Controlling sugar raw material supplies in the bottled beverage industry

W Willyanto*, A C Sembiring and A Sanjaya
Department of Industrial Engineering, Prima Indonesia University, Medan, Indonesia

*willyantos826@gmail.com

Abstract. The right inventory of raw materials will minimize optimal inventory costs. A company that produces bottled beverages in Medan has problems in procuring raw materials, especially sugar, which results in high inventory costs. Therefore, this study will calculate the order of requests using the Economic Order Quantity (EOQ), Period Order Quantity (POQ), and Min-Max. The EOQ method was chosen because it saves storage costs and ordering costs. The data analysis technique in EOQ method is calculating the optimal amount of raw material purchases, the optimal ordering frequency, the message costs, optimal cost savings and total cost of raw material inventory. EOQ method turned out to have a lower total inventory cost compared to the cost of procurement of raw material supplies set by the company, which is Rp. 215,862,536 while the EOQ method is Rp. 210,777,546. From the calculation results, the EOQ method is more efficient, because the company will be able to minimize the total inventory cost of Rp. 5,084,990 or 2.4% lower.

1. Introduction

Inventories in production can be interpreted as idle resources. This idle resource has not been used because it is waiting further processing. The reason is that certain resources cannot be brought in when these resources are needed. So, to ensure the availability of these resources there is a need for supplies that are ready for use when needed. The existence of inventory has consequences in the form of certain risks that must be borne by the company due to the existence of these inventories [1].

Inventory can also be interpreted as raw material, products in process and finished goods which are considered as part of business assets that are ready or will be ready for sale [2]. Inventory saved by the company can be damaged before use. In addition, the company must also bear the costs arising from the existence of these inventories.

PT XYZ is a company engaged in bottled tea. At present, the company must face problems related to the excess supply of raw materials for sugar so that the company must pay extra for the procurement of the sugar raw material. Therefore, the optimal solution to the problem of excess raw material is minimizing inventory storage costs, procurement / regulatory costs, cost of costs and purchasing costs [3]. The purpose of this study was to provide input on the economical quantity ordering method of sugar raw materials that can streamline and save costs at PT XYZ.

This study uses the EOQ, POQ and Min-Max methods as a tool to analyze and compare the cost of inventory of raw materials issued so that the results can be known to be an efficient and cost-effective method of comparison of the three methods. Of the three methods, the EOQ method is the most efficient and saves the total cost of inventory for PT XYZ.
2. Research methods
The object of the study observed was data on sugar raw materials. This research is descriptive research, research that describes a problem then discusses it so that it can produce a conclusion about the problem. The purpose of this study is to minimize the total cost of sugar raw material supplies. The data used in this study are sugar raw material data, message costs, storage costs, and the cost of purchasing raw materials obtained from the company.

The method used in this study is the method of Economic Order Quantity (EOQ), Period Order Quantity (POQ) and Min Max. These methods are used to determine the size of the order quantity and total inventory costs.

2.1. Cyclic forecasting method
The selection of forecasting methods is largely based on data availability and the purpose of planning tools and exercises [4]. The Cyclic Forecasting Method is included in the trend regression method. The tendency method with regression is the basis of the trend line for an equation so that the basis of the equation can be projected the things studied in the future. For short and long term forecasting, the accuracy of forecasting with this method is very good. The form of the function of this cyclic forecasting method is [1]:

\[
\hat{Y}_t = a + b \sin \frac{2\pi n}{n} + c \cos \frac{2\pi n}{n}
\]  

(1)

Where:
\[
\sum Y = na + b \sum \sin \frac{2\pi n}{n} + c \sum \cos \frac{2\pi n}{n}
\]
\[
\sum Y \sin \frac{2\pi n}{n} = a \sum \sin \frac{2\pi n}{n} + b \sum \sin^2 \frac{2\pi n}{n} + c \sum \sin \frac{2\pi n}{n} \cos \frac{2\pi n}{n}
\]
\[
\sum Y \cos \frac{2\pi n}{n} = a \sum \cos \frac{2\pi n}{n} + c \sum \cos^2 \frac{2\pi n}{n} + b \sum \sin \frac{2\pi n}{n} \cos \frac{2\pi n}{n}
\]

2.2. Economic Order Quantity (EOQ)
This model aims to describe the optimal order quantity for goods, so as to minimize the total cost, including storage and ordering costs [5]. This method is also designed to provide optimal solutions in constant demand conditions [6]. Where product demand depends on time and price. The buyer also needs to pay all money to the seller when lot size is accepted [7].

