JKIE (Journal Knowledge Industrial Engineering) Vol. 12, No. 1, April 2025, pp. 29-39

http://jurnal.yudharta.ac.id/v2/index.php/jkie

Journal Knowledge Industrial Engineering

E-ISSN: 2541-4461 | P-ISSN: 2460-0113

Optimization of Production Scheduling to Minimize Makespan in the 54-Ton Flat Carriage Project at PT INKA Multi Solusi

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Article Info

Article history

Received : February 25, 2025

Revised : March 10, 2025

Accepted : April 15, 2025

Published : April 30, 2025

Keywords:

Scheduling;

Makespan;

Optimization;

Production.

ABSTRACT

Efficient production scheduling is essential to achieve optimal operational goals in the manufacturing industry. This study aims to optimize production scheduling on a 54 Ton Flat Carriage manufacturing project at PT INKA Multi Solusi using the Nawaz, Enscore, and Ham (NEH) Method. The main focus of this study is to minimize the total completion time (makespan) in order to improve operational efficiency, reduce costs, and meet deadlines and quality standards that have been set. The NEH method is applied to compare the results with the method commonly used by the company, namely First Come First Serve (FCFS). The results show that the NEH method produces a smaller makespan (1.39 hours) compared to the FCFS method which produces a makespan of 1.41 hours. Thus, the NEH method is proven to be more efficient in reducing makespan and can be used as a reference for better production scheduling. This study also contributes to the allocation of limited resources such as machines, labor, and raw materials, in order to increase the company's productivity and competitiveness amidst the tight competition in the manufacturing industry.

DOI:https://doi.org/10.35891/jkie.v12i1.5912

1. Introduction

In the manufacturing industry, production scheduling plays a very important role in achieving operational efficiency. Scheduling is an important part of the production process before work goes down to the production floor. A poor scheduling system can extend the production completion time which can ultimately reduce the quantity of production produced. In order to avoid extending the production completion time which can ultimately reduce the quantity of production, one strategy that can be done by the company is by scheduling and allocating company resources. With scheduling, the company is expected to be able to make the right decisions in production scheduling so that the minimum production completion time is obtained and demand can be met on time (Taufiq et al., 2021). Production scheduling is the process of planning, organizing, and controlling the sequence and timing of production of goods in a factory. This process involves allocating limited resources such as machines, raw materials, labor, and facilities, to maximize production output or meet market demand at minimum cost. Efficient production scheduling can help companies increase production capacity, reduce lead times, and minimize operating costs (Gymnastiar et al., 2024). Good scheduling not only ensures smooth production processes, but also minimizes the total project completion time or makespan. This is crucial, especially for companies with tight deadlines and specifications.

PT INKA Multi Solusi (IMS) is a company located in Madiun that provides total solution provider services in the field of construction and trade of railway components/spare parts and land transportation products. At PT INKA Multi Solusi, employees work to create a repetitive product or job order system. Job orders are designed to carry out work according to orders. One thing that cannot be controlled by the company is the order request from the buyer. However, the organization limits the number of incoming orders and always tries to be able to work on all orders well. This is proven by the fact that at PT INKA Multi Solusi almost 80% of employees work in the production department, which means that 80% of employees are affected by incoming orders (Agnesta & Hasanah, 2023). PT INKA Multi Solusi as a subsidiary of PT INKA (Persero), has a strategic role in the production of components and transportation projects, including the manufacture of the 54 Ton Flat Carriage project (PPCW 1125). In this project, the main challenge is to ensure that all stages of production, from material cutting to final assembly, can be carried out efficiently to meet the deadlines and quality standards that have been set. This project involves various interdependent activities, so that suboptimal scheduling can lead to increased costs, late delivery, and customer dissatisfaction.

