



Woven Bag Production Scheduling With Heuristic Pour Algorithm and Earliest Due Date

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Abstract

PT. XYZ is a company engaged in manufacturing, especially in producing woven bags, which are plastic sacks made of Polypropylene (PP). PT. XYZ faces the problem of too long makespan time in the application of the First Come First Serve (FCFS) method. Although considered simple, FCFS is less efficient in complex production, especially with variations in processing time. As a result, jobs with longer processing times are often prioritized, resulting in delays in shorter jobs. This causes a longer total completion time and requires the implementation of a more efficient scheduling method to minimize makespan and improve production performance. The purpose of this study was to determine the optimal woven bag production job and to reduce makespan and delays in woven bag production with the Heuristic Pour Algorithm and Earliest due date (EDD) at PT. XYZ. From the calculation results using the first come first serve method with the job sequence 1-2-3-4-5-6, the total makespan value was 33119 or 551 hours 59 minutes. Meanwhile, the calculation using the heuristic pour algorithm method and Earliest due date (EDD) obtained the sequence of jobs 3-2-4-1-6-5 with a total makespan of 28528 minutes or 475 hours 28 minutes. The calculation using EDD also showed a decrease in lateness for each job, where the lateness of job 3 was the smallest, namely -10 days with a due date of 17 days. Based on this research, the percentage decrease in makespan value was 13.86%.

Introduction

In the era of globalization and increasingly tight industrial competition, manufacturing companies must continue to improve efficiency and effectiveness in every aspect of their operations. Efficiency and optimal production management are important factors for the success of a manufacturing company. One thing that companies can do to improve efficiency and production management is to schedule production (Vlachos et al., 2023; Soori et al., 2023).

Production scheduling can be defined as the process of allocating existing resources and machines to complete all work by considering existing limitations. Scheduling refers to the process of using resources to implement a series of activities within a predetermined period, using appropriate methods (Hatim & Ahmad, 2022; Murad et al., 2022; Abdulzahra et al., 2023; Đurasević & Jakobović, 2023).

PT. XYZ is a company engaged in manufacturing, especially in producing woven bags, which are plastic sacks made of Polypropylene (PP). Like many other manufacturing companies, PT XYZ faces the problem of excessively long makespan times caused by the implementation of

the First Come First Serve (FCFS) method. This results in inefficiency in the use of production time, where the total completion time of all work is longer than it should be. To address these issues, a study was conducted on optimizing production scheduling by applying a combination of the Heuristic Pour Algorithm and the Earliest Due Date (EDD) method. With the hope of optimizing the job processing sequence and minimizing makespan in order to achieve production targets on time. In the Heuristic Pour method, determining the priority of job processing is based on a combination approach. The Heuristic Pour method assumes that each job is processed independently and separately on each machine (Damayanti et al., 2023; Rocholl & Mönch, 2021; Zhang et al., 2023; Rohaninejad et al., 2022).

Scheduling has a definition of sequencing or overall work in a production line that is done on several machines. One of the quite important problems in the production system is how to arrange and schedule jobs so that orders can be completed and in accordance with consumer desires (Ardiansyah et al., 2024; Longo et al., 2022; Qin & Lu, 2021). Scheduling has a clear scheme for production stages, saving time and costs, avoiding waste in various production sectors and facilitating monitoring and evaluation in the future (Julyanthry et al., 2020; Serrano-Ruiz et al., 2021). The importance of production scheduling in a company is useful for knowing how long it will take for a product to be made and completed, so that there are no delays in production so that it can be adjusted to the targets set by the company (Hasibuan et al., 2023). Production activity is a product defined as a good or service that is made with added use or value in the production process and becomes the final result of that production process (Sudarso, 2022). In manufacturing companies, production is one aspect that may affect how well a business operates (Nurdin et al., 2019; Agus & Shukri Hajinoor, 2012). Production is the process of converting input into output (Rudiawan et al., 2021; Jiang et al., 2022; Osman et al., 2021).

The Pour Heuristic Algorithm is one of the heuristic approaches in production scheduling that is often used because of its simplicity and flexibility in handling various types of systems with many jobs or complex variables (Łapczyńska et al., 2022; Zhang et al., 2023; Khan et al., 2021). The Pour Heuristic Algorithm has a number of advantages and disadvantages in its application. Among the advantages, this algorithm is able to produce more detailed and accurate calculations, especially in searching for makespan, thus providing faster results compared to several other optimization methods. The Pour Heuristic Algorithm is able to produce efficient job sequences and prioritize urgent jobs, thus minimizing the risk of delays (Toyosito et al., 2021).

