Application of the Economic Order Quantity (EOQ) Method on the Supply of Chemical Materials in the Laboratory of PT. Fajar Surya Wisesa Tbk

Ririn Saputro[1]; Adi Fitra[2]; Susan Kustiwan[3]
Industrial Engineering Study Program, Faculty of Engineering, Pelita Bangsa University
Jl. Kalimalang Inspection No.9 Cibatu, Bekasi, 17530

Abstract:- The chemical inventory management at the Waste Water Treatment Plant (WWTP) Laboratory of PT. Fajar Surya Wisesa Tbk faces challenges in determining the optimal order quantity, ideal reorder time, and appropriate Safety Stock (SS) to minimize ordering and storage costs. This research aims to provide solutions using the Economic Order Quantity (EOQ) method to determine the optimal order quantity, Reorder Point (ROP) calculations to determine the reorder time, and Safety Stock (SS) calculations to maintain the availability of chemical supplies. The research method used is a quantitative method with a descriptive approach. Data is processed using POM for Windows (POM QM) software to calculate EOQ, ROP, and SS. The research results show that using the EOQ method, PT. Fajar Surya Wisesa Tbk can determine the optimal order quantity for each type of chemical. For example, the optimal order quantity for Ammonia Nitrogen is 3 boxes with a total annual cost of Rp 150,525,100. The ROP calculation for Sulfate is 2 boxes, while the SS for Water Hardness is determined to be 1 box. The conclusion of this research is that by applying the EOQ, ROP, and SS methods, PT. Fajar Surya Wisesa Tbk can optimize the chemical inventory management in the WWTP laboratory. This method helps minimize total inventory costs and ensures the availability of chemical supplies for smooth operations. The research recommends the company adopt a more integrated inventory management system and utilize information technology for real-time inventory monitoring, thereby increasing operational efficiency and minimizing the risk of operational disruptions due to inventory shortages.

Keywords:- *Optimization of Chemical Inventory, WWTP Laboratory, Economic Order Quantity (EOQ), Reorder Point (ROP), Safety Stock (SS).*

I. INTRODUCTION

The industry in Indonesia are rapidly growing, leading to diverse industrial waste types that can potentially harm the environment and public health if not managed properly. According to Minister of Public Works Regulation No. 6 of 2011 on the management of water resources, large water users, hotels, restaurants, hospitals, and industries are required to recycle wastewater by establishing recycling installations. PT Fajar Surya Wisesa Tbk (Fajar Paper), one of Indonesia's leading packaging paper producers with an annual installed production capacity exceeding 1.5 million tons, ensures environmental management and monitoring in compliance with government regulations and environmental permits. Their wastewater treatment process is handled by the WWTP department using an anaerobic system, which processes various industrial waste streams from sectors like agriculture, food and beverage, dairy, pulp and paper, textiles, municipal sludge, wastewater, and others [20].

However, observations in the WWTP department's laboratory at PT Fajar Surya Wisesa Tbk revealed inefficiencies in managing chemical inventory, specifically reagents. Problems include excessive inventory and expired materials before use, as depicted in Figure 1. Excess inventory not only affects the quality of stored materials over time but also increases the risk of material expiration, leading to costly waste management issues [2]. To address these issues and ensure optimal inventory levels, an effective inventory management system is crucial.

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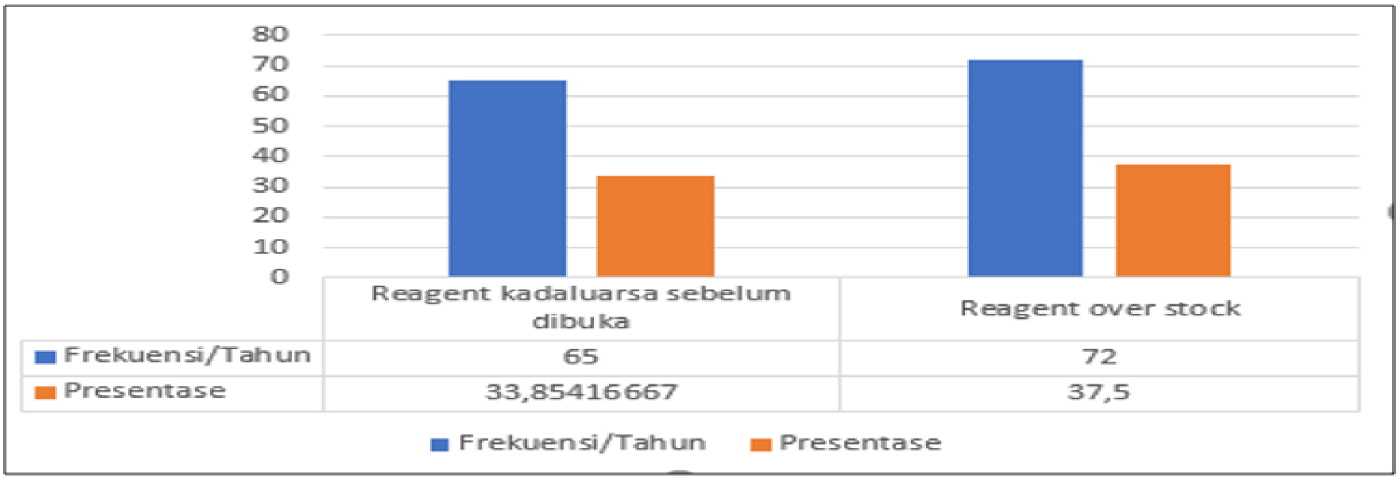

Fig 1 Graph of Reagent Inventory Problems in 2023

Research by Devi Nala Ratih & Sunu Priyawan (2023) on the implementation of the Economic Order Quantity (EOQ) method at PT Sucofindo Surabaya highlighted its effectiveness in optimizing chemical inventory management. Another study by Khariidatul Bahiyyah (2020) on chemical inventory control using EOQ and Reorder Point (ROP) calculations at a water utility in Cimahi demonstrated cost savings in storage and total inventory costs. Based on these studies, applying the EOQ method at PT Fajar Surya Wisesa Tbk's WWTP laboratory can potentially minimize storage costs and optimize inventory levels.

In essence, effective procurement planning and control aim to minimize costs and maximize profitability. Implementing the EOQ analysis, as suggested [19], in chemical inventory management at the WWTP department of PT Fajar Surya Wisesa Tbk is expected to enhance inventory management practices and optimize chemical inventory within the company.

