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BATIK PRODUCTION PROCESS OPTIMIZATION USING PARTICLE SWARM OPTIMIZATION METHOD

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ABSTRACT

This paper presents batik production process optimization using particle swarm optimization (PSO) methods. The process steps of batik are designing, '*nyanting*', staining, '*pelorodan*', and washing. Batik production cost is determined by the efficiency and calculation of output to input ratio in the production process. In this research, PSO method is used for production process optimization on Yogyakarta batik industry. The main objective of this research optimization is to minimize the cost incurred in the production process of batik in order to obtain maximum benefit. PSO method has successfully optimized the production goals to be achieved by minimization the using of raw materials and production time. Optimization results show that in batik production process, there is a saving of raw materials 14.801% and production time saving of time 10.345%.

Keywords: *Batik; Production Process; Optimization; Particle Swarm Optimization.*

1. INTRODUCTION

In the future, the creative industries are into a leading industry in most of Yogyakarta. One of the creative industries that are still the flagship is the batik industry [1]. One of the potential of small and medium industries at the local level was developed in an effort to accelerate economic empowerment. It is commodities eminent in the field of creative industries. This industry is one of the leading industries in Yogyakarta province, where the creative industries have developed into becoming an industry cluster. Batik industry is expected to give a significant role in supporting the industrial sector's contribution to the local revenue of Yogyakarta province.

The comparison between the production cost and selling price can affect the competitiveness in the market. Production cost is determined by the efficiency and calculation of input to output ratio in the production process. Efficiency is a measure maximize results by using capital (labor, material and tools) are minimal. Efficiency can also be interpreted as an effort to use the smallest input to obtain maximum production [2-3]. Thus, the management can combine the factors of production with certain management techniques so as to produce a product effectively and efficiently in the quantity, quality, and time of production.

Business potential batik industry in this province can be demonstrated by the availability of labor is quite large, the amount of demand for batik products are relatively stable, and the number of batik production are also relatively stable, although recent years slightly decreased due to the batik products imported from China. In addition, the batik production process optimization opportunities a distinct advantage for the progress and development of the batik industry, especially in Yogyakarta province. Fig 1 shows the example of Yogyakarta batik.

Soesanti had classified batik pattern based on statistical featrus [4]. The texture of batik image is a characteristic that can be used for classification the types of pattern. The research aims to analyze the performance of classification method in order to recognition the batik pattern.

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(a)

(b)

Fig 1. Example Of Yogyakarta Batik

Each company generally wants to get maximum benefit by optimizing the limited resources available. It can be solved using optimization methods based on particle swarm optimization (PSO). PSO is an artificial intelligence-based optimization method that has been widely used in various fields [5] – [7]. The ability of PSO optimization methods have been tested for computing the low and optimal results [8] – [9].

Tang had presented an improved particle swarm optimization (PSO) method for the hybrid flowshop scheduling (HFS). PSO method is used to minimize total weighted completion time. This problem has a strong practical background in process of industry production [10].

In this study, PSO method is used to optimize the production process of batik on one of Yogyakarta batik industry. The main objective of this research optimization is to minimize the costs incurred in the production process of batik in order to obtain maximum benefit. PSO method can optimize production goals to be achieved by the limits of existing resources. This is confirmed by other scientists who claimed that when companies produce products that vary, the planning method for producing the goods in order to obtain the maximum benefit can be obtained by PSO method. Thus, the PSO method is a method used by the company in producing more than one variation with limited resources.

2. BATIK PRODUCTION PROCESS

Indonesia has been recognized internationally as a pioneer and leading producer of batik. In 2009, UNESCO has named Indonesian batik a masterpiece of the 'Oral and Intangible Heritage of Humanity'. The crowning of course very proud for Indonesia. This fact reflects UNESCO's efforts to move beyond the protection of ancient monuments and encourage living artistic traditions.

The batik tradition is particularly prevalent on the Java island and was handed down from generation to generation. Batik is created either by drawing dots and lines of the resist with a spouted tool called a *canthing*. The process of making batik is described as follows.

1. Process of designing

   The first process is a process of drawing or sketching that wanted in the fabric / silk using a pencil or pen.

2. Process of First *Nyanting*

   After completing the process of designing, the second step is *nyanting,* namely painting fabric with wax using the canting by following a pattern that has been made on both sides of the fabric (back and forth).

3. Process of Staining

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The process is the first coloring process on the part that is not covered by wax by dipping the cloth in a particular color. Once dipped, the fabric in the drying and dried.

4. Process of the Second *Nyanting*

   Once dry, re-do the batik process that is painted using wax using canting using canting to cover parts that will be maintained in the first coloring. Then the process is followed by a second color dyeing process.