The 54-ton flat car project involves high complexity, both in terms of resource allocation, machine management, and workflow arrangement. One indicator of the success of the project is the minimization of total production time or makespan, which reflects how efficiently the entire production process is designed and implemented. In the tight competition conditions in the manufacturing industry, the ability to minimize makespan not only increases productivity but also provides a competitive advantage for the company. One method that can be used to minimize makespan is the Nawaz, Enscore, and Ham (NEH) method. According to Nawaz (1983) the Nawaz, Enscore, and Ham (NEH) method was first created by Muhammad Nawaz, E. Emory Enscore Jr, and Inyong Ham in 1983. Where all jobs must be produced by the machine in the same order, certain heuristic algorithms propose that jobs with higher total processing time should be given higher priority than jobs with lower total processing time (Kurniawan & Suseno, 2023). This method is known for its ability to provide near-optimal solutions in a relatively short computation time. By sorting jobs based on certain priority weights and iteratively arranging the order of operations, the NEH method is able to produce efficient scheduling. Therefore, the application of the NEH method in this project is expected to provide a significant contribution in efforts to minimize makespan.

This study aims to optimize production scheduling on the 54 Ton Flat Carriage manufacturing project at PT INKA Multi Solusi by applying the Nawaz, Enscore, and Ham (NEH) Method. The main focus of the study is to minimize the total production time (makespan) to improve operational efficiency, reduce costs, and ensure the fulfillment of deadlines and quality standards that have been set. In addition, this study aims to identify the best strategy in allocating limited resources such as machines, labor, and raw materials, in order to increase the company's productivity and competitiveness amidst tight competition in the manufacturing industry.

2. Literature Review

Optimization is the process of finding one or more solutions related to the values of one or more objective functions in a problem so that an optimal value is obtained. Optimization aims to improve the performance of production machines so that companies can have good quality and high work results. This goal is used for several companies such as companies engaged in manufacturing in the production process. Optimization is needed by companies in order to optimize the resources used in order to produce products in the expected quality and quantity so that the goals to be achieved by the company can be met. Optimization is one way to provide the best desired results (Irfansah et al., 2023).

Production scheduling is a decision-making process in the service and manufacturing industries that plays an important role in achieving company goals or objectives by allocating resources to. do a number of jobs in a certain period of time. The better a schedule has a big impact on the company and becomes a reference and strategy for the company where the company will get such as increasing profits, reducing delays from deadlines, increasing machine productivity, and reducing idle time is the goal of scheduling. The right scheduling is done depending on the overall complexity of the work, order volume, operational characteristics, and attention to the ultimate goal of scheduling. The better a schedule has a big impact on the company and becomes a reference and strategy for the company where the company will get such as increasing profits, reducing delays from deadlines, increasing machine productivity, and reducing idle time is the goal of scheduling (Stephany & Hadining, 2022). Production Scheduling is defined as the process of organizing, controlling and optimizing work and workload in the production process or manufacturing process. In other words, production scheduling is the determination of the time and place where a production process must be carried out to obtain the desired amount. the path according to what is needed by SMEs. Scheduling or making a schedule is one of the important activities in the production process or work of a project. Scheduling is used as a basis for allocating factory resources such as machines and production equipment, planning human resources to be used, purchasing materials and planning the production process. Good scheduling will have a positive impact on the smooth running of production and minimize production time and costs (Puadah, 2020). Production scheduling is one of the efforts to manage and organize the production process to achieve effective and efficient production. Production scheduling is very necessary for companies to arrange a sequence of work priorities in accordance with the loading of workloads on all work stations if it has been ensured that the need for all sources has been met. In scheduling several activities are involved, namely standard time is the amount of time needed by a qualified worker to complete a task using certain methods, equipment and supplies, materials and environments. Information obtained from the work measurement process will be used to determine work standards (Aritonang, 2021).

The Nawaz, Enscore, Ham (NEH) method is a heuristic algorithm that proposes that jobs with a larger total processing time should be given higher priority than jobs with a smaller total processing time (Irfansah et al., 2023). The Nawaz Enscore Ham (NEH) method was developed in 1983 by Muhammad Nawaz, E. Emory Enscore Jr, and Inyong Ham. "In a typical flowshop, where all jobs must pass through all machines in the same order, certain heuristic algorithms suggest that jobs with higher total processing times should be given higher priority than jobs with lower total processing times." This applies in a typical flowshop, where all jobs must pass through all machines in the same order. The principle of the NEH method is to find the best solution by swapping job positions so that various possible job sequences are obtained to achieve the best results. Production scheduling using the NEH method is carried out to minimize Makespan with several stages. The calculation process using the NEH method is carried out with the following steps:

1. Add up the processing time for each job.
2. Sort the work based on the total processing time of the work from the largest to the smallest.
3. Do iteration, in iteration 1 set K=2 (K= number of jobs).
4. Choose 2 jobs that feel like they are in first and second place in the job ranking.
5. Calculate the makespan value of the partial sequence candidate.
6. In iteration 2 set K=K+1.
7. Choose the job that is third on the job list.
8. Create a new candidate sequence of K+1 by entering the jobs selected in the previous partial candidate sequence.
9. Repeat until the to-do list is complete.
10. 10. Sort the work sequence based on the smallest makespan.
11. Finish

(Sukmono & Nastiti, 2024).

