Journal of Industrial Engineering & Management Research
Vol. 3 No. 4 DOI: https://doi.org/10.7777/jiemar.v2i5
http://www.jiemar.org e-ISSN : 2722-8878

SCHEDULING OF PAINTED PRODUCTS AT PT. ABC WITH A BRANCH, BOUND, AND NEIGHBORHOOD SEARCH ALGORITHM TO MINIMIZE THE MEAN FLOW TIME

Ary Kurniati[1*], Ahmad Fatoni[2], Iqbal Fahmi[3]
[1, 2, 3]Universitas Faletehan, Banten, Indonesia
***Coresponding :* arykurniati92@gmail.com**

Abstract- PT. ABC was a manufactur company which on the job of metal coating (ZINCALUME) and painted coating (COLORBOND). Its product manufacturing was carrried in metal coating MCL 2 (Metal Coating Line 2) plant, paint coating or painting product was the most demanded by costumer expecially in MCL 2. So that, it was needed a processing time quickly, For it solution, appropriately with a scheduling. The background of this research was a PT. ABC has not been able to fill all of customer orders, because MCL 2 machine was be still new, and has not been sequenced that caused bottleneck. Method of this research was a branch and bound and neighborhood search algorthm. The purpose of this research was to minimize mean flow time at MCL 2. Existing scheduling which used by the company was a FCFS (First Come First Served). New scheduling would be divided the products into two batch which based on dimensions that were, 0,20 x 914 mm and 0,25 x 914 mm. In existing conditon, mean flow time on dimensions of 0,20 x 914 mm and 0,25 x 914 mm were 43,23 hours and 182,76 hours. The research's result of mean flow time proved that the new scheduling by using branch and bound and neighborhood search algorthm on batch of 0,20 x 914mm was 18,42 hours, with its sequencing was a job 14- job 21- job 20- job 11- job 15 – job 8- job 3 –job 4- job 9- job 7, and then, with a neighborhood search, its sequencing was a job 14- job 20- job 21- job 11- job 15 – job 8- job 3 –job 4- job 9- job 7. For the bacth of 0,25 x 914mm , on branch and bound algorthm, it sequencing was a job 6- job 18- job 2- job 22- job 5- job 10- job 19- job 16- job 12- job 1- job 23- job 17- job 13, and then with neighborhood search , its sequencing was a job 6- job 18- job 2- job 22- job 5- job 10- job 19- job 12- job 16- job 1- job 17- job 23- job 13, they had 147,13 hours for mean flow time. Lowering of mean flow time between existing conditon with two method which used, on batch of 0,20 x 914 mm was a 57 percent and then for 0,25 x 914 mm, was a 19 percent.

Keywords: Branch and Bound Algorthm, Neighborhood Search Algorthm, Mean Flow Time, FCFS, Batch.

1. INTRODUCTION

Scheduling according to Kenneth R. Baker (Baker, 2008) is the process of allocating resources to select a set of tasks within a certain period of time. This definition can be translated into two different meanings. The first meaning, scheduling is a decision-making function, namely determining the most appropriate schedule. While the second meaning of scheduling is a theory that contains a collection of principles, models, techniques, and logical conclusions in the decision-making process. This decision-making has many important roles in the manufacturing and service industries such as making schedules using several methods that aim to achieve consumer desires and production targets desired by PT. ABC is a steel coating company that produces two main products namely metal coating (ZINCALUME) and paint coating (COLORBOND). The main metal coating product (ZINCALUME) produces bare products with different grades, namely G300 and G550. As for the paint coating product (COLORBOND) it produces a painted product with the same 2 grades as metal coating products, namely G300 and G550. The two main products pass through the production process plant using a Metallic Coating Line (MCL) 2 machine. Based on interviews obtained directly by the MCL 2 manager, PT. ABC, the problems that occur at PT. ABC, namely not being able to fulfill all consumer orders in a timely manner because the mcl 2 machine is new which often results in poor coloring and

