Waste Reduction in Electrical Production Process in PT Petrokimia Gresik Coal Utility Using Value Stream Mapping and FMEA Applications

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***Abstract*— Unit Utilitas Batu Bara (UBB) is one of the power plants owned by PT Petrokimia Gresik which began operating in 2010. UBB consists of a steam boiler with a capacity of 2x150 tons per hour and a power plant with a capacity of 25 megawatt. There is waste in the electricity production process at UBB which is indicated by the value of actual efficiency is low compared to the value of efficiency in the design and performance test. This research discusses efforts to reduce waste in the process of steam and electricity production in UBB by making value stream mapping, identifying waste, conducting root cause analysis, and making FMEA. Through data collection and processing, interviews with expert employees at UBB, as well as comparing reference activities and actual activities, obtained that waste occurs in coal out from coal mill, boiler water, and boiler efficiency. Through analysis 5 whys, obtained fifteen root causes of waste. Through the calculation of events, severity, and detection the risk priority number is obtained. Based on the existing critical risks, through the collection of FMEA worksheets, an estimate of actions to reduce waste that occurred at UBB was obtained. The results showed that all total waste obtained was Rp. 126,364,598.13 / day in UBB. By asking for alternative improvements, a potential savings value of Rp.74,436,596 / day is obtained.**

***Keywords*— waste, value stream, electricity production, utilities unit, FMEA.**

I. INTRODUCTION

PT PETROKIMIA GRESIK is a subsidiary of a state-owned enterprise, PT Pupuk Indonesia (Persero). Located in Gresik Regency and occupying a land area of > 450 Ha, PT Petrokimia Gresik produces various kinds of fertilizers and chemicals [1]. PT Petrokimia Gresik has 26 production units, port facilities, warehousing, offices, sports facilities, employee housing, etc. Therefore, good utility facilities are needed to support the production process and these various facilities. One of the utility facilities that plays an important role in PT Petrokimia Gresik is Unit Utilitas Batu Bara (UBB) or coal utilities unit. UBB produces steam and electricity for various production units at PT Petrokimia Gresik with a total production capacity of 2x150 tons per hour of steam and 25 megawatt electricity [2].

UBB's cost of electricity per kWh in 2018 is high, almost twice as high as the cost of electricity produced by PT Perusahaan Listrik Negara (Persero), PLN [3][4]. UBB's boiler efficiency actual is 8% lower than boiler efficiency design. This data indicates that there is waste in the production process at UBB which must be reduced.

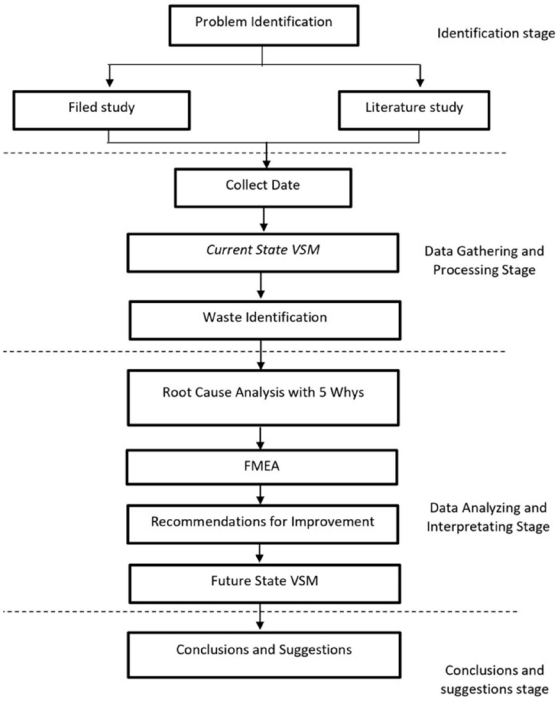

Figure 1. Research Methodology Scheme.

Lean is a process broadly aimed at increasing value added and eliminating waste, and includes techniques geared toward those things [5]. Value stream mapping (VSM) is one of lean tools that can be an extremely powerful tool, combining material processing steps with information flow as well as other important related data[6]. By creating value stream mapping, we can find out the activity of adding value and not adding value that helps identify waste in the production process. One method of finding the root cause of a problem is to use the 5-Whys approach [7]. Failure Mode Effect Analysis (FMEA) is one the most effective and accepted problem solving (PS) tools for most of the companies in the world [8]. The FMEA being a risk assessment tool that mitigates potential failure in system, design, process or service [9]. The objective of this study is to identify the wastes that occurs in UBB, find the root causes of these wastes, and make recommendations for improvements to reduce wastes.

