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Analysis of Raw Material Inventory Planning to Minimise Stock Out and Stock Out Cost Using Min-Max and Eoq Methods at PT XYZ

Salsabila Nurul Fauziah*, Shinta Wahyu Hati*

* Politeknik Negeri Batam
Department of Business and Management
Parkway Street, Batam Centre, Batam 29461, Indonesia
E-mail: salsabilanurulfauziah@gmail.com, shinta@polibatam.ac.id

Abstract

PT XYZ is a manufacturing company that produces and sells wire harnesses for automotive vehicles and related components. There are various types of raw materials in wire harness assembly. Therefore, raw material control planning is important to avoid stock outs and waste of costs. This quantitative descriptive research aims to determine the minimum and maximum inventory limits so that stock outs do not occur, as well as determine the optimum number of orders and the amount of costs that can be saved so that there is no waste of costs. The data analysis techniques used are first, min-max analysis by calculating the minimum and maximum inventory, safety stock and reorder point. Second, EOQ analysis by knowing the annual demand or need for raw materials, the amount of ordering costs and storage costs. The results of the calculation with min-max obtained minimum stock limits (reorder point) terminal A, terminal B and wire A respectively 913 m, 702 m and 1,104 m, maximum limits 1,826 m, 1,405 m and 2,208 m. Based on EOQ calculations, the optimum values are 4,055 m, 2,287 m and 3,911 m. These results can help save costs for each material by 41%, 2% and 6%.

Keywords: Stock Out, Min-Max, Reorder Point, EOQ

1. Introduction

Inventory planning or raw material stock has an important role in the implementation of the production process. The amount of raw material stock has a direct impact on the operational efficiency of the production process (Darmawan et al., 2015). The results of research by Shiau Wei Chan et al. (2017) show that the factor that influences the effectiveness of inventory management is raw material planning. Inventory planning needs to be done to balance the supply of raw materials and orders with the aim of keeping the flow of raw materials connected and running smoothly (Tannady, H; Pratama, Y., 2019). Efficient inventory planning or control allows companies to have the right amount of inventory at the right place and time (Puka et al., 2021).

Inventory management is a process of planning, providing, and controlling the level of raw material inventory needed. Companies need to provide inventory to anticipate unplanned operational conditions (Rusman et al., 2019). In general, there are several internal problems of the company in the inventory section, namely first, due to the large number of orders received, inventory often runs out faster than planned. Second, the raw materials available in the warehouse will be damaged quickly. Third, the honesty of employees in the warehouse does not reach the expected standards, which results in the loss or damage to a number of items in the warehouse (Fahmi, 2016).

Stock outs are the most common problem faced by the majority of companies and this greatly impacts the level of customer expectations and leads to low company performance (Musara Mazanai, 2012). The impact of stock outs is that it will cause production delays, idle workers, idle equipment and unexpected supply orders in warehouse or retail production and this results in lost sales and customer dissatisfaction. In addition, stock outs will also have an impact on the cost of ordering raw materials incurred by the company (Chan et al., 2017).

As happened in a manufacturing company in Batam, PT XYZ, which produces cable harnesses for cars, experienced a stock out in the supply of raw raw materials of the terminal wiredan type. Stock out occurs when product demand is high but the required raw material stock is not available. This is because

the actual stock calculation in the warehouse carried out by employees is less precise and not thorough, resulting in an error in the amount of raw material orders by purchasing staff. Because high production figures occur suddenly, suppliers cannot supply raw materials according to high demand and can only supply based on raw material supplier data sent by purchasing staff before the high production occurred. This will result in production being stopped due to insufficient raw materials.

In addition, stock outs also occur due to delays in the arrival of raw materials from suppliers due to transportation problems, bad weather and so on which results in the delivery of raw materials not arriving on time. In a similar system SAP (System Analysis and Product in Data Processing) used by PT XYZ, there is no reorder point or reorder point for raw materials, namely the level of inventory where the company must place an order or buy back raw materials to avoid stock out. This is also the cause of stock outs occurring. Table 1. shows historical data on the occurrence of stock out materials for terminal A, terminal B and wire A.

TABLE 1
HISTORICAL DATA OF STOCK OUTS

Material	Stock out date	Inventory (M)	requirement (M)
Terminal A	15-Mar-23	12000	14000
	25-Apr-23	0	6000
	15-May-23	6000	12000
	21-Jul-23	12000	26000
	25-Sep-23	6000	19000
	9-Oct-23	12000	26000
	22-Nov-23	16000	20000
Terminal B	30-Jan-23	1000	2000
	25-Apr-23	2000	3000
	22-Jun-23	2000	3000
	31-Aug-23	3000	4000
	27-Sep-23	2000	3000
	15-Nov-23	2000	4000
	19-Dec-23	2000	5000
Wire A	20-Feb-23	1000	3000
	28-Mar-23	1000	4000
	31-Jul-23	5600	5672
	25-Sep-23	8000	15920
	13-Oct-23	8070	8000
	21-Nov-23	7000	8000

There are several types of costs in the inventory system that must be considered by the company, namely purchasing costs, procurement costs, ordering costs, setup costs, storage costs, and backorder or stock out costs (Manzini et al., 2016) (Pazhani et al., 2016). In the case of stock out that occurs at PT XYZ, raw materials that have run out with high demand will be categorized as urgent raw materials with delivery from suppliers using air cargo which requires a lot of money. In addition, there are additional costs when weighing goods with large quantities, the amount of weight increases and the cost increases, so the shipping costs increase. Can be seen in the diagram in figure 1 and figure 2 which shows the stock is not sufficient to meet the needs that cause stock out.