II. LITERATURE REVIEW

- *Company Profile*

PT Fajar Surya Wisesa Tbk (FajarPaper) stands as a leading producer of packaging paper in Indonesia, renowned for its extensive production capacity exceeding 1.5 million tons annually. The company's product line includes Kraft Liner Board (KLB) and Corrugated Medium Paper (CMP), utilized as raw materials for manufacturing packaging boxes such as cardboard boxes. Additionally, they produce Coated Duplex Board (CDB), used for display packaging. Established as a limited liability company on February 29, 1988, FajarPaper later transitioned to a publicly listed company on the Jakarta Stock Exchange on December 19, 1994 (FASW.JK). FajarPaper is recognized for its forward-thinking approach, emphasizing energy conservation and environmental stewardship. All products are crafted from 100% recycled paper, and the company meets its energy needs through its own power generation facilities.

As of March 31, 2023, major shareholders holding 5% or more of Fajar Surya Wisesa Tbk include SCGP Solutions (Singapore) Pte., Ltd. with a stake of 55.23%, and PT Intercipta Sempana with 44.48%. SCGP Solutions (Singapore) Pte., Ltd. is controlled by Siam Cement Public Company Limited, serving as the primary shareholder of FajarPaper.

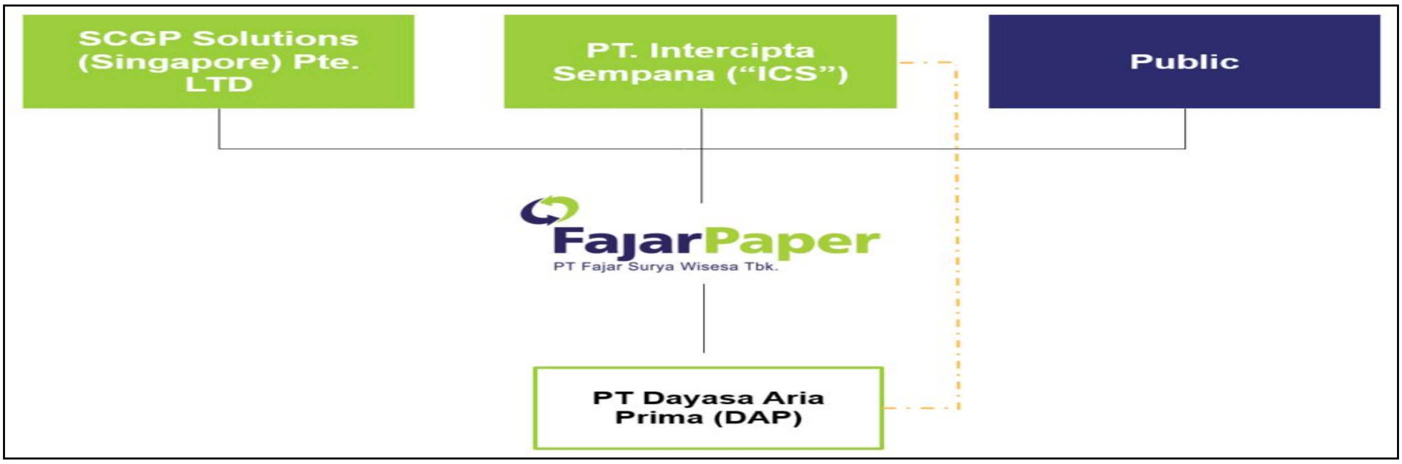

Fig 2 Organizational Structure of PT Fajar Surya Wisesa Tbk

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➢ *Company Vision and Mission*

Vision: To become a world-class industrial paper manufacturer with a focus on recycling and sustainable manufacturing.

Mission: To maintain our position as a leading packaging paper manufacturer in Indonesia and the surrounding region by capitalizing on consumer and industrial market opportunities.

➢ *Definition of Inventory*

According to Heryanto (in Bahiyyah, 2022), inventory refers to a collection of products or materials stored for future use. At PT. Fajar Surya Wisesa, inventory includes chemicals such as Reagent test kit N, Reagent test kit P, Reagent test kit Hardness, Reagent test kit COD 1500, Reagent test kit sulfate, and others. Effective inventory management is crucial to support manufacturing activities by ensuring adequate availability of raw materials, avoiding shortages, and sustaining long-term competitive advantage for the company. Inventory management impacts various operational aspects such as product quality, pricing, production efficiency, and the ability to meet customer demand promptly.

According to Ferawati et al. (2020), inventory of goods is a primary asset in a company categorized into three types: raw materials, work-in-progress, and finished goods. Raw materials and work-in-progress are utilized in production processes to streamline operations, while finished goods are the final products prepared to meet market demand [7]. Effective inventory management can enhance company revenue by maintaining a proper balance between inventory investment and customer service [7] [13].

➢ *Inventory Function*

According to Siahaan & Muhidin (2020), inventory has four main functions that increase the flexibility of company operations: providing a choice of chemicals for production, separating stages of the production process, utilizing bulk purchase discounts, and avoiding inflation and price increases [15]. In the WWTP laboratory, the availability of chemicals must be maintained to ensure a smooth production process.

➢ *Types of Inventory*

According to Sofjan Assauri, inventory is a crucial factor in achieving production efficiency in companies [6]. There are several types of inventory that can be identified:

- Raw Material Inventory: This consists of raw materials used in the production process, sourced from natural resources or purchased from external suppliers.
- Purchased Component Inventory: This type of inventory includes components purchased from external suppliers to support production and product maintenance.
- Work-in-Process Inventory: This inventory includes goods that are currently in the production process. Work-in-process items require further processing before becoming finished products.
- Finished Goods Inventory: These are products that have completed the production process in the factory and are ready to be sold to customers or distributed to other companies.

Each type of inventory plays a specific role in supporting operational production and meeting market demand efficiently. Understanding and effectively managing each type of inventory is essential for optimizing production performance and ensuring customer satisfaction.

➢ *Inventory Costs*

According to Sanjaya & Purnawati (2021), There are four types of inventory costs: holding or carrying costs, ordering costs, setup costs, and stockout or shortage costs [13]. Each cost category includes various components that affect the company's inventory management, ranging from storage to the risk of material shortages.

➢ *Inventory Control*

According to Soeltanong & Sasongko (2021), Inventory control focuses on the optimal storage and use of reagent inventory to maximize economic value [16]. The goal is to "minimize production disruption and prevent excessive capital investment in reagent inventory."

