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Decision Analysis of Airbrake Midterm Production Planning at the Machining Department, PT "X" Bandung

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Abstract

PT "X" Bandung is a state-owned companies and one of its products is vehicle. One of the important subassemblies of the vehicle is the airbrake. This paper is aimed finding and selecting feasible midterm production plan alternatives for the Machining Department for the production of airbrake for the upcoming scheduled three consecutive periods, namely period 1 (12 days), period 2 (12 days), and period 3 (27 days) using decision-making methodology base on Hayes et al., consisting of evaluating the existing capacity to meet orders, defining alternatives for meeting those likely orders, performing financial analysis of each alternative, assessing key criteria or key issues for each alternative, and selecting and defending the alternative to be pursued. We calculated that the existing capacity was insufficient to meet the orders, and therefore, we developed four alternatives. The first alternative was trying to meet the demand using the available resources by accepting the lateness in which penalty costs would have to be calculated based on the contract agreement. The second alternative was adding capacity through overtime and in this regard the overtime costs would be calculated. The third alternative was adding capacity by purchasing new machines in which the capital required would be calculated. And the last alternative was a mix of overtime and the addition of new machines and the related costs would be calculated as well. The alternative with the least cost would be selected. Based on our analysis using two criteria, namely compliance to schedule and costs, we conclude that the last alternative is the best production plan for the company in meeting the demand of airbrake for the upcoming three periods.

Keywords: midterm production planning, decision making methodology, airbrake

I. Introduction

)ne of various products produced by a state-owned manufacturing company in Bandung was vehicle.)ne of important subassemblies for making vehicle is airbrake. The Machining Department had order of ıirbrake for three consecutive periods, namely period 1 consisting of 12 days, period 2 with 12 days, and)eriod 3 with days. Each working day had eight hours. To make these orders, the department could use 8 machines, consisting of nine regular lathes, six special lathes, three regular drills, one special drill, ıne regular mill, and one special mill. The objective of this paper is to propose an aggregate plan for the hree periods. The purpose of this study was to propose a midterm production plan. The earlier draft of ıis paper had been presented in The 11th International Conference on QiR (Quality in Research), akarta, 3-6 August, 2009 (Yuddy and Diaz, 2009).

I. Methodology

'he decision making process methodology used in this paper is adapted from the work of Hayes et.al. 2005), consisting of (1) evaluating the existing capacity to meet orders, (2) defining alternatives for ıeeting those likely orders, (3) performing financial analysis of each alternative, (4) assessing key riteria or key issues for each alternative, and (5) selecting and defending the alternative to be pursued. igure 1 illustrates these steps.

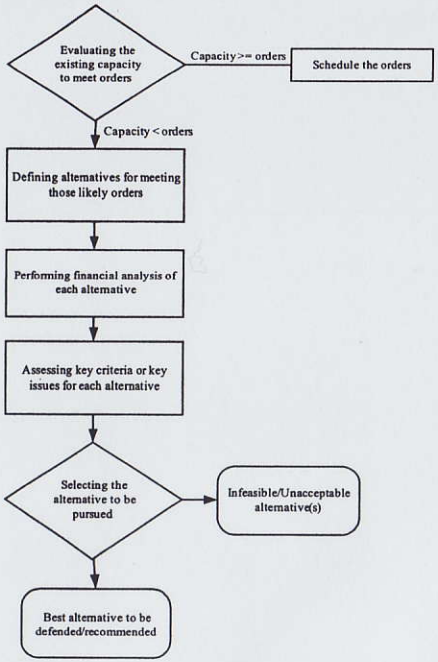

Figure 1. Decision making methodology

The first step, evaluating the existing capacity to meet orders, has been recognized as rough-cut capacity planning (Finch, 2008) to see whether the existing machines would be able to meet the orders or not. If the existing capacity could meet the demand, then we could show the calculation for the proposed production schedule. However, if the existing capacity is not sufficient, then, we would explore alternatives in order to meet those orders (Chase et.al., 2007). All required data were collected in the Machining Department in 2008. Data gathered included parts for making airbrake, routing data, overtime capacity, overtime wage, machine price. Recognizing the confidentiality of parts, we were allowed to use only part initials, instead of their full names. It was stated in the contract that the buyer would terminate its orders if the company failed to deliver the orders at the maximum allowable lateness amounting to 5% of the contract value.

