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The Planning for Upper Shoes Raw Material Inventory Using the Material Requirement Planning (Mrp) Method (Case Study: PT X)

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Abstract

The planning of raw material inventory is one of the essential factors in planning the order of the raw materials that can make a company maintain its production quality. The company's policies can be implemented in various ways, such as in planning the raw materials inventory to avoid shortages and excesses of the raw materials supply. However, X Inc. has not implemented inventory planning properly, making the costs incurred by the company not optimal. Thus, Material Requirement Planning (MRP) will be used to determine the scheduling time and quantity of raw materials for ordering with lot sizing techniques. Lot sizing techniques provide solutions to determine the right quantity of raw material orders and minimum total inventory costs with techniques which are Lot for Lot (LFL), Least Unit Cost (LUC), Economic Order Quantity (EOQ), and Silver-Meal. Based on the calculation results, the four lot sizing techniques show that the LFL technique is the optimal technique compared to other techniques because it produces the minimum inventory cost of IDR566,015,685.05. Thus, the company can profit IDR13,295,563.75 compared to company policy.
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Keywords: Material requirement planning, lot sizing, lot for lot, least unit cost economic order quantitiy, silver-meal.

1. Introduction

The competition in the business world has become more competitive, encouraging various companies to use information and communication as their main advantage, one of which is in the textile and textile product (TPT) industries. In 2022, the performance of TPT industries has increased by 3.34% (kemenperin.go.id: 19-12-2022). TPT industries in Indonesia have experienced significant growth from year to year. In the first quarter of 2022, the TPT industries were able to contribute 6.22% to the total GDP of the non-oil and gas processing industry sector and were also able to absorb 3.65 million people or reach 18.79% of the total manufacturing industry sector workers.

The global phenomena related to the TPT industries in Indonesia, especially in West Java province, have significant impacts. The phenomena include the globalization of trade that opens up international markets, changes in consumption patterns such as consumer tastes, technological developments to improve production efficiency and quality, and the COVID-19 pandemic crisis, which has caused many disruptions. One of the keys to success is that a company must have the right mission, the right strategy for its business, and improve its performance (Hasanati *et al.*, 2019).

The relationship between the textile industry and the raw materials inventory is also related to production efficiency and supply chain management. An efficient and well-organized raw material inventory can help optimize production processes and reduce production costs.

A production planning and control system is needed to meet the current increasing demands and expectations. Besides production, planning, and scheduling are also steps that must be taken at the right time and place to get the best results (Dametew & Kitaw, 2017). One is planning raw materials using the Material Requirement Planning (MRP) method, which is considered appropriate for use because it can optimize inventory, reduce the risk of delays, and increase efficiency.

Based on the previous description, this research is related to the inventory planning for upper shoes raw materials using the Material Requirement Planning (MRP) method with the Lot Sizing techniques, which are Lot for Lot (LFL), Least Unit Cost (LUC), Economic Order Quantity (EOQ), and Silver-Meal. From the calculations using the four techniques above, optimal results will be obtained and compared with the policies applied.

2. Inventory Planning Theory Concept

Planning determines the next steps to take in the future (Plossl et al., 1994). Good planning is needed to get the best results when making decisions. According to Heizer *et al.* (2017), sustainable planning is beneficial for setting strategies and determining the resources needed. Planning is also very important in the manufacturing process. The manufacturing process is a process that converts raw materials into ready-to-use materials (Heizer et al., 2017). By implementing good management, the manufacturing process will run properly without any obstacles. Therefore, factors that affect the production process such as production costs, labor, raw materials, capital, and others need to be considered properly.

Raw materials are components needed in the production process. According to Heizer et al. (2017), raw materials are materials that generally have been bought but have not yet entered the manufacturing process. Raw materials have an important role in planning and management factors, without raw materials the production process will experience problems. According to Hasanati et al. (2019), many raw material suppliers as business partners meet production needs, but on the other hand, consumer demand cannot be met.

