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Application of Material Requirement Planning in Bracket Chamber Production: A Case Study of Automotive Component Company

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A B S T R A C T

This research was conducted to plan material needs and control the production capacity of bracket chambers at an automotive component company. The problems found were company excessively procures raw materials and unbalanced machine capacity in producing bracket chamber products. This research uses stages of the material requirements planning method, including calculating Rough Cut Capacity Planning (RCCP), Material Requirement Planning (MRP), and Capacity Requirement Planning (CRP). Implementing a MRP system enables organisations to accurately ascertain the specific kind, quantity, and timing of materials required for the production process. At the RCCP stage, capacity calculations are carried out on the CNC machine, press 1 and press 2 to find out whether the capacity of each machine can meet the company's MPS. MRP calculations are carried out to determine the optimal raw material ordering schedule using three lot sizing methods, namely Lot For Lot, Economic Order Quantity, and Period Order Quantity. At the CRP stage, each machine's capacity availability report will be made to meet bracket chamber production needs. The results of this research using RCCP and CRP analysis show that press 1 and press 2 have an unbalanced load between availability and actual demand, so it is recommended that these machines can also be used for other production so that the machines are not idle. Material requirements planning should use the Lot For Lot technique because it produces the minimum total inventory costs, namely IDR 12,710,751, with a material ordering frequency of 12 times in 1 year.

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1. INTRODUCTION

The public's need for transportation facilities has resulted in an increase in the demand for automobile components, as well as severe competition among all automotive component firms in Indonesia (Imansuri et al., 2023).

Companies must be able to optimally and efficiently manage available resources (Hasan & Pulansari, 2023). Planning and managing production as much as possible is critical to ensuring that organizations can meet consumer demands at all times. Management's failure to plan raw material demands can lead to insufficient or excess inventory, poor customer service, and diminished corporate earnings due to the high costs associated with inventory. (Werth et al., 2022).

MTG, Ltd is a private firm in Indonesia that manufactures automotive components, particularly big vehicle components such as trucks. This company's production system is Make to Order (MTO), which means that production begins when customers place an order. The huge number of product variants generated necessitates effective control and planning to ensure that the manufacturing process for each product continues to run properly. This company manufactures automotive components, including the Bracket Chamber. The bracket Chamber is a component of four-wheeled vehicles, including huge vehicles such as trucks, which connects the vehicle chassis to the wheels. This product is MTG, Ltd's flagship product due to its strong demand, with 8710 units expected in 2022. A CNC machine (presses 1 and 2) is required for bracket chamber manufacture. Casting bracket Chambers, bushings, and seals are the raw materials used to make bracket chambers. The bracket chamber is a product that is currently facing issues with its raw materials. The issues with the bracket chamber arise from an excessive procurement of raw materials by the company. Consequently, this leads to excess inventory and necessitates enterprises to allocate more funds for the storage of raw materials in warehouses. Hence, the objective of this study is to ascertain the precise quantity of raw material required for chamber brackets, with the aim of mitigating overstock and minimising the associated costs borne by the company. Another problem is the unbalanced machine capacity in producing bracket chamber products.

Previous studies regarding production planning in the automotive sector include forecasting demand and inventory of spare parts using the triple exponential smoothing method (Doresdiana et al., 2021). Furthermore, integrating the information system of material resource planning and supply chain procurement in business processes is designed in Indonesia's local original equipment manufacturer (OEM) for automotive components (Wijaya et al., 2022). Analysis of planning and material requirements at automotive component injection molding companies (Huda & Hartati, 2021) and Y-strainer production (N. V Putri & Gozali, 2021) with the most optimal inventory costs using the lot-for-lot method.

Many methodologies or approaches can be utilized to handle production planning and control challenges, including the Material Requirement Planning (MRP) method. This strategy takes into account both the company's material inventory and its production capacity requirements. In MRP, approximate Rought Cut Capacity Planning (RCCP) calculations are performed to calculate the approximate capacity requirements for the company's Master Production Schedule (MPS) (Setiawan & Usman, 2023). MRP calculations are used to identify the best planning schedule for ordering raw materials, and further analysis is performed using Capacity Requirement Planning (CRP) (Siregar, 2022; Susanti, 2020). Using the MRP approach can help to tackle difficulties such as raw material delivery delays and company overcapacity.
The purpose of this research is to plan the material requirements for bracket chamber products, as well as the company's production capability, using the material requirements plan.