5. Process of the First *Pelorodan*

   The next process is to remove the wax of the fabric by putting or boiling the cloth in hot water on the stove.

6. Process of the Third *Nyanting*

   After a clean cloth of candles and dried, can be carried back to the closing of wax batik process (using canting) to hold the first and second color.

7. Process of Opening and Closing of Patterns

   The process of opening and closing the wax can be repeated according to the number of colors and the complexity of the desired motif.

8. Process of the Second *Pelorodan*

   The process is that the fabric has changed the color of boiled hot water. The aim is to remove the layer of wax, so the motives which have previously drawn clearly visible, previously seen clearly, this immersion will not make motifs that have been drawn exposed to color, because the top of the fabric is still shrouded in a thin layer (wax not completely faded).

9. Process of Washing

   The next process is to wash the batik cloth and then dry it by way of drying or cooling it down in the shade.

3. PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization (PSO) algorithm was first published by Eberhart and Kennedy. The algorithm was inspired by a flock of birds movement in searching of food. The movement model can be used as a powerful optimizer. In one n-dimensional search space, let us assume that the position of the i-th individual is Xi = (xi1, ..., xid, ..., xin) and the speed of the i-th individual is Vi = (vi1, ..., vid, ..., vin). The particle best experience i-th is recorded and represented by Pbesti = (pbesti1, ..., pbestid, ..., pbestin). The best global position for swarm search is Gbesti = (gbest1, ..., gbestd, ..., gbestn). Fig. 2 shows the concept of optimization using PSO. The modified velocity of each particle is calculated based on the personal initial velocity, the distance from the personal best position, and the distance from the global best position, as shown in the following equation:

$$V_i^{(t+1)} = \omega \cdot V_i^{(t)} + c_1 \cdot rand_1(\circ) \cdot (Pbest_i - X_i^{(t)}) + c_2 \cdot rand_2(\circ) \cdot (Gbest_i - X_i^{(t)}) \quad (1)$$

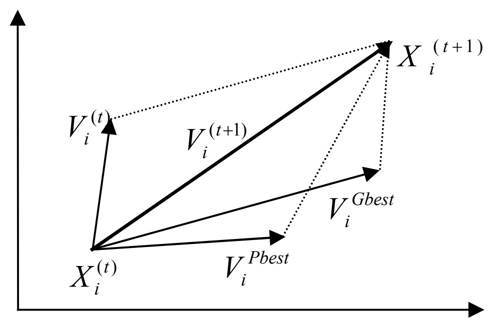

Fig. 2. The Concept Of Optimization Using PSO

Equation (1) determines the velocity vector of the i-th particle. Therefore, the latest position of the particle can be determined by using the equation:

$$X_i^{(t+1)} = X_i^{(t)} + V_i^{(t+1)} \quad (2)$$

where i = 1, 2, ..., N is the index of each particle; t is the number of iterations; $rand_1$(o) and $rand_2$(o) are a random number between 0 and 1; and N is the number of the swarm.

Inertia weights ω can be determined by the equation:

$$\omega^{(t+1)} = \omega^{\max} - \frac{\omega^{\max} - \omega^{\min}}{t_{\max}} \times t \quad (3)$$

where ω_{max} is the maximum inertia weight; ω_{min} is the minimum inertia weight; t_{max} is the maximum number of iterations; and t is the actual number of iterations. The value of inertia weight decrease linearly from 0.9 to 0.5.

The improved PSO algorithm is described as follows:

1. Input the data of the raw materials and processing time in the production process of batik and initialize the parameters of PSO.
2. Run the program of raw materials and processing time in the production process of

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batik to measure the fitness (length) of each particle (pbest) and store it with the best value of fitness (gbest).
3. Update velocity of particle using (1).
4. Update position of particle using (2).
5. Decrease the inertia weight (ω) linearly from 0.9 to 0.4.
6. Perform violation of particle position:
   If particle position pos(j)>mp, then pos(j)=mp
   Else if particle position pos(j)<mp, then pos(j)=1.
7. Perform violation of particle velocity:
   If particle velocity vel(j)>mv, then vel(j)=mv
   Else if particle velocity vel(j)<-mv, then pos(j)= -mv.
8. Decrease the inertia weight (ω) linearly from 0.9 to 0.4.
   Repeat steps 2-8 until a criterion is obtained.

