Optimization of Production Scheduling on the Nct Vipross 255 Machine Using the Heuristic Priority Dispatching Rules Method and Overall Equipment Effectiveness

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ABSTRAK

Penjadwalan didefinisikan sebagai proses pengalokasian sumber-sumber atau mesin – mesin yang ada untuk menjadwalkan sekumpulan tugas dalam jangka waktu tertentu , maka berdasarkan *Priority Dispacthing Rules* satu job yang memiliki prioritas tinggi untuk selanjutnya diproses pada mesin tersebut. Penelitian ini menggunakan penjadwalan Dispatching Rules SPT dan OEE. Hasil penjadwalan produksi yang terbaik yaitu menggunakan aturan SPT dengan nilai Total *Flow Time* dari **1708.61** menit menjadi **1288.14** menit, *Average Flow Time* dari **170.86** menit, menjadi **128.81** menit, *Utilitasn Mesin* dari **20%** menigkat menjadi **26%** dan rata-rata antrian *job* dari **5.06** menit menjadi **3.81** menit. Hasil penjadwalan produksi kedua yang terbaik juga menggunakan aturan SPT kepada seluruh komponen job dengan nilai total *Flow time* maksimal dari **594.35** menit menjadi **348.17** menit, rata-rata *completion time* maksimal **34.96** menit, menjadi **23.7** menit dan rata-rata antrian *job* maksimal **7.23** menit menjadi **5.12** menit, hasil perhitungan nilai *Avaibility Rate (AR)* 5.86%, nilai *Performa Rate (PR)* 91.34%, *Rate Of Quality* 97.15, nilai *Overal Eqiupment Effektivines (OEE)* 83.76%

Kata kunci: Penjadwalan, NCT Vipross 255, Utilitas Mesin

ABSTRACT

Scheduling is defined as the process of allocating resources or machines – machines for scheduling a set of tasks in a specific time period, then based on the Priority of the job one Dispacthing Rules have a high priority for the further processed on the machine. This research uses a scheduling and Dispatching Rules Such As Oee The best production scheduling results i.e. use rules Such As the Total value of Flow Time of 1708.61 minutes into 1288.14 minutes, Average Flow Time of 170.86 minutes, Utilitasn minutes, 128.81 became the engine of the menigkat 20% to 26% and the average queue job from 5.06 seconds be 3.81 minutes. The results of the second best production scheduling also uses the rules to all the components of the job SUCH AS the total value of maximum Flow time of the 594.35 minutes be 348.17 seconds, the average completion time maximum 34.96 seconds, becoming 23.7 seconds and the average queue job maximum 7.23 minutes be 5.12 seconds, the result of the calculation of the value of the Avaibility Rate (AR) 5.86%, the value of the performance Rate (PR) 91.34%, Rate Of Quality 97,15, Overal Eqiupment Effektivines (OEE) 83.76%

Keywords: Scheduling, NCT Vipross 255, utility Machines

INTRODUCTION

PT. X Batam Indonesia is a multinational company engaged in the manufacture of lifting transportation (Elevators and Escalators) and is one of the complete manufacturers whose activities include research and development, production, marketing, installation and maintenance of elevators. The response strategy to buyer demand used by PT. X is Make to Order (MTO) while the production system used by PT. X is the Job Shop production system. On the production floor there are three production departments including, Electrical Controller Department (ECD), Mechanical Department and Electrical Fixture Department (EFD). The production activities carried out by the Electrical Fixture (EFD) Department, where the research will be conducted, are focused on the Vipross 255 Numerical Control Turret Punch (NCTP) machine station. The reason for conducting the research in the EFD department is because the NCT machine often experiences problems with long job processing times. When the Mechanical department runs out of jobs for frame assembly, the ECD department also runs out of jobs for cable connections to the frame. Meanwhile, the EFD jobs on the NCT machine are not yet completed, leaving the mechanical and ECD jobs idle. This idle time ranges from 1.5 hours to 2.5 hours for operators and machines. This is due to the lack of proper scheduling, which makes it impossible to plan production times and product quality effectively. Consequently, jobs on the NCT machine accumulate, and there is also a waiting queue for a certain period, which affects the average completion time and the overall operation completion time (makespan). Furthermore, the NCT machine's utilization is very low. This will affect the production capacity on the NCT machine

because the number of jobs received is not proportional to 1 machine being run, where the NCT machine is the only one in the EFD department. Job execution on the NCT machine is very influential because the NCT machine can balance jobs to other departments, for this reason the author conducted research in the EFD department on the NCT Vipross 255 machine, because of the problems that occur in less than optimal production scheduling.

