



## **Analysis of Chemical Inventory Control in the GGCP Unit Using Forecasting and EOQ Methods at PT. XYZ**

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**Abstract.** PT. XYZ is a company operating in the energy producing industry. Which has 2 types of products, steam power and electricity. Steam in GGCP contains 3 chemicals, namely Amine, phosphate, oxygen scavenger. However, this company experienced an accumulation of excessive chemical stocks and reduced chemical consumption. This research aims to determine the number of company orders and determine overall inventory costs using forecasting methods and economical order quantities. In calculating the Total Inventory Cost (TIC) results, there is a significant calculation where TIC EOQ has an economical cost for Amine chemicals of IDR. 15,879,937 while the company's TIC is IDR. 36,226,539. with forecast results for Amine chemicals of 4148/ltr, phosphate of 3061/ltr, and scavenger oxygen of 5450/ltr. Meanwhile, the EOQ calculation results obtained a value for Amine chemicals of 1361/ltr, phosphate of 1164/ltr and 1554/ltr for oxygen scavenger chemicals.

**Keywords:** Inventory Control, Forecasting, EOQ, Chemicals

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### **1. Introduction**

In the current era of development, more and more industries are developing in Indonesia which require support or encouragement from disciplined management to be able to compete in the industrial world. Where many factors become a reference in a business, one of which is a warehouse layout that is less effective and efficient[1]. A warehouse is a temporary storage place for raw materials, process materials and finished materials[2]. If you just arrange it without designing a good warehouse layout, you will experience difficulties in the operational process of an industry. Good warehouse management can minimize costs, time and energy. Every business organization has an inventory planning and management system. Banks have measures in place to manage their cash inventories. Hospitals have ways to manage blood and medication supplies. Authorities, schools, and of course almost everyone. Manufacturing and production organizations handle inventory planning and management[3].

Inventory control is a very important managerial function, because inventory involves the largest rupiah investment in current assets. Apart from that, if there is excessive inventory in the warehouse, it



will cause the risk of loss and damage to goods to be greater. However, if the company does not have sufficient inventory, it can result in increased costs caused by a shortage of raw materials[4]. Raw materials are a top priority and very vital for an industry in its production process[5]. This makes many companies use various methods to manage raw material inventories[6]. The function of inventory for a company is to be able to provide products optimally, smooth production and also minimize or avoid shortages of raw materials[7]. Forecasting is the process of forecasting a variable (event) in the future based on variable data in the previous period[8].

PT. XZY is a company operating in the energy producing industry. This company has 2 types of products, namely steam and electric power. Steam in GGCP with chemicals Amine, phosphate, oxygen scavenger is pressurized water vapor intended for cooling the ammonia reformer and driving the generator turbine while electric power is electrical energy that is generated or produced from electric power generation facilities for internal and external purposes, in the form of gas turbines. Generator (GTG). However, there are several chemicals that experience a buildup of chemical stocks due to excessive purchasing and lack of chemical consumption, lack of chemical stocks, and difficult to predict future production numbers. This condition will result in the company being unable to maintain product quality and the company's costs will only focus on storing chemical materials.

Given these conditions, companies need appropriate raw material inventory management with more efficient inventory costs[9]. The methods used to help control raw materials are Forecasting which is a forecasting method to find out future values based on past data and Economic Order Quantity is a method which can minimize total inventory costs and optimal purchases. This method was chosen because this company experienced a buildup of stock caused by excessive purchases where forecasting was also needed to determine the amount of raw materials that needed to be ordered in the next period. So this research aims to determine the number of company orders and determine minimal overall inventory costs.

## 2. Methods

Data collection was carried out by observation and direct interviews with raw material control management. The data used are storage cost data, ordering cost data, chemical consumption data, and chemical stock availability data. There are 3 chemicals taken, namely Amine, phosphate, and oxygen scavenger. By using 2 methods, namely forecasting with processing predictions calculating single exponential smoothing and double exponential smoothing and EOQ.

