

Implementing MRP (Material Requirement Planning) for Managing Raw Material Inventory in an Indonesian Plastic Blown Film Company

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Abstract. The inventory costs of raw materials and finished goods for manufacturing companies can reach half of the company's assets. Proficient inventory management is needed to accelerate the production process and prevent overstocking or stock-outs. Raw material inventory planning at the company often experiences overstock of raw materials, which results in material damage and also increases operational storage costs. Therefore, this study aims to implement material requirement planning (MRP) in managing raw material inventories. The Min-Max, Reorder Point (ROP), and Economy Order Quantity (EOQ) methods are used in this research. These three methods are implemented on item code CLKG-15000294 from the PT Sidoraya Utama (PT.SRU) order. The result indicates that the most suitable methods to be implemented according to company conditions are Min-Max and Reorder Point (ROP). The Min-Max method is applied to determine the minimum stock of raw materials, the maximum stock of raw materials, and also the quantity that must be ordered. Meanwhile, the Reorder Point (ROP) method is used as a benchmark for repurchasing after reaching that point. Moreover, the study results also showed that the Min-Max method saved the cost of purchasing PE 1 raw materials by 76.97%, PE 2 raw materials by 64.96%, and PE 3 raw materials by 64.03%.

Introduction

The plastic packaging industry has grown rapidly over the past decade. In 2023, the demand for plastic products is recorded as 8.227 million tons, while 7.1 million tons are produced in Indonesia [1]. High demand for plastic products creates tough competition. That situation led each company to conduct the production process efficiently and exceed customer expectations. The plastic blown film company produces many types of products, consisting of T-shirt bags, sheet on roll, bag on roll, flat bag, tubing on roll, soft loop, hand gloves, garbage bag, and others. With a wide product, the plastic blown film company has abundant customers and needs a large supply of raw materials. The company investigated in this study is located in Mojokerto, East Java, and manufactures plastic bags for both export and domestic markets. It serves 165 active customers and 37 passive customers. Active customers are those who place regular orders, while passive customers only order for specific events. To fulfill customer demand, the company operates six blown film machines, four automatic bag-cutting machines, one punching machine, and two mixers. Therefore, proficient inventory management is needed by the company to ensure customer satisfaction at product delivery time and, on the other hand, avoiding the overstock of raw materials. Overstocking of materials tends to lead to material deterioration and increase inventory costs. Currently, the company does not apply a systematic method to calculate raw material requirements. Instead, staff rely solely on personal experience, leading to a high risk of either overstocking or stockouts. The largest overstock case was identified in the plastic bag product coded CLKG-15000294, ordered by PT Sidoraya Utama (PT.SRU). The main issue lies in the fact that product CLKG-15000294 is a make-to-order (MTO) item with a very large volume, making it difficult for the company to determine the required amount of raw material accurately. Therefore, an appropriate method is needed to estimate raw material

requirements for this product. The raw materials used for manufacturing product CLKG-15000294 consist of three variants of low-density polyethylene (LDPE) and recycled LDPE. The use of recycled LDPE not only reduces production costs but also helps minimize environmental impact [2]. The utilization of recycled materials has gained considerable attention among researchers. For example, a previous study conducted a case study in a plastic manufacturing company [3], focusing on the allocation of recycled material orders and determining the optimal order allocation.

That problem can be solved by utilizing Material Requirement Planning (MRP). MRP is known as a method to determine the amount of materials in the production process [4]. As the most popular method in material management, the material needed can be planned to be received on time with the correct amount and avoid overstocking or shortage of supplies [5]. Therefore, many of the previous studies conducted research for utilizing and developing the method. The closed-loop MRP and MRP II have been proposed in the later period that focused on various aspects of its operation and impact on the firm [3]. Enterprise resource planning (ERP) was developed in the same direction as MRP [6, 7]. Furthermore, for incorporating market demand, demand-driven MRP (DDMRP) was developed. The main feature of this method is incorporating dynamic demand from the customer. MRP and the variations are called push method material management planning. On the other hand, the pull flow system tends to control work-in-process items to the final demand of customers. Several methods of the pull system have been developed. One of the most important methods of a pull system is a kanban system that has a similar approach to just-in-time (JIT) philosophy [8,9].

