Implementation of Lean Manufacturing with Waste Assessment Model (WAM) Approach in A Small Muffler Industry in Purbalingga

Z A Inderawibowo, H Asyari, A A Sibarani

Department of Industrial Engineering, Jenderal Soedirman University, Central Java, Indonesia

Email: zalfaa.inderawibowo@mhs.unsoed.ac.id

Abstract. Small to medium-sized industry (SMEs) is one of the sectors that supports the Indonesian economy, for example in Purbalingga Regency there is MMS K477INE. MMS K477INE is an SME that produces various types of muffler or muffler of a motorbike and it has entered the global market, one of them is a 2 stroke muffler type RX King Telo Kobra. In the muffler production process, it must be done better to fulfill customer demand and satisfaction. However, from the implementation of activities on the production floor, there are several problems so it cannot be denied that the SME there is a waste. Therefore, in this case, it is necessary to apply a lean manufacturing approach to solve the problem using the Waste Assessment Model (WAM). WAM consists of Seven Waste Relationship, Waste Relationship Matrix, and Waste Assessment Questionnaires, which data collection is done through filling out questionnaires and direct observation. The WAM approach is used to find the problem of waste and is supported by the root causes of waste by using Root Cause Analysis. The next stage is to create a recommendation improvement, based on the problems that occur in the highest value waste is motion waste with a value of 26.7%, defect with a value of 18.5%, and transportation with a value of 14%. So that the recommendation improvement that has been created can reduce the value of waste.

1. Introduction

Small to medium-sized industry (SMEs) is one of the sectors that influence economic growth in Indonesia [1]. SME is a representation of the people's economy because it can absorb approximately 90% of the workforce, and contributes 58% to the National Gross Domestic Product [2]. As in Purbalingga Regency currently, it has excellent SME, which is well known and has been marketed throughout Indonesia, as well as online marketed abroad [3]. The number of mufflers SME that have been recorded is 146 SME units with a total muffler production reaching 595.371 units per year [4]. One of the Purbalingga muffler SME that already has a market outside the island of Java such as Bali, Sumatra, and also abroad (India) is MMS K477INE SME. The SME has various types of products for motorized vehicles and cars.

The main objective of small, medium, and large scale industries is to be able to provide satisfaction in fulfilling demands such as product quality or service to customers so that later it will affect the maximum profit that will be obtained [5]. Therefore, the muffler production process, it must be done better to fulfill customer demand and satisfaction. To produce 100 mufflers, it takes 7884.77 minutes

or approximately 5-6 days [6], while the processing time needed to make 1 muffler is 36,813 minutes [7] and has a production capacity of 15-20 muffler per day. Also, MMS K477INE SME has many competitors, so that it continues to improve its production results to complete products at the right time and get profit.

Based on observations made at MMS K477INE SME, there are still many problems, such as goods that can be returned by customers because they are found to be defects, there is no standard time, there is no flow of production information evenly, and the workplace of workers is not well structured as there are items or equipment that are placed out of place. In terms of production time, several problems were found which had caused the MMS K477INE SME to be hampered from fulfilling customer demand. It is possible that the problems in MMS K477INE are caused by waste on the production floor. Therefore, a deeper identification is needed in the process of making the muffler.

Steps that can be taken to reduce waste on the production floor, namely by applying a lean manufacturing approach. A lean approach focuses on efficiency without reducing the effectiveness of the value-added operation process so that workers can do work optimally, reduce waste, and meet customer needs [8]. Models that are suitable and can be used to identify waste include the Waste Assessment Model (WAM). WAM is a model used to simplify the search for waste problems and identify the root causes of waste and can contribute more accurate results in identifying the root causes of waste [9].

The current research uses the WAM approach, which is based on previous research, the method can be used to identify problems, find solutions, and reduce the waste that occurs. This study also used Root Cause Analysis (RCA), namely 5 Why's to help in finding the root of the problem. Furthermore, to overcome the absence of standard time, the researcher performed a standard time calculation because it plays an important role in producing muffler [10]. Efforts from this improvement are expected to reduce waste that occurs on the production floor.

2. Research Methodology

This research uses quantitative and qualitative research. Quantitative research such as calculating cycle time, normal time, standard time, and takt time in the motor muffler production process. While qualitative research with in-depth interviews to obtain information about the sequence of processes and other information as supporting data for quantitative research to be measured. Furthermore, in the study using the Waste Assessment Model (WAM) so that it uses a questionnaire. Data collection using saturated samples, because the population in MMS K477INE is relatively small. This research has the main focus, namely the highest value of waste, which is processed using the Seven Waste Relationship and the Waste Assessment Questionnaire. The production floor problems at MMS K477INE SME are no different from other large industries. So this research is the identification of waste and indicators of causes of problems.