Table 1.
Waste Identification

No	Location	Reference Activity	Actual Activity	Non Value Adding Activity
1	Coal mill	Coal consumption rate 0.18 ton coal/ton steam	Coal consumption rate 0.21 ton coal/ton steam	Coal consumption rate 0.03 ton coal/ton steam
2	Boiler	Boiler water blow down 5.34 ton/hour	Boiler water blow down 16 ton/hour	Boiler water blow down 10.66 ton/hour = 255.84 ton/day
		Efficiency of Boiler A dan B: 85%	Efficiency of Boiler A: 76.7% Efficiency of Boiler B : 76.91%	Efficiency of Boiler A: 8.3% Efficiency of Boiler : 8.09%

Table 2.
Waste Value

No	Location	Reference Activity	Actual Activity	Non Value Adding Activity
1	Coal mill	Coal consumption rate 0.03 ton coal/ton steam	Rp. 815,000.00/ton coal	Rp. 24,450.00/ton steam x 2,540.6 ton steam/day (average daily steam produced) = Rp.62,117,670.00/day
2	Boiler	Boiler water blow down 10.66 ton/hour = 255.84 ton/day	Rp. 21,500.00/ton boiler water	Rp. 5,500,560.00/day
		Efficiency of Boiler A : 8.3% Efficiency of Boiler B : 8.09%	Boiler A: Rp. 3,925,537/1% efficiency/day Boiler B : Rp. 3,234,167/efficiency/day	Boiler A : Rp. 32,581,957.1/day Boiler B : Rp. 26,164,411.03/day

Table 3.
Waste Value

No	(S)	(O)	(D)	(RPN)
1	2.50	10	7.67	**191.67**
2	2.00	10	7.33	**146.67**
3	4.00	10	2.50	100.00
4	3.33	10	7.17	**238.89**
5	3.50	10	5.83	**204.17**
6	3.83	10	1.67	63.89
7	3.67	10	4.67	**174.11**
8	3.17	10	1.50	47.50
9	3.50	10	4.67	**163.33**
10	1.83	5.67	1.83	19.05
11	3.50	7.67	2.33	62.61
12	2.00	10	1.33	26.67
13	1.67	10	1.17	19.44
	Total			1458
		RPN Average		**112.15**

II.METHOD

Process analysis is carried out by obtaining daily process data from the UBB control room and daily anaysis result from factory laboratory during 2018 and 2019. Various information is obtained through discussions and interviews with five experts in UBB and direct observation in the field. The various steps in this study are as showed in Figure 1.

III.RESULTS AND DISCUSSION

Based on the data processing, waste in UBB occurred in the coal mill and boiler area, then the current state value stream mapping is arranged as shown in Figure 2. Waste in UBB is non value adding activity, a gap that occurs between the reference activity and the actual activity. These wastes occur at the coal mill and boiler outlets. Waste identification is shown in Table 1.

From Table 1, waste that occur in UBB are over coal comsumption rate 0.03 toncoal/ton steam, over boiler water blow down 255.84 ton/day, and lack efficiency of boiler A: 8.3% and boiler B : 8.09%. Waste value can be determined by multiplying the non value adding activity with the price of each non value adding activity that occurs. Where the price here is based on prices prevailing at PT Petrokimia Gresik. The waste value can be seen in Table 2.

Root cause analysis of these wastes that occur in UBB is conducted by using 5whys tool. The result is a set of cause of wastes that occur in UBB, as follows :

1. Spare parts of wheat wreath and spring in the coal mill are not yet available.
2. Isokinetic sampling tools have not been installed on coal mill outlets that comply with ASME standards.
3. There is no standard procedure for preventing and handling self combustion in coal stock.
4. Not yet invested in the temperature profile measurement system in the boiler furnace.
5. Late evaluation and replacement of resin at demin plant.
6. The water source of the Bengawan Solo River is polluted.
7. High ash content in coal
8. The number of shoot blowers installed is less.
9. High silica content in boiler water.
10. Super heater spare tube is not yet available.
11. There is a high content of Na2O in coal which triggers fouling.
12. Air preheater spare parts are not yet available.
13. Jacketing insulation material is not ready

After finding the root causes of waste, a failure mode and effect (FMEA) analysis will be arranged. To determine the value of occurrence, severity, and detection using a questionnaire aimed at six staff with a minimum position of superintendent whose filling is done through brainstorming. From the results of the assessment, each value for occurrence,

