

# Flexibility Improvement on Energy Consumption of Punching Machine Based on Green Manufacturing Method at PT Buana Intan Gemilang

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**Abstract.** These days, Green Manufacturing has established become a new technology for professional engineers and manufacturing workers to be an important part in the business world. Green Manufacturing was created to reflect the new manufacturing paradigm techniques to make something become more eco-efficient by reducing the energy consumption. PT Buana Intran Gemilang is one of Textile Company that produce curtain and prayer rug. In the production this company use a Jacquard punching machine designed to cut a hole in material such as card stock. The machine works manually with the flexibility less than 90 percent that led to the longest production time in meeting the demand, thus causing the electrical energy released for this machine is also very high. On the basis of these problems required a system to improve the flexibility of the machine in order to reduce energy consumption and make the company become greener environmentally friendly. From this research generated an automation system based on green manufacturing method which will be applied on a jacquard punching machine that can increase flexibility machine to be more than 90 percent. This system has saving the electricity consumption of 2092 KWh every making a complete fabric pattern.

## 1 Introduction

The continued development of the industrial revolution causes of result of the greater energy being used, but instead the availability of energy in the world is actually depleting. Statistics value of energy use in Indonesia 2014 shows that industry sector become the biggest user of electricity energy, followed by household in the second place, business in the third place and another general sector in the last place. Besides that, the use of electrical energy in the industrial sector continued to increase from year to year. PT. Buana Intan Gemilang is one of the textile company in Banjarnegara, Bandung that produce curtain and prayer rug as its product. PT. Buana Intan Gemilang have several production department, and one of the main part of this company is weaving and preparation department. Punching machine is one of machine that used in preparation department, the function of the machine is to make the jacquard card of the curtain and prayer rug to use in the weaving machine.

Reducing the energy consumption of electricity will impact to all other manufacturing competitive edges, such flexibility. The concept flexibility in manufacturing has become a

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key consideration in the design, operation and management of manufacturing system [1]. By increasing the flexibility the same as make a better manufacturing system. Automation technique is use as one way to control and improve the flexibility of jacquard punching machine. Automation is the technology which can perform a series of process or procedure automatically without human assistance. It implemented with execute a list program of instruction which combine by a control system in perform the instruction [2].

The purpose of this research is improving flexibility of jacquard punching machine using automation system to be able to reduce energy consumption and turn the company to be a green manufacturing company.

## **2 Jacquard Punching Machine**

Jacquard Punching Machine is machine that designed to cut a hole in some material such as paper, metal, or card stock. There are three basic elements of punching device, a punch, a die, and a stripper. The punch is the piece which is driven through the card and cuts the hole. The die serves as a base, supports the card while it is being cut. The stripper serves as a guide for the punch and as a means of stripping the card from the punch after the latter has cut the card.

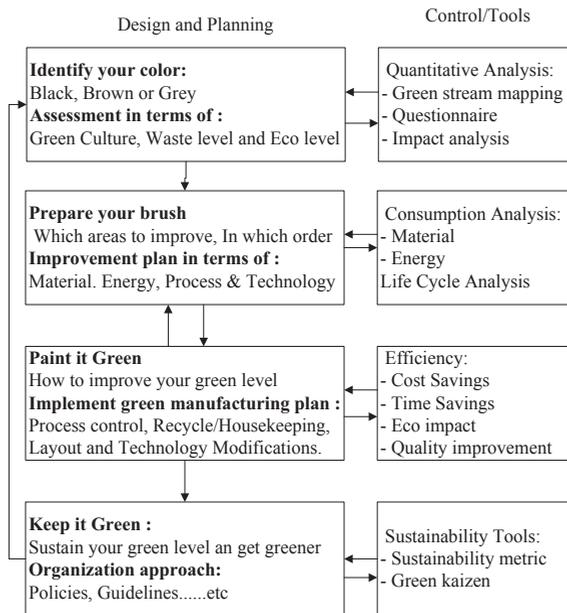
In PT. Buana Intan Gemilang the purpose of jacquard punching machine is to make the pattern card (jacquard card) that will be represent the pattern of the fabric (curtain or prayer mat). The things that should be noted in this process is the hole making process and the precision location of the hole itself. The good quality of jacquard card is a card that does not have any defect. As increasing demand of textile sector and also supports from the government to develop local textile industries, the company must be able to compete with other local competitor by producing high number of product with high quality, and on the right time. The company usually makes the jacquard card with this punching machine in manual way, so its takes an expensive cost for the energy because the machine running in longer time and also low flexibility because the ability to change jacquard is very slow.