### 2.1. Forecasting

It is a prediction of some event or many events that will come. Forecasting or forecasting is also called a very efficient and effective tool[10]. Or interpreted as a form of effort to predict future conditions through testing in the past. This method helps to determine the number of future sales of goods[11].

### 2.2. Single Exponential Smoothing

Used as a short distance estimate. The model assumes that the data fluctuates around a fairly stable average range[12]. The following is the formula for the single exponential smoothing method[13] that is :

$$Y'_{t+1} = \alpha \cdot T_t + (1 - \alpha) \cdot Y'_t \quad (1)$$

Information :

Nr = demand data in period t  
 $\alpha$  = smoothing factor/ constant  
 $Y'_{t+1}$  = forecast for period t

### 2.3. Double Exponential Smoothing

This method is used when the data shows a trend. Exponential smoothing with a trend is like simple smoothing except that two components must be updated every period – the level and the trend. Levels are smoothed estimates of the data values at the end of each period. Trend is a smoothed estimate of average growth at the end of each period[14].

### 2.4. Economic Order Quantity

It is a method of inventory management with efficient inventory purchasing control techniques by minimizing the total cost of ordering and storage costs[15]. The formula used in solving problems using the EOQ method is:[16]that is :

- Calculation of the optimal order level

$$Q = \sqrt{\frac{2.D.S}{H}} \quad (2)$$

- Safety stock calculation

$$SS = Z \times \alpha \quad (3)$$

- Calculation of purchase frequency

$$F = \frac{D}{Q} \quad (4)$$

- Re-order point calculation

$$ROP = (D \times L) + SS \quad (5)$$

- Calculation of total inventory costs

$$TIC = \left( + \left( \frac{D}{Q} \times S \right) \frac{Q}{2} \times H \right) \quad (6)$$

Information :

- Q = Optimum number of units per order (EOQ)
- D = Number of requests for a period
- S = Ordering costfor each order
- H = Storage costs per unit per year
- SS = is a safety stock.
- Z = is the normal standard deviation (standard level).
- A = is the standard deviation of the level of need
- ROP =is the reorder point
- L = is the lead time or waiting time.

## 3. Results and Discussion

Data collection

The data collection process was carried out by means of interviews and direct observation, the following data were obtained:

- a. Chemical demand data for 1 year

**Table 1.** Chemical demand 1 year

Month	Demand (Liters)		
	Amine	Phosphates	Oxygen scavenger
Jan	225	225	225
Feb	375	375	375
Mar	450	450	450
Apr	675	675	675

<b>May</b>	450	450	450
<b>Jun</b>	400	400	400
<b>Jul</b>	250	250	250
<b>Aug</b>	500	500	500
<b>Sept</b>	125	125	125
<b>Oct</b>	425	425	425
<b>Nov</b>	350	350	350
<b>DES</b>	675	675	675
<b>Total</b>	<b>4900</b>	<b>3450</b>	<b>5700</b>

(Source: Company data)

b. Lead time data

*Lead time* is the time interval between ordering a product until the product is received. This data is used to determine the right time to place an order for the product so that the product arrives at the right time.

**Table 2.** Chemical lead time data

<b>No.</b>	<b>Chemical material</b>	<b>Lead time(Sunday)</b>
<b>1</b>	Amine	<b>3</b>
<b>2</b>	Phosphate	<b>3</b>
<b>3</b>	<b>Oxygen Scavanger</b>	<b>3</b>

(Source: Company data)

c. Holding cost data

Carrying costs are the costs incurred by a company to store a product for a certain time before the product is released due to demand.

