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Analysis of Supply Quantity Control of Argon Gas Raw Material at PT. XY

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Abstract

The background in this research is that there is no method used to manage and control the quantity of raw material supplies at PT XY. This situation causes problems in ordering raw materials so that ordering costs and costs for storage will not be optimal. The purpose of this study was to determine the effect of applying the EOQ method to the total cost of raw material inventory at PT. XY. Raw material inventory costs can be minimized by applying the EOQ (Economic Order Quantity) method. This method can show the economic order quantity, optimal purchase frequency, time to reorder/ROP (Re-Order Point), and the amount of safety stock. Data collection was carried out using documentation techniques related to observation inventory documents and interviews with several informants, for data analysis using EOQ by calculating total inventory cost, ROP, reorder frequency and safety stock. The results of calculations and data analysis using the EOQ method show that the total cost of inventory is lower than the company's actual method.

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1. Introduction

Argon gas is a gas that is quite popular among the steel fabrication industry. Argon gas is one of the supports in various activities in the industry. In the need for argon gas, the raw material itself is a vital tool for the company. So it needs to be provided on time. Because, this is necessary so that workers and the production process at the company are not hampered by problems that occur in the production and distribution of the gas vendor.

One of the problems that exist in this company is the lack of optimal determination of the quantity of inventory which causes stock outs or shortages of argon gas needs resulting in additional orders or Additional PO *(Purchase Order)*. Because this will hinder the process of making a product that is produced, so that the process cannot run effectively and efficiently and also has an impact on costs and waiting times for the required raw material requirements and also the occurrence of orders with a sufficiently high quantity, resulting in a buildup of inventory which makes storage costs very high and fraught with risks such as damage to gas leaks. Based on the data obtained, the following table can be seen:

Table 1.1 Data for 2018 to 2022

Period	Clean Needs	Order Quantity	Inventory
2018	6231	6x	5x *stock out*
2019	7853	4x	4x *stock out*
2020	2867	4x	4x *stock out*
2021	7331	5x	5x *stock out*
2022	7944	3x	3x *stock out*

(Source : PT. XY, 2018 to 2022)

In table 1.1 it can be seen that the company experienced a shortage of raw materials, causing the opening of a PO (Purchase Order) every year. In each period an order is placed with a very high quantity, causing a buildup in inventory storage. In 2018, 6 orders were made, with raw material supplies that experienced a shortage (stock out) 5 times a year. In 2019, 4 orders were made, with raw material supplies experiencing a shortage (stock out) 4 times a year. In 2020, orders were made 4 times, with raw material supplies experiencing a shortage (stock out) 4 times a year. In 2021, order raw materials 5 times, with raw material supplies that experience a shortage (stock out) 3 times a year. In 2022 place orders 3 times, with raw material supplies that experience a shortage (stock out) 3 times a year.

So to overcome the problems experienced by the company, the author will make an improvement to the determination of the quantity of inventory for raw material needs that are economical by using the EOQ (Economic Order Quantity) method. Basically this method is to find the most optimal answer to determine the number of orders, reorders (Reorder Point), the amount of safety reserves (Safety Stock). This is done to ensure that the amount of raw materials available does not experience a PO (Purchase Order) shortage or an excess of raw materials in inventory. With the EOQ method, companies can minimize ordering costs so that the quantity remains stable. Therefore, researchers will perform calculations to optimize inventory in 2023 to 2027.

2. Theoritical Review

2.1. Inventory

According to Aulia Ishak (2010) in (Suci Ramadhani, 2018) supplies are goods that have not been used because they are still waiting for further processing. If the

inventory quantity is too large (overstock), this will result in a risk of damage and also high storage costs. Conversely, if the inventory is in shortage (stockout). Thus, it will cause delays in the production process.

2.2. Forecasting

Forecasting is an estimate of the future by measuring current business conditions. According to Rusdiana (2014) forecasting is said to be the most basic way of making a company's production strategy. Meanwhile, Fahmi (2016) argues that forecasting is a form of business that applies several approaches.

2.3. Time Series Analysis

Time series analysis (Time Series) is data collected from time to time where the goal is to provide an overview in the future. From this analysis will produce a history that will be used as a reference in the next forecasting.

a. SMA (Single Moving Average) is forecasting by taking several values, then looking for the average of these values as forecasting in the future.
b. Linear Regression is forecasting which analyzes unknown data by using existing data.
c. The Single Exponential Smoothing Model is a type of forecasting that is included in the moving average category, where past data is still used.