## **3 Research Methodology**

Green manufacturing is a complicated system engineering problem that needs to be surveyed from the view of system engineering, its kind of sustainable development in the field of modern manufacturing. Making the same product using fewer resources and/or energy is a good strategy to make money. In other words, being efficient through preventing waste is both eco as well as money efficiency.

In designing the concept of green manufacturing, implement a system model as a tool to simplify its application [3]. This model system will be applied in case study at PT. Buana Intan Gemilang to be able to assist in applying the concept of green manufacturing so as to improve the flexibility of the punching machine.

Some of benefits of green manufacturing are (1) Controls and reduces material waste in manufacturing cycles. (2) Preserves capital and saves money. (3) Improve productivity and increases cost savings. (4) Helps drive and influence corporate behavior both internal and external to ensure sustainability. (5) Easy adaptability to changing rules in environmental regulations and legislation [3]. Figure 1 shows a step by step flow diagram of the process.

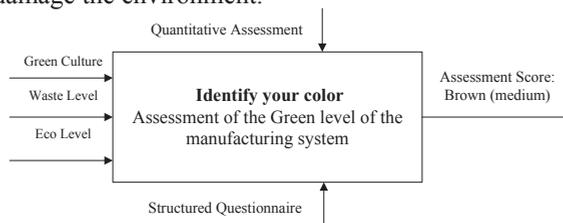


**Fig. 1.** System model for green manufacturing [4]

• Stage 1: Color Identification

The process of color identification in PT. Buana Intan Gemilang was done by questionnaire method that distributed to some operator of jacquard punching machine. This process is done to find out the current state of the company, so it can easily determine what actions can be taking. Questionnaires distributed to 5 operators of punching machine that really know the condition of machine and company.

Base on the result of questionnaire it can be concluded that PT. Buana Intan Gemilang in the brown (medium) position, with the energy of the system have bigger percentage better than the material which means it needs an improvement in part of energy usage. The company has not enough energy-saving in the use of electricity but in terms of waste not too polluting because of all good material of raw materials as well as the rest of the result of production does not damage the environment.

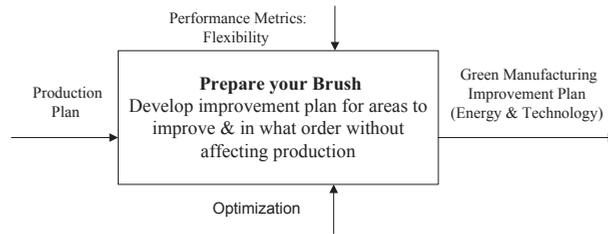


**Fig. 2.** Model for identification color [4]

• Stage 2: Improvement Object

In this part the process of planning on the improvement is about what will the company done on the way to make the company greener without affecting the results and production planning. The development process of this improvement will be focused on the energy consumption section of the punching machine up to the implementation of a new technology on the machine that can support the energy saving process itself. Jacquard

punching machine is a machine that is designed to cut a hole in some materials such as paper, metal or card. Aspects to be studied further from the results of this improvement application are the flexibility aspect of the punching machine.



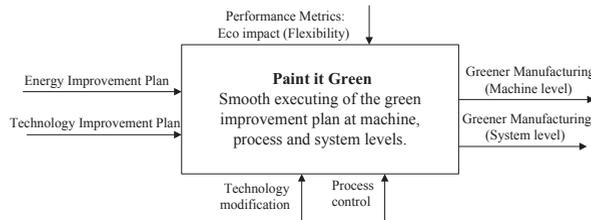
**Fig. 3.** Model for green improvement [4]

• Stage 3: Green Implementation

The next process is implementation of all the strategies that have been designed on the punching machine. Automation technology that applied to punching machines will be measured based on changes in production time and energy consumption of punching machines. If the automated punching machine has faster production time and less energy consumption with the amount of production that can meet the targets set by PT.Buana Intan Gemilang, the company has succeeded in increasing the color category from brown to green category.