Since plastic bag products are manufactured based on production volume forecasts related to customer orders, and use several similar materials with variations, the MRP method is considered more suitable for addressing the problem compared to JIT. Specifically, this applies to the plastic bag product with code CLKG-15000294. In general, JIT offers the advantage of reducing holding costs and becomes a more cost-effective system as demand levels increase [10]. However, JIT carries a risk of stockouts [9, 11]. Moreover, because several products share similar materials, a stockout situation would not only affect product CLKG-15000294 but also many other products. Given this condition, the MRP method is more appropriate to implement in the company, as it minimizes the risk of stockouts and ensures raw material availability [12].

Several implementations have been applied using MRP. The previous research dealt with the order release mechanism [13]. The research compares and simulates the methods for handling highly varied flow and job shops with bottlenecks. Furthermore, the research compares the Drum-Buffer-Rope (DBR) method and Workload Control in terms of order release to the production floor. The improvement of production planning through finite-capacity MRP is also proposed in another research [14]. The research proposed a capacity-oriented MRP that combines the traditional MRP procedure with linear programming. Unfortunately, the previous research did not conduct empirical research and compare the efficiency of several methods in a blown plastic company under uncertainty orders in MTO circumstances.

In a plastic injection molding company, a hybrid MRP–JIT system was proposed [15]. The study applied the MRP system to manage polymer plastic pellets as raw materials and developed a conceptual design of the MRP–JIT system to address production challenges. However, the research did not discuss the practical implementation of MRP methods, nor did it compare alternative methods to determine the most suitable approach for the plastic industry. In another study on the plastic industry, several MRP methods were applied in a blow molding company to produce plastic bottles [16]. Unfortunately, this research did not present data on existing material stock or purchasing costs. Moreover, the study did not provide a comparison between the current practice and the proposed method. A further case study in a plastic company also employed MRP [17]. The motivation for this research stemmed from the fact that company staff managed raw materials largely based on personal experience and observation, without systematic calculation. Although the study conducted empirical research grounded in the company's actual problems, it did not explore multiple MRP methods or provide a comparative analysis of the results.

Our research has the same spirit as the others research in utilizing the MRP method. Similar to [15], this study examines a plastic product company and addresses a real problem in a plastic bag packaging company. Furthermore, continuing and improving the previous research [17], by considering the very large amount of the raw material order and the make-to-order product of the plastic bag product with code CLKG-15000294, our research intends to compare several methods of MRP to find the most suitable method. Therefore, this research utilizes min-max, reorder point (ROP) and Economic Order Quantity (EOQ) methods for solving the problems. This research contributes to the company choosing the most appropriate method for managing the material and inventory planning. By using the most suitable method, the plastic blown film company can manage material requirements efficiently, and avoid overstock of raw materials. The remainder of this paper is organized as follows. Section 2 illustrates the model development and analytical models. Section 3 presents the results and discussion. Section 5 summarizes present conclusions and provides recommendations for future work.

Methodology

The company used some variations of raw material when producing plastic-blown film using six different machines. For producing a plastic bag product with the code CLKG-15000294 that was ordered by PT Sidoraya Utama (PT.SRU), the company uses LDPE with three variations. The product is consumed at 75% LDPE variant 1, 5% LDPE variant 2, 10 % LDPE variant 3, and 10% recycled LDPE. The Bill of Material (BOM) of product CLKG-15000294 is shown in Fig. 1.