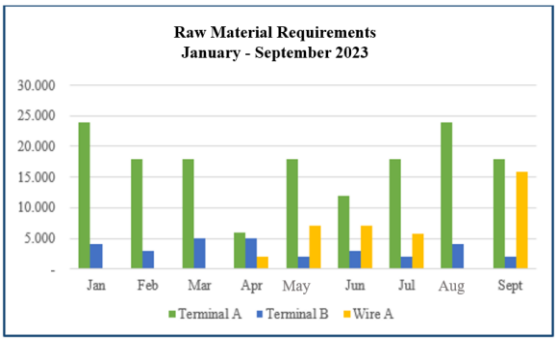

Figure 1: Diagram of Raw Material Requirements

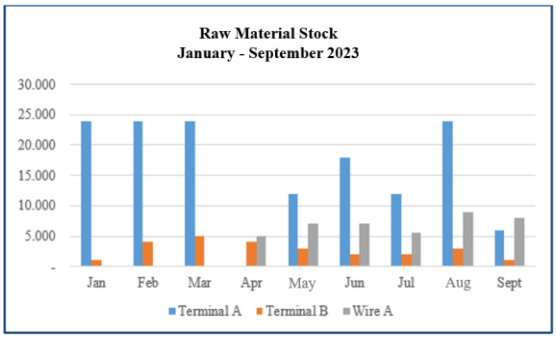

Figure 2 Diagram of Raw Material Stock

Raw materials need to be identified and analyzed further because they are widely used in many products with high demand. From the problems that occur at PT XYZ, effective inventory planning and control is needed by taking into account the use and number of orders, so that the company can quickly adjust to changes in demand, reduce inventory shortages, and minimize costs incurred due to irregular purchases of raw materials.

Researchers proposed an approach using the min-max and EOQ methods. In line with the research of Fihti and Sindikia (2016), min-max serves to analyze the minimum and maximum amount of inventory that must be stored. While EOQ is to analyze the amount of raw material purchase costs that can be saved by the company (Kartika Hasibuan et al., 2022). The results of previous research show

that with the analysis of raw material order planning, it finds its point again and produces the amount of costs that can be saved by the company (Rachmawati & Lentari, 2022) (Tannady, H; Pratama, Y., 2019). Based on the explanation that has been stated, it is important to analyze raw material inventory planning to minimize stock out and stock out costs using the min-max and EOQ methods at PT XYZ.

Based on the background that has been described, problems can be formulated, namely first, how PT XYZ conducts raw material inventory planning. Second, how to evaluate the inventory planning process. Third, how to determine the minimum and maximum limits using the min-max method to prevent stock outs in managing raw material inventory at PT XYZ. Finally, how to determine the optimal ordering of raw materials using the EOQ (Economic Order Quantity) method to minimize stock out costs.

Based on the formulation of the problem above, this research has the following objectives: first, to find out PT XYZ in planning raw material inventory. Second, knowing the results of the evaluation of the inventory planning process. Third, knowing in determining the minimum and maximum limits using the min-max method to prevent stock outs in managing raw material inventory at PT XYZ. Finally, knowing how to determine the ordering of raw materials using the EOQ (Economic Order Quantity) method optimally to minimize stock out costs.

The results of this research are expected to provide practical and theoretical benefits. Practically, this research has the benefit that it can first help companies consider making raw material inventory planning decisions and determine strategies to save raw material ordering costs.

Then theoretically this research has benefits, namely first, this research can be used as a reference for readers and further researchers related to inventory planning using min-max and EOQ. Second, through this research, researchers can gain a better understanding of the usefulness of min-max in terms of determining the minimum and maximum amount of raw material purchases, EOQ to provide recommendations on how much cost the company can save if there is no stock out.

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2. Literatur Review

Raw Material

Raw materials are materials, parts, and components that have been delivered to a company but have not yet been used (Waters, 2003).

Wire Harness Material

Wire harness or cable harness is a series of cables with the function of sending signals or electrical power that has an important role in connecting the various components in it (Kamal et al., 2018).

Planning

Planning plays an important role in the company for the next step. Careful planning and mistakes can have positive and negative impacts in the future, so the planning carried out always considers the long-term impact that can be felt (Fahmi, 2016).

Inventory Control

Inventory control is a set of activities that coordinate purchasing, production, and distribution to maximize the availability of raw materials for production or the availability of finished products for customers (Farahani et al., 2011). When managing inventory, logisticians need to consider three relevant costs simultaneously-the cost of carrying (storing) products, the cost of ordering products, and the cost of stocking out (Murphy & Knemeyer, 2018).

Stock out

A stock out situation is when there is a shortage of goods or no goods available. This situation can result in disrupted production activities, unmet customer demand, additional costs due to lack of inventory, and failed opportunities for profit (Sarjono, 2013). In addition, stock outs can also because additional costs called stock out costs. According to Slamet (2007) stock out cost is the cost incurred due to delays in the delivery of supplies of raw materials and spare parts (Amin Kadafi & Delvina, 2021).

Safety Stock

Safety stock is the amount of stock required to prevent stock-outs due to demand and supplier uncertainty. The system must be prepared to provide the required amount of safety stock in order to maintain the required level of service in the face of uncertain demand and lead times from suppliers. Safety stock is kept when demand or orders fluctuate and lead times for products are uncertain (Rushton et al., 2014).

Reorder point (ROP)

When a company needs to order raw materials back to control stock, this is known as the reorder point (Fahmi, 2016). Reorder point (ROP) occurs when the amount of inventory in stock decreases continuously so that we determine how many minimum inventory levels must be considered so that there is no shortage of inventory (Sholehah et al., 2021).

Min-max

The min-max method calculation is needed to determine the amount of raw material inventory needed, so as to prevent shortages at the minimum level and avoid excess inventory at the maximum level (Mail et al., 2018).

EOQ

EOQ introduced by Ford W. Harris in 1915 (Farahani et al., 2011) is a simple model that illustrates the trade-off between ordering and storage costs. In general, there are three types of variables in EOQ that are clearly displayed (Fahmi, 2016), namely:

a. Total cost
b. Ordering cost
c. Storage cost

3. Research Methods

This research is conducted with a quantitative approach that is descriptive in nature. Researchers adapted research on the Application of the Min-max Method for Minimizing Stockout and Overstock of Raw Material Inventory by Rachmawati and Lentari (2022) and a book entitled Production and Operations Management by Irham Fahmi (2016). Then, the evaluation that will be carried out refers to the raw material purchase planning process of PT XYZ. The concept and indicators for this research can be seen in table 2 below.

