Flowshop Production Scheduling Using the CDS Method, Bat Algorithm, and Genetic Algorithms To Minimize Makespan At PT. Paku Gajah Mas

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Abstract

Scheduling is an important part of the production process. Flow shop scheduling is a continuous movement of units through a series of work stations arranged based on products. PT. Paku Gajah Mas is an industrial manufacturing company that produces various sizes of nails. Orders are produced according to incoming orders and have a First Come First Serve scheduling system. Scheduling in PT. Paku Gajah Mas is still not optimal due to frequent delays in orders reaching the buyer. The data used in this research is demand data for August 2020. This study aims to find the best scheduling by finding the smallest makespan value of each proposed method. The methods used in this research include the CDS method, the Genetic Algorithm, and the Bat Algorithm. Based on the analysis, it was found that the best scheduling method with the smallest makespan value for PT. Paku Gajah Mas uses a genetic method with the results of 488.16 minutes makespan and an increase of 7.35% from the current scheduling time.

Keywords

Scheduling; Makespan; Campbell Dudek Smitch (CDS); Genetic Algorithm; Bat Algorithm

1. Introduction

Production of an activity or process to create and provide benefits (utility) of goods or services. There are various kinds of activities in the production process, starting from the production planning process, scheduling production activities, quality control, packaging, shipping, and the resulting factory waste. The process of scheduling is a part that needs attention. Scheduling is the activity of allocating existing resources or machines to carry out tasks within a specific time. PT. Paku Gajah Mas is a business engaged in the manufacturing industry which produces nails. The company has a make to order manufacturing system and uses a First Come First Serve (FCFS) scheduling system. The system creates a state when demand increases, multiple orders crash, and requests build up. The production system applied in this company is not optimal yet. It is necessary to reschedule to minimize the total turnaround time to fulfill consumer orders on time.

Therefore, it is necessary to reschedule to minimize the total turnaround time to fulfill customer orders and make optimal production process scheduling. The method used in this research is the CDS method, genetic algorithm, and Bat Algorithm.

2. Literature Review

2.1. Scheduling

Conway and Forgaty (1967) explained that scheduling is the task of assigning each operation to a specific position or time scale of the particular machine and frequently includes determination of start and completion time. Scheduling is the activity of allocating existing resources or machines to carry out tasks within a specific time. Scheduling is indispensable for managing various things, such as; in an industrial company, production scheduling is needed to manage labor, machinery, production processes, and the purchase of materials.

Scheduling is prepared by considering various limitations to minimize processing time, waiting time and make it efficient. Scheduling that positively impacts scheduling has low operating costs and delivery times and gets a high customer load. Scheduling problems will arise when a set of tasks come together at a specific time (per month, per week, per day), while resources such as machinery and equipment are limited.

2.2. Flow Shop

Scheduling flowshop is the continuous movement of units through a series of work stations arranged by-product. Flow shop scheduling, which has the same routing (the same sequence for the usage of machines), is called flow shop permutation scheduling (Pinedo, 2002). Flow shop workflow is divided into four categories:

a. Pure Flow Shop
   In this flowshop, all workflows on the same process line through all machines.
b. General Flow Shop
   The process flow patterns are not identical. Each job does not always pass through all the working machines.
c. Flow Reentrant Shop
   At the inflow shop, the machines can be passed more than once.
d. Store Hybrid / Compound Flow
   One machine in a machine set can store by a group of machines. This group of machines is generally parallel machines or batch lines that are formed by parallel machines

2.3. CDS algorithm

The Campbell Duddek Smith method is a method based on the Johnson algorithm developed by H.G. Campbell, R.A Dudek, and M.L. Smith. Johnson's algorithm is an algorithm for scheduling many jobs on two serial machines. In this scheduling, efforts are made to get the smallest makespan value from the existing scheduling possibilities. Scheduling that has the smallest makespan value is the order of the best job execution. The steps in compiling the CDS algorithm scheduling (Campbell Dudek Smith) are as follows:

a. Determine the number of iterations that is, the number of machines -1
b. Take the first scheduling (K = 1).
c. Follow the Johnson rule.
d. Move the tasks from the list and arrange them in the form of a schedule.

Here are the stages of the calculation using the CDS, which is illustrated by a flow chart shown in Figure 1 below.

