

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 thing for professional engineers and manufacturing workers to be an important part in the business world. Green manufacturing is a method for manufacturing that minimizes waste and pollution. These goals are often achieved through product and process design (Thomas, 2001). Green Manufacturing was created to reflect the new manufacturing paradigm techniques to make something become more eco-efficient by reducing the energy consumption.

Jacquard punching machine is a machine that designed to cut a hole in material such as card stock named jacquard card. This card controlled the weaving process in textile industry to enabling produce the patterns of fabric. This machine is still working manually with the flexibility less than 90 percent that led to the longest production time in meeting the request, 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 be able to reduce energy consumption and make the company become more green environmentally friendly.

From this research generated an automation system 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.

Keywords: Green Manufacturing, Automated System, Jacquard Punching Machine, Flexibility

1. Introduction

The continued development of the industrial revolution then 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. Beside that, the use of electrical energy in the industrial sector continue to increase from year to year. PT. Buana Intan Gemilang is one of the textile company in Banjaran, Bandung that produce curtain and prayer mat. 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 machine has function to make the jacquard card of the curtain and prayer mat on the cardboard 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 key consideration in the design, operation and management of manufacturing system (Sethi & Sethi, 1990). By increasing the flexibility the same as make a better manufacturing system. Automation technique is use as one way to controll 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 (Groover, 2001).

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

2. Literature Study

2.1 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.



Figure 1. Jacquard punching machine

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 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 make 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.

2.2 Green Manufacturing Method

In designing the concept of green manufacturing, Deif (2011) implemented a system model as a tool to simplify its application. 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. Figure IV.4 shows a step by step flow diagram of the process.

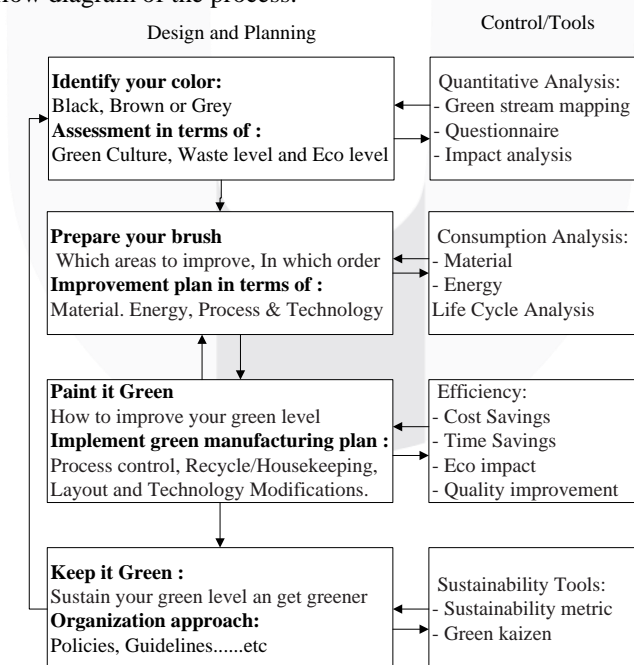


Figure 2. System model for green manufacturing

a. Stage 1: Color Identification

The process of color identification in PT. Buana Intan Gemilang was doing 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 take. 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.

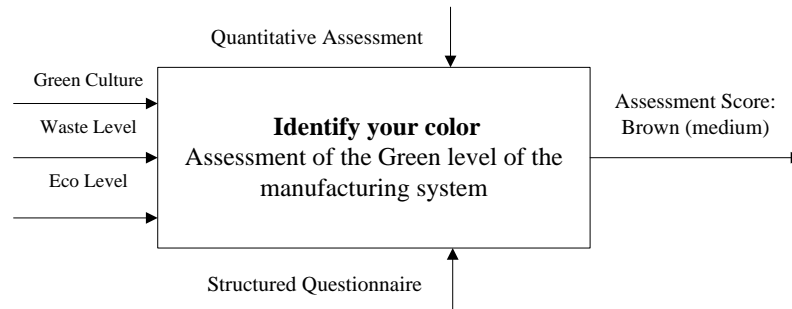


Figure 3. Model for identification color

b. 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 more green 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 it self. 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 improvent application is the flexibility aspect of the punching machine.