**Table 3.** Holding costs

	<b>Electricity cost</b>	<b>Total</b>
<b>air conditioning</b>	Rp. 311,904	Rp. 500,201
<b>Lamps (3)</b>	Rp. 124,761	
<b>Computer</b>	Rp. 63,536	
	<b>Labor costs</b>	
<b>Warehouse staff</b>	Rp. 6,750,000	Rp. 11,350,000
<b>Security guard</b>	Rp. 4,600,000	
	<b>Maintenance costs</b>	
<b>Maintenance costs</b>	Rp. 490,000	Rp. 490,000
	<b>Total costs in 1 month</b>	<b>Rp. 12,340,201</b>
	<b>Total costs in 1 year (12 months)</b>	<b>Rp. 148,082,412</b>

(Source: Company data)

Because there is only 1 chemical supplier, the calculation of holding cost per liter is directly based on each chemical. Holding cost/chemical formula = (Total cost x percentage (chemical))/D.

Example of Amine holding costs

$$= (\text{Rp. } 148,082,412 \times 32.96\%) / 4184$$

$$= \text{Rp. } 48,804,790/\text{yr}$$

For further chemicals, see the following table.

**Table 4.** Chemical holding cost data

<b>Chemical material</b>	<b>Demand Chemicals 1 year (Liter)</b>	<b>Percentage</b>	<b> Holding costs (Rupiah)</b>
Amine	4184	32.96%	Rp. 11,664
Phosphate	3061	24.11%	
Oxygen scavenger	5450	42.93%	
<b>Total</b>	<b>12695</b>	<b>100%</b>	

(Source: Company data)

d. Message cost data

These costs are costs incurred for goods ordering activities, starting from ordering until the goods are available.

**Table 5.** Message fees

	<b>Electricity cost</b>	<b>Total</b>
<b>air conditioning</b>	Rp. 311,904	Rp. 375,440
<b>Computer</b>	Rp. 63,536	
	<b>Labor costs</b>	
<b>Warehouse staff</b>	Rp. 6,750,000	Rp. 6,750,000
	<b>Internet costs</b>	
<b>Internet costs 100 mbps</b>	Rp. 625,000	Rp. 625,000
	<b>Total costs in 1 month</b>	<b>Rp. 7,750,440</b>

(Source: Company data)

Because the chemical supplier only has 1 partner, the ordering cost calculation directly looks for each jerry can. The ordering cost formula for each jerry can = total cost / amount of chemicals  
 = Rp. 7,750,440/3  
 = Rp. 2,583,480/ltr

**Data processing**

**Forecasting calculations**

This experimental method is used to determine the demand for chemicals in the next year. Where forecasting techniques are used to determine the size of demand which is very close to the actual value. This research uses two methods, namely single exponential smoothing (Single Exponential Smoothing) and double exponential smoothing (Double Exponential Smoothing). The following is the processing of requests for chemicals (Amine, phosphate, oxygen scavenger) using the Single Exponential Smoothing method  $\alpha = 0.3$ .

**Table 6.** Calculation of Amine error using the Single Exponential Smoothing method

<b>Period</b>	<b>Demand</b>	<b>Single exponential smoothing</b>				
		<b>Forecast</b>	<b>Error</b>	<b> e </b>	<b>(e<sup>^2</sup>)</b>	<b> e/At x100%</b>
<b>1</b>	225					
<b>2</b>	375	4	-371	150.00	22500.00	40.00%
<b>3</b>	450	-107.3	-557.3	105.00	11025.00	23.33%
<b>4</b>	675	-274.49	-949.49	246.00	60516.00	36.44%
<b>5</b>	450	-559,337	-1009.34	175.80	30905.64	39.07%

<b>6</b>	400	-862.138	-1262.14	85.16	7252.23	21.29%
<b>7</b>	250	-1240.78	-1490.78	167.03	27899.69	66.81%
<b>8</b>	500	-1688.01	-2188.01	216.59	46912.79	43.32%
<b>9</b>	125	-2344.42	-2469.42	331.68	110012.47	265.35%
<b>10</b>	425	-3085.24	-3510.24	233.66	54598.75	54.98%
<b>11</b>	350	-4138.32	-4488.32	28.27	799.04	8.08%
<b>12</b>	675	-5484.81	-6159.81	319.35	101982.22	47.31%
<b>Total</b>	4900	-19780.8	-24455.8	2058.54	474403.82	<b>645.98%</b>
			89.50193	20626.25		28.09%
			<b>MAD</b>	<b>MSE</b>		<b>MAPE</b>