Of the three types of forecasting models above, there is validation using several indicators as follows:

a. Mean Absolute Deviation (MAD) a calculation by averaging calculations from actual or absolute values.
b. Mean Square Error (MSE) a calculation that is squared from the MAD calculation results. The forecast value can be used as a reference for further forecasting.
c. Mean Absolute Percentage Error (MAPE) a value from the results of forecasting that has the lowest or smallest percentage weight is said to be valid or accurate.

2.4. *Economic Order Quantity* (EOQ)

According to Fahmi (2016) EOQ (Economic Order Quantity) is a calculation model that uses a mathematical model, where this method is for determining the optimal number of orders by minimizing the total cost of ordering and storage costs. There are several factors that must be met by the company, namely:

a. The number of requests is fairly constant
b. Have a base price in order to be able to do the calculations.
c. Other inventory costs must also be calculated in large or small purchases of raw material inventories. There are several costs, namely holding costs, ordering costs, inventory fixed costs, usage costs (Actual Demand), lead time, safety stock and reorder points.

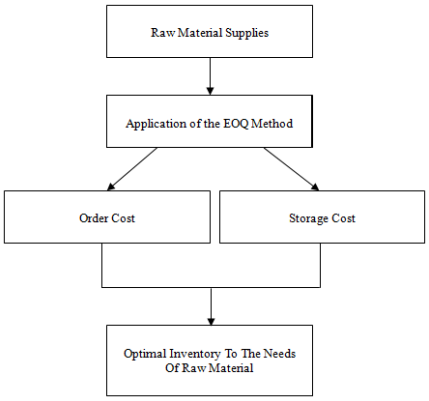

Figure 2.1 Framework

3. Research Methods

The method used by researchers is the Economic Order Quantity (EOQ) which can emphasize optimal inventory and minimize inventory costs. Data processing method used by researchers is qualitative. Data obtained by researchers through observation, interviews and company data from the period 2018 to 2022. The population of this study is raw material inventory at PT. XY.

3.1 Data Analysis Technique

According to Karyawati (2018) the data analysis method used is the Economic Order Quantity (EOQ) where this method can control raw material supplies to determine how many orders of raw materials are economical so that there are no shortages or excesses of raw materials.

a. Ordering Cost / Booking Cost

$$Ordering\ Cost = \frac{S}{f}$$

Information :
tS = Order cost per order
F = Order frequency per period

b. Storage Cost

$$Storage\ Cost = \frac{S}{D}$$

Information :
S = Cost of each order per period
D = Number of needs (units per year)

c. *Economic Order Quantity* (EOQ)

$$EOQ = \frac{\sqrt{2.d.s}}{h}$$

Information :
D = Number of needs (units per year)
S = Order cost per order
H = storage cost (unit per year)

d. Total Inventory Cost /TIC

$$TIC = \frac{D}{Q}\mathrm{S} + \frac{Q}{2}\mathrm{H}$$

Information :
D = Number of needs (units per year)
Q = Number of items per order
S = Order cost per order
H = storage cost (units per year)

e. Safety Stock

SS =(Usage Max – daily usage average)Lead Time

f. Re-Order Point

$$ROP = (\ LT\ x\ D\ ) + SS$$

Information :
ROP = Reorder Point
D = Number of needs (units per year)

L = Long waiting time (Lead Time)
SS =Safety stock

e. Frekuensi Pemesanan

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

Information :
D = Number of needs per unit time
Q = Number of items per order

4. Results And Discussion

4.1 Ordering Cost

Ordering costs are the cost of each purchase such as shipping costs, telephone costs, employee costs, and internet costs.

a. Shipping Cost
It is assumed that the company is IDR 500.000 per order.

b. Telephone Cost
It is assumed to be IDR 192/per 10 seconds. Ordering time takes 10 minutes per 1 message.

Total Call Cost = 60 (second) x 192
= 11.520 per order

a. Employee Costs
These costs arise because there is labor in preparing and sending letters and sending e-mails, as well as printing paper. The time used for all of the above activities is 30 minutes.