2. LITERATURE REVIEW

Production planning and control is the activity of planning and controlling input, carrying out processes, and producing output from a production system in order to meet consumer demand as quickly as possible while minimizing costs (Lumban Raja, 2022). Material Requirement Planning (MRP) is a logical procedure for processing the master production schedule into net requirements for all raw materials (Putri & Nurcaya, 2020). Several MRP methods include the LFL technique, this technique constantly recalculates (is dynamic), especially if there is a change in net requirements. The aim of using this technique is to minimize storage costs so that the storage costs are zero. Next is the EOQ technique, which has a fixed lot size and involves ordering costs and holding costs. Orders are placed if the amount of inventory cannot meet the desired needs. This technique is usually used for a one-year planning horizon. Meanwhile, the POQ method of ordering intervals is determined by a calculation based on classical EOQ logic, modified to be used on requests with discrete periods. Of course, results can be obtained regarding the size of the number of orders that must be placed and the order period interval (Sukma Adhiyasa et al., 2023). The main purpose of CRP is a comparison between available capacity loads and actual needs (Ramya et al., 2019)

3. RESEARCH METHOD

This research applies the MRP method at the MTG, Ltd company for bracket chamber products. Data was collected between February 2023 and April 2023. The bracket chamber is a component of four-wheeled vehicles, particularly trucks, that connects the chassis to the wheels. The production system for Bracket Chamber products at this company is Make to Order (MTO), so production is carried out when there is an order from the customer. The research process is as follows and can be seen in Figure 1: (1)Data collection. Primary data collected includes bill of materials, MPS, inventory status and inventory cost. (2)Calculate MRP including RCCP, MRP and CRP. The RCCP calculation is carried out to determine the rough capacity requirements for bracket chamber production and whether the available capacity is sufficient. The MRP calculation aims to obtain an optimal schedule with minimum costs. The technique for determining the MRP lot size in this research uses 3 Lot Sizing methods, namely Lot For Lot (LFL), Economic Order Quantity (EOQ), and Period Order Quantity (POQ). After obtaining the order schedule from the MRP method with the selected lot size, the CRP calculation is carried out to determine whether the company's production capacity is sufficient.

1. Analysis of calculation results

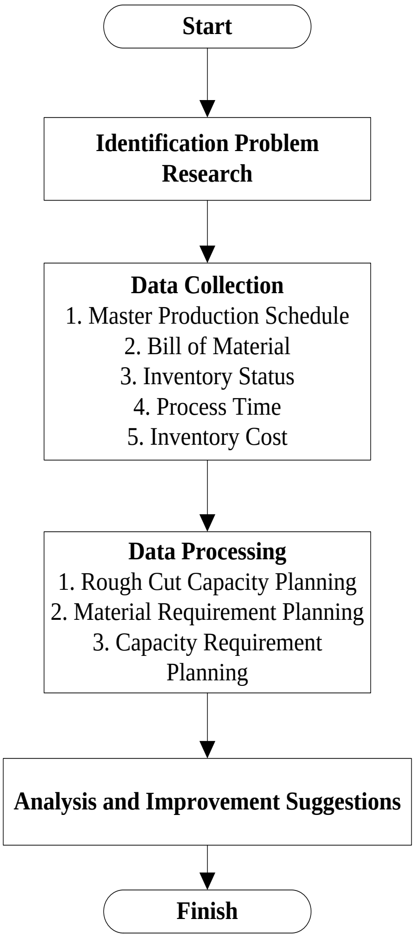

Figure 1. Research framework

4. RESULT AND DISCUSSION

4.1 Data Analysis

Some of the data that has been obtained to complete this research includes machine details (Table 1), MPS (Table 2), product structure, on hand inventory and lead time (Table 3), inventory costs (Table 4). Inventory costs in the research consist of ordering costs and holding costs. The ordering cost components consist of expedition costs, driver costs, loading and unloading costs, and administration costs. Meanwhile, the storage cost component consists of warehouse maintenance, forklift, and electricity costs.