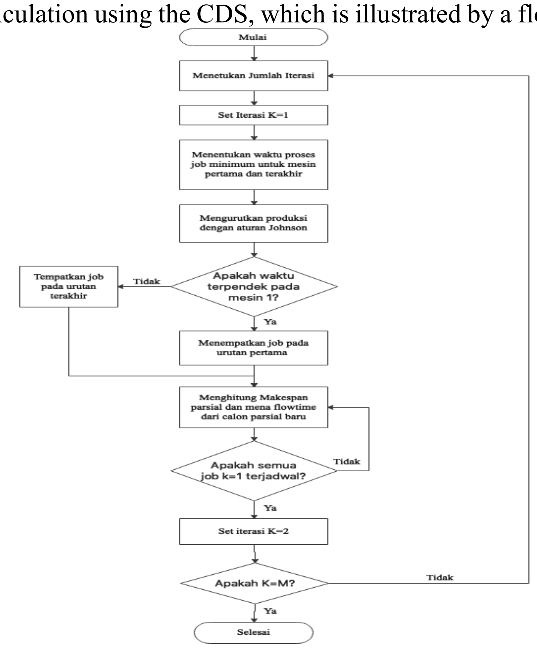

Figure 1 CDS Flowchart

2.4. Bat algorithm

Bat Algorithm (BA) is a metaheuristic algorithm. Xin-She Yang introduced the Bat Algorithm method around 2010. This algorithm is inspired by bats' behavior that distinguishes food sources and obstacles and estimates food sources' distance. The bat algorithm function to minimize makespan uses the following equation:

$$C_{max} \geq C_{js} \quad (1)$$

$$C_{js} = S_{js} + P_{sj} \quad (2)$$

The equation solution for the new position and the new velocity at iteration t for the movement of the bat is as follows:

$$f_i = f_{min} + (f_{max} - f_{min})\beta \quad (3)$$

$$v_i^t = v_i^{t-1} + (x_i^{t-1} - x_*)f_i \quad (4)$$

$$x_i^t = x_i^{t-1} + v_i^t \quad (5)$$

As for the movement to find a local solution, the equations used are as follows:

$$x_{new} = x_* + \vartheta A^t \quad (6)$$

The following is a flow chart of the Bat Algorithm method used, as shown in Figure 2.

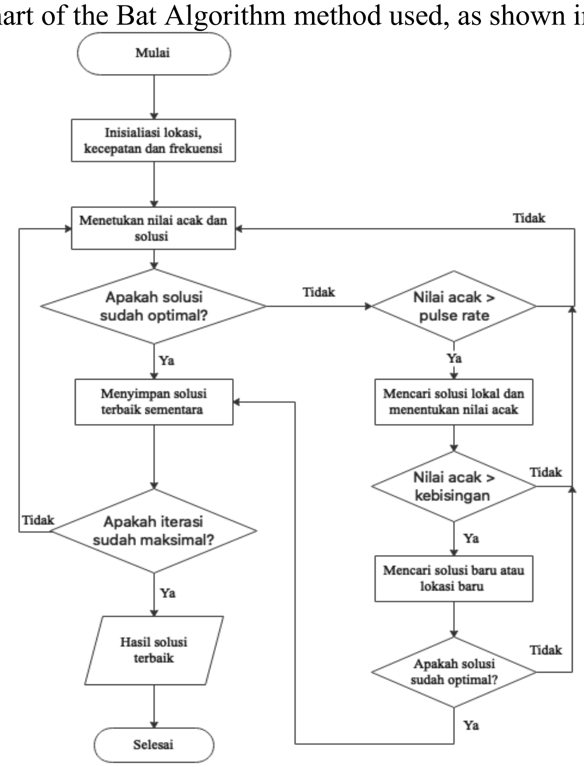

Figure 2. BAT Flowchart

2.5. Genetic algorithm

The genetic algorithm is an algorithm pioneered by John Holland in 1975, which is stochastic. The advantage of this algorithm is intrinsic freedom and flexibility to choose the desired solution. Genetic algorithms work on the coding of the set of resolutions instead of the set of resolutions alone. The scheduling procedure using the Genetic Algorithm method is as follows:

a. Initialization of the initial population is an approach to obtaining initial chromosomes.
b. Perform individual coding.
c. Determine the objective function.
d. Determine the value of fitness.
e. It is conducting a selection to determine the parent that is reproduced based on the cumulative fitness function.
f. Perform a crossover or crossover.
g. Perform mutations with the mutation probability value (pm).

