Raw Material Inventory Control Analysis with Compare EOQ Method and Min-Max Stock in PT Dirgantara Indonesia

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Abstract. Non-metallic raw material is a raw material that is a general requirement in the aircraft production process. The remaining raw materials become a waste for the company. But if the raw materials are not available, the production process cannot run and can disrupt the predetermined production targets. If the raw material has a quantity that is more than the amount needed it will result in overstock in the warehouse. And non-metallic raw materials that have an expired period cannot be used anymore because they have passed the expiration date which can be detrimental to the company. For this reason, planning for the supply of non-metallic raw material raw materials must be appropriate so that the raw materials are ready to be used in the right amount at the right time for the aircraft production process. In this study, data processing for inventory control will be carried out using the EOQ (Economic Order Quantity) and min-max stock methods. The results of the calculation of ordering raw materials using the EOQ method obtained the number of raw materials ordered were Elastomeric adhesive of 8.080 kg, epoxy adhesive of 5.879 kg, low adhesion sealant of 8.295 kg, polysulfide sealant of 8.579 kg, and conductive sealant of 7.403 kg. Calculation of ordering raw materials using the Min-Max method, the number of raw materials ordered, Elastomeric adhesive was 12 kg, epoxy adhesive was 10 kg, low adhesion sealant was 16.66 kg, polysulfide was 13.33 kg, and conductive sealant was 8.336 kg.

Keywords: Economic Order Quantity (EOQ), Minimum Maksimum (Min-Max).

1 Introduction

The supply of the world's small companies is one of the most important keys. All organizations certainly have a planning system and inventory control system [1]. Inventory is a stock of various materials or resources used in the organization. Inventory is the main part of working capital in the form of assets that always change at any time [2][3][4][5]. Inventories can be in the form of materials or goods provided for use by the company, whether in the form of raw materials, work in progress, or finished goods stored by the company in anticipation of a shortage of raw materials and maintaining the smooth operation of the company [6][7][8]. Raw materials are materials that make up the entire finished product. In obtaining raw materials, the company not only incurs costs in the amount of the purchase price of raw materials, but also incurs purchasing, warehousing, and other acquisition costs [9].

In company operations, inventory management is defined as the process of planning, organizing, and controlling inventory to minimize costs whilst balancing supply and demand, and it accounts for approximately half of the logistics costs that a company has to bear; raw materials, work in progress (WIP), finished products, distribution stocks, maintenance, repair, and operational supplies (MROS) are involved, and the costs associated with their management order/production costs (depending on the external purchase or internal production), stock keeping costs and stock out costs [10].

At PT Dirgantara Indonesia itself, there are 2 (two) procurements, namely in the form of ac (Aircraft) and none (Aircraft). For non-aircraft, the focus is more on the Need for Goods and Services (KBJ), while for the procurement of materials at PT Dirgantara Indonesia, it is more on aircraft. In procuring materials, several materials are classified, such as non-metal raw materials, metal raw materials, standard parts, and avionic electronics & instruments.

The non-Metal raw material is raw material that is a general requirement for the manufacture of aircraft. The material to be ordered is an adhesive type material and a sealant material type material.

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In a manufacturing company, if the supply of raw materials is lacking or even out of stock, it can hamper the production process and even result in the cessation of the production process. Conversely, if there is too much inventory (overstock), it can cause waste. Investments that are too large in inventory will be directly proportional to storage costs, namely costs incurred in connection with the storage activities of purchased raw materials [11]. Many studies have no doubt contributed to the development of this research field, such as [12] Exponential smoothing techniques are used to ensure the least cost of shares and fees.

2 Research Methods

The data collected is then processed so that it can be used in research. The stages of data processing carried out in this study are:

2.1. Calculation of the Economic Order Quantity (EOQ)

The Economic Order Quantity (EOQ) method is the number of material purchases that will be able to achieve the minimum inventory costs. Thus it is expected that with this optimal purchase quantity inventory costs will be reduced to the lowest possible so that the efficiency of material inventory within the company concerned can be carried out properly.[13] [14][15][16][17].

The most well-known inventory management methods are the economic order quantity (EOQ) or economic lot size (ELS) models. These methods can be used for both purchased and self-produced goods [18].

