Nawaz, Enscore, Ham (NEH) Algorithm To Minimization Of Makespan In Furniture Company

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Abstract. This study describes production scheduling to minimize the delay in delivering products to consumers. Production scheduling using Nawaz, Enscore, Ham (NEH) Algorithm is done to minimize the total processing time of the product so that the product is finished on time. The fulfillment of due date affects the process of delivering products to consumers. Production scheduling is done in the furniture industry that runs the First-Come-First-Serve (FCFS) scheduling system. This study also compares the performance of the FCFS scheduling system with NEH Algorithm. FCFS scheduling is the existing scheduling system that has been implemented. The results of production scheduling with the NEH algorithm indicate the time required to complete all of orders (makespan) more shorter than the First Come First Serve method. the NEH Algorithm is smaller at 78.61 hours or 5.07% than company's actual method, the FCFS system. The performance of NEH algorithm also proves that it is better than company's actual method with the efficiency index value of 1.05.

1. Introduction
The performance of a company is less than optimal if the company only maximizes the use of existing resources without observes to the other factors. The company also needs to make a mature work plan and the company provides good service to the consumers with on time delivery products and lead time production according to due date. Mature work planning done by making a good production scheduling. Good scheduling have an impact to the increase of effectiveness and efficiency of the company's production system to reduce production costs.

The problem often happens is the company are several times experienced delays in delivery to consumers. This is due to the length of processing time in product. The FCFS scheduling system applied by the company has not been able to generate scheduling in accordance to company’s condition and causes the total lead time of all orders (makespan) and makespan obtained can not meet the deadline of total lead time (due date). In addition, the type of product varies and the stage of workmanship with the use of the same machine also causes the delay due to the bottleneck. Therefore, it is necessary to reschedule to minimize total lead time in order to fulfill customer's order.

Scheduling is the process of allocating resources to select a set of tasks within a certain time[1]. In organization, scheduling contains a plan for clarification and jobs priority must be done in a predetermined operation. It means the scheduling is related to setting up the time to do certain resources in the system. It is directly using the equipment, tools, facilities and human activities and maximizing the efficiency of system and the capacity utilization [2]. Scheduling is carried out in every
organization regardless in its characteristic of activities. Production scheduling is one of the most prominent activities at the operational level of organization to stay competitive in demanding the consumer markets. It is related to the optimization of performance measures, all functions are running well to goal achievement of fulfilling customer satisfaction, for example the efficiency of resources usage, time delivery of products in accordance with the deadlines provided by costumers, and the production costs reduction [4].

Flowshop scheduling is one of the most frequent problems in scheduling. Flow shop scheduling is a one part of the production process with the same job. Problems of flowshop scheduling can be presented with various methods, one of them is Nawaz Enscore and Ham algorithms. Nawaz, Enscore, and Ham (NEH) algorithms developed by Nawaz, Enscore and Ham (NEH) in 1983 [5]. NEH (Nawaz, Enscore, Ham) Algorithms are efficient algorithms works by minimizing the makespan. The proposed algorithm was obtained by modifying the NEH algorithm and resulting in an improved quality solution with algorithmic complexity similar to the original algorithm [6].

Production scheduling problems have been largely resolved in previous studies. The research was conducted in one of the industries outsole production in Banten. The study was conducted by comparing production scheduling using Campbell Dudek Smith and Nawaz Enscore and Ham methods with actual scheduling applied by the company [7]. The new bond breaking mechanism is based on the estimated idle time of different data processing operations to choose an alternative that has the lowest estimated value. The computational experiments performed shows that this mechanism outperforms than the existing ones [8].

Based on previous research, this research uses NEH algorithm in scheduling flowshop manufacture of furniture company. The study was conducted by comparing the performance of NEH algorithm with actual company method to get better information in minimizing the total lead time.

2. Methodology

This study was conducted at one of the furniture companies in Medan City, Indonesia. The objective of this studies is getting the sequence of production process and scheduling system of leaf door production process. This study start from an observation to monitor and see the company’s condition directly. From the results of observation, established the formulation of problem based on the existing company’s condition for research purposes can be applied. The purpose of this study is determined the better scheduling to give a solution of the existing problems. Hereafter, the data collection becomes an input in conducting this research. Required data in the form of cycle time, demand, production capacity, and number of machines used. The cycle time is obtained by measuring time using stopwatch time study. Stopwatch time study is the simplest method of time measurement and therefore this method is used more often than the other time measurement methods. By these data, data processing is done by several stages, ie data uniformity test, data adequacy test, standard time calculation and processing time, and production scheduling.

