http://jurnal.yudharta.ac.id/v2/index.php/jkie

Journal Knowledge Industrial Engineering

E-ISSN: 2541-4461 | P-ISSN: 2460-0113

Inventory Control of Raw Material Requirement in NPK Fertilizer Production Using the Min-Max Method at PT ABC

Shelany Andhika Putri[a], Tranggono[b]

[a,b] Department of Industrial Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Indonesia

Corresponding Autor : shelanyandk@gmail.com

Article Info

Article history

Received : December 25, 2025

Revised : January 25, 2025

Accepted : April 10, 2025

Published : April 30, 2025

Keywords: (3-5 words).

Inventory Control;

Min-Max;

Production;

Raw Materials.

ABSTRACT

PT ABC, a company in the fertilizer and chemical industry. One of the fertilizer products produced is NPK fertilizer, which is highly beneficial for enhancing the quantity and quality of agricultural products, making it a crucial input for farmers. To ensure efficient production and customer satisfaction, it is necessary to calculate inventory control for raw materials for products. In this study, the forecasting method that has the lowest error value is the double exponential smoothing method with MAPE 12% and MAD 17311. Where the forecasting results for each raw material will be used to calculate raw material requirements with the min-max method. The minimum stock levels for Ammonia (NH3) are 3,981 tons; Sulfuric Acid (SA) 8,391 tons; Phosporic Acid (PA) 6,037 tons; DAP 16,578 tons; KCL 64,859 tons; ZA 9,485 tons; and Urea 114 tons. The maximum stock levels for Ammonia (NH3) are 5,292 tons; Sulfuric Acid (SA) 11,147 tons; Phosporic Acid (PA) 8,243 tons; DAP 8,243 tons; KCL 109,823 tons; ZA 12,312 tons; and Urea 169 tons.

DOI: https://doi.org/10.35891/jkie.v12i1.5842

1. Introduction

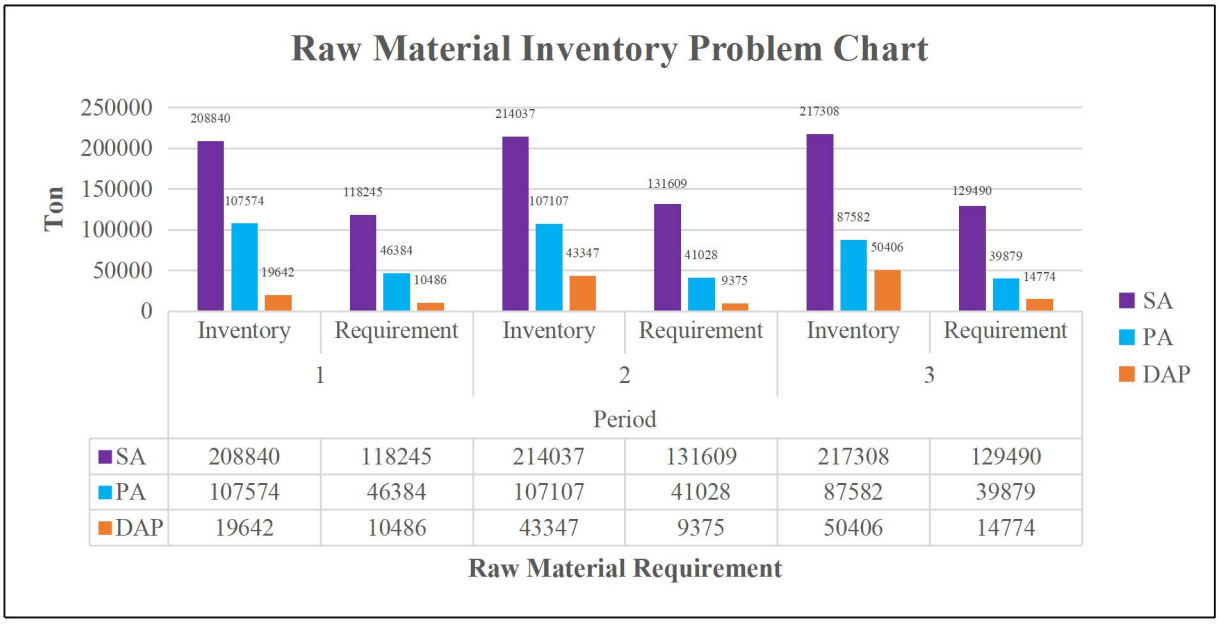
The manufacturing industry in Indonesia has experienced significant growth and development in recent years. It makes increasingly fierce the business competition because there is a lot of competitors vying for dominance in the market. With the expansion of industrial activities in Indonesia, the company is required to maintain effective and efficient business process on an ongoing basis. It imperative to developed so that company can continue to compete the market and obtain maximum profits. Industrial activity can be defined as the process of transforming raw material to finished products. In the Industrial activity, inventory control is one of the things that must be planned properly and carefully.