The EOQ formula that is commonly used is:

$$EOQ = \sqrt{\frac{2\,D\,S}{H}} \tag{1}$$

Economic order quantity/frequency :

$$F = \frac{D}{Q} \tag{2}$$

Total annual inventory cost:

$$TC = \frac{D}{Q}\,S + \frac{Q}{2}\,H \tag{3}$$

Information :
D = Number of goods needed (units/year)
S = Cost per order
H = storage cost per unit per year
Q = Number of orders (units/orders)
F = Order frequency (times/year)
TC = total inventory cost (rupiah/year)

2.2. Calculation of Minimum Maximum Stock (Min-Max)

The concept of the Min-max method was developed based on a simple thought to maintain the continuity of the operation of a factory, certain types of goods in a minimum quantity should be available in stock so that at any time something is damaged, it can be replaced immediately. However, there should not be too many items available in the inventory, there is a maximum so that the costs are not too expensive [19][20][21][22].

The calculation of the min-max method is as follows:

$$\boldsymbol{Q = Max - Min} \tag{4}$$

Information :
Q: The amount that needs to be replenished
Max: Maximum Stock
Minimum: Minimum Stock

Purchases which are calculated by multiplying the time of order (in months) and the average usage in one month plus the safety stock, so

Min = Request per month x (lifetime- Lead time)

Max = Maximum stock, is the maximum amount allowed to be stored in inventory. To determine the maximum stock level can be formulated as follows:

Max = ROP + Minimum stock

The total cost of inventory for min-max is as follows :

$$TC\ Min - Max = (F\ x\ S) + (\left(\frac{Q}{2}\right) + SS\ x\ H) \quad (5)$$

Information :
Q: Demand / Material Requests
S: Order fee/one-time order
H: Storage fee
F: Message frequency

3 Results and Discussion

Non-metal raw materials that are a general requirement for the aircraft production process at PT. Dirgantara Indonesia are as follows :

Table 1. Requirement Non Metal Rawa Material

No	*Material Name*	Material Specification	Needs/Year (Kg)
1	*ELASTOMERIC ADHESIVE*	Z-15.101	24
2	*EPOXY ADHESIVE*	Z-15.201	12
3	*LOW ADHESION SEALANT*	Z-16.160	20
4	*POLYSULFIDE SEALANTS*	Z-16.176	16
5	*CONDUCTIVE SEALANT*	Z-16.177	10

The lead time required between the goods being ordered and arriving at the company is as follows:

Table 2. Lead time Non Metal Raw Material

No.	*Material Name*	*Material Specification*	*Lead Time (Hari)*
1	*ELASTOMERIC ADHESIVE*	*Z-15.101*	120
2	*EPOXY ADHESIVE*	*Z-15.201*	120
3	*LOW ADHESION SEALANT*	*Z-16.160*	120
4	*POLYSULFIDE SEALANTS*	*Z-16.176*	120
5	*CONDUCTIVE SEALANT*	*Z-16.177*	120

Calculation of Economic Order Quantity (EOQ)

1) *Economic Order Quantity* (EOQ) Elastomeric Adhesive

$$EOQ = \sqrt{\frac{2\ x\ 2\ x\ 96}{50}}$$

$$= 9{,}6$$

$$Frequency = \frac{Demand}{EOQ}$$

$$= \frac{24}{9{,}6} = 2{,}5 \approx 3$$

Because the lead time is known to be 4 months, the raw material requirements for 1 month are as follows:

- Needs/year = 24 kg/year, then ;
- Needs / month = 24 kg/12 = 2 kg/month
- Requirement during lead time = 4 x 2 = 8 kg/month So, R = 8 kg

$$TC = \frac{24}{9,6}96 + \frac{9,6}{2}50$$
$$TC = €480$$

2) *Economic Order Quantity* (EOQ) Epoxy Adhesive

$$EOQ = \sqrt{\frac{2\ x\ 12\ x\ 72}{50}}$$
= 5.879

Frequency = $\frac{12}{5,879}$= 2,04 ≈2 Kali

Because the lead time is known to be 4 months, the raw material requirements for 1 month are as follows:

- Needs/year = 12 kg/year, then ;
- Needs / month = 12 kg/12 = 1 kg/month
- Requirement during lead time = 4 x 1 = 4 kg/month So, R = 4 kg

$$TC = \frac{12}{5,879}72 + \frac{5,879}{2}50$$
$$TC = €293,94$$

3) Economic Order Quantity (EOQ) E Low Adhesion Sealant

$$EOQ = \sqrt{\frac{2\ x\ 20\ x\ 86}{50}}$$
= 8,295

Frekuensi = $\frac{20}{8,295}$= 2,414 ≈2 kali

Because the lead time is known to be 4 months, the raw material requirements for 1 month are as follows:

- Needs/year = 20 kg/year, then ;
- Needs / month = 20 kg/12 = 1.666 kg/month
- Needs during lead time = 4 x 1.666 = 6.664 kg/month So, R = 6.664 kg So, R = 4 kg

$$TC = \frac{20}{8,295}86 + \frac{8,295}{2}50$$
$$TC = €414,73$$

4) Economic Order Quantity (EOQ) Polysulfide Sealants

$$EOQ = \sqrt{\frac{2\ x\ 16\ x\ 115}{50}}$$
= 8,579

Frekuensi = $\frac{16}{8,579}$= 1,87 ≈2 kali

Because the lead time is known to be 4 months, the raw material requirements for 1 month are as follows:

• Needs/year = 16 kg/year, then ;
• Needs / month = 16 kg/12 = 1.333 kg/month
• Needs during lead time = 4 x 1.333 = 5.332 kg/month So, R = 5.332

$$TC = \frac{16}{8{,}579}115 + \frac{8{,}579}{2}50$$

$$TC = €428{,}96$$

5) Economic Order Quantity (EOQ) Conductive Sealant

$$EOQ = \sqrt{\frac{2\ x\ 10\ x\ 137}{50}}$$

$$= 7{,}403$$

$$\text{Frekuensi} = \frac{10}{7{,}403} = 1{,}35 \approx 1 \text{ kali}$$

Because the lead time is known to be 4 months, the raw material requirements for 1 month are as follows:

Needs/year = 10 kg/year, then ;
• Needs / month = 10 kg/12 = 0.833 kg/month
• Requirement during lead time = 4 x 0.833 = 3.332 kg/month
• So, R = 3.332 kg

$$TC = \frac{10}{7{,}403}137 + \frac{7{,}403}{2}50$$

$$TC = €370{,}14$$

Minimum Maximum Stock Calculation (Min-Max)

1) Minimum Maximum Stock (Min-Max) Elastomeric Adhesive

To ensure that there is no shortage during the lead time, the company will set a minimum stock or safety stock to prevent delayed deliveries and excess usage on average per month during the lead time. Use of 2 months is set to a minimum stock, this is based on the expiry period of the Elastomeric Adhesive material for 6 months minus the lead time of 4 months. The demand for a year is 24,000 grams/year, the demand for a year is divided by 12 months to find out the demand for 1 month. Where the demand for 1 month is 2000 grams/month.

Minimum Stock Level taking into account the material's expired period
Min = 2000 x 2 months
4000 grams = 4 kg

To find out the amount of inventory on hand at a time when an order must be held again. Depending on the lead time and demand during the lead time, and the Elastomeric Adhesive material the demand during the lead time is 4 months is 8000 grams.

request during lead time
2000 x 4 months
8000 grams = 8 kg

Optimum order quantity for Elastomeric Adhesive ROP material = Minimum stock level + Demand During Lead Time
= 4000 grams + 8000 grams
= 12000 grams = 12 kg

Because the Elastomeric Adhesive material has a lifetime period, which is 6 months, the company determines that the Elastomeric Adhesive material in inventory cannot exceed the maximum level in the inventory.