TABLE 2
RESEARCH CONCEPTS AND INDICATORS

No	Concept	Indicator	Item
1	Identify and evaluate inventory planning	Planning procedure or process	Identify and evaluate procedures in planning raw material inventory
		Determination of the minimum and maximum amount of inventory	Identify ways to determine minimum and maximum inventory limits
		Raw material ordering process	Evaluate the raw material ordering process carried out by the purchasing department
2	*Min-max* (Rachmawati & Lentari, 2022)	*Safety stock*	Calculate the safety stock that must be kept to avoid stock shortages.
		Minimum stock	Calculate minimum stock and determine when to order raw materials.
		Maximum stock	Determine the maximum limit of the amounts of raw materials stored
		Order quantity in one order	Calculate how much to order raw materials in one order.
		ROP (*Reorder point*)	Calculating when reordering can be done
		Ordering frequency in one year	Calculates how often products are reordered in one year
3	EOQ (Fahmi, 2016)	Demand in one year	Amount of raw materials required for one year.
		Ordering cost	The fixed cost of placing an order.
		Storage cost	Cost of holding the product in inventory.
		Total cost	Total cost related to inventory.

The data sources used are primary and secondary data. Primary sources provide data directly to data

collectors (Hardani et al., 2020). Primary data comes from the opinions of resource persons regarding the causes and consequences of stock outs through interviews, observation and documentation in an incentive manner. Furthermore, secondary data sources have information provided to researchers through intermediaries, such as other people or certain documents (Hardani et al., 2020). Researchers use secondary data derived from cost data, usage and purchase of raw materials.

The research location or research conducted by researchers is at PT XYZ Batam City. The object studied in this study is the raw material of cable harness, namely terminal A, terminal B and wireA. The data collection techniques used in this research are observation, interviews and documentation.

Min-max

The min-max analysis in this study is used to find the minimum and maximum inventory. The maximum and minimum inventory amounts are calculated based on the raw material requirements for a certain period of time. In addition to raw material requirements, the maximum and minimum inventory quantities are determined based on lead time and safety stock. Below are the mathematical formulas and steps applied in inventory management using the min-max method.

1) *Safety stock*
   Inventory of raw materials to anticipate the need and arrival of uncertain raw materials (Hugos, 2018). The following is the safety stock formulation (Setiawan & Hati, 2023).
   SS=Sd x Z x LT
   Description:
   SS = *Safety Stock*
   Sd = Standard deviation of demand
   Z = *Service level*
   LT = *Lead time*
2) *Minimum stock*
   The minimum amount at which an order should be placed based on the average demand for raw materials.
   Minimum *stock* = (LT x AU) + SS
   Description:
   AU = Average Unit (average usage during waiting time).
3) *Maximum Stock*
   Limits on the maximum amount of raw material inventory that can be stored.
   Maximum *stock* = 2 x (LT x AU) + SS
4) *Reorder point* (ROP)
   In determining the ROP, things such as the amount of safety stock and material usage during the time before the order comes (lead time) must be considered. This is because this determines the amount of remaining inventory that has been warehoused before the reorder is placed. The reorder point is formulated as follows:
   ROP = (LT x AU) + SS
5) Determine the order frequency in one year (F)
   Calculating the frequency of raw material orders based on total demand for one year (D).
   $$F = \frac{D}{EOQ}$$

EOQ

The EOQ (Economic Order Quantity) mathematical model is used to determine the optimal order quantity of goods or raw materials in order to meet the estimated demand with minimal inventory costs (Fahmi, 2016). The formula for measuring EOQ:

$$EOQ = \frac{\sqrt{2\,(D)(OC)}}{CC}$$

Description:
EOQ = Economic Order Quantity
D = annual demand or need
OC = ordering cost
CC = storage cost
In using EOQ, according to Agus Sartono, there are basic assumptions, namely:

a. Sales levels can be estimated.
b. Constant in material usage.
c. Ordering can be done quickly.
d. Delivery can be made quickly.

Based on the above explanation, EOQ is an effort by the company, especially the production and warehouse departments, which is expected to always create a balanced and stable condition in various situations. Figure 3 illustrates how this balance is achieved between holding costs and ordering costs. There is a certain quantity (quantity range) that provides the lowest total cost (Q0) or EOQ (Rushton et al., 2014).

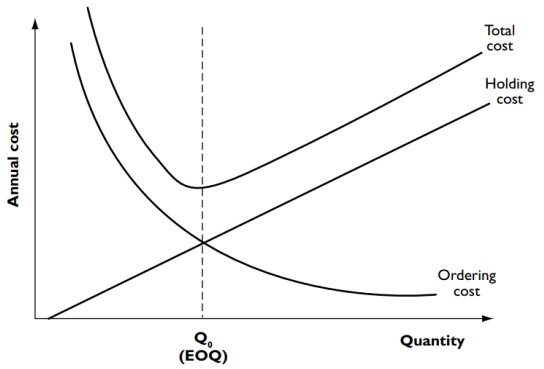

Figure 3: EOQ Principle

The company must fulfill several factors to achieve the lowest total cost (Ahyari, 1995). These factors are:

1) Estimated use of raw materials
2) Price of raw materials
3) Inventory costs consisting of:

a. Storage costs
b. Ordering or purchasing costs

4) Pemakaian senyatanya
5) Waktu tunggu

The calculation of the total inventory cost is as follows:

$$TIC = \left(\frac{D}{Q} \text{ x } S\right) + \left(\frac{Q}{2} \text{ x } H\right)$$

Description:

Q = Order quantity

D = Requirement

S = Ordering cost

H = Storage cost

4. Results

Raw Material Inventory Planning Procedure

The procedure for planning the purchase of raw material inventory at PT XYZ is described in the Figure 4 flowchart below.