The EDD method is a job ordering based on the fastest due date. Jobs with the earliest due date must be scheduled first than jobs with the latest due date. This rule aims to minimize the maximum delay or minimize the maximum delay size of a job (Mulya et al., 2020). This method sorts based on the smallest due date so that jobs with the closest request time are worked on first (Safitri, 2019). The parameters required in scheduling with the Earliest due date method are the processing time and due date of each job (Febianti & Mardiana, 2019; Yazdani et al., 2021; Strahl & Gounaris, 2023). Based on the description of the problems above, this study was conducted to optimize the woven bag production process at PT. XYZ using the Heuristic Pour and Earliest Due Date algorithms. It is expected that this approach can provide more effective decisions in production scheduling, so as to maximize machine performance, reduce makespan, and reduce delays. Thus, the company can be more efficient in achieving production targets and meeting consumer demand in a timely manner.

Methods

To effectively solve scheduling problems, a systematic approach is required to identify root causes and implement efficient solutions. This study begins by determining an optimal job sequence to enhance production efficiency. The initial step involves selecting the job with the

shortest processing time from the list of available jobs. This selection is crucial as jobs with shorter processing times tend to be completed faster, thereby reducing the total completion time. After selecting the job with the shortest processing time, the next step is to sequentially add jobs with longer processing times that were not previously selected. This iterative approach considers all available sequencing options to determine the most efficient job order.

Once all processing times are set, the researcher calculates the total completion time (C_i), representing the moment each job is completed. This calculation provides insight into how each job contributes to overall completion time. After computing C_i , jobs are sorted in increasing order to determine an optimized job sequence. This step ensures that job scheduling is arranged to minimize total completion time while maintaining process efficiency.

After obtaining an initial job sequence, the next step is to compute the maximum completion time (F_{max}), which represents the longest completion time among all jobs. This F_{max} calculation evaluates the efficiency of the selected sequence. If the computed F_{max} is not minimized, the previous steps from selecting the first job to computing F_{max} must be repeated iteratively for each job in the sequence. The objective is to optimize the job sequence until the minimum F_{max} is achieved, which will be used for further analysis.

Following the optimization of F_{max} , the study incorporates scheduling based on Earliest Due Date (EDD). Jobs are sorted according to their due dates, allowing researchers to compute the completion time for each job while also evaluating key scheduling performance metrics, including average lateness, average completion time, resource utilization, and job flow efficiency. These metrics are essential in assessing overall production performance and ensuring that the optimized job sequence meets target deadlines. From the conducted analyses, the final step is to select the job sequence with the lowest F_{max} value, reflecting an effort to identify a scheduling strategy that minimizes makespan the primary objective of this study. Additionally, future research could explore the integration of advanced heuristic and metaheuristic methods to further enhance scheduling efficiency in complex production environments.

Results and Discussion

Production Scheduling Data

To conduct production scheduling research at PT. XYZ requires the completion time of each job on each machine used in the production process. the following is a recapitulation of the completion time of jobs 1, 2, 3, 4, 5, and 6 on each machine.

Table 1. Completion Time for Each Job (Minutes)

Job	M1	M2	M3	M4	M5	M6
Job 1	2870	2332	2203	493	1193	223
Job 2	5513	9836	1182	260	612	118
Job 3	2267	1944	2217	464	1101	210
Job 4	5876	9493	1192	250	563	109
Job 5	2025	1895	1771	431	986	221
Job 6	2519	2160	2463	515	1223	234

The table shows the time data required to complete each job on each machine. Each number listed in the table describes the time required to complete each job on each machine. After obtaining the completion time data for each job, you can continue by calculating the scheduling to determine the makespan using the scheduling method.

Scheduling with company method (First Come First Serve Method)

The scheduling method applied by the company in its production process is the First Come First Serve (FCFS) method, which is an approach that prioritizes the order of job arrival without considering completion time or other priorities. In this case, it means that the order of jobs worked on by the company follows the previously determined order of arrival, which are specifically job 1, job 2, job 3, job 4, job 5, and job 6, so that each job will be completed according to the existing queue without any intervention to change or prioritize one job over another. The following is the makespan obtained from calculations using the FCFS method.

