Raw Materials Inventory Planning in Automotive Industries by EOQ Method Consider with the Contract Agreement

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Abstract. One of industrial sector that currently continuous growing up is automotive industry. Safety glass is a kind of automotive component that always has improvement and development. To support production running well, raw materials supply inventory has to be considered and managed as well. Poly Vinyl Butyral (PVB) as raw material is purchased from 2 suppliers and both of them have a contract agreement. Inventory shall be set up to fulfill the demand and follow the contract. By use Economic Order Quantity (EOQ) Method, inventory is calculated to minimize the cost. So the research objective is to determine inventory system of PVB and inventory cost by optimum. Then researcher got the result is EOQ Method can reduce the inventory cost around 52% than last period by keep consideration with the contact agreement.

Keywords: Inventory, Planning, EOQ, Automotive

1. Introduction

Automotive industries are continue growing up and become strategic industries because have relation with another economic sectors, absorb bigger employee, and drive middle and micro industrial sector, and utilize simple technologies until complex technology. Indonesia becomes one of countries in South East Asia that has big quantity car production after Thailand. It is proved by some car manufactures from Japan like Toyota, Honda, Suzuki, Nissan, Mitsubishi, Isuzu, Hino built their plants in Indonesia.

Automotive safety glass is important automotive component that shall follow international standard. Two kind of automotive safety glasses are tempered safety glass and laminated safety glass. To produce it, raw materials required are basic glass and polyvinyl butyral (PVB). PVB is used for laminated safety glass only.

AMF is international safety glass group which produces for safety glass car maker manufacture since 1985. Basic glass they can get it from internal plant and buy from their group in overseas, but for PVB they should buy from the suppliers due to no plant in their group and material special handling which is PVB should be kept in cold storage by temperature below than 10⁰C. To fulfill demand from customer AFG buy PVB from two suppliers with contract agreement as term condition. There for, needs a good inventory planning to minimize their cost. From both suppliers, only PVB Standard Clear type that is managed in the contact.

Zhao and You (2016) studied an EOQ inventory models by pre-sale policy to reduce items where demand depends on the inventory on-hand and items price. Yang, et al. (2015) considered dynamic inventory control and optimize problem at price arrangement on inventory system by adjustment price. Ghorbel, et al. (2014) compared from previews about research works dealing with replenishment
policies and concluded that inventory should consider the uncertainty on the parameters such as demand, availability, lead time and etc. Nishard and Arunkumar (2018) studied EOQ to be proposed to the company due to current inventory management is not proper which cause overstock and sometimes stock out.

According to Ristono (2013) inventory can be interpreted as goods that are stored for use or sale in the future or period to come. Inventories consist of raw material inventory, semi-finished material inventory and finished goods inventory. Inventories of raw materials and semi-finished materials are stored before used or put into the production process, while inventories of finished goods or merchandise are stored before being sold or marketed. Inventory or inventory is a technique for material management related to inventory. Material management in inventory carried out with several inputs used, namely: the demand that occurs (demand) and the costs associated with storage, and costs if there is a shortage of inventory (shortage).

Inventory control according to Assauri (2010) is one of the activities of the sequence of activities that are closely linked to each other in all of the company's production operations in accordance with what has been planned in advance both in time, quantity, quality and cost.

\[
EOQ = \sqrt{\frac{2DS}{C}}
\]  
(1)

Where is:
EOQ = Economic Order Quantity
S = Ordering Cost
D = Demand QTy per period
C = Holding Cost

Next determine the total cost of supplies (TIC) by adding up the cost of ordering and holding costs. The formula is as follows.

\[
TIC = \left(\frac{D}{Q} \times S\right) + \left[\frac{Q}{2} \times H\right]
\]  
(2)

Where is:
TIC = Total inventory cost
D = Demand, units per year
Q = Number of items each time ordered
S = Order Cost every time order
H = Storage costs, units per year

A safety stock is an additional inventory held to protect or protect the possibility of a material shortage (stock out). According to Assauri (2010) the possibility of stock out can be caused by the use of raw materials that are greater than originally estimated or the delay in the arrival of raw materials ordered. To determine the cost of safety stock, statistical analysis is used, which is to consider the deviations that have occurred between the estimated use of raw materials and actual use so that the standard deviation is known. The standard deviation formula is as follows.

\[
SD = \sqrt{\frac{\sum(x-\bar{x})^2}{n}}
\]  
(3)

Where is:
SD = Standard Deviation
x = Demand Qty
\(\bar{x}\) = Demand Average
n = Data Qty

While the formula used to calculate the safety stock is as follows.

\[
SS = SD \times Z
\]  
(4)
Where is 
SS = Safety Stock
SD = Standard Deviation
Z = Safety factor used by the company

In this case, the safety factor in question is the large probability used by the company for the occurrence of stock out. For example, a company uses a probability of 1% for a stock out, then by using a normal frequency distribution table, the value of Z0.01 = 2.33 (Heizer and Render, 2013).

