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Implementation of Material Requirements Planning to Minimize Stockout and Material Procurement Costs in Volume Damper Production

Adiksa Madha Putra*[1], Siti Mundari[2]

[1,2] Program Studi Teknik Industri, Fakultas Teknik, Universitas 17 Agustus 1945 Surabaya, Indonesia

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ABSTRACT

CV. XYZ is a manufacturing company producing HVAC accessories, particularly volume dampers, which faces inventory control problems due to the absence of a structured Material Requirements Planning (MRP) system. These issues have resulted in stockouts, production delays, and inefficiencies in material procurement. This study aims to identify the most appropriate MRP method to fulfill customer demand while minimizing procurement costs. A quantitative approach was employed, including standard time measurement, aggregate planning, Master Production Scheduling (MPS), and MRP analysis using Lot For Lot (LFL), Economic Order Quantity (EOQ), and Fixed Period Requirement (FPR) lot-sizing techniques. The results indicate that the LFL method provides the most effective inventory planning performance by aligning material orders with actual demand, thereby reducing inventory-related costs and minimizing the risk of stockouts. The implementation of MRP also demonstrates significant improvements in procurement efficiency compared with the company's existing practice. This study contributes to the inventory management literature by integrating standard time measurement, aggregate planning, Master Production Scheduling (MPS), and MRP within a unified framework for inventory planning and stockout mitigation. Therefore, the adoption of MRP with the LFL technique is recommended to support more efficient inventory management and production planning.

1. Introduction

Inventory management is a critical function in manufacturing systems because it directly affects production continuity, operational efficiency, and customer service performance. Ineffective inventory control may lead to excessive holding costs, material shortages, and production disruptions that negatively impact organizational performance. For manufacturing companies, lack of inventory poses the risk of failing to fulfill demand, which means losing the opportunity to earn profit. According to Sunyoto [1], inventory control is a set of policies to determine the level of inventory that must be maintained, when orders should be placed, and how many units should be ordered at a time in the right quality and quantity.

In today's increasingly competitive manufacturing environment, companies are required to maintain a balance between product availability and inventory costs. Effective inventory management plays a critical role in supporting production continuity, minimizing operational delays, and improving customer satisfaction. Conversely, poor inventory planning may result in excessive stock accumulation, increased holding costs, production disruptions, and stockout conditions that negatively affect organizational performance and profitability. Therefore, an effective inventory control system is necessary to ensure that raw materials are available in the right quantity and at the right time to support production requirements [2].

One of the commonly used approaches in production inventory management is Material Requirements Planning (MRP). MRP is a systematic inventory planning approach used to determine the quantity and timing of raw material procurement based on production schedules and product structures. MRP integrates demand forecasts, inventory records, lead times, and bill of materials (BOM) information to calculate material requirements accurately and support production activities. The implementation of MRP can reduce inventory-related costs, prevent material shortages, improve production efficiency, and enhance coordination among

Email: adiksamadhaputra@gmail.com (Putra, A. M.)*, mundari@untag-sby.ac.id (Mundari, S.)

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* Writer correspondence

purchasing, warehousing, and production functions. Consequently, MRP is widely adopted in manufacturing environments to improve inventory control and support timely fulfillment of customer demand [3].

Recent developments in Industry 4.0 have transformed traditional inventory management practices through the integration of digital technologies such as the Internet of Things (IoT), cyber-physical systems, real-time data analytics, and smart manufacturing platforms. These technologies enable more responsive inventory control, improved demand visibility, and enhanced decision-making capabilities [4]. Nevertheless, many small and medium-sized manufacturing enterprises still rely on conventional planning approaches due to resource limitations and implementation complexity. Consequently, understanding the effectiveness of traditional MRP techniques remains relevant, particularly for organizations that have not yet fully adopted digital inventory systems [5].

Recent studies have emphasized the role of Enterprise Resource Planning (ERP) systems, digital supply chains, and real-time analytics in enhancing inventory visibility and improving material planning performance. The integration of digital technologies enables organizations to respond more effectively to demand fluctuations, optimize inventory levels, and support data-driven decision-making across the supply chain. However, the implementation of such technologies remains challenging for many small and medium-sized enterprises due to financial, technical, and organizational constraints [6].