Table 2. Makespan Value with First Come First Serve (FCFS) Method

Job	Machine	Start	End	Job	Machine	Start	End
1	1	0	2900	4	1	11200	17756
1	2	2900	7594	4	2	17756	27279
1	3	7594	9812	4	3	27279	28486
1	4	9812	10315	4	4	28486	28746
1	5	10315	11518	4	5	28746	29319
1	6	11518	11756	4	6	29319	29443
2	1	2900	8803	5	1	17756	20561
2	2	8803	18669	5	2	20561	24380
2	3	18669	19866	5	3	24380	26166
2	4	19866	20136	5	4	26166	26607
2	5	20136	20758	5	5	26607	27603
2	6	20758	20891	5	6	27603	27839
3	1	8803	11200	6	1	20561	23560
3	2	11200	15117	6	2	23560	27909
3	3	15117	17349	6	3	27909	31112
3	4	17349	17823	6	4	31112	31637
3	5	17823	18934	6	5	31637	32870
3	6	18934	19159	6	6	32870	33119

From the calculations in the table above, it can be seen that for company scheduling with job sequence 1-2-3-4-5-6, the makespan value is 33119 or 551 hours 59 minutes.

Scheduling with the Pour Heuristic Algorithm and Earliest Due Date

Determine The First Order

To determine the first order in the pour heuristic algorithm, all jobs will be placed as the first order. Job 1 is placed as the first order at the beginning of the first order determination process followed by Job 2, Job 3, Job 4, Job 5, and Job 6. The processing time for job 1 on each machine will be replaced with 0, while the processing time for jobs 2, 3, 4, 5, and 6 is based on the completion time. Next, continue by determining the smallest processing time of each machine. Then, the processing time is added from the smallest to the largest to calculate the completion time of each job. In this calculation, Job 2 is obtained as the first order because it has the smallest makespan value of 32937 minutes compared to other jobs, which are 33338 minutes when it occupies the first order. The results of the makespan calculation when Job 2 occupies the first order can be seen in Table 1.3.

Table 3. Makespan Value For Job 2 as First Order

Job	Machine	Start	End	Job	Machine	Start	End
2	1	0	5513	1	1	9895	2870
2	2	5543	9836	1	2	12795	2332
2	3	15409	1182	1	3	15157	2211
2	4	16606	260	1	4	17383	493

Job	Machine	Start	End	Job	Machine	Start	End
2	5	16876	612	1	5	17886	1193
2	6	17498	118	1	6	19089	223
5	1	5543	2025	6	1	12795	2519
5	2	7598	1895	6	2	15344	2160
5	3	9523	1771	6	3	17534	2463
5	4	11309	431	6	4	20012	515
5	5	11750	986	6	5	20537	1223
5	6	12746	221	6	6	21770	234
3	1	7598	2267	4	1	15344	5876
3	2	9895	1944	4	2	21250	9493
3	3	11869	2217	4	3	30773	1192
3	4	14101	464	4	4	31980	250
3	5	14575	1101	4	5	32240	563
3	6	15686	210	4	6	32813	109

Determine The Second Order

This second order determination does not require job 2 because job 2 was selected to occupy the first order in the previous stage. To determine the second order in the pour heuristic algorithm, all jobs will be placed as the first order. In this calculation, job 2 is obtained as the first sequence because it has the smallest makespan value, which is 32937 minutes compared to other jobs, which are 27394 minutes in job 1, job 5, and job 6. Meanwhile, job 3 has a makespan value of 30640 minutes. The results of the makespan calculation when Job 4 occupies the first order can be seen in Table 4.

Table 4. Makespan Value For Job 4 as First Order

Job	Machine	Start	End		Job	Machine	Start	End
4	1	0	5906		2	4	24567	24837
4	2	5906	15429		2	5	24837	25459
4	3	15429	16636		2	6	25459	25592
4	4	16636	16896		1	1	13504	16404
4	5	16896	17469		1	2	16404	18766
4	6	17469	17593		1	3	18766	20992
5	1	5906	7961		1	4	20992	21495
5	2	7961	9886		1	5	21495	22698
5	3	9886	11672		1	6	22698	22936
5	4	11672	12113		6	1	16404	18953
5	5	12113	13109		6	2	18953	21143
5	6	13109	13345		6	3	21143	23621
2	1	7961	13504		6	4	23621	24146
2	2	13504	23370		6	5	24146	25379
2	3	23370	24567		6	6	25379	25628

Determine The Third Order

This third order determination does not require job 2 and job 4 because job 2 was selected to be the first order and job 4 was selected to be the second order in the previous stage. In this calculation, job 6 is obtained as the first order because it has the smallest makespan value of 16333 minutes compared to other jobs which is 16476 minutes when it is the first order. The results of the makespan calculation when job 6 ranks first can be seen from table 1.5.