The following is a flow chart of the genetic algorithm, which can be seen in Figure 3.

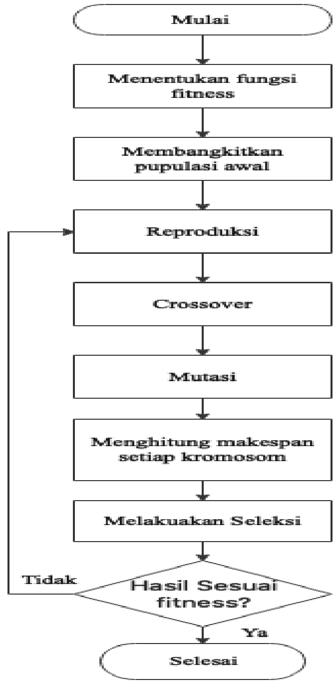

Figure 3 Genetic algorithm Flowchart

3. Research Methodology

The research method begins with conducting research first, identifying problems, and conducting literature studies. After that, the data were collected for processing data to make the makespan calculation. After that, the best model was selected from the three proposed methods and designed in the form of a program to facilitate existing calculations.

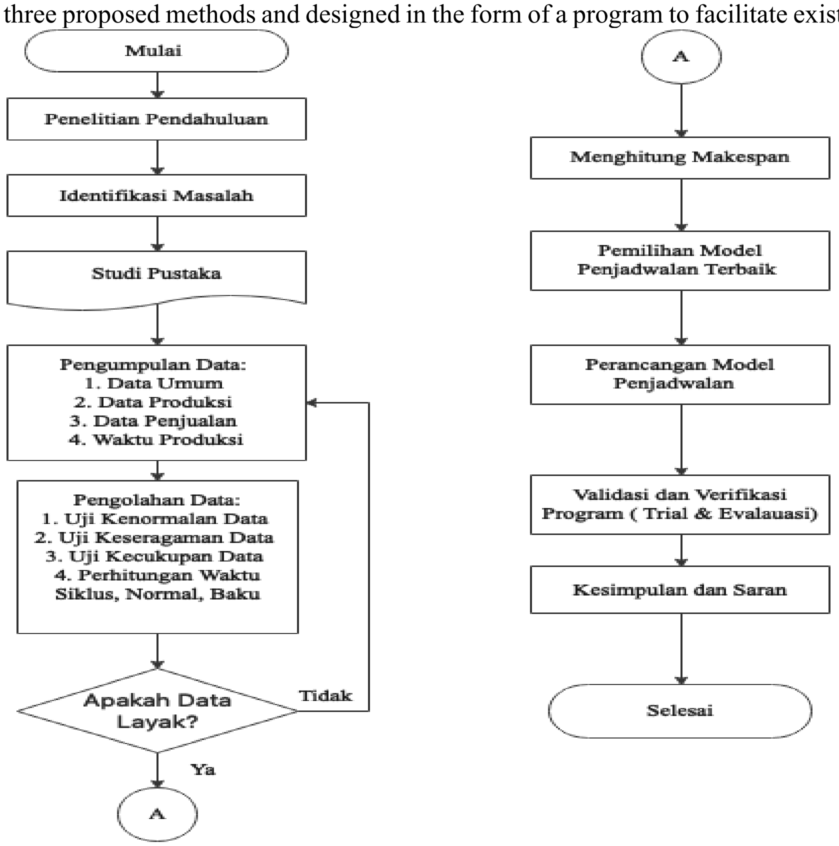

Figure 1 Research Flowchart

4. Data Collection

4.1 Production data and list of machines

The company's production data were based on product demand in Augustus 2020 can be found in Table 1. The following is the machines' list, along with the capacity of each machine.