Inventory is an asset with a stationary state waiting for the next process in the form of production as in manufacturing, marketing as in distribution, and consumption activities in offices (Bahagia, 2006). Inventory is also a stock of materials whose purpose is to facilitate the production process or meet customer needs (Schroeder & Goldstein, 2018). One of the inventory planning for raw materials can use the Material Requirement Planning Method.

2.1. Material Requirement Planning (MRP)

Material Requirement Planning (MRP) is a method that relies on information system process of production plans and order plans for required component materials (Wulandari & Donoriyanto, 2022). MRP enables companies to use suitable raw materials in appropriate quantities and complete the production process on time.

2.2. Lot Sizing Techniques

Lot Sizing is a technique used to determine the order quantity of inventory items and determine the requirements for their components (Plossl *et al.*, 1994). The size of the order can be determined based on a fixed order quantity, order period, and procurement costs. The Lot for Lot technique aims to minimize storage costs and can recalculate if there is a change in net requirements. The Least Unit Cost technique can determine the size of the ordering lot based on the lot that provides the smallest per-unit unit cost and the Economic Order Quantity technique determines the fixed optimal ordering quantity. While the Silver-Meal technique has the smallest unit inventory cost per period.

2.2.1. Lot for Lot (LFL)

Lot for lot is a process to determine the lot size in meeting material needs, which is equal to the amount of demand required and ordering that is carried out in the L period before the goods are needed (Bahagia, 2006). According to Hartati and Sa'durrifki (2022), the amount of raw material ordered is based on the actual amount of need so that no inventory is stored. So, the costs incurred are only ordering costs. There are two policies in procurement using the Lot for Lot method, namely (Bahagia, 2006):

a. The size of the ordering lot (Q) is equal to the number of requests in the planning time period (D_t).
b. Planned order release of inventory is done L period before the goods are needed.

2.2.2. Least Unit Cost (LUC)

The order lot size is optimal when the per-unit unit cost is the smallest. The size of the ordering lot size is determined in the following ways (Bahagia, 2006):

a. Calculating the per-unit cost starting from period one, then calculating period two.
b. Comparing the per-unit costs of periods one and two. If the unit cost per-unit of period two is greater than period one, then period one is best.
c. However, if the value is smaller, you can continue to the next period until the n period, where the unit cost is greater than the $n-1$ period.
d. Do the calculation for the next period until the N period.

2.2.3. Economic Order Quantity (EOQ)

Economic order quantity is calculation technique used to determine the number of optimal order with a predetermined quantity and when is the right time for the company to place a reorder (Tannady *et al*, 2021). Optimal ordering occurs at the point where the ordering cost and carrying cost curves intersect. With the EOQ graph, optimal ordering occurs at the point where ordering costs equal storage costs (Heizer et al., 2017). So that the total inventory can be written as follows:

$$O_T = O_{bT} + O_{pT} + O_{sT} \tag{1}$$

where:

O_T : Total inventory cost
O_{bT} : Total purchasing goods cost
O_{pT} : Total ordering cost
O_{sT} : Total storage cost

The optimal ordering quantity is obtained by the following calculation.

$$\frac{D}{Q^*} O_p = \frac{Q^*}{2} O_s$$
$$2DO_p = Q^{*2}\, O_s$$
$$Q^{*2} = \frac{2DO_p}{2}$$
$$Q^* = \sqrt{\frac{2DO_p}{O_s}} \tag{2}$$

Optimal order quantity is also obtained from a decrease in total inventory costs, including purchasing, storage, and ordering costs. By using equation (1), it can be transformed into the following form:

$$O_T = O_{bT} + O_{pT} + O_{sT}$$
$$O_T = O_b.D + \frac{Q^*}{2} O_s + \frac{D}{Q^*} O_p \tag{3}$$

Since equation (3) is a function that is the total cost of inventory affected by the optimal order quantity (Q^*), to get the optimal order quantity value, equation (3) must be derived from Q^* so that $f'(Q^*) = 0$.

