Production planning and control: a case study in stone crusher company

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Abstract. PT. Z is one of the companies engaged in the stone crusher business. The problem at PT Z is frequent delays in fulfilling customers order, significantly when demand increases. Based on the observations, it is known that PT Z performs production planning and control intuitively. It shows that PT Z does not yet have a production planning and control system in its production process. Solutions to overcome the problems faced by PT Z, namely by planning and controlling production, include (1) Forecasting, (2) Aggregate Planning (AP), (3) MPS, and (4) Rough Cut Capacity Planning (RCCP). The strategy used in AP in this study is the Chase Strategy. In addition, the approach used in RCCP in this study is Capacity Planning Using Overall Factors (CPOF) approach. The purpose of this research is to provide proposals of production planning and control at PT Z to overcome the problem of delays. The results showed that AP resulted in a total cost of IDR 635,150,000 per year with a final inventory of 140 tons which met the safety stock requirements of 50 tons even though there was firing in the 17th period. RCCP, which became the validation of MPS, shows that the production capacity was 192 hours per month, and the average production capacity requirement was 172 hours per month, with the highest value of 190.4 hours and the lowest value of 163.68 hours. Based on the results of the RCCP, it can be stated if the MPS can be used.

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1 Introduction

PT. Z is one of the companies engaged in the stone crusher business in Banyumas that produces split stones. The current state of production goes by intuition. Thus, the production carried out follows the results of the previous period's demand, which resulted in the problem of non-fulfillment of demand. So far, the company has carried out backorders to overcome the problem of delays, but this strategy is not suitable to be implemented in the long term. This condition can lead to increased production costs incurred by the company because the cost of raw materials with backorders is much more expensive. Based on the observations, it is known that PT Z performs production planning and control intuitively. It shows that PT Z does not yet have a production planning and control system in its production process. The absence of production planning and control at PT Z is the main trigger for the delay in order fulfillment experienced.

Production planning and control need to be done because it includes the organization and planning of the production process in general, for example, scheduling, delivery, inspection, coordination, material management, engineering, and tools, up to operating hours [1][2]. Production planning and control is essential because it will affect sales, marketing, operational activities, finance, and product development [3][4]. Production planning and control affect all production processes, from the amount produced, production time, and existing resources to the improvement of the lack of resources [5].

Production planning and control begins with Aggregate Planning (AP) until the validation of the Master Production Schedule using Rough Cut Capacity Planning (RCCP) [6]. In the manufacturing industry, aggregate planning is used as an analytical material in production planning with the problem of decreasing inventory levels or not meeting demand [7]. Aggregate Planning can be done using three methods: Level Strategy, Chase Strategy, and Mixed Strategy [8]. The Chase Strategy method was chosen in this study because it can be used to change the level of production to match the forecasted demand during planning [9] [10] [11] [12]. Aggregate planning will be disaggregated into Master Production Scheduling (MPS). The MPS was made as a short-term production plan that still refers to aggregate planning [13]. MPS was validated using Rough Cut Capacity Planning (RCCP) [14]. Three methods can complete Rough Cut Capacity Planning (RCCP), namely Capacity Planning Using Overall Factors (CPOF), Bill of Labor Approach (BOLA), and Resources Profile Approach (RPA) [15]. The RCCP method can be used to solve the problem of non-fulfillment of demand at PT. Z is Capacity Planning Using Overall Factors (CPOF). The CPOF method was chosen because the calculation method is relatively easy, multiplying the historical proportion by the total quantity of MPS in a certain period for each workstation [16]. Thus, the proposed production planning and control is expected to overcome the unfulfilled demand at PT. Z.

2 Methodology

The data was collected by direct observation, interviews with PT. Z, and based on the company's historical data. Interviews were conducted with the head of the production section, production operators, and officers in the Production Planning and Control section. Direct observations were carried out to determine the production system, production process, processing time and planning running at PT. Z. Historical data is needed to determine the pattern of split stone demand and the available capacity at PT. Z. The research was carried out in several stages as shown in Figure 1.