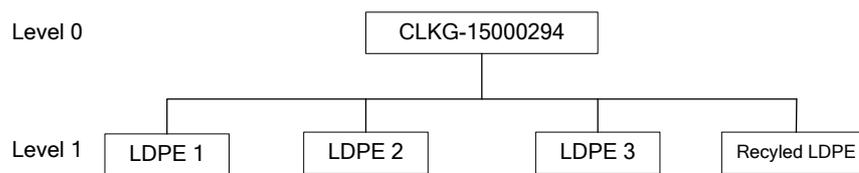


Fig. 1 Bill of Material of Product CLKG-15000294

Based on the Bill of Materials (BOM), the production of 1 kg of product CLKG-15000294 requires 0.75 kg of LDPE Variant 1, 0.05 kg of LDPE Variant 2, 0.10 kg of LDPE Variant 3, and 1.00 kg of clear recycled LDPE. To address the problem, three different methods are applied: the Min–Max method, the Reorder Point (ROP), and the Economic Order Quantity (EOQ). After performing the calculations and establishing the MRP using these methods, the results are compared to identify the most suitable approach. The research framework is illustrated in Fig. 2.

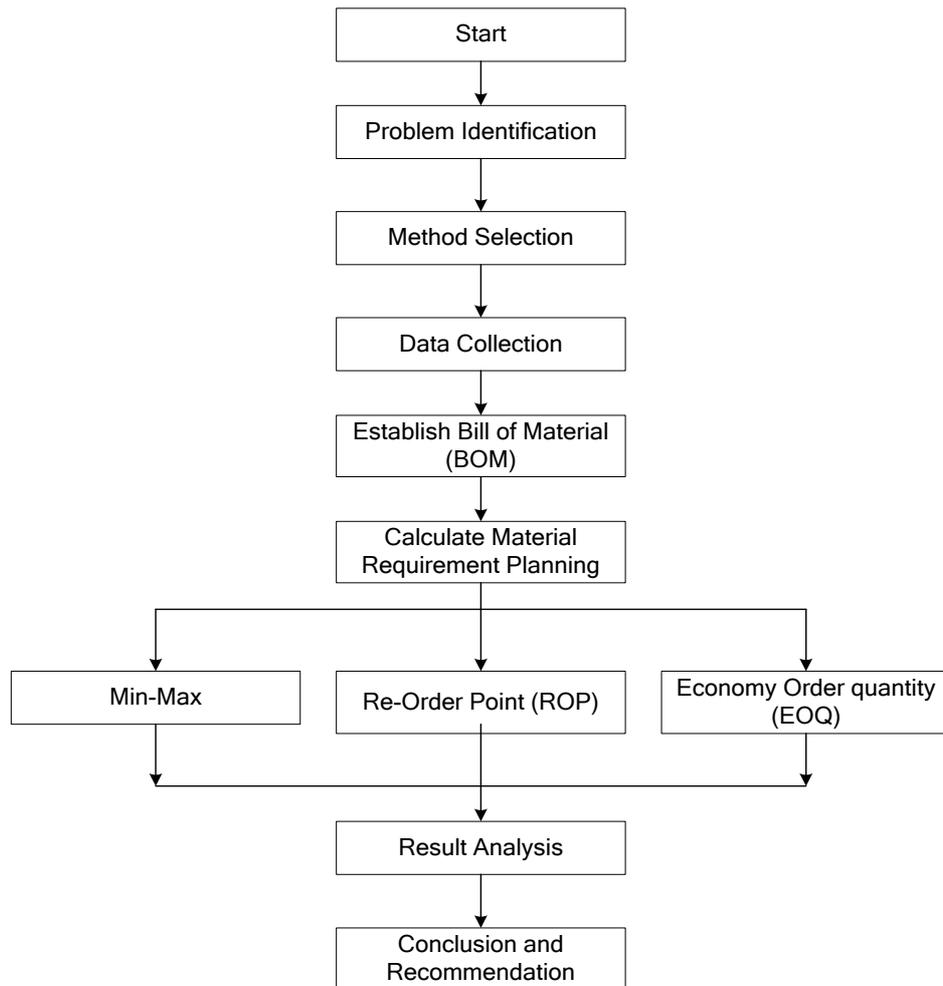


Fig.2. Method for Solving the problem

Firstly, we identified the problem for the company, and found that there was overstock and also stock out material for producing plastic bag CLKG-15000294. Then, we explore the suitable method for solving the problem. Furthermore, based on the collected data, we establish the Bill of Material (BOM). Secondly, utilizing the BOM, we calculate material requirements using three different approaches. In the last stage, based on the results, we conduct an analysis, make a comparison between the approaches, and make a conclusion and recommendation to the company.