$$\frac{dO_T}{dQ^*} = 0$$
$$\frac{d(O_{bT} + O_{pT} + O_{sT})}{dQ^*} = 0$$
$$\frac{d(O_b.D)}{dQ^*} + \frac{d(\frac{D}{Q^*} O_p)}{dQ^*} + \frac{d(\frac{Q^*}{2} O_s)}{dQ^*} = 0$$
$$0 + \frac{O_s}{2} + (-\frac{D.O_p}{(Q^*)^2}) = 0$$
$$\frac{O_s}{2} = \left(\frac{D}{Q^{*2}}\right) O_p$$
$$(Q^*)^2 = \frac{2.D.O_p}{O_s}$$
$$Q^* = \sqrt{\frac{2DO_p}{O_s}}$$

where:

O_T : Total inventory cost
O_{pT} : Total ordering cost
O_{sT} : Total storage cost
O_s : Storage cost
O_p : Order cost
D : Total requests in one year
Q^* : Optimal ordering cost

2.2.4. Silver-Meal

To determine the lot size, it can be done by carrying the steps below:

a. Start with the lot that meets the time period ($T = 1$) and calculate the unit inventory cost per period (O_{si}).
b. Add the demand for the next period to the previous lot size and calculate O_{si+1}.
c. However, if $O_{si+1} > O_i$ then it is at the optimal value to be achieved in period T and the optimal lot size is q_t.
d. Go back to step 1 until all periods have been covered.
e. Calculate the ordering lot size q_t.

3. Materials and Methods

3.1. Materials

The research object in this research is secondary data in the form of provision of the main raw materials used to manufacture upper shoes, including polyester thread, rubber thread, transparent thread, adhesive thread, water, dyes, and caustic soda. The raw material data used is production data for one year, from February 2022 to January 2023. This research was conducted at PT X, which is located in Solokan Jeruk Village, Solokan Jeruk District, Bandung Regency.

3.2. Methods

The steps taken to obtain the service model from the obtained data are as follows:

a. Collecting data on raw materials for upper shoes.
b. Processing of data that has been collected using the MRP method with lot sizing techniques. There are four stages in solving using the MRP method: netting calculations, determining to a lot, determining to offset, and determining to explode.
c. Calculating the cost of raw material inventory for upper shoes using the four lot sizing techniques, namely LFL, LUC, EOQ, and Silver-Meal.
d. Comparing the results of the optimal inventory cost calculation of lot sizing techniques.
e. Presentation of data that has been calculated following the technique used.
f. Concluding the stages that have been carried out.

4. Results and Discussion

4.1. Data Collection

The data used is raw material inventory data for upper shoes from February 2022 to January 2023. The data consists of raw material requirements for the production of upper shoes, production demand data per month, price data per unit of material, lead time for each material, ordering costs per unit per month, and storage costs per unit per month.

4.2. Production Demands

Production demand is product sales data for one year every month, starting from February 2022 to January 2023. Production demand data is presented in Table 1.

Table 1: Production Demands of Upper Shoes

Period (Month)	Total of Demands (Pair)
February 2022	7,000
March 2022	3,000
April 2022	7,200
May 2022	4,500
June 2022	4,800
July 2022	5,800
August 2022	13,100
September 2022	6,800
October 2022	8,500
November 2022	8,125
December 2022	5,575
January 2023	5,785
Total	80,185

4.3. Inventory Records

Inventory records illustrates the total inventory of each component making up the upper shoes for each period. The inventory status of shoe tops is presented in Table 2.