3. Results

The results are outlined according the proposed methodology used in this study as mentioned above.

3.1. Evaluating the existing capacity to meet orders

As mentioned previously, this step has also been known as rough-cut capacity analysis (Finch, 2008). In this regard, rough cut capacity analyses for the nine regular lathes for the three periods are shown in Tables 1, 2, and 3. In each table, components to be processed, their corresponding required units, and the calculated hours requires are presented. The required hours for period 1, 2, and 3 were 1,531.2; 2,692.2; and 3,692.8 hours respectively. The capacity of regular working hours for period 1 and 2 was 864 hours each and for period 3 was 1,944 hours. For the three periods, the total capacity available was 3,672 hours. Therefore, the existing capacity of regular lathes was less than the required one.

Table 1. Rough cut capacity analysis for regular lathe for period 1

Component	Units required	Hours required
B1	135	72.0
B2	135	43.2
B3	135	58.0
B4	135	72.0
B5	135	72.0
CDV	135	90
COO	135	108.0
PT	105	56.0
DB	270	144.0
BH	65	270.0
TC	190	190
RP	105	56.0
CI	270	180.0
P	105	120.0
Total		1,531.2

The existing capacity of special lathe for periods 1, and 2 was 576 hours each, and 1,296 hours for period 3. The required hours for the same periods are shown in Table 4, 5, and 6. The capacity of periods 1 and was less than the required one, while the capacity for period 3 was more than the required one. For the overall three periods, the total existing capacity (2,448 hours) was less than the required capacity (2,949.2 hours).

Table 2. Rough cut capacity analysis for regular lathe for period 2

Component	Units required	Hours required
B1	169	90.1
B2	169	54.1
B3	515	206.0
B4	169	90.1
B5	169	90.1
CDV	169	112.7
COO	169	135.2
PT	279	148.8
DB	338	180.2
BH	230	460.0
TC	432	432.0
RP	279	148.8
CI	338	225.3
P	279	318.9
Total		2,692.3

Table 3. Rough cut capacity analysis for regular lathe for period 3

Component	Units required	Hours required
B1	216	115.2
B2	216	69.1
B3	216	115.2
B4	216	115.2
CDV	216	144.0
COO	216	172.8
PT	50	26.7
LNFN	1,500	2,333.4
DB	432	230.4
RP	50	26.7
CI	432	288.0
P	50	57.1
Total		3,693.8

Table 4. Rough cut capacity analysis for special lathe for period 1

Component	Units required	Hours required
LH1	145	46.4
LH2	145	23.2
LH3	145	89.2
LH4	145	46.4
CDV	135	90.0
DCP	65	17.3
VB	145	46.4
FL	145	46.4
COO	135	72.0
Total		477.4

For three regular drills, the existing capacity for periods 1 and 2 was 288 hours, and for period 3 was 648 hours. The required hours for periods 1, 2, and 3 are shown in Tables 7, 8, and 9 and these exceed the existing capacity.

Table 5. Rough cut capacity analysis for special lathe for period 2

Component	Units required	Hours required
RH1	515	164.8
LH1	515	164.8
RH2	515	82.4
LH2	515	82.4
RH3	515	316.9
LH3	515	316.9
CDV	169	112.7
DCP	450	120.0
VB	515	164.8
FL	515	164.8
TH	140	44.8
RH4	515	164.8
LH4	515	164.8
COO	169	90.1
Total		2,155.0

Table 6. Rough cut capacity analysis for special lathe for period 3

Component	Units required	Hours required
CDV	216	144.0
DCP	216	57.6
COO	216	115.2
Total		316.8

Table 7. Rough cut capacity analysis for regular drill for period 1

Component	Units required	Hours required
CDV	135	108.0
CI	135	108.0
DB	135	72.0
B1	135	72.0
Total		360.0

Table 8. Rough cut capacity analysis for regular drill for period 2

Component	Units required	Hours required
CDV	169	135.2
CI	169	135.2
DB	169	90.1
B1	169	90.1
Total		450.6

Table 9. Rough cut capacity analysis for regular drill for period 3

Component	Units required	Hours required
CDV	216	172.8
CI	216	172.8
DB	216	115.2
B1	216	115.2
LNFN	500	200.0
Total		776.0

The existing capacity for special drill, special mill, and special mill was the same because each had one machine. The existing capacity for periods 1 and 2 was 96 hours each, and 216 hours for period 3. The

required hours for special drill, regular mill, and special mill are shown in Table 10, 11, and 12 respectively. The required hours for special drill were higher that the existing capacity for all three periods. The required hours for regular mill were less than the existing capacity for all three periods. The required hours for special mill were higher than the existing capacity in period 3.