➢ *Economic Order Quantity (EOQ)*

F.W. Haris formulated the EOQ method in 1915 to achieve economic order quantity. According to Dardanella1 et al. (2022), EOQ is a method of maximizing the acquisition of goods by minimizing the use of costs and can increase the effectiveness of product goods in business [3]. Laoli et al. (2022) added that EOQ answers two important questions: when to order and how much to order [9].

$$EOQ = \sqrt{\frac{2 \text{ x S x D}}{H}}$$

Description:

EOQ : Economic Order Quantity
D : Demand
S : Order cost per order
H : Storage cost/unit/year

Bahiyyah et al. (2022) defined EOQ as a quantitative method that can be used by management as inventory control with an order size that minimizes the sum of storage costs and ordering costs. Ova Novi Irama & Murni Dahlena (2021) mentioned five EOQ assumptions, including constant demand, item independence, immediate receipt, no stockout, and constant price [12]. Dian Friana Hidayat & Joko Hardono (2022) emphasized that EOQ "aims to minimize Total Inventory Cost" and achieve the optimal number of ordering units by emphasizing the minimum possible cost [4].

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Laoli (2022) defines Safety Stock as a condition to anticipate uncertainties that may cause the company to run out of stock [9]. Mikharani et al. (2022) add that Safety Stock is "an inventory method that is created or held to maintain the possibility of stock shortages or overstocks," and provide the calculation formula: Safety Stock = (maximum daily sales x maximum lead time) - (average daily sales x average lead time) [10].

Sukamdani et al. (2020) define ROP as the time or point at which another order must be placed in such a way that the arrival or receipt of the ordered goods [17]. Taska & Yulianti (2020) added that ROP is how much time the company should place an order, so that the arrival of the order is right with the exhaustion of materials, and suggested two policies for determining ROP: setting the amount of use during lead time plus Safety Stock, and setting an economic lead time [18].

ROP = d * L

Description:

ROP : Reorder Point
d : Demand per day
L : Waiting time for new orders in days

The relationship between EOQ, Safety Stock and ROP can be described as the following graph:

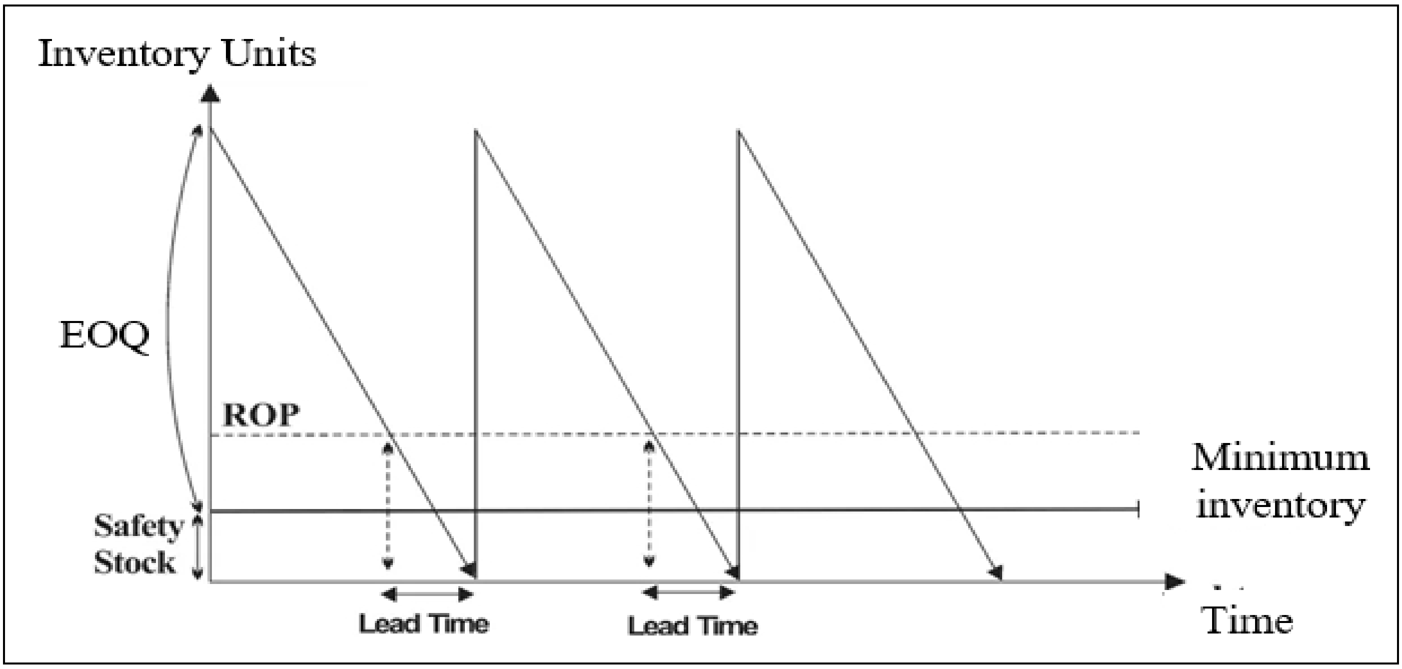

Fig 3 EOQ Safety Stock Relationship, and Reorder Point
Source: (Bakhtiar et al., 2023)

The graph shows that the optimal Reorder Point (ROP) occurs at the intersection point between inventory reduction and lead time. Ordering at this point ensures new materials arrive when Safety Stock runs out, preventing shortages or overstocks.

- ➢ *POM QM For Windows*

Pom QM for Windows is software designed to facilitate quantitative analysis and modeling in various fields of business and management. Its main features include quantitative analysis, optimization modeling, simulation and forecasting, project management, and an easy-to-use interface. The software is useful for students, faculty, and professionals who want to analyze data and make data-driven decisions in business and management contexts.

- ➢ *Research Gap*

Researchers have conducted a literature study of several previous studies, such as a study entitled "Chemical Inventory Control with EOQ (Economic Order Quantity) and ROP (Reorder Point) Calculations at the Cimahi City Drinking Water BLUD. " by Khariidatul Bahiyyah and "Analysis of the Implementation of the Economic Order Quantity (EOQ) Method as a Planning and Control Tool for Laboratory Chemicals at PT Sucofindo Surabaya" by Devi Nala Ratih, Sunu Priyawan. The research provides information related to the research methods used, namely the EOQ and ROP methods only. From some of these studies, researchers are interested in applying these methods with different objects, namely chemical supplies in the WWTP department laboratory of PT Fajar Surya Wisesa Tbk. using the EOQ method by simultaneously calculating Safety Stock which is expected to achieve ideal chemical stock management so as to reduce the issue of over stock and expired chemicals before use.

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III. RESEARCH METHODS

A. Research Design

This research uses quantitative methods with measured data from the WWTP laboratory of PT Fajar Surya Wisesa Tbk. The preliminary stage involved structured planning, starting with the creation of a flowchart as a frame of reference for the research to ensure the flow is in accordance with the research objectives.