Table 1. Machine details

Machine	Process	Operator	Part	Setup Time (Minutes)	Run Time (Minutes)	Process Time (Minutes)
CNC	Operation 1 Operation 2		Casting	2.8	19.3	22.1
Press 1	Assy Bushing	1 person	Bushing	0.8	1.7	2.5
Press 2	Assy Seal		Seal	0.8	1.7	2.5

Table 2. Master production schedule (January to December 2023)

	Period											
	1	2	3	4	5	6	7	8	9	10	11	12
Master Production Schedule (Units)	600	560	630	640	480	488	1038	930	870	858	808	544

Table 3. Bill of material, on hand inventory and lead time

Row	Product Details	Component Name	Quantity (pcs)	On Hand Inventoty (pcs)	Lead Time (Month)
1		Bracket Chamber	1	80	-
2		Casting Bracket Chamber	1	80	1
3		Bushing	1	80	2
4		Seal	1	80	2

Table 4. Inventory cost

Row	Component Name	Supplier	Ordering Cost (IDR/year)	Holding Cost (IDR/year)
1	Casting Bracket Chamber	JIC, Ltd	7,339,200	4,086,251
2	Bushing	TTI, Ltd	2,136,000	355,326
3	Seal	TTI, Ltd		

4.2 Rought Cut Capacity Planning Calculation

RCCP calculations are carried out to measure the capacity required to implement MPS. If the results of the RCCP calculation indicate that the MPS is feasible, then the MPS can be continued with the MRP process to determine the company's material requirements planning. The RCCP calculation in this research uses the Capacity Planning Using Overal Factor Approach (CPOF) approach.

In order to know whether the available capacity can meet MPS needs, a calculation is carried out by subtracting the capacity requirement value from the available capacity. Suppose a minus (-) value is obtained. In that case, it indicates that there is still available capacity, which means the capacity requirement can be met. However, if what is obtained is the plus value (+), the capacity requirement exceeds the company's available capacity. Utilization calculations are carried out to determine the extent to which capacity is used, and effectiveness calculations determine whether the available capacity is effective in implementing the company's MPS.

Table 5. Identify machine capacity availability

Machine	Period	Capacity Requirements (unit)	Capacity available (unit)	Varians	Utilization	Effectiveness
CNC	January	600	1099,5	-499,5	55%	1,8
	February	560	1099,5	-539,5	51%	2,0
	March	630	1099,5	-469,5	57%	1,7
	April	640	1099,5	-459,5	58%	1,7
	May	480	1099,5	-619,5	44%	2,3
	June	488	1099,5	-611,5	44%	2,3
	July	1038	1099,5	-61,5	94%	1,1
	August	930	1099,5	-169,5	85%	1,2
	September	870	1099,5	-229,5	79%	1,3
	October	858	1099,5	-241,5	78%	1,3
	November	808	1099,5	-291,5	73%	1,4
	December	544	1099,5	-555,5	49%	2,0
Press 1 and Press 2	January	600	9720	-9120,0	6%	16,2
	February	560	9720	-9160,0	6%	17,4
	March	630	9720	-9090,0	6%	15,4
	April	640	9720	-9080,0	7%	15,2
	May	480	9720	-9240,0	5%	20,3
	June	488	9720	-9232,0	5%	19,9
	July	1038	9720	-8682,0	11%	9,4
	August	930	9720	-8790,0	10%	10,5
	September	870	9720	-8850,0	9%	11,2
	October	858	9720	-8862,0	9%	11,3
	November	808	9720	-8912,0	8%	12,0
	December	544	9720	-9176,0	6%	17,9

The results of the RCCP calculation using the CPOF approach for each machine are summarized in the image of the load profile diagram in Figures 2 to 4.