4. BATIK PRODUCTION PROCESS OPTIMIZATION

The main objective of optimization in this research is to minimize production costs include raw materials and processing time in the production process of batik in order to obtain maximum benefit. The objective function in the optimization is shown in the following equations:

a. Minimization of raw materials

$$f_1(X) = \sum_{i=1}^{k} R_i \qquad (4)$$

b. Minimization of processing time

$$f_2(X) = \sum_{i=1}^{k} T_i \qquad (5)$$

The multi-objective formulation of batik production process could be defined as follow:

$$\max J(X) = \| f(X) - f_0 \|_2 = \sqrt{(f_1(X) - f_{o1})^2 + (f_2(X) - f_{o2})^2} \qquad (6)$$

Subject to:

$$F(x) = 0 \qquad (7)$$

$$T_{i,\min} \le T_i \le T_{i,\max} \qquad (8)$$

$$P_{i,\min} \le P_i \le P_{i,\max} \qquad (9)$$

where f_1(X) is a cost function of raw materials; f_2(X) is a cost function of processing time; R_i is a raw variable of batik and T_i is a processing time variable of batik processing.

Furthermore, based on cost functions as expressed in the equation (4) to the equation (7) conducted a multi-objective optimization to optimize the production process of batik in one of Yogyakarta batik industry.

5. RESULTS AND DISCUSSION

In this section, the results of multi-objective optimizations of batik production process includes raw materials and processing time in the production process of batik are described. Demand for raw materials and process time used in the production process of batik to produce 100 pieces of batik cloth shown in Table I.

Table II shows the raw material and process time in batik process production before optimization. Raw material costs are stated in Rupiah, which indicates the amount of the cost needed for the procurement of raw materials to produce 100 batik cloths. The processing time is expressed in hours, which shows the amount of time required for the production process 100 batik cloths.

Table I: Raw Material In Batik Process Production

Stages of Process	Raw Material
Molani	white cloth
First *Pencantingan*	wax
Nembok	wax
Staining	dye
Second *Pencantingan*	wax
First *Pelorodan*	hot water
Third *Pencantingan*	wax
Opening and Closing of Patterns	wax
Second *Pelorodan*	hot water
Washing	water

In this production process using 4 pieces stove for *mencanting*. As for the process *pelorodan* used 2 pieces of gas stoves. The production process is carried out for 7 hours a day, 6 days a week. The production process is done by 10 employees. The production costs are calculated without taking into account salaries.

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As shown in Table II that prior to the optimization of the production process of batik, the costs of raw materials needed is US$ 787.88 with as many as 116 hours of production time.

Table II: Raw Material Cost And Process Time In Batik Process Production Before Optimization

Stages of Process	Raw Material Cost (US$)	Process Time (hours)
Molani	393.94	14
First *Pencantingan*	45.45	24
Staining	242.42	10
Second *Pencantingan*	45.45	22
First *Pelorodan*	7.58	8
Third *Pencantingan*	30.30	14
Opening and Closing of Patterns	7.58	8
Second *Pelorodan*	7.58	8
Washing	7.58	8
Total	**787.88**	**116**

Table III: Raw Material Cost And Process Time In Batik Process Production After Optimization

Stages of Process	Raw Material Cost (US$)	Process Time (hours)
Molani	348.48	12
First *Nyanting*	37.88	22
Staining	212.12	9
Second *Pencantingan*	22.73	21
First *Pelorodan*	6.82	7
Third Ny*anting*	22.73	12
Opening and Closing of Patterns	6.82	7
Second *Pelorodan*	6.82	7
Washing	6.82	7
Total	**671.21**	**104**
Saving (%)	**14.801**	**10.345**

Results of batik production process optimization using PSO method is shown in Table III. As shown in Table III that after the optimization of the production process of batik, the costs of raw materials needed is US$ 671.21 with as many as 104 hours of production time. Optimization results show that there is a saving of raw materials amounted to 14.801%. Results also showed an optimization of production time savings of 116 hours to 105 hours, or 10.345%. These savings would have an impact on improving operational efficiency in the batik industry. This optimization is expected to help strengthen the competitiveness of Yogyakarta batik industry.

Furthermore, in order to further analyze the results of the production process optimization using PSO method, the optimization results are shown in graph format as shown in Fig. 3 to Fig. 6. Fig. 3 shows raw material cost of batik process production before and after optimization while Fig. 4 shows process of batik process production before and after optimization. In Figure 3 has shown graphically that at each stage of the production process of batik, operating costs decreased significantly with the implementation of PSO optimization method. A decrease in operating costs is very important for the batik industry in Indonesia. It is due to that most of the batik industry in Indonesia is the micro and small-scale industries. Production cost savings is certainly very significant for the survival of the industry.

