DISTRIBUTION PROCESS DESIGN TO IMPROVE SUSTAINABILITY OF MANUFACTURING EFFICIENCY

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ABSTRACT

Recently, sustainability manufacturing has a great attention by researcher and practitioner. Sustainable manufacturing is the design of manufactured that can maximize positive impact to environmental while conserving energy and natural resources. It must cover the entire process within the company, not only in the production process but also distribution process. Distribution process is one of the marketing activities that directly relate to consumers and has a large enough role in creating the benefits of an item. Mapping the process to find out the process suitability of the company towards the principle of sustainable manufacturing needs to be done in order to find out which points need to be improved. In this research, we used Sustainable Value Stream Mapping that gives results several problems in packaging and stuffing processes. This research was focus on stuffing because it has the most problems, starting from economic performance: poor cost efficiency (28.1%), bad time efficiency (28.1%), bad worker satisfaction (46.47%), bad training level (0%), and poor safety level (36.84%). These problems will be reduced by material handling investments. We analyze the alternative using NPV and ergonomics assessment. The investment of stacker can increase the company's performance result on the principle of sustainable manufacturing at the stuffing process produced economic indicators: good time efficiency (80%), good cost efficiency (90%), and good efficiency inventory (82%). Environmental indicators: good energy efficiency (80%). Social indicators: good safety level (100%) and training level remains poor (25%).

Keywords: Sustainable Manufacturing, Sustainable Value Stream Mapping, Net Present Value, Material Handling Investment.

1. INTRODUCTION

The current industry at the global level has had a strict level of competition and dynamic. The company's ability to analyze problems from internal and external companies is required in the company's performance optimization to survive. The company is an object of economic sciences, where the company is an institution organized and run to provide goods and services to the community with a motive of profit. In the effort to provide such goods and services companies do various activities such as production, marketing, spending, research, and development. For a company, activities that are the frontline that is directly related to consumers are marketing. One of the marketing activities that is directly related to the consumer and has a considerable role in creating the benefit of an item is distribution (Kotler, 2000).

The distribution process is generally considered as waste in the supply chain because it does not add value to the product. However, the distribution is inevitable so what can be done is to implement an efficient distribution process. The thorough identification of the distribution process is important to know what needs to be improved so that efficiency increases and eliminates the lower efficiency. Industry in the present era is demanded not only to optimize profit but also pay attention to social and environmental factors or commonly referred to as sustainable manufacturing (Taubitz, 2010). Sustainable Manufacturing is created when the production process also minimizes the adverse impacts on the environment, Conservation of energy and natural resources, safe for workers, communities, and consumers but still economically healthy (USDOC, 2011).

The sustainable manufacturing principle will also apply to the product distribution process. Good distribution is done by providing the right material with the right amount, in the right conditions, in the right place, in the right position, in the right order, to produce the right cost with the right method (Tompkins, 2010). Precisely interpreted can fulfill all aspects of consideration in sustainable manufacturing. The right cost does not mean the lowest cost. The minimization of cost is to be the wrong goal in designing the distribution system. A more precise goal is to design the most efficient distribution system at a reasonable cost (Parvini, 2011). The efficient distribution is achieved by the minimum time, worker, waste, and cost accompanied by maximum security and safety (Fellows, 2017). One method that can be used to mapping the distribution process is Value Stream Mapping or VSM, which is a method by mapping the process flow and information flow of the product to see which activities Give added value and not give added value (Rother & Shook, 2003). If the mapping method performed with VSM is implemented using the sustainable manufacturing principle, it will produce Sustainable VSM tools that are useful in mapping process flow and information on the triple bottom line namely Economics, social, and environmental (Faulkner & Badurdeen, 2014).

A manufacturing company that manufactures wood furniture products such as tables, chairs, cabinets, and so on is set as research object. The company's consumers to date come from Australia and Japan. Products are manufactured in the company based on the demand of consumers (make to order). The products are shipped to consumers using the forwarding service. Distribution of products using goods vessels in the port. The mapping of the distribution process to the company follows an indicator that exists on SUS-VSM for a furniture company with a sample of research is a cross foot table product as many as 8 products. Sus-VSM is made up of economic, environmental and social indicators. Economic indicators include time, product defects, inventory, and cost. Environmental indicators include material and energy aspects. Social indicators include aspects of health, safety, contentment, and training (Hartini et al., 2018). However, the baseline assessment in safety indicators does not match the distribution activity. Therefore, the safety indicator follows the calculation of OWAS which is a method of measuring work attitude that encodes the working attitude on the back, hands, feet, and weight of the load (Karhu et al, 1981). The OWAS

assessment is more in line with safety indicators because there is no machine involvement and is dominated by manual activity by workers.