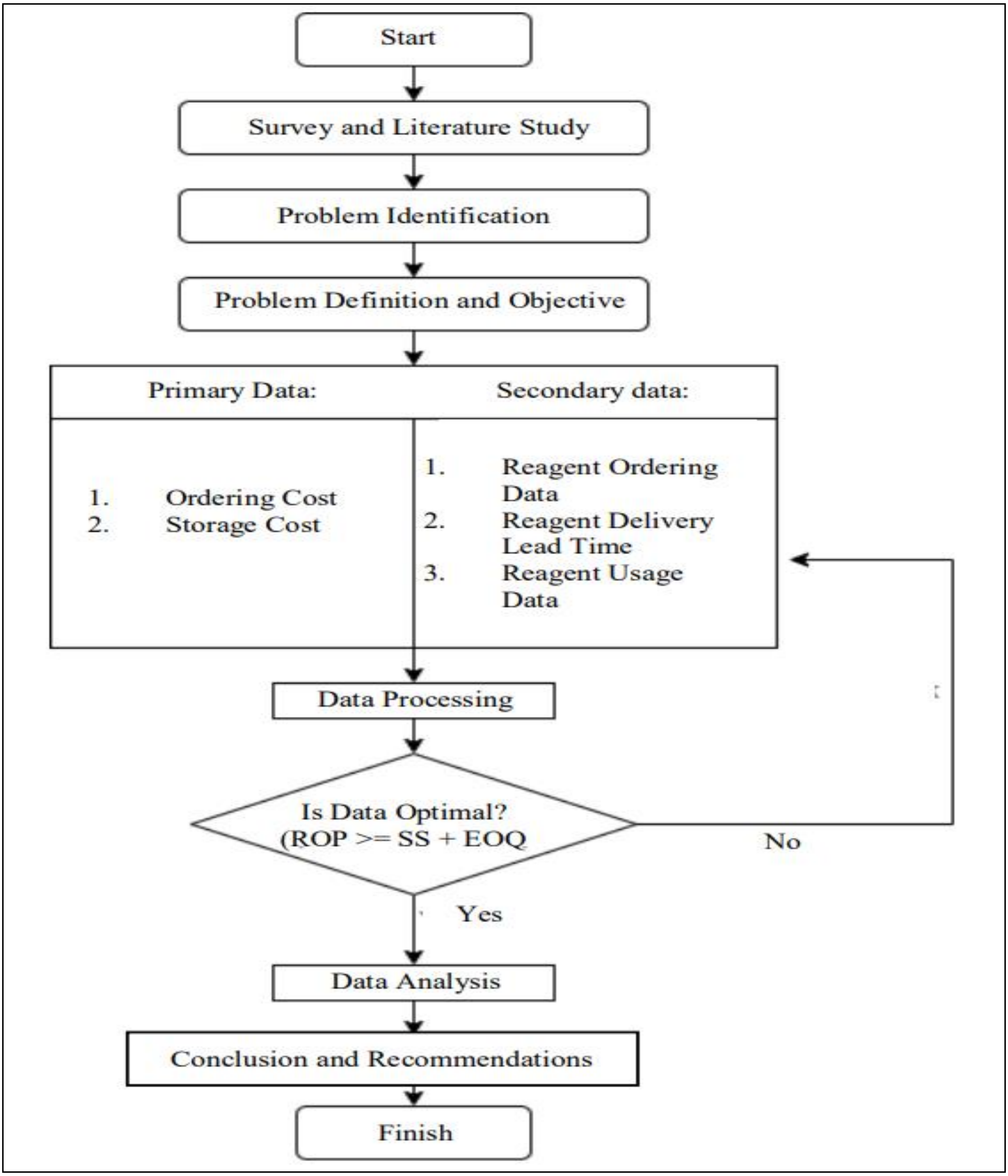

Fig 4 Research Flow Chart

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B. *Location and Time of Research*

The field study was conducted for 4 weeks in the laboratory of the WWTP Department of PT Fajar Surya Wisesa Tbk, located at Jln. Abdul Muis 30, Central Jakarta 10160, Indonesia. The implementation time followed the working hours of the company's employees.

C. *Data Collection Technique*

The data used in this research is quantitative. To collect the data, the following methods were employed:

➢ *Field Study*

This technique involves direct observation in the WWTP department laboratory at PT. Fajar Surya Wisesa Tbk. The research utilized several data sources:

- *Primary Data:*

Collected through direct interviews and observations, including data on ordering costs per order and annual per-unit reagent storage costs.

- *Secondary Data:*

Obtained from company information, encompassing reagent ordering and delivery lead time data, reagent usage data for 2022, and the quantity of orders in 2022.

➢ *Literature Study*

This involves studying, analyzing, comparing, and citing theories and concepts from various literature sources such as books, scientific works, journals, and other relevant sources related to the research topic.

D. *Data Analysis Technique*

➢ *Data tabulation*

- *Organizing Data in the form of a List or Table*

Example: tabulation of ordering quantity and usage of chemicals/reagents in the WWTP department laboratory of PT Fajar Surya Wisesa Tbk.

Table 1 Tabulation of Reagent usage and Order Quantity Data

Month	Ordering (in pack)			Usage (in packs)		
	Reagent x	*Reagent* y	*Reagent* z	*Reagent* x	*Reagent* y	*Reagent* z
January						
February						
March						
...						
etc..						

- *Supplier Data and Delivery Lead time*

Each reagent supplier has a different delivery lead time. The reagent delivery lead time data based on the supplier will be tabulated as in table 2.

Table 2 Tabulation of Supplier Data and Lead Time

No	Reagent type	Supplier	*Lead time*
1	*Reagent* x		
2	*Reagent* y		
3	Etc..		

- *Reagent Ordering Cost and Storage Cost Data*

The calculation of annual per-unit reagent storage and ordering costs is a crucial aspect of inventory management. Storage costs include chemical management, while ordering costs include admin services and loading and unloading. This cost data will be tabulated for further analysis.

Table 3 Tabulation of Storage Cost and Order Cost Data for each Reagent

No	Reagent type	Storage cost	Ordering cost
1	*Reagent* x	Rp.	Rp.
2	*Reagent* y	Rp.	Rp.
3	...	...	...
4	...	...	...
5	Etc..	Rp.	Rp.