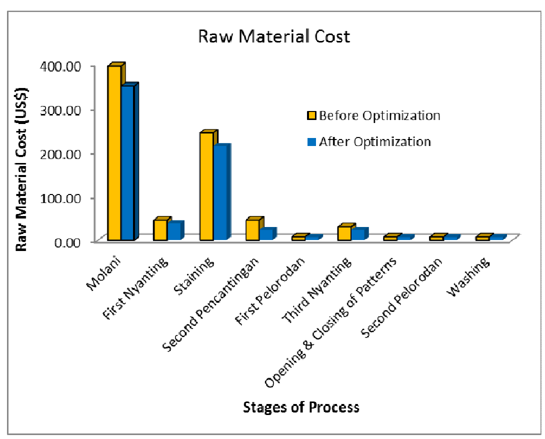

Fig. 3. Raw Material Cost Of Batik Process Production Before And After Optimization

In Figure 4 has shown graphically that at each stage of the production process of batik, the process time production also decreased significantly with the implementation of PSO optimization method. A decrease in the production process time is very important for the efficiency and performance of the

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batik industry in Indonesia. A decrease in the production process time was of course quite an impact on increasing the productivity of the batik industry.

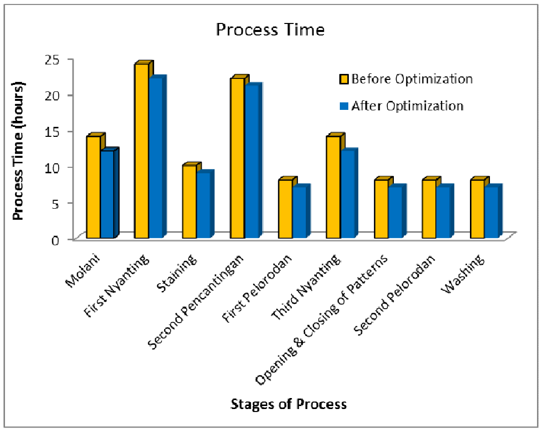

Fig. 4. Process Of Batik Process Production Before And After Optimization

Fig. 5 shows total of raw material cost in batik process production before and after optimization while Fig. 6 shows total of process time in batik process production before and after optimization. As shown in Figure 5, the total cost after optimization decreased very significantly with the implementation of PSO optimization method. Decrease significantly were also seen on the total production time, as shown in Figure 6, the total time of 116 hours to 104 hours. A decrease in the cost and time of production is of course improving the performance and productivity of the batik industry.

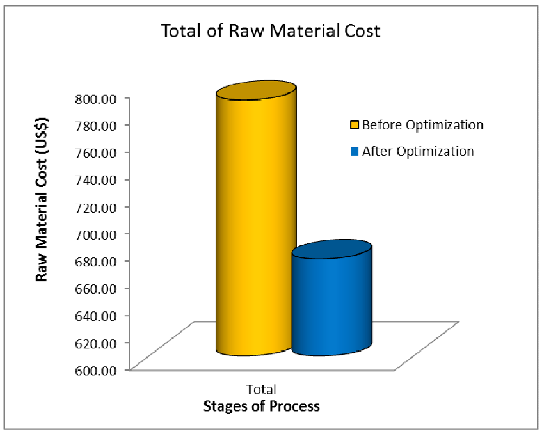

Fig. 5. Total Of Raw Material Cost In Batik Process Production Before And After Optimization

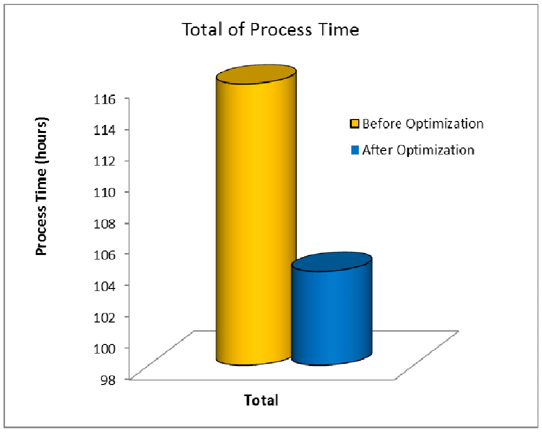

Fig. 6. Total Of Process Time In Batik Process Production Before And After Optimization

6. CONCLUSION

This paper presents batik production process optimization using particle swarm optimization (PSO) method. Optimization results show that in batik production process, there is a saving of raw materials 4.801%. Results also showed an optimization of production time saving of 116 hours to 104 hours, or 10.345%**.** These savings would have an impact on improving operational efficiency in the batik industry. This optimization is expected to help strengthen the competitiveness of Yogyakarta batik industry.

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