Maximum Stock Level
Max = ROP + Minimum Stock Max = 12000 + 4000
Max = 16000 grams = 16 kg

Q = Maximum – Minimum
= 16000 – 4000
= 12000 grams = 12 kg

$$Frequency = \frac{24}{2}$$
$$= 12$$

Min-max total cost method

$$TC\ Min - Max = (2\ x\ 96) + \left(\left(\frac{12}{2}\right) + 4\right) x\ 50)$$
$$TC\ Min - max = 692$$

2) Minimum Maximum Stock (Min-Max) Epoxy Adhesive

To ensure that there is no shortage during the lead time, the company will set a minimum stock or safety stock to prevent delayed deliveries and excess usage on average per month during the lead time. The usage of 2 months is set to a minimum stock, this is based on the period of expiration of the Epoxy Adhesive material for 6 months minus the lead time of 4 months. The demand for a year is 12,000 grams/year, the demand for a year is divided by 12 months to find out the demand for 1 month. Where the demand for 1 month is 1000 grams/month.

Minimum Stock Level taking into account the material's expired period
Min = 1000 x 2 months
2000 grams = 2 kg

To find out the amount of inventory on hand at a time when an order must be held again. Depending on the lead time and demand during the lead time, and the Epoxy Adhesive material the demand during the lead time is 4 months is 8000 grams.

request during lead time
2000 x 4 months
8000 grams = 8 kg
Optimum order quantity for Epoxy Adhesive
ROP = Minimum stock level + Demand During Lead Time
= 2000 grams + 8000 grams
= 10000 grams = 10 kg

Because the Epoxy Adhesive material has a lifetime period, which is for 6 months, the company determines in inventory for the Epoxy Adhesive material, it cannot exceed the maximum level in the inventory.

Maximum Stock Level
Max = ROP + Minimum Stock Max = 10000 + 2000
Max = 12000 grams = 12 kg
Q = Maximum – Minimum
= 12000 – 2000
= 10000 grams = 10 kg

$$Frequency = \frac{12}{10}$$
$$= 1{,}2$$

Min-max total cost method

$$TC\ Min - Max = (1\ x\ 72) + \left(\left(\frac{10}{2}\right) + 2\right) x\ 50)$$
$$TC\ Min - max = 422$$

3) Minimum Maximum Stock (Min-Max) Low Adhesion Sealant

To ensure that there is no shortage during the lead time, the company will set a minimum stock or safety stock to prevent delayed deliveries and excess usage on average per month during the lead time. 2 months of usage is set to minimum stock, this is based on the Low Adhesion material expiration period of 6 months minus a 4-month lead time. The demand for a year is 20,000 grams/year, the demand for a

year is divided by 12 months to find out the demand for 1 month. Where the demand for 1 month is 2000 grams/month.

Minimum Stock Level taking into account the material expiration period Min = 1666 x 2 months

3332 grams = 3.332 kg

To find out the amount of inventory on hand at a time when an order must be held again. Depending on the lead time and demand during the lead time, the material Low Adhesion Sealant demand during the lead time is 4 months is 13.332 grams.

request during lead time

3332 x 4 months

13328 grams = 13.328 kg

Optimum order quantity for Low Adhesion Sealant material ROP = Minimum stock level + Demand During Lead Time

= 3332 grams + 13328 grams

= 16660 grams = 16.66 kg

Because the Low Adhesion material has a lifetime period, which is 6 months, the company sets the inventory for Low Adhesion material, it cannot exceed the maximum level in the inventory.

Maximum Stock Level

Max = ROP + Minimum Stock Max = 16660 + 3332

Max = 19992 grams = 19.992 kg

Q = Maximum – Minimum

= 19992 – 3332

= 16660 grams = 16.66 kg

$$Frequency = \frac{20}{116{,}66}$$

= 1,2 = 1 kali

$$TC\ Min - Max = (1\ x\ 86) + \left(\left(\frac{16{,}66}{2}\right) + 3{,}33\right) x\ 50)$$

$TC\ Min - max$ = €669

4) Minimum Maximum Stock (Min-Max) of Polysulfide Sealants

To ensure that there is no shortage during the lead time, the company will set a minimum stock or safety stock to prevent delayed deliveries and excess usage on average per month during the lead time. Use of 2 months is set to a minimum stock, this is based on the period of expiration of the Polysulfide Sealants material for 6 months minus the 4-month lead time. Demand for a year is 16,000 grams/year, demand for a year is divided

12 months to find out the demand for 1 month. Where the demand for 1 month is 1333 grams/month.

