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Prediction of Carbon Emissions Footprint in Batik Industry Toward Green Manufacturing

[1]Sukirman, [1]Chairul Saleh, [2]Nur Rachman Dzakiyullah and [1]Ghaida Fatcha Mubiena,
[1]Citra Hajar Al Asqolani and [1]Jalu Adam Ismayanda
[1]Department of Industrial Engineering, Faculty of Industrial Technology,
Universitas Islam Indonesia, Yogyakarta, Indonesia
[2]Department of Information Technology, Universitas Aisyiyah Yogyakarta, Indonesia

Abstract: Batik industry participate donating environmental pollution by waste produced in the form of liquid, solid and gas. Among the three types of waste that needs to be addressed is waste in the form of CO_2 is rated 85% of global warming. This research is conducted to predict of the production of CO_2 emissions in PT Danar Hadi to be a green manufacturing company. In this research, the prediction of CO_2 emissions is calculated by plant simulation based on the energy comsumption used in supply chain activities during the production period in 2015. The result shows that PT. Danar Hadi produces a total CO_2 emissions around 4950 kg. CO_2/month while the value of threshold is 8000 kg.CO_2/month. That is mean PT. Danar Hadi has excess CO_2 emissions around 3050 kg.CO_2/month.

Key words: Green manufacturing, carbon emissions, plant simulation, PT, CO_2

INTRODUCTION

According to World Bank, Indonesia is ranked 14 in the world of countries with CO_2 emission released to the atmosphere around 433.989 million tones and the emission per capita is 1.8 metric tons in 2010. The production of carbon emission is caused by energy consumption of liquid, solid, gas and gas flaring fuels. The increasing carbon emission in earth's atmosphere has already given effect on climate change (Fong *et al*., 2009). IPPC (2007) stated that human is responsible for this condition, because human activities causes global warming. One of the company which is participated donating environmental pollution is batik industry. We have known that the batik industry produced carbon emissions either obtained from the use of electricity (electrical energy) and the production process such as waxing, tasting (staining) and pelorotan (heating) (Borshalina, 2015).

Their activities that are environmentally unfriendly production was one factor that contributed to environmental damage. Furthermore, the waste gas using a process that results from the burning of fuel energy as a night tasting and waxing. Implementation of green manufacturing on production system (sustainable production system) in the company must be conducted to minimize environmental impact and energy consumption that encompasses design, production, processing, packaging, transportation and use of products ih the manufacturing industry that continous or discrete (Sezen and Cankaya, 2013). Green Supply Chain Management (GSCM) can cut the cost of materials purchasing and energy consumption, can reduce the cost of waste treatment and disposal and avoid penalties in cases of environmental accidents. Many researches have been conducted related to CO_2 emission caused by the supply chain activities inside the industrial process. Qi *et al*. (2014) conducted a study on impact of energy and emissions CO_2 for the result of renewable energy development in China. The result showed that the electricity made a contribution that is relatively simple. The calculation of carbon emission on supply chain managemnet also conducted in Hyundai Motor (Sundarakani *et al*., 2010).

Ozawa-Maida *et al*. (2013) stated that the carbon emission can be done with calculating its energy consumption. Zhang *et al*. (2014) suggests that lead to the formation of CO_2 frost utilization for the removal of CO_2 from natural gas, frost prediction using a CO_2point that proves ethanolbath CO_2 frost formation at temperatures 192, 2-201,1K at a pressure of 329-446 kPa. This research could predict the carbon emissions footprint caused by the use of energy, such as waxing, electrical, pelorotan, etc. in batik industry to be a green manufacturing company.

Corresponding Author: Sukirman, Department of Industrial Engineering, Faculty of Industrial Technology, Universitas Islam Indonesia, Yogyakarta, Indonesia

Literature review: Green Supply Chain Management (GrSCM) Green Supply Chain Management (GrSCM) is the integration of thought environment into Supply Chain Management (SCM), including product design, material purchase and selection of suppliers, manufacturing processes, delivery of finished products to the consumer and also the management of the product after its useful life ends (Srivastava, 2007). Integration of green manufacturing has a positive effect on the growth of the company in terms of profits, sales, market share and most important in terms of size of the causes of the existing waste.