Journal of Industrial Engineering & Management Research
Vol. 3 No. 4 DOI: https://doi.org/10.7777/jiemar.v2i5
http://www.jiemar.org e-ISSN : 2722-8878

coating processes. And also because the process has not been sequenced according to the sequence so that it experiences a bottleneck in the welder and surface processes, especially the manufacture of painted I-2 products which results in a long time to complete and causes wip (work in process) which affects product manufacturing so that research on painted products is needed in MCL 2. Based on consumer demand, PT. ABC uses a make to order production type, where product manufacturing is based on consumer demand. With this type of production, PT. ABC needs to make an optimal production schedule so that consumer demand reaches consumers quickly. With optimal production scheduling, consumer satisfaction is maintained and the company can compete with other companies engaged in the same field. Therefore, it is proposed to fix the problems currently being faced by PT. ABC by scheduling painted products at PT. ABC which aims to minimize the mean flowtime by using the branch and bound method and the neighborhood search method which will be compared with the existing method at the company. So that all requests from various consumers can be fulfilled quickly, especially for painted products which undergo a long coating process and can find out the minimum average overall time on mcl 2. In general, the Branch and Bound algorithm is the most common procedure for finding optimal solutions such as scheduling problems. In the Branch and Bound algorithm, there are three main parts, namely: lower bound (LB) expressions, search and branching strategies. In this procedure, a problem is broken down into several sub-problems that represent a partial division of labor. The nodes continue to branch further until a complete solution is obtained (Sutanto, 2004).

A. Scheduling

Scheduling is a good measuring tool for aggregate planning. The actual orders at this stage will be assigned first to certain resources (facilities, workers and equipment). Then work sequencing is carried out at each processing center so that optimal utilization of existing capacity is achieved. In this scheduling, requests for certain products (types and quantities) from MPS will be assigned to certain processing centers for the daily period. (Judge and Prasetyawan, 2008). Meanwhile, according to (Baker and Trietsch 2018), scheduling is the allocation of resources to select a set of tasks within a certain period of time.

Scheduling according to Morton (1993) in Bastian Edward's thesis is part of making decisions about adjusting activities and resources in order to complete a set of work so that it is on time and has the desired quality. The decisions referred to in this schedule include sequencing, start and finish times of work (timing), and the order of operations of a job (routing). Because scheduling problems are always related to production sequences, the definition is determining the order of arrival of the various jobs that must be completed within a certain time (Ghith and Tolba 2022). In the scheduling process there are two important elements, namely the sequence of jobs that provide optimal solutions and the allocation of resources. Characteristics of resources include quantitative and qualitative capacities, namely what kind and in what quantity the resource has. Process time, start time and process end time.

B. Scheduling Purpose

According to Bedworth (1987) in the book Planning and Control Production (Judge and Prasetyawan, 2008), scheduling has the following objectives:

a) Increase the use of resources or reduce waiting times so that the total processing time can be reduced and productivity can be increased.
b) Reducing inventory of semi-finished goods or reducing the number of jobs waiting in queues when existing resources are still working on other tasks. Baker's theory states that if the work flow of a schedule is constant, then queues that reduce the average flow time will reduce the average work-in-progress inventory.
c) Reducing some delays in work that has a deadline for completion so that it will minimize penalty costs (delay costs).
d) Helping decision making regarding factory capacity planning and the type of capacity needed so that additional expensive costs can be avoided.

When planning a production schedule, what must be considered is the availability of available

Journal of Industrial Engineering & Management Research
Vol. 3 No. 4 DOI: https://doi.org/10.7777/jiemar.v2i5
http://www.jiemar.org e-ISSN : 2722-8878

resources, whether in the form of labour, processing equipment or raw materials. Because the resources that are owned are changing (especially operators and raw materials), then scheduling can be seen as a dynamic program (Sc 2014).

C. Scheduling System Input

According to (Sambodo, Silalahi, and Firdaus 2022), the input to the scheduling system is obtained from determining the capacity requirements of scheduled orders in terms of the specific types and resources used. On the product, it can be determined from the operation worksheet (containing the skills and equipment needed, standard time, etc.) and BOM (containing the needs for components and supporting materials). The quality of the scheduling decision is greatly influenced by the accuracy of the estimated inputs. Therefore, the maintenance of up-to-date records on the status of manpower and available equipment and changes in capacity resulting from changes in product/process design is critical.