3. Result and Discussion

3.1. Calculation Cycle Time, Normal Time, Standar Time, and Takt Time

The cycle time of this research is the time of the activities carried out when producing the muffler, and this cycle time is the average time needed for the entire processing time at each work station. So that from the 11 the muffler manufacturing process takes 148.54 minutes/muffler. To measure the time that takes into account the performance rating from the calculation of the normal time calculation using the performance rating from Westinghouse. There are four things that are assessed in determining the performance rating, namely skill, condition, effort, and consistency, these values are based on workers and the processes carried out so that the total normal time of the whole process is 174.36 minutes.

Next is the calculation of standard time. It’s to measure the time considering the allowances. This research using personal allowances (talking with colleagues, going to the bathroom, drinking, smoking, and other things that are personal), fatigue allowance (coffee break), and delay allowances

(other supporting raw materials). From the consideration of allowances, the total processing time is 202.16 minutes.

Takt time can be used as a reference for how long the production process can complete the work of each workpiece so that it can fulfill customer needs. Then the takt time can also indicate how often a product should be produced in a day to meet the average customer demand. The calculation of the takt time needs the available working hours in one day, which is 400 minutes after deducting the break time for 80 minutes, and need an average product produced for the finished in one day of 20 mufflers.

Table 1 Calculation of Muffler Manufacturing Time (minute)

No.	Process	Cycle Time	Normal Time	Standar Time	*Takt Time*
1	Pattern Making	16.22	18.98	22.00	
2	Cutting Plates	11.74	13.74	15.93	
3	Rolling plates with beating	9.17	10.09	11.70	
4	Welding	14.53	17.44	20.22	
5	Rolling plates with machine roll	17.50	19.25	22.32	
6	Grinding	12.76	14.93	17.31	20
7	Welding (graft)	33.13	39.75	46.09	
8	Grinding (Hand grinding)	1.84	2.20	2.55	
9	Polishing	11.16	13.39	15.53	
10	Welding (rotary)	14.67	17.60	20.41	
11	Finishing	5.83	6.99	8.11	

3.2. Waste Assessment Model (WAM)

3.3.1 Seven Waste Relationship

Table 2 The Level of Linkages Waste

No.	**Question Type**	**Total Score**	**Level of Correlation**	**No.**	**Question Type**	**Total Score**	**Level of Correlation**
1	O_I	9	**I**	17	M_W	9	**I**
2	O_D	4	**O**	18	M_P	12	**E**
3	O_M	6	**O**	19	T_O	5	**O**
4	O_T	10	**I**	20	T_I	3	**U**
5	O_W	10	**I**	21	T_D	10	**I**
6	I_O	1	**U**	22	T_M	16	**A**
7	I_D	6	**O**	23	T_W	16	**A**
8	I_M	2	**U**	24	P_O	3	**U**
9	I_T	2	**U**	25	P_I	3	**U**
10	D_O	4	**O**	26	P_D	9	**I**
11	D_I	3	**U**	27	P_M	14	**E**
12	D_M	14	**E**	28	P_W	12	**E**
13	D_T	16	**A**	29	W_O	5	**O**
14	D_W	10	**I**	30	W_I	5	**O**
15	M_I	2	**U**	31	W_D	2	**U**
16	M_D	9	**I**				

As in Table 1, several processes have a greater time than the takt time. This means that cycle times and standard times if below the takt time, indicating the current process to fulfill customer demand can be done more quickly or on time. Meanwhile, the cycle time and standard time are above the takt time, indicates that the process is running slower than it should be. If it has a value above the takt time,

usually there is a problem such as long processing time, excessive input components, a lot of work in progress, etc., so that the target cannot be fulfilled.

Every waste has a relationship with each other which is caused by the influence of each waste which can appear directly or indirectly [9]. The calculation of the relationship between these wastes is obtained from a questionnaire conducted through discussions and interviews by the owner of MMS K477INE. After that, the total weight of each question is obtained so that the level of linkages is obtained. In Table 2, there are the results of the scores and levels of linkages that have been converted to symbols as in Table 3.

Table 3. The Range of Linkage Score Between Waste

Range	**Type of Relationship**	**Symbol**
15-18	*Absolutely Necessary*	A
11-14	*Especially Important*	E
7-10	*Important*	I
4-6	*Ordinary Closeness*	O
1-3	*Unimportant*	U

3.3.2 Waste Relationship Matrix

The Waste Relationship Matrix (WRM) is a matrix that can be used to determine the relationship level of the seven types of waste. WAM is obtained by converting the SWR results into letter notation on a relationship matrix. This relationship can be seen in the rows and columns. Rows show the effect of special waste on certain types of waste, and columns show the waste that is influenced by other wastes.