Table 5. Makespan Value For Job 6 as First Order

Job	Machine	Start	End		Job	Machine	Start	End
6	1	0	2549		3	1	4604	6901
6	2	2549	4739		3	2	6901	8875
6	3	4739	7217		3	3	8875	11107
6	4	7217	7742		3	4	11107	11581
6	5	7742	8975		3	5	11581	12692
6	6	8975	9224		3	6	12692	12917
5	1	2549	4604		1	1	6901	9801
5	2	4604	6529		1	2	9801	12163
5	3	6529	8315		1	3	12163	14389
5	4	8315	8756		1	4	14389	14892
5	5	8756	9752		1	5	14892	16095
5	6	9752	9988		1	6	16095	16333

Determine The Fourth Order

This fourth order determination does not require job 2, job 4, and job 6 because job 2 was selected to be the first order, job 4 was selected to be the second order, and job 6 was selected to be the third order in the previous stage. In this calculation, job 1 is obtained as the first order because it has the smallest makespan value of 13268 minutes compared to other jobs which is 13784 minutes when it ranks first. The results of the makespan calculation when job 1 ranks first can be seen from table 6.

Table 6. Makespan Value For Job 1 as First Order

Job	Machine	Start	End		Job	Machine	Start	End
1	1	0	2900		5	4	8666	9107
1	2	2900	5262		5	5	9107	10103
1	3	5262	7488		5	6	10103	10339
1	4	7488	7991		3	1	4955	7252
1	5	7991	9194		3	2	7252	9226
1	6	9194	9432		3	3	9226	11458
5	1	2900	4955		3	4	11458	11932
5	2	4955	6880		3	5	11932	13043
5	3	6880	8666		3	6	13043	13268

Determine The Fifth Order

The determination of the fifth sequence only requires jobs 3 and 5 because jobs 2, job 4, job 6, and job 1 were selected to occupy the first, second, third, and fourth sequences in the previous stage. In this calculation, job 1 is obtained as the first sequence because it has the smallest makespan value of 9736 minutes compared to job 5 which is 10368 minutes when it occupies the first sequence. The results of the makespan calculation when job 3 occupies the first sequence can be seen in table 7.

Table 7. Makespan Value For Job 3 as First Order

Job	Machine	Start	End		Job	Machine	Start	End
3	1	0	2297		5	1	2297	4352
3	2	2297	4271		5	2	4352	6277
3	3	4271	6503		5	3	6277	8063
3	4	6503	6977		5	4	8063	8504
3	5	6977	8088		5	5	8504	9500
3	6	8088	8313		5	6	9500	9736

From Table 7, with job 3 as the first order, the makespan value is 9736 minutes. For the makespan value of job 5 as the first order, the makespan value is 10368 minutes. Thus, job 2 can be selected as the fifth order because it has the smallest makespan value. Job 5 is then selected as the sixth order with a makespan of 10368 minutes. This arrangement demonstrates a systematic approach in determining job sequences based on the makespan criteria, ensuring that the production schedule is optimized to reduce idle time and maximize efficiency.

Based on production scheduling with Heuristic Algorithm To obtain the job sequence, namely jobs 2-4-1-6-3-5. Recapitulation of Completion time for 2, 4, 1, 6, 3, and 5 can be seen in the following table:

Table 8. Makespan Value of Pour Heuristic Algorithm Scheduling

Job	Machine	Start	End		Job	Machine	Start	End
2	1	0	5543		6	1	14349	16898
2	2	5543	15409		6	2	16898	21247
2	3	15409	16606		6	3	21247	23725
2	4	16606	16876		6	4	23725	24250
2	5	16876	17498		6	5	24250	25483
2	6	17498	17631		6	6	25483	25732
4	1	5543	11449		3	1	16898	19195
4	2	11449	20972		3	2	19195	23112
4	3	20972	22179		3	3	23112	25344
4	4	22179	22439		3	4	25344	25818
4	5	22439	23012		3	5	25818	26929
4	6	23012	23136		3	6	26929	27154
1	1	11449	14349		5	1	19195	21250
1	2	14349	19043		5	2	21250	25069
1	3	19043	21261		5	3	25069	26855
1	4	21261	21764		5	4	26855	27296
1	5	21764	22967		5	5	27296	28292
1	6	22967	23205		5	6	28292	28528

From the calculations in the table above, it can be seen that for company scheduling with a job sequence of 2-4-1-6-3-5, the makespan value is 28528 minutes. After obtaining the Completion time value from scheduling with the Pour Heuristic Algorithm, it is continued by calculating the delay with the rule that if the delay > 0 then there is a delay and if the delay ≤ 0 then there is no delay. To calculate the delay, the following formula is used.

Lateness job 2 = Completion time job 2 - Due Date (menit)

$$= 17631 - 25920 = -8289 = -138 \text{ jam } 9 \text{ menit}$$

Table 9. Lateness Value For Each Job

Job	Completion Time	Due Date (Day)	Lateness (Minute)	Lateness (Day)
Job 2	Woven Bag 65 kg	18	-8289	-6
Job 4	Woven Bag 100 kg	18	-2784	-2
Job 1	Woven Bag 50 kg	23	-9915	-7
Job 6	Woven Bag 25 kg	24	-11355	-6
Job 3	Woven Bag 25 kg	17	2674	2
Job 5	Woven Bag 10 kg	23	-4592	-3

From the table above, the lateness value for each job can be seen. Job 2 has a lateness value of -6, job 4 has a lateness value of -2, job 1 has a lateness value of -7, job 6 has a lateness value of -6, job 3 has a lateness value of 2, and job 5 has a lateness value of -3.

Determine the Order Based on the Due Date

Scheduling is done by reviewing the due date and considering the delay based on the Pour Heuristic Algorithm. The scheduling results show that job 3 is delayed by 2 days. To overcome this, job 3 is placed in the first sequence because it has a large lateness and a small due date. Thus, the job sequence obtained is 3-2-4-1-6-5, then the completion time calculation is carried out. Recapitulation of completion time for jobs 3, 2, 4, 1, 6, and 5 can be seen in the following table:

Table 10. Makespan Value For Order Based on Due Date

Job	Machine	Start	End	Job	Machine	Start	End
3	1	0	2297	1	1	13746	16646
3	2	2297	6214	1	2	16646	21340
3	3	6214	8446	1	3	21340	23558
3	4	8446	8920	1	4	23558	24061
3	5	8920	10031	1	5	24061	25264
3	6	10031	10256	1	6	25264	25502
2	1	2297	7840	6	1	16646	19195
2	2	7840	17706	6	2	19195	23544
2	3	17706	18903	6	3	23544	26022
2	4	18903	19173	6	4	26022	26547
2	5	19173	19795	6	5	26547	27780
2	6	19795	19928	6	6	27780	28029
4	1	7840	13746	5	1	19195	21250
4	2	13746	23269	5	2	21250	25069
4	3	23269	24476	5	3	25069	26855
4	4	24476	24736	5	4	26855	27296
4	5	24736	25309	5	5	27296	28292
4	6	25309	25433	5	6	28292	28528

From the table above with the job order based on the due date, the makespan value is 28528 minutes. After obtaining the completion time value, it is continued by calculating the delay with the rule if the delay > 0 then there is a delay and if the delay ≤ 0 then there is no delay. To calculate the delay, the following formula is used.

$$\text{Lateness job 3} = \text{Completion Time job 3} - \text{Due Date}$$

$$= 10256 \text{ minutes} - 24480 \text{ minutes} = -2716$$

The recapitulation of lateness calculations for jobs , 2, 4, 1, 6, and 5 can be seen in the following table.