D. Scheduling System Output

To ensure a smooth flow of work going through the production stages, the scheduling system must form output activities, including the following (Hakim and Prasetyawan, 2008):

a) Loading

Loading involves adjusting capacity requirements for orders received and estimated with available capacity. Loading is done by assigning orders to certain facilities, operators and equipment.

b) Sequencing

Sorting is the assignment of which orders are which prioritized for processing first if a facility must process many jobs

c) Job Priority (Dispatching)

Is a work priority about which jobs are selected and prioritized for processing.

d) Scheduling Performance Control

Scheduling performance control is carried out by:

1) Reviewing the status of orders as they pass through a particular system.
2) Rearranging sequences, for example: expediting orders that are far behind or have top priority.

e) Updating Schedule

Updating the schedule is carried out as a reflection of the operating conditions that occur by revising priorities.

2. METHOD

A. Type of Research

This chapter will explain the steps in conducting the research as well as an explanation of the steps in the two algorithms of the scheduling method used in the research. This chapter consists of five sections including problem solving flow charts, neighborhood search algorithms, branch and bound algorithms. The data collection was carried out by knowing historical production data at the metallic coating line (MCL) 2 production process plant in the first week of entry in mid-March 2013. And the data obtained is an item description that explains the type of product, product thickness and width and product grade. Order quantity (tons), runtime machine in March 2013. From the collection of data that has been collected then it is more specific, the data is combined according to the date of the manufacturing process and obtained as many as 23 jobs in the March period that have been worked on. In addition, it also knows the existing scheduling carried out by PT. ABC. If all the data has been obtained, then calculations are performed using scheduling, both existing and using two algorithms, namely the branch and bound algorithm and the neighborhood search algorithm which will then be compared with the results of the mean flow time which

Journal of Industrial Engineering & Management Research
Vol. 3 No. 4 DOI: https://doi.org/10.7777/jiemar.v2i5
http://www.jiemar.org e-ISSN : 2722-8878

previously calculated the start time and finish time and its completion time.

3. RESULTS AND DISCUSSION

Table 3.1 Schedule First Batch (0.20 x 914 mm) In Order SPT (Hours)

No	No Job	Item Description	Total Runtime	Start Time	Finish Time	Completion Time
1	14	0.20 x 914mm Gemilang AZ100 G300 Steel Merah Merapi DB NIR	1,39	0	1,39	1,39
2	J.S	Job Sisipan	0,75	1,39	2,14	2,14
3	20	0.20 x 914mm Gemilang AZ100 G300 Steel Hijau Borneo DB NIR	1,39	2,14	3,54	3,54
4	J.S	Job Sisipan	0,75	3,54	4,29	4,29
5	21	0.20 x 914mm Gemilang AZ100 G300 Steel Biru Bromo DB NIR	1,39	4,29	5,68	5,68
6	J.S	Job Sisipan	0,75	5,68	6,43	6,43
7	11	0.20 x 914mm Gemilang AZ100 G300 Steel Merah Carita DB NIR	2,29	6,43	8,72	8,72
8	15	0.20 x 914mm Gemilang AZ100 G300 Steel Merah Carita DB NIR	1,79	8,72	10,50	10,50
9	8	0.20 x 914mm Gemilang SS AZ100 G300 Stl Merah Carita DB NIR	5,08	10,50	15,58	15,58
10	J.S	Job Sisipan	0,75	15,58	16,33	16,33
11	3	0.20 x 914mm Gemilang SS AZ100 G300 Steel Biru Bromo DB NIR	8,09	16,33	24,42	24,42
12	J.S	Job Sisipan	0,75	24,42	25,17	25,17
13	4	0.20 x 914mm Gemilang SS AZ100 G300 Stl Hijau Borneo DB NIR	8,61	25,17	33,78	33,78
14	9	0.20 x 914mm Gemilang SS AZ100 G300 Stl Hijau Borneo DB NIR	8,11	33,78	41,90	41,90
15	J.S	Job Sisipan	0,75	41,90	42,65	42,65
16	7	0.20 x 914mm Gemilang SS AZ100 G300 Stl Merah Merapi DB NIR	9,62	42,65	52,27	52,27
		Total Flow time				**294,78**
		Mean Flow Time				**18,42**

Based on table 3.1 above, it can be seen that scheduling painted products in MCL 2 using the branch and bound and neighborhood search algorithms, obtained a mean flow time value of 18.42 hours for job sequences with dimensions of 0.20 x 914 mm. At stage 1, the best schedule sequence for the 0.20 x 914 mm batch obtained from the neighborhood search method is the first schedule sequence at S1, with schedule variations 14-20-21-11-15-8-3-4-7- 9 and the mean flow time obtained is 18.42 hours. Because the value of T' = T '', which is the result of the mean flow time of the initial schedule, is the same as the result of the mean flow time using a variation of the schedule from the neighborhood search method, the process only needs to continue until stage 1.