The novelty of this study does not lie in the development of a new optimization algorithm but in the integration of standard time measurement, aggregate planning, Master Production Scheduling (MPS), and MRP within a unified framework for inventory decision-making. Furthermore, this study simultaneously evaluates three commonly used lot-sizing techniques (LFL, EOQ, and FPR) and quantifies both stockout-related revenue losses and procurement inefficiencies in a volume damper manufacturing environment. This integrated approach provides a more comprehensive basis for inventory planning and managerial decision-making in small and medium-sized HVAC component manufacturers. Therefore, the contribution of this study should be viewed as an application-oriented and integrative contribution that extends the practical implementation of MRP in a specific manufacturing context rather than as the development of a new inventory optimization method. The present study focuses on deterministic material planning using MRP-based lot-sizing techniques derived from aggregate planning and the MPS. Therefore, safety stock and reorder point policies, which are commonly applied under demand and lead-time uncertainty conditions, are considered beyond the scope of this research. Future studies may incorporate these inventory control parameters to further strengthen stockout mitigation strategies and inventory system robustness.

CV. XYZ has been operating since 2005 and is located at Jalan Ngingas Selatan, Kecamatan Waru, Sidoarjo. The organization produces HVAC (Heating, Ventilation, Air Conditioning) accessories and one of its main products is the volume damper – a device installed in air duct systems (ducting) to regulate air flow volume. The product consists of several components/parts as shown in Table 1.

Table 1
Volume Damper Components

No	Level	Code	Description	Quantity (pcs)
1	0	VD	Volume Damper	1
2	1	F	Frame	1
3	1	B	Blade	2
4	1	E	Ankle	1
5	2	P1	Rivet	20
6	2	PB	Blade Plate	4
7	2	PS	Side Plate	2
8	2	PA	Base Plate	2
9	2	TPB	Blade Support Blade	2
10	2	TA	Base Post	2
11	2	AE1	Ankle Axle	2
12	2	PE	Ankle Plate	3
13	2	M	Ear Nut	1
14	2	S	Stickers	1
15	2	R1	Ring M8	6

The volume damper product is categorized as a multi-component product because it is assembled from various interconnected parts and subcomponents. The production process requires accurate coordination between the availability of raw materials and the production schedule. If one component is unavailable, the entire assembly process can be delayed, causing production stoppages and delivery delays to customers. Therefore, planning for raw material requirements becomes an essential factor in ensuring smooth production activities.

The main problem faced is stockouts due to the absence of a structured material requirements planning system. During the period March 2025 – February 2026, there were 54 units that could not be produced due to raw material shortages, resulting in revenue losses of Rp 97,762,140 (Table 2).

Table 2
Production Capacity, Demand, and Stockout Data (March 2025–February 2026)

Month	Capacity (unit)	Demand (unit)	Stockout	Revenue Loss
March 2025	69	57	0	-
April 2025	63	60	0	-
May 2025	75	89	14	Rp25.345.740
June 2025	69	82	13	Rp 23.535.330
July 2025	81	87	6	Rp 10.862.460
August 2025	78	78	0	-
September 2025	75	75	0	-
October 2025	81	83	2	Rp 3.620.820
November 2025	75	88	13	Rp 23.535.330
December 2025	78	84	6	Rp 10.862.460
January 2026	75	73	0	-
February 2026	69	65	0	-
Total			**54**	**Rp97.762.140**

The stockout conditions experienced by the organization indicate that the current inventory control system has not been able to anticipate fluctuations in demand and production needs effectively. Raw material procurement is still conducted conventionally based on estimation and immediate production requests, causing inconsistencies in inventory availability. This condition not only disrupts the production process but also impacts customer trust and company competitiveness. Delays in fulfilling customer orders may lead to customer dissatisfaction and the possibility of losing future business opportunities. Therefore, improvements in production planning and inventory control systems are urgently needed to reduce the risk of stockouts and improve operational performance.

In addition to stockout problems, inefficient procurement activities may also increase inventory-related costs, such as ordering costs and holding costs. Excessive procurement can result in overstock conditions and high storage expenses, while insufficient procurement leads to production interruptions. Consequently, determining an appropriate lot sizing method becomes important in achieving cost efficiency and ensuring material availability. Several lot-sizing techniques are commonly applied within MRP systems, including Lot for Lot (LFL), Economic Order Quantity (EOQ), and Fixed Period Requirement (FPR). Each technique employs a different ordering strategy and offers distinct advantages depending on demand patterns, ordering costs, holding costs, and inventory conditions. LFL minimizes inventory carrying costs by ordering according to actual requirements, EOQ aims to balance ordering and holding costs through an optimal order quantity, while FPR determines procurement quantities based on fixed ordering intervals. Therefore, a comparative evaluation of these methods is necessary to identify the most appropriate inventory planning approach for the company's operational conditions [7].

