Comparison of first come first served and ant colony algorithm method for door leaf production scheduling

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Abstract. Private company produces doors according to the customer orders (make to order) with various types of products. The company several times experiencing delay of delivery to consumers so that the main cause of the occur in the company caused by the length of the lead time. The length of the lead time occur due to the increased varied quantity of consumer demand when the product processing step use the same machine. The company implements First Come First Served (FCFS) scheduling system but does not able to produce an appropriate scheduling. The value of the makespan with the FCFS method is 2579.40 hours with the sequence of door leaf job products 1-2-3-4-5-6 namely colonial 6P, Carolina 5P, Napoleon, GD-1L, SP-2P, and GD-D456. The company reschedules to minimize the makespan using the ant colony algorithm and compares the results of the scheduling with the FCFS method. The order of product process using the ant colony algorithm are jobs 1-6-4-3-5-2 followed by colonial 6P, GD-D456, GD-1L, Napoleon, SP-2P and Carolina 5P with lower makespan values of 2500 hours. The results of the actual method using FCFS and the proposed method using the ant colony algorithm comparison shows an efficiency value of 3,057%.

1. Introduction
During the era of technological progress, each company compete each other to always create an effective and efficient production process. Competition in industrial at this time affects to industrial growth which has influence on companies to increase overall efficiency in production activities. The complications and challenges for production processes are how to optimally manage the accessible machines and human resources [1]. One effort to compete with the other companies is by scheduling production. Production scheduling is very vital in the production process of a product in the company, when production is a process or a way to add the products quantity using certain methods by considering the optimal level of production by minimizing the total time spent and cost saving spent for one time production process.

Great scheduling reduces idle time in production units and decrease goods during the process [2]. Scheduling alludes to the organization of standards, strategies, and mechanisms that oversee the solicitation where assets are determined for different procedures and the undertaking must be terminated [3]. Scheduling of tasks and resources has always been the prime concern in the performance of any scheduling strategy. Scheduling refers to the methodology followed for assigning tasks to machines [4]. Scheduling is used to reduce production time. Reducing production time is an important factor for companies which their main objectives are to maximize profits and minimize costs by reducing the makespan. To achieve these objectives must follow the scientific methods for scheduling production time [5].

Several scheduling methods are widely used to minimize makespan. One of these methods are called First Come First Served (FCFS). First Come, First Served (FCFS), is a type of simple scheduling algorithm, FIFO is a method where the processes are laid out in a first in and first out order. Because context switches appear only upon process termination, and no need for grouping of the process queue is required, scheduling overhead is minimal The FCFS scheduling is fair in a human
perspective but not for jobs that are long to make short jobs wait and less important jobs make important jobs idle. FCFS is easier to spot than the other schemes since it offers time.

The FCFS design is unusual in scheduling interactive users because it does not guarantee a great response time. FCFS scheduling is simple, you only need to write and understand [6]. First come first serve is easier to do and the application is also easy. It’s suitability are usually towards batch systems however it is not effective enough for time sharing systems. Scheduling is fair for smaller burst times but it's unfair to process larger burst time [7]. FCFS or FIFO can be defined as a process that arrives first will be served first. If there is a process to arrive at the same time, the services they carried through their order in the queue [8]. The process in the queue behind had to wait until all the process in front of him is complete. Any process that is on ready status put in FCFS queue according to the time of arrival. Figure 1 shows how the FCFS works.

The process which has been done does enter the queue anymore. However, here the process which burst time is short must wait for the other process to be finished [9]. FCFS scheduling method is a simple method by means of assigning jobs which come first according to the time of issuance of the order and done in advance by selecting the machine with the smallest ready time. This method is widely used because of its practicality but this method is usually far from optimal because of the lack of consideration of the factors that affect the size of the desired performance. Due to the practicality, the result of the FCFS method can be used as a reference as the zero point on optimality closeness assessment [10].