**Fig. 4.** Frame work automation system [4]



**Fig. 5.** Model for green implementation [4]

• Stage 4: Keep it Green

The last step is keep it green where green manufacturing realization should have sustainability as in an inherent component in any green planning activity. The expected output at this stage is some green manufacturing policies and guidelines on the operation of the machine. Some trainings conducted to educate operators on how to maintain the achieve improvements and also creation of standard work to sustain improve paint performance.



**Fig. 6.** Model for keep it green [4]

### 3 Results

The Energy consumption on AC Motor punching machine:

Table 1. Specification of AC Motor [14]

Name of Motor Pump ZD1200627	P(kW)	V(v)	I(A)		
	55	380	134,2		
	Phase	V(i-i)	if(A)	Cos θ	μ
	R	387	112	0,86	0,95
	S	385	118		
T	385	113			

The load is calculated use by power analysis tool and power value at 100% loading. For three phase motor, the step is to determine the input power with the following equation:

$$P_i = \frac{V \times I \times \text{Cos } \phi \times \sqrt{3}}{1000} \text{ kwh}$$

$$P_i = \frac{385,67 \times 114 \times \text{Cos } 0,86 \times \sqrt{3}}{1000} \text{ kwh} = 49,7993$$

Determine the value of incoming power at full load.

$$P_r = \frac{P}{\eta_r} \text{ kwh}$$

$$P_r = \frac{75}{0,95} \text{ kwh} = 78,9474 \text{ kwh}$$

Then calculate the load in %

$$\text{Load} = \frac{P_i}{P_r} \times 100\%$$

Load = Output power expressed in% nominal power value

$$\text{Load} = \frac{49,7993}{78,9474} \times 100\% = 63\%$$

To get the cost incurred by the use of a punching machine can be calculated by the equation below, based on energy data used and the cost of electrical energy / kWh.

Cost Saving = kWh/year × Rp/kWh

$$\text{Load} = \frac{49,7993}{78,9474} \times 100\% = 63\%$$

$$= 49,7993 \text{ kwh}$$

$$P_r = \frac{75}{0,95} \text{ kwh} = 78,9474$$

$$\text{Load} = \frac{49,7993}{78,9474} \times 100\%$$

$$\text{Load} = 63\%$$

$$\text{Motor Load} = 75 \text{ kW} \times 63\%$$

$$= 47,3093$$

$$W = P \times t$$

$$= 49,7993 \times 8 \text{ hour}$$

$$= 398,3942967 \text{ kWh}$$

Energy consumption for 1 day

Automation systems have been successfully applied to punching machines and have increased the flexibility of the punching machines to match the expected expectations. With automation systems, the production time and setup time of the punching machine can be reduced and the flexibility increases. Reduction of production time and setup time would increase the flexibility so that will reduce the consumption energy of the company.

From the observation it is known:

- Working time per day = 7 hours x 60 = 420 seconds
- Cost for energy electricity = Rp 1467,8 Rp/kWh
- Energy (W) = 348,6 kWh
- Cost Energy per day = Rp 511.668

This formula is used to calculate the flexibility of the machine [6]:

$$\text{Flexibility of punching machine} = \left(1 - \frac{\text{switching time}}{\text{total work hour}}\right) \times 100\%$$

Switching time = setup time/day (minutes)

Total work hour = work hour/day (minutes)

a. Existing system

- Production time per product = 5.386 minutes
- Production per day = working time / production time