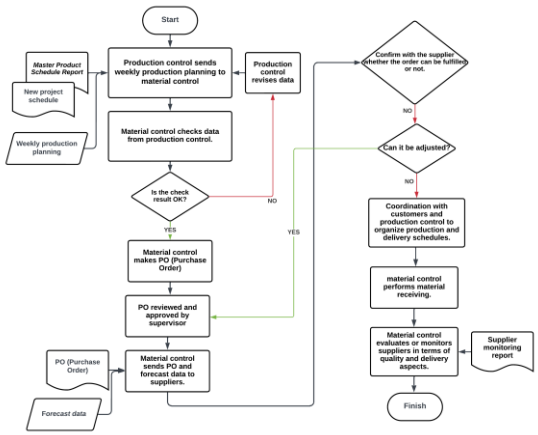

Figure 4: Flowchart of Raw Material Planning and Purchasing

It starts with production control sending weekly production planning documents to material control. Then the material control purchasing staff checks the data from production control including the production schedule for new projects or new production. If there are errors in the data, production control revises the data in the weekly production planning document and sends it back to material control. From this data, the material control purchasing staff can make a PO (Purchase Order). After the PO is created and released, the PO will be reviewed and approved by the supervisor. Next, send and confirm the PO and supplier data for material needs to the supplier via e-mail whether the order can be fulfilled or not. If it cannot be fulfilled, check and confirm with the relevant department (for example: production department) whether it can be adjusted to the production schedule. If it can be adjusted, material control will revise the PO and send the revised PO back to the supplier. If there is a delay in the arrival of raw materials, material control coordinates with production control and the customer to arrange the production and delivery schedule. When the goods arrive, material control receives the materials and checks the materials by quality control. In the final stage, material control evaluates or monitors suppliers in terms of quality and delivery aspects in collaboration with the quality assurance department.

In making POs, there are stages until the PO is sent to the supplier. The stages in making a PO are as follows.

1) Ensure all inputs related to material receipts and disbursements have been completed.
2) Through the system, purchasing staff requests MPS (Master Production Schedule). Then, confirm the MPS.
3) Verify the error list on MRP. Usually, the error is in the form of a material code that has not been registered due to a new product, so the material must be registered first.
4) Calculating MRP through the system. At this stage MRP calculates material transactions that occur during the week.
5) After MRP has finished calculating material transactions, MRP will then suggest what materials should be ordered. At this stage, even though MRP has provided data and the amount of material that must be ordered, purchasing staff still have to make sure whether the material must be ordered at that time or not. The amount or quantity of material also needs to be confirmed again by calculating the actual stock in the warehouse and the remaining material usage in the production line.
6) The purchasing staff creates and releases the PO through the system. Then the PO document is printed as a pdf file and sent to the supplier via e-mail.

Raw Material Planning Process Evaluation

The findings of the observations made by the researchers are that the process of planning and purchasing raw materials has been carried out in accordance with the procedure. To handle stock outs until now, material control coordinates with production control and customers to arrange production and delivery schedules. The handling process needs to be coordinated with many related parties and the parent company. This is reinforced by the results of an interview with the purchasing section of material control "the production control section is tasked with finding products that use the same material. If there is excess material in a line, it must be distributed to the line experiencing material stock out, changing the production and shipping schedule for the line experiencing the material stock out". In addition, it takes a long time. Thus, the

handling process is not effective. Below is Table 3 which shows the results of the evaluation of the raw material planning process.

TABLE 3
EVALUATION RESULTS OF RAW MATERIAL INVENTORY PLANNING PROCESS

No	Planning and Inventory Phase	Evaluation Results
1	Production control sends weekly production planning to material control.	Already appropriate
2	Material control checks data from production control including the production schedule for the new project.	Already appropriate
3	If there is a production control error, revise the weekly production planning data.	Already appropriate
4	Material control makes PO (Purchase Order)	There is no reorder point and maximum order quantity
5	After release, the PO will be reviewed by the supervisor.	Already appropriate
6	Material control sends PO and supplier data to supplier.	Already appropriate
7	Confirmation to the supplier whether the order can be fulfilled or not.	Already appropriate
8	If it cannot be fulfilled, check and confirm with the relevant department (for example: production department) whether it can be adjusted to the production schedule.	Already appropriate, this step is also carried out when stock outs occur.
9	If it can be adjusted, material control will revise the PO and send the revised PO back to the supplier.	Already appropriate
10	If there is a delay in the arrival of raw materials, material control coordinates with production control and the customer to arrange production and delivery schedules.	Already appropriate, this step is also carried out when stock outs occur.
11	When the goods arrive, material control carries out material receipt.	Already appropriate
12	Material control evaluates or monitors suppliers in terms of quality and delivery.	Already appropriate

Another observation result is found in the MRP (Material Requirement Planning) document. PT XYZ MRP document contains material requirements and suppliers that will be used for production and must be purchased. There are several categories of material purchases or POs, namely urgent and regular. From this MRP, it can be seen how much material stock is lacking, material inventory, and material arrival along with the PO number. In the PO making procedure, it is known that so far there is no reorder point in MRP, this is in accordance with what the purchasing foreman said "Not using ROP (Rorder Point), only monitoring and analyzing the amounts of raw materials that must be purchased through MRP". In addition, related to material stock, MRP only displays the amount of stock available, does not display the minimum and maximum storage limits.

During this time, purchasing staff always check and analyze MRP manually to find out which materials must be purchased and the amount. In this case, the reorder point becomes important to cover the erratic use of raw materials caused by production fluctuations and also in managing inventory it is necessary to determine at what point the inventory should be ordered to maintain inventory at the optimal point, not too much but also not less (Umry & Singgih, 2019). Based on the results of the interview, the purchasing admin said that "the average lead time is 14 days". Lead time affects the size of the reorder point in raw material inventory management. The longer the lead time, the higher the reorder point required to maintain adequate inventory availability. This needs to be considered to avoid high production rates, but the supply of raw materials is running low. In addition, raw materials or materials for terminal A, terminal B and wire A are included in the urgent material category, this is based on an interview with the purchasing admin who said "Yes, including the urgent category, because these materials can expire and are used in many products", so it is very important to avoid stock outs.

The amount of material ordered does not have a maximum limit, there is only a minimum limit, so the purchasing staff orders a large amount of material without knowing whether the material will be over or not. This is in accordance with the results of an interview with the purchasing foreman, namely "there is no maximum limit, there is only a minimum order".

When a stock out occurs, the purchasing staff will make a PO by air at a higher cost than by sea, this is in accordance with what the purchasing leader said

in the interview, namely "ordering raw materials that are experiencing stock out (urgent)". The shipping cost is made an information form containing the raw materials sent, the amount of raw materials, the name of the supplier, the reason for ordering by air and the cost. If the stock out occurs due to a sudden increase in production demand, the parent company will be responsible for paying the cost. However, if the stock out occurs due to the error of PT XYZ staff or employees both when ordering and handling materials, then PT XYZ will be responsible for paying. In this case, the reorder point is needed, which is the point or amount needed to order raw materials again to control stock (Fahmi, 2016).