Based on the problems that occur, the author conducted research by implementing a production scheduling system and can implement it so that the NCT Vipross 255 machine can be more optimal. Scheduling is defined as the process of allocating existing resources or machines to carry out a set of tasks within a certain period of time, in the scheduling there are heurisdtic Priority Dispathcing rules, which are scheduling rules that regulate jobs on a machine that will be processed first based on certain priorities, when the machine has finished processing one job, then based on Priority Dispatching Rules, Overall Equipment Effectiveness one job is selected that has the highest priority to be further processed on the machine. so that the machine can run more optimally and better production results.

RESEARCH METHODS

This research aims to provide suggestions for continuous improvement in the performance of the production process at PT X Batam in the Electrical Fixture department of the NCT Vibros 255 Machine. Improvements begin with the order acceptance cycle and lead to increased productivity and efficiency. Improvements include optimizing average completion time, minimizing job queue waiting time, and improving product quality. Planning is needed to optimize average completion time, minimize job queue waiting time, and improve machine utility and product quality.

The research framework used in this study is explained as follows:

1. Study the mechanical department's lack of assembly jobs, long job queues, idle NJT machines lasting 1.5 to 2.5 hours, imbalanced job arrivals with 5 to 35 jobs, and very low machine utilization.
2. Develop a production scheduling optimization plan, including accelerating job processing times and minimizing machine idle time to increase machine utilization and improve production results.
3. Analyze risks in the machine scheduling and production process control stages at PT X Batam Indonesia.

First Come first Serve (FCFS)

According to this rule, the scheduling sequence is based on the arrival time of the job or customer order, so the job that arrives first or is done first and so on for the following jobs. As formulated by E. Biegel [10], several general terms used to discuss production scheduling are as follows:

1. Processing time
2. Makespan (Ms)
3. Ready time (Rj)
4. Waiting time
5. Flow time
6. Completion time
7. Due date
8. Lateness
9. Avarage Lateness
10. Tardiness
11. Slack time
12. Utulitazion Machine (U)
13. Critical ratio (CR)
14. Avarege Completion time
15. avarage n job system

Shortest Procesing Time First (SPT)

According to this rule, jobs are sorted based on the shortest processing time will be processed first and then continued by other jogs until the job with the longest processing time, this is useful for balancing the workload between machines arranged in parallel. Scheduling is used to find the average value of the flow time on one processor because the processing time of each job depends on the process sequence. If processes 1,2,3,……..n, are carried out sequentially, then for each process time is determined starting from:

$t1 < t2 < t3 \ldots\ldots\ldots tn$

The average flow time is calculated using the equation:

$$\bar{F}s = \underline{1}(F1+F2) = \underline{1}(t1+t1+t2)$$

Where:

$F1 = t1$

$F2 = t1+t2$

Scheduling with the SPT approach begins by sorting the work processing time from the

smallest to the largest, because the ones with the fastest processing time are done first so that the number of late jobs will be minimal.

Overal Equpment Effectiviness (OEE)

The things done in implementing OEE in company X Batam Indonesia are:

1. Measure

Ask operators to calculate cycle times, downtime, and production output.

Use this information to identify variations in cycle times, patterns in downtime, and product quality issues.

2. Analysis

Ask operators to identify bottlenecks, causes of downtime and factors affecting cycle time.

3. Priority

Determine the root cause of downtime, and the solutions that will keep the elevator and escalator production process running smoothly.

4. Action

Set goals for improving efficiency and hold operators accountable for achieving them. Operators take regular measurements to check that production goals are being met.