Data uniformity test is an useful test to ensure that the data collected comes from the same system. Through this test detects any differences and data out of control then discarded and not used in data processing operations calculations. Then adequacy data test. This test is conducted to determine that the data taken from the practical had been sufficient to be used in solving the existing problems. The stipulation of total observation data is done by using the formula after determining the level of confidence and level of accuracy in the research. The formula used in determining the amount of observational data is as follows:

\[ N' = \frac{40 \sqrt{\sum x_i^2 -(\sum x_i)^2}}{\sum x_i}^2 \]  

If N’ less than N so the data is sufficient and can be used as a research data. N is the amount data observed. After that, the calculation of normal time and standard time is done. The cycle time obtained from the measurement results is given adjustment and allowance by westinghouse method in order to obtain the normal time becomes input in standard time calculation [7]. Standard time calculations are performed at each type of door leaf at each work center by formula.
Ws = Wn × \frac{100\% - Allowance}{100\%} \tag{2}

W_s is the standard time and W_n is the normal time. By the formula above, get the standard time and used to compute the lead time. Formulation of lead time is calculated using the following formula:

\text{Lead Time (t_{ij}) = Setup time + \left(\frac{\text{standard time} \times \text{demand}}{\text{product capacity/unit/process}}\right)} \tag{3}

Then production scheduling using Nawaz, Enscore and Ham (NEH) algorithm is performed. The NEH algorithm is one of the heuristic algorithms which suggests that jobs with greater total processing time should be given a greater priority than jobs with a smaller total processing time [9]. Production scheduling with NEH algorithm is done to minimize the makespan by several stages. The first stage is the sum of the process time at each job and do the job-job sorting according to the number of processes starting from the largest to the smallest and the result of this sequence is called the job-job sorting list. Next grab the first and second job on the job-job list then calculate the partial makespan number and the mean flow time to determine the selected partial order with the smallest makespan value, then do the same step as in the previous stage until the overall job sequence is obtained. Determination of the job sequence is done by looking at the smallest makespan value at each job. If a new partial order candidate has the same smallest partial makespan value, then the new partial order candidate is selected by looking at the smaller partial mean flow time value and if the smallest partial mean flow time value is more than one then the new partial sequence will be randomly selected [10].

3. Result and Discussion

3.1. Data Uniformity Test

Uniformity test is performed to see if data collected through uniform observation (at control limits) or not where a data said to be uniform if the data is within the upper control limit (BKA) and lower control limit (BKB). The results obtained in this test indicates that the average time of making each type of door leaf at all work centers is still within the control limits and the data collected is uniform.

3.2. Data Adequacy Test

Data adequacy test is conducted to see if the data has been obtained is sufficient for data processing operations. The number of observations made in the study as much as 10 times. With 95% confidence level and 5% accuracy level, it is found that the amount of observation data at each type product at each work station is sufficient where the value for the whole work center on making at each type door leaf is smaller than the number of observations made which is there is no additional measurements are required.

3.3. Standard Time

Standard time is calculated after find the normal time and allowance where the allowance percentage is the off time allowance given to each worker. Recapitulation of standard time in work centre 1 untill 6 can be seen in Table 1.

| Product Type | WC 1 | WC 2 | WC 3 | WC 4 | WC 5 | WC 6 |
|--------------|------|------|------|------|------|------|
| A | 16,18 | 21,84 | 40,15 | 19,03 | 25,71 | 5,02 |
| B | 16,61 | 21,57 | 40,13 | 16,62 | 25,70 | 5,00 |
| C | 15,48 | 20,67 | 40,03 | 14,25 | 25,72 | 5,02 |
| D | 11,90 | 17,03 | 39,09 | 11,50 | 25,60 | 5,01 |
| E | 11,78 | 19,50 | 39,66 | 12,64 | 25,65 | 4,99 |
| F | 12,30 | 20,47 | 39,78 | 13,79 | 25,83 | 5,14 |
3.4. Lead Time

Calculation of lead time is affected by the number of machines of the company, the production / machine capacity and standard time to create a product. Recapitulation of lead time at each job in all work stations can be seen in Table 2.

