Design of Job Scheduling System and Software for Packaging Process with SPT, EDD, LPT, CDS and NEH algorithm at PT. ACP

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Design of Job Scheduling System and Software for Packaging Process with SPT, EDD, LPT, CDS and NEH algorithm at PT. ACP

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Abstract. PT. Avesta Continental Pack is a manufacturer of flexible packaging for pharmaceutical products. The company faces ineffective production scheduling and repeatedly failed to finish orders at the expected time limit. Customers requesting orders in different finishing time contributes in causing delays in the delivery process. Consequently, customers ended up claiming the fee because of the late delivery. Therefore, a more advanced scheduling system will assist the company in managing the delivery time. The purpose of this research is to establish the most effective job scheduling arrangement to minimize mean tardiness as well as mean lateness job. As the production process uses flow shop method, this research applies heuristic methods, such as Earliest Due Date (EDD) method, Short Processing Time (SPT), Nawaz, Enscore, and Ham (NEH) algorithm and Campbell, Dudek, and Smith (CDS) algorithm. The result shows that SPT method provides the most optimum outcome, specifically by reducing mean tardiness by 801.81 minutes or 85.57% and decreasing mean lateness job by 2 or 66.67%. The best job sequence is subsequently job 8 - job 4 - job 1 - job 6 - job 7 - job 5 - job 2 - job 3, which minimizes the average delay time from 937.05 minutes to 135.24 minutes.
Keywords: Flow Shop Scheduling; Mean Tardiness; Mean Lateness Job, Heuristic Scheduling Method

1. Introduction

Rapid industrialization has caused companies to be highly competitive. To fulfil market demands, manufacturing companies are inquired to achieve a certain level of effectivity and efficiency in their production process. One of the ways to reach the target of production is by arranging meticulous scheduling and job management. Inefficient job scheduling causes massive pile up in the product processing stage, increases the total of production time, and inflicts lateness of the product delivery time. PT. Avesta Continental Pack is a company that manufactures flexible packaging for pharmaceutical products. PT. Avesta Continental Pack is a large and reputable company that regularly acquires numerous demands of production as shown in the increasing number of their machines, employees, and operators. Its production process includes printing, inspection, laminating, slitting, and packaging.

The company has been having difficulties in meeting the expected delivery time. Based on the last 3 months data in 2017, there was 28.92% delay in October, 25.5% in November, and 23.83% in December. One of the main causes of the delay is ineffective production scheduling, which was mostly arranged manually. Companies must pay for a penalty claim for the delay which also reduces consumers' trust and satisfaction. The company serves customers' orders using First Come First Serve (FCFS) method. Unfortunately, this method failed to solve the delay delivery time problem.

2. Method

2.1. Terminology of scheduling

Scheduling method is included in the body of science, particularly related to frameworks, techniques, and understandings of the systems (Baker, 1974). In manufacturing companies, types of scheduling have similar structures. It contains a set of jobs to be calculated and a set of machines available to execute the jobs. General problem regarding scheduling revolves around the failure to arrange the timing of jobs based on the capability of the machines. This problem frequently comes up during the decision-making process as the result of using ineffective scheduling method.

While Krajewski and Ritzman (2001) stated that scheduling is the allocation of resources from time to time to support the implementation and completion of a specific work activity. Decisions regarding companies' resources allocation (human resources, capacity resources, production equipment or machines, and time) should realize the efficient and the effective use of resources in the process of producing the right amount of output at the expected time and in a certain expected quality (Subagyo, 2000).

2.2. Nawaz, Enscore, dan Ham (NEH) Algorithm Scheduling Method

Nawaz, Enscore, dan Ham (NEH) method was first coined by Muhammad Nawaz, E. Emory Enscore Jr, and Inyong Ham in year 1983. In a general flow shop, where all the jobs must be produced by the machines in the same order, certain heuristic algorithms propose that the jobs with higher total processing time should be given a higher priority than the jobs with less total processing time (Nawaz et. al., 1983).