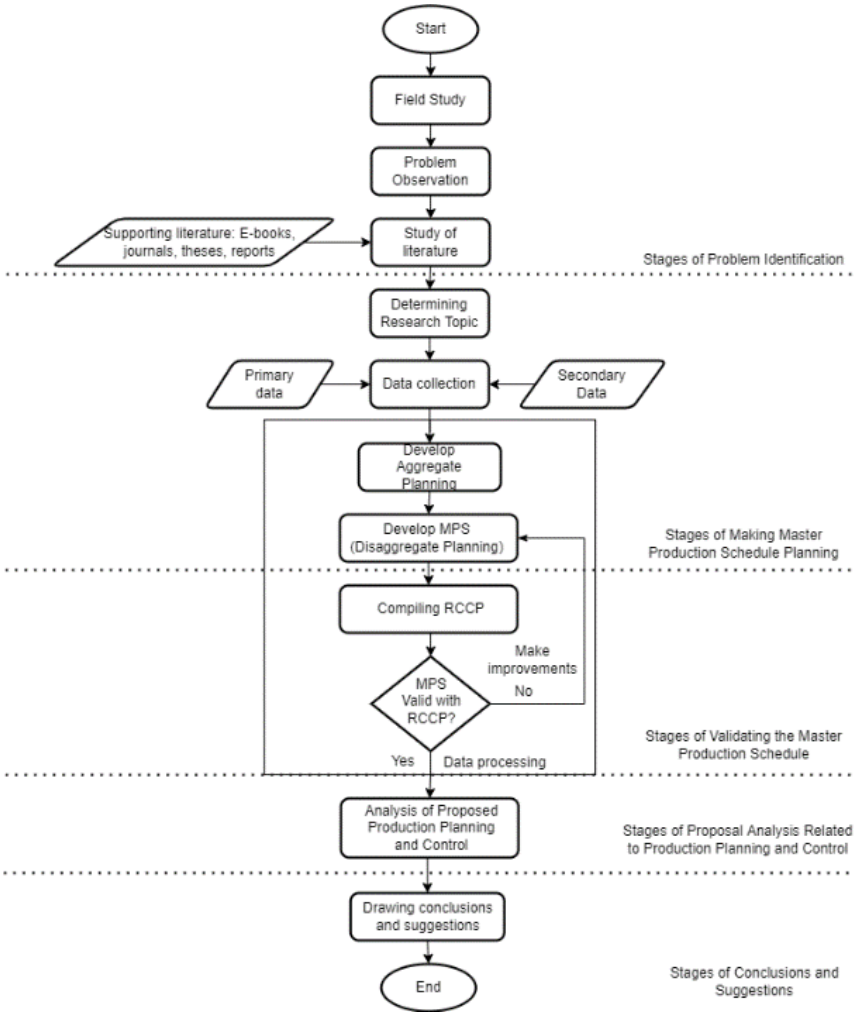

Fig. 1. Research Flowchart

3 Result and Discussion

The results of data processing in this study begin with forecasting demand. The results of forecasting demand are used to develop Aggregate Planning using the Chase Strategy method. The results of the Aggregate Planning will be disaggregated to determine the forecast for each type of product or become the Master Production Scheduling for each type of product. The results of the MPS were validated using the Rough Cut Capacity Planning (RCCP) Overall Factor Capacity Planning (CPOF) method.

3.1 Forecasting

Forecasting is calculated using four methods: (1) Single Average, (2) Moving Average 3 period, (3) Moving Average 4 period, and (4) Single Exponential Smoothing methods. After the forecasting calculations have been made, errors will be tested using MAD, MSE, and MAPE. Demand forecasting used Single Average done with calculation using the equation 1.

$$F_{t+1} = \sum_{t=1}^{n} \frac{X_t}{n} \quad (1)$$

Example for the calculation used Single Average method shows as follows:

$$F_{t+1} = \sum_{t=1}^{n} \frac{X_t}{n}$$

$$F_4 = \frac{(1497 + 887 + 1003)}{3}$$

$$F_{t+1} = 1129\ ton$$

Next, forecasting done used Moving Average 3 period with formula in the equation 2.

$$F_t = \frac{\sum_{t=1}^{n} Di}{n} \quad (2)$$

Example for the calculation used Moving Average method shows as follows:

$$F_t = \frac{\sum_{t=1}^{n} Di}{n}$$

$$F_4 = \frac{(1497 + 887 + 1003)}{3}$$

$$F_4 = 1129\ ton$$

Next, forecasting done used Moving Average 4 period used the same formula in the equation 2. The differences just in n, which use 4 period. Example for the calculation used Moving Average 4 period method shows as follows:

$$F_t = \frac{\sum_{t=1}^{n} Di}{n}$$

$$F_5 = \frac{(1497 + 887 + 1003 + 1004)}{4}$$

$$F_5 = 1097.75\ ton$$

Then the last method that use in this research is Single Exponential Smoothing method with calculation in equation 3.