The EOQ formula that can be used is [1]:

\[
EOQ = \sqrt{\frac{2AD}{h}}
\]

(2)

Where:
D = demand level, unit per year
Q = quantity of goods economy for each order (EOQ)
A = cost per order
h = storage costs (rupiah / unit / year)
Q indicates that the optimal order quantity, known as the EOQ method.
Total cost

\[
TC = A \frac{D}{Q} + h \frac{Q}{2}
\]

(3)
2.3. Period Order Quantity (POQ)
Quantity Order Period (POQ) is a model with the best overall performance, for which the number of fixed periods is determined as the economic time between the order and / or the number of fixed periods as lot size [8]. The period lot quantity order rule is based on the same theory as the number of economic orders. This is calculated by dividing the EOQ by the level of demand, the order placed to meet the requirements for the calculated time interval. The number of orders placed in one year is the same as the number of economic orders, but the number ordered each time varies. Thus, the ordering costs are the same but, because the number of orders is determined by actual demand, recorded costs are reduced [9].

The POQ formula that can be used is [1].

\[
\text{Order frequency per year} = \frac{\text{order per year}}{\text{EOQ}} \quad (4)
\]

\[
\text{Order interval} = \frac{\text{number of periods in 1 year}}{\text{frequency of bookings per year}} \quad (5)
\]

Total inventory costs

\[
= \text{message costs} + \text{save costs} \quad (6)
\]

\[
= (\text{message frequency} \times \text{message cost}) + \left(\frac{Q}{2}\right) + \text{safety stock}) \quad (7)
\]

2.4. MIN MAX
In contrast to the EOQ concept and periodic planning formula, the concept of minimum and maximum inventory is not based on regular calculation, but can be done at any time, with the concept of 'reorder point' or reorder point [10].

\[
Q = \text{Max} - \text{Min} \quad (8)
\]

Q = the amount that needs to be ordered to replenish inventory
Min = Minimum stock
Max = Maximum stock

\[
\text{Min} = (T \times C) + R \quad (8)
\]

\[
\text{Max} = 2 (T \times C) \quad (9)
\]

Total cost

\[
P_D + \left(\frac{D}{Q}\right) \times C_o + C_c D \quad (10)
\]

Where:
P: material prices
D: Demand / material demand
Co: once ordered booking fees
Cc: storage fee

3. Results and discussion

3.1. Calculation of forecasting demand for sugar raw materials
The first stage in this study is the calculation of forecasting the demand for sugar raw materials for 2018. To calculate the forecast demand for sugar raw materials the method used is the cyclic forecasting method. The cyclic forecasting method is used because data on the demand for sugar raw materials have a tendency to rise or fall continuously. From the results of the calculation of data sharing in 2017 using the cyclic forecasting method the following equations are obtained:
A = \frac{3.299,700.60}{12} = 274.975,05

B = \frac{(2)(-417.371.58)}{12} = -69.561,93

C = \frac{(2)(-155.686.44)}{12} = -25.947,74

so, \ Y'(t) = 274.975,05 - 69.561,93 \sin \frac{2\pi t}{n} - 25.947,74 \cos \frac{2\pi t}{n}

By using the above equation for forecasting the cyclic method, the results of the forecast results of the total demand for sugar raw materials for 2018 are as follows:

Table 1. Forecast of demand for sugar raw materials in 2018.

| Month   | Of many requests (Xi) |
|---------|-----------------------|
| January | 217.619,541           |
| February| 201.918,43            |
| March   | 205.153,62            |
| April   | 227.429,98            |
| May     | 261.813,51            |
| June    | 300.227,17            |
| July    | 332.330,56            |
| August  | 348.031,67            |
| September| 344.796,47           |
| October | 322.520,07            |
| November| 288.136,59            |
| December| 249.722,93            |

\sum x_{2018} = 3.299,700.54 \text{ kilogram}

From the results in table 1. That the results of forecasting the cyclic method for the demand for sugar raw materials in 2018 are 3,299,700.54 kilograms.