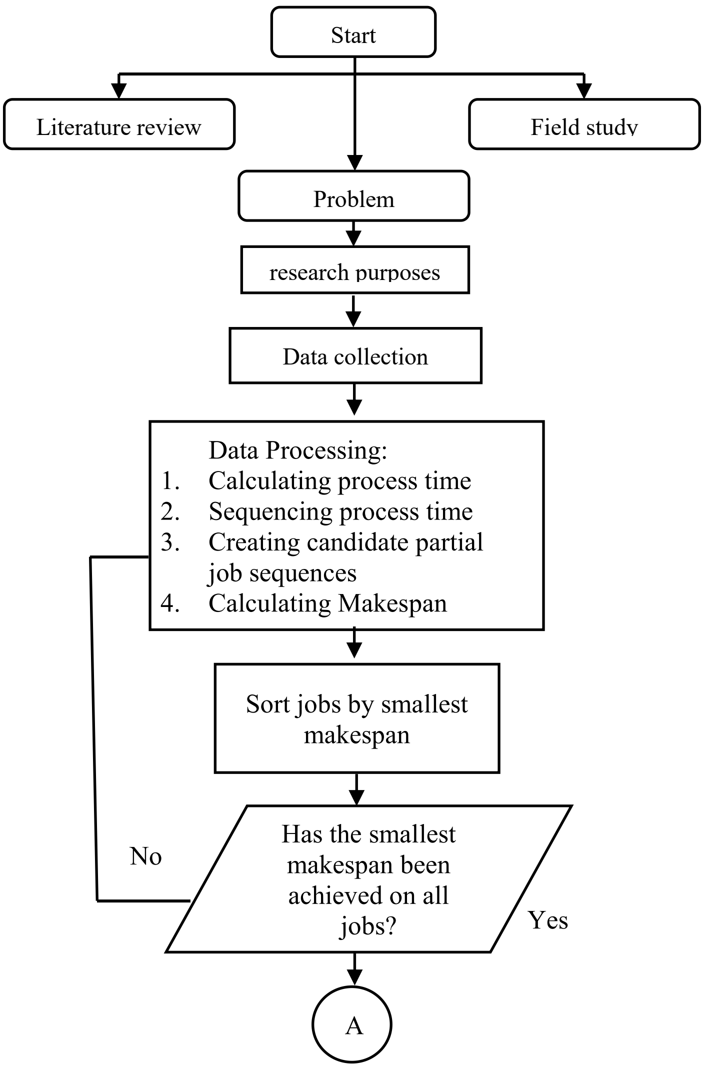
The First Come First Serve (FCFS) method is one of the simplest and most widely used scheduling methods in production systems or queue management. The main principle of this method is to serve jobs or orders based on the order of arrival without considering other priorities. First come first served (FCFS) or often known as first in first out (FIFO) is a non-priority schedule. FCFS is the simplest schedule, namely tasks are given a processing time quota based on the arrival time. When the task gets a processing time quota, the task is run until it is finished (Budiyantoro, 2018). FCFS (First Come First Served) is a method where orders that arrive first are prioritized for processing (Mutiara & Azalia, 2023). FCFS (First Come First Served) method, in this method every process that is ready will be prioritized over others without considering other criteria (Purwati & Sari, 2020). Customer order data is recorded in the order of arrival, the order that arrives first will be recorded in the first order and continued with the order that arrives second and so on until the last order arrives (Kurniawan & Suseno, 2023).