$$F_{t+1} = \sum_{i=t-n+1}^{t} \alpha X_t + (1-\alpha)F_t \quad (3)$$

When done forecasting used Single Exponential Smoothing method, in this research use α=0.8. It's because the historical data used is the latest data so that the alpha value is close to zero. Not only that, the alpha value was chosen because it provides an optimal forecast with the smallest error value. Example for the calculation used Exponential Smoothing method shows as follows:

$$F_{t+1} = \sum_{i=t-n+1}^{t} \alpha X_t + (1-\alpha)F_t$$

$$F_4 = \sum_{i=4}^{t} 0.8(1003) + (1-0.8)\ 1009$$

$$F_4 = 1005\ \text{ton}$$

After forecasting, error testing is done with MAD using equation 4, MSE using equation 5, and MAPE using equation 6.

$$MAD = \frac{\sum_{t=1}^{n} |A_t - F_t|}{n} \quad (4)$$

$$MSE = \frac{\sum_{t=1}^{n} (A_t - F_t)^2}{n} \quad (5)$$

$$MAPE = \left(\frac{100}{n}\right) \sum_{t=1}^{n} \left|\frac{A_t - F_t}{A_t}\right| \quad (6)$$

Forecasting results are compared by looking at the value of the error test performed. The results show that the Moving Average 3 period method produces the smallest error with a value of MAD 293.39, MSE 158731, and MAPE 0.249. So, forecasting the next 12 periods using the Moving Average 3 method. The results of the forecasting period for the 13 months of January 2022 to the period of December 24, 2022 are the reference for the next process shows in Table 1.

Table 1. Forecasting result

Period	Forecasting Results (tons)
13	1190
14	1082
15	1023
16	1098
17	1068
18	1063
19	1076
20	1069
21	1069
22	1072
23	1070
24	1070

3.2 Aggregate Planning

Aggregate Planning carried out in this study uses Chase Strategy. The result of Aggregate Planning shows in Table 2. The final result of the proposed reduction of employees from 7 to 6 people is to maximize the existing workforce and fulfill the demand with a lower production capacity. The proposal resulted in a total expenditure of IDR 866,150,000 per year. Total expenditure using aggregate is lower because otherwise, it will result in expenditure of IDR. 919,800,000 with a percentage savings of 6% with a difference of IDR 53,650,000.

Table 2. Result of Aggregate Planning

MONTH	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
Regular workers (A)	7	7	7	7	7	6	6	6	6	6	6	6	
Overtime (B)													
Unit Produced (C)	1190	1190	1190	1190	1190	1020	1020	1020	1020	1020	1020	1020	13090
MONTH	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**TOTAL**
Demand Forecasting (D)	1190	1082	1023	1098	1068	1063	1076	1069	1069	1072	1070	1070	12950
Subcontracting (E)													0
Inventory (F)	0	108	275	367	489	446	390	341	292	240	190	140	3278

Back Order/ Lost Sales (G)													0
Cost (in thousand)													
Regular Time (H)	Rp14,000	Rp14,000	Rp14,000	Rp14,000	Rp14,000	Rp12,000	Rp12,000	Rp12,000	Rp12,000	Rp12,000	Rp12,000	Rp12,000	Rp154,000
Overtime (I)													Rp -
Production (J)	Rp62,650	Rp62,650	Rp62,650	Rp62,650	Rp62,650	Rp56,700	Rp56,700	Rp56,700	Rp56,700	Rp56,700	Rp56,700	Rp56,700	Rp710,150
Hire/ Layoff (K)					Rp2,000								Rp2,000
Subcontracting (L)													Rp-
Inventory Carry (M)													Rp-
Back Order/ Lost Sales (M)													Rp-
TOTAL	**Rp76,650**	**Rp76,650**	**Rp76,650**	**Rp76,650**	**Rp78,650**	**Rp68,700**	**Rp68,700**	**Rp68,700**	**Rp68,700**	**Rp68,700**	**Rp68,700**	**Rp68,700**	**Rp866,150**

3.3 Master Production Schedule

MPS can be generated after the disaggregation process. The results of the MPS that have been produced shows in Table 3.