Table 3.2 S1 Schedule Variation In Batch 0.25 X 914mm (Stage 2) With Neighborhood Search (hours)

No	Job	Item Description	Total Time	Start Time	Finish Time	Completion Time
1	6	0.25 x 914mm Gemilang AZ100 G300 Steel Hijau Borneo DB NIR	7,79	52,27	60,06	60,06
2	J.S	Job Sisipan	0,75	60,06	60,81	60,81
3	18	0.25 x 914mm Gemilang AZ100 G300 Steel Merah Carita DB NIR	8,50	60,81	69,31	69,31
4	J.S	Job Sisipan	0,75	69,31	70,06	70,06
5	2	0.25 x 914mm Gemilang AZ100 G300 Steel Merah Merapi DB NIR	14,80	70,06	84,86	84,86
6	J.S	Job Sisipan	0,75	84,86	85,61	85,61
7	22	0.25 x 914mm Gemilang AZ100 G300 Steel Biru Bromo DB NIR	11,55	85,61	97,15	97,15
8	J.S	Job Sisipan	0,75	97,15	97,90	97,90
9	5	0.25 x 914mm Gemilang AZ100 G300 Steel Merah Merapi DB NIR	14,80	97,90	112,70	112,70
10	10	0.25 x 914mm Gemilang AZ100 G300 Steel Merah Merapi DB NIR	14,30	112,70	127,00	127,00
11	19	0.25 x 914mm Gemilang AZ100 G300 Steel Merah Merapi DB NIR	14,30	127,00	141,30	141,30
12	J.S	Job Sisipan	0,75	141,30	142,05	142,05
13	12	0.25 x 914mm Gemilang AZ100 G300 Steel Biru Bromo DB NIR	16,95	142,05	159,00	159,00
14	16	0.25 x 914mm Gemilang AZ100 G300 Steel Biru Bromo DB NIR	16,45	159,00	175,44	175,44
15	J.S	Job Sisipan	0,75	175,44	176,19	176,19

Journal of Industrial Engineering & Management Research
Vol. 3 No. 4 DOI: https://doi.org/10.7777/jiemar.v2i5
http://www.jiemar.org e-ISSN : 2722-8878

16	1	0.25 x 914mm Gemilang AZ100 G300 Steel Merah Carita DB NIR	25,53	176,19	201,72	201,72
17	J.S	Job Sisipan	0,75	201,72	202,47	202,47
18	17	0.25 x 914mm Gemilang AZ100 G300 Steel Merah Merapi DB NIR	26,08	202,47	228,55	228,55
19	23	0.25 x 914mm Gemilang AZ100 G300 Steel Merah Merapi DB NIR	25,58	228,55	254,13	254,13
20	J.S	Job Sisipan	0,75	254,13	254,88	254,88
21	13	0.25 x 914mm Gemilang AZ100 G300 Steel Merah Carita DB NIR	33,53	254,88	288,41	288,41
		Total *Flow time*				**3089,64**
		Mean Flow Time				**147,13**

Based on table 3.2 above, it can be seen that at dimensions of 0.25 x 914 mm, the mean flow time value is 147.13 hours. Scheduling on batches of 0.25 x 914 mm using the same method. Before calculating the schedule using this method, it is necessary to have an initial schedule sequence that has been sorted using SPT, namely 6-18-22-2-5-10-19-12-16-1-17-23-13. Starting at stage 1 with the first job order