Raw Material Inventory Data

Wireharness raw material inventory data in the form of terminal A, terminal B and wireA can be seen in the following table 4, 5 and 6:

TABLE 4

TERMINAL A INVENTORY DATA FOR 2023

Month	Purchase	Usage
January	18.000	11.000
February	17.000	10.000
March	12.000	13.000
April	10.000	11.000
May	6.000	7.000
June	14.000	9.000
July	12.000	13.000
August	16.000	12.000
September	6.000	9.000
October	9.000	10.000
November	16.000	12.000
December	12.000	13.000

TABLE 5

TERMINAL B INVENTORY DATA 2023

Month	Purchase	Usage
January	1.000	4.000
February	4.000	3.000
March	5.000	5.000
April	4.000	5.000
May	3.000	2.000
June	2.000	3.000
July	2.000	2.000
August	3.000	4.000
September	1.000	2.000
October	4.000	4.000
November	2.000	4.000
December	2.000	2.000

TABLE 6

WIRE A INVENTORY DATA FOR 2023

Month	Purchase	Usage
January	1.000	1.000
February	1.000	1.000
March	1.000	1.000
April	5.000	2.000
May	7.000	7.000
June	7.000	7.000
July	5.600	5.672
August	9.000	8.000
September	8.000	15.920
October	8.070	8.000
November	7.000	8.000
December	7.470	6.500

From the data in the table above, it is obtained that the total inventory in one year for terminal A is 148,000 meters, terminal B is 33,000 meters, and wireA is 67,140 meters. Meanwhile, the total usage of terminal A was 130,000 meters, terminal B was 43,000 meters and wireA was 67,592 meters. From the purchase and usage data, it can be seen that the three materials experienced stock outs. The following graph presents a comparison of the purchase and use of the three raw materials.

Raw Material Ordering Data

PT XYZ ordered raw materials in 2023 for terminal A is 36 times, terminal B 25 times and wireA 30 times. After analyzing the order made, it is still insufficient for use. The following table 7 present the recapitulation of raw material ordering.

TABLE 7

ORDER RECAPITULATION

Terminal A	
Month	Quantity
January	14.000
February	11.000
March	12.000
April	10.000
May	6.000
June	12.000
July	12.000
August	13.000
September	6.000
October	9.000
November	10.000
December	12.000

Terminal B	
Month	Quantity
January	1.000
February	3.000
March	5.000
April	4.000
May	3.000
June	2.000
July	2.000
August	4.000
September	1.000
October	4.000
November	2.000
December	2.000

Wire A	
Month	Quantity
January	1.000
February	1.000
March	1.000
April	5.000
May	7.000
June	7.000
July	5.600
August	9.000
September	8.000
October	8.070
November	7.000
December	10.000

Raw Material Price Data

The prices of terminal A, terminal B and wireA raw materials can be seen in the table 3 below:

TABLE 8

RAW MATERIAL PRICE DATA

Raw Material	Contents of 1 Box or Spool (M)	Price/Pack (Usd)	Price/Pack (Idr)
Terminal A	1000	114,00	Rp 1.875.000
Terminal B	1000	93,93	Rp 1.507.000
*Wire*A	1000	143,35	Rp 2.300.000

Raw Material Ordering Cost Data

Ordering costs include processing costs, processing fees, and order documentation. In addition, ordering costs also include insurance costs, additional handling costs, and transportation or delivery to the company site. The raw materials ordered come from Japan suppliers. Table 9 and 10 show details oridering costs.

TABLE 9

BREAKDOWN OF ORDERING COSTS

Ordering Cost	
Order processing	Rp 386.000
Purchase Processing Cost	Rp 673.000
Order Documentation	Rp 11.445.198
Transportation costs	Rp 6.641.622
Insurance costs	6.0%
Other handling costs	Rp 700.000

TABLE 10

RAW MATERIAL ORDERING COST

Raw material ordering cost	
Terminal A	Rp 22.076.320
Terminal B	Rp 20.995.243
*Wire*A	Rp 22.101.820

Raw Material Storage Cost Data

Raw material storage costs consist of warehouse maintenance costs, employee salaries, equipment costs, insurance costs and taxes. The details and calculation of storage costs per unit are as follows in table 11 and 12:

TABLE 11

BREAKDOWN OF STORAGE COSTS

Storage costs	
Warehouse maintenance costs	Rp 2.500.000
Employee salary	Rp 8.000.000
Equipment costs	Rp 1.700.000
Insurance costs	0.5%
Taxes	Rp 825.000

TABLE 12

RAW MATERIAL STORAGE COST

Raw Material Storage Cost	
Terminal A	Rp 351.675
Terminal B	Rp 345.163
*Wire*A	Rp 195.375

Raw material storage cost per unit for terminal A is 2.7%, terminal B is 2.65% and wire A is 1.5% of the total storage cost.

Special Conditions

When there is a stock out of raw materials, the purchasing staff will order raw materials by air transportation (by air). Where this order incurs quite expensive costs. The following table 13 are the costs that arise when ordering by air.

TABLE 13

ADDITIONAL BOOKING COST BY AIR

Costs	Amount (USD)
Fuel	2.62
Charges collect fee	3% *of the weight and valuation*
documentation charge	50 per *shipmet*
handling charge	100 per *shipment*
Phisical check	108 per *shipment*
Terminal storage	0.25
Regulated agent	0.15
export declaration	30 per *items*
AWB Fee	5 per HAWB

Calculation of Total Inventory Cost with the company's actual inventory

Order data, raw material prices, ordering costs, and storage costs are used to calculate the company's total inventory costs. The calculation of the company's TIC in one period is as follows:

1) Terminal A

$$TIC = \left(\frac{D}{Q} \text{ x } S\right) + \left(\frac{Q}{2} \text{ x } H\right)$$

$$TIC = \left(\frac{130.000}{12.300} \text{ x } 22.076.320\right) + \left(\frac{12.300}{2} \text{ x } 351.675\right)$$

= 233.326.956 + 2.162.803.222

= Rp 2.396.130.177

2) Terminal B

$$TIC = \left(\frac{43.000}{2.800} \text{ x } 20.995.243\right) + \left(\frac{2.800}{2} \text{ x } 351.675\right)$$

= 322.426.939 + 483.228.035

= Rp 805.654.975

3) *Wire* A

$$TIC = \left(\frac{67.592}{5.600} \text{ x } 22.101.820\right) + \left(\frac{5.600}{2} \text{ x } 195.375\right)$$

= 266.768.963 + 547.050.788

= Rp 813.819.751

TIC = Rp 4.015.604.903

Based on calculations, using data on raw material usage, order quantity, storage costs and order costs, the company's total inventory cost (TIC) per month for terminal A is Rp 2,396,130,177, terminal B is Rp 805,654,975, and wire A is Rp 813,819,751.