Result and Discussion

For overcoming overconsumption of the raw materials, this research utilizes the MRP method for controlling and regulating the supply of raw materials to the production. In this research, we conduct empirical experiments in the company. The data was collected from the production period 2023 at the company.

Master Production Schedule

Based on the data of the company, Master Production Schedule of product plastic bag CLKG-15000294 is shown in Table 1.

Table 1. *Master Production Schedule* and demand CLKG-15000294 period 2023

Month	Date												Demand (kg)
	7	15	16	17	23	24	26	27	28	29	30	31	
January							1,000						1,000
February								625					625
March											350		350
April				325									325
May												600	600
June													0
July		625							500	625		50	1,800
August			1,175										1,175
September													0
October	625					625							1,250
November													0
December					1,175								1,175
Average												691,67	

Table 1 shows that the demand for product CLKG-15000294 averages 691.67 kg per month. The Master Production Schedule (MPS) in Table 1 covers the production plan for the year 2023, from January to December. This dataset was selected for the present study because it represents the most recent company data. The results indicate that the highest demand occurred in July, with fluctuations throughout the year. The product is a type of plastic packaging used for chicken meat; therefore, its demand is closely influenced by fluctuations in chicken meat consumption. This circumstance leads to an increase in product demand whenever the demand for chicken meat rises.

Purchased Material

Furthermore, we also found the company data of purchasing data of raw material that shown in Table 2.

Table 2. Amount of Purchasing Raw Material

Materials	Month	Amount (Kg)
LDPE 1	January	24,750
	March	24,750
	May	24,750
	June	24,750
	July	24,750
	August	24,750
	October	24,750
	November	24,750
	December	24,750
LDPE 2	January	15,000
	March	15,000
	June	15,000
	July	15,000
	August	15,000
	November	15,000
	December	15,000
LDPE 3	January	15,000
	April	15,000
	May	15,000
	July	15,000
	August	15,000
	December	15,000

Table 2 indicates that the company purchases fixed-lot quantities of LDPE 1, LDPE 2, and LDPE 3 periodically throughout 2023, from January to December, while recycled LDPE is produced internally from recycled materials. The table further shows that the purchasing volume for LDPE 1 is 24,000 kg, whereas LDPE 2 and LDPE 3 are each purchased at 15,000 kg. The purchasing quantities of these raw materials remain fixed each month, as company staff rely solely on experience rather than systematic calculation in determining procurement needs.

Safety Stock

Based on the company data, we calculate the safety stock for the company. Safety stock is very important for a manufacturing company for ensuring the company can fulfill the customer order on time. The safety stock is calculated based on eq.1.

$$SS = (MaxU \times MaxLT) - (AvgUD \times AvgLT) \quad (1)$$

Where:

- SS = Safety stock
- MaxU = Maximum Uses
- MaxLT = Maximum Lead Time
- AvgUD = Average uses of material daily
- AvgLT = Average Lead Time

The calculation result is described in Table 3.

Table 3. Safety stock calculation

Material	Maximum uses (Kg)	Maximum Lead time (days)	Average uses daily (Kg)	Average Lead time (days)	Safety Stock (kg)
LDPE 1	881	7	17.05	4.5	6,092
LDPE 2	59	7	1.14	4.5	406
LDPE 3	118	7	2.27	4.5	812

Re-Order Point (ROP)

The Reorder Point (ROP) indicates the time at which the company should purchase raw materials to avoid stockouts. At the same time, ROP helps minimize the risk of overstocking. In this study, the ROP method is applied because it enables the company to prevent stockouts, reduce excess inventory, and maintain sufficient stock to meet customer demand. The calculation of ROP takes into account the lead time of material orders to determine the appropriate ordering period, as expressed in Eq. (2).

$$ROP = AvgU \times LT + SS \quad (2)$$

Where:

ROP = Reorder point

AvgU = Average uses yearly

LT = Lead time

SS = Safety stock

The calculation result of ROP is shown in Table 4.