Table 11. Lateness Value For Each Job

Job	Completion Time	Due Date (Day)	Lateness (Minute)	Lateness (Day)
Job 3	10256	17	-14224	-10
Job 2	19928	18	-5992	-4
Job 4	25433	18	-487	0
Job 1	25502	23	-7618	-5
Job 6	28019	24	-6531	-5
Job 5	28528	23	-4592	-3

From the table above, the lateness value for each job can be seen. Job 3 has a lateness value of -10, job 2 has a lateness value of -4, job 4 has a lateness value of 0, job 1 has a lateness value of -5, job 6 has a lateness value of -5, and job 5 has a lateness value of -3. Based on the results above, the selected job sequence is 3-2-4-1-6-5 with a makespan value of 28528 or 475 hours 28 minutes.

From these results, the Pour and EDD Heuristic Algorithms not only produce a more optimal makespan, but also improve the timeliness of each job completion, which ultimately increases efficiency and effectiveness in the production process. Thus, the Pour and EDD Heuristic Algorithm methods are proven to be superior in arranging the sequence of work and achieving better completion times compared to the FCFS method.

Based on the calculation of production scheduling with the 3 methods, the following summary of the scheduling results is obtained.

Tabel 12. Comparison of Results of Each Scheduling Method

Scheduling Method	Job Sequence	Makespan
FCFS (Company Method)	1-2-3-4-5-6	551 hours 59 minutes
Pour Heuristic Algorithm and Earliest Due Date	3-2-4-1-6-5	475 hours 28 minutes

The results of the scheduling calculation show that the FCFS method compared to the proposed method of the Pour Heuristic Algorithm and Earliest Due Date produces a 13.86% reduction in makespan, from 551 hours 59 minutes to 475 hours 28 minutes. From the table, it is known that scheduling with the proposed method, namely the Pour Heuristic Algorithm and Earliest due date with the sequence 3-2-4-1-6-5 with a makespan of 475 hours 28 minutes which has a smaller makespan value compared to the company method (FCFS). Where by using the FCFS method with the sequence 1-2-3-4-5-6, a makespan of 551 hours 59 minutes is obtained. Thus, the proposed method, namely the Pour Heuristic Algorithm and Earliest due date is accepted because it has a smaller makespan value compared to the company method. Both of these methods have proven to be more efficient in arranging the sequence of work, which in turn optimizes the completion time of each job and reduces delays (Lateness).

Conclusion

Comparison of three production scheduling methods—FCFS, Pour Heuristic Algorithm, and Earliest Due Date (EDD)—shows differences in job sequence and completion time. The FCFS method produces a sequence of 1-2-3-4-5-6 with a total makespan of 551 hours 59 minutes. In addition, this method causes a delay in job 3 for 2 days from the due date. Meanwhile, the application of Pour Heuristic Algorithm and EDD produces a different job sequence, namely 3-2-4-1-6-5, with a smaller makespan of 475 hours 28 minutes. Lateness of job 3 also decreased to -10 days, indicating that this method is more optimal in reducing delays.

The use of Pour Heuristic Algorithm and EDD is proven to be more efficient than the FCFS method because it is able to reduce makespan by 13.86%, from 551 hours 59 minutes to 475 hours 28 minutes. In addition, this method also significantly reduces lateness in each job, so that the production schedule becomes more optimal. With these results, it can be concluded that the combination of Pour Heuristic Algorithm and EDD is more effective in improving production efficiency compared to the FCFS method.

References

Abdulzahra, A. M. K., Al-Qurabat, A. K. M., & Abdulzahra, S. A. (2023). Optimizing energy consumption in WSN-based IoT using unequal clustering and sleep scheduling methods. *Internet of Things*, 22, 100765. <http://dx.doi.org/10.1016/j.iot.2023.100765>