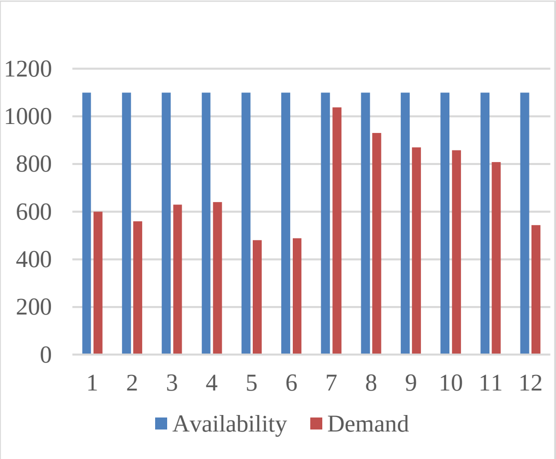

Figure 2. Load profile CNC machine

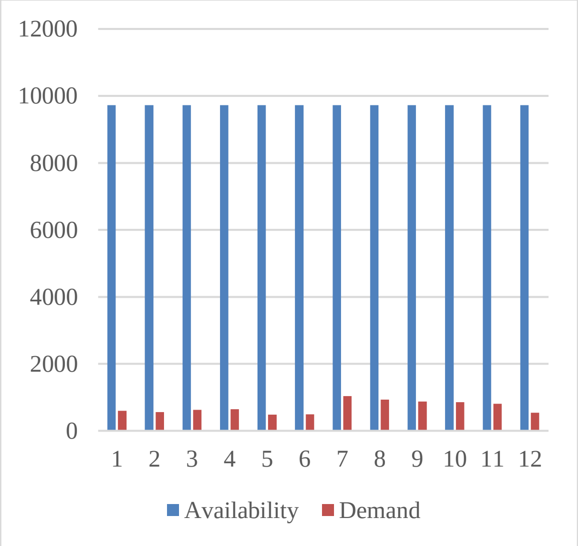

Figure 3. Load profile Press 1 machine

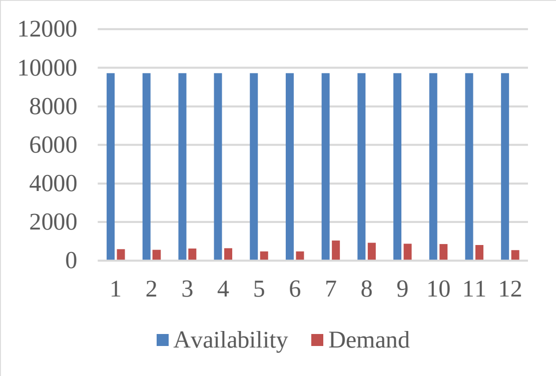

Figure 4. Load profile Press 2 machine

Based on Figure 2-4, there is a comparison between the available capacity on each machine and the capacity required to carry out MPS for bracket chamber products. The available capacity of CNC machines for each period is 1099.5 units, while press machine 1 and press machine 2 have a capacity of 9,720 units. So, it can be concluded that the company's MPS can be run well because capacity requirements are met and there is no shortage of available capacity on each machine. Next, the MRP calculation will be carried out to determine the material ordering schedule with an optimal schedule and minimum costs.

4.3 Material Requirement Planning Calculation

MRP calculations aim at the best lot size for the most optimal schedule. The technique for determining lot size in this research was carried out using 3 methods, namely Lot For Lot (LFL), Economic Order Quantity (EOQ), and Period Order Quantity (POQ). Calculations were also carried out to determine the safety stock of raw material for the bracket chamber to avoid running out of material. The calculations are as follows:

1. *Lot for Lot (LFL)*

Based on the results of the MRP calculation using the LFL method, the total inventory costs for each component making up the bracket chamber can be seen in Table 5.