2.3. Campbell, Dudek, dan Smith (CDS) Scheduling Method

This method was introduced by H.G. Campbell, R.A. Dudek, and M.L. Smith (1970), and it is based on the Johnson algorithm scheduling method. This method solves the problem of n jobs in m flow shop machines. Campbell, Dudek, and Smith (CDS) scheduling method is one of the many methods of production scheduling that can minimize the number of late jobs. The CDS method looks for the best priority sequence by combining the existing work stations into two groups of machines. Machines in both groups are sorted by priority based on the shortest processing time. Hence, the shortest processing machine is sorted to be the first. Meanwhile, the longest processing machine is sorted to be the last (Herjanto, 2007).

3. Results and Discussion

3.1. Data Collection

The collected time data refers to the setup time data from each main process. The setup time data was collected on March 21, 2018. The 30 set up time data were recorded for each process.

3.2. Data Testing

Data testing in this research includes normality test, uniformity test, and adequacy test. If the data is tested and declared feasible, then it is feasible for next data processing. All processed data involve some

adjustment factors. For example, the standard time for 1 colour of printing process can be obtained as below:

$$\text{Standard time} = 74{,}13 * (1 + 52\%) = 112{,}68 \text{ menit (Karanjkar,2008)}$$

3.3. Data Calculation

The data for this research includes date of order, product data, order quantity, and delivery deadline time. The following table is the production data taken from the period of 8 January 2018 to 12 January 2018. Research Production data shows in Table 1.

After obtaining the research production data in table 1, the number of orders in the roll units will be converted into meters to find out the length of raw material needed to make the roll.

Table 1. Research Production Data

Job	Product Name	Date of Order	Quantity (Roll)	Measurement	Colours	Due Date
1	MICROTINA CAPSULE	1/8/2018	1620	130 x 500 Meter	3	1/21/2018
2	GRANTUSIF KAPLET	1/8/2018	1450	261 x 500 meter	2	1/20/2018
3	MIXAGRIP FLU & BATUK	1/9/2018	815	350 x 500 meter	5	1/24/2018
4	VIFERRON EXP KAPLET	1/9/2018	670	292 x 500 meter	1	1/20/2018
5	GLIQUIDONE TABLET	1/10/2018	1760	187 x 500 Meter	3	1/21/2018
6	CEFADROXIL KAPS	1/10/2018	900	260 x 500 Meter	5	1/20/2018
7	ORNAMENT	1/11/2018	1000	260 x 500 meter	1	1/21/2018
8	ANTIMO ANAK RASA JERUK	1/12/2018	850	180 x 500 Meter	7	1/22/2018

Data of customers' orders from 8 January 2018 to 12 January 2018 which was collected in each process and each job for each machine is shown in Table 2.

Table 2. Processing Time in each Machine

	Processing and Setup Time (minutes)				
Job	Printing	Inspection	Laminating	Slitting	Total Time
1	2938	1856	2316	1893	9004
2	5114	3323	4076	3360	15873
3	5779	3735	4571	3772	17858
4	2416	1535	1931	1572	7455
5	4187	2689	3315	2726	12917
6	3270	2063	2564	2100	9995
7	3550	2292	2839	2329	11009
8	2157	1299	1647	1336	6438

The data of processing time for each machine was recorded by monitoring the speed of each production machine. For example, the calculations for obtaining processing time on a printing machine for job 1 are as follows.

Process time= $\frac{measurement\ of\ raw\ material\ needed}{speed\ of\ the\ machine} + set\ up\ time = \frac{222750\ m}{80\ m/minutes} + 154{,}1\ minutes = 2938{,}48\ minutes$. (Herjanto, 2007)