RESULTS AND DISCUSSION

Scheduling Results (*Dispatch per Job*)

This scheduling rule uses First Come First Serve (FCFS), Shortest Processing Time (SPT) and Longest Processing Time (LPT)

Scheduling Sequence Results

The following is the scheduling sequence obtained :

1. Based on the rules FCFS : job 1- job 2 – job 3 – job 4 – job 5 – job 6 – job 7 job 8 – job 9 job 10.
2. Based on the rules SPT : job 7 - job 1- job 9 – job 5 – job 6 – job 8 – job 2 – job 3 – job 10 – job 4
3. Based on the rules LPT : job 4 – job 10 – job 3 – job 2 – job 8 – job 6 – job 7 – job 1 –job 5 – job 6

Residence Time Results (Flow Time)

1. Based on the rules FCFS : residence time = 1708.61 minutes
2. Based on the rules SPT : residence time = 1288,14 minutes
3. Based on the rules LPT : residence time = 2429,09 minutes

Average completion time results (Avarage Completion Time)

1. Based on the rules FCFS : Average time to completion = 170.86 minutes
2. Based on the rules SPT : Average time to completion = 128,81 minutes
3. Based on the rules LPT : Average time to completion = 242,91 minutes

Machine Utility Results (Utulitazion Machine)

1. Based on the rules FCFS : Machine Utilities = 20%
2. Based on the rules SPT : Machine Utilities = 26%
3. Based on the rules LPT : Machine Utilities = 14%

Average result of job queue on machine (Avarage n job in system)

1. Berdasarkan aturan FCFS : Rata-rata antrian job dalam mesim = 5,06 Menit
2. Berdasarkan aturan SPT : Rata-rata antrian job dalam mesim = 3.18 menit
3. Berdasarkan aturan LPT : Rata-rata antrian job dalam mesim = 7.18 menit

Scheduling Results (Dispatch Job Components)

1. The order of each job component

Based on the FCFS rules, the job sequence is 1-2-3-4-5-6-7-8-9-10, then the scheduling sequence obtained from each job component, then the rules for each job component use the SPT rules as follows :

1. Job 1, has five (5) components of FCFS rules: 1-2-3-4-5, SPT rules: 3-5-4-1-2,

2. Job 2, has 4 components of FCFS rules: 1-2-3-4, and rules like: 2-3-4-1
3. Job 3, has 12 components of FCFS rules: 1-2-3-4-5-6-7-8-9-10-11-12, and rules like: 2-8-5-12-3-9-4-6-7-11-10
4. Job 4, has 17 components of FCFS rules 1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17, and rules such as: 16-4-5-9-10-3-6-7-14-8-13-17-12-2-1-11-15
5. Job 5, has two components: FCFS rules: 1-2, and SPT rules: 2-1
6. Job 6, has one component: FCFS rule: 1, and SPT rule: 1
7. Job 7, has 6 components of FCFS rules: 1-2-3-4-5-6, and rules like: 5-6-3-2-4-1
8. Job 8, has 9 components of FCFS rules: 1-2-3-4-5-6-7-8-9, and rules like: 4-3-7-8-9-5-1-6
9. Job 9, has 5 components of FCFS rules: 1-2-3-4-5, and rules like: 5-2-4-3-1
10. Job 10, has 13 components of FCFS rules: 1-2-3-4-5-6-7-8-9-10-11-12-13, and rules like: 13-10-12-7-11-4-6-9-3-1-5-8-2.

Average completion time results (Avarage Completion Time)

1. Job 1, for FCFS average completion time = 11.41 minutes and the rule as average completion time decreases to = 6.97 minutes
2. Job 2, for FCFS average completion time = 20.41 minutes and the rule as average completion time decreases to = 11.89 minutes
3. Job 3, for FCFS average completion time = 15.35 minutes and the rule as such average completion time decreases to = 12.16 minutes
4. Job 4, for FCFS average completion time = 34.96 minutes and the rule as average completion time decreases to = 20.48 minutes
5. Job 5, for FCFS average completion time = 19.53 minutes and the rule as average completion time decreases to = 12.38 minutes
6. Job 6, for FCFS average completion time = 23.70 minutes and the rule is that average completion time decreases to = 23.70 minutes
7. Job 7, for FCFS average completion time = 9.75 minutes and the rule as average completion time decreases to = 6.05 minutes
8. Job 8, for FCFS average completion time = 13.72 minutes and the rule as such average completion time decreases to = 11.93 minutes
9. Job 9, for FCFS average completion time = 13.10 minutes and the rule as such average completion time decreases to = 8.93 minutes
10. Job 10, for FCFS average completion time = 29.91 minutes and the rule as such average completion time decreases to = 19.59 minutes