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➢ *Forecasting Demand*

Data processing uses forecasting methods to determine reagent demand. Based on the data pattern, observation period, and forecasting period, the selected methods are Simple Moving Average and Single Exponential Smoothing for short-term forecasting. According to Faradisa & Rizal (2024), these two methods are suitable for forecasting reagent demand in the coming period [5].

$$SMA = \frac{d_1 + d_2 + \cdots . + d_n}{n}$$

Description:

SMA: Single Moving Average of the next period
d_n : is the historical demand data of time period n
n : Number of time periods

$$SES = F_{t-1} + \alpha(D_{t-1} - F_{t-1})$$

Description:

SES : *Single Exponential Smoothing*
F_{t-1} : Forecasting period (t-1)
D_{t-1} : Actual demand of period (t-1)
α : actual demand of period (t-1)

The selection of the best forecasting method is done by comparing the smallest error values using MAD, MSE, and MAPE. According to Dardanella1 et al. (2022), 'the one with the lowest error rate or MAD, MSE, and MAPE values is the best forecasting method that can be used [3].

$$MAD = \frac{\sum[D - F]}{n}$$

Description:

D : Actual value in period t
F : Forecast value in period t
n : Number of periods

$$MSE = \frac{\sum[D - F]^2}{n}$$

Description:

D : Actual value in period t
F : Forecast value in period t
n : Number of periods

$$MAPE = \frac{\sum[D - F]^2}{\sum D}$$

Description:

D : Actual value in period t
F : Forecast value in period t

➢ *Economic Order Quantity (EOQ) Analysis*

Economic Order Quantity (EOQ) analysis is used to determine the economical amount of reagent ordering in a year, preventing shortages or overstocks. EOQ calculations consider ordering costs, storage costs, and demand.

$$EOQ = \sqrt{\frac{2 \text{ x S x D}}{H}}$$

Description:

EOQ : Economic Order Quantity
D : Demand
S : Order cost per order
H : Storage cost/unit/year

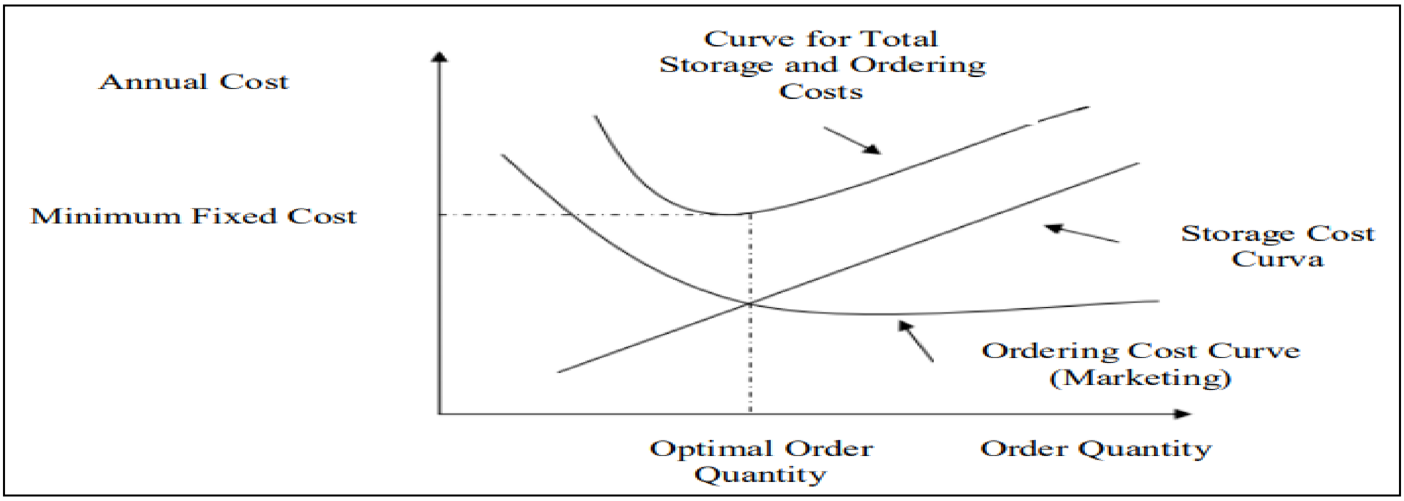

Fig 5 Graph of the relationship between message costs and storage costs
Source: (Octaviani & Imaroh, 2020)

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The optimal order quantity is achieved when there is a balance between ordering costs and holding costs. Ordering in large quantities (large lots) reduces ordering costs but increases holding costs. Conversely, ordering in small quantities (small lots) increases ordering costs but reduces holding costs. Therefore, the Economic Order Quantity (EOQ) model aims to maintain an optimal order quantity that strikes a balance between these costs. Using the EOQ model, the optimal order quantity occurs at the point where the total ordering costs equal the total holding costs.

➤ *Safety Stock (SS) Calculation*

Safety Stock is important to maintain a smooth business process. According to Afrimarsa et al. (2022), Safety Stock 'helps avoid the danger of running out of materials' in case of problems in the business cycle [1]. However, Setiawan (2019) reminded that 'excessive amounts of Safety Stock will also cause new problems, namely high storage costs [14]. The EOQ method is used to calculate the optimal Safety Stock. Therefore, using the EOQ method, Safety Stock is calculated using the following formula:

SS= ($usage_{max}$-$usage_{average}$) x Lead time

➤ *Reorder Point (ROP) Calculation*

Reorder Point determines the reorder point before inventory runs out. According to Chaeroni & Rizkiyah (2024), it is 'the point at which inventory has reached such a low point that an order must be placed immediately' [2]. Itsna R et al. (2023) explain that 'Reorder Point is the product of the lead time required to order and the average usage of the item [8]. The following is the Reorder Point calculation formula:

$$ROP = (d \; x \; Lt) + SS$$

Description:

ROP : *Reorder Point*
d : Average use of reagent
Lt : *Lead time*
SS : *Safety Stock*

➤ *Total Inventory Cost Calculation*

Total Inventory Cost includes the cost of ordering and storing reagents. According to Itsna R et al. (2023), 'when inventory is material purchased from outside, the costs associated with this inventory are ordering costs and storage costs' [8]. In this case, storage costs include two rooms: reagent space for direct use and storage space for stock. Storage costs are calculated using the following equation:

$$Annual\ holding\ cost = \frac{Q}{2}H$$

Description:

Q : number of units per order
H : Unit storage cost per year

Order cost covers the cost of placing and receiving orders, including administration, shipping insurance, and unloading. Setup costs include preparation of equipment and production facilities. In this context, reagent ordering costs consist of laboratory admin service costs for ordering and unloading costs when the reagents arrive.

$$Annual\ setup\ cost = \frac{D}{Q}S$$

Description:

D: demand per time period
Q: number of units per order
S: order cost per order

After calculation and analysis using the EOQ, Safety Stock, and Reorder Point methods, the results are interpreted by comparing reagent inventory management before and after the application of the EOQ method. The focus of the comparison is on the potential savings in total inventory costs incurred by the company.