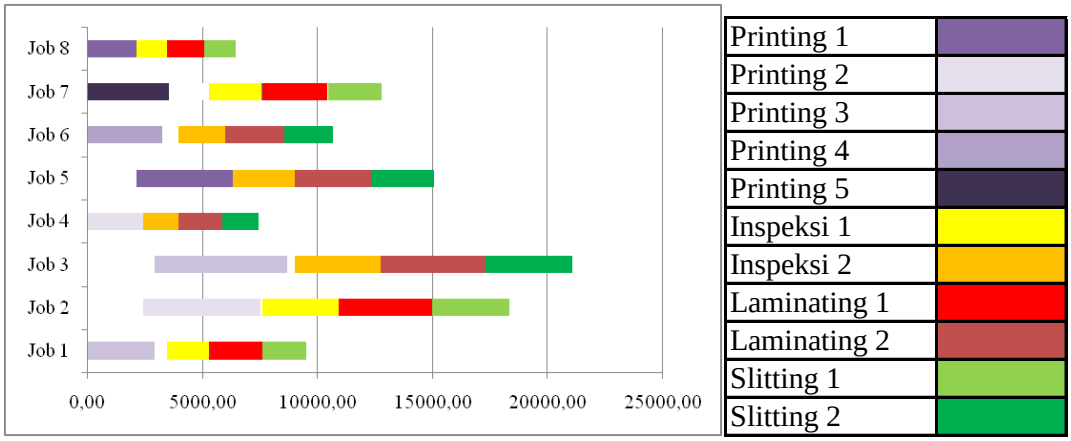

Figure 1. Gantt Chart of SPT Scheduling Method

The Shortest Processing Time (SPT) scheduling method (Heizer, 2005) sorts 8 jobs based on the shortest to the longest total processing time. In this scheduling method, the sequence of the job preparation results in 8-4-1-6-7-5-2-3 order with 1 late job and the mean tardiness of 135.24 minutes. Gantt Chart Scheduling with SPT Method shows in Figure 1. Sorting the 8 jobs starting from the longest to the shortest total processing time (LPT) as shown in Table 3.

Table 3 Sorted Job with LPT Scheduling Method

	Processing and Setup Time (minutes)				
Job	Printing	Inspection	Laminating	Slitting	Total Time
3	5779	3735	4571	3772	17858
2	5114	3323	4076	3360	15873
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1	2938	1856	2316	1893	9004
4	2416	1535	1931	1572	7455
8	2157	1299	1647	1336	6438

In NEH scheduling algorithm, the best job sequence is 3-2-5-7-8-6-1-4, which resulted in 3 late jobs and mean tardiness of 355.04 minutes. The Gantt Scheduling Chart with the NEH Method is shown in Figure 2.

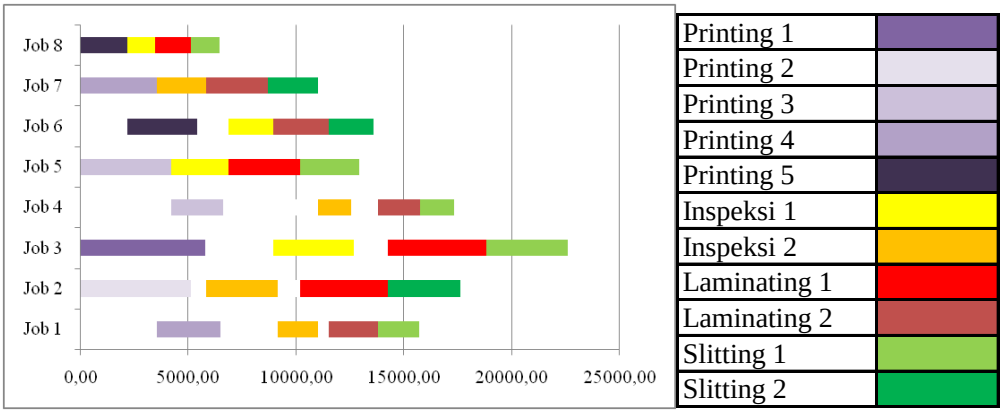

Figure 2. Gantt Chart of NEH Scheduling Method

Table 4 Sorted Job First Iteration with CDS algorithm

	Printing	Slitting
Job 1	2938	1893
Job 2	5114	3360
Job 3	5779	3772
Job 4	2416	1572
Job 5	4187	2726
Job 6	3270	2100
Job 7	3550	2329
Job 8	2157	1336

The First Job Iteration Ordering Table with the CDS Algorithm is shown in Table 4. As shown at Table 5, the shortest processing time is at job 8. Therefore, based on Johnson's method, the job 8 will be placed in the back order and will be removed from this job order in the next calculation. In CDS scheduling algorithm acquires a job sequence scheduling from 3 iterations.