Previous studies have reported the successful application of Material Requirements Planning (MRP) in improving inventory control and reducing procurement costs across various manufacturing sectors. For example, Kaffi et al. [8] applied MRP to raw material planning in furniture manufacturing, while Purnama and Pulansari [9] demonstrated the effectiveness of MRP in minimizing inventory costs in food production. Similarly, several studies have compared different lot-sizing techniques to identify the most cost-efficient inventory policy. However, these studies generally focused on inventory planning without integrating production capacity analysis, standard time measurement, aggregate planning, and Master Production Scheduling (MPS) within a single decision-making framework.

Although previous studies have demonstrated the effectiveness of Material Requirements Planning (MRP) in improving inventory control and reducing inventory costs, most of these studies have been conducted in general manufacturing settings and have not comprehensively integrated standard time measurement, aggregate planning, Master Production Scheduling (MPS), and comparative lot-sizing analysis. Furthermore, limited attention has been given to small and medium-sized HVAC component manufacturers that experience stockout problems due to inadequate material planning. Therefore, this study addresses this research gap by evaluating the implementation of MRP using LFL, EOQ, and FPR techniques in a volume damper production system to minimize stockout risks and material procurement costs.

Based on these problems, this research is important to provide recommendations for improving the production planning and inventory control system at CV. XYZ. By implementing Material Requirements Planning integrated with aggregate planning and master production scheduling, the company is expected to minimize stockout occurrences, optimize raw material procurement, and improve production efficiency. Furthermore, the results of this study are expected to serve as a reference for similar manufacturing companies facing inventory planning and material procurement challenges. To address the identified research gap and demonstrate the practical contribution of the proposed framework, this study integrates production capacity analysis, production planning, and inventory planning into a comprehensive decision-support approach for minimizing stockout risks and procurement costs. This study aims to: (1) determine the standard time for the volume damper production process, (2) develop aggregate planning and master production scheduling, (3) calculate MRP using the LFL, EOQ, and FPR lot sizing techniques, and (4) analyze cost losses due to stockout conditions and inefficiency in material procurement.

2. Research methods

This research was conducted at CV. XYZ, a manufacturing company located in Waru, Sidoarjo, Indonesia, focusing on the production process of volume dampers. A quantitative approach was employed using both primary and secondary data. Primary data were collected through direct observation, interviews, and stopwatch time studies, while secondary data were obtained from company records, including historical demand data, inventory records, bill of materials (BOM), production capacity data, and procurement cost information.

The research procedure consisted of four main stages: data collection, standard time measurement, production planning, and inventory planning analysis (see Figure 1). Standard time measurement was performed to determine production capacity. To ensure the reliability of the observed working time, data adequacy and data uniformity tests were conducted before calculating the standard time. The results were then used to develop aggregate planning and a MPS. Subsequently, MRP was calculated using three lot-sizing techniques: Lot for Lot (LFL), Economic Order Quantity (EOQ), and Fixed Period Requirement (FPR). Finally, a cost analysis was conducted to compare the existing procurement system with the proposed MRP alternatives and identify the most efficient inventory planning method. The performance of each lot-sizing technique was evaluated based on total inventory-related costs, including ordering and holding costs, to determine the most cost-effective material planning strategy for the company.