Table 10. Rough cut capacity analysis for special drill

Component	Units required	Hours required
COO	Period I: 135	216.0
	Period II: 169	270.4
	Period III: 216	345.6

Table 11. Rough cut capacity analysis for regular mill

Component	Units required	Hours required
COO	Period I: 135	54.0
	Period II: 169	67.6
	Period III: 216	86.4

Table 12. Rough cut capacity analysis for special mill

Component	Units required	Hours required
LNFN	Period III: 500	1,333.3

Based on the above calculation, we conclude that the existing capacity was unable to meet the hours required.

3.2. Defining alternatives for meeting those likely orders

Because the existing capacity was unable to meet the order, we then explore and analyze possible consequences for each alternative. Based on our observation and discussion with the Machining Department in 2008 we finally came up with four possible alternatives: (1) fulfilling the orders using the existing capacity, but with lateness, (2) using available overtime, (3) adding the existing capacity by purchasing new machines, and (4) a mix of overtime and adding new machines. The use of subcontracting as mentioned in Chase et. al. (2007) was not possible because of the nature of the military components that are not allowed to be outsourced.

3.3. Performing financial analysis of each alternative

In this step, we analyze consequences of each alternative and calculate its associated costs whenever necessary. A summary of alternative 1, fulfilling the orders using the existing capacity, is shown in Table 13. As we can see, the total shortage of regular lathe was 4,245 hours. Using nine machines and eight hours per day, this shortage equals 59 working days late. For special lathe, the shortage was 501.2 hours or 11 days late. By the same calculations, the lateness for regular drill, special drill, and special mill were 16, 52, and 116 days respectively.

Alternative 2 sought to meet the orders using the available overtime. Each working day allowed four overtime hours. Therefore, using nine regular lathes, the shortage of 4,245 hours equals 118 days. With daily overtime wage of 60,000 rupiahs, the total overtime cost would be 63.72 million rupiahs. The similar calculations for the other machines are summarized in Table 14.

Table 13. Consequences of Alternative 1 (fulfilling the orders using the existing capacity)

Regular lathe	
Total hours required	7,917.3
Total hours available	3,672.0
Total shortage	4,245.3
Lateness (days)	59
Special lathe	
Total hours required	2,949.2
Total hours available	2,448.0
Total shortage	501.2
Lateness (days)	11
Regular drill	
Total hours required	1,586.7
Total hours available	1,224.0
Total shortage	362.7
Lateness (days)	16
Special drill	
Total hours required	832.0
Total hours available	408.0
Total shortage	424.0
Lateness (days)	53
Regular mill	
Total hours required	208.0
Total hours available	408.0
Total shortage	0
Special mill	
Total hours required	1,333.3
Total hours available	408.0
Total shortage	925.3
Lateness (days)	116

Table 14. Consequences of Alternative 2 (using available overtime)

Regular lathe	
Total hours required	7,917.3
Total hours available	3,672.0
Total shortage (hours)	4,245.3
Overtime/day (hours)	36
Overtime required (day)	118
Overtime cost/day (rupiah)	60,000
Total overtime cost (rupiah)	63,720,000
Special lathe	
Total hours required	2,949.2
Total hours available	2,040
Total shortage	909.2
Overtime required	24
Overtime per day	38
Overtime cost/day	60,000
Total overtime cost	13,680,000

Table 14. Consequences of Alternative 2 (using available overtime) continued.