The term "Inventory" is used to described all organizational resources in anticipation of meeting future demand (Fadhilah & Saifudin, 2023). Inventory Control is crucial element in the production process, ensuring that operations run efficiently and smoothly. Without accurate inventory calculation, it causes the company unable to complete market demand on time and will cause significant losses. Inventory should not bee too large because it will lead to higher cost, and nor too small because it may hinder the production process. In general, there are several inventory problems that commonly occur, including underproduction, overproduction, stockouts, delivery delays, and inventory mismatches (Rachmawati & Lentari, 2022).

Raw material is the main components needed to make a product, and their availability must be maintained to ensure smooth production. Insufficient raw materials can disrupt production, while excess inventory may increase storage costs and the risk of damage. In general, raw material inventory planning includes all activity start from determining the quantity and type of materials needed, identifying source of suppliers, to purchasing and transporting them to production site. Effective raw material requirement planning aims to ensure that raw materials are available in sufficient quantities, on time, dan with an efficient cost

One of the methods that usually used in planning raw materials is the Min-Max Stock Method. The Min-Max Stock Method is a method of controlling raw materials based on the assumption that if the inventory has exceeded the minimum limits and is approaching the limits of Safety Stock, the Reorder or reordering of raw materials must be done (Darmawan et al., 2023). By employing the min-max method, it is possible to ascertain the minimum and maximum inventory that must be maintained by the company in order to prevent any excess or shortage of stock that could disrupt production activities.

PT ABC is one of the companies engaged in the fertilizer and chemical industry. PT ABC established with the objective of providing support to the government's initiative to enhance national agricultural production. Total fertilizer production currently reaches 8.9 million tons/year. PT ABC produces a variety of fertilizers and chemicals, the production of which is traded throughout Indonesia and abroad. One of the fertilizer products produced is NPK fertilizer, which is highly beneficial for enhancing the quantity and quality of agricultural products, making it a crucial input for farmers. It is therefore imperative that the production of NPK fertilizer continue to operate effectively and efficiently in order to maintain the requisite levels of customer satisfaction. In the production of NPK fertilizer at PT ABC, several issues were identified regarding the availability of raw materials, specifically SA, PA, and DAP, over a three-month period. The following data outlines the inventory of raw materials and the requirements at PT ABC during this three-month timeframe, highlighting the problems related to the availability of raw materials for NPK fertilizer production.



	1		2		3	
SA	208840	118245	214037	131609	217308	129490
PA	107574	46384	107107	41028	87582	39879
DAP	19642	10486	43347	9375	50406	14774

Figure 1. Raw Material SA, PA, and DAP Raw Material Inventory Problem Chart

In the Figure 1, it can be seen that the raw materials SA, PA, and DAP often experience overstock, which can result in increased storage costs for the company.

The objective of this study is to determine inventory control for raw materials utilized in the production of NPK fertilizers at PT ABC. On method that can solve inventory problems is the Min-Max Method. The Min-Max Method, helps companies to identifying the optimal level of inventory in

order to meet demand without excess or lack of stock. By using Min-Max Method, companies can identify the minimum and maximum quantities of raw materials inventory that are required. By determining the minimum and maximum quantities of NPK fertilizer raw materials, PT ABC can avoid excessive inventory costs and prevent disruptions in the production process. The implementation of this method provides direct benefits to the company by maintaining supply chain stability and improving service quality for consumers. Therefore, it is crucial to conduct an analysis of the inventory control of NPK fertilizer production at PT ABC using the Min-Max method. Given these challenges, it is expected that the adoption of the Min-Max method will positively impact the company's inventory control processes, enhancing the effectiveness and efficiency of PT ABC management of NPK fertilizer raw materials.