Table 5. LFL calculation

Part Name	Order Frequency	Ordering Cost (IDR)
Casting Bracket Chamber	12	7,377,905
Seal	12	2,136,000
Bushing	12	2,136,000
Total Inventory Cost		**11,611,200**

2. *Economic Order Quantity (EOQ)*

Economic Order Quantity (EOQ) is a method of fulfilling the need for raw materials or components based on the most economical ordering costs with the formula:

Nilai EOQ komponen *Casting Bracket* :

$$EOQ = \sqrt{\frac{2\,DS}{H}}$$

$$= \sqrt{\frac{2 \times 8446 \times Rp.\ 611.600,}{Rp.\ 484}}$$

= 4621 Pcs

Nilai EOQ komponen *Bushing* dan *Seal* :

$$EOQ = \sqrt{\frac{2\,DS}{H}}$$

$$= \sqrt{\frac{2 \times 8446 \times Rp.\ 178.000,}{Rp.\ 42}}$$

= 8462 Pcs

Based on the calculation of the EOQ value, the most economical order value for casting bracket chamber raw material components is 4621 Pcs in one order. Meanwhile, the raw material components for Bushings and Seals are 8462 Pcs. The total inventory costs obtained using the EOQ method can be seen in Table 6.

Table 6. EOQ calculation

Part Name	Order Frequency	Ordering Cost (IDR)
Casting Bracket Chamber	2	14,183,960
Seal	1	2,308,912
Bushing	1	2,308,912
Total Inventory Cost		**18,801,784**

3. *Period Order Quantity (POQ)*

After calculating the POQ, it was found that planning the needs for casting bracket chamber components is done by placing an order to meet the raw material needs for the next 7 periods in one order. Meanwhile, for raw material components for bushings and seals, orders are made equal to the raw material requirements for the next 12 periods in one order. Inventory costs obtained using the POQ method can be seen in Table 7.

Table 7. POQ calculation

Part Name	Order Frequency	Ordering Cost (IDR)
Casting Bracket	2	11.631.868
Seal	1	2.260.528
Bushing	1	2.260.528
Total Inventory Cost		**15.974.924**

Based on MRP calculations using the LFL, EOQ, and POQ methods, it was found that the method with the minimum inventory costs was LFL. Thus, planning the material requirements for the bracket chamber using the LFL method is the chosen method.

The next stage is calculating safety stock. Determining Safety Stock in this research uses statistical methods by looking for the standard deviation of material requirements/year. The company has a Service Level of 80% with a deviation of 20%. So, the policy factor (K) value at a frequency level of service of 80% is 0.84 (Table Z). So, the calculation for Safety Stock for each component of the Bracket Chamber raw material is as follows:

1. Bracket Chamber
   Safety Sotck = Z √LT (σd)
   = 0.84 x √1 x 179.8
   = 151.39
   ≈ 152 pcs

2. Bushing dan Seal
   Safety Sotck = Z √LT (σd)
   = 0.84 x √2 x 179.8
   = 214.10
   ≈ 215 pcs

4.4 Capacity Requirement Planning Calculation

After knowing the actual capacity for bracket chamber production in each period, a CRP calculation can be made for bracket chamber production, which contains details of available time, actual utilization and efficiency, capacity requirements, and available capacity at the company. The results of calculating the available capacity on each machine will be compared with the existing capacity requirements to produce chamber brackets. Based on the comparison results, it will be known whether the company's available capacity is sufficient to meet needs, and a decision will be made as to whether additional working hours are needed to meet the production needs of chamber brackets.

Before making CRP calculations, capacity must be calculated. Based on CRP calculations, it is known that the available capacity on the CNC machine, Press 1 and Press 2, is 21,931 minutes/period. Based on Figure 5, the comparison of available capacity with actual needs is sufficient.