Tabel 4.
FMEA Worksheet

No	Waste	Failure Cause	Failure Effect	Recommended Action
1	Over coal consumption rate	Spare parts of wheat wreath and spring in the coal mill are not yet available.	Coal mill is not working well The size of coal dust is over specifications, mesh-200 min70% is not achieved Coal burning is not perfect	Invest in spare parts for wheat wreath and spring coal mill
2	Over coal consumption rate	Not yet installed isokinetic sampling tool that conforms to ASME standards	The coal mesh sampling method is considered less accurate	Carry out investment in isokinetic equipment that complies with ASME standards [10]
3	Over coal consumption rate	Not yet invested in temperature profile measurement system in boiler furnaces	Temperature adjustment at each corner of the combustion chamber is less accurate No perfect fire ball is formed Burning coal is less than perfect	Carry out investments temperature profile measurement system in the furnace boiler
4	Boiler water loss	Late evaluation and replacement of resin at demin plant	High levels of SiO_2 in boiler feed water Drainable boiler water is carried out continuously	Substitute all resins in the demin plant Conduct continuous resin evaluation of each annual improvement of the Coal Utilities Unit
5	Loss efficiency	High ash content in coal	Slagging has occurred on the outside of the boiler tube The heat transfer in the boiler tube is not optimal High flue gas temperature	Addition of sootblower to UBB boilers Doing coating ceramic coating on the entire tube boiler [11]. Make a self burning prevention procedure on coal stock Making anti self burning spray facility
6	Loss efficiency	High silica content in boiler water	Crust deposits occur on the inside of the tube The heat transfer in the boiler tube is not optimal High flue gas temperatur	Perform chemical cleaning inside the boiler tube to remove silica deposits [12]

Table 5.
Estimated Waste After Repair

No.	Location	Non Value adding activity	Potential Savings	Estimated waste
1.	Coal mill	Coal consumption rate 0.03 ton coal/ton steam	Coal consumption rate 0.02 ton coal/ton steam	Coal consumption rate 0.01 ton coal/ton steam
2	Boiler	Boiler water blow down 10.66 ton/hour = 255.84 ton/day Boiler A efficiency : 8.3% Boiler B efficiency : 8.09%	Boiler water blow down 8.5 ton/hour = 204 ton/day Boiler A dan B efficiency : 4%	Boiler water blow down 51.84 ton/day Boiler A efficiency: 4.3% Boiler B efficiency : 4.09%

Tabel 6.
Potential Saving Value

No.	Location	Potential saving	Price	Waste Value
1.	Coal mill	Coal consumption rate 0.02 ton coal/ton steam	Rp. 815,000.00/ton coal	Rp. 16,300.00/ton steam x 2,540.6 ton steam/day (average daily steam production) = Rp.41,411,780.00/day
2	Boiler	Boiler water blow down 204 ton/day	Rp. 21,500.00/ton boiler water	Rp. 4,386,000.00/day
		Boiler A efficiency: 4% Boiler B efficiency : 4%	Boiler A : Rp. 3,925,537/1% efficiency/day Boiler B : Rp. 3,234,167/ efficiency/day	Boiler A : Rp. 15,702,148.00 /day Boiler B : Rp. 12,936,668.00 /day
Total Potential Saving Value				**Rp.74,436,596.00/day**

severity, detection, and risk priority number (RPN) can be obtained, which can be seen in Table 3.

The critical RPN value is determined from the average RPN value of all risks. Based on the critical RPN value above, 6 (six) critical risks are obtained. Furthermore, an FMEA worksheet was created to determine the failure effect and recommended actions that can be taken to reduce waste in the Coal Utilities Unit, as presented in Table 4.

By implementing the recommended action above, it is expected that potential savings will occur at the Coal Utilities Unit. After obtaining potential savings data, it is expected that the amount of waste in the PT Petrokimia Gresik Coal Utilities Unit will be reduced. By calculating the difference between waste before repair and the potential savings, then the estimated waste after repair is shown in the Table 5.

Based on the estimated waste after the improvements contained in Table 5 above, it can then be determined the estimated value of potential saving and estimated value of the waste that occurs in the Coal Utilities Unit after repair by multiplying the potential savind and the estimated waste with the price of each waste that occurs. Where the price here is based on prices prevailing at PT Petrokimia Gresik. The potential saving value and estimated value of waste can be seen in Table 6 – 7.