Calculation of Standard Deviation of Raw Material Usage

Standard deviation or deviation value is used as a basis for calculating safety stock, namely seeing how much deviation value occurs from the average over the last few months (Ratningsih, 2021).

$$S_d = \sqrt{\frac{\sum(x-\bar{x})^2}{n}}$$

Description:

n = number of orders for raw materials

x = total raw material requirements

$\bar{x}$ = average raw material requirements

The calculation of the use of raw materials for terminal A, terminal B and wireA for one year can be seen in the following table 14, 15 and 16.

TABLE 14

TERMINAL A STANDARD DEVIATION

Month	Usage (x)	Average ($\bar{x}$)	Deviation ($x - \bar{x}$)	Deviation Square ($(x - \bar{x})^2$)
January 2023	11.000	10.833	167	27.778
February 2023	10.000	10.833	-833	694.444
March 2023	13.000	10.833	2167	4.694.444
April 2023	11.000	10.833	167	27.778
Mei 2023	7.000	10.833	-3833	14.694.444
June 2023	9.000	10.833	-1833	3.361.111
July 2023	13.000	10.833	2167	4.694.444
August 2023	12.000	10.833	1167	1.361.111
September 2023	9.000	10.833	-1833	3.361.111
October 2023	10.000	10.833	-833	694.444
November 2023	12.000	10.833	1167	1.361.111
December 2023	13.000	10.833	2167	4.694.444
Total ($\sum(x - \bar{x})^2$)				**39.666.667**
Number of raw material orders (n)				**1.525.641**
Standard deviation				**1.235**

TABLE 15

TERMINAL B STANDARD DEVIATION

Month	Usage (x)	Average ($\bar{x}$)	Deviation ($x - \bar{x}$)	Deviation Square ($(x - \bar{x})^2$)
Januari 2023	4.000	3.583	417	173.611
Februari 2023	3.000	3.583	-583	340.278
Maret 2023	5.000	3.583	1417	2.006.944
April 2023	5.000	3.583	1417	2.006.944
Mei 2023	2.000	3.583	-1583	2.506.944
Juni 2023	3.000	3.583	-583	340.278
Juli 2023	2.000	3.583	-1583	2.506.944
Agustus 2023	4.000	3.583	417	173.611
September 2023	2.000	3.583	-1583	2.506.944
Oktober 2023	4.000	3.583	417	173.611
November 2023	4.000	3.583	417	173.611
Desember 2023	5.000	3.583	1417	2.006.944
Total ($\sum(x - \bar{x})^2$)				**14.916.667**
Number of raw material orders (n)				**596.667**
Standard deviation				**772**

TABLE 16

WIRE A STANDARD DEVIATION

Month	Usage (x)	Average ($\bar{x}$)	Deviation ($x - \bar{x}$)	Deviation Square ($(x - \bar{x})^2$)
Januari 2023	1.000	5.633	-4633	21.461.600

Februari 2023	3.000	5.633	-2633	6.930.934
Maret 2023	4.000	5.633	-1633	2.665.600
April 2023	4.000	5.633	-1633	2.665.600
Mei 2023	5.000	5.633	-633	400.267
Juni 2023	5.000	5.633	-633	400.267
Juli 2023	5.672	5.633	39	1.547
Agustus 2023	8.000	5.633	2367	5.604.267
September 2023	8.920	5.633	3287	10.806.560
Oktober 2023	8.000	5.633	2367	5.604.267
November 2023	10.000	5.633	4367	19.073.600
Desember 2023	5.000	5.633	-633	400.267
Total ($\sum(x-\overline{x})^2$)				**76.014.779**
Number of raw material orders (n)				**2.533.826**
Standard deviation				**1.592**

Based on the table above, it can be seen that the average use of total raw material purchases per month for terminal A is 10,833 meters, terminal B is 3,583 meters and wireA is 5,663 meters. Then, the standard deviation for terminal A is 1,235 meters, terminal B is 772 meters and wireA is 1,592 meters.

Determination of Minimum and Maximum Limits of Raw Material Inventory Planning Using the Min-max Method

The calculation of raw material inventory using the min-max method is as follows:

1) *Safety Stock*
   Calculation of safety stock using a 90% service level, then the value of Z = 1.28.
   $SS = Sd$ x Z x LT
   a. Terminal A
      SS = 1.235 x 1,28 x 0,47
      = 743
   b. Terminal B
      SS = 772 x 1,28 x 0,47
      = 465
   c. *Wire* A
      SS = 1.592 x 1,28 x 0,47
      = 958
2) Minimum *stock*
   Minimum stock = (LD x AU) + SS
   a. Terminal A
      Minimum stock = (0,47 x 361) + 743
      = 913
   b. Terminal B
      Minimum stock = (0,47 x 478) + 465
      = 702
   c. *Wire*A
      Minimum stock = (0,47 x 662) + 958
      = 1.104
3) *Maximum Stock*
   Maximum stock = 2 x (LD x AU) + SS
   a. Terminal A
      Maximum stock = 2x(0,47x672) + 743
      = 1.826
   b. Terminal B
      Maximum stock =2x (0,47 x 478) + 465
      = 1.405
   c. *Wire*A
      Maximum stock =2 x (0,47 x 662) + 958
      = 2.208
4) ROP (*Reorder point*)
   ROP = (LD x AU) + SS
   a. Terminal A
      ROP = (0,47x 361) + 743
      = 913
   b. Terminal B
      ROP = (0,47 x 478) + 465
      = 702
   c. *Wire* A
      ROP = (0,47 x 662) + 958
      = 1.104