**Table 7.** Calculation of Amine error using the Double Exponential Smoothing method

Period	Demand	Double exponential smoothing						
		ICE	Trends	Forecast	Error	e	(e <sup>2</sup> )	e/At x100%
<b>1</b>	225							
<b>2</b>	375	225	0	225	150	150	22500	40.00%
<b>3</b>	450	270	9	279	171	171	29241	38.00%
<b>4</b>	675	330.3	17.46	347.76	327.24	327.24	107086	48.48%
<b>5</b>	450	445,932	33.6024	479.5344	-29.5344	29.5344	872.2808	6.56%
<b>6</b>	400	470.6741	25.10986	495.7839	-95.7839	95.78394	9174.562	23.95%
<b>7</b>	250	467.0488	14.34085	481.3896	-231.39	231.3896	53541.15	92.56%
<b>8</b>	500	411.9727	-2.4107	409,562	90.43797	90.43797	8179.027	18.09%
<b>9</b>	125	436.6934	3.497721	440.1911	-315,191	315.1911	99345.45	252.15%
<b>10</b>	425	345.6338	-16.1133	329.5205	95.47949	95.47949	9116.334	22.47%
<b>11</b>	350	358.1644	-7.16186	351.0025	-1.00249	1.00249	1.004986	0.29%
<b>12</b>	675	350.7017	-5.78964	344.9121	330.0879	330.0879	108958	48.90%
<b>Total</b>	4900	4112.121	71.53533	4183.656	491.3438	1837.147	448014.8	<b>591.44%</b>
					44.67	167.01		53.77%
					<b>MAD</b>	<b>MSE</b>		<b>MAPE</b>

**Table 8.** Calculation of MAD, MSE, MAPE for Phosphate chemicals

METHOD	MAD	MSE	MAPE
<b>SINGLE ES</b>	57.43	9441.33	23.13%
<b>DOUBLE ES</b>	14.90	106.34	46.78%

**Table 9.** MAD, MSE, MAPE results for oxygen scavenger chemicals

METHOD	MAD	MSE	MAPE
<b>SINGLE ES</b>	81.37	20295.02	26.88%
<b>DOUBLE ES</b>	-20.45	151.32	50.74%

Based on the calculations in tables 6, 7, 8, and 9, it can be concluded that the forecasting results using the double exponential smoothing method are better than the single exponential smoothing method. This is proven by the MAD value of the double exponential smoothing method being smaller than the single exponential smoothing method. Where the MAD value of double exponential smoothing for Amine chemicals is 44.67, phosphate is 14.90, and oxygen scavenger is -20.45. Meanwhile, single exponential smoothing for Amine chemicals was 89.50, phosphate was 57.43, and oxygen scavenger was 81.37. So companies can use the double exponential smoothing method to be able to predict demand for three chemicals in the future.

### EOQ (Economic Order Quantity) Calculation

After forecasting demand, the next stage in this research is calculating the optimal order quantity using the EOQ method. The following is the data needed for this calculation, namely:

D = Demand Amine = 4184, phosphate = 3061, oxygen scavenger = 5450

S = Order Cost Rp. 2,583,480

H = Storage costs Rp. 11,664

L = Lead time 3 weeks

So the settlement of chemicals based on the EOQ method can be completed as follows:

$$Q_{\text{Amine}} = \sqrt{\frac{2 \cdot D \cdot S}{H}} = \sqrt{\frac{2 \times 4184 \times 2.583.480}{11.664}} = 1361$$

$$Q_{\text{phosphate}} = \sqrt{\frac{2 \cdot D \cdot S}{H}} = \sqrt{\frac{2 \times 3061 \times 2.583.480}{11.664}} = 1164$$

$$Q_{\text{oxygen scavenger}} = \sqrt{\frac{2 \cdot D \cdot S}{H}} = \sqrt{\frac{2 \times 5450 \times 2.583.480}{11.664}} = 1554$$

So, The optimal frequency of ordering chemicals that needs to be made by the company based on the EOQ calculation for one Amine order is 1361/ltr, phosphate is 1164/ltr, and oxygen scavenger is 1554/ltr.