Minimum Stock Level taking into account the material's expired period

Min = 1333 x 2 months

= 2666 grams = 2.67 kg

To find out the amount of inventory on hand at a time when an order must be held again. Depending on the lead time and demand during the lead time, and the material Polysulfide Sealants demand during the lead time is 4 months is 10664 grams.

request during lead time

2666 x 4 months

10664 grams ≈ 10.664 kg

Optimum order quantity for Polysulfide Sealants material ROP = Minimum stock level + Demand During Lead Time

= 2666 grams + 10664 grams

= 13330 grams = 13.33 kg

Because the Polysulfide Sealants material has a lifetime period, which is 6 months, the company determines that the inventory for the Polysulfide Sealants material cannot exceed the maximum level in the inventory.

Maximum Stock Level

Max = ROP + Minimum Stock Max = 13330 + 2666

Max = 15996 grams = 15.996 kg

• Q = Maximum – Minimum

= 15996 – 2666

= 13330 grams = 13.33 kg

$$Frequency = \frac{16}{13,33}$$

$$= 1,2 \approx 1 \text{ Kali}$$

$$TC\ Min - Max = (1\ x\ 115) + \left(\left(\frac{13,33}{2}\right) + 2,67\right) x\ 50)$$

$$TC\ Min - max = €581,75$$

5) Minimum Maximum Stock (Min-Max) Conductive Sealant

To ensure that there is no shortage during the lead time, the company will set a minimum stock or safety stock to prevent delayed deliveries and excess usage on average per month during the lead time. 2 months of usage is set to minimum stock, this is based on a 6-month Conductive Sealant period minus a 4-month lead time. Demand for a year as much 10.00 gram/year, the demand for a year is divided by 12 months to find out the demand for 1 month. Where the demand for 1 month is 833 grams/month.

Minimum Stock Level taking into account the material's expired period

Min = 833 x 2 months

1666 gram = 1,666 kg

To find out the amount of inventory on hand at a time when an order must be held again. Depending on the lead time and demand during the lead time, and the material Conductive Sealant demand during the lead time is 4 months is 6664 grams.

request during lead time

1666 x 4 months

6664 grams = 6.664 kg

Optimum order quantity for Conductive Sealant ROP material = Minimum stock level + Demand During Lead Time

= 1666 grams + 6664 grams

= 8330 grams = 8.33 kg

Because the Conductive Sealant material has a lifetime period, i.e. for 6 months, the company sets the inventory for the Conductive Sealant material, it cannot exceed the maximum level in the inventory.

Maximum Stock Level

Max = ROP + Minimum Stock Max = 8330 + 1666

Max = 9996 grams = 9.996 kg

Q = Maximum – Minimum

= 9996 – 1660

= 8336 grams = 8.336 kg

$$Frequency = \frac{10}{34}$$

$$= 1,19 \approx 1 \text{ Kali}$$

$$TC\ Min - Max = (1\ x\ 137) + \left(\left(\frac{8,336}{2}\right) + 1,66\right) x\ 50)$$

$$TC\ Min - max = €428,4$$

ECONOMIC ORDER QUANTITY ANALYSIS

The results of calculating the number of raw materials ordered and the frequency can be seen in Table 1

Table 3. EOQ Calculation Results

Material Name	**Material Specification**	**Q**	***Frequency***
ELASTOMERIC ADHESIVE	*Z-15.101*	9,6	3
EPOXY ADHESIVE	*Z-15.201*	5,879	2
LOW ADHESION SEALANT	*Z-16.160*	8,295	2
POLYSULFIDE SEALANT	*Z-16.176*	8,579	2
CONDUCTIVE SEALANT	*Z-16.177*	7,403	1

From the results of calculating the number of raw materials and order frequency using the EOQ Elastomeric adhesive method, the amount ordered was 9.6 kg with an order frequency of 3 times in one period, the amount of epoxy adhesive ordered was 5.879 kg with an order frequency of 2 times in a year. one period, the ordered quantity of low adhesion sealant was 8.295 kg with an ordering frequency of 2 times in one period, the ordered quantity of polysulfide sealant was 8.579 kg with an ordering frequency of 2 times in one period, and the amount of conductive sealant ordered was 7.403 kg with an order frequency of 1 time in one period.