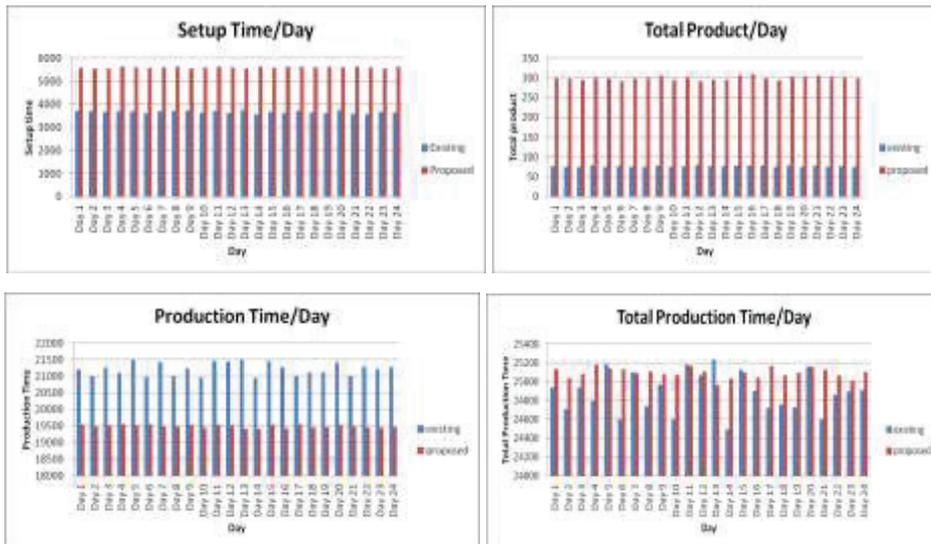
$$\text{Production per day} = 420 / 5.386 = 77 \text{ unit}$$

$$\text{Flexibility of punching machine} = \left(1 - \frac{62}{420}\right) \times 100\% = 85.2\%$$

b. Proposed System

- Production time per product = 1.4 minutes
- Production per day = working time / production time

$$\text{Production per day} = 420 / 1.4 = 300 \text{ unit}$$



**Fig. 7.** Comparison of existing and proposed condition

Figure 7 shows the comparison of existing and proposed condition. The comparison is done to see the whether the proposed condition is better or not. Table 4 shows the comparison summary of the production condition.

Table 2. Comparison production condition

	<b>Proposed System (Automation)</b>	<b>Existing System (Manual)</b>
Working time/day	420	420
Production time (minutes/unit)	1.08	4.6
Production per day (unit)	300	77
Production per month (unit)	7195	1845
Flexibility of machine	94.2 %	85.2 %

Base on that calculation it can be conclude that automation system can increase the flexibility of machine as well the green manufacturing. The impact has successfully implemented and automation system has running as expected for increasing the flexibility of the jacquard punching machine. This also results in companies to be toward greener manufacturing, where companies can save more energy. The comparison for energy use can see below.

Table 3. Comparison of the use of electric energy

	Proposed System (Automation)	Existing system (Manual)
Total production (unit)	600	600
Total day	2	8
Electricity/day (KWh)	348.6	348.6
Total Electricity (KWh)	697.2	2788.8
Cost / KWh	Rp. 1,467.80	Rp. 1,467.80
Cost	Rp. 1,023,350.16	Rp. 4,093,400.64

Base on the calculation costs incurred by companies to produce a number of jacquard cards with punching machines that have been applied green manufacturing methods require a cheaper cost than before the automation. It can be concluded that with applied green manufacturing method using automation system can save cost of production and also save the usage of energy that make the company to be green manufacturing company.

## 4 Conclusion

The automation system was adopt to the punching machine to make the production time faster so it can significantly increase the flexibility and decrease the energy usage of the punching machine. Based on the analysis result of the system that has been designed and implemented, was conclude as follow:

1. The flexibility of punching machines increased 9 percent from before it was automated because the setup time was reduced.
2. The processing time of jacquard card making is 240 seconds faster than before it was automated due to decrease in setup time.
3. The machine setup time is 38 minutes faster than before it was automated because of the automation technology that has been applied to the machine.
4. The energy that can be saved to create a whole pattern of curtain fabric (600 jacquard cards) is 2092 Kwh.

So the company's color level increased to green after the adoption of the automation system and the company can reduce the energy consumption significantly.

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