4. DISCUSSION

The criterion size in this study is to minimize the mean flow time in the flow shop pattern at PT.ABC. Mean flow time is the average time needed to complete a job. In general, the mean flow time is closely related to the makespan and the number of jobs done, the higher the makespan and jobs done, the higher the resulting mean flow time . This Mean Flow time functions in achieving production targets, because it can minimize shop time so that the completion time for doing a job can be faster. The scheduling that is done is forward scheduling and for the initial schedule the SPT (Short Processing Time) method is used, while the proposed scheduling uses the Branch and Bound and Neighborhood Search methods. The SPT method serves as an upper bound value for the branch and bound algorithm and can find out the job order that produces a smaller mean flow time value so that it is more effective and efficient, and can also help in minimizing calculations using the two methods. The Branch and Bound and Neighborhood Search methods are used, because these two methods can produce solutions that are close to optimal in a relatively short time. In the scheduling of the branch and bound algorithm, it is done by finding the node with the smallest number of makespans so that it will form a new node until the next which eventually forms a tracking tree consisting of several levels and jobs. And the node will stop, if all jobs have been scheduled. The size of the criteria in this study is to minimize the mean flow time in the flow shop pattern at PT. ABC. Mean flow time is the average time needed to complete a job. In general, the mean flow time is closely related to the makespan and the number of jobs done, the higher the makespan and jobs done, the higher the resulting mean flow time. This Mean Flow time functions in achieving production targets, because it can minimize shop time so that the completion time for doing a job can be faster. The scheduling that is done is forward scheduling and for the initial schedule the SPT (Short Processing Time) method is used, while the proposed scheduling uses the Branch and Bound and Neighborhood Search methods (Saiful, Rapi, and Flannery 2014). The SPT method serves as an upper bound value for the branch and bound algorithm and can find out the job order that produces a smaller mean flow time value so that it is more effective and efficient, and can also help in minimizing calculations using the two methods. The Branch and Bound and Neighborhood Search methods are used, because these two methods can produce solutions that are close to optimal in a relatively short time (Herry Christian Palit, Tessa Vanina Soetanto, and Hermin Novianti 2003). In the scheduling of the branch and bound algorithm, it is done by finding the node with the smallest number of makespans so that it will form a new node until the next which eventually forms a tracking tree consisting of several levels and jobs. And the node will stop, if all jobs have been scheduled (Ismawati Khotimah, Hagni Wijayanti, and Sri Setyaningsih 2021). The advantages of using the Branch and Bound method, there is an enumeration process and limits used, the enumeration process here is trying all possible answers and if it does not meet the desired conditions such as the lower bound value obtained is greater than the upper bound, then a knot will be cut that does not meet condition (Herry Christian Palit, Tessa Vanina Soetanto, and Hermin Novianti 2003). As for the Neighborhood Search method, this is done by exchanging adjacent jobs or with other jobs to produce a different job sequence accompanied by a

Journal of Industrial Engineering & Management Research
Vol. 3 No. 4 DOI: https://doi.org/10.7777/jiemar.v2i5
http://www.jiemar.org e-ISSN : 2722-8878

different mean flow time. (Saiful, Rapi, and Flannery 2014). The advantage of using this method is that it is more effective to find out which schedule variation has the minimum mean flow time value. The use of two methods is used to find out which schedule variation produces a smaller mean flow time value, so that it can be used as a suggestion on the part of the company and to prove that the Branch and Bound and Neighborhood Search algorithms can produce production schedules with good schedule results in relatively unnecessary time long time. And used as a comparison between the existing schedule with variations of the schedule using the two methods (Saiful, Rapi, and Flannery 2014)

5. CONCLUSION

Based on the results of job scheduling analysis using branch and bound algorithms and neighborhood search, including:

1) Scheduling painted products in MCL 2 using the branch and bound and neighborhood search algorithms, obtained a mean flow time value of 18.42 hours for job sequences with dimensions of 0.20 x 914mm compared to the existing condition of 43.23 hours. Then for the dimensions of 0.25 x 914 mm, the mean flow time value is 147.13 hours compared to the existing conditions with a value of 182.76 hours. From these two values, we can minimize the mean flow time.
2) For the criteria of minimizing the mean flow time, the branch and bound and neighborhood search algorithms provide smaller mean flow time values for each product dimension. On products with dimensions of 0.20 x 914 mm, 18.42 hours with job order (14-20-21-11-15-8-3-4-9-7) and (14-21-20-11-15 -8-3-4-9-7). Then for a product dimension of 0.25 x 914 mm it is 147.13 hours with a different job order, namely (6-18-2-22-5-10-19-16-12-1-23-17-13) and (6-18-2-22-5-10-19-12-16-1-17-23-13), compared to the existing schedule which has a value of 43.23 hours for dimensions of 0.20 x 914 mm and 182, 76 hours for product dimensions 0.25 x 914mm. So it shows a decrease from the existing conditions, namely 57% in a batch of 0.20 x 914mm and 19% in a batch of 0.25 x 914.