Salary	Rp. 4.350.000
Working hours 1 day	8 hours
number of months of work	22 days
Phone time, print and others	0.5 hours (30 second)

Employee Costs = $\frac{\text{Employee Salary}}{\text{Number of hours worked per month}}$
= $\frac{4.350.00}{176}$
= 12.358 per 30 minute / order

b. Internet Cost

Internet cost per month PT. XY IDR 60,000,000 and is subject to 5% for the warehouse of all internet fees.

Internet Cost = $\frac{5 \times 60.000.000 : 2}{100}$
= 1.500.000 per month
(In one month there are 2 purchase orders or orders)

From the calculation above, the results of the total cost of ordering can be seen as follows:

Table 4.1 Total Order Cost 2018 to 2022

Period	Order Cost (Rp)
2018	2.060.878 / per order
2019	2.060.878 / per order
2020	2.060.878 / per order
2021	2.048.520 / per order
2022	2.048.520 / per order

4.2 Storage Cost

These costs arise due to building rental costs, damage costs, employee costs, electricity costs.

a. Building Rental Fee
The land fee is IDR 138,000/M. the land used is 576 M2. It is assumed that the cost incurred by the company is 15% of the total cost

Land rebt = rent expense x land cost

$$= \frac{15 \times 138.000}{100}$$

= 20.700 / per month

b. Damage Costs

Costs incurred due to defects or damage during storage. The company has set a damage fee of IDR 561,000 / month.

c. Employee Costs

These costs arise due to the cost of labor in the warehouse department. The company has assumed 20% on the cost of storing argon gas.

Employee Costs= load percentage X salary

$$= \frac{20 \times 4.350.000}{100}$$

= 870.000 / per month

d. Electricity Costs

This fee is charged at IDR 750,000,000 per year and is assumed to be 1% of the company's costs.

Electricity Costs= Persen beban biaya x biaya listrik

$$= \frac{1 \times 750.000.000}{100}$$

= 7.500.000 / per month

The total cost of storing argon gas per year is described in the following table:

Table 4.2 Total Storage Cost 2018 to 2022

Period	Storage Cost (Rp)
2018	40.162 / Cylinder
2019	31.867 / Cylinder
2020	87.287 / Cylinder
2021	34.136 / Cylinder
2022	31.502 / Cylinder

The table above is a calculation of the cost of storing argon gas in a year. To get this value, all costs included in storage costs are added then multiplied by 12 months in one period and then divided by the number of needs per period.

Forecasting

Table 4.3 Forecasting 2023 to 2027

Year	Period	Sale Y	SMA *(Single Moving Average)*	SEM *(Single Exponential Smoothing Model)*	Regresi Linier
2023	January		794,0	801	727
	February		665	734,7	711
	March		648,3	698	695
	April		626,3	666,6	679
	May		605	642	663
	Juny		561,3	617	647
	July		573	573,6	631
	August		619,8	594,8	615
	September		591,8	609	599
	October		590	584,6	583
	November		619,8	602	567
	December		619,5	610,6	551
2024	January		729,5	722	681
	February		656,6	693,5	671
	March		637	670,9	661
	April		615,6	648,6	651
	May		583	626,8	641
	Juny		567	594	631
	July		596	583,5	621
	August		605,8	601,6	611
	September		590,9	596,7	601
	October		604,8	593	591
	November		618,8	606	581
	December		618,5	612	571

Year	Period	Sale Y	SMA *(Single Moving Average)*	SEM *(Single Exponential Smoothing Model)*	Regresi Linier
2025	January		693	680,5	654
	February		646,9	668,6	647
	March		626	652,9	641
	April		599	634	635
	May		575	608,7	628
	Juny		581,8	587,9	622
	July		601	592	615
	August		598	598,9	609
	September		597,8	594,9	603
	October		611,8	599,8	596
	November		618,4	609	590
	December		618	613,6	584
2026	January		670	656,8	635
	February		636,7	651,8	631
	March		612,9	639	628
	April		587	619	624
	May		578	597	620
	Juny		591	589,5	616
	July		599,7	595	612
	August		598	596,8	608
	September		604,8	597	604
	October		615	604,	600
	November		618,2	611,	597
	December		617,5	614,7	593
2027	January		653	641	622
	February		624,8	639	620
	March		600	626	618
	April		582,8	606,6	616
	May		584,9	592,5	614
	Juny		595,5	592	612
	July		598,9	595,8	610
	August		601	596,9	608
	September		609,9	600,9	606
	October		616,6	608	604
	November		617,9	613	602
	December		617,7	615	600

