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Production capacity planning in motorcycle assembly line using CRP method at P T XYZ

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Abstract. PT XYZ is an automotive manufacturing company that produces a motorcycle. In an effort to meet the needs of consumers precisely and quickly, PT XYZ deals with problems in terms of fulfilling the capacity in accordance with consumer demand. The problem of imbalanced production capacity occurred in assembly line 3 that produced motorcycle of FU types, consisting of 3 workgroups, namely sub assy, mainline RH, and mainline LH. The imbalance between the capacity and load was due to many work elements of an operator. Thus the load on each work in the three workgroups was greater than the available capacity. This problem was solved using the method of Capacity Requirement Planning/CRP. Based on the result using CRP, the production load of each workgroup was calculated as follows: sub assy of 115,690 minutes, mainline RH of 186,000 minutes and mainline LH of 218,701 minutes. This result showed an overload capacity in the assembly line and led to a production loss of 868 units in January, 836 units in February, and 867 units in March. It is possible to solve this under loading problem through overtime and work weekends.

1. Introduction

PT XYZ is an automotive manufacturing company that produces a motorcycle. In an effort to meet the needs of consumers properly and quickly, PT XYZ deals with problems in terms of fulfilling the capacity in accordance with consumer demand. The problem of imbalanced production capacity occurred in assembly line 3 that produced motorcycle of FU types, consisting of 3 workgroups, namely sub assy, mainline RH, and mainline LH. The imbalance between the capacity and load was due to many work elements of an operator. Thus the load on each work in the three workgroups was greater than the available capacity.

The balance between production load or consumer demand and capacity to be fulfilled by PT XYZ greatly affects the consistency of master production schedule and generates a loss in term of time and production; hence the problem found in assembly line 3 (three) of PT XYZ should be solved using the method of Capacity Requirement Planning/CRP.

Capacity Requirement Planning (CRP) is a method applied to plan the production capacity requirement; thus production process in a company runs well and in accordance with the production



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plan that has been designed by the company [1]. CRP has the ability to adjust the level of order arrival to the available capacity by identifying the work center area that is in overload or underload situation.

Calculation of capacity using this method is expected to provide improvement proposals to PT XYZ in order to balance between consumer ordering and capability of production capacity in PT XYZ. Thus the planned production schedule is applied properly.

1.1. Problem statement

The imbalance between capacity and consumer demand or load leads to problems in capacity requirement planning. The problem formulation in this study includes:

1. How is the analysis result of Capacity Requirement Planning (CRP) applied in the workgroup of sub assy, mainline RH, and mainline LH in assembly line 3 (three) of PT XYZ ?
2. How is the improvement proposal to production capacity in the workgroup of sub assy, mainline RH, and mainline LH using the CRP method ?

1.2. Research Purpose

The purpose of this study is listed as follows:

1. To produce the analysis of Capacity Requirement Planning (CRP) applied in the workgroup of sub assy, mainline RH, and mainline LH in assembly line 3 (three) of PT XYZ
2. To determine the improvement proposal concerning the production capacity in the workgroup of sub assy, mainline RH, and mainline LH using the CRP method.

2. Theoretical background

Capacity Requirement Planning is a process to determine the workload of each work center based on the production schedule [2]. CRP is an important step in controlling manufacture. The capacity requirement planning CRP examines the assumption and identifies areas with capacity overload and underload. Thus planner will be able to take appropriate action. In Capacity Requirement Planning (CRP), the workload in each work station is determined. Three things are required To determine/plan the capacity requirement [2]: 1. Work Center, 2. Load, 3. Capacity.

Analysis of Capacity Requirement Planning (CRP) requires separated calculation related to the need for setup time and run time. Analysis of CRP is more detailed than that of RCCP since CRP analysis requires information of standard setup time and standard run-time per unit item to be made. The calculation of operation time per unit in CRP analysis is done using the formula as follows [3].

3. Result and Discussion

PT XYZ only was found to have one shift work in a day, starting from 07.30 WIB to 16.30 WIB. There were 20 workdays in January, 19 workdays in February, and 19 workdays in March. Actual work time from Monday-Thursday was 485 minutes, while it was 445 minutes on Friday. The data required for calculation of capacity using the CRP method included the production quantity in the assembly line of PT XYZ. The quantity of motorcycle production based on information obtained from PT XYZ reached 3,500 units in January, 3,000 units in February, and 3,200 units in March.

3.1. Calculation of normal time

The normal time for each task is calculated by multiplying cycle time obtained by rating factors. The normal time for each task in the workgroup of sub assy, mainline RH, and mainline LH was calculated using the following formula [4, 5]:

$$\text{Normal time (Wn)} = \text{Ws} \times (1 + \text{Rating Factor})$$

Moreover, the result of normal time calculation for each task is presented in Table 1.

Table 1. Calculation of normal time.