Table 1. Product order data for August 2020
(Source: Company Data)

No	Product Name	Packing	Capacity Product (kg)	Total PO (box)
1.	Paku ¾"	30 kg (15 inner box/2 kg)	6540	218
2.	Paku 1"	30 kg (6 inner box/5kg)	13800	460
3.	Paku 1¼"		8070	269
4.	Paku 3"		6420	214
5	Paku 4"	30 kg	7950	265

Table 2. Machine and Production Personnel
(Source: Company Data)

Process	Machine or Personal Name	Capacity	Machine or Personal	Setup Time (minute)
Drawing	Drawing Machine	500 kg	2 Unit	1,5
Cutting	Nail Machine	300-500 kg	5 Unit	1,5
Glossing 1	Big Glossing Machine	500 kg	2 Unit	0,5
Glossing 2	Small Glossing Machine	300 kg	2 Unit	0,5
Packing	Manual (Tenaga Kerja Manusia)	30-50 box	5 Person	0,5

4.2 Time measurement

Research measuring time was carried out at PT. Paku Gajah Mas with direct observation techniques in the production section using a stopwatch. Production data collected is data in August 2020. Table 3 shows a summary of the cycle time measurement.

Table 3. Summary of cycle time measurement

Job	Drawing	Cutting	Glossing 1	Glossing 2	Packing
Paku 4"	42.30	76.60	51.83	62.50	43.00
Paku 3"	51.80	77.07	51.83	65.13	41.90
Paku 1¼"	62.03	77.40	52.13	74.37	41.97
Paku 1"	68.07	78.50	52.60	76.90	42.47
Paku ¾"	77.70	81.03	52.30	81.93	42.07

4.3 Data Testing

For the next step, the data testing in this study included a normality test, uniformity test, and data adequacy test. These three tests are carried out by assuming that each machine operator is working in normal condition. The normality test was carried out using the Kolmogorov Smirnov method with the help of SPSS 20. The uniformity test was carried out to ascertain what cycle times were at the control limit. Simultaneously, the data adequacy test uses a 95% confidence level and a 5% accuracy level. If all of the data had been tested, then all data will continue with data processing.

4.4 Data processing

From the tests carried out, the next step is to calculate the processing time. The result of the standard time calculation is then added to the setup time of each machine.

Process Time = (Standard Time x Order Quantity) + Setup Time………………..(7)
Table 4 shows the results of processing time calculations.

Table 4. Processing time

Job	Drawing	Cutting	Glossing 1	Glossing 2	Packing
Paku 4"	59.66	98.78	52.33	63.00	46.08
Paku 3"	72.73	99.37	52.33	65.63	44.91
Paku 1¼"	86.80	99.80	52.63	74.87	44.98
Paku 1"	95.09	101.20	53.10	77.40	45.51
Paku ¾"	108.34	104.41	52.80	82.43	45.09

4.5 Current company scheduling

PT. Paku Gajah Mas use scheduling, which is carried out according to incoming requests or what is also known as the First Come First Serve method. Scheduling of PT. Paku Gajah Mas can be seen in Table 5. below.

Table 5. Calculation results of the FCFS method (in a minute)

Job	Penarikan		Pemotongan		*Glossing 1*		*Glossing 2*		*Packing*	
	Mulai	Selesai	Mulai	Selesai	Mulai	Selesai	Mulai	Selesai	Mulai	Selesai
Paku 3"	0	72.73	72.73	172.10	172.10	224.43	224.43	290.06	290.06	334.97
Paku ¾"	0	108.34	108.34	212.75	212.75	265.55	265.55	347.98	347.98	393.07
Paku 1"	72.73	167.82	167.82	269.02	269.02	322.12	322.12	399.52	399.52	445.03
Paku 4"	108.34	168.00	168.00	266.78	266.78	319.11	347.98	410.98	410.98	457.06
Paku 1¼"	167.82	254.62	254.62	354.42	354.42	407.05	407.05	481.92	481.92	526.90
Makespan										*526.90*
Mean Flow Time										*431.41*

Based on calculations using existing methods in PT. Paku Gajah Mas, this scheduling produces a makespan value of 526.90 minutes and a mean flow time of 431.41 minutes. From the existing scheduling, in this research, it is proposed to use several methods to find the smallest makespan value in the existing scheduling.

4.6 CDS scheduling

Campbell, Dudek, and Smith (CDS) Algorithm scheduling is done with five jobs using five types of machines. The number of iterations performed is calculated using the formula k = m -1. Where m is the number of machines used, the total iteration performed is four iterations because there are five stages. After determining the number of existing iterations, then the iteration which has the smallest makespan is carried out, namely at the time of iteration 1 with the sequence Paku 4 "- Paku 1" - Paku ¾ "-Paku 1 ¼" - Paku 3 with a makespan value of 518.18 minutes and mean flow time 423.45 minutes The Makespan value for each iteration can be seen in Table 6. below.