Table 4 Waste Relationship Matrix

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

Table 5 Waste Matrix Value

F/T	O	I	D	M	T	P	W	*Score*	%
O	10	6	4	4	6	0	6	**36**	**15%**
I	2	10	4	2	2	0	0	**20**	**8%**
D	4	2	10	8	10	0	6	**40**	**17%**
M	8	6	6	10	0	8	6	**44**	**18%**
T	4	2	6	10	10	0	10	**42**	**18%**
P	2	2	6	8	0	10	8	**36**	**15%**
W	4	4	2	0	0	0	10	**20**	**8%**
Score	34	32	38	42	28	18	46	**238**	**100%**
%	**14%**	**13%**	**16%**	**18%**	**12%**	**8%**	**19%**	**100%**	

The WRM results can be seen in Table 4, to calculate the calculation from each type of waste to other types of waste, it can be entered from symbol to number with references A = 10, E = 8, I = 6, O = 4, U = 2, and X = 0 [9]. These results show that the value of “from motion and transportation” has the highest percentage, which is 18%. This explains that motion and transportation have the greatest impact among other factors for the occurrence of waste. While the value of "to waiting" also has the highest percentage value, namely 19%, therefore the most waste waiting is caused by other wastes.

3.3.3 Waste Assessment Questionare

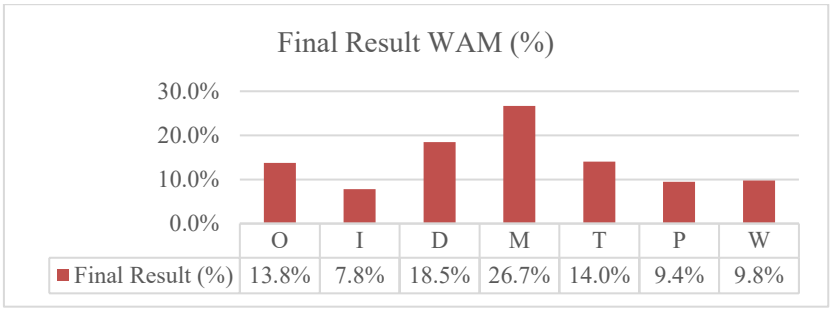

Figure 2. Final Result WAM

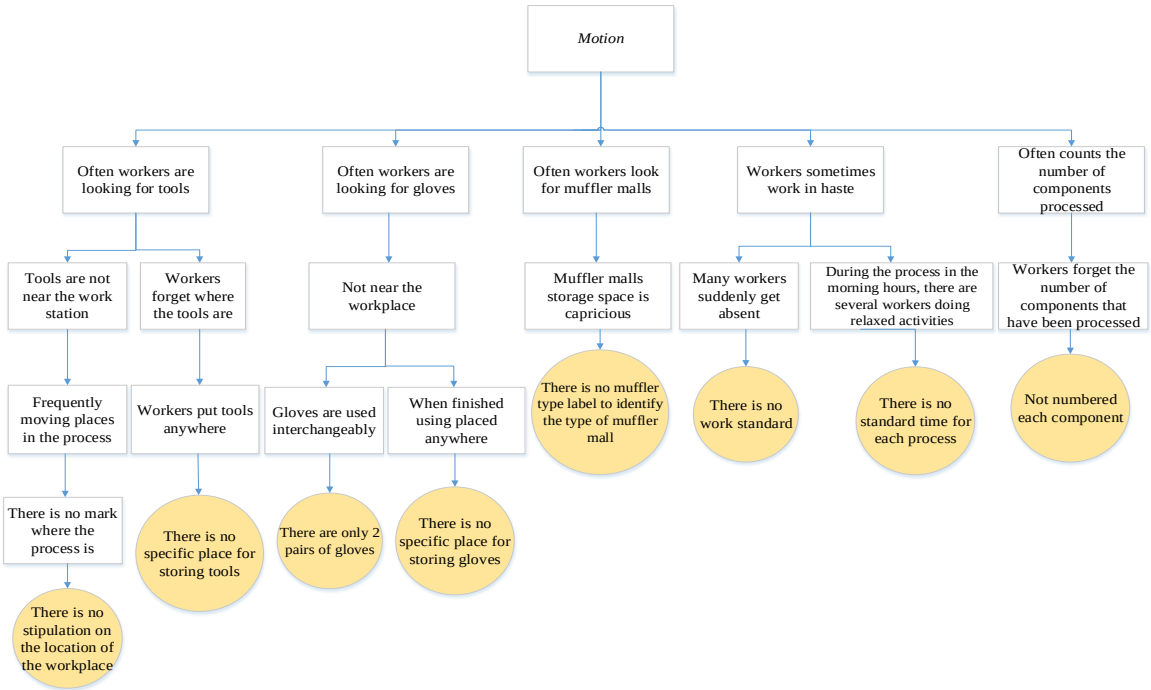

Figure 3. Root Cause in Motion

The value of waste that has been carried out at the WRM stage is used for the initial WAQ assessment based on the type of question. The WAQ approach consists of 68 different questions, each question representing an activity or condition that can lead to waste. Questions are marked with the words "from" and "to". From the results of data processing, WAQ obtained waste results from rank one to seven as in Figure 2, namely the waste overproduction value is 13.8%, then inventory waste is 7.8%, defect waste 18.5%, motion waste 26.7%, transportation waste 14%, overprocessing waste 9.4%, and waiting waste is 9.8%. From the results of the ranking, the highest waste rating is the movement of waste, therefore it is done accurately to determine the root cause of waste.

3.3. Root Cause Analysis (RCA) and Recommendation of Improvement

This section will identify the root causes of the three biggest wastes using the 5 Why's which is illustrated in a tree diagram. From the results of making RCA, it can be seen in Figure 3 for motion waste, then Figure 4 for defect waste, and Figure 5 for transportation waste.