Based on the Sus-VSM description above, improvement will focus on the stuffing process because it is the process with the most problems. As an illustration, the stuffing process experiences many problems because the whole stuffing process is done manually starting from the worker pushing the product to the mouth of the container. Then, the product is transported by 4-5 people because the mass of the product weighs around 50-100 kilograms and is raised as high as 1.5 meters from the warehouse floor to the mouth of the container. After that, the products are arranged in containers by workers. Stuffing takes a long time about half a working day or about 4 hours. Workers who do stuffing are workers from the production department. That caused the worker to leave his job for a long time. Though stuffing involves around 8 out of 20 workers from the production department. Products transported into containers range from 100-150 pieces.

The solution to the problem of stuffing that a lot will be reduced using an investment analysis of material handling equipment (MHE). MHE that is suitable for stuffing activities and following the principles of sustainable manufacturing are electric forklifts and electric stackers. Then, the use of the tool will increase the efficiency of the stuffing process because the activity is carried out by the tool while the human role is only as an operator so that the processing time will be faster and not tiring workers. The use of both tools can also improve work posture. This means that the work posture is ergonomic and the load does not exceed the limit because the load is carried by the tool. In essence, the stuffing problems that exist in the Sus-VSM are too heavy workloads, too long processing time, too many inefficient activities, low inventory efficiency, and non-economic work postures can be reduced with MHE investment.

Before making an MHE investment, it is necessary to analyze the costs that will be incurred so that in addition to meeting the principles of sustainable manufacturing, it is also hoped that this investment will have a reasonable cost. One of the tools that can be used to conduct cost analysis is the Net Present Value (G Newnan, 2003). The alternative that will be carried out with the NPV cost analysis only alternatives with material handling costs which are lower than the manual one. The results of the NPV can measure the cost savings made by the company.

2. LITERATURE REVIEW

2.1 Sustainable Value Stream Mapping

Value Stream Mapping (VSM) is used as an illustration to help identify hidden waste and the source of the waste itself. Whereas sus-VSM is a development of VSM by combining existing metrics with sustainability metrics, namely the triple bottom line (economic, environmental and social) so that the sus-VSM is expected to provide a clear picture of the company's performance from the economic, environmental and social aspects (Faulkner & Badurdeen, 2014).

The steps in mapping all existing activities with sustainable value stream mapping are as follows (Faulkner & Badurdeen, 2014):

1. Identify sustainable manufacturing metrics that are appropriate for the type of industry
2. Measuring economic matrices include data related to PPIC, production processing time, data from suppliers to consumers.
3. Measuring environmental metrics
4. Measuring social metrics

2.2 Material Handling Cost

Generally, material handling costs will be divided into three classifications:

- Costs associated with transporting raw materials from the source to the factory and shipping the finished product to the company's customers.
- In-Plant Receiving and Storage, the costs incurred in the context of moving material from one process to the next to the distribution of the final product.
- Handling materials are carried out by workers on their work machines and also the process of assembling products that take place on a worker's desk.

To analyze material handling costs, the following factors should be considered, namely:

- Material
  Including cost of machinery/equipment investment, all material costs related to material handling, maintenance costs, energy costs, costs for oil, costs for equipment for assembly on the bench, installation costs (including costs for all materials and wages for workers and realignments).
- Salary and Wages
  Including direct labor cost (all workers participating in the operation of material handling equipment) and training Cost for workers/operators to operate material handling equipment.
- Financial Charge
  Including the interest for material handling equipment investment and the insurance costs, depreciation and others.

The main purpose of material handling planning is to minimize production costs because material handling is very influential in the operation and design of facilities implemented. Some objectives of the material handling system include (Meyers, 1993):

1. Maintain product quality, reduce the potential for damage, and protect the material.
2. Maintain safety and security for workers and develop working conditions.
3. Increase productivity:
4. Increase the level of facility usage
5. Reducing dead weight
6. As an inventory control

Some material handling activities that need to be taken into account are the transfer of materials to the warehouse of raw materials and out of the finished warehouse as well as the transferor transportation that occurs within the factory. Factors that influence the calculation of material handling cost include the distance from one work station to another and the cost of transportation per meter of movement. The measurement of the mileage is adjusted to the conditions in the field. Thus, if the mileage has been determined and the frequency of material handling has been calculated, material handling cost can be known, where:

Total Material Handling Cost = (Material handling cost per meter) × (Distance) × (Frequency) (1)

2.3 Depreciation Cost

Depreciation is a portion of the costs of fixed assets that are systematically allocated to costs in each accounting period (Baridwan, 2010). Meanwhile, in another sense, depreciation is the allocation of an asset that can be depreciated over its estimated useful life that will be charged directly or indirectly to income (Indonesia, 2009). The straight-line method is the method used in this study. The straight-line depreciation method is based on the assumption that the value of an asset decreases linearly (proportional) to the time or age of the asset. This method is calculated based on (Baridwan, 2010):

$$d = d_i = \frac{I-L}{N} \quad (2)$$

$$D_t = \sum_{i=1}^{t} d_i \quad (3)$$

$$B_t = I - D_t \quad (4)$$

Where,
d = di = cost of depreciation to i
I = initial investment
L = residual value at the end of economic life
N = economic age (years)
Dt = accumulative depreciation at time t
Bt = investment value at the end of year t

2.3 Net Present Value

Net present value can be interpreted as net value at present, based on the concept of pulling all cash flows to the current point. By pulling all cash flows both in and out during the life of the product (investment) to its present value, then determine what the net amount is, will get the value of whether an investment is profitable or not (Husnan & Muhammad, 2014). NPV values can be calculated using the following equation:

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} \quad (5)$$

Where,
Bt = income in year t
Ct = expenditure in year t
i = interest rate

NPV> 0, means the investment is feasible to run because it has positive (profitable) results
NPV = 0, the project does not experience profits or losses when it is run
NPV> 0, you should not run because the investment has suffered losses

3. RESEARCH METHOD

The object to be investigated is the problem that exists in the distribution process, especially the stuffing process of a furniture manufacturing with the principle of Sustainable Manufacturing. The problem is measured using a mapping from Sustainable Value Stream Mapping.

The scope of the discussion raised from the distribution process as a problem is limited to problems that are stuffing because it has the most problems. Problems in stuffing are cost efficiency paid to poor workers only 28.1%, efficient activities carried out by workers also only 28.1%, the bad safety level of workers at 36.84%, and poor training levels of 0%.

Determination of alternatives that can be used depends on the root of the problem that exists in the process so that the proposed alternatives can include solving several problems. The root of the problem in the stuffing sub process is that it still uses the manual method to load heavy-loaded products into large quantities of containers. Forklifts and stackers are alternatives that correspond to the types of activities that exist in the stuffing process. Besides, both of them are also known to be able to increase the efficiency of economic and social factors, but they are still not harmful to environmental factors because they are both powered by electricity. Significant differences are both in speed, electricity, and investment costs. However, both of these tools have the same purpose and purpose so that it is needed which tools are appropriate to the needs and can be declared worthy of investment

MH's concerns will cover all matters related to the stuffing process and calculate the costs used when stuffing. In Table 1 are the variables that are considered in the calculation of material handling cost in the stuffing process with manuals, stackers, and forklifts.

In the previous process, MHE was selected with the lowest material handling cost consideration. The next step is to conduct a feasibility analysis of selected MHE investments with NPV to find out whether there are cost savings made by the company if investing even though it is known that it has improved performance on the principle of sustainable manufacturing.

The effect of investment tools is implemented on existing indicators in the Sus-VSM so that it can see a picture of the difference between the value before the investment is made and afterward. From these differences will be seen the level of improvement made by the investment of tools.

Table 1. Material Handling Cost Variables

Manual	**Electric Stacker**	**Forklifts**
Employee Salary Stuffing Time	Stacker Prices the residual value of the stacker Speed Transport Distance Loading- Unloading Time Economic age Electricity Comsumption Electricity Cost Number of Employee	Forklift Prices the residual value of the stacker Speed Transport Distance Loading- Unloading Time Economic age Electricity Comsumption Electricity Cost Number of Employee

4. RESULT AND DISCUSSION

4.1 Alternatives Options Definition

Alternative options is defines base on the principle of using tools that can be operated with the help of machines to facilitate the user due to poor OWAS ratings in **Table 2**.

Table 2. Manual Material Handling Activity Assessment

No.	Activity	Code	Category
1	Push	1122	1
2	Transport	2242	4
Safety Efficiency			36.84%

Then alternatives were chosen to replace the current method described in **Table 3**.