Minimum-Maximum Stock ANALYSIS

Table 4. Min-Max Calculation Results

Material Name	*Material Specification*	*Q*	*Frequency*
ELASTOMERIC ADHESIVE	Z-15.101	12	2
EPOXY ADHESIVE	Z-15.201	10	1
LOW ADHESION SEALANT	Z-16.160	16,66	1
POLYSULFIDE SEALANTS	Z-16.176	13,33	1
CONDUCTIVE SEALANT	Z-16.177	8,336	1

From the results of calculating the number of raw materials and the frequency of orders using the Min-Max method. For elastomeric adhesive the amount ordered is 12 kg with an order frequency of 2 times in one period, for epoxy adhesive the amount ordered is 10 kg with an order frequency of 1 time in a period, for low adhesive sealant the amount ordered is 16.66 kg with an order frequency of 1 time in one period, the amount of polysulfide sealant ordered was 13.33 kg with an order frequency of 1 time in one period, and the amount of conductive sealant ordered was 8.336 kg with an order frequency of 1 time in one period.

COMPARISON ANALYSIS

The magnitude of the savings in total inventory costs can be seen by calculating the total cost (TC), which is determined by the value of the number of raw materials ordered, ordering costs, and holding costs. Then it can be seen the comparison of the total cost of EOQ and Min-Max in Table 1 is as follows:

Table 5. Comparison of the total cost of EOQ and Mix-Max

Material Name	*Material Specification*	*Total cost*	
		EOQ	*Min-max*
ELASTOMERIC ADHESIVE	*Z-15.101*	€480	€692
EPOXY ADHESIVE	*Z-15.201*	€293,94	€422
LOW ADHESION SEALANT	*Z-16.160*	€414,73	€669
POLYSULFIDE SEALANTS	*Z-16.176*	€428,96	€581,75
CONDUCTIVE SEALANT	*Z-16.177*	€370,14	€428,4

Table 5 explains the difference in total inventory costs between the EOQ method and the Min-max method. From these calculations, it can be seen that the total cost of inventory that must be incurred by the company using the EOQ method is lower when compared to the total cost of inventory that must be issued by using the min-max method. This can happen because the material is ordered in a quantity that exceeds the quantity needed and results in high storage costs. In addition, in the company, if there is leftover material that has passed the expiration date, it cannot be used. So the company must place an order again for the next production.

Based on Table 5 the total inventory costs incurred by the company using the EOQ (Economic Order Quantity) method are obtained more efficiently. Where the total cost of supplies produced for elastomeric adhesive material is € 480, epoxy adhesive material is € 293.94, low adhesion sealant is € 414.73, polysulfide sealant is € 428.96, and conductive sealant is 370.14.

The total inventory costs incurred by the company using the Min-Max method (Minimum Stock-Maximum Stock) obtained the total inventory costs generated for elastomeric adhesive material is € 692, the epoxy adhesive material is € 422, low adhesion sealant is € 669, polysulfide sealant is €581.75, and conductive sealant is 428.4.

4 Conclusion

1. Comparison of the EOQ and Min-Max methods that have been carried out, the total cost of EOQ inventory is lower than the Min-Max method. This is because the total inventory cost incurred using the Min-Max method for elastomeric adhesive materials is € 692, epoxy adhesive materials is € 422, low adhesion sealant is € 669, polysulfide sealant is € 581.75, and conductive sealant is € 428.4 while the total inventory costs incurred by the company using the EOQ (Economic Order Quantity) method are the total inventory costs generated for elastomeric adhesive material is €480, the epoxy adhesive material is €293.94, low adhesion sealant is €414.73, polysulfide sealant is €428.96, and conductive sealant is €370.14.
2. The EOQ method has a lower level of risk than the Min-Max method because in this method, the company does not need a warehouse with a large capacity to store raw materials, and the company also does not spend a lot of funds on storage costs, the remaining raw materials have passed expired can also be minimized.
3. As a suggestion, the EOQ and Min Max methods are easy to apply in the procurement of non-metallic raw materials at PT. Dirgantara Indonesia. Thus, it can be used in planning the needs of non-metallic raw materials, so that there is no accumulation of non-metallic raw materials.

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