Table 6. Makespan for each iteration (in a minute)

Iterasi	*Makespan*	*Mean Flowtime*
1	518.18	423.45
2	518.27	439.67
3	518.27	439.67
4	518.27	439.67

The best makespan calculation at the time of iteration 1 and can be found in table 7.

Table 7. CDS method calculation result (in minutes)

Job	Penarikan		Pemotongan		*Glossing 1*		*Glossing 2*		*Packing*	
	Mulai	Selesai	Mulai	Selesai	Mulai	Selesai	Mulai	Selesai	Mulai	Selesai
Paku 4"	0	59.66	59.66	158.44	158.44	210.77	210.77	273.77	273.77	319.85
Paku 1"	0.00	95.09	95.09	196.29	196.29	249.39	249.39	326.79	326.79	372.30
Paku ¾"	59.66	168.00	168.00	272.41	272.41	325.21	325.21	407.64	407.64	452.73
Paku 1 ¼"	95.09	181.89	181.89	281.69	281.69	334.32	334.32	409.19	409.19	454.17
Paku 3"	168.00	240.73	240.73	340.10	340.10	392.43	407.64	473.27	473.27	518.18
Makespan										*518.18*
Mean Flow Time										*423.45*

4.7 Genetic algorithm scheduling

Scheduling using a genetic algorithm uses several parameters, namely the parameter (pop size; pc; pm) = (30; 0.95; 0.01). Next, determine coordinated random notation as much as pop size. Every existing chromosome is calculated for makespan and fitness value. After getting the makespan value, the selection, evaluation, crossover, and mutation stages are carried out. From the mutation stage results, the makespan and fitness values are calculated again for each existing chromosome. The last step is choosing the makespan value and the smallest fitness value from all chromosomes. The genetic algorithm calculation process stops in the second generation with the job sequence Paku 4" - Paku ¾"- Paku 1¼"- Paku 1"- Paku 3" with makespan 484.30 minutes and flowtime 419.32 minutes. The second generation was discontinued due to the value of makespan and fitness value obtained are no longer changing results of chromosome recapitulation, and scheduling makespan using genetic algorithm methods can be seen in Table 8. and Table 9. below.

Table 8. Recapitulation of Chromosome Results

General	Chromosome Arrangement	Makespan (minutes)	Flowtime (minutes)	Fitness
I	ACDBE	484.30	419.32	0.00206484
II	ACDBE	484.30	419.32	0.00206484

Table 9. Scheduling Recommendations Using the Genetic Algorithm Method (Minutes)

Job	Penarikan		Pemotongan		*Glossing 1*		*Glossing 2*		*Packing*	
	Mulai	Selesai	Mulai	Selesai	Mulai	Selesai	Mulai	Selesai	Mulai	Selesai
Paku 4"	0.00	59.66	59.66	158.44	158.44	210.77	210.77	273.77	273.77	319.85
Paku ¾"	0.00	108.34	108.34	212.75	212.75	265.55	265.55	347.98	347.98	393.07
Paku 1¼"	59.66	146.46	146.46	246.26	246.26	298.89	298.89	373.76	373.76	418.74
Paku 1"	108.34	203.43	203.43	304.63	304.63	357.73	357.73	435.13	435.13	480.64
Paku 3"	146.46	219.19	219.19	318.56	318.56	370.89	373.76	439.39	439.39	484.30
Makespan										*484.30*
Mean Flow Time										*419.32*

4.8 Bat algorithm scheduling

Bat Algorithm (BA) is a metaheuristic algorithm introduced by Xin-She Yang around 2010. This algorithm is inspired by bats' behavior that distinguishes food sources and obstacles and estimates food sources' distance. The first step in this method is to determine the random number for the initial position and initial speed with the formula for the number of machines multiplied by the number of jobs available. Then the next step is to determine the parameters. The parameters used in the bat algorithm are bat_size = 10, Qmin = 0, Qmax = 1, $\alpha = 0.9$, $\gamma = 0.9$, A_i = 1, r_i = 0.3, MaxIteration = 2. Random value limit [a, b] with a = 0 and b = 1. The next step is to compare the makespan obtained between the old solution and the new solution calculated in the next iteration. The resulting update solution is shown in Table 10. Below

Table 10. Update Solution (in minutes)