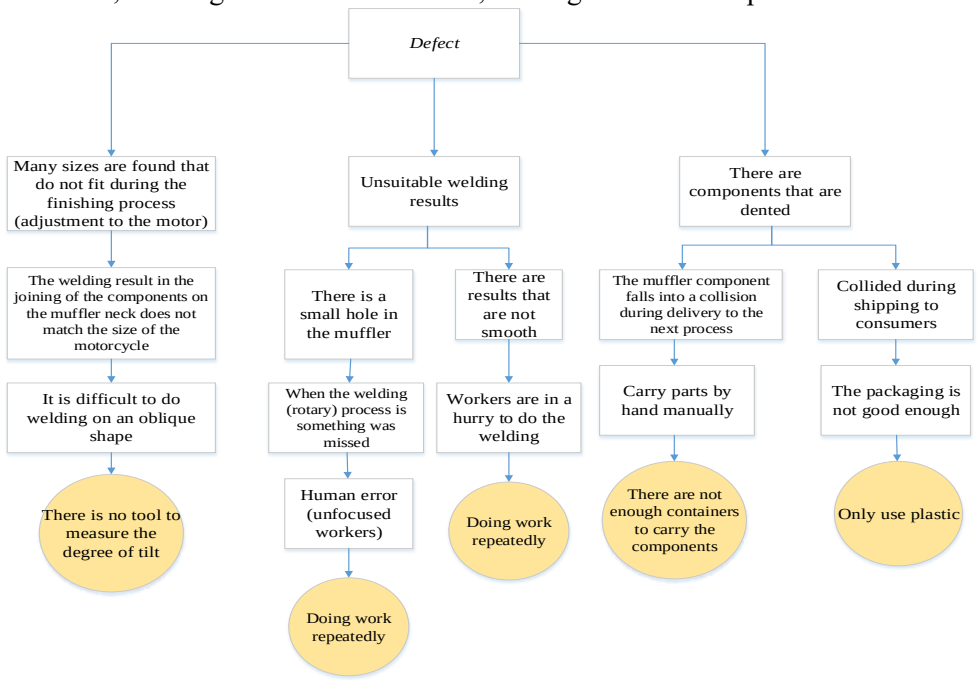

Figure 4. Root Cause in Defect

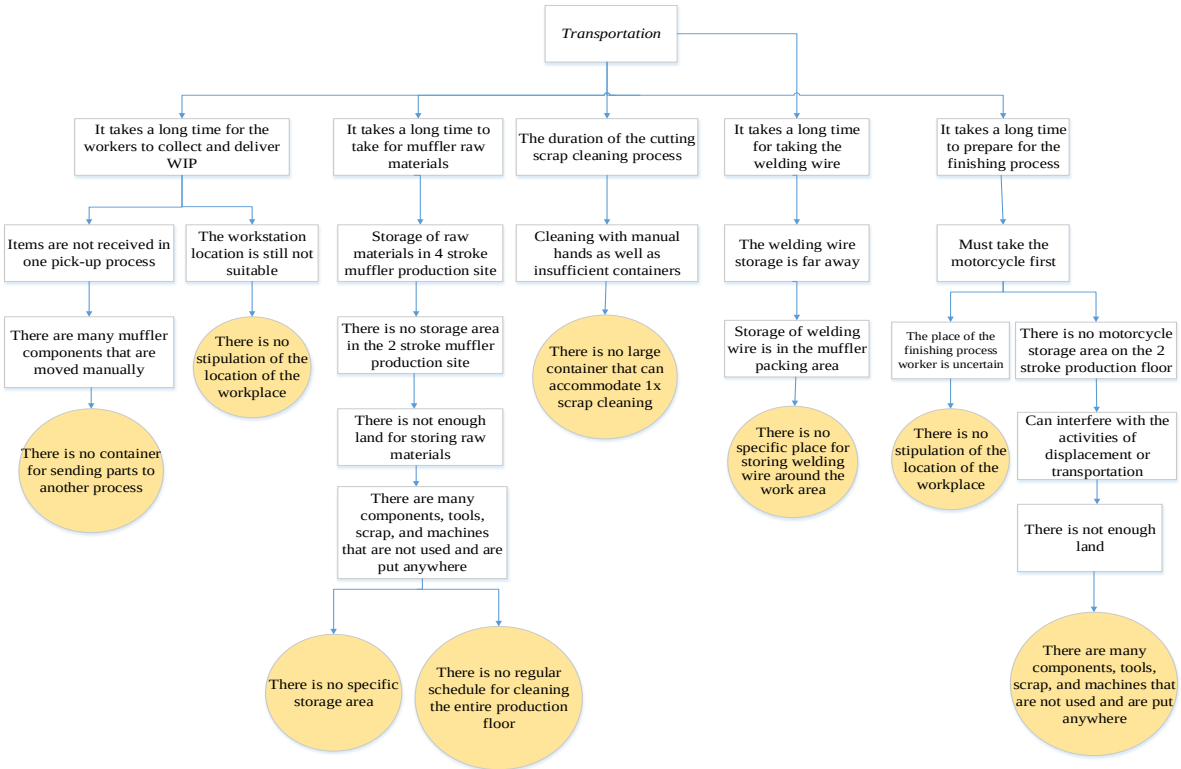

Figure 5. Root Cause in Transportation

3.4. Recommendations and Improvement Planning

After knowing the root cause of the three wastes, there are several recommendations for improvement as in Table 6. It is necessary for improvements in order to provide satisfaction in fulfilling customer demands. Through these improvement efforts, it is hoped that it can reduce unnecessary activities or activities that are non-value added. Based on the recommendations for improvements that have been made in this research, some of them are implemented as can be seen in Table 7.

Tabel 6. Recommendation of Improvement

Waste	Sub Waste	Root Cause	Recommended Improvements
Motion	Often workers look for tools	There is no fixed of the location of the workplace and there is no specific place for storage tools	Creating a storage area for tools, making layout improvements, and implementing 5S
	Often workers look for muffler malls	There is no muffler type label to identify the type of muffler malls	Making muffler type labels in storage malls
	Workers sometimes work in haste	There is no standard time for each process	Make measurement and set standard times
Defect	There are components that are dented	There are not enough containers to carry the components	Give container enough for each component
		Only use plastic in packaging	Using cardboard or wood in muffler packaging
	Poor welding results	Doing work repeatedly	Pay attention to work capability and conduct job training for workers