Determination of Raw Material Ordering Planning Using the EOQ Method to Minimize Stock Out Costs

The calculation of raw material inventory using the Economic order quantity (EOQ) method in one period is as follows:

1) *Economic Order Quantity* (EOQ)

$$\text{EOQ} = \frac{\sqrt{2\,(\text{D})(\text{OC})}}{\text{CC}}$$

   a. Terminal A

$$\text{EOQ} = \frac{\sqrt{2\,(130.000)(22.076.320)}}{351.675}$$

   = $\sqrt{16.443.229}$
   = 4.055
   b. Terminal B

$$\text{EOQ} = \frac{\sqrt{2\,(43.000)(20.995.243)}}{345.163}$$

   = $\sqrt{5.231.127}$
   = 2.287
   c. *Wire*A

$$\text{EOQ} = \frac{\sqrt{2\,(67.592)(22.101.820)}}{193.375}$$

   = $\sqrt{15.292.684}$
   = 3.911

2) Ordering Frequency

$$F = \frac{D}{EOQ}$$

a. Terminal A

$$F = \frac{130.000}{4.055}$$

= 32 times

b. Terminal B

$$F = \frac{43.000}{2.287}$$

= 19 times

c. *Wire*A

$$F = \frac{67.592}{3.911}$$

= 17 times

From the results of the calculation of the frequency of raw materials based on the EOQ method for terminal A 32 times, terminal B 19 times and wire A 17 times.

3) *Total Inventory Cost* EOQ

$$TIC = \left(\frac{D}{Q} \text{ x } S\right) + \left(\frac{Q}{2} \text{ x } H\right)$$

a. Terminal A

$$TIC = \left(\frac{130.000}{4.055} \text{ x } 22.076.320\right) + \left(\frac{4.055}{2} \text{ x } 351.675\right)$$

= 707.744.468 + 713.025.481

= Rp 1.420.769.948

b. Terminal B

$$TIC = \left(\frac{43.000}{2.287} \text{ x } 20.995.243\right) + \left(\frac{2.287}{2} \text{ x } 345.163\right)$$

= 394.750.962 + 394.693.891

= Rp 789.444.852

c. *Wire* A

$$TIC = \left(\frac{67.592}{3.911} \text{ x } 22.101.820\right) + \left(\frac{3.911}{2} \text{ x } 195.375\right)$$

= 381.975.509 + 382.055.813

= Rp 764.031.322

TIC keseluruhan = Rp 2.974.246.122

By using data on the use of raw materials in 2023, as well as the order quantity, storage cost, and order cost, the above calculation results in the company's Total Inventory Cost (TIC) using EOQ for terminal A of Rp 1,420,769,948, terminal B of Rp 789,444,852, and wire A of Rp 764,031,322.

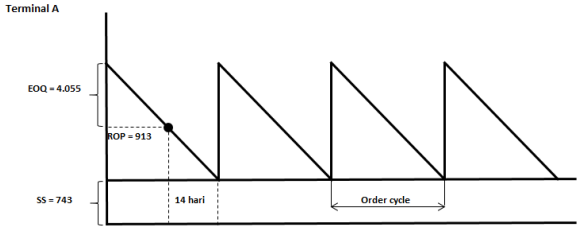

Figure 5: Graph of EOQ, ROP And Safety Stock of Terminal A

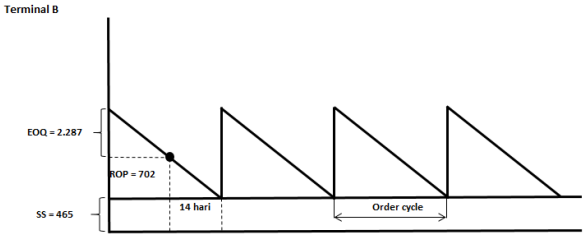

Figure 6: Graph of EOQ, ROP And Safety Stock Of Terminal B

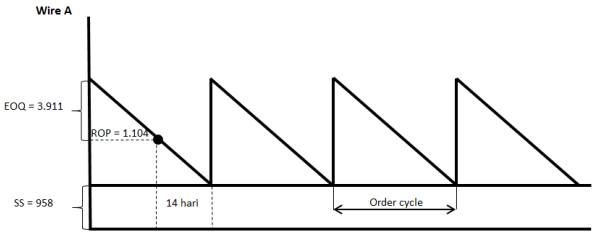

Figure 7: Graph Of EOQ, ROP And Safety Stock of Wire A

The results of the calculation of EOQ, ROP and safety stock has been shown on fidure 5 until 7, are expected to increase the effectiveness of material procurement because the company can determine the best time to reorder materials so that inventory needs are still met.

5. Discussion

Material stock control is one of the important things that must be considered and requires a targeted and systematic approach. This is because material inventory can affect how smoothly a business operates and allocates funds. An in-depth analysis of material inventory planning and control must also be carried out to ensure that there is no shortage of inventory (stock out) (Setiawan & Hati, 2023). The raw material inventory planning that has been carried out by PT XYZ has been carried out in accordance with the established procedures. Raw material control activities in the field are carried out by each employee, leader and supervisor. Actual stock calculations have also been carried out once a week.

The occurrence of stock outs has a significant negative impact on the company's operational sustainability, one of which is a line stop or production line stop until a decision is made by management. The handling of stock outs that have been carried out is that the material control department directly coordinates with production control to change the production schedule and delivery of products affected by stock out materials. The handling process also needs to be coordinated with many related parties and the parent company. If it turns out that the stock out material is still available in other lines, it will be distributed to the production line affected by the stock out material. In

addition, when a stock out occurs, the purchasing staff will make a PO by air so that the material arrives faster for immediate use. This is very risky because the cost of shipping by air must be borne by PT XYZ, where the cost is quite high compared to shipping materials by sea.

In the MRP (Material Requirement Planning) document there is no ROP (Reorder point), minimum and maximum amount of raw material storage. MRP only displays the amount of stock available. So, purchasing staff always check and analyze MRP to find out the amount of material that must be purchased. In addition, lead time will affect the number of reorder points. This needs to be considered to maintain the availability of raw materials when production numbers increase. Then, the impact of stock outs will cause the production line to be temporarily suspended until the required materials are available. From the results of interviews, observations and evaluations, it was found that the raw material planning process was ineffective, especially in determining the amount ordered.