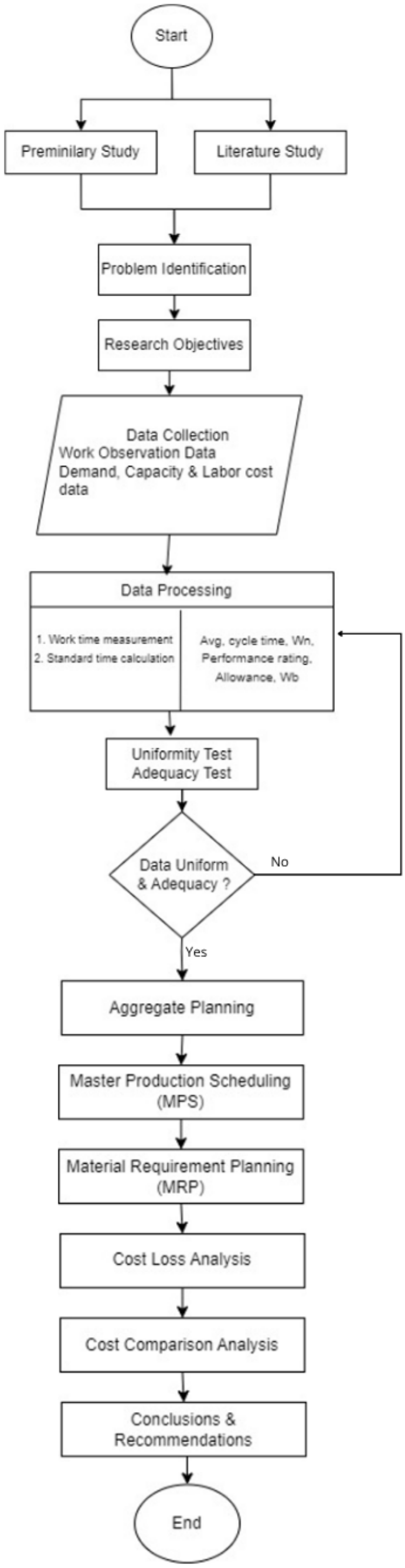

Figure 1. Research Framework

2.1 Standard Time Measurement

Standard time measurement is carried out using the stopwatch time study method with 30 observations per work element. Work measurement was conducted to determine the standard processing time required in the production of volume dampers. The standard time is important because it becomes the basis for determining production capacity, labor requirements, and production scheduling. The stopwatch time study method was chosen because it is suitable for repetitive production activities and provides relatively accurate measurement results. In this study, each work element was observed repeatedly to obtain representative cycle time data and reduce measurement errors. The observed work elements included cutting, assembling, drilling, riveting, and finishing activities involved in the production process. The observed times were then tested for data uniformity and adequacy to ensure that the collected data were statistically acceptable. Furthermore, performance rating and allowance factors were applied to determine the normal time and standard time for each work element.

a. Cycle Time :

$$W_s = \frac{\sum_{i=1}^{n} x_i}{n}$$

where Ws is the average cycle time, xi is the observed cycle time for observation i, and n is the total number of observations.

b. Uniformity Test:
UCL = x̄ + k (SD)
LCL = x̄ − k (SD)

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

where UCL is the upper control limit, LCL is the lower control limit, x̄ is the average observation time, k is the confidence coefficient, and SD is the standard deviation.

c. Adequacy Test:

$$N' = \left[\frac{k}{s}\sqrt{\frac{N\sum x_i^2 - (\sum x_i)^2}{(\sum x_i)^2}}\right]^2$$

where N′ is the required number of observations, N is the number of observed data points, k is the confidence level coefficient, and s is the desired accuracy level.

d. Normal Time:
$W_n = W_s \times PR$ (PR = Performance Rating Westinghouse)
where Wn is the normal time, Ws is the observed cycle time, and PR is the performance rating based on the Westinghouse rating system.

e. Standard Time:
$W_b = W_n \times (1 + A)$

where Wb is the standard time and A represents the allowance factor. The allowance factor was set at 15% based on direct observations of production activities and consideration of standard work measurement practices. The allowance includes personal needs, worker fatigue, and unavoidable delays that occur during the production process. This value is consistent with commonly applied allowance ranges in industrial engineering and work measurement studies [10].

