Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2020, 7(7):217-227

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Strategy Production Scheduling for Optimalization Production Planning (Case Study in Medical Devices Company)

Defi Norita, Ririn Regiana Dwi Satya

Industrial Engineering Department, Faculty of Engineering, Mercu Buana University, Jakarta
Industrial Engineering Department, Faculty of Engineering and Computer Science, Indraprasta University PGRI, Jakarta
defi.norita@gmail.com, ririn.regiana86@gmail.com

Abstract Manufacturing companies that produce medical devices in their operational processes have not implemented effective production scheduling, in which case the process of completing a number of orders has been delayed from the established due date. In conducting the production process, the company requires makespan of the production process, the high of makespan raises the waiting time for other types of products and impedes the activities of the production process so that production scheduling is needed. The purpose of production scheduling is to increase resource use or reduce waiting time, so that total processing time can be reduced and productivity can be increased. The methods used in this study are Forecasting (Forecasting), Master Production Schedule (MPS), Campbell, Dudeck and Smith (CDS) and Aggregate Planning. Furthermore, in this study the results of the application of the CDS method produced a makepan time of 1061 minutes with a sequence of work assignments 2-7-4-3-8-6-1-5. The application of the CDS method can reduce the company's makepan by 1200 minutes in each production process of 8 types its products. The next step is to use aggregate planning in making production planning decisions at the company, aggregate planning uses 3 alternatives including variations in inventory levels, labor and subcontracts. The best results with the lowest cost are the second alternative because it produces the lowest cost among the three alternatives. The second alternative resulted in a fee of Rp 235,838,968. It is expected that by reducing the makespan, the company can achieve production targets according to consumer demand so that the company can avoid delays in shipping and increase consumer confidence.

Keywords Production Scheduling, Forecasting (Forecasting), Master Production Schedule (MPS), Campbell, Dudeck and Smith (CDS) and Aggregate Planning

1. Introduction

Production scheduling in the industrial world, both manufacturing and agro-industry has an important role as a form of decision making. The company strives to have the most effective and efficient scheduling so as to increase the productivity produced with the minimum total cost and time. Scheduling itself is a design activity in the form of allocating resources both machinery and labor to carry out a set of tasks according to the process within a certain period of time. The first step in planning a production schedule, which must be considered is the availability of available resources, whether in the form of labor, processor equipment or raw materials. Good scheduling will have a positive impact, namely lower operating costs and delivery time, which can ultimately increase customer satisfaction.

Outline scheduling can be distinguished in scheduling for job shops and flow shops. The problem that distinguishes between job shops and flow shops is workflow patterns that do not have the same process stages. Flow shop scheduling is the flow pattern of N jobs that go through the same process (in the same direction) [1].

Flow shop model is a work that is considered as a collection of operations where the implementation of a special precendent structure. Flow shop production scheduling has a method that can be used, namely the Campbell Dudeck and Smith Method.

This study uses the Campbell Dudeck and Smith method which is expected by the company to find out the minimum or most effective total processing time. The purpose of scheduling with the Campbell Dudek Smith method is to minimize the time of makingpan production machines [2]. This is needed to adjust consumer demand for products so that it is expected that services to consumers can be met properly. This research was conducted to determine the company's production scheduling that is most effective in the time of completion of its operations. The application of the Campbell Dudeck and Smith method in the company is expected to get production scheduling and job processing processes that are more effective for the implementation of its production process activities, but still pay attention and prioritize product quality. The next process is decision making using aggregate planning, where aggregate planning is used to adjust production capability in the face of uncertain market demands by optimizing the use of available labor and production equipment so that the total production costs incurred by the company can be reduced to a minimum [3-17].