Table 3. Material Handling Efficiency Alternatives

No.	Tool Type	Activity	Code (Category)	Safety Efficienvy
1	Push	Transport with sitting	1111(1)	100%
2	Transport	Transport with standing	1121(1)	100%

4.2 Material Handling Cost

Material handling cost calculation is influenced by several variables. Material handling is calculated based on 3 scenarios namely using manual material handling, forklift, and stacker showed in table 4.

Table 4. Material Handling Calculation

No.	Method	erial Handling Cost (IDR)	Duration (hour)
1	Manual	864,912	4
2	Forklift	1,007,402	0.92
3	Electric Stacker	436,428	1.83

4.3 Net Present Value

Once an alternative is chosen, it will then be included in the NPV calculation by considering the aspects in **Table 5**.

Table 5. Input Data for Net Present Value Calculation

No.	Aspects	Value	Data Sources
1	Employee Salary	Increase 5% / year	Company
2	Depreciation	7% /year	Indotara.com
3	Maintenance Cost	IDR 500,000, increase 5% / year	Indotara.com
4.	Electricity Cost	Increase 5.11% / year	PLN
5.	Discount factor	6.75%	Interest rate of BI

All of the data input then included in the cash flow calculation of the investment plan for the next 10 years, the NPV results will be obtained in **Table 6.**

Table 6. Net Present Value

Year	Net Benefit	DF (i = 6.75)	Present Value
0	(36,900,000)	1.00	(36,900,000)
1	6,411,233	0.94	6,005,838
2	6,885,842	0.88	6,042,564
3	7,384,177	0.82	6,070,136
4	7,907,423	0.77	6,089,245
5	8,456,825	0.72	6,100,535
6	9,033,692	0.68	6,104,611
7	9,639,396	0.63	6,102,034
8	10,275,378	0.59	6,093,330
9	10,943,152	0.56	6,078,991
10	11,644,307	0.52	6,059,473
NET PRESENT VALUE			23,846,757

4.4 Investment Effect on Sus-VSM

At the end of the calculation, it will be seen again how the investment performance in the Sus-VSM assessment as described in **Figure 1**.