3.2. Calculation of the amount of safety stock

With the availability of safety supplies, additional costs will arise in the storage of this additional inventory. To determine the number of safety supplies, a standard deviation value (\sigma) is required for each sugar raw material each year studied and also the safety factor (Z) used by the company. The mathematical model in this calculation is as follows:

SS = Z \times \sigma

By using the formula above, it is obtained the recapitulation of the results of the number of Safety Stocks as can be seen in Table 2.

Table 2. Determination of the amount of safety stock.

| Year | Safety Stock |
|------|--------------|
| 2015 | 3.467 sack   |
| 2016 | 1.045 sack   |
| 2017 | 5.743 sack   |

3.3. Calculation of the reorder point

The reorder point occurs when the amount of inventory contained in the stock decreases continuously, therefore the company determines the reorder point that must be done by the company so as not to run out of stock (stockout) or excess stock (over stock). Data obtained from the company shows that the
data lead time is 7 days, then $L = \frac{7}{365}$, then we get the recapitulation of the results of the Reorder Point as can be seen in Table 3.

**Table 3.** Determining the ordering point.

| Year | Reorder Point |
|------|---------------|
| 2015 | 1.530 sack    |
| 2016 | 446 sack      |
| 2017 | 1.265 sack    |

3.4. *Calculation of the ratio of the total cost of sugar raw material supplies*

Based on data on message costs, storage costs and raw material demand data obtained so that the calculation of the comparison of the total cost of raw material inventory can be calculated. To calculate the ratio of total inventory costs, the Economic Order Quantity method, the Period Order Quantity and Min-Max used. The following is the result of calculating the total inventory cost of each method can be seen in Table 4.

**Table 4.** Calculation of the ratio of total inventory costs.

| EOQ         | POQ            | MIN MAX        |
|-------------|----------------|----------------|
| Rp. 231.751.296 | Rp. 444.136.000 | Rp.5.005.434.483 |
| Rp. 125.147.967 | Rp. 189.305.148  | Rp. 1.511.819.224  |
| Rp. 210.777.546 | Rp. 668.519.200  | Rp. 4.154.333.412  |

From the results of Table 2, it can be seen that the EOQ method has a lower total inventory cost compared to the POQ method, and Min-Max.

3.5. *Discussion*

In calculating the comparison of total inventory costs, the EOQ method has a lower total inventory cost compared to the POQ method, Min-Max and the Company method. It turns out that the company's 2017 raw material inventory costs Rp. 215.862.536, the cost of raw material inventory for the 2017 POQ method is Rp.668.519.200, the cost of Min Max's raw material inventory in 2017 is Rp. 4.154.333.412 while the EOQ method has a lower total inventory cost of Rp. 210.777.546 so that with the implementation of this EOQ method the company will be able to minimize the total inventory cost of Rp 5,084,990 or 2.4%. Comparison between EOQ, POQ, Min-Max methods and costs incurred by the company can be seen in Table 5.

**Table 5.** Comparison policy EOQ, POQ, Min-Max and company policies.

| Year | Company policies | EOQ         | POQ            | MIN MAX        |
|------|------------------|-------------|----------------|----------------|
| 2015 | Rp. 237.717.864 | Rp. 231.751.296 | Rp. 444.136.000 | Rp.5.005.434.483 |
| 2016 | Rp. 131.505.085 | Rp. 125.147.967 | Rp. 189.305.148  | Rp. 1.511.819.224  |
| 2017 | Rp. 215.862.536 | Rp. 210.777.546 | Rp. 668.519.200  | Rp. 4.154.333.412  |

4. *Conclusion*

Based on a comparative analysis of total inventory costs by using the Economic Order Quantity (EOQ) method, Period Order Quantity (POQ) and Min-Max with the total inventory costs incurred by the company, the most optimal and low EOQ method is the total cost of Rp. 210.777.546 compared to the cost of raw material inventory of the POQ method of Rp.668.519.200, the cost of raw material inventory method Min-Max is Rp. 4.154.333.412 while the total cost of the company's raw material inventory is Rp. 215.862.536. From the results above, it can be concluded that the improvement of the method used will have a positive impact on the company. by using the EOQ method, the total cost of inventory can be reduced by Rp. 5,084,990 or 2.4% of the costs incurred by the company.
Acknowledgment
The author would like to thank the Industrial Engineering lecturer at the University of Indonesia for their support and gratitude to the tea beverage industry who was willing to be the object of research and staff at PT XYZ who helped and shared information to complete this study.

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