A manufacturing company that manufactures medical devices. The operational process at company has not implemented an effective production scheduling where the production process takes a long time so that the company experiences delays in product delivery. The products that are experiencing delays in the production process are TSN 015 A, TSN 014-3, TSN 9806 WHSD, TSN 014 D, TSN 014 S, TLC 1H, TSN 015 B and TLC 2 HT LED. This problem occurs because of the high makespan in the product processing process so that the completion of a number of orders has been delayed from the due date that has been set. The production process itself is carried out through several processes including sanding, painting, laser, assembling, electro, QC and Packing. The following is the job operating time data for each production machine that works in units of minutes:

Table 1: Job Operating Time Data for Each Production Machine (minutes)

Job	**Machine**						
	Pengamplasan	**Painting**	**Laser**	**Assembling**	**Elektro**	**QC**	**Packing**
TSN 015 A	11	45	3	52	50	125	10
TSN 014 - 3	6	40	4	30	40	117	8
TSN 9806 WHSD	7	43	5	60	63	100	14
TSN 014 D	9	42	4	38	40	120	9
TSN 014 S	8	39	3	35	35	122	7
TLC 1 H	9	60	6	60	70	120	13
TSN 015 B	5	35	5	40	47	108	9
TLC 2 HT LED	10	56	7	60	64	122	11

Table 1 data above can be seen that the production process takes a long time so it is feared the production process exceeds the specified due date. Therefore it is necessary to do a study to improve production scheduling in medical equipment companies.

2. Material and Methods

In carrying out research, a research design is needed so that it can assist in determining the research steps. The systematic stages in the design of this study are:

Forecasting

Historical data requests are used as input for forecasting. From the demand data is then plotted into a graph to find out the pattern of the data whether it follows the pattern of random data, trends, seasonal, and others. Forecasting method used is Single Exponential Smoothing to predict future needs chosen by following the type of data patterns that have been plotted and processed using the WinQSB application calculation.

Master Production Schedule (MPS)

A company must conduct production planning, this aims to the process of determining the level of output as a whole in order to meet the desired level of sales of the company and according to consumer demand.

This production plan, based on the results of the calculation of forecasting and actual demand from consumers, is used as material for the production plan. Based on the production plan obtained will then be broken down into MPS to show the quantity of the final product that will be produced for each time period (weekly or daily).