Table 4. Re-Order Point

Materials	Average uses yearly (Kg) a	Lead time (days) b	Safety Stock (kg) c	ROP (kg) c+(axb)
LDPE 1	518.75	4	6,092	8,167
LDPE 2	34.58	4	406	544
LDPE 3	69.17	4	812	1,089

Min-Max Method

The min-max method is used to determine the minimum and maximum stock of raw material in the warehouse. Furthermore, the min-max method can be used to decide the amount of material ordered by the company. This research uses min-max as one method in the research since simpler and triggers reorders based on set levels and triggering an order when stock falls to the MIN level to replenish it up to the MAX level. The method consists of:

a. Determine minimum stock

Defined as the minimum amount of raw material that should be sufficient for the production process. The amount is calculated using eq. 2.

The calculation result is described un Table 5.

Table 5. Minimum Stock for CLKG-15000294

Materials	Average uses yearly (Kg) a	Lead time (days) b	Safety Stock (kg) c	Minimum stock (kg) c+(axb)
LDPE 1	518.75	4	6,092	8,167
LDPE 2	3.58	4	406	544
LDPE 3	69.17	4	812	1,089

As shown in the table, minimum stock is equal to ROP in Table 4.

b. Determine Maximum Stocks

After calculate the minimum stocks, the method uses eq. 3 for determining the maximum stock.

$$MaxS = 2(AvgU \times LT) + SS \quad (3)$$

Where:

MaxS = Maximum Stock

AvgU = Average uses yearly

LT = Lead time

SS = Safety Stock

The result of the maximum stock calculation is described in the Table 6.

Table 6. Maximum Stock for CLKG-15000294.

Materials	Average uses yearly (Kg) a	Lead time (days) b	Safety Stock (kg) c	Max stock (Kg) 2(axb)+c
LDPE 1	518.75	4	6.092	10,242
LDPE 2	34.58	4	406	683
LDPE 3	69.17	4	812	1,366

After calculating the minimum and maximum amount of raw materials needed for producing CLKG-15000294, we intend to determine the order quantity based on the min-max method. The calculation follows eq. 4.

$$\text{Order Quantity} = 2 \times LT \times AvgU \quad (4)$$

Economic Order Quantity (EOQ)

In this paper, we also establish MRP by utilizing EOQ. Economic Order Quantity is known as a method for searching for the optimum number of orders to minimize the purchasing cost. The EOQ is calculated by using eq.5.

$$EOQ = \sqrt{\frac{2DS}{H}} \quad (5)$$

Where:

EOQ = Economic Order Quantity

D = Yearly uses

S = Price/Unit product

H = Holding cost

The calculation result is shown in Table7.

Table 7. Economy Order Quantity for CLKG-15000294

Materials	<i> Holding cost (Rp.) H</i>	<i> Yearly uses (Kg) D</i>	<i> Price/unit product (Kg) S</i>	$\text{EOQ (kg)} = \sqrt{\frac{2DS}{H}}$	EOQ (Rp.)
LDPE 1	182.50	6,225	33,030	1.501	49,580,120.92
LDPE 2	182.50	415	42,086	437	18,412,556,31
LDPE 3	182.50	830	49,121	668	32,833,866.62

Discussion

In this paper, we use three kinds of MRP methods, which consist of the min-max method, ROP and EOQ. In this section, we discuss the result and compare the three methods by considering the situation on the company.

a. Number of Inventory

The comparison of the number inventory is described in Table 8.

Table 8. Comparison the number of inventory *Min-Max*, *Reorder Point (ROP)*, and *Economy Order Quantity (EOQ)*

Materials	<i> Existing Condition (Kg)</i>	<i> Min stock (Kg)</i>	<i> Order quantity Min-max (Kg)</i>	ROP (kg)	EOQ(kg)
LDPE 1	21,500	8,167	4,150	8,167	1,501
LDPE 2	15,000	544	277	544	437
LDPE 3	15,000	1,089	553	1,089	668

Furthermore, we also compare the cost between the methods that described in Table.9.