Table 5. Calculation Result of Each Iteration with CDS Algorithm

Iteration	Job Sorted	Mean Tardiness (minutes)
K1	3-2-5-7-6-1-4-8	520.73
K2	3-2-5-7-6-1-4-8	520.73
K3	3-2-5-7-6-1-4-8	520.73

Table 5 exhibits three iterations which resulted the same mean tardiness. The job sequence with CDS algorithm generates 3-2-5-7-6-1-4-8 which caused 1 late job and mean tardiness of 520.73 minutes. Gantt Chart Scheduling with the CDS Method exhibit in Figure 3.

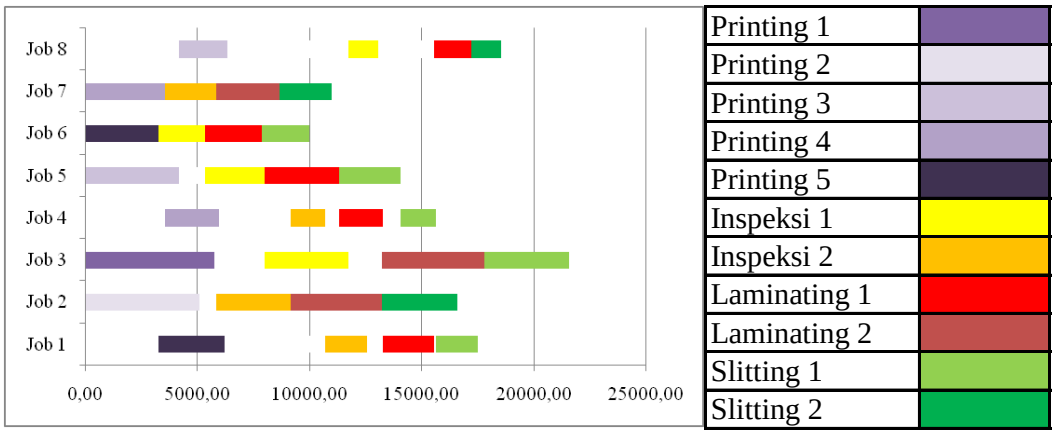

Figure 3. Gantt Chart CDS Scheduling Method

After all the calculation with EDD, SPT, NEH algorithms, and CDS scheduling algorithms and methods (Gozali, 2014), the next step is comparing the best results. Comparison of all scheduling methods is shown in Table 6.

Table 6. Comparison of the Result of Each Method

Method	Mean Tardiness (mnt)	Reducing (mnt)	% reducing	No Lateness jobs
Initial	937.05	-	-	3
EDD	355.63	581.42	62	3
SPT	135.24	801.81	86	1
NEH	355.04	582.01	62	3
CDS	520.73	416.32	44	1

