that occur (Henny & Budiman, 2018). Lukmandaono et al (2019) applied Value Stream Analysis Tools (VALSAT) to map specific streams to processes that have added value. There are seven types of tools used in VALSAT namely Process Activity Mapping (PAM), Production Variety Funnel, Demand Amplification Mapping, Physical Structure, Decision Point Analysis, Quality Filter Mapping, Supply Chain Matrix (Lukmandono, Hariastuti, Suparto, & Saputra, 2019). Furthermore, Amrina et al (2019) also used VALSAT combined with the Waste Relationship Matrix (WRM), Waste Assessment Questionnaire (WAQ), fishbone diagrams, and Failure Mode and Effect Analysis (FMEA). Some of these methods are used to eliminate some of the waste in the rubber production process (Amrina, Putri, & Anjani, 2019). In addition to the methods mentioned, Rewers et al (2016) mentioned several tools to eliminate waste such as 5S, Single Minute Exchange of Die (SMED), Kanban, Jidoka, Hoshin Kanri, Heijunka, Standardized Work, Poka-Yoke, Kamishibai, Kaizen, and others (Rewers, Trojanowska, & Chabowski, 2016).

In implementing the concept of lean thinking, the company tries to cut costs that occur during the production process by reducing all types of waste that occur. Waste reduction process must be carried out continuously. But in the process of continuous improvement requires a number of initial conditions: (i) workers are given the trust to be responsible for the effectiveness of the work done, (ii) workers must have adequate skills and knowledge related to the methods applied by the company, and (iii) workers have full commitment to do the methods that the company specified so that company goals can be achieved (Alves, Dinis-Carvalho, Sousa, Moreira, & Lima, 2011).

Increasing consumer demand and global competition increase the degree of individualization and competition among manufacturing companies. Manufacturing companies try to meet consumer demand by creating high product variety, which is called mass customization (Hu, 2013). The existence of mass customization will cause increased costs in the production process. Thus, it needs to use benefit-cost analysis to find out whether the costs incurred are proportional to the benefits obtained.

Benefit-cost analysis is a method often used to assess the benefits of a project and public investment policy (Lekh & Virendra, 2014). The objectives of using benefit-cost analysis are: (i) evaluating the value of economic benefits in a particular project, (ii) comparing two or more projects, (iii) evaluating alternative business decisions, (iv) examining economic actions whether they have an impact on social welfare (Shively, 2012). Besides used to analyze a public project, benefit-cost analysis is also used in manufacturing. Comanita et al (2017) use cost-benefit analysis to evaluate a production process that has a major impact on the condition of the surrounding environment when compared with the benefits to the social. Evaluation of economic performance and efficiency on the environment using the object of production waste produced during the production process takes place (Comanita, et al., 2017).

OEE is part of Total Productive Maintenance (TPM) that measures the effectiveness of machine/equipment. OEE has several benefits, these are: (i) improve product quality, (ii) increase productivity, (iii) increase labor efficiency, and (iv) reduce equipment/machine downtime and maintenance costs. In measuring the effectiveness of an equipment/machine, OEE has three elements, namely availability rate, performance rate, and quality rate. Furthermore, these tools can be used to identify six big losses and can be used as a recommendation to reduce the occurrence of losses (Sayuti, Juliananda, Fatimah, & Syarifuddin, 2019).

Reducing losses with OEE has been used by many manufacturing companies. PT. MBI is a beverage industry that has machines that are used continuously. PT. MBI wants to determine the value of OEE and losses that occur in the production of drinks. OEE values obtained indicate that production line 2 is still below standard and found five losses. So that PT. MBI must make some improvements to reduce the possibility of losses (Rimawan, Kholil, & Hendri, 2018). The same thing was done by PT. TMI is engaged in the automotive field. In the case study at PT. The TMI proves that the low OEE value is caused by the six big losses factor. The occurrence of six big losses is very influential on the effectiveness of production (Herrry, Farida & Lutfia, 2018). Furthermore, an analysis of productivity improvement was investigated on the production of hard disc spare parts in a company in Batam. This study uses a combination of OEE, FMEA, and fuzzy values. OEE is used to find out how effective the engine is when operating. While FMEA and fuzzy logic are useful for identifying the causal factors of machine problems that result in losses. Thus, the actual OEE value can be improvised on target (Hunusalela, Perdana, & Usman, 2019).

Some of the methods mentioned above have not convinced companies to implement the recommendations they formulated. Therefore a future analysis is needed that considers several aspects such as benefits, technical preparation, and financial consequences. The details of the following aspects will be summarized into a matrix. The matrix will be used to determine the priority level in making final decisions. The decision is expected to be able to reduce waste effectively and efficiently.