Task	Ws (minute)	Rating Factor	Wn (minute)
Sub Assy (Bracket Upper)	1.20	1+0.09	1.31
Main Line RH (Assembling of Swing Arm, Prop stand)	1.44	1+0.09	1.57
Main Line LH (Numbering Frame)	1.84	1+0.11	2.04

3.2. Calculation of Standard Time

Standard time is measured by multiplying normal time by an allowance that has been determined previously. The normal time for each task in the workgroup of sub assy, mainline RH, and mainline LH was computed using the following formula [4,5]:

$$\text{Standard Time (WS)} = W_n \times (1 + \text{Allowance})$$

The data of the calculation result of standard time are shown in Table 2 below.

Table 2. Calculation of standard time.

Task	Wn (minute)	Allowance	Wn (minute)
Sub Assy (Bracket Upper)	1.31	0.17	1.53
Main Line RH (Assembling of Swing Arm, Prop stand)	1.57	0.17	1.84
Main Line LH (Numbering Frame)	2.04	0.17	2.39

3.3. Calculation of Available Work Time

Measurement of available work time was performed to obtain information about the work hour of the operator in the assembly line of PT XYZ. The calculation was done for January, February, and March using the following formula [6]:

$$\text{Work Time on Day} = \text{Actual Work Time} \times \text{Number of Work Day}$$

Calculation example for January:

- Work Time Monday – Thursday = Actual Work Time x Number of Work Day = 485 minutes x 16 days = 7,760 minutes
- Work Hour on Friday = 445 minutes x 4 days = 1,780 minutes
- Total Work Hour = 7,760 + 1,780 = 9,540 minutes

Table 3. Recapitulation of calculation of work time/month.

Month	Work Time (minute)
January	9,540
February	9,055
March	9,055

3.4. Efficiency and Utilization

Efficiency in the assembly line of PT XYZ in January, February, and March was measured to be 75%, 72%, and 73%, respectively. Utilization is the ratio of comparison between the required work time and available work time. The formula of utilization is as follows [7]:

$$\text{Utilization} = (\text{Actual work time for production} / \text{Available work time}) \times 100\%$$

Table 4. Calculation of utilization.

Task	Utilization (%)		
	January	February	March
Sub Assy (Bracket Upper)	0.56	0.51	0.54
Main Line RH (Assembling of Swing Arm, Prop stand)	0.68	0.61	0.65
Main Line LH (Numbering Frame)	0.88	0.79	0.84

3.5. Calculation of Available Capacity

Calculation of available capacity was performed for each task in the workgroup of sub assy, mainline RH and mainline LH. The formula used to calculate available capacity is as follows [7]:

$$\text{Available Capacity} = \text{Available Work Time} \times \text{Efficiency} \times \text{Utilization}$$

Table 5. Calculation of available capacity.

Description	January	February	March
Bracket Upper			
A (minute)	9,540	9,055	9,055
Efficiency (%)	0.75	0.72	0.73
Utilization (%)	0.56	0.51	0.54
Available Capacity (minute)	4,007	3,325	3,569
Assembling of <i>Swing Arm, Propstand</i>			
A (minute)	9,540	9,055	9,055
Efficiency (%)	0.75	0.72	0.73
Utilization (%)	0.68	0.61	0.65
Available Capacity (minute)	4,865	3,977	4,297
Numbering Frame			
A (minute)	9,540	9,055	9,055
Efficiency (%)	0.75	0.72	0.73
Utilization (%)	0.88	0.79	0.84
Available Capacity (minute)	6,296	5,150	5,553

Based on the result of calculation for available capacity, the quantity of product expected to produce in the assembly line of PT XYZ: In January, assembly line could produce 2,632 units, resulted from the calculation of total available capacity in a minute divided by total standard time. According to the schedule, the assembly line should have produced 3,500 units in January. Hence 868 units should be added. Moreover, available capacity in February reached 2,164 units, yet the schedule of PT XYZ targeted 3,000 units. Thus 836 units were still required. In March, the calculation showed that the assembly line only produced 2,333 units of the required that amounted to 3,200 units. Therefore, there was a lack of 867 units.

3.6. Calculation of Load using CRP Method

Before the result of actual requirement or termed load is obtained, total operation time should be determined. Total operation time is calculated using several formulas: The formula for calculating setup time per unit is as follows [8]:

Setup Time/Unit (Minute) = Setup Time/Lot (Minute) / Lot Size
The formula for calculating operation, Time per unit is as follows:

Operation Time Per Unit = Run Time / Unit + Setup Time Unit The formula for calculating total operation time is as follows:

$$\text{Total Operation Time} = \text{Lot Size} \times \text{Operation Time Per Unit}$$

After all those formulas were determined, Total Operation Time was calculated. Example of calculation is written below:

3.7. Bracket Upper

Lot Size in the assembly line of PT XYZ amounted to 60 units. Since information obtained from PT XYZ showed that the production preparation time required by the company reached 0.0543 minutes, setup time/unit calculated was 0.0009 minute. Moreover, the operation time/unit of 1.5309 was determined by adding Run Time (standard time) with setup time/unit. The last one, total operation time, was obtained by multiplying lot size by Operation time/unit, resulted in 91.85 minutes. After *total operation time was determined*, production load was further calculated using the following formula [7-9]:

$$\text{Load} = (\text{Total Operation Time} \times \text{Production Quantity per Month}) / \text{Lot Size}$$

The result is presented in Table 6 as follows:

Table 6. Calculation of load.