2.2 Aggregate Planning and Master Production Scheduling

Aggregate planning is compiled to determine regular and overtime production capacity to meet demand over 12 periods. The demand values used in aggregate planning were obtained from historical company demand records covering the period March 2025 to February 2026. Since the objective of this study was to evaluate inventory planning and procurement performance under known demand conditions, no separate forecasting model was developed. The historical demand data were directly utilized as planning inputs for aggregate planning, MPS and MRP calculations. The output of aggregate planning is used as the basis for preparing the Master Production Schedule (MPS), which becomes the main input for MRP calculations. Aggregate planning is an important stage in production planning because it aims to balance production capacity with forecasted demand over a medium-term planning horizon. Through aggregate planning, the organization can determine the optimal combination of regular production, overtime, workforce utilization, and inventory levels to satisfy customer demand efficiently [11]. In this research, aggregate planning was prepared using historical demand data for a 12-month period to estimate future production requirements. The result of aggregate planning was then translated into the MPS, which specifies the quantity and timing of finished products to be produced in each production period. The MPS functions as a detailed operational plan that coordinates production activities and material procurement. Accurate MPS preparation is essential because errors in scheduling may cause shortages or excess inventory that affect operational performance and company costs. Therefore, the MPS generated in this study became the primary input in the MRP calculation process [12].

2.3 Material Requirements Planning (MRP)

MRP is calculated using three lot sizing techniques: (1) LFL – ordering according to actual demand each period; (2) EOQ – ordering based on the optimal economic quantity; and (3) FPR – ordering with a fixed period interval. MRP is used to determine the quantity and timing of raw material procurement based on the production schedule and product structure. The implementation of MRP allows companies to identify net material requirements by considering gross requirements, inventory on hand, scheduled receipts, and lead time for each component. In this study, MRP calculations were performed for all components involved in the volume damper production process based on the BOM. The EOQ formula used is:

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

where EOQ is the economic order quantity, D is annual demand, S is ordering cost per order, and H is annual holding cost per unit.

2.4 Cost Analysis (Job Order Costing)

Cost loss analysis is carried out using the Job Order Costing approach to compare actual material procurement costs with the costs generated through the MRP approach. The cost analysis stage was conducted to evaluate the financial impact of implementing the proposed MRP system compared to the production system existing procurement system. The Job Order Costing approach was selected because the production process involves specific orders and requires detailed calculation of material-related costs for each production activity [13]. The analysis focused on comparing ordering costs, holding costs, and total inventory costs generated by each lot sizing technique [14]. In addition, the analysis also considered the cost losses caused by stockout conditions experienced by the company during the observation period. By comparing the actual company condition with the proposed MRP methods, this study aimed to determine the potential cost savings and operational improvements that could be achieved through systematic material planning. The lot sizing method that produced the lowest total inventory cost while maintaining material availability was considered the most effective approach for the production system. The total MRP cost formula is:

$$TC = (I \times HC) + (OF \times OC)$$

where TC is the total inventory cost, I is inventory quantity, HC is holding cost per unit, OF is order frequency, and OC is ordering cost per order.

3. Results and Discussion

3.1 Standard Production Time for Volume Damper

Based on 30 measurements per work element, all data were declared uniform (within UCL and LCL bounds) and adequate (N' < N = 30). Performance rating assessment using the Westinghouse system produced adjustment factors ranging from +0.10 to +0.12 (P = 1.10–1.12), indicating that operators work at above-average rates. The allowance factor is set at 15%, covering personal needs, fatigue, and unavoidable delays. A summary of standard times is presented in Table 3. Based on Table 3, the total standard production time for one unit of volume damper is 1,898 seconds or approximately 31.6 minutes per unit. This standard time data is used as the basis for calculating production capacity in aggregate planning.

Table 3
Summary of Standard Production Time for Volume Damper

Work Element	Ws (second)	Wn (second)	Allowance (%)	Wb (second)
Aluminum Plate Cutting	312	343	15%	395
Forming/Bending Frame	248	273	15%	314
Blade Assembly	186	205	15%	236
Frame and Blade Assembly	224	246	15%	283
Engkel & Accessories Installation	178	196	15%	225
Sticker & Finishing Installation	142	156	15%	180
Quality Inspection	112	123	15%	141
Packing	98	108	15%	124
Total Standard Time per Unit				1.898

3.2 Aggregate Planning and Master Production Scheduling

Aggregate planning is prepared based on regular production capacity (normal working hours) and overtime capacity. The aggregate demand results over 12 periods show a total demand of 921 units with an average of 76.75 units per period. The aggregate planning results indicate that the available production capacity is generally sufficient to satisfy projected demand, provided that material availability is properly managed [16]. These findings highlight that stockout conditions experienced by the company are primarily related to inventory planning deficiencies rather than production capacity limitations.