$X_{i,j}$	Acak I	Ai	*makespan* (Solusi Lama)	*makespan* (Solusi Baru)	*makespan* (Solusi update)
$X_{1,j}$	0.778	1	612.72	545.67	545.67
$X_{2,j}$	0.054	1	519.44	545.67	519.44
$X_{3,j}$	0.727	1	585.58	681.05	585.58
X_{4j}	0.817	1	495.91	546.98	495.91
$X_{5,j}$	0.121	1	533.89	588.61	533.89
$X_{6,j}$	0.365	1	587.53	596.19	587.53
$X_{7,j}$	0.386	1	640.32	531.25	531.25
$X_{8,j}$	0.315	1	604.66	536.71	536.71
$X_{9,j}$	0.758	1	578.69	602.7	578.69
$X_{10,j}$	0.040	1	545.76	545.35	545.35

The update solution is obtained by comparing the smallest makespan value between the old and the new solutions. After getting the update solution, this position's makespan value is obtained, as shown in Table 11below.

Table 11. Makespan Value of Position Update (in minutes)

$X_{i,j}$	*makespan*
$X_{1,j}$	552.15
$X_{2,j}$	519.44
$X_{3,j}$	585.58
X_{4j}	495.95
$X_{5,j}$	533.89
$X_{6,j}$	587.53
$X_{7,j}$	557.69
$X_{8,j}$	514.64
$X_{9,j}$	609.90
$X_{10,j}$	545.35

It is found that the makespan time using the bat method scheduling algorithm, which is chosen with the smallest value, is bat 4, which is 495.95 minutes in the sequence 1-1-1-2-3-2-1-2-1-3-2-3-4-4-2-5-3-4-3-5-5-4-5-4-4. Job 1 is done on machine one for initial work, and then job 1 is done on machine 2, then work on machine 3, the job 3 is done by machine 1, after that do the next jobs up to job 4 on the machine.

5. Results and Discussion

5.1. Scheduling comparison of FCFS, CDS, Bat algorithm, Genetic algorithm

Based on the analysis that has been done, it is found that scheduling using the CDS method, genetic algorithm, and bat algorithm produces a smaller makespan compared to the makespan value of FCFS that exists in the company today.
The best result of the CDS method is during iteration I with the sequence Nail 4 "- Paku 1" - Paku ¾ "-Paku 1 ¼" - Paku 3 "with makespan value 518.18 minutes and mean flow time 42.45 minutes. Using the CDS method is has an efficiency index of 1.017, while the genetic algorithm method produces a smaller makespan, namely 484.3

minutes with the job sequence Paku 4" - Paku ¾"- Paku 1¼"- Paku 1"- Paku 3". And in the bat method, the resulting makespan time algorithm is 514.35 minutes, with the order of scheduling using the bat algorithm is 1-1-1-1-2-3-2-1-2-1-3-2-3-4-4-2-5-3-4-3-5-5-4-5-4-4. The state improvement value for this bat algorithm method is 6.24% of relative error.

Table 12. Comparison of CDS, Genetic Algorithm, and Bat Algorithm

	FCFS	**CDS**	**Genetic Algorithm**	***Bat Algorithm***
Urutan Job	Paku 3" - Paku ¾" - Paku 1" - Paku 4" - Paku 1 ¼ "	Paku 4" - Paku 1"- Paku ¾"-Paku 1¼"- Paku 3"	Paku 4" - Paku ¾"- Paku 1¼"- Paku 1"- Paku 3"	Paku 4" - Paku 3"- Paku 1¼" - Paku 1- Paku ¾"
Makespan	526.90	518.18	484.3	495.95
Mean Flowtime	431.41	423.45	419.32	424.66
Efficiency Index	-	1.017	1.09	1.062
Relative Error	-	1.68%	8.80%	6.24%

5.2 Program Desing

Java GUI (Graphic User Interface) is a Java language program created using a GUI-based application to add several components. Java GUI has functionalities that make application programs designed to be able to run on several different platforms. Scheduling programs that have been designed using the Java GUI are the main menu with two options, namely files and data. In the file selection is a menu that contains a menu for processing the data. The data that has been inputted will be processed and produce all scheduling sequences, makespan time, and flow time. Meanwhile, the data menu is a menu for entering and storing data needed in scheduling calculations. In this data menu, there are two parts (manage products and manage machines). The visual design of the scheduling application can be found in Figures 2, 3, and 4.