3. Methodology

This study focuses on the production scheduling of the 54 Ton Flat Carriage project (PPCW 1125) using the Nawaz Enscore Ham (NEH) method, which is one of the methods that can be used to overcome the problem of production delays that cause production targets not to be achieved. The Nawaz Enscore Ham method has been used to implement production scheduling in estimating the completion time of consumer orders accurately so that there are no delays in sending consumer orders. (Syabani & Setiafindari, 2022). The data collection methods used in this study are as follows:

- Secondary data, namely data obtained by researchers indirectly. The data needed are production process data, production process time data, production machine data and product demand data. This secondary data refers to Manufacturing Drawing, Load Analysis calculations, and Master Production Schedule.

The following is a research flow diagram that describes the stages in conducting scheduling research using the Nawaz Enscore Ham (NEH) method.



DOI: https://doi.org/10.35891/jkie. v12i1.5912 I Vol. 12, No. 1, April 2025, pp. 29-39

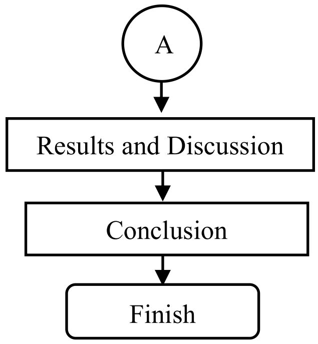


Figure 1. Flowchart

4. Results and Discussion

a. Nawaz, Enscore, dan Ham (NEH)

The results and discussion using the Nawaz, Enscore, and Ham (NEH) method according to the stages in the method can be explained in the following description:

1. Calculating Total Production Process Time

The following is the production process time data for several jobs on the 54 Ton Flat Carriage project at PT INKA Multi Solusi by calculating the total production process time for each job by knowing which is the largest total time. The results of the calculation of production time can be seen in table 1 below:

Table 1. Production Process Time

Job/ Machine	J1	J2	J3	J4	J5
M1	0,13	0,13	0,15	0,15	0,25
M2	0,13	0,13	0,15	0,6	0,25
Total	0,26	0,26	0,3	0,75	0,5

Description:
M= Machine
P= Job

2. Total Work Time Measurement

After calculating the total production time, the next step is to sort the total production time results from the largest. This is in accordance with the principle of the NEH method, where tasks with a longer overall completion time should be prioritized. Therefore, the sorting is done based on the total production time. The total time for each job can be seen in table 2 below:

Table 2. Total Job Time Measurement

Code	Sequence	Time
J4	1	0,75
J5	2	0,5
J3	3	0,3
J1	4	0,26
J2	5	0,26

In table 2, the measurement of total production time for each job is obtained with the first sequence being J4 with a total production time of 0.75; the second sequence being J5 with a total production time of 0.5; the third sequence being J3 with a total production time of 0.3; the fourth sequence being J1 with a total production time of 0.26 and the last sequence being J2 with a total production time of 0.26.

3. Arrange Iteration 1, X=2

The next step is to do iteration X=2, which is to choose the first two jobs based on the order of the largest total production time. In this study, iteration X=2 includes jobs J4 and J5. After that, create two other partial sequence alternatives. Calculate the makespan for iteration X=2 by adding up the production time and setup time. The results of the makespan calculation for iteration X=2 can be seen in the table below:

Table 3. Makespan Iteration 1, J4-J5

Machine	Time	J4	J5
M1	Start	0	0,15
	Finish	0,15	0,40
M2	Start	0,15	0,75
	Finish	0,75	1,00

In Table 3, the results of the makespan calculation for iteration X=2 on the partial sequence alternative 1 show a makespan value of 1.00 with a job sequence of J4-J5. Meanwhile, in the makespan calculation for iteration X=2 alternative 2, although using the same calculation method, the job sequence applied is different, namely J5-J4, which produces a makespan value of 1.10. The following is the makespan calculation for the job sequence J5-J4 in the table below:

Table 4. Makespan Iteration 1, J5-J4

Machine	Time	J5	J4
M1	Start	0	0,25
	Finish	0,25	0,40
M2	Start	0,25	0,50
	Finish	0,50	1,10

4. Arrange Iteration 2, X = 3

The next step is to increase the number of iterations to X = X+1 from i. After completing the iteration with X = 2, the next iteration is carried out with the value of X = 3. In this iteration, there are three job sequences that will form partial sequence candidates, with varying makespan calculation results for each alternative. In the previous iteration, the partial sequence was arranged based on the two jobs with the largest total production time. For iteration X = 3, the job with the third largest total production time is added to the sequence. Thus, in the first alternative, the partial sequence candidates are J4-J5-J3. The results of the makespan calculation for iteration X = 3 can be seen in Table 5 below:

Table 5. Makespan Iteration 2, J4-J5-J3

Machine	Time	J4	J5	J3
M1	Start	0	0,15	0,40
	Finish	0,15	0,40	0,55
M2	Start	0,15	0,75	1,00
	Finish	0,75	1,00	1,15

In Table 5, the results of the makespan calculation at iteration X = 3 for the candidate partial sequence alternative 1 produce a makespan of 1.15 with the job sequence J4-J5-J3. Furthermore, the makespan calculation at iteration X = 3 for alternative 2, with the job sequence J5-J3-J4, produces a makespan value of 1.25. The results of the makespan calculation at the job sequence J5-J3-J4 can be seen in Table 6 below:

Table 6. Makespan Iteration 2, J5-J3-J4

Machine	Time	J5	J3	J4
M1	Start	0	0,25	0,40
	Finish	0,25	0,40	0,55
M2	Start	0,25	0,50	0,65
	Finish	0,50	0,65	1,25

In the next partial sequence candidate X = 3, the results of the makespan calculation for the alternative partial sequence candidate 3 with the job sequence J3-J4-J5 produced a makespan of 1.15. The results of the makespan calculation for alternative 3 can be seen in table 7 below:

Table 7. Makespan Iteration 2, J3-J4-J5

Machine	Time	J3	J4	J5
M1	Start	0	0,15	0,30
	Finish	0,15	0,30	0,55
M2	Start	0,15	0,30	0,90
	Finish	0,30	0,90	1,15

5. Arrange iteration 3, X = 4

In this iteration, there are four job sequences that will form the partial sequence candidates, with varying makespan calculation results for each alternative. In the previous iteration, the partial sequence was arranged based on the three jobs with the largest total production time. For iteration X = 4, the job with the fourth largest total production time is added to the sequence. Thus, in the first alternative, the partial sequence candidates are J4-J5-J3-J1. The makespan calculation results for iteration X = 4 can be seen in Table 8 below:

Table 8. Makespan Iteration 3, J4-J5-J3-J1

Machine	Time	J4	J5	J3	J1
M1	Start	0	0,15	0,40	0,55
	Finish	0,15	0,40	0,55	0,68
M2	Start	0,15	0,75	1,00	1,15
	Finish	0,75	1,00	1,15	1,28

In table 8 from the results of the makespan calculation of iteration X = 4 alternative candidate partial sequence 1, the makespan is 1.28 with the job sequence J4-J5-J3-J1. Next, the makespan calculation of iteration X = 4 alternative 2 will be carried out with the same calculation, namely in the job sequence J5-J3-J1-J4, the makespan value is 1.38. The results of the makespan calculation in the job sequence J5-J3-J1-J4 can be seen in table 9 below:

Table 9. Makespan Iteration 3, J5-J3-J1-J4

Machine	Time	J5	J3	J1	J4
M1	Start	0	0,25	0,40	0,53
	Finish	0,25	0,40	0,53	0,68
M2	Start	0,25	0,50	0,65	0,78
	Finish	0,50	0,65	0,78	1,38

In table 9 from the results of the calculation of makespan iteration X = 4 alternative candidate partial sequence 2, the makespan is 1.38 with the job sequence J5-J3-J1-J4. Next, the calculation of makespan iteration X = 4 alternative 3 will be carried out with the same calculation, namely in the job sequence J3-J1-J4-J5, the makespan value is 1.28. The results of the calculation of makespan in the job sequence J3-J1-J4-J5 can be seen in table 10 below:

Table 10. Makespan Iteration 3, J3-J1-J4-J5

Machine	Time	J3	J1	J4	J5
M1	Start	0	0,15	0,28	0,43
	Finish	0,15	0,28	0,43	0,68
M2	Start	0,15	0,30	0,43	1,03
	Finish	0,30	0,43	1,03	1,28