Energy on the machine: In general, the energy can be divided into primary and secondary energy. Primary energy is solar energy and secondary energy is the energy that is formed or derived from primary energy. Wind energy, electric energy, human energy, biomass energy, animal energy and fossil energy is classified into secondary energy (Hua *et al*., 2011). Systems such as machines and living creatures need energy there. Various forms of energy but all types of energy must fulfill various conditions that can be converted into other energy, to comply with the law of energy eternity.

The types of commercial energy most used are oil and gas, coal and hydropower. Then followed other forms of energy such as geothermal energy, nuclear energy, electricity and so on. Each of these forms of energy has a value of its own heat or energy value. In addition, each form of energy was also measured by volume or by weight.

Carbon emission policy: Carbon emissions trading system is also called the "cap and trade". It is intended if the amount of carbon emissions exceed the limit carbon cap, then a company must buy carbon credits or pay the social costs due to the excess emissions produced. Whereas if otherwise, then the company can sell carbon credits on corporate profits. As a rule can be seen in the following provisions:

- If $a<a_0$, then the company must buy carbon credits or pay the social costs
- If $a>a_0$, then the company does not pay the social costs and can sell carbon credits
- If $a = a_0$, then the company does not buy and sell carbon credits

Information:

- "a" is cap carbon policies per time, it is assumed (8,000 kg. Of CO_2/month)
- a_0 is cap carbon per unit time

As for the payment of social costs according to equation using the following equation: price = \$ 0.2/ton.CO_2 carbon.

MATERIALS AND METHODS

Developing conceptual model: This study describes a model built and the establishment of framework for measurement of carbon emission footprint that is produced by a company. The input of the model is the element-element in production process, clearly in Fig. 1.

Simulation modelling: Use of data in production process for processing plant simulation because the plant simulation can help to predict the carbon emission footprint. The method consist of the simplication of the production flow, plant simulation modelling and validation of model.

Simplication of the production flow: Simplication of the production flow must be conducted because the limitations of the software, as in Fig. 2.

Plant simulation modelling: Constructing the plant simulation modelling for identify carbon emission footprint in production process as in Fig. 3.