Recapitulation of Error Values and Discussion

Error value recapitulation is used to determine the validity of the method that has been used in demand forecasting. To see whether the above forecast is valid or not, you have to look for the error values of the three forecasting. MAD itself measures the accuracy of forecasting by averaging the estimated error, a smaller MAD error value indicates a better method used in a data. MSE itself has an average squared error between the actual value and the forecast value, while MAPE has a variety of values if it can be said to be good, if the percentage error value is smaller then the forecast is said to be good. The following are variations in MAPE values:

Table 4.4 MAPE Value Range

Range MAPE	Meaning
<10%	Forecasting is very good
10-20%	Forecasting is good
20-50%	Fortune telling
>50%	Bad forecast

Table 4.5 MAD Value Range

Range MAD	Meaning
76-100	Very high
75-51	Tall
50-26	Currently
25-0	Low

Table 4.6 MSE Value Range

Range MSE	Arti
>1000	Very high
510-750	Tall
500-260	Currently
250-0	Low

The results of the recapitulation of error values can be seen in the following table:

Table 4.7 Comparison Result Data Error Value Recapitulation

Error Analysis	Single Moving Average				
	2023	2024	2025	2026	2027
MAD	28(c)	16(l)	11(l)	8(l)	6(l)
MSE	1902(vh)	540(t)	205(l)	103(l)	64(l)
MAPE	4%(vg)	3%(vg)	2%(vg)	1%(vg)	1%(vg)
Error Analysis	Single Exponential Smoothing				
	2023	2024	2025	2026	2027
MAD	36(c)	21(l)	15(l)	11(l)	8(l)
MSE	2128(vh)	770(vh)	369(c)	216(l)	140(l)
MAPE	5%(vg)	3%(vg)	2%(vg)	2%(vg)	1%(vg)
Error Analysis	Regresi Linier				
	2023	2024	2025	2026	2027
MAD	56,9 (t)	35(c)	26(c)	22(l)	18,3(l)
MSE	5477(vh)	2158(vh)	1152(vh)	737(t)	500(c)
MAPE	8,5%(vg)	5,4%(vg)	4,2%(vg)	96,4%(bf)	3%(vg)

Table 4.8 Results of Data Taken for 2023 to 2027

Period	Single Moving Average				
	2023	2024	2025	2026	2027
January	794,0	729,5	693	670	653
February	665	656,6	646,9	636,7	624,8
March	648,3	637	626	612,9	600
April	626,3	615,6	599	587	582,8
May	605	583	575	578	584,9
Juny	561,3	567	581,8	591	595,5
July	573	596	601	599,7	598,9
August	619,8	605,8	598	598	601
September	591,8	590,9	597,8	604,8	609,9
October	590	604,8	611,8	615	616,6
November	619,5	618,8	618,4	618,2	617,6
December	619	618	618	617	617
Total	7513	7423	7366,7	7328,3	7302
MAD	6				
MSE	64				
MAPE	1%				

From the forecasting results above, the Single Moving Average method has the smallest error value with a MAD value of 6, MSE of 64 and MAPE of 1%. Thus it can be said that the Single Moving Average is the best method for forecasting the demand for Argon Gas at PT. XY.

When determining a good forecasting method, it is necessary to look at the magnitude of the error or error in the forecasting method. Whether the error value is valid or not is seen from the smaller the error value, the better the forecasting results.

4.3 Economic Order Quantity (EOQ)

According to Fahmi (2016) EOQ (Economic Order Quantity) is a calculation model that uses a mathematical model, where this method is for determining the optimal number of orders by minimizing the total cost of ordering and storage costs.

$$EOQ = \frac{\sqrt{2DS}}{H}$$

To calculate the EOQ value, it can be seen from the above cost values and the results of quantity forecasting. The following is the result of calculating the Economic Order Quantity for 2023 to 2027 as follows:

Example :

$$EOQ = \frac{\sqrt{2DS}}{H}$$
$$= \frac{\sqrt{2x7513x2.060.878}}{40.162}$$
$$= 878,1 \text{ per one order}$$