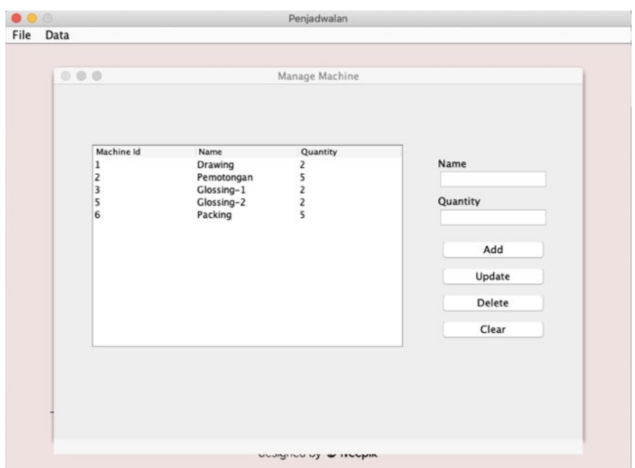

Figure 2. Input view for a machine

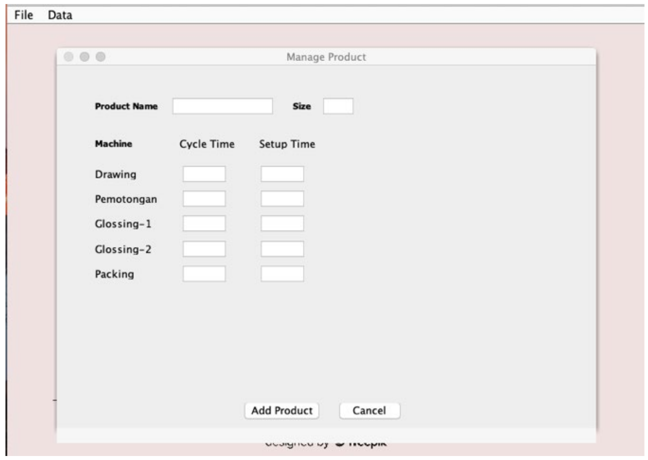

Figure 3. Input view for product and process time of scheduling

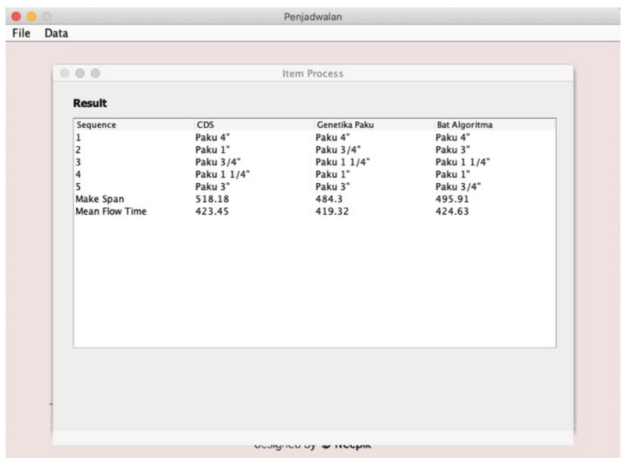

Figure 4. Output calculation

In program validation, the production data in August 2020 was inputted into the program to test whether the program was following the predetermined algorithm. The job sequences, makespan, and mean flow time results of the program's calculations were compared with manual calculation results. According to the comparison result, a similar sequence of jobs, makespan, and mean flow time were obtained. The comparison results of makespan and mean flow time calculation can be seen in Table 13.

Table 13. Program Validation

	Manual calculation		Program calculation	
	Makespan	Mean Flowtime	Makespan	Mean Flowtime
CDS Algorihtm	518.18	423.45	518.18	423.45
Genetic Algorithm	484.3	419.32	484.3	419.32
Bat Algorithm	495.95	424.66	495.91	424.63

6. Conclusion

The smallest makespan value is obtained from the resulting three methods to be a good scheduling proposal for PT. Paku Gajah Mas is using a genetic algorithm method. The makespan time using the genetic algorithm method becomes 484.3 minutes, while the makespan time for the company method is FCFD is 526.90 minutes. The reduced makespan time is 42.6 minutes, and by using the genetic method, it is obtained that the efficiency index 1.09. So that for the scheduling of the company PT. Paku Gajah Mas proposed using the genetic algorithm method in scheduling the products to be produced.