Table 9. Total Cost Comparison between *Min-Max*, *Reorder Point (ROP)*, dan *Economy Order Quantity (EOQ)*

Materials	<i> Existing Condition (Rp.)</i>	<i> Min stock (Rp.)</i>	<i> Order quantity (Rp.)</i>	ROP (Rp.)	EOQ (Rp.)
LDPE 1	710,135,712	269,752,595	137,072,707	269,752,595	49,580,121
LDPE 2	631,290,000	22,914,434	11,643,793	22,914,434	18,412,556
LDPE 3	73,813,440	53,489,403	27,180,229	53,489,403	32,833,867

Based on Table 8 and Table 9, for LDPE 1 and LDPE 2, the minimum amount of inventory and total cost are achieved by using EOQ. The use of EOQ has economic advantages compared to the existing quantity order. Furthermore, the min-max method and ROP, even though not superior to the EOQ method, are still more economical compared to the existing quantity order. In the use of EOQ, the material cost per unit depends on the number of orders, in which more ordered materials tend to decrease the cost [18]. However, based on the master scheduling in Table 1, the demand in July is 1,800 Kg and the uses of LDPE 1 are equal to 1,400 Kg, while the economic order using EOQ is only

1,501 Kg. That situation will lead to stocking out raw materials when considering the material lead time. Therefore, good material requirement planning should consider not only the total cost but also lead time and safety stock.

The min-max method has a goal to arrange material requirement planning, minimize the cost, and avoid stockouts [19]. The min-max method also considers the inventory continuously, meaning that when raw material stock reaches the reorder point, the company will issue the reorder [20]. Moreover, the min-max method is most suitable for the raw material purchasing process under uncertainty and fluctuation [21]. Therefore, to overcome the fluctuating demand of the CLKG 15000294 product, the use of the min-max method is more appropriate. Even if the cost is higher compared to the EOQ method, the min-max method is selected to solve the problem, since the method provides more economical material planning. The comparison is provided in Table 10.

Table 10. Cost Comparison

Materials	Existing Cost (Rp.)	Cost Min-max method (Rp.)	Savings Cost (Rp.)
LDPE 1	710,135,712	137,072,707.20	680,409,100.80
LDPE 2	631,290,000	11,643,793.33	619,646,206.67
LDPE 3	736,813,440	27,180,229.12	709,633,210.88

The most advantages aspect of the min-max method is that the company can determine the minimum inventory precisely. Furthermore, the company can respond to the demand fluctuations efficiently and deal with the rapid change in demand. Even though the min-max method is considered the most appropriate method for solving the problem considering the circumstances of the CLKG 15000294 product, the ROP and EOQ methods have several advantages with some constraints. The ROP method is utilized in order to determine the time to issue the purchased order. However, the drawback of only considering the ROP method is that the company has difficulty ensuring the lower limit and upper limit of raw material inventory. On the other hand, the EOQ method is the best method in the scenario when the need for raw materials is certain, the lead time can be determined precisely, the cost structure can be fixed, there is sufficient capacity inventory, and there is enough money to purchase the lot of material.

Conclusion

In this paper, we propose the most appropriate method for implementing Material Requirement Planning for managing raw materials in a plastic blown film company. For numerical experiment purposes, we assessed bag plastic code CLKG 15000294 in the plastic blow molding company. Furthermore, we compared the results using three methods consisting of the min-max method, ROP, EOQ, and existing conditions in the company. The result indicates that the company has purchased raw materials excessively and leads to inventory overstock. Moreover, the overstocking also causes inefficient costs in the company. All of the MRP methods show a better result compared to the existing material planning in the company. However, dealing with the fluctuation and uncertainty of product CLKG 15000294, the most appropriate method is the min-max method. The company can implement the EOQ method if the need for material is certain, the lead time can be determined precisely, and the company has no constraints on inventory and sufficient funds to purchase the lot of material.

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