### Safety Stock Calculation

*Safety stock* is the company's ability to create inventory conditions that are always safe or full of security with the hope that the company will never experience a shortage of inventory. The following is a calculation of safety stock for chemicals. The following is the calculation:

Amine chemicals  $SS = z \cdot x \cdot \sigma = 1645 \times 1107 = 1821$  ltr

Phosphate chemicals  $SS = z \cdot x \cdot \sigma = 1645 \times 810 = 1332$  ltr

Oxygen scavenger chemicals  $SS = z \cdot x \cdot \sigma = 1645 \times 1442 = 2372$  ltr

So, with a standard deviation of 1645, the chemical safety stock that the company needs to have is Amine of 1821/ltr, phosphate 1332/ltr, and oxygen scavenger of 2372/ltr.

### Purchase Frequency Calculation

The optimal frequency of purchasing chemicals can be solved by calculating as follows:

Amine chemicals  $F = \frac{D}{Q} = \frac{4184}{1361} = 3,07 \approx 3$

Phosphate chemicals  $F = \frac{D}{Q} = \frac{3061}{1164} = 2,62 \approx 3$

Oxygen scavenger chemicals  $F = \frac{D}{Q} = \frac{5450}{1554} = 3,50 \approx 4$

So, The optimal frequency of chemical purchases that companies need to make is Amine 3 times, phosphate 3 times, while oxygen scavenger 4 times a year.

### Re-Order Point Calculation

If it is assumed that the company has 52 weeks to work, then to obtain an accurate reorder point size it can be completed as follows:

- a. Calculating average monthly demand:

$$\text{Amine} = d = \frac{D}{n} = \frac{4184}{12} = 348,66 \approx 349$$

$$\text{Phosphates} = d = \frac{D}{n} = \frac{3061}{12} = 255,08 \approx 255$$

$$\text{Oxygen scavenger} = d = \frac{D}{n} = \frac{5450}{12} = 454,16 \approx 454$$

- b. Lead timebooking: 3 weeks

- c. Calculating ROP

$$\text{Amine} = \text{ROP} = d \times L + \text{SS} = 349 \times 3 + 1821 = 2867$$

$$\text{Phosphates} = \text{ROP} = d \times L + \text{SS} = 255 \times 3 + 1332 = 2098$$

$$\text{Oxygen scavenger} = \text{ROP} = d \times L + \text{SS} = 454 \times 3 + 2372 = 3735$$

So, Based on the results of the ROP calculation, the company needs to reorder chemicals if the inventory has reached an Amine inventory quantity of 2867/ltr, phosphate of 2098/ltr, oxygen scavenger of 3735/ltr.

### Calculation of Total Inventory Cost (TIC)

TIC here aims to prove that if there is an optimal amount of raw material purchases, which is calculated using the EOQ method, it will be achieved if the total cost of raw material inventory is minimal. The following is the TIC calculation for chemicals as follows:

$$\begin{aligned} \text{TIC EOQ Amine} &= \left( \frac{D}{Q} \times S \right) + \left( \frac{Q}{2} \times H \right) \\ &= \left( \frac{4184}{1361} \times 2.583.480 \right) + \left( \frac{1361}{2} \times 11.664 \right) \\ &= \text{Rp. } 15,879,937 \end{aligned}$$