Regular drill	
Total hours required	1,586.7
Total hours available	1,224.0
Total shortage	362.7
Overtime required	12
Overtime per day	31
Overtime cost/day	60,000
Total overtime cost	5,580,000
Special drill	
Total hours required	832.0
Total hours available	408.0
Total shortage	424,0
Overtime required	4
Overtime per day	106
Overtime cost/day	60,000
Total overtime cost	6,360,000
Special mill	
Total hours required	1,333.3
Total hours available	408.0
Total shortage	925.3
Overtime required	4
Overtime per day	232
Overtime cost/day	60,000
Total overtime cost	13,920,000

Alternative 3 is adding the existing capacity by purchasing new machines. For nine regular lathes with a total of 51 regular working days and hours per day, the shortage of 4,245.3 hours as shown in Table 15, equals 11 machines. The price of each machine was 100 million rupiahs. The new machines would require 11 new operators. There was not any problem with additional space required for the new machines. The remaining calculations for the other machines are shown in Tables 15, 16, 17, 18, and 19.

Table 15. Consequences of alternative 3 for regular lathe

Total hours required	7,917.3
Total hours available	3,672.0
Total shortage	4,245.3
Number of machine required	11
Number of operator required	11
Machine price (rupiahs)	100,000,000
Salary/day (rupiahs)	60,000
Total machine cost (rupiahs)	1,100,000,000
Total operator cost (rupiahs)	33,660,000
Total additional cost (rupiahs)	1,133,660,000

Table 16. Consequences of alternative 3 for special lathe

Total hours required	2,949.2
Total hours available	2,040.0
Total shortage	909.2
Number of machine required	3
Number of operator required	3
Machine price (rupiahs)	100,000,000
Salary/day (rupiahs)	60,000
Total machine cost (rupiahs)	300,000,000
Total operator cost (rupiahs)	9,180,000
Total additional cost (rupiahs)	309,180,000

Table 17. Consequences of alternative 3 for regular drill

Total hours required	1,586.7
Total hours available	1,224.0
Total shortage	362.7
Number of machine required	1
Number of operator required	1
Machine price (rupiahs)	35,000,000
Salary/day (rupiahs) (rupiahs)	60,000
Total machine cost (rupiahs)	35,000,000
Total operator cost (rupiahs)	3,060,000
Total additional cost (rupiahs)	38,060,000

Table 18. Consequences of alternative 3 for special drill

Total hours required	832.0
Total hours available	408.0
Total shortage	424.0
Number of machine required	2
Number of operator required	2
Machine price (rupiahs)	35,000,000
Salary/day (rupiahs)	60,000
Total machine cost (rupiahs)	70,000,000
Total operator cost (rupiahs)	6,120,000
Total additional cost (rupiahs)	76,120,000

Table 19. Consequences of alternative 3 for special mill

Total hours required	1,333.3
Total hours available	408.0
Total shortage	925.3
Number of machine required	3
Number of operator required	3
Machine price (rupiahs)	25,000,000
Salary/day (rupiahs)	60,000
Total machine cost (rupiahs)	75,000,000
Total operator cost (rupiahs)	9,180,000
Total additional cost (rupiahs)	84,180,000

Alternative 4 is a mix of overtime and adding new machines. We recognize that there many combinations of this mix and we did not enumerate them one by one. Instead, we firstly use the overtime during the 51 days and then the remaining shortage would be met by adding or purchasing new machines. For nine regular lathes as shown in Table 20, the overtime capacity for 51 days with 4 hours each day was 1,836 hours and thus the shortage after using the overtime would be 2,409.3 hours. This shortage could be fulfilled by adding four new machines and their overtime for 49 days. Adding three machines would result in overtime days more than 51 days, and adding five machines would be more expensive. The calculations for the other machines are summarized in Table 21 for regular drills, and Table 22 for special mill.

Table 20. Consequences of alternative 4 for regular lathe

Total hours required	7,917.3
Total hours available	3,672.0
Total shortage	4,245.3
Overtime	1,836
Shortage after overtime	2,409.3
Additional 4 machines	1,632
Shortage after adding new machine	777.3
Overtime with new machines (days)	49
Machine cost (4 units) (rupiahs)	400,000,000
Operator cost (4 workers) (rupiah)	12,240,000
Overtime cost (9 workers) (rupiahs	36,720,000
Overtime cost 4 workers in 49 days (rupiahs)	15,680,000
Total additional cost (rupiahs)	464,640,000

Table 21. Consequences of alternative 4 for regular drill

Total hours required	832.0
Total hours available	408.0
Total shortage	424.0
Additional 1 machine	408
Shortage after adding 1 machine	16
Overtime with new machine (days)	2
Machine cost (rupiahs)	35,000,000
Operator cost (1 worker) (rupiahs)	3,060,000
Overtime cost for 2 workers for 2 days (rupiahs)	320,000
Total additional cost (rupiahs)	38,380,000