The method used for disaggregation is Cut and Fit. The first step is to find the percentage of families. The results of production or demand 12 months ago at PT Z 71% of the demand consisted of family 1 and the remaining 29% was family 2 twice as large as family 2. The next step is to find the percentage of items. In Table 3 it is known that the item split 1-2 has the largest percentage with a value of 62%. It states that they most orders in family 1 are split 1-2. Meanwhile, for family 2, the largest percentage is 73%, namely stone ash items. This value can be used as a reference for the company that the highest consumer demand is for split 1-2 products and stone ash.

Table 3. Master Production Schedule

Family	**Item**	**Period**											
		13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Main	**Split3-5**	19	17	16	17	17	17	17	17	17	17	17	17
	Split 2-3	304	276	261	281	273	272	275	273	273	274	273	273
	Split 1-2	529	481	455	488	475	472	478	475	475	476	475	475
Secondary	**Sirtu**	94	86	81	87	84	84	85	84	84	85	85	85
	Stone Ash	247	225	213	228	222	221	224	222	222	223	222	222

3.4 Rough Cut Capacity Planning

MPS can be generated after the disaggregation process. The results of the MPS that have been produced shows in Table 3.

Production of split stone at PT Z takes 0.16 hours to produce 1 ton of stone. If the work is carried out for a maximum of 8 hours/day, the maximum total split stone produced is 50 tons/day or 1200 tons/month. Capacity calculations are carried out for the total of all capacities and for each work station.

Validation is done by comparing the available capacity with the required capacity. The available capacity per month is 192 hours, while the highest demand capacity is in the 13th period, namely January 2022 with a total demand of 190.4 hours. Meanwhile, the lowest required capacity is 163.68 in the 15th period, namely March 2022. Thus, the MPS is declared valid because the available capacity is higher than the required capacity.

Table 4. Rough Cut Capacity Planning

Work Station	13	14	15	16	17	18	19	20	21	22	23	24
Drop	11.9	10.82	10.23	10.98	10.68	10.63	10.76	10.69	10.69	10.72	10.7	10.7
Primary Crusher	35.7	32.46	30.69	32.94	32.04	31.89	32.28	32.07	32.07	32.16	32.1	32.1
Screen Vibration 1	27.37	24.886	23.529	25.254	24.564	24.449	24.748	24.587	24.587	24.656	24.61	24.61
Secondary Cone Crusher	29.75	27.05	25.575	27.45	26.7	26.575	26.9	26.725	26.725	26.8	26.75	26.75
Screen Vibration 2	23.8	21.64	20.46	21.96	21.36	21.26	21.52	21.38	21.38	21.44	21.4	21.4
Termitary Cone Crusher	23.8	21.64	20.46	21.96	21.36	21.26	21.52	21.38	21.38	21.44	21.4	21.4
Screen Vibration 3	20.23	18.394	17.391	18.666	18.156	18.071	18.292	18.173	18.173	18.224	18.19	18.19
Impact Crusher	17.85	16.23	15.345	16.47	16.02	15.945	16.14	16.035	16.035	16.08	16.05	16.05
Total	**190.4**	**173.12**	**163.68**	**175.68**	**170.88**	**170.08**	**172.16**	**171.04**	**171.04**	**171.52**	**171.2**	**171.2**

4 Conclusions

Equations Production planning and control begins with recapitulating demand data for family 1, namely the main product and family 2 by-products, employee data, and costs incurred during production. Demand data as a reference for forecasting or forecasting demand for the next 12 months. Forecasting is done using the Moving Average 3 method with the lowest error, namely MAPE 0.249. Aggregate Planning is carried out using the Chase Strategy method with the results of the proposed reduction of employees from 7 people to 6 people. The reduction in staff reduces the amount of production but still meets existing needs and has a final inventory above the safety stock value. The total cost incurred by the company if using the Chase Strategy method is Rp. 866,150,000, - per year, equivalent to 6% savings compared to expenses without aggregate planning. The Master Production Schedule is generated from disaggregate using the Cut and Fit method with the results of the production schedule for each type of product. MPS validation using RCCP with CPOF method. Calculation of the CPOF method is used to calculate the available capacity and the required capacity of each demand in the MPS. The available capacity owned by the company is 192 hours/month. Meanwhile, the highest demand capacity is 190.4 hours/month in the 13th period, namely January 2022. With these results it can be stated that the MPS is valid because it is able to be fulfilled by the available capacity.

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