2. METHODOLOGY

The methodology used in this paper can be seen in the Figure 1 below.

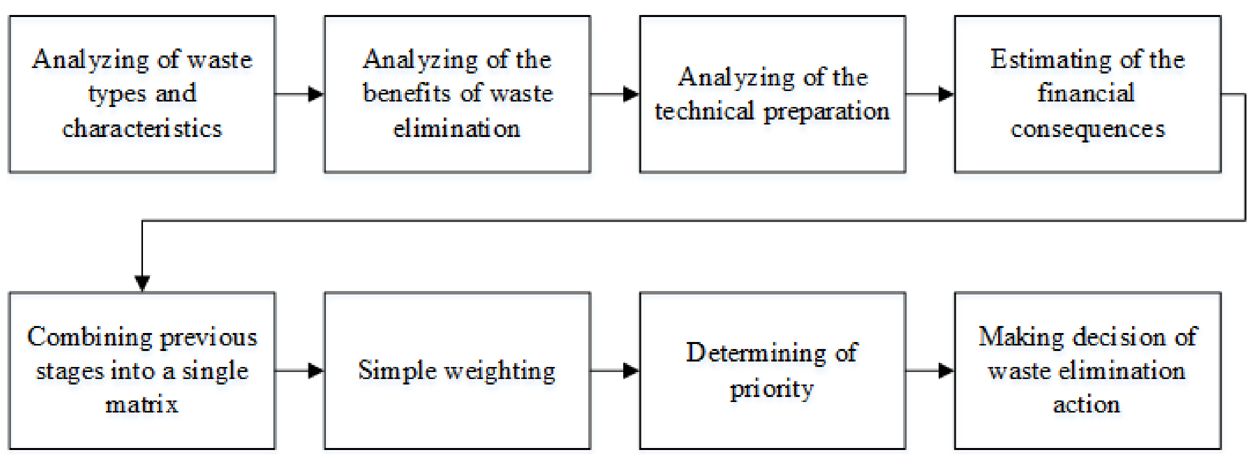

Figure 1. Methodology

An understanding of waste types and their characteristics needs to be linked to the 5 principles of lean thinking. It aims to determine the value of each waste to the overall business value of the lean manufacturing concept. The characteristic in question is whether waste has a direct or indirect impact on the manufacturing system that is currently running or evaluated.

Impact analysis is needed to determine the initial determination of the level of importance of each waste elimination action (or it can also be referred to as improvement).

After analyzing the types and characteristics of waste, an analysis of the benefits of waste elimination action is carried out. Benefits are analyzed based on contributions to the elements forming overall equipment efficiency, namely availability, performance, and quality. The availability contribution is analyzed based on that the intended action will be able to increase the availability of the existing manufacturing system. While the contribution of performance is seen more on the effect on production speed so that the amount of product output that is expected to increase. Furthermore, the contribution to quality is analyzed based on that the action to be carried out will reduce the defect. This benefit analysis can also be expanded by calculating the financial value of the benefits that have been identified. Further analysis can also be done through the analysis of potential revenue from the implementation of improvements carried out.

The next stage is technical preparation analysis, identifying resource requirements related to man, machine, material, and method. Man's needs are intended to find out the number of resources needed, and the divisions or capabilities related to do the improvement. Machine or can also be expanded with the use of tools are machines which will experience improvement and which machines, or tools will be involved in improvement actions related to waste elimination action. Material needs are identified as the type and amount of material needed to make improvements. The method is the most complicated thing because the improvement method has a very wide variety. The method used can be a single method or a combination of several methods.

Financial consequences are estimates of the need for money from waste elimination action. In general, improvement measures can be seen from how much the implementation costs of the recommendations given. These cost needs also need to be supplemented by hidden costs, which include a decrease in productivity. The decline in productivity is possible as a side effect of an increase in the overall equipment efficiency element, for example, an increase in production speed (performance) makes the defect rate increase (quality).

Finally, the overall previous stages will be combined into a single matrix that can be used to determine priorities. This decision analysis can be done by considering various criteria with a simple weighting. Determination of priority or ranking is done by processing numbers from different units into unit percentages that can be used as a comparison. Thus, the waste elimination action that has been formulated is complete with various consequences and needs, as well as overall value for improvement options to be implemented.

3. RESULT AND DISCUSSION

This research was conducted on three types of companies, namely project-based manufacturing, make to order manufacturing with discrete products (metal forms) and continuous products (liquid forms). Typical continuous production of metal form products and liquid form products is based on daily operations, while project-based is determined from the project is run until the end is marked by handover to the customer.