Transportation	It takes a long time to take for muffler raw materials	There is no specific storage area	Make improvements to the layout and implementation of 5S
	The duration of the cutting scrap cleaning process	There is no large container that can accommodate one-time scrap cleaning	Provide sufficient base under the cutting tool for scrap containers

4. Conclusions

Based on the research that has been done, the value "from motion" and "from transportation" is 18%, and "to waiting" has a value of 19%. This explains that motion waste and transportation waste have the greatest impact among other factors for the occurrence of waste, and the waste of waiting is mostly caused by other wastes. After that, the tree highest type of waste in 2 stroke type muffler MMS K477INE is waste motion with a value of 26.7%, defect waste with a value 18.5%, and transportation waste with a value 14%. There are several recommendations for improvements that can be given to reduce motion waste in the muffler manufacturing process, that is designing the production layout, making tools storage, implementing 5S, making muffler type labels in mall storage areas, making standardization for each worker especially regarding absenteeism permits, make measurement and set standard time, and number each component.

Tabel 7 Implementation Result

Waste	Implementation	Before	After
Motion	Label muffler type in muffler mall storage		
	Standar Time	---	202.16 minutes / muffler
Defect	Provision of containers for components		
	The base for collecting scrap is in the cutting process		
Transportation	Improved layout by approaching the raw material storage distance with the pattern making process	---	

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