- Agus, A., & Shukri Hajinoor, M. (2012). Lean production supply chain management as driver towards enhancing product quality and business performance: Case study of manufacturing companies in Malaysia. *International Journal of Quality & Reliability Management*, 29(1), 92-121. <http://dx.doi.org/10.1108/02656711211190891>
- Ardiansyah, F., Yohanes, E. A., Radyanto, M. R., & Hayati, E. N. (2024). *Perencanaan Dan Penjadwalan Produksi Pada Industri Motor*. PT. Literasi Nusantara Abadi Grup.
- Damayanti, R. A., Tastrawati, N. K. T., & Sari, K. (2023). Analisis Penjadwalan Produksi Menggunakan Metode Nawaz Ensore Ham (NEH) Dan Heuristic Pour Dalam Meminimumkan Total Waktu Produksi. *E-Jurnal Matematika*, 12(3), 216. <https://doi.org/10.24843/mtk.2023.v12.i03.p422>
- Đurasević, M., & Jakobović, D. (2023). Heuristic and metaheuristic methods for the parallel unrelated machines scheduling problem: a survey. *Artificial Intelligence Review*, 56(4), 3181-3289. <http://dx.doi.org/10.1007/s10462-022-10247-9>
- Febianti, E., & Mardiana, A. (2019). Penjadwalan Produksi Single Machine Pada Pipa Longitudinal Welding Mesin Erw 2 Di Pt. Xyz. *Journal Industrial Servicess*, 5(1), 23–29. <https://doi.org/10.36055/jiss.v5i1.6495>
- Hasibuan, A., Islam, U., Utara, S., Ningtyas, C. P., Haluoleo, U., Tahendrika, A., Atma, U., Makassar, J., & Yunani, A. (2023). *MANAJEMEN PRODUKSI & OPERASI*. PT sada Kurnia Pustaka.
- Hatim, H. A., & Ahmad, F. (2022). Pendekatan Algoritma Genetika Dalam Upaya Optimalisasi Penjadwalan Di Pt. Nuansa Indah. *JISI: Jurnal Integrasi Sistem Industri*, 9(2), 145. <https://doi.org/10.24853/jisi.9.2.145-154>
- Jiang, T., Yu, Y., Jahanger, A., & Balsalobre-Lorente, D. (2022). Structural emissions reduction of China's power and heating industry under the goal of “double carbon”: A perspective from input-output analysis. *Sustainable Production and Consumption*, 31, 346-356.
- Julyanthry, Siagian, V., Asmeati, Simanullang, A. H. R., Pandarangga, A. P., Purba, S. P. B., Pintauli, R. F., Rahmadana, M. F., & M, E. A. S. (2020). *Manajemen Produksi dan Operasi*. Yayasan Kita Menulis.
- Khan, I. S., Ghafoor, U., & Zahid, T. (2021). Meta-heuristic approach for the development of alternative process plans in a reconfigurable production environment. *IEEE Access*, 9, 113508-113520. <http://dx.doi.org/10.1109/ACCESS.2021.3104116>
- Łapczyńska, D., Łapczyński, K., Burduk, A., & Machado, J. (2022). Solving the problem of scheduling the production process based on heuristic algorithms. *Journal of Universal Computer Science (JUCS)*, 28(3). <http://dx.doi.org/10.3897/jucs.80750>
- Longo, F., Mirabelli, G., Nicoletti, L., & Solina, V. (2022). An ontology-based, general-purpose and Industry 4.0-ready architecture for supporting the smart operator (Part I–Mixed reality case). *Journal of Manufacturing Systems*, 64, 594-612. <https://doi.org/10.1016/j.jmsy.2024.01.001>
- Mulya, M. F., Trisanto, D., & Rismawati, N. (2020). Analisis Dan Implementasi Metode Earliest Due Date (EDD) Untuk Meminimalisir Keterlambatan Dalam Proses Penjadwalan Perbaikan Kendaraan. *Faktor Exacta*, 13(3), 168–175. <https://doi.org/10.30998/faktorexacta.v13i3.7254>
- Murad, S. A., Muzahid, A. J. M., Azmi, Z. R. M., Hoque, M. I., & Kowsher, M. (2022). A review on job scheduling technique in cloud computing and priority rule based intelligent framework. *Journal of King Saud University-Computer and Information Sciences*, 34(6), 2309-2331. <http://dx.doi.org/10.1016/j.jksuci.2022.03.027>