➤ *Conclusions and Suggestions*

This research will produce conclusions and suggestions for improving the company's system and further research. With an exploratory approach, the research aims to determine Economic Order Quantity (EOQ), Reorder Point (ROP), and Safety Stock (SS) to optimize inventory management and overcome demand uncertainty.

IV. RESULTS AND DISCUSSION

A. *Profile of the Final Project Object*

The laboratory in the Waste Water Treatment Plant (WWTP) department at PT Fajar Surya Wisesa Tbk uses various chemicals in its operations. So that to manage chemical inventory efficiently, a method is needed that is able to determine the optimum order quantity so that total costs can be minimized. The Economic Order Quantity (EOQ) method is the right approach to achieve this goal, by calculating the optimal order quantity based on ordering costs and storage costs [11]. In addition, it is necessary to do Reorder Point (ROP) to determine the ideal time to reorder inventory based on average daily demand and lead time and pay attention to Safety Stock (SS) to minimize the risk of running out of inventory.

B. *Data Collection*

➤ *Chemical Usage Data*

Chemical usage data is collected during a certain period to determine the pattern of use and demand for materials in the laboratory. This data includes monthly usage (boxes per month) and average daily usage (boxes per day).

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Table 4 Chemical Usage

Chemical Name	Chemical Usage (month/vial)	Vial/Box Contents	Total Usage Box/month	Total Expenses /month
Ammonia Nitrogen	168	50 vial	4 box	10,416,000
Sulfate	20	25 vial	1 box	1,912,000
Phosphate	48	25 vial	2 box	3,571,200
Water Hardness	120	25 vial	3 box	7,968,000
Reagen set,Aluminum Aluminion	8	50 vial	1 box	384,000
Reagent KIT HACH COD	252	150 vial	2 box	7,224,000
			total	31,475,200

➢ *Cost Data*

To calculate EOQ, ROP, and SS, we need cost data related to ordering and storing chemicals. This data includes; Ordering cost per order (Rp), Storage cost per unit per year (Rp), and Cost per unit (Rp).

Table 5 Cost Data

Chemical Name	Ordering Cost (RP)	Storage Cost (RP/unit/year)	Cost Per Unit (RP/box)
Ammonia Nitrogen	50,000	620,000	3,100,000
Sulfate	50,000	478,000	2,390,000
Phosphate	50,000	372,000	1,860,000
Water Hardness	50,000	332,000	1,660,000
Aluminum Aluminion reagent set	50,000	480,000	2,400,000
Reagent KIT HACH COD	50,000	860,000	4,300,000

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➢ *Data Processing*

- *Ammonia, Nitrogen*

QM for Windows - [Data] Results

Ammonia, Nitrogen Solution

Parameter	Value	Parameter	Value
Demand rate(D)	48	Optimal order quantity (Q*)	2.78
Setup/ordering cost(S)	50000	Maximum Inventory Level (Imax)	2.78
Holding/carrying cost(H)	620000	Average inventory	1.39
Unit cost	3100000	Orders per period (N)	17.25
		Annual Setup cost	862554.4
		Annual Holding cost	862554.3
		Total Inventory (Holding + Setup) Cost	1725109.0
		Unit costs (PD)	148800000
		Total Cost (including units)	150525100

Fig 6 EOQ Calculation for Ammonia

Based on the calculation results from POM for Windows software (POM QM) for the chemical Ammonia, Nitrogen, the annual demand (Demand Rate) was recorded as 48 boxes per year. The ordering cost per order (Setup/Ordering Cost) is IDR 50,000, while the storage cost per unit per year (Holding/Carrying Cost) is IDR 620,000 per box, with a unit cost of IDR 3,100,000 per box.

Calculations show that the Optimal Order Quantity (Q*) is 2.78 boxes, which is usually rounded up to 3 boxes for practical purposes. The maximum inventory level (Imax) that can be achieved after the new order arrives is 3 boxes, while the average inventory held during a period (Average Inventory) is about 1.39 boxes or 2 boxes.

The number of orders to be placed per year (Orders per Period, N) is about 17.25 times or 18 times. The total ordering cost per year (Annual Setup Cost) is recorded at Rp 862,554.4, and the total storage cost per year (Annual Holding Cost) is Rp 862,554.3. Thus, the total inventory cost (Total Inventory Holding + Setup Cost) is Rp 1,725,109.0, while the unit cost (Unit Costs, PD) is Rp 148,800,000, making the total annual cost (Total Cost including units) Rp 150,525,100.

- *Calculation Safety Stock (SS)*

Safety Stock = (Maximum Daily Demand * Maximum Lead time) - (Average Daily Demand * Average Lead time)
Safety Stock = $(0.2\times10) - (0.13\times7)$
Safety Stock = 1.09 boxes ≈ 1 box

- *Reorder Point (ROP) Calculation*

ROP = (Average Daily Demand * Average Lead time) + Safety Stock
ROP = $(0.13\times7) + 1$
ROP = 0.91 + 1
ROP=1.91 boxes ≈ 2 boxes

With the results of this calculation, PT Fajar Surya Wisesa Tbk can order 3 boxes each time an order is placed to minimize total costs. Reordering should be done when the inventory reaches 2 boxes to ensure that the inventory does not run out before the next shipment arrives. Safety Stock of 1 box is kept as a buffer to overcome uncertainty in demand and lead time.

- *Sulfate*

QM for Windows - [Data] Results

Sulfate Solution

Parameter	Value	Parameter	Value
Demand rate(D)	12	Optimal order quantity (Q*)	1.58
Setup/ordering cost(S)	50000	Maximum Inventory Level (Imax)	1.58
Holding/carrying cost(H)	478000	Average inventory	.79
Unit cost	2390000	Orders per period (N)	7.57
		Annual Setup cost	378681.9
		Annual Holding cost	378681.9
		Total Inventory (Holding + Setup) Cost	757363.9
		Unit costs (PD)	28680000
		Total Cost (including units)	29437360

Fig 7 EOQ Calculation for Sulfate

Calculations show that the Optimal Order Quantity (Q*) is 1.58 boxes, which is usually rounded up to 2 boxes for practical purposes. The maximum inventory level (Imax) that can be achieved after the new order arrives is 2 boxes, while the average inventory held during a period (Average Inventory) is about 0.79 boxes or 1 box.

The number of orders to be placed per year (Orders per Period, N) is about 7.57 times or 8 times. The total ordering cost per year (Annual Setup Cost) is recorded at Rp 378,681.9, and the total storage cost per year (Annual Holding Cost) is Rp 378,681.9. Thus, the total inventory cost (Total Inventory Holding + Setup Cost) is IDR 757,363.9, while the unit cost (Unit Costs, PD) is IDR 28,680,000, making the total annual cost (Total Cost including units) IDR 29,437,360.