Machine Utility Results (Utilitazion Machine)

1. Job 1, for FCFS rule Machine Utilization = 28% and for spt rule Machine Utilization increases to = 47%
2. Job 2, for FCFS rule Machine Utilization = 34% and for spt rule Machine Utilization increased to = 58%
3. Job 3, for FCFS rule Machine utility = 15% and spt rule Machine utility increases to = 20%
4. Job 4, for FCFS rule Machine Utilization = 14% and spt rule Machine Utilization increases to = 24%
5. Job 5, for FCFS rule Machine Utilization = 54% and spt rule Machine Utilization increased to = 86%
6. Job 6, for FCFS rule Machine utility = 100% and rule spt Machine utility increased to = 100%
7. Job 7, for FCFS rule Machine Utilization = 24% and spt rule Machine Utilization increases to = 38%
8. Job 8, for FCFS rule Machine Utilization = 23% and spt rule Machine Utilization increases to = 26%

9. Job 9, for FCFS rule Machine Utilization = 28% and spt rule Machine Utilization increases to = 41%

10. Job 10, for FCFS rule Machine Utilization = 21% and spt rule Machine Utilization increases to = 32%

Average Job Queue Results in Machine (Average and Job in system)

1. Job 1, for FCFS rule the average job queue in the machine = 3.51 minutes and for SPT rule the average job queue in the machine decreases to = 2.14 minutes

2. Job 2, for FCFS rule the average job queue in the machine = 2.95 minutes and for SPT rule the average job queue in the machine decreases to = 1.72 minutes

3. Job 3, for FCFS rule the average job queue in the machine = 6.46 minutes and for SPT rule the average job queue in the machine decreases to = 5.12 minutes

4. Job 4, for FCFS rule the average job queue in the machine = 7.23 minutes and for SPT rule the average job queue in the machine decreases to = 4.24 minutes

5. Job 5, for FCFS rule the average job queue in the machine = 1.84 minutes and for SPT rule the average job queue in the machine decreases to = 1.16 minutes

6. Job 6, for FCFS rule the average job queue in the machine = 1.0 minutes and for SPT rule the average job queue in the machine decreases to = 1.0 minutes

7. Job 7, for FCFS rule the average job queue in the machine = 4.24 minutes and for SPT rule the average job queue in the machine decreases to = 2.63 minutes

8. Job 8, for FCFS rule the average job queue in the machine = 4.44 minutes and for SPT rule the average job queue in the machine decreases to = 3.87 minutes

9. Job 9, for FCFS rule the average job queue in the machine = 3.54 minutes and for SPT rule the average job queue in the machine decreases to = 2.41 minutes

10. Job 10, for FCFS rule the average job queue in the machine = 4.78 minutes and for SPT rule the average job queue in the machine decreases to = 3.13 minutes

Company Scheduling Before Repair

The company's scheduling using FCFS (First Come First Serve), which prioritizes the first job entered, can be seen in Table 1.

Table 1. Scheduling using FCFS

JOB	**PROCES TIME (Menit)**	**FLOW TIME (Menit)**
1	16.25	16.25
2	27.65	43.90
3	28.50	72.40
4	82.20	145.60
5	21.27	175.97
6	23.70	199.57
7	13.82	213.39
8	24.70	238.09
9	18.52	256.61
10	81.32	337.93
TOTAL	**337.93**	**1708.61**
AVARAGE COMPLETION TIME		**170.86**
UTILIZATION		**0.20**
AVARAGE N JOB IN SYSTEM		**5.06**

Based on the table above, the total Flow time is 1708.61 minutes, the average Completion Time is 170.86 minutes, the machine utilization is 20% and the average number of job queues in the machine is 5.06 minutes.

Post-Repair Scheduling

This proposed method uses a scheduling method, which uses the SPT (Shortest Processing Time) rule by prioritizing work from the shortest time to the longest time for each job, the results of the proposed scheduling are shown in Table 2.