Another method is also often used for scheduling production is the Ant Colony method. The ant colony algorithm, successfully applied to the traveling salesman problem (TSP) by Dorigo et al, is distinguished by positive feedback and self-organizing, making it more capable to apply in complex scheduling problems with uncertainties. However, so far no researcher has applied the Ant colony algorithm to attempt to solve the surgery scheduling problem [11]. The algorithm ant colony optimization or ant algorithms are algorithms that originally inspired by the behavior of ants, many developed that the ant species is very sensitive to noise, most species of ants communicate between individuals and individuals, or between individuals and their environment, ant species can produce a liquid chemical called pheromone, where the fluid can leave a trail of ants pheromone trail that can be followed by other ants such as during the process of foraging ants. Ant colony optimization algorithm using transition rules and pheromone update rules as a guide to select the next trail [12].

Many previous studies have been carried out in the production scheduling problem. G Kakhani, et al (2015) conducted a research on Analysis of Priority Scheduling Algorithm on the basis of FCFS & SJF for Similar Priority Jobs of CPU predict to choose which of the process in the ready queue will be assigned to the CPU. There are different types of scheduling algorithms available for taking decision. One of them is Priority Scheduling Algorithm, which is based on the priority assigned to each process. In priority scheduling the processes are executed on the basis of priority, the process having highest priority is executed first. In case of similar priority FCFS is used. The priority scheduling algorithm is used in such a way that, in case of similar priority SJF algorithm is used instead of FCFS and average waiting time and average turnaround time is calculated. The comparative analysis is performed on the SJF based priority scheduling and FCFS based priority scheduling to compare the average waiting time and average turnaround time [13].

2. Methodology
The following study was conducted at a private company which engaged in door leaf manufacturing. The first step is to measure time by determining the rating factor and allowance. Furthermore, the data uniformity test and data adequacy test are performed. The next step is the determination of lead time calculated by the formula below:

\[
\text{Lead Time (t_l)} = \text{Setup Time} + \frac{\text{Standard Time \times Demand Quantity}}{\text{Machine Quantity}}
\]  

The production process is based on First Come First Served (FCFS) and the company's scheduling method is the FCFS rule by determining the order in which jobs are performed first. The
data needed is the order of the door leaf product work and the lead time of each job to get the makespan value. After obtain the value of makespan using FCFS method, the company then compares the result of makespan with the proposed method, which is the ant colony algorithm method. In recent years, the application of ant colony optimization algorithm (ACO) to solve the vehicle routing problem has become a research focus. Zhong-Yun Liu improves the basic ant colony algorithm, and adjusts dynamically volatile factor for solving a dynamic vehicle routing problem with time Windows.

Rui-Chen Yang, Yong-Fu Zhou improve the ant colony algorithm from visibility, the information concentration and the parameters, and adopt the exchange method to search for solving the logistics distribution vehicle routing problem. The Ant Colony Algorithm is a population-based heuristic algorithm to solve complicated combinatorial optimization problems. As a swarm intelligent technology, ACO has strong ability of the global optimization and the parallelism, and it can get results quickly and have obvious advantages in the dynamic optimization [14]. The first step of the ant colony algorithm is to create a graph represents the overall door leaf production process. Then an alternative assignment of the initial few iterations is determined based on the production time for each initial job. Iteration will end after the lowest makespan value is obtained using the job order proposed. The final step is the comparison between the actual makespan values using the FCFS method and the proposed using the ant colony algorithm method of Efficiency Index (EI) and Relative Error (RE) calculation [15].

3. Result and discussion

3.1. Actual scheduling using FCFS method

The scheduling method used by the company is using the FCFS (First Come First Served) rule, consists of 6 machines, namely machine A, machine B, machine C, machine D, machine E and machine F and 6 jobs namely job 1, job 2, job 3, job 4, job 5 and job 6. Scheduling with the current FCFS approach of job order can be seen in Table 1 [16].

| Job | Types of Door Leaf |
|-----|--------------------|
| 1   | Colonial 6P        |
| 2   | Carolina 5P        |
| 3   | Napoleon           |
| 4   | GD-1L              |
| 5   | SP-2P              |
| 6   | GD-D456            |