Table 4.9 EOQ Calculation Results 2023 to 2027

Period	EOQ (Unit)
2023	878,1 / per one order
2024	979,9 / per one order
2025	589,9 / per one order
2026	937,8 / per one order
2027	974,5 / per one order

Table 4.10 EOQ Calculation Results 2018 to 2022

Period	EOQ (Unit)
2018	6.394,7 / per one order
2019	10.157,26 / per one order
2020	13.538,2 / per one order
2021	8.798,7 / per one order
2022	1.048,2 / per one order

From the table above it can be seen that the results of the EOQ calculation function to determine the number of orders that are economical in each year 2023 to 2027 compared to 2018 to 2022. From 2018 to 2022 there is a shortage of inventory and are forced to make additional orders (Additional Orders) which are quite high, this will carries high costs and risks.

4.4 Total Inventory Cost (TIC)

Is a calculation that shows that the optimal purchase of raw materials, then calculated using EOQ then produces a minimum total cost of raw material inventory.

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

The following is the calculation of the total inventory cost for 2023 to 2027:

Example :

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

$$\mathrm{TC} = \frac{7531}{878}\ 2.060.878 + \frac{878}{2}\ 40.162$$

$$TC = 17.634.825 + 17.631.118$$

$$TC = \mathrm{Rp}\ 32.116.524$$

Table 4.11 Result Data on Total Inventory Costs for 2023 to 2027

Period	Total Cost Inventory (Rp)
2023	35.265.943 /year
2024	31.224.929/year
2025	51.481.983/year
2026	32.014.229/year
2027	30.699.064/year

Table 4.12 Result Data on Total Inventory Costs for 2018 to 2022

Period	Total Cost Inventory (Rp)
2018	33.223.476 /year
2019	39.522.021/year
2020	39.524.991/year
2021	35.267.702/year
2022	47.854.208/year

From the table above, the inventory costs incurred for economic orders or Economic Order Quantity in 2023 to 2027, the total TIC from the above data is IDR 180,686,148. If it is concluded that the actual cost used by the company is IDR 195,392,398, there is at least IDR 14,706,250 more economical than the company's method.

4.5 *Safety Stock*

In the case experienced, the company did not set a reserve inventory (safety stock). If Safety Stock is determined, it will protect the possibility of damage or shortage of raw materials (Stock Out). With this the researcher calculates

safety stock for the coming year, the company has set a Lead Time of 7 days per order. The following is the calculation for the 2023 to 2027 safety stock:

Safety Stock = (Maximum usage-(Average usage)) Lead Time

Example :

SS = (794 – 620) x 7
SS = 174 x 7
SS = 1.218 cylinder / month

Table 4.13 Safety Stock Result Data for 2023 to 2027

Period	Safety Stock (unit)
2023	1218 cylinder / month
2024	777 cylinder / month
2025	525 cylinder / month
2026	364 cylinder / month
2027	245 cylinder / month

To obtain maximum usage and average usage, it can be seen from the forecasting results or tables for 2023 to 2027. From the safety stock results above, companies can calculate Lead Time Demand with reference to the amount of net needs in 2023 to 2027 as follows :

LTD = (Lead Time x Average Usage)

Example :

Year 2023
LTD = 7 x 21 of (net requirement/number of days a year)
= 147 days

Table 4.14 Lead Time Result Data for 2023 to 2027

Period	*Lead Time*
2023	147 days
2024	140 days
2025	140 days
2026	140 days
2027	140 days

The results above show that the waiting time for 2023 to 2027 is when ordering raw materials until the arrival of these raw materials to the warehouse. In 2018 to 2022 there is no Lead Time calculation, this is what causes the inventory not to arrive on time because there is no calculation of when the goods will arrive at the warehouse. That way the order quantity is not stable.

4.6 Reorder Point

Reordering is a procurement of reordering if the condition of the warehouse already needs to be added by the company. Calculation of the reorder point for the average use of argon gas per day for 2023 21 cylinders, and for 2024 to 2027 20 cylinders with a lead time of 7 days. The following is the calculation for Reorder Points from 2023 to 2027:

RP = (LT x D) + SS

Example :

Year 2023
RP = (7x21) + 1218
= 147 + 1218
= 1365 Cylinders / Order

Table 4. 15 Reorder Point Results Data for 2023 to 2027

Period	*Reorder Point (unit)*
2023	1365 cylinder / order
2024	917 cylinder / order
2025	665 cylinder / order
2026	504 cylinder / order
2027	385 cylinder / order

In cases that occur, the company does not set a Re-order Point, so what happens is a stock out. In this case the researcher calculates the Re-order Point so that the raw materials in the warehouse are added to the inventory before running out. That way inventory does not run out of raw materials (Stock Out) prematurely.