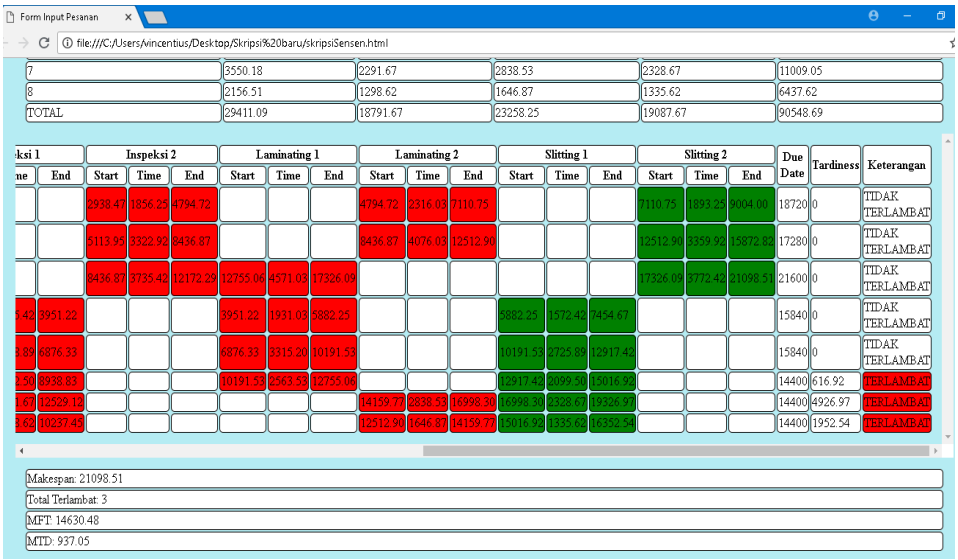

Figure 4 Input screen from scheduling method for this company

After finding the best proposed method that can minimize the delay time (mean tardiness) and the number of late jobs, a decision-making system is designed to conduct production scheduling using the SPT method which is the best proposed method. This system provides the best solution for scheduling method and capable of producing the best output. The application created is a web-based application, which means that this application can be used in web browsers, such as Google Chrome, Mozilla Firefox, and Microsoft Edge. This application has two main screens, including the scheduling input screen that contains order input and capacity, and the other screen to generate output from the scheduling or the process screen. Figure 4 exhibits the results of scheduling calculations by the FCFS method which resulted in 3 late jobs and an average delay time (MTD) of 937.05 minutes.

To minimize these conditions (lateness and tardiness), the SPT scheduling method produces the best solution. The output display of SPT Scheduling method shows in Figure 5.

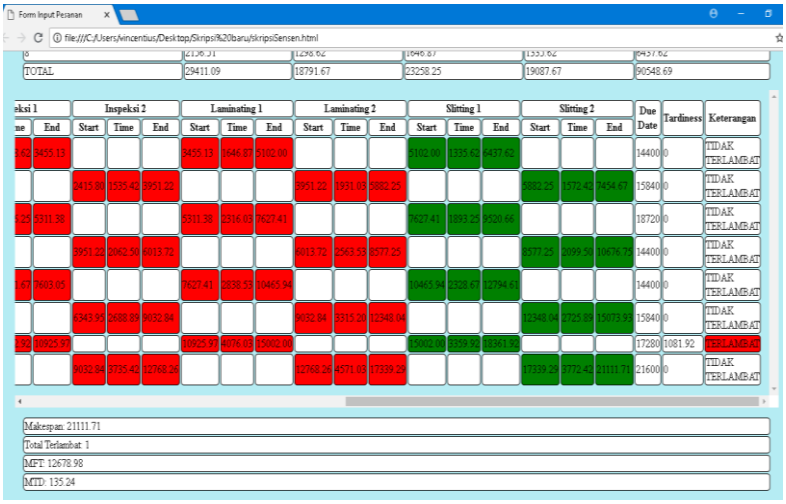

Figure 5. Output screen of SPT scheduling method for this company

4. Discussion and conclusion

Tyagi (2017) stated that eight Dispatching rules as SPT, LPT, EDD, MDD, FCFS, LCFS, MST and CR, an exact algorithm as Branch and Bound algorithm, Johnson‘s algorithm for two and three machines flow shop scheduling problems are described. In addition, four constructed and four improved heuristic algorithms are proposed for more than three machines scheduling problems. Palmer, Gupta, CDS, and NEH heuristic algorithm are proposed as constructed heuristic algorithm. Metaheuristic algorithms works as an Improved heuristic algorithm. Genetic Algorithm, Ant Colony Optimization, Simulated Annealing and Tabu Search are proposed as Improved Heuristic algorithms. All the proposed techniques are effective for solving the scheduling problems in various environments for obtaining the optimum or near optimum sequences.