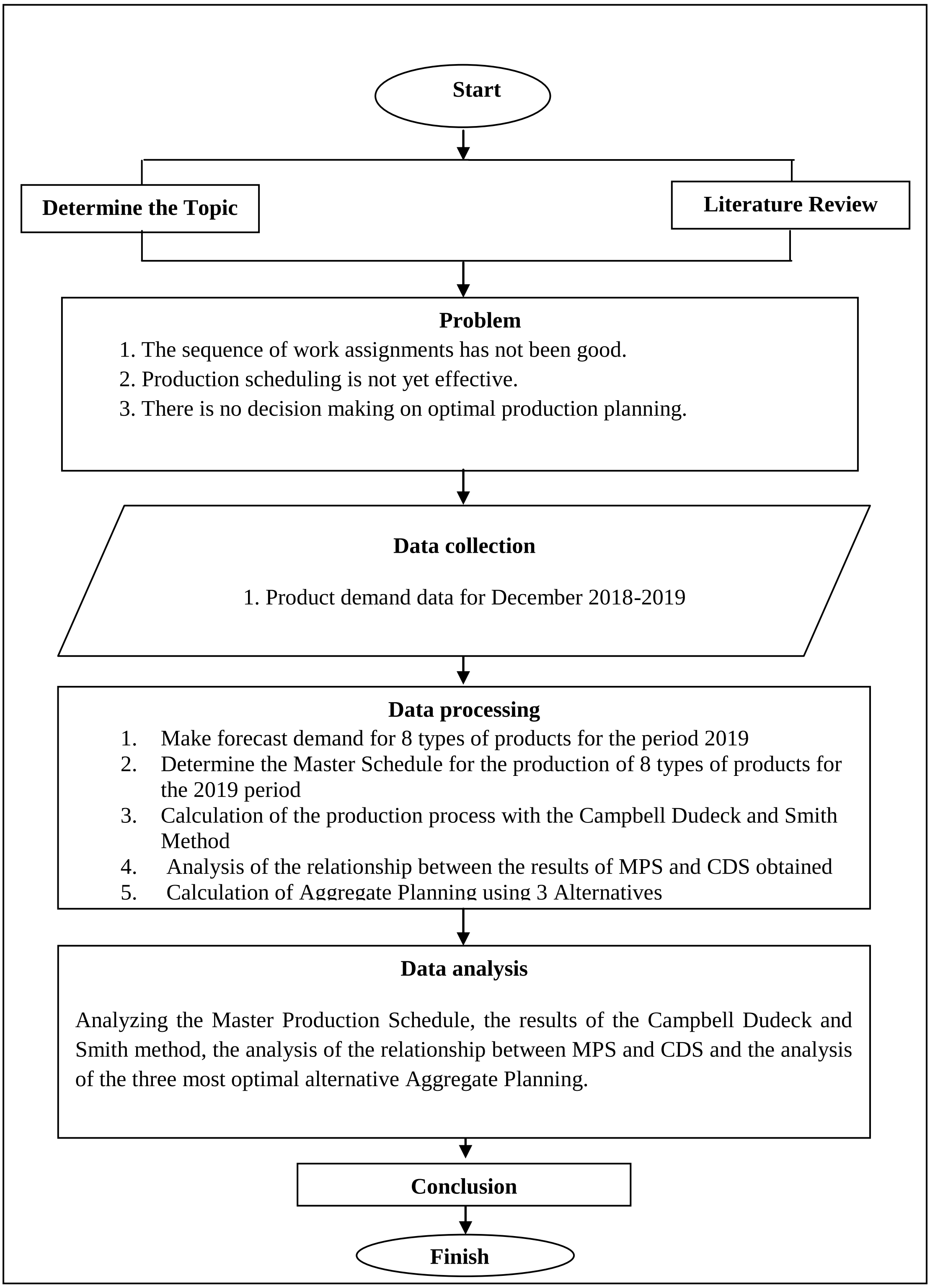

Figure 1: Research Steps

The final results of the MPS are then made into a comparison between data processing performed by the Campbell Dudeck and Smith (CDS) method.

The Campbell Dudeck and Smith (CDS) Method

Calculation of the Campbell Dudek and Smith method is carried out with the following steps:

a. Set K = 1. For all available tasks, look for the minimum price of tki, 1 and tki, 2 which is the process time of the first and second machines in the k iteration.
b. If the minimum time obtained on the first machine (eg tki, 1) then place the task in the initial order, if the minimum time obtained on the second machine (eg tki, 2) the task is placed in the last sequence.
c. Remove the tasks from the list and sort them. The total time t1,1, namely the process time of job 1 on machine 1. Total time t1,2, namely t1,1 + t1,2. The total time t2,1 is t1,1 + t2,1. The total time t2,2 is max {t1,2, t2,1} + t2,2 and so on. If there are still tasks left, repeat step 1, otherwise if there are no more tasks left, the sorting has been completed.

Aggregate Planning

Aggregate Planning using the results data comparing the results of the MPS and the Campbell, Dudek and Smith (CDS) method. Aggregate planning is done by trial and error method using three alternatives namely variations in inventory levels, variations in the number of workers and subcontracting strategies. Aggregate Planning is used to be the best production planning decision making proposal among the three alternatives.

3. Result and Discussion

Forecasting

Forecasting methods applied to this data processing using the Single Exponential Smoothing method. Forecasting is done to get product demand forecasting data in 2018. The data used in the forecasting method is to use product demand data TSN 015 A, TSN 014-3, TSN 9806 WHSD, TSN 014 D, TSN 014 S, TLC 1 H, TSN 015 B and TLC 2 HT LED during the period December 2018 - December 2019. The data processing method of Single Exponential Smoothing uses the WinQSB application.

Master Production Schedule (MPS)

The Master Production Schedule (MPS) is used to plan the production process of an output related to the quantity and time period. MPS data is obtained from sales plan results plus actuaul orders. The processing of Master Production Schedule (MPS) data is TSN 015 A, TSN 014-3, TSN 9806 WHSD, TSN 014 D, TSN 014 S, TLC 1H, TSN 015 B and TLC 2 HT LED. The following are the results of the resume of the Master Production Schedule (MPS) of the eight types of products TSN 015 A, TSN 014-3, TSN 9806 WHSD, TSN 014 D, TSN 014 S, TLC 1H, TSN 015 B and TLC 2 HT LED.