3.3 Material Requirement Planning (MRP) Calculation

MRP is calculated for all volume damper components (21 items) using three lot sizing techniques. As a representative example, Table 4 shows the MRP calculation using the LFL technique for the main material Aluminum 0.5 mm (Blade). Total MRP LFL cost for Aluminum material = (Σ inventory × Rp 69,755) + (order frequency × Rp 225,000) = Rp 34,579,510 for aluminum 0.5 mm and 1.5 mm. It should be noted that this cost represents only the procurement cost of aluminum materials (0.5 mm and 1.5 mm) used as a representative example in the MRP calculation. The total optimum MRP cost reported in the subsequent analysis includes the aggregated procurement costs of all components contained in the volume damper BOM [16].

The Blade component is presented as a representative example of the MRP calculation procedure. The same calculation logic, including gross requirements determination, net requirements calculation, lot-sizing application, and planned order release scheduling, was consistently applied to all components contained in the volume damper BOM. Due to space limitations, detailed MRP tables for all components are not presented in the manuscript. However, all component-level calculations were incorporated into the total procurement cost analysis and cost comparison results reported in the subsequent section.

3.4 Recapitulation and Comparison of Lot Sizing Costs

Table 5 shows a comparison of total procurement costs for all volume damper components using the three lot sizing techniques over 12 periods. The comparison results in Table 5 show that the LFL technique produces the lowest procurement cost for aluminum materials (0.5 mm and 1.5 mm), amounting to IDR 34,579,510. This value represents only the procurement cost of aluminum materials used as a representative example in the MRP analysis [17]. When all components included in the volume damper BOM are considered, the total optimum MRP procurement cost reaches IDR 137,640,614. Compared with the company's actual procurement cost of IDR 198,728,310, the implementation of the optimum MRP plan could reduce procurement-related waste by IDR 61,087,696. These findings indicate that the absence of a structured material requirements planning system contributes significantly to procurement inefficiencies and unnecessary inventory-related costs.

Table 4
Example of MRP LFL – Component Blade

Component: Blade (Al 0.5mm) | Lead Time: 2 months | Lot Size: LFL	Mar	Apr	May	Jun	Jul	Agu	Sep	Oct	Nov	Dec	Jan	Feb
Gross Requirement	114	120	178	164	174	156	150	166	176	168	146	130
Beginning Inventory	8	0	0	0	0	0	0	0	0	0	0	0
Net Requirement	106	120	178	164	174	156	150	166	176	168	146	130
Lot Size (LFL)	106	120	178	164	174	156	150	166	176	168	146	130
Planned Order Release	178	164	174	156	150	166	176	168	146	130	0	0

Table 5
Lot Sizing Cost Recapitulation

Lot Sizing Method	Total Cost for All Components	Aluminum Cost (0.5mm + 1.5mm)	Note
LFL (Lot For Lot)	Rp 254.381.290	Rp 34.579.510	Most Economical
EOQ (Economic Order Quantity)	Rp 1.166.346.805	Rp 343.442.255	Highest Cost
FPR (Fixed Period Requirement)	Rp 656.210.854	Rp 177.100.030	Moderate Cost
Company Actual Cost	Rp 198.728.310	–	Without MRP

The superior performance of the LFL technique can be attributed to its ordering policy, which matches procurement quantities directly with actual material requirements in each period. This approach minimizes excess inventory and reduces holding costs, making it particularly suitable for environments characterized by fluctuating demand and limited storage capacity. In contrast, EOQ tends to generate larger order quantities that increase inventory carrying costs, while FPR may result in additional inventory accumulation due to fixed ordering intervals. From an operational efficiency perspective, the implementation of MRP with the LFL technique enables better synchronization between material procurement and production schedules. By aligning procurement quantities with actual requirements, the organization can reduce waiting time caused by material shortages, minimize production interruptions, and improve resource utilization throughout the manufacturing process [18], [19]. Consequently, production activities can be executed more consistently and efficiently.

The inventory behavior observed in this study indicates that the LFL technique minimizes inventory accumulation because procurement decisions are directly linked to period-specific demand. This behavior contrasts with EOQ and FPR approaches, which tend to generate larger inventory balances due to economic order quantities or fixed ordering intervals. Lower inventory levels reduce holding costs and decrease the risk of excess inventory becoming obsolete or underutilized.