Gozali (2014) found that NEH is the best solution compared to CDS and Gupta Scheduling Method. Febianti (2017) stated that CDS, NEH and Heuristic Pour scheduling method achieved all the best same result. Jungwattanakit (2006a) declared that the simple dispatching rules the SPT, LPT, ERD, and HSE rules are good algorithms whereas for the flow shop makespan heuristics, the NEH algorithm is most superior to the other constructive algorithms. Jungwattanakit (2006b) also found that the NEH algorithm is an excellent constructive algorithm for minimizing the objective functions. The NEH algorithm is the most superior compared to the other constructive algorithms.

The results in this research show that from the proposed methods using EDD, SPT, NEH, and CDS scheduling methods, the best scheduling method is the Shortest Processing Time (SPT) method. This research also found that the best job sequence is job 8 - job 4 - job 1 - job 6 - job 7 - job 5 - job 2 - job 3, which minimizes the average delay time from 937.05 minutes to 135.24 minutes, meaning this calculation reduces 801.81 minutes or 85.57% tardiness. Moreover, this calculation also reduces late jobs from 3 jobs to 1 job. The scheduling application system is web-based; hence it is easy to use. It also contains comparisons of all proposed methods, so the scheduling processes will calculate quickly and accurately.

5. References

[1] Baker, K. R. 1974. *Introduction to Sequencing and Scheduling*. John Wiley & Sons.
[2] Campbell, H. G., Dudek, R. A., & Smith, M. L. 1970. A heuristic algorithm for the n job, m machine sequencing problem. Management science, **16** 10, B-630.
[3] Febianti, E., & Zikry, Z. 2018. PENJADWALAN PRODUKSI FLOWSHOP DENGAN METODE CAMPBELL DUDEK SMITH, NAWAZ ENSCORE HAM DAN HEURISTIC POUR. In Prosiding Seminar Nasional Teknologi, Inovasi dan Aplikasi di Lingkungan Tropis 1 1, pp. 25-33).
[4] Gozali, L., Ariyanti, S., & Natali, F. L 2014 Machine Scheduling Proposed for Minimizing Makespan at PT Adiperkasa Anugrah Pratama, *7th International Seminar on Industrial Engineering and Management*, Bali, Indonesia pp PS1-PS6
[5] Heizer, Jay and, B. Render 2005. *Manajemen Operasi* Ed 7 Jilid 2. Jakarta : Salemba Empat, Indonesia
[6] Harjanto, E. 2007. *Manajemen Operasi* Ed 3. Grasindo, Indonesia
[7] Jungwattanakit, J., Reodecha, M., Chaovalitwongse, P., & Werner, F. 2006a. Sequencing heuristics for flexible flow shop scheduling problems with unrelated parallel machines and setup times. In *Proceedings of the 2006 IE network national conference*, Bangkok, Thailand (pp. 1-8).
[8] Jungwattanakit, J., Reodecha, M., Chaovalitwongse, P., & Werner, F. 2006b. *Sequencing algorithms for flexible flow shop problems with unrelated parallel machines, setup times, and dual criteria*. Univ., Fak. für Mathematik.
[9] Karanjkar, A. 2008. *Manufacturing and Operations Management*. Nıralı Prakashan.
[10] Krajewski, L. J., & Ritzman, L. P. 2001. *Operations management: strategy and an*alysis. Pearson College Division.
[11] Subagyo, P. 2000. *Manajemen Operasi*. BPFE Yogyakarta, Indonesia
[12] Nawaz, M., Enscore Jr, E. E., & Ham, I. 1983. *A heuristic algorithm for the m-machine, n-job flow-shop sequencing problem*. Omega, **11**(1), 91-95.
[13] Tyagi, N., Tripathi, R. P., & Chandramouli, A. B. 2017. SEQUENCING AND SCHEDULING METHODOLOGIES. In Proceedings of National Conference on Future Innovations & Research in Science and Technology **22**, p. 23.