Tabel 2: *Master Produuction Schedule* 2019 (Perday)

Month	Product							
	TSN 015 A	TSN 014-3	TSN 9806 WHSD	TSN 014 D	TSN 014 S	TLC 1 H	TSN 015 B	TLC 2 HT LED
January	3	4	3	2	2	3	2	2
February	3	4	3	3	3	3	2	2
March	3	3	3	2	3	3	3	2
April	3	3	3	3	2	3	3	2
May	3	3	3	2	2	3	2	2
June	3	4	3	3	3	3	3	3
July	3	4	3	3	3	3	3	2
August	3	3	3	3	3	3	3	3
September	3	4	4	3	2	3	3	3
October	3	4	4	3	3	3	3	3
November	3	4	3	3	3	3	3	3
December	3	4	3	3	3	3	3	3

Based on table 3 it can be seen that the results of the Master Produuction Schedule are obtained from the forecasting results of 8 product requests. The results obtained from the MPS data processing are the planned production of 8 products for one day every month during 2018. The average production plan every day is 23 products.

Production Scheduling with the Campbell, Dudeck and Smith method

Efforts to get the optimal makespan value will be used by the CDS method where this method is a development of Johnson's Algorithm. The data to be processed using the CDS method consists of 8 job 7 machines in which all jobs have the same processing sequence. The following is the job operating time data for each production machine that works in minutes

Table 3: Scheduling 8 *Job* 7 Machine

Job	**Machine**						
	1	2	3	4	5	6	7
1	11	45	3	52	50	125	10
2	6	40	4	30	40	117	8
3	7	43	5	60	63	100	14
4	9	42	4	38	40	120	9
5	8	39	3	35	35	122	7
6	9	60	6	60	70	120	13
7	5	35	5	40	47	108	9
8	10	56	7	60	64	122	11

The CDS method is applied to minimize the total time of the initial makespan. The CDS method can be applied and produces iterations. The number of iterations is k = m - 1 = 7 - 1 = 6. The seven iterations are obtained by comparing the time of each job on each machine.

First iteration, k = 1

t1j, 1 = tj, 1

t1j, 2 = tj, 7

Table 4: First iteration

Job	**Total processing time (minutes)**	
	$t^1_{j,1}$	$t^1_{j,2}$
1	11	10
2	6	8
3	7	14
4	9	9
5	8	7
6	9	13
7	5	9
8	10	11

Based on the first iteration in table 4.5 for k = 1, it produces working order 7 - 2 - 3 - 6 - 8 - 1 - 4 - 5. Then iterates until the 6th iteration.

Sixth iteration, k = 6

t6j, 1 = tj, 1 + tj, 2 + tj, 3 + tj, 4 + tj, 5 + tj, 6

t6j, 2 = tj, 2 + tj, 3 + tj, 4 + tj, 5 + tj, 6 + tj, 7

Tabel 5: Sixth iteration

Job	**Total processing time (minutes)**	
	$t^6_{j,1}$	$t^6_{j,2}$
1	286	285
2	237	239
3	278	285
4	253	253
5	242	241
6	325	329
7	240	244
8	319	320

Based on the first iteration in table 4.15 for k = 6 produces work order 2 - 7 - 4 - 3 - 8 - 6 - 1 - 5.

Table 6: Sixth Total Iteration Time

Job	Processing Time on Each Machine (minutes)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
2	6	46	50	80	120	237	245
7	11	81	88	128	175	345	354
4	20	123	127	166	215	465	474
3	27	166	171	231	294	565	579
8	37	222	229	291	358	687	698
6	46	282	288	351	428	807	820
1	57	327	330	403	478	932	942
5	65	366	369	438	513	1054	1061

The work order results obtained in the sixth iteration are used as work order of the production process so that the total time of makespan is obtained as in table 6 which is 1061 minutes. The results of the makespan for each iteration of the CDS method data processing are presented as in table 7, from the six iterations in table 7, the minimum makespan value of 1061 minutes is obtained in the sixth iteration with job work sequences of 2 - 7 - 4 - 3 - 8 - 6 - 1 - 5.

Table 7: Makespan value for each iteration

Iterasi (*k*)	Makespan Value (minutes)
1	1073
2	1079
3	1079
4	1067
5	1067
6	1061

Based on the results of iteration 8 job 7 Machine, it can be seen that the initial makespan of the total production process time is 2261 minutes, by applying the CDS method the company can minimize the production process time with the total time of makingpan 1061 minutes. So that a difference of 1200 minutes is obtained in each production process.

Analysis of the Relationship of MPS and CDS

Calculation of analysis of the relationship between MPS and CDS is based on the results of data that have been obtained in previous calculations. When the makespan of CDS calculation produces 1061 minutes to produce 8 units of product, the average time of makespan CDS is 132.6 minutes so that it can be said that each 1 unit of product requires a production process time of 132.6 minutes. The analysis of the relationship between MPS and CDS is carried out to determine the time of day production process of a company in producing its products in accordance with the expected MPS. This calculation is also used to determine the average production time for each product unit.