Table 2: Inventory Status of Components Making Up Upper Shoes

Material	Period of t month	0	1	2	3	…	12	Total
Polyester Thread	Gross requirement (D_t)		735	315	756	…	608	8420
	Receipt of the order (IOO_t)		900	250	700	…	600	8450
	Available inventory (I_t)		165	100	44	…	30	630
Rubber Thread	Gross requirement (D_t)		52.5	22.5	54	…	43.5	601.75
	Receipt of the order (IOO_t)		60	25	50	…	45	610
	Available inventory (I_t)		7.5	10	6	…	8.25	101.25
Transparent Thread	Gross requirement (D_t)		52.5	22.5	54	…	44.5	605.75
	Receipt of the order (IOO_t)		60	20	75	…	50	612.5
	Available inventory (I_t)		7.5	5	26	…	6.75	100.5
AdhesiveThread	Gross requirement (D_t)		210	90	216	…	173.55	2405.55
	Receipt of the order (IOO_t)		225	80	225	…	170	2420
	Available inventory (I_t)		15	5	14	…	14.45	117.7
Dyes	Gross requirement (D_t)		17	8	18	…	15	194
	Receipt of the order (IOO_t)		20	12	20	…	18	202
	Available inventory (I_t)		3	7	9	…	8	76
Caustic Soda	Gross requirement (D_t)		70	30	72	…	57.85	801.85
	Receipt of the order (IOO_t)		75	35	75	…	55	816
	Available inventory (I_t)		5	10	13	…	14.15	128.9

4.4. Inventory Costs

4.4.1. Purchase Costs

Purchase costs are incurred to purchase inventory items. The cost of purchasing each component of the constituent materials is presented in Table 3.

Table 3: Cost of Purchasing Water Raw Materials

Material	Cost Per Unit (IDR/kg)
Polyester Thread	30,000
Rubber Thread	25,000
Transparent Thread	60,000
AdhesiveThread	40,000
Dyes	600,000
Caustic Soda	24,000

There is one type of raw material that does not require waiting time for ordering, water. Water availability is always accessible, so the costs incurred for water procurement depend on the quantity used each period. The costs incurred for water usage are presented in Table 4.

Table 4: Cost of Using Water

Period (Month)	Usage Amount (l)	Cost (IDR)
February 2022	1.116	14,005.8
March 2022	477	5,986.35
April 2022	1.152	14,457.6
May 2022	720	9,036
June 2022	765	9,600.75
July 2022	936	11,746.8
August 2022	2.097	26,317.35
September 2022	1.089	13,666.95
October 2022	1.359	17,055.45
November 2022	1.305	16,377.75
December 2022	963	12,085.65
January 2023	972	12,198.6
Total	12.951	162,535.05

4.4.2. Storage Costs

Storage costs are costs incurred to store goods for a certain period of time. PT X incurs a number of costs for storing goods in the warehouse, namely electricity costs of 4.5% and maintenance costs of 3% of the purchase price of raw material components. Storage costs are presented in Table 5

Table 5: Storage Costs

Material	Electricity Cost (IDR)	Maintenance Cost (IDR)	Storage Costs Total (IDR)
Polyester Thread	1,350	900	2,250
Rubber Thread	1,125	750	1,875
Transparent Thread	2,700	1,800	4,500
AdhesiveThread	1,800	1,200	3,000
Dyes	27,000	18,000	45,000
Caustic Soda	1,080	720	1,800

4.4.3. Comparative Analysis of Data Processing Results

The comparison results of the calculation of raw material inventory costs for upper shoes products are carried out by comparing four lot sizing techniques, namely LFL, LUC, EOQ, and Silver-Meal. Details of the order plan for each raw material component using the LFL technique are presented in Table 6.

Table 6: Plan Ordering with The LFL Technique

Ordering Plan	Period of t month						Total
	0	1	2	3	…	12	
Polyester Thread	735	315	756	472.5	…	0	8420
Rubber Thread	52.5	22.5	54	33.75	…	0	601.75
Transparent Thread	52.5	22.5	54	33.75	…	0	605.75

AdhesiveThread	210	90	216	135	…	0	2405.55
Dyes	17	8	18	11	…	0	194
Caustic Soda	70	30	72	45	…	0	801.85

By producing the smallest value for each material component, the order for dyes and caustic soda will be made 7 times and the other components 11 times. Details of the plan to order each component of raw materials using the LUC technique are presented in Table 7.