According to Heizer and Render (2013) ROP is an inventory level where when inventory has reached that level, orders must be made immediately and ROP can be calculated with the following formula:

$$\text{ROP} = (D \times L) + SS$$

(5)

Where is:
ROP = Reorder Point
D = Needs Qty per unit time
L = Lead time
SS = Safety Stock

Then, how to plan inventory system of PVB by optimum to fulfill customer demand, so material shortage can be avoided if there is increasing demand? And how much inventory cost of PVB materials?

The objective this research is to determine inventory system of PVB and inventory cost by optimum.

2. Methods

This research is done by quantitative method. To do a measurement, every phenomenon is explained to the some variables and indicators. Each decided variables measured by giving numeric symbols that are different according to the related information. So, calculation technique by mathematical numeric can be done and can get result a conclusion that is generally in a parameter.

The research is exploratory and interview is used by opened question and answer than systematically question. The purpose of this study is to obtain empirical data that can be used in formulating, expanding, and verifying theories and solving problems from phenomena that are obtained theoretically and scientifically. In addition, this research is expected to be a material for further research to develop several methods besides the methods that have been done.

Population and sample is collected only for PVB material and focus to the actual consumption in the last period and the forecasting in the next period that was calculated by Production Planning Department.

Analysis will be done by use Economic Order Quantity. Sensitivity analysis in the EOQ model has significance for management, because after all the results of the EOQ calculation are not the final decision. What the EOQ model shows is an input for management in establishing the final inventory policy decision. Even though EOQ recommends a certain amount of purchases economical in every order, but EOQ may not have considered all aspects of the supply situation. Therefore also, the decision maker must have the freedom to modify the purchase amount recommended by EOQ to be able to meet the environmental characteristics of the inventory problem faced.

According to Tampubolon (2018) sensitivity analysis is very important because the results of the analysis can provide clues to the size error both in terms of cost calculations and in the quantity of inventory. To calculate the analysis of excess quantities, it can be calculated by the following equation (Tampubolon, 2018):

$$\text{EOQ} = \frac{1}{2} \left( \text{EOQ} + \frac{\text{EOQ}^2}{Q} \right)$$

(6)

Where is:
EOQ = EOQ calculation
Q = Q number of orders specified by the company is not based on EOQ
If Q is not the same as EOQ, it will result in marginal costs that will be borne by the company. While marginal cost is the sensitivity ratio obtained minus the lowest sensitivity ratio multiplied by the total inventory cost. If it is made in the form of an equation it is as follows:

$$\text{Marginal cost} = (\text{sensitivity ratio} - 1) \times \text{total inventory cost}$$

(7)

3. Result and Discussion

AMF inform that previous PVB Standard Clear has inventory cost around US $ 3,733,355.105. Based on information that was collected Ordering Cost (S): US $ 15,000 per one time order, PVB plan consumption (D) as informed in Table 1. and PVB unit price (I) is adjusted according to the contract price with both of suppliers as informed on Table 2. And Holding cost (C) is 20%

Table 1 Production Planning PVB (unit in Square meter (Sqm))

| Month | Standard Clear |
|-------|----------------|
| Jan-19| 117.191        |
| Feb-19| 117.191        |
| Mar-19| 117.191        |
| Apr-19| 117.191        |
| May-19| 117.191        |
| Jun-19| 117.191        |
| Jul-19| 117.191        |
| Aug-19| 117.191        |
| Sep-19| 117.191        |
| Oct-19| 117.191        |
| Nov-19| 117.191        |
| Dec-19| 117.191        |
| TOTAL | 1,406.286      |

Table 2. PVB Contract Information

| Vendor  | Contract Qty | Rebate | Unit Price | Order Amount | Rebate |
|---------|--------------|--------|------------|--------------|--------|
| Vendor A| 1,100,000    | 1%     | $ 4.00     | $ 4,400,000  | $ 4,400|
| Vendor B| 600,000      | #N/A   | $ 4.40     | $ 2,640,000  |        |
| TOTAL Contract | 1,700,000 | TOTAL Amount | $ 7,040,000 |        |