2. Literature Review

Inventory

Inventory can be defined as a stock of materials intentionally held to facilitate the production flow and meet customer demand. Inventory control refers to a series of management policies that determine the optimal inventory levels to maintain and the best timing for reordering to replenish stock. This system ensures the availability of the necessary inventory in the required quantity and quality at the right time. Inventory control is the ability of a company to organize and manage all of its goods, including raw materials, semi-finished products, and finished goods, in a way that guarantees their consistent availability, regardless of market fluctuations (Anjelica et al., 2023).

Inventory plays a significant role in facilitating company operations. There are several objectives of inventory management, including:

a. Eliminating the impact of uncertainty.
b. Allowing flexibility for production and purchasing management.
c. Anticipating changes in demand and supply.
d. Mitigating the risk of price increases.
e. Aligning with the production schedule.
f. Reducing the risk of late delivery of materials.
g. Maintaining inventory of seasonally produced goods.
h. Anticipating forecasted demand.
i. Taking advantage of quantity discounts.
j. Ensuring commitment to customers.

(Manik & Marbun, 2021)

Min-Max Method

The Min-Max Stock method is a raw material control approach based on the premise that when inventory exceeds the minimum level and approaches the safety stock limit, reordering of raw materials must be initiated (Darmawan et al., 2023). The minimum (Min) inventory level serves as a trigger for reordering, while the maximum (Max) inventory level represents the target stock level to be maintained after reordering. The difference between the maximum and minimum levels is often interpreted as the Economic Order Quantity (EOQ). In this method, the minimum and maximum quantities for each item are determined. The minimum level represents a safety margin to prevent shortages, and it also indicates when reordering should take place, with the aim of maintaining optimal inventory levels. The implementation of the Min-Max Stock method is based on physical observation or the recording of relevant data (Widiyanto, 2021). The following is the formula used to calculate the minimum and maximum inventory:

Min Inventory = (Average usage per period * Lead time) + SS.....(1)
Max Inventory = 2 * (Average usage per period * Lead time) + SS.....(2)

Safety Stock

Safety stock, also known as reserve inventory, represents the amount of inventory kept beyond the normal inventory level to account for uncertainties in customer demand, unanticipated delivery delays, or other risks that may affect product availability (Lestari & Rustandi, 2024). The primary objective of safety stock is to minimize the likelihood of stock-outs and the associated costs, including storage costs and total stock-out costs. As the reorder point increases, the additional storage cost also rises, a direct result of maintaining safety stock. The advantage of safety stock is that it can be used to cover sudden spikes in demand, ensuring that production or customer orders are met even during unexpected demand surges (Anjelica et al., 2023). The formula for calculating safety stock (SS) is as follows:

$$SS = Z \times SD \times \sqrt{LT} \quad \text{.....(3)}$$

Where:

- SS = Safety stock
- SD = Standard deviation of raw material requirements
- Z = Z-score, representing the desired service level (e.g., 2.326 for a 99% service level)
- LT = Lead time (in periods)

Reorder Point

The reorder point (ROP) is defined as the inventory level at which action must be taken to replenish goods. It represents the threshold at which inventory needs to be restocked, signaling the purchasing department to place an order to replenish the inventory. This point reflects the consumption rate of materials, with an established tolerance for material exhaustion, which results in the depletion of available stock during the lead time required to obtain additional inventory. If the reorder point is set too low, materials or goods may run out before the new inventory arrives. On the other hand, if the reorder point is set too high, it may lead to excessive costs and unnecessary investments (Heizer, 2015). The following formula can be used to calculate the reorder point:

$$ROP = (T \times LT) + SS \quad \text{.....(4)}$$

Where:

- ROP = Reorder point
- T = Average demand per period
- LT = Lead time in periods

Order Frequency (F) and Order Quantity (Q)

Order frequency (N) refers to the number of orders placed by the company within a given period. The order frequency for one year (F) based on annual demand can be calculated as follows:

$$F = D / Q \quad \text{..... (5)}$$

Where:

- F = Order frequency
- D = Annual demand (requirements)
- Q = Order quantity

Order quantity (Q) represents the amount ordered per period. The formula for order quantity is as follows:

$$Q = \text{Max Stock} - \text{Min Stock} \quad \text{..... (6)}$$

3. Methodology

The research methodology is quantitative research by calculating of inventory control for raw materials utilized in the production on NPK fertilizer using Min-Max Method. The data used as a source of research data is divided into two types, namely secondary data and primary data. This research was conducted at PT ABC, with the data needed are 12-period raw material demand data, 12-period raw material procurement data, and lead time data. The following is a flowchart from this research:

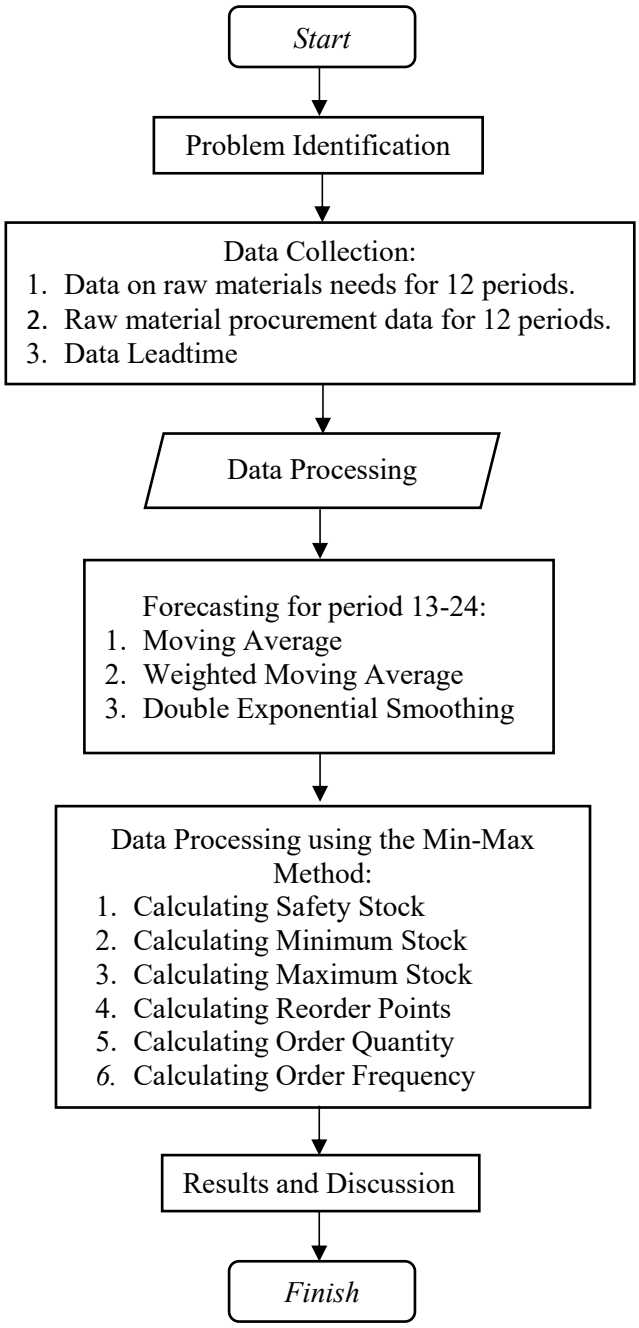


Figure 2. Flowchart

4. Results and Discussion

Inventory control in this research using the Min-Max Method by calculating safety stock, minimum stock, maximum stock, reorder point, order frequency, and order quantity. The data taken is Master Production Result on 12 period. The data ar shown in Table 1 below:

Tabel 1. Raw Material Requirement Data for NPK Fertilizer

	Raw Material Requirement							Ton
Period	**NH3**	**SA**	**PA**	**DAP**	**KCL**	**ZA**	**Urea**	**Total**
1	6893	17024	19864	5093	17950	7158	0	73982
2	7759	17653	24617	4017	17535	8974	20	80575
3	13765	27195	30904	4887	17892	27541	2207	124391
4	15169	31224	31795	9295	26860	17456	1325	133124
5	12852	27894	28276	10314	24206	17068	1346	121956