According to (Jhons & Harding, 2011) to ensure inventory control works well, the three main questions to be answered are what to control, how much to order, and when to reorder. Facing the problems that occur at PT XYZ related to the inefficiency of material stock control, the right method is needed to solve it. Alternatives to the problems that occur can use the min-max method to determine the minimum and maximum limits of material stock, then determine the reorder point (ROP) to find out when to reorder and determine safety stock is additional stock prepared to prevent stock outs. Furthermore, using the economic order quantity (EOQ) method to determine the optimum amount in one order.

Based on the results of the interview, the service level used is 90%, meaning that the request for material use can be fulfilled with a probability of 90%, while the probability of not fulfilling the request is 10%. At PT XYZ, it can be seen that the safety stock for terminal A inventory is 1,937 meters, terminal B 465 meters, and wire A 958 meters. Therefore, the company should add inventory to anticipate possible material shortages or stock outs.

Minimum stock is the limit at which the company must purchase raw materials again or reorder point (ROP) which is calculated by multiplying the monthly order time and monthly average usage plus safety stock. This means that if the stock material inventory has reached the amount of the minimum calculation, an order must be placed immediately to avoid stock out. If the amount of inventory is below the minimum inventory level, it means that there is a shortage of inventory and a reorder point must be placed. This is due to the use of raw materials at a certain time is too large while the amount of inventory is less. So, to fill this inventory shortage, safety stock is needed. Meanwhile, maximum stock is the maximum amount or limit recommended for material storage. The min-max method can see the minimum inventory for terminal A 913, terminal B 702 and wireA 1,104 and the maximum inventory for terminal A 1,826, terminal B 1,405 and wireA 1,104. If the Min-max stock method is used to control raw material stocks, the production process will be better because it is more detailed to meet production needs, not less and not more (Kinanthi et al., 2016).

EOQ (Economic Order Quantity) is a method used to calculate optimal ordering. This is reinforced by research (Dyatmika & Krisnadewara, 2018) which states that the EOQ method is the most commonly used mathematical model in inventory management. EOQ is used to determine ordering at the optimum cost and balance between inventory costs and additional costs. At PT XYZ, it can be seen that the EOQ for terminal A inventory is 4,055 meters, terminal B is 2,287 meters, and wire A is 3,911 meters.

Furthermore, the number of order frequencies can be calculated by dividing the demand for one year related to the optimal order quantity of raw materials. From the results of the calculation of the frequency of raw materials based on the EOQ method for terminal A as many as 32 times, terminal B 19 times and wireA 17 times. While the frequency of procurement carried out by the company for terminal A is 36 times, terminal B 25 times and wire A 30 times.

TABLE 17

TIC COMPARISON

Raw material	PT XYZ TIC (Rp)	EOQ TIC (Rp)	Difference	Efficiency
Terminal A	2.396.130.177	1.420.769.948	975.360.229	41%
Terminal B	805.654.975	789.444.852	16.210.123	2%
Wire A	813.819.751	764.031.322	49.788.429	6%

It can be seen in the table 17 above, this shows that the frequency calculation with the EOQ method is carried out to avoid stock outs with the most optimal amount but still considers ordering and storage costs.

6. Conclusions

Based on the results of data processing and analysis that has been carried out, it can be concluded that PT XYZ has carried out planning according to predetermined steps or procedures. From the results of the evaluation of inventory planning, it was found that there was ineffectiveness in determining the amount of raw materials to be ordered because in the planning process there was no reorder point and minimum and maximum limits that could cause

stock out. After the calculation, the reorder point and minimum stock values for terminal A, terminal B and wireA are 913 meters, 702 meters, and 1,104 meters, respectively. While the values for maximum stock for terminal A, terminal B, and wireA are 1,826 meters, 1,405 meters and 2,208 meters, respectively. Then, the safety stock is 743 meters, 465 meters and 958 meters respectively.

Based on the results of EOQ and Total Inventory Cost (TIC) calculations, it can be seen that the frequency of ordering does not consider the optimum amount and cost of storage and ordering of raw materials. The optimum number of orders resulting from the EOQ calculation for terminal A, terminal B and wireA are 4,055 meters, 2,287 meters and 3,911 meters, respectively. After determining the TIC using EOQ, the difference between the company's TIC and EOQ TIC can be seen. The company's TIC without using EOQ for terminal A is Rp 2,396,130,177, terminal B is Rp 805,654,975 and wire A is Rp 813,819,751. Meanwhile, the TIC using EOQ for terminal A is IDR 1,420,769,948, terminal B is IDR 789,444,852 and wire A is IDR 764,031,322. There is a difference which means that PT XYZ can save costs for terminal A worth Rp 975,360,229 (efficiency of 41%), terminal B Rp 16,210,123 (efficiency of 2%) and wire A Rp 49,788,429 (efficiency of 6%). The difference shows that using EOQ obtained the optimum number of orders and cost savings.

This research suggestion, in considering raw material inventory planning and security inventory management, PT XYZ must set reorder points, minimum and maximum limits using the Min-max method to avoid stock outs and maintain a smooth production process. Based on the calculation results using the Economic Order Quantity (EOQ) method, the company needs to set the optimum order limit while still considering ordering and storage costs to remain efficient and not wasteful.

Then, it is recommended to implement min-max and EOQ systematically, namely the calculations or parameters of the two methods are entered or configured into the system used by PT XYZ, so that the system can monitor and issue the amount of purchase orders when the stock reaches a minimum or ROP based on the optimal amount of EOQ calculations. It is hoped that this application can also be carried out in all types of materials in PT XYZ.

In addition, PT XYZ can also apply the FIFO (First In First Out) inventory method, where the first incoming raw material will be used first to avoid expiration and quality degradation, because PT XYZ produces various types of products and requires a large volume of inventory, as well as to avoid the accumulation of old stock which has an effect on efficiency and product quality. With the FIFO method, the company can also continue to provide safety stock, handle fluctuations in demand and help overcome disruptions in the production process if raw materials do not arrive on time according to the lead time.

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