From the table above, the price of PVB standard clear films used by using an average of the total value purchased from the two suppliers divided by the amount of PVB purchased so that the price per unit (I) is US $ 4.14. From the results of the forecasting, the need for Standard Clear PVB for the next period (D) is 1,406,286 m² with the number of contracts agreed upon with both suppliers (Q) of 1,700,000 m². If the number of orders to Vendor A meets the agreed contract, the company will get a rebate of 1% of the purchase value of US $ 4,400 which can reduce inventory costs. Assuming that in one month there are 4 weeks. Then EOQ is calculated as formula (1) and total cost (TC) in Table 3.
it has obtained the Priority inventory safety factor used by the company is 1.8
(ROP using equation (5)) in a theoretical study, safety stock using equation (5)
This means that Q is equivalent to EOQ so there is no marginal cost borne by the company. So that a rebate of US $ 4,400 can be obtained as purchase profit.
After calculating the EOQ, the next step is the calculation of Safety Stock and ROP. Standard deviation is calculated by using equation (3) in a theoretical study, safety stock using equation (4) and ROP using equation (5). In this calculation it is assumed that in 1 week there are 4 weeks to calculate the number of requests in 1 month, while the average weekly demand is obtained from the number of requests in one year divided by 52 weeks with the assumption in one year there are 52 weeks. The inventory safety factor used by the company is 1.8 weeks to avoid fluctuations demand from customers and in the ROP calculation the specified delivery time / lead time of delivery is 6/7 days or 0.86 weeks assuming 4 days of shipping on shipping and 2 days for complete the Customs and Clarance process at the Port. The company has established a 2-day Customs Clearance process because it has obtained the Priority Facility from Customs. So that the calculation is obtained as in Table 4. Below

### Table 3. EOQ and TC PVB Standard Clear

| Month  | Demand (m$^2$) | Unit Price ($US$) | Order Cost ($US$) | Demand per Week (m$^2$) | Holding Cost C | EOQ (m$^2$) | TC with EOQ ($US$) |
|--------|----------------|------------------|------------------|-------------------------|----------------|-------------|------------------|
| Jan-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| Feb-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| Mar-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| Apr-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| May-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| Jun-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| Jul-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| Aug-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| Sep-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| Oct-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| Nov-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| Dec-19 | 117.191        | 4.14             | 15,000           | 29,297.6                | 20%            | 32.581      | 148.269          |
| TOTAL  | 1,406,286      |                  |                  |                         |                | 390,970     | 1,779,229        |

Because the company already has a contract with an agreed supplier of 1,700,000 sqm, then assuming there are 52 weeks in one year the number of orders that must be done in one week is 1,700,000 / 52 = 32,692 m$^2$

$$\frac{EOQ}{Q} = \frac{1}{2} \left[ \frac{EOQ}{Q} + \frac{Q}{EOQ} \right] = \frac{1}{2} \left[ \frac{31581}{32692} + \frac{32692}{31581} \right] = 1.000005836977161$$

### Table 4. Safety Stock and ROP PVB Standard Clear

| Month  | Qty Demand (m$^2$) | Planned Demand per Week (m$^2$) | Average Demand per Week (m$^2$) | EOQ (m$^2$) | Safety Stock (m$^2$) | ROP (m$^2$) |
|--------|--------------------|---------------------------------|---------------------------------|-------------|---------------------|------------|
| Jan-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| Feb-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| Mar-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| Apr-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| May-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| Jun-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| Jul-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| Aug-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| Sep-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| Oct-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| Nov-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
| Dec-19 | 117.190.5          | 29.297.6                        | 27.044.0                        | 32.581      | 2.028.3             | 25.208.8   |
From Table 4 can be seen the figure of Safety Stocks and ROP (Figure 1) as below.

![Figure 1. Safety Stock and ROP PVB Standard Clear](image)

In calculating the total inventory cost, a greater result is obtained because the number of contracts with suppliers is greater than the number of demand forecasts in the coming period. So that there is an excess that must be borne by the company resulting in the total inventory costs being greater when compared to using the total cost calculation of the EOQ method. So that if marginal cost is formulated due to excesses that must be borne as follows:

$$\text{Marginal cost} = (\text{sensitivity ratio} - 1) \times \text{total inventory cost}$$  \hspace{1cm} (8)

Marginal costs are increases in total costs that come from the production of one unit of output. Marginal cost measures the additional input costs needed to produce each unit of subsequent output. Because fixed costs do not change when there are output costs, marginal costs reflect changes in variable costs. The cause of the marginal cost to the company is the excess stock that must be borne.

Determination of the economic order Quantity (EOQ) is done if the supply of raw materials depends on several suppliers, so it is necessary to consider the amount of material inventory purchases as needed. This is consistent with the data obtained that the company already has a purchase cooperation contract with the supplier of PVB material.

4. Conclusion

Standard Clear PVB inventory costs decreased 52% from US $ 3,733,355.105 to US $ 1,779,225.156. From the number of contracts agreed with the supplier for PVB Standard Clear did not result a marginal cost and the sales rebate could be given from the suppliers as purchase profit around US $ 4,400.

EOQ calculation should be reviewed for the next period if there is alteration of contract agreement related the term condition about volume and unit price. And it can be consideration for AMF to check the inventory planning for another materials.

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