Table 8: Analysis of the Relationship of MPS and CDS

Month	MPS Product Perday	Production Time Per Day (minutes)	Production Time Per Hour (hour)	Number of Workers Per Shift
January	21	2815	46.9	6
February	22	2854	47.6	6
March	21	2816	46.9	6
April	22	2973	49.6	6
May	22	2914	48.6	6
June	24	3230	53.8	7
July	25	3355	55.9	7
August	23	3040	50.7	6
September	25	3270	54.5	7
October	26	3511	58.5	7
November	25	3379	56.3	7
December	24	3157	52.6	7
Total	281	37315	621.9	7
Mean	23	3110	51.8	6

Based on table 8 above, the production time obtained from MPS per day product is multiplied by the average time of makespan CDS so that the average production time per day is 51.8 hours or rounded to 52 hours. While the number of workers needed per day is obtained from the time of production per day for 1 work shift, then the average worker needed is 6 people per day. The results from table 4.18 can be used as a reference calculation to get the average production time of each worker, then the average production time can be calculated as follows:
a. Average time of production / Average number of workers = 52/6 = 8.6 hours / person.
b. Average MPS per day / Average number of workers = 23/6 = 3.8 units / person.
c. Average production time per worker = 8.6 / 3.8 = 2.2 hours / unit.
The results obtained from the above calculations can be seen that the time required by a worker to complete one product is 2.2 hours per day.

Aggregate Planning

Aggregate planning is made to adjust the ability of production in the face of uncertain market demands by optimizing the use of available labor and production equipment so that the total cost of production can be reduced to a minimum. Aggregate planning is done by trial and error method where the amount of energy is fixed and the structure of the cost is linear. Aggregate planning data processing uses time data obtained from the data analysis results of the relationship between MPS and CDS. The following is the demand data and production data needed for aggregate planning, namely:

Table 9: Demand

Month	Number of working days	Forecast Demand (perday)	Forecast Demand (perbulan)
January	22	21	467
February	19	22	409
March	21	21	446
April	21	22	471
May	20	22	440
June	15	24	365
July	22	25	556
August	21	23	481
September	19	25	469
October	23	26	609
November	21	25	535
December	18	24	429
Total	242	281	5676

Based on table 9 demand data and production data above, there are 3 alternative strategies that will be used for aggregate planning, namely alternative inventory level variations, alternative variations in the number of workers and alternative subcontract strategies. The following is an aggregate planning data processing:

a. Alternative 1 variation in inventory levels

The first alternative is used to determine variations in inventory levels, the following is the data needed for Alternative 1:

1) Average production inventory / day = 5676/242 = 23.4 units / day rounded up to 23 units / day.

2) 1 unit of product needs 2.2 hours, while working hours per day is 8 hours, so that 1 employee produces 8 / 2.2 = 3.6 units / day rounded up to 4 units / day.

3) To produce 23 units / day requires labor of 23/4 = 5.7 people rounded to 6 people.

The complete calculation for alternative 1 is as follows:

Table 10: Alternatif 1

Month	Estimated Demand (monthly)	Number of working days	Production Amount	Inventory Changes	Inventory Accumulation
January	467	22	516	49	49
February	409	19	446	37	86
March	446	21	493	47	132
April	471	21	493	22	154
May	440	20	469	30	184
June	365	15	352	-14	170
July	556	22	516	-40	130
August	481	21	493	11	141
September	469	19	446	-23	118
October	609	23	539	-69	49
November	535	21	493	-43	6
December	429	18	422	-6	0
Total	5676	242	5676	0	1220

Costs incurred on alternative 1, namely:
1) Labor Costs: 6 × 242 × Rp 165,500, - = Rp 240,306,000
2) Inventory Cost: 1220 × IDR 15,000 - = IDR 18,301,070
Amount = Rp. 258,607,070

Based on the data in table 4.20 obtained the results of data processing that will be used to calculate the costs incurred in alternative 1. Costs incurred in alternative 1, namely labor costs and inventory costs. The total cost needed for Alternative 1 is IDR 258,607,070.

b. Alternative 2 variations in the number of workers

The second alternative is used to determine variations in the number of workers, here are the data needed for alternative 2:

1) At the beginning of the period the number of workers = 6 people, while the number of workers needed in January = 467/22/4 = 5 people.
2) Labor costs = 22 × 5 × Rp. 165,500.00 = Rp. 19,320,056.00 and so on.