$$\text{Phosphates} = \text{Rp. } 13,582,653$$

$$\text{Oxygen scavenger} = \text{Rp. } 18,123,880$$

$$\text{Total} = \text{Rp. } \mathbf{47,586,478}$$

So, The TIC from the EOQ calculation that must be paid by the Amine chemical company is IDR. 15,879,937, phosphaste of Rp. 13,582,653, and oxygen scavenger Rp. 18,123,880/year. With a total of Rp. 47,586,478/year. Meanwhile, TIC issued based on company policy can be calculated as follows:

$$\begin{aligned} \text{TIC Amine company} &= 5,224,780 + (2,583,480 \times 12) \\ &= \text{Rp. } 36,226,539 \end{aligned}$$

$$\text{Phosphates} = \text{Rp. } 34,476,846$$

$$\text{Oxygen scavenger} = \text{Rp. } 37,247,194$$

$$\text{Total} = \text{Rp. } \mathbf{107,950,579}$$



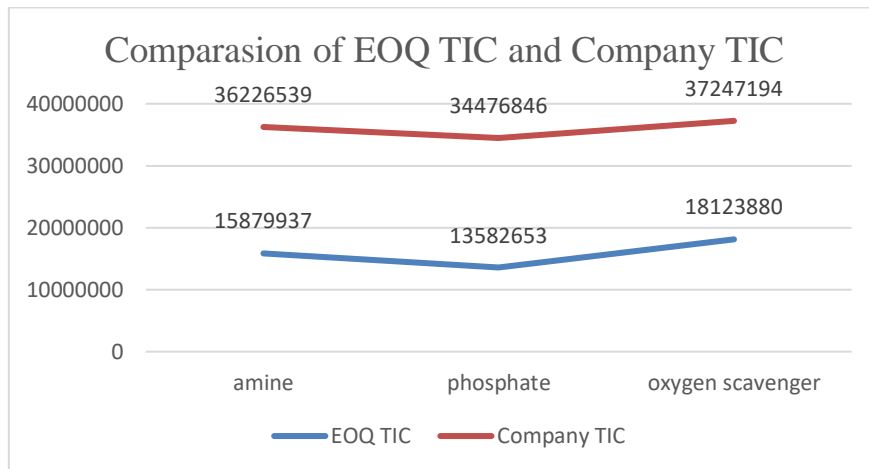


Figure 1. Comparasion TIC

So, based on company policy where chemical orders are made every month, the costs that will be incurred are Rp. 36,226,539, phosphate Rp. 34,476,846, and oxygen scavenger Rp. 37,247,194/year. With a total of Rp. 107,950,579.

#### 4. Conclusion

Based on the results of research using the forecasting and EOQ methods, it was concluded that the forecasting and EOQ methods were more precise and optimal than the company's. This research has forecast results for demand for Amine chemicals of 4184/ltr with the best MAD test result of 44.67. The optimal purchase frequency is 1361/ltr with 3 purchases a year. Orders can be made if the Amine inventory level has reached ROP at 2867/ltr. ltr, and the company gets a safety stock size of 1821/ltr. After that, the phosphate chemical has a forecasting result of 3061/ltr, with the best MAD test result of 14.90. The optimal purchase frequency is 1361/ltr with 3 purchases a year. Orders can be made if the phosphate inventory level has reached the ROP in 2098. /ltr, and the company gets a safety stock size of 1332/ltr. And the chemical oxygen scavenger is 5450/ltr with the best MAD test result of -20.45. The optimal purchase frequency is 1554/ltr with 4 purchases a year. Orders can be made if the oxygen scavenger inventory level has reached ROP at 3735/ltr. and the company got a safety stock size of 2372/ltr. The TIC calculation also produces results for 3 chemicals where the TIC EOQ gets a value of Rp. 47,586,478/year Meanwhile, the TIC issued based on company policy is IDR. 107,950,579. So that an economic value is obtained when calculating TIC using the EOQ method.

This research has limitations in the methods taken, because both methods have the same similarities and shortcomings. In future research, it is hoped that the data samples will be taken over one year and can represent the data needed. Apart from that, further research can use or choose other methods to determine accurate total inventory costs

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