From a supply chain perspective, improved material availability contributes to more reliable production planning and order fulfillment performance [20]. The reduction of stockout incidents enhances coordination between procurement, warehouse, and production functions, thereby improving the responsiveness of the manufacturing system to customer demand. In addition, more accurate material planning can reduce emergency purchasing activities and mitigate disruptions across the internal supply chain.

From a managerial standpoint, the findings suggest that inventory planning decisions should not focus solely on minimizing procurement costs. Managers should also consider the impact of inventory policies on production continuity, customer service levels, and operational stability. The results demonstrate that adopting MRP-supported procurement planning can serve as a strategic tool for balancing cost efficiency and service performance within manufacturing operations.

3.5 Cost Loss Analysis

Table 6 shows the recapitulation of costs ranging from revenue losses to cost losses from actual results minus MRP results. The comparison demonstrates that the existing material procurement system resulted in significantly higher procurement costs than the proposed MRP approach.

Table 6
Comparison of Actual and MRP Costs

Description	Total Cost
Company Actual Cost	Rp 198.728.310
MRP Cost (Optimum)	Rp 137.640.614
Waste Difference	Rp 61.087.696
Revenue Loss Due to Stockout	Rp 97.762.140

The company's actual procurement cost reached Rp 198,728,310, whereas the optimal MRP scenario using the Lot-for-Lot (LFL) technique reduced the total procurement cost to Rp 137,640,614, generating a potential cost saving (waste difference) of Rp 61,087,696, or approximately 30.74%. This reduction was primarily achieved by synchronizing procurement quantities with actual production requirements, thereby minimizing unnecessary inventory accumulation and excessive holding costs. In addition to procurement inefficiencies, the company experienced revenue losses of Rp 97,762,140 due to stockout conditions that prevented the production of 54 units during the observed period. These findings indicate that the absence of a structured material planning system not only increases procurement expenses but also negatively affects production continuity and sales performance. Therefore, implementing the MRP system with the LFL lot-sizing technique provides both operational and financial benefits by reducing inventory waste, minimizing stockout occurrences, and improving the company's ability to meet customer demand in a timely manner.

4. Conclusion

Based on the analysis results, the following conclusions can be drawn The Lot For Lot (LFL) technique is the most ideal MRP method for procuring aluminum raw materials (0.5 mm and 1.5 mm) for volume damper products. LFL produces the lowest total material procurement cost of Rp 34,579,510, far more efficient than EOQ (Rp 343,442,255) and FPR (Rp 177,100,030). The LFL technique is efficient because orders are placed according to actual demand each period, preventing inventory buildup. The cost losses experienced by CV. XYZ during the period March 2025 – February 2026 are significant. Revenue losses due to stockouts reached Rp 97,762,140 (54 units not produced). The difference between actual material procurement costs (Rp 198,728,310) and the optimum MRP cost (Rp 137,640,614) of Rp 61,087,696 illustrates the waste caused by the absence of a structured material requirements planning system in the production system. The consistent application of the MRP method with the LFL technique has the potential to eliminate stockout incidents and reduce material procurement costs, enabling the production system to fulfill all consumer demand more efficiently.

This study contributes to inventory management literature by demonstrating the effectiveness of integrating standard time measurement, aggregate planning, and MRP in reducing inventory inefficiencies within a make-to-order manufacturing environment. The findings also provide practical guidance for manufacturing firms facing stockout and procurement planning challenges. From a managerial perspective, the implementation of MRP with the LFL technique can assist manufacturing companies in improving procurement planning, reducing inventory waste, and enhancing customer service performance through more reliable material availability. The proposed approach may also serve as a practical reference for small and medium-sized manufacturing enterprises seeking to minimize stockout risks and improve inventory control effectiveness. Although this study focuses on conventional MRP implementation, the findings provide a foundation for future integration with digital inventory systems, smart manufacturing technologies, and Industry 4.0-based production planning environments. The proposed framework may support the transition toward more data-driven and intelligent inventory management practices, particularly for small and medium-sized manufacturing enterprises seeking to improve operational visibility and decision-making quality. Future research may investigate the integration of MRP with ERP platforms, digital supply chain technologies, and intelligent inventory management systems to improve planning accuracy, operational responsiveness, and supply chain resilience in manufacturing environments. This study is limited to a single product and a single manufacturing company. Future research may expand the analysis to multiple products, incorporate demand uncertainty, and evaluate advanced inventory optimization approaches to further improve material planning performance.

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