The complete calculations for alternative 2 are as follows:

Tabel 11: Alternatif 2

Month	Estimated Demand (monthly)	Number of working days	labor needs	Labor Cost		Add Labor	Reduction Labor
January	467	22	5	Rp	19.320.056,25	-	1
February	409	19	5	Rp	16.917.410,00	-	-
March	446	21	5	Rp	18.450.995,06	-	-
April	471	21	6	Rp	19.477.527,43	1	-
May	440	20	5	Rp	18.184.523,51	-	1
June	365	15	6	Rp	15.115.464,31	1	-
July	556	22	6	Rp	23.024.507,27	-	-
August	481	21	6	Rp	19.914.819,73	-	-
September	469	19	6	Rp	19.384.437,69	-	-
October	609	23	7	Rp	25.189.410,14	1	-
November	535	21	6	Rp	22.139.284,40	-	1
December	429	18	6	Rp	17.730.533,04	-	-
Total	5676	242	70	Rp	234.848.968,84	3	3

Costs incurred in alternative 2, namely:
1) Labor Costs = Rp. 234,848,968
2) Additional Labor Costs: 3 × IDR 150,000 - = IDR 450,000
3) Labor Reduction Costs: 3 × Rp. 180,000, - = Rp. 540,000
Amount = Rp. 235,838,968

Based on the data table 111 obtained data processing results that will be used to calculate the costs incurred in alternative 2. Costs incurred in alternative 2, namely labor costs, labor costs and labor reduction costs. The amount needed in alternative 2 is IDR 235,838,968.

b. Alternative 3, Subcontracting strategies

The third alternative is used to determine variations in the number of workers, here are the data needed for alternative 3:

1) Labor is determined according to the lowest demand, namely demand in June = 365, average production per day = 365/15 = 24 units.
2) Workforce needed = 24/4 = 6 people. The number of workers during January-December is maintained at 6 people.

The complete calculations for alternative 3 are as follows:

Table 12: Alternatif 3

Month	Estimated Demand (monthly)	Number of working days	Production Amount	Inventory	Sub Contract
January	467	22	528	61	-
February	409	19	456	47	-
March	446	21	504	58	-
April	471	21	504	33	-
May	440	20	480	40	-
June	365	15	360	-	5
July	556	22	528	-	28
August	481	21	504	23	-
September	469	19	456	-	13
October	609	23	552	-	57
November	535	21	504	-	31
December	429	18	432	3	-
Total	5676	242	5808	61	134

Total monthly production is obtained by multiplying the number of working days with the number of workers with the average TK production / day. Example of the June production amount = 15 × 6 × 4 = 360 units and so on. Shortage of production of 5 units is fulfilled by sub-contract.

Costs incurred in alternative 3 are:
1) Labor Costs: 6 × 242 × Rp 165,500, - = Rp 240,306,000
2) Inventory Cost: 61 × Rp 15,000, - = Rp 915,000
3) Subcontract Fee: 134 × IDR 70,000 - = IDR 9,394,979
Amount = IDR 250,615,979

Based on the data table 12 obtained data processing results that will be used to calculate the costs incurred in alternative 3. Costs incurred in alternative 3 are labor costs, inventory costs and sub-contract costs. The total cost needed for Alternative 3 is IDR 250,615,979.

Based on the three alternatives, namely alternative variations in inventory levels, alternative variations in the number of workers and alternative subcontract strategies in the processing of aggregate planning data, obtained a decision making the best production planning where the company must take the second alternative decision namely the variation in the number of workers because the second alternative produces costs lowest among the three alternatives. The second alternative generates a fee of Rp 235,838,968, - which means that the company will spend the costs for labor costs either adding labor or reducing labor without additional costs for inventory or subcontracting costs with other parties.