First, waste characteristics need to be defined and understood to be associated with improvement measures carried out based on OEE parameters. The type and amount of waste can be determined by each company according to improvement needs. In this paper, the three companies use 7 waste that can be defined quickly and easily. The waste is defects, over-processing, excessive motion, transportation, unnecessary inventory, waiting, and overproduction.

Second, the formulation of a matrix for the elimination of waste elimination action (WEA) priority is carried out in three stages. The first stage, benefits analysis is the process of identifying the effect or contribution of each waste elimination action related to each type of waste. The following result in Table 1 is an example table of the contribution values of each waste elimination action to the parameters of availability, performance, and quality as elements in overall equipment efficiency.

Table 1. Benefit analysis related to overall equipment efficiency

Waste	WEA	Availability		Performance		Quality	
		Symbol	Value	Symbol	Value	Symbol	Value
1.Defect	WEA11	AX11	0,35	PX11	0,65	QX11	0,73
	WEA12	AX12	0,90	PX12	0,98	QX12	0,68
2.Overprocessing	WEA21	AX21	0,80	PX21	0,11	QX21	0,00
	WEA22	AX22	0,35	PX22	0,70	QX22	0,36
3.Excesive motion	WEA31	AX31	0,97	PX31	0,45	QX31	0,26
	WEA32	AX32	0,26	PX32	0,12	QX32	0,31
4.Transportation	WEA41	AX41	0,25	PX41	0,08	QX41	0,05
	WEA42	AX42	0,38	PX42	0,58	QX42	0,37
5.Unnecessary inventory	WEA51	AX51	0,37	PX51	0,72	QX51	0,39
	WEA52	AX52	0,44	PX52	0,65	QX52	0,89
6.Waiting	WEA61	AX61	0,40	PX61	0,47	QX61	0,14
	WEA62	AX62	0,05	PX62	0,29	QX62	0,71
7.Overproduction	WEA71	AX71	0,95	PX71	0,25	QX71	0,52
	WEA72	AX72	0,29	PX72	0,78	QX72	0,74

Notes: AXij means contribution value toward availability from related waste i and waste elimination action j (e.g. AX11 related to defect waste and waste elimination action 1)

The Second Stage, Preparation Analysis is the process of identifying resource needs in man, machine, material and method of each recommended waste elimination action. The Table 2 is an example table for determining the needs and normalization (determining index value) of each value.

Table 2. Preparation analysis related to need of resources

WEA	Man (MN)			Machine (MC)			Material (MT)			Method (MD)		
	Symbol	Amount	Value	Symbol	Amount	Value	Symbol	Amount	Value	Symbol	Amount	Value
WEA11	MN11	6	0,67	MC11	5,50	0,47	MT11	30,73	0,99	MD11	5	1,00
WEA12	MN12	5	0,56	MC12	11,00	0,94	MT12	30,68	0,99	MD12	1	0,20
WEA21	MN21	2	0,22	MC21	10,00	0,85	MT21	30	0,97	MD21	1	0,20
WEA22	MN22	9	1,00	MC22	5,50	0,47	MT22	30,36	0,98	MD22	4	0,80
WEA31	MN31	6	0,67	MC31	11,70	1,00	MT31	30,26	0,98	MD31	5	1,00
WEA32	MN32	7	0,78	MC32	4,60	0,39	MT32	30,31	0,98	MD32	2	0,40
WEA41	MN41	5	0,56	MC41	4,50	0,38	MT41	30,05	0,97	MD41	4	0,80
WEA42	MN42	8	0,89	MC42	5,80	0,50	MT42	30,37	0,98	MD42	5	1,00
WEA51	MN51	6	0,67	MC51	5,70	0,49	MT51	30,39	0,98	MD51	4	0,80
WEA52	MN52	9	1,00	MC52	6,40	0,55	MT52	30,89	1,00	MD52	5	1,00
WEA61	MN61	5	0,56	MC61	6,00	0,51	MT61	30,14	0,98	MD61	1	0,20
WEA62	MN62	9	1,00	MC62	2,50	0,21	MT62	30,71	0,99	MD62	2	0,40
WEA71	MN71	6	0,67	MC71	11,50	0,98	MT71	30,52	0,99	MD71	1	0,20
WEA72	MN72	4	0,44	MC72	4,90	0,42	MT72	30,74	1,00	MD72	1	0,20

Note: Each value is the proportion of related amount compare with its biggest amount value

The third stage, Financial Consequences is the process of identifying potential revenue and implementation costs for each recommended waste elimination action. Table 3 is a sample table of analysis results and how to determine the index value of each waste elimination action. Furthermore, at the final stage, a combination of the three matrices is designed to get the desired ranking or priority. The example result is described in Table 4.