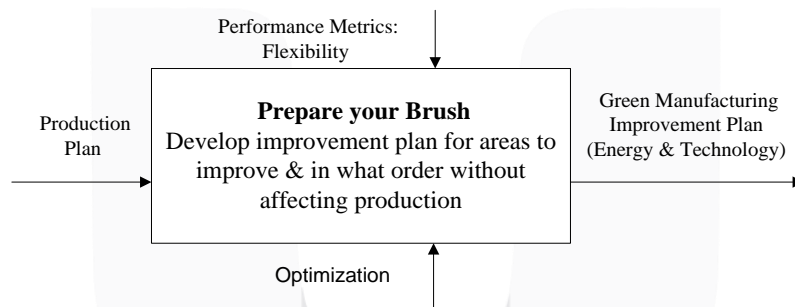


Figure 4. Model for green improvement

c. 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.



Figure 5. Frame work automation system

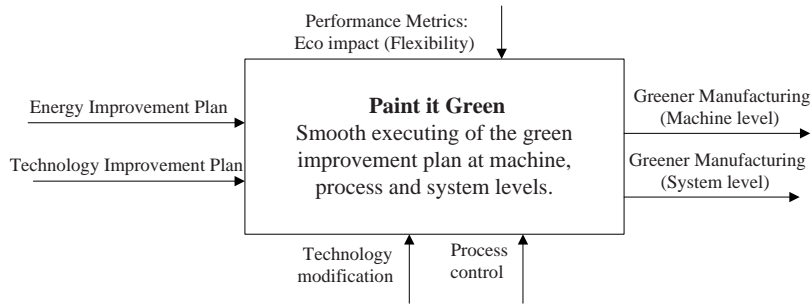


Figure 6. Model for green implementation

d. 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.

3. Result

Energy consumption on AC Motor punching machine

Table 2. Specification of AC Motor

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

By calculating the load as the ratio between input power (measured 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:

$$P_i = \frac{V \times I \times \cos \phi \times \sqrt{3}}{1000} \text{ kwh} \tag{1}$$

P_i = three phase power (kW)
 V = voltage (V)
 I = current (A)

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

Determine the value of incoming power at full load.

$$P_r = \frac{P}{\eta_r} \text{ kwh} \tag{2}$$

Whereas :

P_r = incoming power at full load (kW)
 P = power (kW)
 η_r = Efficiency at full load

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

Then calculate the load in %

$$\text{Load} = \frac{P_i}{P_r} \times 100\% \tag{3}$$

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/tahun × Rp/kWh

$$P_i = \frac{385,67 \times 114 \times \cos 0,86 \times \sqrt{3}}{1000} \text{ kWh}$$

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

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

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

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

$$\begin{aligned} \text{Motor Load} &= 75 \text{ kW} \times 63\% \\ &= 47,3093 \end{aligned}$$

$$\begin{aligned} W &= P \times t \\ &= 49,7993 \times 8 \text{ jam} \end{aligned} \tag{4}$$

$$= 398,3942967 \text{ kWh energy consumption for 1 day}$$

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.

Table 2. Production existing data

Hari	Production Time (sec)	Setup Time (sec)	Total Time Production	Total Product/day
Wednesday, February 1, 2017	21209	3728	24937	77
Thursday, February 2, 2017	21004	3706	24710	75
Friday, February 3, 2017	21275	3666	24941	75
Saturday, February 4, 2017	21098	3696	24794	79
Monday, February 6, 2017	21494	3694	25188	76
Tuesday, February 7, 2017	20978	3624	24602	77
Wednesday, February 8, 2017	21419	3685	25104	75
Thursday, February 9, 2017	21015	3724	24739	76
Friday, February 10, 2017	21242	3728	24970	78
Saturday, February 11, 2017	20961	3648	24609	75
Monday, February 13, 2017	21464	3716	25180	77
Tuesday, February 14, 2017	21447	3620	25067	80
Wednesday, February 15, 2017	21498	3737	25235	77
Thursday, February 16, 2017	20945	3555	24500	77
Friday, February 17, 2017	21455	3672	25127	78
Saturday, February 18, 2017	21280	3620	24900	79
Monday, February 20, 2017	20997	3726	24723	78
Tuesday, February 21, 2017	21119	3639	24758	75
Wednesday, February 22, 2017	21112	3613	24725	78
Thursday, February 23, 2017	21411	3750	25161	76