4.7 Order Frequency

The order frequency itself is the ideal number of purchases, which are made in one period to minimize inventory costs. Whereas it is known that the amount of Argon Gas Demand is 2023 7513 Cylinder, 2024 7423 Cylinder, 2025 7368 Cylinder, 2026 7328 Cylinder, 2027 7302 Cylinder and the number of orders using the Economic Order Quantity (Q) method is 2023 878 cylinder , Year 2024 980 cylinders, Year 2025 590 cylinders, Year 2026 938 cylinders, Year 2027 975 cylinders. The following is the calculation of the frequency of orders from 2023 to 2027:

$$f = \frac{Q}{D}$$

Example :

Year 2023

$$f = \frac{7513}{878}$$

$$= 8.557 \text{ Frequency / Year}$$

Table 4.16 Data on Order Frequency Results for 2023 to 2027

Period	Order Frequency(unit)
2023	8,557 Frequency / year
2024	7,793 Frequency / year
2025	12,49 Frequency / year
226	7.831 Frequency / year
2027	7,489 Frequency / year

When compared with the previous actual data in 2018 6 times, 2019 4 times, 2020 4 times, 2021 5 times and 2022 3 times. from that year there is a shortage of raw material supplies so that when ordering there will be an increase in the quantity of orders so that costs and risks will also be high, then with the Economic Order Quantity method, the frequency of each order has been calculated and the results are for 2023 9 times, 2024 8 times, 2025 12 times, 2026 8 times and 2027 7 times a year.

Table 4.17 Comparison Of How The Company With The Economic Order Quantity Method

No	Information	Inventory Quantity	Total Inventory	Safety Stock	Reorder Point	Order Frequency
1	Company Data 2018	1039	Rp33.223.476	-	-	6
2	Company Data 2019	1963	Rp39.522.021	-	-	4
3	Company Data 2020	717	Rp39.524.991	-	-	4
4	Company Data 2021	1.466	Rp35.267.702	-	-	5
5	Company Data 2022	2.648	Rp47.854.208	-	-	3
6	EOQ 2023 results	878	Rp35.265.943	1.218	1365	9
7	EOQ 2024 results	980	Rp31.224.929	777	917	8
8	EOQ 2025 results	590	Rp51.481.648	525	665	12
9	EOQ 2026 results	938	Rp32.014.229	364	504	8
10	EOQ 2027 results	975	Rp30.699.064	245	385	7

5. Conclusions And Recommendations

5.1 Conclusions

In accordance with the research objective is to determine the optimal

supply of raw materials by using the Economic Order Quantity method so as not to experience a shortage of inventory (stock out) so as not to cause orders with a very high quantity in each period.

The results of using the Economic Order Quantity method for 2023 to 2027 in determining optimal inventory have a total inventory cost value of IDR 180,686,148, Safety Stock of 3,129 and Reorder Point of 3,836. Meanwhile, company data for 2018 to 2022 shows the total cost of inventory (TIC) of IDR 195,392,398 and does not have Safety Stock and Re-Order Points.

If it is concluded with the company's actual costs, the total inventory cost (TIC) with the Economic Order Quantity method is Rp. 14,706,250 more efficient. This is tested by forecasting which shows the smallest error value with a MAD value of 6, MSE of 64 and MAPE of 1%. Thus it can be said that the Single Moving Average forecasting is good for predicting the demand for Argon Gas quantity at PT. XY.

5.2 Recommendations

Based on the results of the conclusions that have been put forward, the researcher provides input to the company to review the regulations or policies for supplying raw materials that have been implemented by the company. Input from researchers for companies should try the Economic Order Quantity (EOQ) method in optimizing the quantity of argon gas so that supplies are managed so that expenses can be minimized. And for further research, it is possible to complete the Economic Order by using software such as POM (Production and Operations Management) to calculate inventory costs.

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