- *Safety Stock (SS) Calculation*

Safety Stock = (Maximum Daily Demand * Maximum Lead time) - (Average Daily Demand * Average Lead time)
Safety Stock = (0.05×10) - (0.033×7)
Safety Stock = 0.5 - 0.231
Safety Stock = 0.269 box ≈ 1 box

- *Reorder Point (ROP) Calculation*

ROP = (Average Daily Demand * Average Lead time) + Safety Stock
ROP = (0.033×7) + 1
ROP = 0.231 + 1
ROP = 1.231 boxes ≈ 2 boxes

PT Fajar Surya Wisesa Tbk can order 2 boxes each time an order is placed to minimize the total cost. Reordering should be done when the inventory reaches 2 boxes to ensure that the inventory does not run out before the next shipment arrives. Safety Stock of 1 box is kept as a buffer to overcome uncertainty in demand and lead time.

- *Phosphate*

QM for Windows - [Data] Results

Phospate Solution

Parameter	Value		Parameter	Value
Demand rate(D)	24		Optimal order quantity (Q*)	2.54
Setup/ordering cost(S)	50000		Maximum Inventory Level (Imax)	2.54
Holding/carrying cost(H)	372000		Average inventory	1.27
Unit cost	1860000		Orders per period (N)	9.45
			Annual Setup cost	472440.5
			Annual Holding cost	472440.5
			Total Inventory (Holding + Setup) Cost	944880.9
			Unit costs (PD)	44640000
			Total Cost (including units)	45584880

Fig 8 EOQ Calculation for Phosphates

The calculation shows that the most optimal order quantity (Optimal Order Quantity, Q*) is 2.54 boxes, which is usually rounded up to 3 boxes. The maximum inventory level (Imax) that can be achieved after the new order arrives is 3 boxes, while the average inventory held during a period (Average Inventory) is about 1.27 boxes or 2 boxes.

The number of orders to be placed per year (Orders per Period, N) is about 9.45 times or 10 times. The total ordering cost per year (Annual Setup Cost) is recorded at IDR 472,440.5, and the total storage cost per year (Annual Holding Cost) is IDR 472,440.5. Thus, the total inventory cost (Total Inventory Holding + Setup Cost) is Rp 944,880.9, while the unit cost (Unit Costs, PD) is Rp 44,640,000, making the total annual cost (Total Cost including units) Rp 45,584,880.

- *Safety Stock (SS) Calculation*

Safety Stock = (Maximum Daily Demand * Maximum Lead time) - (Average Daily Demand * Average Lead time)
Safety Stock = (0.1×10) - (0.067×7)
Safety Stock = 1-0.469
Safety Stock = 0.531 box ≈ 1 box

- *Reorder Point (ROP) Calculation*

ROP = (Average Daily Demand * Average Lead time) + Safety Stock
ROP = (0.067×7) + 1
ROP = 0.469 + 1
ROP = 1.469 boxes ≈ 2 boxes

PT Fajar Surya Wisesa Tbk can order 3 boxes each time an order is placed to minimize the total cost. Reordering should be done when the inventory reaches 2 boxes to ensure that the inventory does not run out before the next shipment arrives. Safety Stock of 1 box is kept as a buffer to overcome uncertainty in demand and lead time.

- *Water Hardness*

QM for Windows - [Data] Results

Water Hardness Solution

Parameter	Value		Parameter	Value
Demand rate(D)	36		Optimal order quantity (Q*)	3.29
Setup/ordering cost(S)	50000		Maximum Inventory Level (Imax)	3.29
Holding/carrying cost(H)	332000		Average inventory	1.65
Unit cost	1660000		Orders per period (N)	10.93
			Annual Setup cost	546626
			Annual Holding cost	546626
			Total Inventory (Holding + Setup) Cost	1093252
			Unit costs (PD)	59760000
			Total Cost (including units)	60853250

Fig 9 EOQ Calculation for Water Hardness

The calculation shows that the most optimal order quantity (Optimal Order Quantity, Q*) is 3.29 boxes, which is usually rounded up to 3 boxes. The maximum inventory level (Imax) that can be achieved after the new order arrives is 3.29 boxes, while the average inventory held during a period (Average Inventory) is about 1.65 boxes or 2 boxes.

The number of orders to be placed per year (Orders per Period, N) is about 10.93 times or 11 times. The total ordering cost per year (Annual Setup Cost) is recorded at Rp 546,626, and the total storage cost per year (Annual Holding Cost) is Rp 546,626. Thus, the total inventory cost (Total Inventory Holding + Setup Cost) is Rp 1,093,252, while the unit cost (Unit Costs, PD) is Rp 59,760,000, making the total annual cost (Total Cost including units) Rp 60,853,250.

- *Safety Stock (SS) Calculation*

Safety Stock = (Maximum Daily Demand * Maximum Lead time) - (Average Daily Demand * Average Lead time)

Safety Stock = $(0.13\times10) - (0.1\times7)$
Safety Stock = 1.3-0.7
Safety Stock = 0.6 box ≈ 1 box

- *Reorder Point (ROP) Calculation*

ROP = (Average Daily Demand * Average Lead time) + Safety Stock
ROP = $(0.1\times7) + 1$ ROP = 0.7 + 1
ROP = 1.7 boxes ≈ 2 boxes

PT Fajar Surya Wisesa Tbk can order 3 boxes each time an order is placed to minimize the total cost. Reordering should be done when the inventory reaches 2 boxes to ensure that the inventory does not run out before the next shipment arrives. Safety Stock of 1 box is kept as a buffer to overcome uncertainty in demand and lead time.

- *Reagent Set, Aluminum Alloy*

QM for Windows - [Data] Results

Reagen Set Solution

Parameter	Value		Parameter	Value
Demand rate(D)	12		Optimal order quantity (Q*)	1.58
Setup/ordering cost(S)	50000		Maximum Inventory Level (Imax)	1.58
Holding/carrying cost(H)	480000		Average inventory	.79
Unit cost	2400000		Orders per period (N)	7.59
			Annual Setup cost	379473.3
			Annual Holding cost	379473.3
			Total Inventory (Holding + Setup) Cost	758946.6
			Unit costs (PD)	28800000
			Total Cost (including units)	29558950

Fig 10 EOQ Calculation for Reagent Sets

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The calculation shows that the most optimal order quantity (Optimal Order Quantity, Q*) is 1.58 boxes, which is usually rounded up to 2 boxes. The maximum inventory level (Maximum Inventory Level, Imax) that can be achieved after the new order arrives is 1.58 boxes, while the average inventory held during a period (Average Inventory) is about 0.79 boxes or 1 box.