4. Conclucsion

Based on the results of research and discussion that has been done, the following conclusions can be drawn:

1. Based on the research that has been done, to determine the sequence of good workmanship using the Campbell, Dudeck and Smith (CDS) method can help companies to get a sequence of workmanship that can minimize the production process time. The CDS method produces the eighth order of product types by ranking the lowest production time to be placed at the beginning and end of the production process. The results of the assignment of the tasks obtained by the CDS method are 2 - 7 - 4 - 3 - 8 - 6 - 1 - 5 or TSN 014 - 3 - TSN 015 B - TSN 014 D - TSN 9806 WHSD - TLC 2 HT LED - TLC 1 H - TSN 015 A - TSN 014 S.
2. 2. Determine effective production scheduling improvements by applying the CDS method in production scheduling can reduce the production process makespan so that the total production process time can be reduced and productivity can be increased. Research using the CDS method produces a production process makespan of 1061 minutes, which means that the CDS method can reduce a company's makepan with a total initial production process time of 2261, makespan which can be reduced by 1200 minutes in each production process of 8 types of products. The average production process time obtained from the CDS method to produce 1 type of product is 132.6 minutes.
3. 3. The use of aggregate planning in production planning decision-making produces three alternatives, namely alternative variations in inventory levels, alternative variations in the number of workers and alternative subcontract strategies. Based on research that has been done, the amount of cost needed in alternative 1 is IDR 258,607,070, alternative 2 is IDR 235,838,968, and alternative 3 is IDR 250,615,979. Decision making that can be taken is the second alternative, because in the production process the company only has to add workers when demand is rising and the reduction in labor when demand is down. Reduction of labor is done in January and July, while the addition of labor is done twice, namely in March and July. The second alternative generates a cost of Rp 235,838,968, - which means the company will spend labor costs in one year and for labor costs both adding labor and reducing labor.

Reference

[1]. Sugino, W. & Abdullah, M. (2013). *Penjadwalan Produksi Menggunakan Metode FCFS, CDS dan GUPTA*. 6 (3), hlm. 225-230.

[2]. Nadia, V., Saridewi, D.R, & Sianto, M.S. (2010). *Penjadwalan Produksi dan Perencanaan Persediaan Bahan Baku di PT Wahana Lentera Raya*. 9 (2), hlm. 179-192.

[3]. Gasperz, Vincent. (2017). *Production Planning and Inventory Control*. Jakarta : Ghalia Indonesia.

[4]. Baker, Kennenth R., Trietsch. (2009). *Principles of Sequencing and Scheduling*. America : John Wiley & Sons, Inc.

[5]. Biegel, John E. (2007). *Perencanaan Produksi*. Jakarta : Akademika Perindo.

[6]. Conway, Richard W., Maxwell, William L., Miller, Louis W. (2001). *Theory of Scheduling*. America : Addison-Wesley Publishing Company.

[7]. Ginting, Rosnani. (2009). *Penjadwalan Mesin*. Yogyakarta : Graha Ilmu.

[8]. Ginting, Rosnani. (2007). *Sistem Produksi*. Yogyakarta : Graha Ilmu.

[9]. Hakim, Arman. (2008). *Perencanaan dan Pengendalian Produksi*. Surabaya : Graha Ilmu.

[10]. Hakim, Arman. (2005). *Manajemen Industri*. Yogyakarta : Penerbit Andi.

[11]. Herjanto, Eddy. (2008). *Manajemen Operasi*. Jakarta : Grasindo.

[12]. Kusuma, Hendra. (2009). *Manajemen Produksi, Perencanaan dan Pengendalian Produksi*. Yogyakarta: Penerbit Andi.

[13]. Sofjan, Assauri. (2004). *Teknik dan Metode Peramalan*. Jakarta: Fakultas Ekonomi Universitas Indonesia.
[14]. Sofjan, Assauri. (2008). *Manajemen Produksi dan Operasi*. Jakarta : Fakultas Ekonomi Universitas Indonesia.
[15]. Sofyan, Diana Khairani. (2013). *Perencanaan dan Pengendalian Produksi*. Yogyakarta : Graha Ilmu.
[16]. Teguh,Baroto. (2002). *Perencanaan dan Pengendalian Produksi*. Jakarta : Ghalia Indonesia
[17]. Christianta, Y. & Sunarni, T. (2012). *Usulan Penjadwalan Produksi dengan Metode Campbell Dudek and Smith pada PT Pan Panel Palembang*. 26 (2), hlm. 30-35.