Table 22. Consequences of alternative 4 for special mill

Total hours required	1,333.3
Total hours available	408.0
Total shortage	925.3
Additional 2 machines	816.0
Shortage after adding new machines	109.0
Overtime with new machines (days)	14
Machine cost (2 units) (rupiahs)	75,000,000
Operator cost (2 workers) (rupiahs)	6,120,000
Overtime cost for 3 workers for 14 days (rupiahs)	3,360,000
Total additional cost (rupiahs) (rupiahs)	84,480,000

4. Assessing key criteria or key issues for each alternative

ur discussion with Machining Department revealed two key criteria, namely compliance with the :hedule and costs. The former criterion indicated that any alternative with lateness beyond the lowable schedule was prohibited because this would cause contract termination. The latter criterion ıided that any feasible alternative with the lowest cost would be the preferred one. The discussion also ɔncluded that these two criteria are non-compensatory and the compliance with the schedule would be ɜed as the primary criterion for selecting the feasible alternatives.

3.5. Selecting and defending the alternative to be pursued

Based on the analysis, we can see that alternative 1, operating with the existing capacity, would be unacceptable because the lateness exceeds the maximum allowable limits and this would result in termination of the contract which is unwanted by the company. The similar situation would occur with alternative 2, adding capacity using overtime in which shortages in regular lathe, special drill, and special mill would also cause lateness which would result in contract termination. Therefore, this alternative was unwanted as well by the company. Alternative 3, adding capacity by purchasing new machines can meet the required hours and therefore fulfill the order as scheduled. The total cost for this alternative was 1.641 billion rupiahs. The last alternative, adding capacity by using overtime and purchasing new machines could fulfill the order and the schedule. The total additional costs of this alternative would be 606.76 million rupiahs. Therefore, among the four alternatives, alternative 4 would be the best one. The summary of the four alternatives are shown in Table 23.

Table 23. Summary of all alternatives

Alternative	Cost (rupiahs)	Consequences
1. Operating with the existing capacity		
Regular lathe	0	Contract terminated due to lateness
Special lathe	0	Contract terminated due to lateness
Regular drill	0	Contract terminated due to lateness
Special drill	0	Contract terminated due to lateness
Regular mill	0	Contract terminated due to lateness
Total	0	Contract terminated due to lateness
2. Adding capacity using overtime		
Regular lathe	63,720,000	Contract terminated due to lateness
Special lathe	13,680,000	Can fulfill the order
Regular drill	5,580,000	Can fulfill the order
Special drill	6,360,000	Contract terminated due to lateness
Special mill	13,920,000	Contract terminated due to lateness
Total	103,260,000	Contract terminated due to lateness

Table 23. Summary of all alternatives (continued)

Alternative	Cost (rupiahs)	Consequences
1. Adding capacity by adding new machines		
Regular lathe	1,133,660,000	Can fulfill the order
Special lathe	309,180,000	Can fulfill the order
Regular drill	38,060,000	Can fulfill the order
Special drill	76,120,000	Can fulfill the order
Special mill	84,180,000	Can fulfill the order
Total	1,641,200,000	Can fulfill the order
2. Adding capacity through a mix of overtime and adding new machines		
Regular lathe	464,640,000	Can fulfill the order
Special lathe	13,680,000	Can fulfill the order using overtime
Regular drill	5,580,000	Can fulfill the order using overtime
Special drill	38,380,000	Can fulfill the order
Special mill	84,480,000	Can fulfill the order
Total	606,760,000	Can fulfill the order

5. Conclusions and Limitation

The orders for the three periods would be unable to meet either using the available capacity or using overtime. These orders could be fulfilled as scheduled through purchasing six new machines or a mix of overtime and purchasing four new machines. The best alternative would be the mix of overtime and purchasing four new machines. We acknowledge that this alternative might not be the optimal one because we approach our problem using the heuristic approach. Therefore, a possible further research would be to use the mathematical programming approach in order to find the optimal solution of the problem (Nahmias, 2005). However, we would like to inform that any mathematical model that would include holding costs might face difficulties in getting these numbers because of the absence of these costs in the company.

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