Based on the job order, the schedule used as a solution to the actual conditions in the company are Job 1 - Job 2 - Job 3 - Job 4 - Job 5 - Job 6 with the calculation of makespan in Table 2 [17].

| Machine | Job 1 | Job 2 | Job 3 | Job 4 | Job 5 | Job 6 |
|---------|-------|-------|-------|-------|-------|-------|
| A       | Start | 0,00  | 70,92 | 327,73| 453,11| 455,93| 460,42|
|         | End   | 70,92 | 327,73| 453,11| 455,93| 460,42| 466,25|
| B       | Start | 70,92 | 327,73| 739,49| 864,86| 869,97| 877,67|
|         | End   | 178,66| 739,49| 864,86| 869,97| 877,67| 887,59|
| C       | Start | 178,66| 739,49| 1476,71| 1867,81| 1879,00| 1894,03|
|         | End   | 369,33| 1476,71| 1867,81| 1879,00| 1894,03| 1912,75|
| D       | Start | 369,33| 1476,71| 1867,81| 2009,91| 2013,18| 2017,98|

Table 1. Job order of door leaf product

Table 2. Makespan of FCFS method
From the above table it can be seen that the value of makespan with the company's actual method is 2579.40 hours.

### 3.2. Scheduling using ant colony algorithm method

The ant colony algorithm method is performed with several iterations until the lowest makespan value is obtained based on the proposed job order are performed. Based on the job order, the schedule used as a solution to the better conditions in the company namely Job 1 - Job 6 - Job 4 - Job 3 - Job 5 - Job 2 with the calculation of makespan in Table 3 [18].

**Table 3. Makespan of ant colony algorithm method**

| Machine | Job Order | | | | |
|---------|-----------|--------|--------|--------|--------|
|         | Start     | End    | Start  | End    | Start  |
| C       | 178.66    | 188.59 | 193.69 | 414.74 | 422.44 |
|         | 369.33    | 388.06 | 399.25 | 805.83 | 820.87 |
| D       | 369.33    | 461.45 | 468.00 | 805.83 | 947.93 |
|         | 461.45    | 468.00 | 471.27 | 947.93 | 952.73 |
| E       | 461.45    | 585.46 | 597.56 | 947.93 | 1203.26|
|         | 585.46    | 609.76 | 612.14 | 1203.26| 1253.22|
| F       | 609.76    | 612.14 | 613.57 | 1253.22| 1255.12|

Based on the iteration results, it is found that the makespan value is 2500.54 hours.

### 3.3. Comparison of FCFS and ant colony algorithm method

To compare the method (ant colony algorithm and FCFS method) can be used **Efficiency Index (EI)** and **Relative Error (RE)** parameter [19].

\[
Efficiency\ Index\ (EI) = \frac{2579.40}{2500.54} = 1.03
\]

Because the value of EI > 1, the ant colony algorithm method has a better performance than the FCFS method used by the company [20].

\[
RE = \frac{2579.40 - 2500.54}{2579.40} \times 100\% = 3.057\%
\]

Then the difference in the value of the makespan obtained for the two methods is 3.057%. Based on the results of the efficiency index and relative error, it is found that the results of the production scheduling are designed better than the actual scheduling applied by the company. The results of this study indicates that prioritizing the job order is done first based on the lead time product and the last is based on the demands quantity if a continuous order job sequency [21].
4. Conclusion
Companies engaged in the door leaf industry experiencing delay in schedules delivery due to the long lead time using the FCFS method with a makespan value of 2579.40 hours in the job or are job 1, job 2, job 3, job 4, job 5 and job 6 namely colonial 6P, Carolina 5P, Napoleon, GD-1L, SP-2P, and GD-D456. The company reschedules using the ant colony algorithm method. The job order of product lead time using the ant colony algorithm are job 1, job 6, job 4, job 3, job 5 and job 2 followed by colonial 6P, GD-D456, GD-1L, Napoleon, SP-2P and Carolina 5P with lower makespan values than FCFS method of 2500 hours. The comparison result of the actual method using FCFS and the proposed method using the ant colony algorithm shows an efficiency value of 3.057%.

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