| WC | Lead Time at Each Job (Hour) |
|----|-----------------------------|
|    | Job A | Job B | Job C | Job D | Job E | Job F |
| 1  | 45.99 | 182.38| 90.42 | 2.12  | 2.75  | 3.55  |
| 2  | 49.20 | 188.27| 96.03 | 2.42  | 3.38  | 4.40  |
| 3  | 6.06  | 23.42 | 12.41 | 0.36  | 0.45  | 0.57  |
| 4  | 182.85| 629.28| 336.51| 8.24  | 9.27  | 11.49 |
| 5  | 20.96 | 77.72 | 41.00 | 1.26  | 1.64  | 2.04  |
| 6  | 46.48 | 173.43| 92.12 | 2.57  | 3.49  | 4.28  |

3.5. Company Actual Scheduling

Based on the job sequencing in accordance to method of the company is form of First Come First Serve (FCFS) where the first order once comes done or resolved first, then get the job sequence is job A - job B - job C - job D - job E - job F with the value of makespan obtained about 1549.3 hours.

3.6. Scheduling by Nawaz, Enscore, and Ham (NEH) Algorithm

Production scheduling using Nawaz Enscore and Ham (NEH) algorithm is implemented by doing some iterations. The job sequence starts from having two jobs (set K = 2, takes 2 number of jobs from the largest to the smallest) where the data entered is only the sequence of jobs on the smallest makespan. Recapitulation of partial order for all jobs based on process stages using NEH algorithm can be seen in Table 3.

| Iteration to- | Job Sequence | Makespan Value (hours) | Mean Flow time (hours) |
|--------------|--------------|------------------------|-----------------------|
| 1            | Job B – Job C | 1492.98                |                       |
|              | Job C – Job B | **1415.79**            |                       |
| 2            | Job C – Job B – Job A | 1462.28 |                       |
|              | Job C – Job A – Job B | 1598.65 |                       |
|              | Job A – Job C – Job B | 1501.03 |                       |
| 3            | Job F – Job C – Job B – Job A | 1465.83 |                       |
|              | Job C – Job F – Job B – Job A | 1473.76 |                       |
|              | Job C – Job B – Job F – Job A | 1466.56 |                       |
|              | Job C – Job B – Job A – Job F | 1466.56 |                       |
| 4            | Job E – Job F – Job C – Job B – Job A | 1468.58 | **1445.33**           |
|              | Job F – Job E – Job C – Job B – Job A | 1468.58 | 1445.33               |
|              | Job F – Job C – Job E – Job B – Job A | 1475.10 | 1451.86               |
|              | Job F – Job C – Job B – Job E – Job A | 1469.32 | 1446.08               |
|              | Job F – Job C – Job B – Job A – Job E | 1469.32 | 1467.57               |
Table 3. Alternative of Makespan Value (continued)

| Iteration to- | Job Sequence               | Makespan Value (hours) | Mean Flow time (hours) |
|--------------|----------------------------|------------------------|------------------------|
| 5            | Job D – Job E – Job F – Job C – Job B – Job A | 1470.69                | 1447.45                |
|              | Job E – Job D – Job F – Job C – Job B – Job A  | 1470.69                | 1447.45                |
|              | Job E – Job F – Job D – Job C – Job B – Job A  | 1476.81                | 1453.57                |
|              | Job E – Job F – Job C – Job B – Job D – Job A  | 1471.14                | 1447.90                |
|              | Job E – Job F – Job C – Job B – Job A – Job D  | 1471.14                | 1471.14                |

Based on the table, it is found that the scheduling sequence chosen is the job D-job E-job F-job C-job B-job A. The job sequence obtained the makespan value of 1470.69 hours. NEH makespan algorithm value is shorter when compared with the company's initial method of FCFS method. By comparing the makespan of both methods, it is found that the performance value of 1.05 where this result shows that NEH algorithm has better performance than the actual method of company. The results ensure the statement that NEH algorithm is an incremental construction algorithm awarded as the best heuristic method in the flow shop problem and is able to provides some solutions in resolving problems of the company related the delay of lead time affects to the lead time cost. In addition, these results also reinforce that the use of the Nawaz Enscore and Ham (NEH) algorithm produces a shorter makespan compared to the First Come First Serve (FCFS) method where both methods are based on the priority rule which gives guidance on sorting the work to be done [11].

4. Conclusion
Production scheduling problems often occurs because of delay in product delivery to consumers due to lead time product takes a long time. NEH algorithm is one method can be used in handling the problem of production scheduling. The results obtained by this algorithm indicates that the time required to complete the product is shorter than the actual method currently applied by the company. NEH Algorithm able to minimize the makespan 5.07% than FCFS scheduling system. NEH algorithm performance also proved better than the actual method with the efficiency index value of 1.05.

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