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Biography

Tira Natasha, was born in Indonesia in 1998. She is an undergraduate student of Tarumanagara University majoring in Industrial Engineering. She is active in the organization and has worked as an engineering laboratory assistant. Shae had an internship at PT. Asri Pancawarna at quality control division and researched scheduling system at PT. Paku Gajah Mas to achieve her Bachelor's degree.

Lina Gozali is a lecturer in the Industrial Engineering Department at Universitas Tarumangara since 2006 and a free-lance lecturer at Universitas Trisakti since 1995. She got her Bachelor's degree at Trisakti University, Jakarta - Indonesia, then she graduated Master's Degree at STIE IBII, Jakarta – Indonesia, and graduated with her Ph.D. at Universiti Teknologi Malaysia, Kuala Lumpur – Malaysia in 2018. Her apprentice college experience was in paper at Kertas Bekasi Teguh, shoe at PT Jaya Harapan Barutama, automotive chain drive industry at Federal Superior Chain Manufacturing. She teaches Production System and Supply Chain Management Subjects and her Ph.D. research about Indonesian Business Incubator. She actively writes for almost 40 publications since 2008 in the Industrial Engineering research sector, such as Production Scheduling, Plant LayOut, Maintenance, Line Balancing, Supply Chain Management, Production Planning, and Inventory Control. She had been worked at PT. Astra Otoparts Tbk as International.

Lamto Widodo is a lecturer at Tarumanagara University Jakarta since 1994, joining the Mechanical Engineering Department.; he is involved as a team for the Industrial Engineering Department opening in 2004-2005. He was starting in 2005 as a lecturer in the Industrial Engineering Department. Obtained a Bachelor's degree at the Sepuluh Nopember Institute of Technology Surabaya (ITS), then completed a Master's degree at the University of Indonesia (UI) and graduated with the title Dr. at the Bogor Agricultural Institute (IPB). He is engaged in research and publication in Product Design and Ergonomics, Production Systems, and Engineering Economics and teaches at many universities in Jakarta. He has published nearly 30 publications in the field of Industrial Engineering research both nationally and internationally. Active in various professional organizations, especially in the field of Ergonomics

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Frans Jusuf Daywin was born in Makasar, Indonesia on 24th November 1942. is a lecturer in the Department of Agricultural Engineering at Faculty of Agricultural Technology Bogor Agricultural University since 1964 conducted teaching, research, and extension work in the field of farm power and machinery and become a professor in Internal Combustion Engine and Farm Power directing and supervising undergraduate and graduate students thesis and dissertation and retired as a professor in 2007. In 1994 up to present as a professor in Internal Combustion Engine and Farm Power at Mechanical Engineering Program Study and Industrial Engineering Program Study Universitas Tarumanagara, directing and supervising undergraduate student's theses in Agricultural Engineering and Food Engineering Desain. In 2016 up to present teaching undergraduate courses of the introduction of concept technology, research methodology, and seminar, writing a scientific paper and scientific communication, and directing and supervising undergraduate student's theses in Industrial Engineering Program Study at the Faculty of Engineering Universitas Tarumanagara. He got his Ir degree in Agricultural Engineering, Bogor Agricultural University Indonesia in 1966, and finished the Master of Science in Agricultural Engineering at the University of Philippines, Los Banos, the Philippines 1981, and got the Doctor in Agricultural Engineering, Bogor Agricultural University Indonesia in 1991. He joined 4-month farm machinery training at ISEKI CO, AOTS, Japan in 1969 and 14 days agricultural engineering training at IRRI, Los Banos the Philippines, in March 1980. He received the honors "SATYA LANCANA KARYA SATYA XXX TAHUN" from the President of the Republic of Indonesia, April 22nd, 2006, and received appreciation as Team Jury from the Government of Indonesia Minister of Industry in Industry Start-Up 2008. He did several research and survey in the field of farm machinery, farm mechanization, agricultural engineering feasibility study in-field performance and cost analysis, land clearing and soil preparation in secondary forest and alang-alang field farm 1966 up to 1998. Up till now he is still doing research in designing food processing engineering in agriculture products. Up to the present he already elaborated as a conceptor of about 20 Indonesia National Standard (SNI) in the field of machinery and equipment. He joins the Professional Societies as a member: Indonesia Society of Agricultural Engineers (PERTETA); Indonesia Society of Engineers (PII); member of BKM-PII, and member of Majelis Penilai Insinyur Profesional BKM-PII.

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