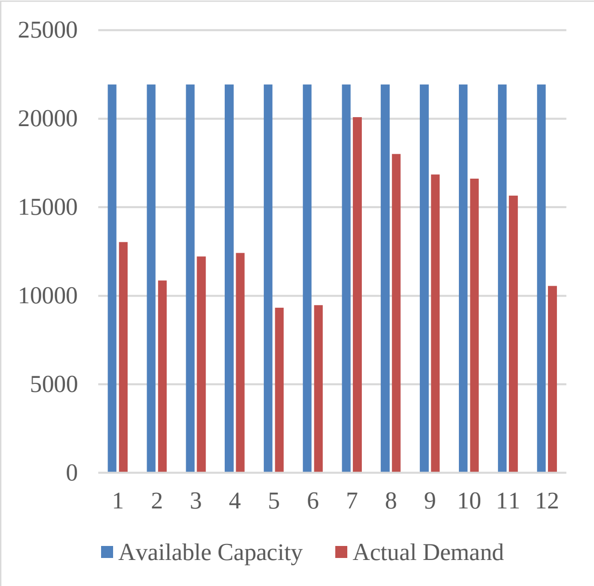

Figure 5. Load profile CRP CNC machine

Meanwhile, for Press 1 and Press 2 machines (Figures 6 and 7), the ratio between the available capacity is much greater than the actual needs, causing Press 1 and Press 2 machines to be often idle. The machine can be used for other production.

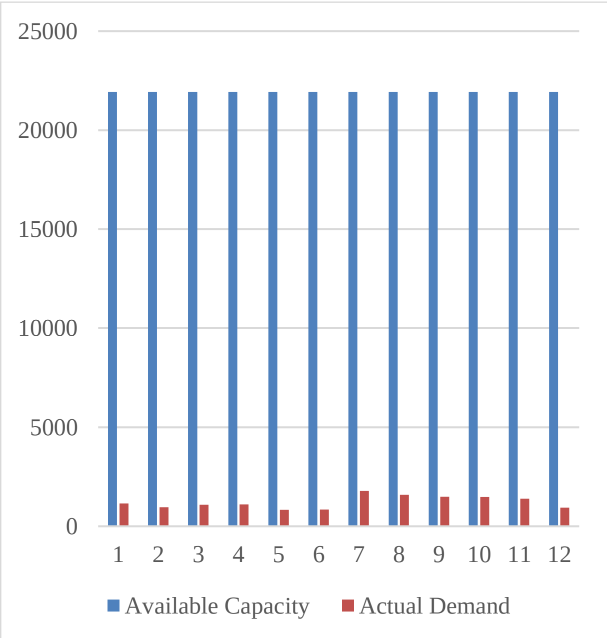

Figure 6. Load profile CRP Press 1 machine

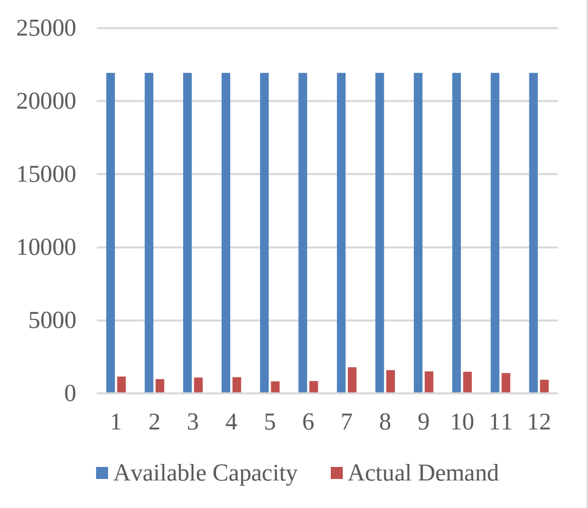

Figure 7. Load profile CRP Press 2 machine

5. CONCLUSION

Based on the results of RCCP calculations, it is known that the available capacity of CNC machines is 1,100 units/period and press machines is 9,720 units/period. Meanwhile, the average need for chamber bracket production is 704 units/period. Thus, MPS can be implemented because the available capacity can meet production needs. Furthermore, the LFL method is chosen for material planning because it produces the minimum inventory costs of IDR. 12,710,751, and the frequency of ordering raw materials is 12 times in 1 year. Finally, based on the CRP calculation results, it is known that the available capacity on the CNC machine is 21,931 minutes, with the average actual requirement being 13,756 minutes/period. Meanwhile, for press 1 and press 2 machines, the available capacity for each machine is 21,931 minutes, with the average actual requirement being 1,223 minutes/period. The large difference between available capacity and actual needs on press machine 1 and press machine 2 often causes the machine to idle. Therefore, press machines 1 and 2 can be used for other production. Further research can be continued by implementing an Enterprise Resource Planning (ERP) system, especially in material requirement planning.

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