Work Group	January	February	March
<i>Bracket Upper</i> (min)	5,358	4,593	4,899
<i>Assembling of Swing Arm, Prop stand</i> (min)	6,092	5,222	5,570
<i>Numbering Frame</i> (min)	8,367	7,172	7,650

4. Analysis and Discussion

4.1. Analysis of Capacity using CRP Method

Following data processing, CRP analysis was applied to determine whether capacity and load were in balance or not. Increased productivity is done by improving the working method of the picking process, and the operating system needs control and integration from the manufacturer, supplier, and logistics partner [10, 11]. The result is presented in Table 7 as follows:

Table 7. Analysis of CRP.

Description	January	February	March	Total
Bracket Upper				
Available Time (min)	9,540	9,055	9,055	27,650
Available Capacity (min)	4,007	3,325	3,569	10,901
Load (min)	5,358	4,593	4,899	14,840
Underload (min)	-1,351	-1,268	-1,330	-3,949
Loss (multiplied by task)	883	829	869	2,581
Assembling of Swing Arm, Prop stand				
Available Time (min)	9,540	9,055	9,055	27,650
Available Capacity (min)	4,865	3,977	4,297	13,139
Load (min)	6,442	5,522	5,890	17,854
Underload (min)	-1,577	-1,545	-1,593	-4,715
Loss (multiplied by task)	857	840	866	2,563
Numbering Frame				

Available Time (min)	9,540	9,055	9,055	27,650
Available Capacity (min)	6,296	5,150	5,553	16,999
Load (min)	8,367	7,172	7,650	23,189
Underload (min)	-2,071	-2,022	-2,097	-6,190
Loss (multiplied by task)	867	846	877	2,590

Loss (multiplied by task) was obtained through the calculation of capacity under load (minute) divided by standard time. All tasks listed above represented the workgroup of sub assy, mainline RH and mainline LH that experienced capacity under load, thus improvement is required to meet the production schedule.

4.2. Capacity Improvement Proposal using CRP Method

The existence of capacity underload insists the company balances production load with available capacity. One effort to increase the capacity is to schedule overtime or work weekends.

Table 8. Improvement proposal.

Description	January	February	March	Total
Bracket Upper				
Available Time (min)	12,780	12,655	12,535	37,970
Efficiency (%)	0.75	0.73	0.75	
Utilization (%)	0.56	0.51	0.54	
Available Capacity (min)	5,368	4,647	4,941	14,956
Rough Capacity (min)	5,358	4,593	4,899	14,850
Underload (min)	+10	+54	+42	+106
Assembling of Swing Arm, Prop stand				
Available Time (min)	12,780	12,655	12,535	37,970
Efficiency (%)	0.75	0.73	0.75	
Utilization (%)	0.68	0.61	0.65	
Available Capacity (min)	6,518	5,558	5,948	18,024
Rough Capacity (min)	6,442	5,522	5,890	17,854
Underload (min)	+76	+36	+58	+170
Numbering Frame				
Available Time (min)	12,780	12,655	12,535	37,970
Efficiency (%)	0.75	0.73	0.75	
Utilization (%)	0.88	0.79	0.84	
Available Capacity (min)	8,435	7,198	7,686	23,319
Rough Capacity (min)	8,367	7,172	7,650	23,189
Underload (min)	+68	+26	+36	+130

Table 8 shows that available production capacity will be able to meet the production load compared to the previous situation. Lack of production due to capacity under load, which reached 868 units in January, 836 units in February, and 867 units in March could be fulfilled.

5. Conclusion

Based on the result of data analysis performed, the conclusion drawn is as follows:

1. Results of analysis using the CRP method for a workgroup of sub assy, mainline RH, and mainline LH showed that all tasks conducted by the three workgroups in the assembly line had available production capacity that was lower than the production load. This problem led to a lack of quantity produced in January, February, and March of 868 units, 863 units, and 867 units, respectively.

2. Improvement proposed to balance the capacity and load is to schedule overtime and work weekends. In January, there should be work weekends on Saturday for four weeks with previous actual work time from 420 minutes to 1,680 minutes and overtime of 2 hours for 13 days. In February, there should be work weekends on Saturday for four weeks with previous actual work time from 420 minutes to 1.680 minutes and overtime of 2 hours for 16 days. In March, there should be work weekends on Saturday for four weeks with a previous actual work time of 420 minutes to 1.680 minutes and overtime of 2 hours for 15 days.

6. Recommendation

Moreover, the recommendation for this study is listed as follows:

1. The company should check production capacity underload and adjust it to overtime and work weekends in order to achieve production load and production capacity balance.
2. Capacity improvement proposal using the CRP method should be applied by the company on condition that the schedule proposal for overtime and work weekends is approved by the company.

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