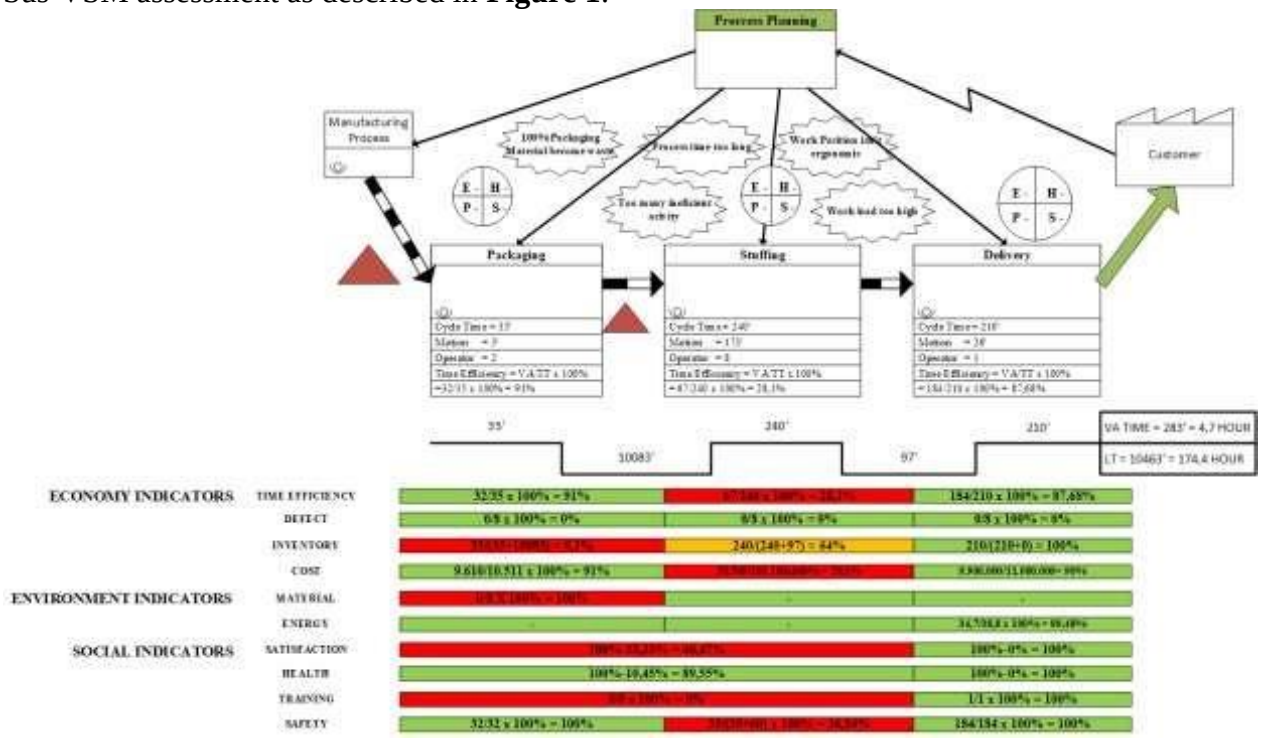

Figure 1. Sus-VSM

5. ANALYSIS

The selection of the chosen tool is based on the cost factor incurred by the company to carry out the stuffing process. The manual method produces a fee of IDR 864,912 so that the chosen tool must be under IDR 864,912 to be accepted as a proposed tool to replace the manual method because the price is one of the basic aspects of sustainable manufacturing principles. The cost incurred on

the forklift is IDR 1,007,402 which means this price is 16% higher than the price that appears by the manual method so that the use of forklifts cannot be accepted to replace the manual method although it can increase the transport time from 4 hours to 0.92 hours. Moreover, the stacker costs are IDR 436,428 which means that the company saves costs to be incurred by 49.53% and the time it's resulted comparable to the company stuffing activity which is 58% faster than the manual method. By that, the stacker is more valuable than a forklift. The stacker is more promising for investment if seen from the perspective of sustainable manufacturing of an economic standpoint. The stacker also saves more electricity usage compared to forklifts by 64% by environmental consideration. From a social standpoint, workers will be more pleased with the existence of a forklift because it helps faster the works and does not require human labor in its operation but this is not an important matter if it is seen an increase in social aspects from the manual method to the use of forklifts because it can reduce the fatigue experienced by workers significantly and when compared with forklifts, both tools alike change the OWAS category from category 4 (code 2242) to the category 1 (1111).

Besides, the investment to the company is getting cost savings and has a significant impact on the main objective of the research, which is the principles of sustainable manufacturing. The effect of stacker selection for companies on sustainable manufacturing principle is to reduce the cycle times by 54% from 4 hours to 1.83 hours because the stacker can reduce the fatigue experienced by workers and faster movement. Stacker also reduces non-value added activity by 87% from 2.8 hours to 0.36 hours due to stuffing activities that no longer require much rest and movement. The next effect is reducing the number of workers involved with 50% from 8 to 4 because human functions are replaced by machines.

The influence of economic indicators is increasing the activity efficiency by 52% from 28.1% to 80%, increasing material handling cost savings from IDR 864,912 to 436,428, increasing inventory efficiency by 10.2% from 71.8% to 82%, increasing cost efficiency by 62% from 28.1% to 90%. The influence of environmental indicators is by using the use of electrical energy with an efficiency of 80%. Then the influence on social indicators is an increase in the level of work safety by 63.16% from 36.84% to 100%, the training level increased by 25% because the stacker operators must be given training. Moreover, the company is now only losing 4.1% of productivity compared to the initial loses of 20%.

6. CONCLUSION

This study concludes that the problems that occur in the distribution process in a furniture manufacturing based on Sus-VSM are in the first two sub processes namely packaging and stuffing. The economic problems are poor inventory efficiency, environmental problems in packaging, and social problems are the poor level of employee satisfaction. The problems in stuffing are economic problems related to poor time efficiency. Then the social problem is poor safety level and the 4 hour stuffing process which decreasing productivity by 20%. To solve those problems, There are 2 alternatives to solve those problems in terms of material handling investment, namely forklift, and stacker. Both of them are sourced from non-diesel electricity so they are following the principles of sustainable manufacturing on environmental aspects. The alternative chosen is the stacker because it has a cheaper material handling cost compared to the cost of a manual material handling of forklift, and it can reduce processing time.

Stacker gives an impact for the company in the principle of sustainable manufacturing in terms of reducing cycle time, reducing non-value added activity, and reducing the number of workers involved. The effect of economic indicators is to increase the efficiency of activities, increase the material handling cost savings, increase the cost efficiency, and reduce inventory

efficiency. The effect of environmental indicators is only those that initially did not use any energy into the use of electrical energy with an efficiency of 80%. Then the effect on social indicators is increasing the level of work safety and training activities for operators. Moreover, the other benefit is to reduce the level of productivity loss on the production line which supported by the company that can make savings of IDR 23,846,757 during the investment period.

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