The number of orders to be placed per year (Orders per Period, N) is about 7.59 times or 8 times. The total ordering cost per year (Annual Setup Cost) is recorded at Rp 379,473.3, and the total storage cost per year (Annual Holding Cost) is Rp 379,473.3. Thus, the total inventory cost (Total Inventory Holding + Setup Cost) is IDR 758,946.6, while the unit cost (Unit Costs, PD) is IDR 28,800,000, making the total annual cost (Total Cost including units) IDR 29,558,950.

- *Safety Stock (SS) Calculation*

Safety Stock = (Maximum Daily Demand * Maximum Lead time) - (Average Daily Demand * Average Lead time)
Safety Stock = (0.05×10) - (0.033×7)
Safety Stock = 0.5 - 0.231
Safety Stock = 0.269 box ≈ 1 box

- *Reorder Point (ROP) Calculation*

ROP = (Average Daily Demand * Average Lead time) + Safety Stock
ROP = (0.033×7) + 1
ROP = 0.231 + 1
ROP = 1.231 boxes ≈ 2 boxes

PT Fajar Surya Wisesa Tbk can order 2 boxes each time an order is placed to minimize the total cost. Reordering should be done when the inventory reaches 2 boxes to ensure that the inventory does not run out before the next shipment arrives. Safety Stock of 1 box is kept as a buffer to overcome uncertainty in demand and lead time.

- *HACH COD KIT Reagent*

QM for Windows - [Data] Results

Reagen KIT HACH COD Solution

Parameter	Value		Parameter	Value
Demand rate(D)	24		Optimal order quantity (Q*)	1.67
Setup/ordering cost(S)	50000		Maximum Inventory Level (Imax)	1.67
Holding/carrying cost(H)	860000		Average inventory	.84
Unit cost	4300000		Orders per period (N)	14.37
			Annual Setup cost	718331.4
			Annual Holding cost	718331.4
			Total Inventory (Holding + Setup) Cost	1436663.0
			Unit costs (PD)	103200000
			Total Cost (including units)	104636700

Fig 11 EOQ Calculation for COD HACH KIT Reagents

Based on the calculation results from POM for Windows (POM QM) software for the chemical Reagent KIT HACH COD, the annual demand rate is recorded at 24 boxes per year. The ordering cost per order is Rp 50,000, while the holding/carrying cost per unit per year is Rp 860,000 per box, with a unit cost of Rp 4,300,000 per box.

The calculation shows that the most optimal order quantity (Optimal Order Quantity, Q*) is 1.67 boxes, which is usually rounded up to 2 boxes. The maximum inventory level (Maximum Inventory Level, Imax) that can be achieved after the new order arrives is 1.67 boxes, while the average inventory held during a period (Average Inventory) is about 0.84 boxes or 1 box.

The number of orders to be placed per year (Orders per Period, N) is about 14.37 times or 15 times. The total ordering cost per year (Annual Setup Cost) is recorded at Rp 718,331.4, and the total storage cost per year (Annual Holding Cost) is Rp 718,331.4. Thus, the total inventory cost (Total Inventory Holding + Setup Cost) is Rp 1,436,663.0, while the unit cost (Unit Costs, PD) is Rp 103,200,000, making the total annual cost (Total Cost including units) Rp 104,636,700.

- *Safety Stock (SS) Calculation*

Safety Stock = (Maximum Daily Demand * Maximum Lead time) - (Average Daily Demand * Average Lead time)
Safety Stock = (0.1×10) - (0.067×7)
Safety Stock = 1 - 0.469
Safety Stock = 0.531 box ≈ 1 box

- *Reorder Point (ROP) Calculation*

ROP = (Average Daily Demand * Average Lead time) + Safety Stock ROP = (0.067×7) + 1
ROP=0.469 + 1
ROP=1.469 boxes ≈ 2 boxes

PT. Fajar Surya Wisesa Tbk can order 2 boxes each time to minimize total costs, with reordering done when inventory reaches 2 boxes to ensure supplies do not run out before the next delivery. A Safety Stock of 1 box is maintained as a buffer to address uncertainties in demand and lead time. Prior to implementing the EOQ method, PT. Fajar Surya Wisesa Tbk faced significant inventory issues. Overstock reached 375%, indicating an imbalance between available materials and actual company needs. Additionally, around 34% of the inventory expired before use, resulting in substantial losses. Chemical usage varied, but on average only required 12-24 boxes per year, showing that existing inventory far exceeded actual needs, leading to high storage and ordering costs.

Before adopting the EOQ method, the company did not have specific calculations for Reorder Point (ROP) and Safety Stock (SS). Orders were typically based on estimates or when stock was nearly depleted, without considering lead time or demand, and additional inventory storage was done without clear calculations to anticipate demand or lead time uncertainties. This irregular planning resulted in many unused materials, causing wastage and inefficiency.

V. CONCLUSIONS AND SUGGESTIONS

A. Conclusion

- Based on the calculations, efficient EOQ quantities are determined as follows: Ammonia Nitrogen: 3 boxes per order, Sulfate: 2 boxes per order, Phosphate: 3 boxes per order, Water Hardness: 3 boxes per order, Aluminum Aluminion Reagent Set: 2 boxes per order, and HACH COD Reagent KIT: 2 boxes per order.
- According to the ROP calculations for various types of chemicals, the Reorder Point is determined to be every 6 weeks, with each order consisting of 2 boxes per chemical.
- The calculated Safety Stock (SS) determines an optimal stock level of 1 box per chemical.

B. Suggestions

Based on the identified benefits of the research, here are some recommendations:

➢ *For Researchers*

- Enhance the ability to implement theoretical knowledge from academic studies into practical situations and explore other relevant methods to enhance inventory management effectiveness.
- Conduct further in-depth research on various inventory control methods, including EOQ, and how these methods can be tailored to meet specific needs and conditions across different industries.

➢ *For the Company*

- Utilize the research findings as a guide to improve inventory management systems in the laboratory.
- Regularly evaluate the strengths and weaknesses of the current inventory system. Use these evaluations for continuous improvement to ensure inventory remains at optimal levels according to operational needs.

➢ *For Universities*

- Incorporate the research findings into academic discourse at both the faculty and university levels.
- Use this research as additional material for research references and learning at Universitas Pelita Bangsa.

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All contributions have been instrumental in expanding our understanding of the importance of efficient and sustainable inventory management. Through this collaboration, we hope that the findings of this research will contribute meaningfully to the development of best practices in chemical inventory management in the industry and inspire further research in this field.

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