Tabel 7.
Estimated Waste Value

No.	Location	Estimated Waste	Price	Waste Value
1.	Coal mill	Coal consumption rate 0.01 ton coal/ton steam	Rp. 815,000.00/ton coal	Rp. 8,150.00/ton steam x 2,540.6 ton steam/day (average daily steam production) = Rp.20,705,890.00/day
2	Boiler	Boiler water blow down 51.84 ton/day	Rp. 21,500.00/ton boiler water	Rp. 1,114,560.00/day
		Boiler A efficiency: 4.3% Boiler B efficiency : 4.09%	Boiler A : Rp. 3,925,537/1% efficiency/day Boiler B : Rp. 3,234,167/ efficiency/day	Boiler A : Rp. 16,879,809.10 /day Boiler B : Rp. 13,227,743.03 /day
Total estimated waste value				**Rp.51,928,002.13/day**

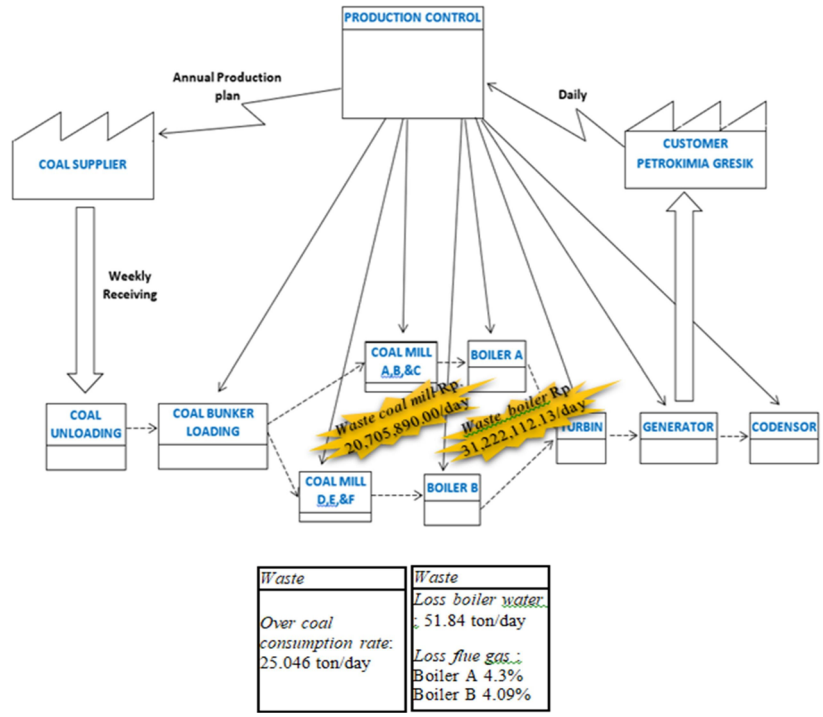

Figure 2. Future State Value Stream Mapping

Based on the identification of waste after repairs, a future state mapping of the business process of the Coal Utilities Unit is developed as shown in Figure 3.

IV.CONCLUSION

Some conclusions from this study are:

1. Through value stream analysis, there are three production activities that result waste in UBB: over coal consumption rate, loss of boiler water, and loss of flue gas.
2. Based on the analysis of the root causes of the problem with 5 why's there are fifteen factors causing waste generation in the Coal Utilities Unit of PT Petrokimia Gresik, based on the assessment of risk priority number there are six causative factors that should get management attention, namely:
   a. Spare parts of wheat wreath and spring coal mill are not yet available,
   b. Not yet installed isokinetic sampling tool that conforms to ASME standards.
   c. Not yet invested in temperature profile measurement system in boiler furnaces.
   d. Late evaluation and replacement of resin at demin plant.
   e. High ash content in coal.
   f. High silica content in boiler water.
3. There are eight proposed improvements that can be done to reduce waste in the electricity production process at the PT Petrokimia Gresik Coal Utilities Unit, namely:
   a. Invest in spare parts for wheat wreath and spring coal mill.
   b. Carry out investment in isokinetic equipment that complies with ASME standards.
   c. Invest in a temperature profile measurement system in the boiler furnace.
   d. Substitute all resins in the demin plant.
   e. Conduct continuous resin evaluation of each annual improvement of the Coal Utilities Unit.
   f. Addition of sootblower to UBB boilers.
   g. Coating ceramic coatings on all boiler tubes.
4. Perform chemical cleaning inside the boiler tube to remove silica deposits.AcknowledgmentThe authors are grateful to PT Petrokimia Gresik for all financial support, information and data in this study. We specifically thank Tawil, Ani Mardiyani, Yahyo, Sumarwiyah, Dian Yuli Astuti, Royyan Fauzan, Hana Mafaza, and Wildan Ahyar for all spirits support.

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