Table 2. Scheduling using SPT

JOB	**PROCES TIME (Menit)**	**FLOW TIME (Menit)**
7	13.82	13.82
1	16.25	30.07
9	18.52	48.59
5	21.27	69.86
6	23.70	93.56
8	24.70	118.26
2	27.65	145.91
3	28.50	174.41
10	81.32	255.73
4	82.20	337.93
TOTAL	**337.93**	**1288.14**
AVARAGE COMPLETION TIME		**128.81**
UTILIZATION		**0.26**
AVARAGE N JOB IN SYSTEM		**3.81**

Based on the table above, the total Flow time is 1288.14 minutes, the average Completion Time is 128.81 minutes, the machine utilization is 26% and the average number of job queues in the machine is 3.81 minutes.

Calculation of Overall Equipment Effectiveness (OEE)

The results of the PR calculation during 2016 can be seen in table 4.2. From the calculation, it can be concluded that the average performance rate in 2016 was close to JIMP which was 95% (Nakajima 1998 with an average of 91.34% and in January it was 79.76 which was the lowest due to the waiting time on the NJT Vibros 255 machine being too long so that the product had an idle run rate.

Table 3. Performance Rate calculation results

No	Priode	Output	Cycle Time	Output X CT	Operation time	PR
1	Januari	73500	0.02	1470	1843	79,76
2	Februai	87500	0.02	1750	1835	95,37
3	Maret	86500	0.02	1730	1843	93,87
4	April	85500	0.02	1710	1943	88,01
5	Mei	73000	0.02	1460	1743	83,76
6	Juni	97000	0.02	1940	1943	99,85
7	Juli	93500	0.02	1870	1943	96,24
8	Agustus	85500	0.02	1710	1943	88,01
9	September	88500	0.02	1770	1843	96,04
10	Oktober	75800	0.02	1516	1743	86,98
			Rata-Rata			91.34

Calculation of Rate of Quality (OR)

The calculation results show that the quality rate in 2016 did not meet the JIMP standard of 99% (Nakajima, 1998). This was due to long waiting times for products.

Table 4. Calculation of Quality Rate

No	Priode	Output	Defect	RQ
1	Januari	73500	2.300	96.87
2	Feb	87500	2.560	97.07
3	Mar	86500	2.450	97.16
4	Apr	85500	2.340	97.26
5	Mei	73000	2.350	96.78
6	Juni	97000	2.650	97.26
7	Juli	93500	2.367	97.46
8	Agustus	85500	1.980	97.68
9	September	88500	2.540	97.12
10	Oktober	75800	2.390	96.84
				97.15

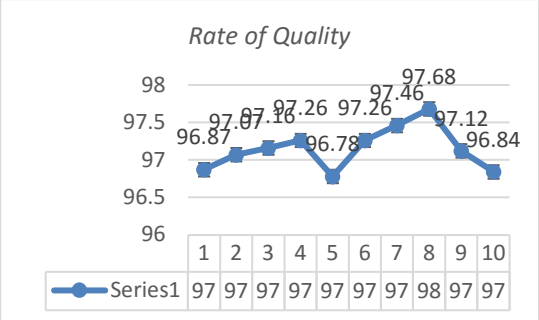


Figure 1. Calculation of Rate of Quality

Calculation of Overall Equipment Effectiveness (OEE)

The results of the OEE calculation during 2016 can be seen in table 5. From the calculation results, it is known that the OEE value is 74.48%. OEE with the standards determined by JIMP for the ideal index according to Nakajima (1998) should have an OEE value of 85%, namely the multiplication of 90% availability, 90% performance and 90% rate of quality. The graph of the OEE calculation results for the NJT Vibros 255 machine can be seen in the picture, it is known that the value of the machine's effectiveness, so that the value can be increased to reach a minimum of 85%.

Table 5. OEE Calculation Results

Priode	**AR**	**PR**	**QR**	**OEE**
Januari	93.85	79.76	96.87	72.51
Feb	96.39	95.57	97.07	89.42
Mar	96.49	93.87	97.16	80.00
Apr	98.78	88.01	97.26	84.55
Mei	95.29	83.76	96.78	77.24
Juni	95.78	99.85	97.26	93.01
Juli	92.75	96.24	97.46	86.99
Agustus	95.95	88.01	97.68	82.48
September	94.60	96.04	97.12	88.23
Oktober	98.77	86.98	96.84	83.19
Rata-Rata				**83.76**

The results of the company's scheduling research using FCFS with the proposed scheduling, namely the SPT rules, are shown in Table 6.