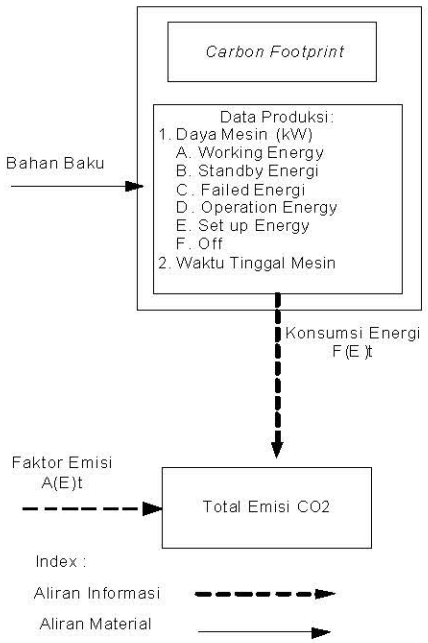

Fig. 1: Conceptual model

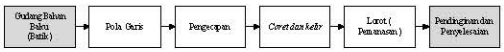

Fig. 2: Simplication of production flow

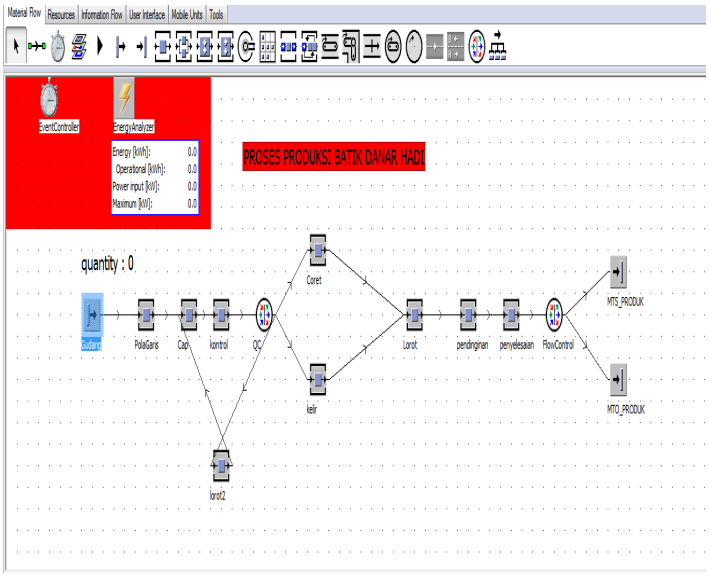

Fig. 3: Plant simulation modelling

Validation: Validation is used to test the model building confidence. Where confidence in plant simulation is when the result, for example the total product in the real system has the similar behavior with the model simulation. There are many methods to validate a model in plant simulation. In this research, validation model is conducted by Mean Average Percentage Error (MAPE). Verifying structure means directly comparing structure of a model with structure of the real system that has represented by the model. Structure verification may include review of model assumptions by highly knowledgeable person that well aware about corresponding parts of the real system.

RESULTS AND DISCUSSION

Based on the simulation results obtained for a one-day simulation of production as follows (Fig. 4): Batik production for product 1 (MTS) has around 21 outputs and 14 products 2 for MTO. For a production value of 100%, this is because all the machine work without stopping or continuous. Moreover, it can be seen the amount of energy produced during a production day as the following Table 1. Based on a simulation model that has been made, it has been known that the energy consumption is used on each machine. Moreover, it can also unknown energy consumption every day. Thus, based on the results of the energy can be known total CO_2 emissions produced at each station. Based on the total daily energy consumption can be calculated CO_2 emission values as follows:

$$E^{E}_{CO_2} = \sum_{t=1}^{t=T} A_{(E)t} \times E_{(E)t}$$

Simulation time: 1:00:00:00.0000

Cumulated Statistics of the Parts which the Drain Deleted

Object	Name	Mean Life Time	Throughput	TPH	Production	Transport	Storage	Value added	Portion
MTS_Produk	kainrol	2:09:52.0291	21	1	100.00%	0.00%	0.00%	70.22%	
MTO_Produk	kainrol	2:12:53.2921	14	1	100.00%	0.00%	0.00%	69.07%	

Fig. 4: The result of simulation

$$227.3\text{kWh} \times 0.725\text{kg / kWh}$$

$$164.8\text{kg.Co}_2$$

The calculation is based on CO_2 emission value obtained by kg.CO_2 every day. So we get the results of the energy expended by each station in a single day of production is as follows:

Based on Table 2 it can be seen energy usage and the amount of carbon emissions produced each stations. From the above table resulted in a total overall energy consumption in one day as much kWh. In addition, it is able to provide information about the station that produces the greatest carbon emissions. From the table it is known that it is the station that produces the greatest carbon emissions are tasting 75.30 kg.CO_2 and indirect energy value of 227.3 kwh. To compare value exist of CO_2 emission, first perform the calculation of CO_2 emissions during the first period of the rollers (May to October) and CO_2 emission values obtained as follows: In Table 3 CO_2 emission values obtained during the first month of production by 4950 kg.CO_2. The value is the value obtained by multiplying the value of CO_2 emissions

during the first day with the number of days during the period of production in one month. Based on the table 4:14 can be seen the value generated by the plant during the period of 4950 kg CO_2 so that. The data obtains the value, so it can be concluded that emissions issued by the company do not exceed the limit of carbon emissions and the company can sell the excess CO_2 to other companies for 3050.

In the above calculation of the social cost of carbon emissions released by Batik Danar Hadi not exceed predetermined threshold so that the sodium absorption ratio is obligated to pay the social cost to the government of the excess emissions produced. In studies Hua *et al.* (2011) the price of carbon emissions for each excess of $ 0.2/ton CO_2. Based on this, it can be seen costs to be incurred by the company for: = $ 0

So that, the calculation of social costs by PT. Dana Hadi does not have to pay social costs but sell excess emissions there. And also the social costs incurred only help the local people. .

CONCLUSION

Based on result of the prediction of carbon emission footprint, PT. Danar Hadi has total carbon emission around 4950 kg.CO_2/month. While the threshold value 8000 kg.CO_2/month so PT. Danar Hadi can sell excess carbon emissions to other companies. Excess carbon emissions around 3050 kg.CO_2/month. That is means PT. Danar Hadi is one of the green manufacturing company in Indonesia.

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