Based on the implementation of three types of manufacturing companies with project-based characteristics, make to order (discrete product) and make to order (continuous product) the analysis results are obtained in Table 5.

Table 3. Financial concequences related to revenue and implementation cost

WEA	Revenue (R)			COST (C)		
	Symbol	Amount	Value	Symbol	Amount	Value
WEA11	R11	912	0,97	C11	184	0,57
WEA12	R12	504	0,54	C12	153	0,64
WEA21	R21	541	0,57	C21	162	0,62
WEA22	R22	672	0,71	C22	430	0,00
WEA31	R31	472	0,50	C31	295	0,31
WEA32	R32	207	0,22	C32	172	0,60
WEA41	R41	337	0,36	C41	128	0,70
WEA42	R42	310	0,33	C42	123	0,71
WEA51	R51	555	0,59	C51	129	0,70
WEA52	R52	823	0,87	C52	236	0,45
WEA61	R61	453	0,48	C61	209	0,51
WEA62	R62	809	0,86	C62	312	0,27
WEA71	R71	942	1,00	C71	101	0,77
WEA72	R72	218	0,23	C72	99	0,77

Note: Each value is the proportion of related amount compare with its biggest amount value, as the cost is on the other hand (biggest the amount, smallest the value)

Table 4. Overall calculation towards priority determination

WEA	AX	PX	QX	MN	MC	MT	MD	R	C	Weighted	Priority
WEA11	0,35	0,65	0,73	0,67	0,47	0,99	1,00	0,97	0,57	0,709	4
WEA12	0,90	0,98	0,68	0,56	0,94	0,99	0,20	0,54	0,64	0,734	2
WEA21	0,80	0,11	0,00	0,22	0,85	0,97	0,20	0,57	0,62	0,516	11
WEA22	0,35	0,70	0,36	1,00	0,47	0,98	0,80	0,71	0,00	0,586	8
WEA31	0,97	0,45	0,26	0,67	1,00	0,98	1,00	0,50	0,31	0,662	5
WEA32	0,26	0,12	0,31	0,78	0,39	0,98	0,40	0,22	0,60	0,453	14
WEA41	0,25	0,08	0,05	0,56	0,38	0,97	0,80	0,36	0,70	0,476	13
WEA42	0,38	0,58	0,37	0,89	0,50	0,98	1,00	0,33	0,71	0,640	7
WEA51	0,37	0,72	0,39	0,67	0,49	0,98	0,80	0,59	0,70	0,657	6
WEA52	0,44	0,65	0,89	1,00	0,55	1,00	1,00	0,87	0,45	0,736	1
WEA61	0,40	0,47	0,14	0,56	0,51	0,98	0,20	0,48	0,51	0,508	12
WEA62	0,05	0,29	0,71	1,00	0,21	0,99	0,40	0,86	0,27	0,520	10
WEA71	0,95	0,25	0,52	0,67	0,98	0,99	0,20	1,00	0,77	0,721	3
WEA72	0,29	0,78	0,74	0,44	0,42	1,00	0,20	0,23	0,77	0,561	9
Weight	0,10	0,15	0,05	0,10	0,10	0,12	0,08	0,14	0,16	---	---

Note: weighted value is multiplication (sum-product) of weight and each value of variable

Table 5. Several findings in 3 companies

Stage	Project Based	Make to order (discrete product)	Make to order (continuous product)
Benefit Analysis	Idle time between project might cause the difference to measure exact availability, performance and quality rate	Easier to measure all the overall equipment efficiency elements	Should have clear approachc in determining how to measure performance and quality rate
Preparation Analysis	Similarity in resources need between projects needs a very clear approach	There is no significant problem has been found	There is no significant problem has been found
Financial Consequences	Project that have previous learning curve might lead to cheaper implementation cost	There is no significant problem has been found	There is no significant problem has been found

4. CONCLUSIONS

The stages of the methodology proposed in the form of matrix processing have considered aspects of OEE which is a general Key Performance Indicator for manufacturing systems including a target value of 85% as a sign of world-class company. The overall value generated will be able to complete or be used as a comparison of the assessment of waste elimination action that has existed so far. Implementation in three different types of industries illustrates the needs to make various adjustments to the parameter used in this research. However, the basic sequential stages can be used as the template for analyzing other types of manufacturing systems as well.

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