Table 6. Summary comparison of company scheduling with the proposed scheduling

Dispatching Rule Criteria	Company Scheduling	Scheduling Proposal	Results
	FCFS	SPT	
Total Flow Time	1708,61 Minute	1288.14	
Average Completion Time	170,86 Minute	128.81	Better Scheduling of Proposed SPT Rules
Utilitazion Machine	20%	26%	
Average n Job in System	5.06 Minute	3.81	

With the results in the summery table above, the total flow time from 1708.61 minutes decreased to 1288.14 minutes, the average flow time from 170.86 minutes decreased to 128.81 minutes, the machine utilization from 20% increased to 26% and the average job queue from 5.06 minutes decreased to 3.81 minutes, then the best method is to use NCT machine scheduling with 10 jobs for one machine with SPT sequencing priority rules.

As explained above, the best rule is to use the SPT rule. From this SPT rule, each job component can be improved by better scheduling. This is because, in addition to the actual occurrence within the company for each job, the job components are executed sequentially. Therefore, the second study was able to improve by minimizing the total flow time, average completion time, and average job queue time on each machine for each job component. The following is a summary of the second method in Table 4.4.2.

From the results in the table above, the maximum total flow time decreased from 594.35 minutes to 348.17 minutes, the maximum average completion time decreased from 34.96 minutes to 23.7 minutes, and the average job queue time decreased from 7.23 minutes to 5.12 minutes.

Because the scheduling was performed on a single machine, the author emphasizes that using this scheduling method, the machine utilization value in the first schedule was already good, and it could be further improved in the second schedule. As shown in Table 7.

Table 7. Comparison of Machine Utility Values with the SPT Scheduling Method

	Before Repair	After Repair
	FCFS (component)	SPT (component)
Job	Machine Utilities (%)	Machine Utilities (%)
1	28%	47%
2	34%	58%
3	15%	20%
4	14%	24%
5	54%	86%
6	100%	100%
7	24%	38%
8	23%	26%
9	28%	41%
10	21%	32%
Minimum	14%	20%
Average	27%	41%
Maximum	54%	86%

From the results of the table above, the average machine utilization increased from 27% to 41%, for a value of 100% in job 6, the author entered the maximum value because the processing of the components is one package (nesting process) on the NCT machine. Based on the description above, the best production scheduling is to use SPT (Shortest Processing Time), which has the result of minimizing the total flow time and the smallest average job queue and also for the highest machine utility value, not only for dispatching using SPT (Shortest Processing Time) so that it really supports the production process on the NCT Vibross 225 machine. And the calculation value of the Availability Rate (AR) of 95.86% has met the Japan Institute of Plan maintenance standards, the Performance Rate value of 91.34%, Rate of Quality 84.62% has not met the JIMP standard due to the product waiting time between one process to another, Overall Equipment Effectiveness (OEE) 73.48% and can still be increased to 86% with Shortest Process Time (SPT) scheduling thus the purpose of this study can Minimize the average completion time, Minimize Job queues, Increase the utility value of the NCT Viproos 255 machine, Improve the quality of the products produced can be applied in the product processing process on the NJT Vibros 255 Machine.

CONCLUSION

Based on the research conducted, several conclusions can be drawn as follows::

1. The best production scheduling results were achieved using the SPT rule, with the initial Total Flow Time decreasing from 1708.61 minutes to 1288.14 minutes, and the Average Flow Time decreasing from 170.86 minutes to 128.82 minutes.
2. The average job queue on the NJT Vibros 255 machine decreased from 5.06 minutes to 3.81 minutes.
3. Machine utility improved from 20% to 26%.
4. The calculated Availability Rate (AR) was 95.86%, the Performance Rate (PR) was 91.34%, and the Rate of Quality was 97.15, while the Overall Equipment Effectiveness (OEE) was 83.76%.

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