In table 10 from the results of the calculation of makespan iteration X = 4 alternative candidate partial sequence 3, the makespan is 1.28 with the job sequence J3-J1-J4-J5. Next, the calculation of makespan iteration X = 4 alternative 4 will be carried out with the same calculation, namely in the job sequence J1-J4-J5-J3, the makespan value is 1.26. The results of the calculation of makespan in the job sequence J1-J4-J5-J3 can be seen in table 11 below:

Table 11. Makespan Iteration 3, J1-J4-J5-J3

Machine	Time	J1	J4	J5	J3
M1	Start	0	0,15	0,28	0,53
	Finish	0,13	0,28	0,43	0,68
M2	Start	0,13	0,26	0,86	1,11
	Finish	0,26	0,86	1,11	1,26

6. Arrange iteration 4, X = 5

In this iteration, there are five job sequences that will form the partial sequence candidates, with varying makespan calculation results for each alternative. In the previous iteration, the partial sequence was arranged based on the four jobs with the largest total production time. For iteration X = 5, the job with the fifth largest total production time is added to the sequence. Thus, in the first alternative, the partial sequence candidates are J4-J5-J3-J1-J2. The makespan calculation results for iteration X = 5 can be seen in Table 12 below:

Table 12. Makespan Iteration 4, J4-J5-J3-J1-J2

Machine	Time	J4	J5	J3	J1	J2
M1	Start	0	0,15	0,40	0,55	0,68
	Finish	0,15	0,40	0,55	0,68	0,81
M2	Start	0,15	0,75	1,00	1,15	1,28
	Finish	0,75	1,00	1,15	1,28	1,41

In table 12 from the results of the makespan calculation of iteration X = 5 alternative candidate partial sequence 1, the makespan is 1.41 with the job sequence J4-J5-J3-J1-J2. Next, the makespan calculation of iteration X = 4 alternative 2 will be carried out with the same calculation, namely in the job sequence J5-J3-J1-J2-J4, the makespan value is 1.51. The results of the makespan calculation in the job sequence J5-J3-J1-J2-J4 can be seen in table 13 below:

Table 13. Makespan Iteration 4, J5-J3-J1-J2-J4

Machine	Time	J5	J3	J1	J2	J4
M1	Start	0	0,25	0,40	0,53	0,66
	Finish	0,25	0,40	0,53	0,66	0,81
M2	Start	0,25	0,50	0,65	0,78	0,91
	Finish	0,50	0,65	0,78	0,91	1,51

In table 12 from the results of the calculation of makespan iteration X = 5 alternative candidate partial sequence 2, the makespan is 1.51 with the job sequence J5-J3-J1-J2-J4. Next, the calculation of makespan iteration X = 4 alternative 3 will be carried out with the same calculation, namely in the job sequence J3-J1-J2-J4-J5, the makespan value is 1.51. The results of the calculation of makespan in the job sequence J3-J1-J2-J4-J5 can be seen in table 14 below:

Table 14. Makespan Iteration 4, J3-J1-J2-J4-J5

Machine	Time	J3	J1	J2	J4	J5
M1	Start	0	0,15	0,28	0,41	0,56
	Finish	0,15	0,28	0,41	0,56	0,81
M2	Start	0,15	0,30	0,43	0,56	1,16
	Finish	0,30	0,43	0,56	1,16	1,41

In table 14 from the results of the makespan calculation of iteration X = 5 alternative candidate partial sequence 3, the makespan is 1.41 with the job sequence J5-J3-J1-J2-J4. Next, the makespan calculation of iteration X = 4 alternative 4 will be carried out with the same calculation, namely in the job sequence J1-J2-J4-J5-J3, the makespan value is 1.54. The results of the makespan calculation in the job sequence J1-J2-J4-J5-J3 can be seen in table 15 below:

Table 15. Makespan Iteration 4, J1-J2-J4-J5-J3

Machine	Time	J1	J2	J4	J5	J3
M1	Start	0	0,13	0,26	0,41	0,66
	Finish	0,13	0,26	0,41	0,66	0,81
M2	Start	0,13	0,26	0,39	0,99	1,24
	Finish	0,26	0,39	0,99	1,24	1,54

In table 15 from the results of the calculation of makespan iteration X = 5 alternative candidate partial sequence 4, the makespan is 1.41 with the job sequence J1-J2-J4-J5-J3. Next, the calculation of makespan iteration X = 4 alternative 5 will be carried out with the same calculation, namely in the job sequence J2-J4-J5-J3-J1, the makespan value is 1.39. The results of the calculation of makespan in the job sequence J2-J4-J5-J3-J1 can be seen in table 16 below:

Table 16. Makespan Iteration 4, J2-J4-J5-J3-J1

Machine	Time	J2	J4	J5	J3	J1
M1	Start	0	0,13	0,28	0,53	0,68
	Finish	0,13	0,28	0,53	0,68	0,81
M2	Start	0,13	0,26	0,86	1,11	1,26
	Finish	0,26	0,86	1,11	1,26	1,39

7. NEH Makespan Method Recapitulation

After the calculation to determine the makespan value of 5 jobs, 4 iterations were obtained that can be compared to find out which sequence produces the smallest makespan value. The recapitulation of makespan calculations can be seen in Table 17 below:

Table 17. Makespan Recapitulation (Hours)

Itarate To	Job Sequence	Makespan
1	J4-J5	1,00
	J5-J4	1,10
2	J4-J5-J3	1,15
	J5-J3-J4	1,25
	J3-J4-J5	1,15
3	J4-J5-J3-J1	1,28
	J5-J3-J1-J4	1,38
	J3-J1-J4-J5	1,28
	J1-J4-J5-J3	1,26
4	J4-J5-J3-J1-J2	1,41
	J5-J3-J1-J2-J4	1,51
	J3-J1-J2-J4-J5	1.41
	J1-J2-J4-J5-J3	1,54
	J2-J4-J5-J3-J1	1,39

In Table 17, a recapitulation of the data processing results covering all iterations and work sequences carried out during the production process of the 54 Ton Flat Carriage project is carried out. The selected makespan result is the smallest makespan with all work sequences included in it. Based on Table 17, the smallest makespan result obtained through the application of the NEH method is 1.39 hours, with the work sequence of Job 2, Job 4, Job 5, Job 3, and finally Job 1. Therefore, the production sequence of the 54 Ton Flat Carriage project components is Job 2, Job 4, Job 5, Job 3, and Job 1.

b. First Come First Serve (FCFS)

PT INKA Multi Solusi uses the First Come First Serve (FCFS) method in scheduling each job based on the first job to arrive, the first job to arrive can be sorted into J4-J5-J1-J2-J3. Based on this sequence, makespan calculations can be made as in table 18.:

Table 18. Makespan FCFS

Machine	Time	J2	J4	J5	J3	J1
M1	Start	0	0,15	0,40	0,53	0,66
	Finish	0,15	0,40	0,53	0,66	0,81
M2	Start	0,15	0,60	0,85	0,98	1,11
	Finish	0,60	0,85	0,98	1,11	1,41

Based on Table 18, the results of the makespan calculation using the First Come First Serve method are obtained, where the work or job that arrives first will be worked on first. The order of the jobs that first arrive is J4, J5, J1, J2, and J3, with the results of the makespan calculation of 1.41 hours for a total of 5 jobs and 2 machines.

Table 19. Comparison of makespan results (hours)

Metode	Urutan Job	Makespan
Company (FCFS)	J2-J4-J5-J3-J1	1,41
NEH	J4-J5-J1-J2-J3	1,39

After processing the data by comparing two methods, namely the method used by the company (FCFS) and the method applied by the researcher (NEH), the recapitulation results are obtained as listed in Table 19. Based on these results, it can be seen that the NEH method has a smaller makespan compared to the method used by the company. The NEH method produces a makespan value of 1.39 (hours), while the FCFS method produces a larger makespan value, namely 1.41 (hours).

5. Conclusion

Based on the results of the analysis and discussion that have been presented, it can be concluded that the total completion time using the NEH method is more efficient compared to the method commonly applied by companies, namely the FCFS method. In the FCFS method, a makespan of 1.41 (hours) is obtained with the work sequence J2-J4-J5-J3-J1. Meanwhile, in the NEH method, the makespan obtained is 1.39 (hours) after four iterations, with the work sequence J4-J5-J1-J2-J3. This proves that calculations using the NEH method can reduce makespan, so this method can be a useful reference for companies in scheduling production processes.

As a suggestion for further research, it is recommended to try several other scheduling methods to obtain more optimal comparisons and results.

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