Friday, February 24, 2017	21020	3582	24602	79
Saturday, February 25, 2017	21286	3571	24857	75
Monday, February 27, 2017	21217	3678	24895	77
Tuesday, February 28, 2017	21273	3644	24917	76
TOTAL	509219	88022	597241	1845
AVERAGE	21217.45833	3667.583333	24885.04167	76.875
ROUNDUP	21218	3668	24886	77

Table 3. Production proposed data

Hari	Production Time (sec)	Setup Time (sec)	Total Time Production	Total Product/day
Wednesday, February 1, 2017	19542	5589	25131	300
Thursday, February 2, 2017	19490	5549	25039	298
Friday, February 3, 2017	19521	5561	25082	296
Saturday, February 4, 2017	19545	5635	25180	301
Monday, February 6, 2017	19528	5616	25144	298
Tuesday, February 7, 2017	19556	5577	25133	293
Wednesday, February 8, 2017	19477	5613	25090	299
Thursday, February 9, 2017	19475	5630	25105	301
Friday, February 10, 2017	19533	5552	25085	306
Saturday, February 11, 2017	19456	5616	25072	296
Monday, February 13, 2017	19531	5638	25169	300
Tuesday, February 14, 2017	19518	5592	25110	292
Wednesday, February 15, 2017	19417	5548	24965	295
Thursday, February 16, 2017	19412	5622	25034	296
Friday, February 17, 2017	19528	5566	25094	307
Saturday, February 18, 2017	19424	5622	25046	310
Monday, February 20, 2017	19545	5623	25168	299
Tuesday, February 21, 2017	19457	5608	25065	294
Wednesday, February 22, 2017	19463	5630	25093	303
Thursday, February 23, 2017	19541	5617	25158	303
Friday, February 24, 2017	19494	5630	25124	306
Saturday, February 25, 2017	19454	5611	25065	303
Monday, February 27, 2017	19455	5559	25014	301
Tuesday, February 28, 2017	19461	5640	25101	298
TOTAL	467823	134444	602267	7195
AVERAGE	19492.625	5601.833333	25094.45833	299.7916667
ROUNDUP	19493	5602	25095	300

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:

$$\text{Flexibility of punching machine} = \left(1 - \frac{\text{switching time}}{\text{total work hour}}\right) \times 100\% \quad (5)$$

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

Production per day = $420 / 5.386 = 77$ pcs

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

b. Proposed System

- Production time per product = 1.4 minutes

- Production per day = working time / production time

Production per day = $420 / 1.4 = 300$ pcs

$$\text{Flexibility of punching machine} = \left(1 - \frac{24}{420}\right) \times 100\% = 94.2\%$$

Table 4. Comparison production condition

	Proposed System (Automation)	Existing System (Manual)
Working time/day	420	420
Production time (minutes/pcs)	1.08	4.6
Production per day (pcs)	300	77
Production per month (pcs)	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.

Impact from Automation system design successfully implemented and automation system running as expected for increasing the flexibility of the jacquard punching machine. This also results in companies becoming more green manufacturing, where companies can save more energy. The comparison for use energy can see below.

Tabel 5. Comparison of the use of electric energy

	Proposed System (Automation)	Existing system (Manual)
Total production (pcs)	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. The total cost that can be saved by the company can be seen below:

Base on the calculation biaya yang dikeluarkan perusahaan untuk memproduksi jacquard kartu dengan jumlah yang sama lebih memerlukan biaya yang sedikit dari pada sebelum di otomasi. Total biaya yang dapat dihemat oleh perusahaan dapat dilihat di bawah:

Total savings cost = cost after automation - cost before automation

$$= \text{Rp } 4,093,400.64 - \text{Rp } 1,023,350.16$$

$$= \text{Rp } 3,070,050.48$$

It can be concluded that with applied green manufacturing method using automation system can Saving cost of production and also saving the usage of energy that make the company to be green manufacturing company.

6. 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.
2. The processing time of jacquard card making is 256 seconds faster than before it was automated.
3. The machine setup time is 38 minutes faster than before it was automated.
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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