Table 7: Plan Ordering with The LUC Technique

Ordering Plan	Period of t month						Total
	0	1	2	3	⋯	12	
Polyester Thread	735	1071	0	472.5	⋯	0	8420
Rubber Thread	198.75	0	0	0	⋯	0	601.75
Transparent Thread	129	0	0	211.75	⋯	0	605.75
AdhesiveThread	300	0	351	0	⋯	0	2,405.55
Dyes	25	0	29	0	⋯	0	194
Caustic Soda	323	0	0	0	⋯	0	801.85

Details of the plan to order each component of raw materials using the EOQ technique are presented in Table 8.

Table 8: Plan Ordering with The EOQ Technique

Ordering Plan	Period of t month						Total
	0	1	2	3	⋯	12	
Polyester Thread	790	790	790	0	⋯	0	8,690
Rubber Thread	231	0	0	0	⋯	0	693
Transparent Thread	150	0	0	150	⋯	0	750
AdhesiveThread	366	0	366	0	⋯	0	2,562
Dyes	33	0	33	0	⋯	0	198
Caustic Soda	334	0	0	0	⋯	0	1,002

Dyes and caustic soda will be ordered 6 times and other components 11 times. Details of the ordering plan for each raw material component using the Silver-Meal technique are presented in Table 9.

Table 9: Plan Ordering with the Silver-Meal Technique

Ordering Plan	Period of t month						Total
	0	1	2	3	⋯	12	
Polyester Thread	1,050	0	756	472.5	⋯	0	8,420
Rubber Thread	1,987.5	0	0	0	⋯	0	2390.5
Transparent Thread	162.75	0	0	0	⋯	0	605.75
AdhesiveThread	300	0	351	0	⋯	0	2,405.55
Dyes	25	0	29	0	⋯	0	170
Caustic Soda	217	0	0	0	⋯	0	801.85

Based on the calculation of raw material inventory data for upper shoes with the MRP method, it can be seen the comparison of inventory costs from each lot sizing technique presented in Table 10.

Table 10: Comparison of Inventory Costs with Lot Sizing Techniques

Inventory Costs	LFL	LUC	EOQ	Silver-Meal	Company Policy
Purchase Costs	IDR536,015,685.05	IDR536,015,685.05	IDR568,515,535.05	IDR580,736,435.05	IDR543,246,535.05
Order Costs	IDR30,000,000	IDR21,500,000	IDR18,000,000	IDR20,000,000	IDR30,000,000
Storage Costs	IDR0	IDR14,854,173.75	IDR34,803,888.75	IDR14,076,483.75	IDR6,064,713.75
Total Inventory Costs	IDR566,015,685.05	IDR572,369,858.80	IDR621,319,423.80	IDR614,812,918.80	IDR579,311,248.80

Thus, the LFL technique is the most optimal lot-sizing technique compared to other techniques because the company can incur the smallest total inventory costs. Compared to the costs incurred by the company, by applying the LFL technique, inventory costs will be reduced by IDR13,295,563.75 of the company's policy costs.

5. Conclussion

Based on the discussion on the previous chapters, the conclusion can be drawn:

a. Calculation of raw material inventory for making upper shoes using the MRP method at X Inc. with the LFL technique resulted in a total inventory cost of Rp566.015.685,05, with the LUC technique resulting in a total inventory cost of Rp572.369.858,80, with the EOQ technique resulting in a total inventory cost of Rp621.319.423,80, and with the Silver-Meal technique resulting in a total inventory cost of Rp614.812.918,80.

b. The most optimal lot-sizing technique in making upper shoes is the Lot for Lot (LFL) technique because it resulted in the smallest total inventory cost compared to other lot-sizing techniques. So, the company can save expenses by Rp13.295.563,75 compared to the costs incurred.

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