6. REFERENCE

Baker, Kenneth R., and Dan Trietsch. 2018. “Principles of Sequencing and Scheduling: Second Edition.” Principles of Sequencing and Scheduling: 1–633.

Ghith, Ehab Seif, and Farid Abdel Aziz Tolba. 2022. “Design and Optimization of PID Controller Using Various Algorithms for Micro-Robotics System.” Journal of Robotics and Control (JRC) 3(3): 244–56.

Herry Christian Palit, Tessa Vanina Soetanto, and Hermin Novianti. 2003. “PENJADWALAN PRODUKSI FLEXIBLE FLOWSHOPS DENGAN SEQUENCE-DEPENDENT SETUP TIMES MENGGUNAKAN METODE RELAKSASI LAGRANGIAN (Studi Kasus Pada PT. Cahaya Angkasa Abadi).” Jurnal Teknik Industri 5(2): 111–19. http://puslit2.petra.ac.id/ejournal/index.php/ind/article/view/16027.

Ismawati Khotimah, Hagni Wijayanti, and Sri Setyaningsih. 2021. “Penjadwalan Integer Linear Programming Pada Penjadwalan Produksi Tipe Flowshop Dan Program Optimasi Waktu Dengan Metode Branch and Bound.” JMT : Jurnal Matematika dan Terapan 3(1): 44–51.

Saiful, Mangngenre, Amrin Rapi, and Wendy Flannery. 2014. “Penjadwalan Produksi Dengan Metode Branch and Bound Pada Pt. Xyz.” Bksti: 2–6. http://repository.unhas.ac.id/bitstream/handle/123456789/10832/JURNAL UNTUK BKSTI 2014-IPUL

MAKASSAR.pdf;jsessionid=5F7920A6FE4F38D98AC375755EC064E9?sequence=1.

Pinedo, M., 2008. Scheduling Theory, Algorithms, and System Thirt Edition. Springer. New York.

Riyanti, Eka. 2004. Application of the Branch And Bound Algorithm for Determining Routes for Attractions. Thesis Department of Informatics Engineering, Faculty of Engineering and Computer Science, Indonesian Computer University: Bandung.

Purwanto, A., & Sudargini, Y. (2021). Partial least squares structural squation modeling (PLS-SEM) analysis for social and management research: a literature review. Journal of Industrial Engineering & Management Research, 2(4), 114-123.

Sambodo, Maxensius Tri, Mesnan Silalahi, and Nur Firdaus. 2022. "Exploration of Technological Disruptive in the Energy Sector in Indonesia: Toward Low Carbon Development." *SSRN Electronic Journal*: 1–19.

Sc, B. 2014. "Industrial Engineering and Management Science." *Industrial Engineering and Management Science*.

Sutanto, Gunado. 2000. Branch And Bound Algorithm And Genetic Algorithm For Flowshop Scheduling With Multiple Purpose Functions. Thesis Department of Industrial Engineering, Faculty of Engineering, Petra Christian University: Surabaya.

Sutanto, J., et. al. 2004. Brach and Bound Algorithm for Scheduling Problems on Parallel Machines. Journal of Informatics Engineering. Computational Science and Engineering Laboratory. Informatics Engineering Department: ITB

Syahril, S., Sihotang, M., Hadinegoro, R., Sulastri, E., Rochmad, I., Cahyono, Y., & Purwanto, A. (2022). Hospitals Cusptomer e-loyalty: How The Role of e-service quality, e-recovery service quality and e-satisfaction?. UJoST-Universal Journal of Science and Technology, 1(1), 23-27.

Suyanto. 2010. Deterministic or Probabilistic Optimization Algorithm. Science House. Yogyakarta.

Trijayanto, Bastian E. 2012. Comparison of Scheduling Methods on Single Machine Flow Shop Flow Patterns with Existing Schedules, Insertion Techniques, and Neighborhood Search. Thesis Department of Industrial Engineering, Faculty of Engineering, University of Sultan Ageng Tirtayasa: Cilegon.