- Nuridin, N., Novia, N., Rahman, A., & Suhada, R. (2019). Potensi Industri Produk Makanan Halal Di Kota Palu. *Jurnal Ilmu Ekonomi Dan Bisnis Islam*, 1(1), 1–12. <https://doi.org/10.24239/jiebi.v1i1.1.1-12>
- Osman, A. I., Mehta, N., Elgarahy, A. M., Al-Hinai, A., Al-Muhtaseb, A. A. H., & Rooney, D. W. (2021). Conversion of biomass to biofuels and life cycle assessment: a review. *Environmental chemistry letters*, 19, 4075–4118. <http://dx.doi.org/10.1007/s10311-021-01273-0>
- Qin, Z., & Lu, Y. (2021). Self-organizing manufacturing network: A paradigm towards smart manufacturing in mass personalization. *Journal of Manufacturing Systems*, 60, 35–47. <http://dx.doi.org/10.1016/j.jmsy.2021.04.016>
- Rocholl, J., & Mönch, L. (2021). Decomposition heuristics for parallel-machine multiple orders per job scheduling problems with a common due date. *Journal of the Operational Research Society*, 72(8), 1737–1753. <http://dx.doi.org/10.1080/01605682.2019.1640589>
- Rohaninejad, M., Tavakkoli-Moghaddam, R., Vahedi-Nouri, B., Hanzálek, Z., & Shirazian, S. (2022). A hybrid learning-based meta-heuristic algorithm for scheduling of an additive manufacturing system consisting of parallel SLM machines. *International Journal of Production Research*, 60(20), 6205–6225. <http://dx.doi.org/10.1080/00207543.2021.1987550>
- Rudiawan, H., Kunci, K., & Produksi, M. (2021). Peranan Manajemen Produksi dalam Menyelaraskan Kinerja Perusahaan. *Jurnal Manajemen FE-UB*, 9(2), 66.
- Safitri, M. D. A. (2019). Penjadwalan Produksi Untuk Meminimasi Keterlambatan Distribusi Dengan Metode Earliest Due Date. *Prosiding SemNas Teknik UMAHA*, 1, 48–55. <https://doi.org/10.51804/prosiding.v1i0.665>
- Serrano-Ruiz, J. C., Mula, J., & Poler, R. (2021). Smart master production schedule for the supply chain: a conceptual framework. *Computers*, 10(12), 156. <http://dx.doi.org/10.3390/computers10120156>
- Soori, M., Arezoo, B., & Dastres, R. (2023). Internet of things for smart factories in industry 4.0, a review. *Internet of Things and Cyber-Physical Systems*, 3, 192–204. <https://doi.org/10.1016/j.iotcps.2023.04.006>
- Strahl, W. R., & Gounaris, C. E. (2023). A priority rule for scheduling shared due dates in the resource-constrained project scheduling problem. *Computers & Industrial Engineering*, 183, 109442. <https://doi.org/10.1016/j.cie.2023.109442>
- Sudarso, A. (2022). Pemanfaatan Basis Data, Perangkat Lunak Dan Mesin Industri Dalam Meningkatkan Produksi Perusahaan (Literature Review Executive Support System (Ess) for Business). *Jurnal Manajemen Pendidikan Dan Ilmu Sosial*, 3(1), 1–14. <https://doi.org/10.38035/jmpis.v3i1.838>
- Toyosito, R. E., Citra Ramadhanti, L., & Bustommy, A. Y. (2021). Penjadwalan Flow Shop dengan Metode Algoritma Heuristik Pour, Algoritma Campbell Dudek And Smith, Algoritma Tabu Search di Industri Porcelain Tableware. *Jurnal JITES*, 1(1). <http://dx.doi.org/10.63494/jites.v1i1.10>
- Vlachos, I. P., Pascazzi, R. M., Zobolas, G., Repoussis, P., & Giannakis, M. (2023). Lean manufacturing systems in the area of Industry 4.0: A lean automation plan of AGVs/IoT integration. *Production planning & control*, 34(4), 345–358. <http://dx.doi.org/10.1080/09537287.2021.1917720>
- Yazdani, M., Kabirifar, K., Fathollahi-Fard, A. M., & Mojtahedi, M. (2021). Production scheduling of off-site prefabricated construction components considering sequence

dependent due dates. *Environmental Science and Pollution Research*, 1-17.
<https://doi.org/10.1007/s11356-021-16285-0>

Zhang, F., Mei, Y., Nguyen, S., & Zhang, M. (2023). Survey on genetic programming and machine learning techniques for heuristic design in job shop scheduling. *IEEE Transactions on Evolutionary Computation*, 28(1), 147-167.
<http://dx.doi.org/10.1109/TEVC.2023.3255246>

Zhang, Z. Q., Wu, F. C., Qian, B., Hu, R., Wang, L., & Jin, H. P. (2023). A Q-learning-based hyper-heuristic evolutionary algorithm for the distributed flexible job-shop scheduling problem with crane transportation. *Expert Systems with Applications*, 234, 121050.
<http://dx.doi.org/10.1016/j.eswa.2023.121050>