Raw Material Requirement								Ton
Period	**NH3**	**SA**	**PA**	**DAP**	**KCL**	**ZA**	**Urea**	**Total**
6	13079	25670	28093	6900	18458	22834	928	115962
7	19921	38331	33930	9016	33092	34281	1670	170241
8	18806	41059	33707	9406	32798	33565	1263	170604
9	25972	53923	48406	9085	45702	44693	1690	229471
10	25491	54809	48821	12371	46740	49727	1377	239336
11	25440	54915	49099	10421	45835	53839	969	240518
12	26003	54279	46385	9065	42138	55140	1082	234092
Total	211150	443976	423897	99870	369206	372276	13877	
Average	17596	36998	35325	8323	30767	31023	1156	

Table 1 shows the amount of raw material required for NPK fertiliser in 12 periods. The data is then used as historical data in forecasting raw material requirements for the next 12 periods.

Forecasting

Once the data has been obtained, forecasting is then carried out using the moving average, weighted moving average, and double exponential smoothing methods. With a weight of 3 periods, W1 = 0,5; W2 = 0,3; and W3 = 0,1. The alpha value is 0,22 and the beta value is 0,16. Error calculations are presented in table 2.

Table 2. Error Calculation of The Forecasting

Error	Moving Average	Weighted Moving Average	Double Exponential Smoothing
MAPE	18%	14,925%	12%
MAD	33022	27792,25	17311
MSE	1589843486	1221237000	440431864

Based on the results of these forecasting calculations on the table 2, it can be seen that the method that has the smallest MAPE and MAD values is the Double Exponential Smoothing method. Forecasting calculations are conducted using the double exponential smoothing method on each raw material for the production of NPK fertilizer.

Table 3. Forecasting Results of Each Raw Material Needs on 13-24 Period

Raw Material Requirement Forecast							Ton
Period	**NH3**	**SA**	**PA**	**DAP**	**KCL**	**ZA**	**Urea**
13	29626	62209	52346,7	11666	50448,8	60468	1484,83
14	31462,7	66086	54982,1	12149,9	53478	65049	1523,46
15	33299,4	69962	57617,6	12633,8	56507,2	69630	1562,08
16	35136	73838	60253	13117,8	59536,4	74211	1600,71
17	36972,7	77714	62888,5	13601,7	62565,6	78791	1639,33
18	38809,4	81590	65523,9	14085,6	65594,7	83372	1677,96
19	40646,1	85466	68159,4	14569,5	68623,9	87953	1716,59
20	42482,7	89343	70794,9	15053,5	71653,1	92534	1755,21
21	44319,4	93219	73430,3	15537,4	74682,3	97115	1793,84
22	46156,1	97095	76065,8	16021,3	77711,5	101696	1832,46
23	47992,8	100971	78701,2	16505,2	80740,7	106276	1871,09
24	49829,5	104847	81336,7	16989,1	83769,9	110857	1909,72
Total	476732,8	1002340	802100,1	171930,8	805312,1	1027952	20367,3
Average	39727,7	83528,3	66841,7	14327,6	67109,3	85662,7	1697,3
SD	6340,3	13380,7	9097,7	1670,5	10456,9	15813,2	133,3

Inventory Control Using Min-Max Method

1. Safety Stock

Safety stock is calculated by considering the service level, which the company has set at 99%. A service level of 99% corresponds to a Z-score of 2.326, reflecting the company's commitment to meeting 99% of production demand. The safety stock calculation is based on the lead time and the forecasted raw material requirements for production periods 13–24. The following is an example of a safety stock calculation for ammonia raw materials:

Lead time (LT) : 0,033 Month
SD : 6340,31
Safety stock = Zscore x SD x √LT
= 2,326 x 6340,31 x √0,033
= 2,326 x 6340,31 x 0,181
= 2669 Ton

The results of the calculation indicate that the company is required to maintain a minimum stock of ammonia at a level of 2669 tons over the course of a single month.

2. Minimum Stock

The following is an example of a minimum stock calculation using the Min-Max method for ammonia raw materials.

Requirement Average (T) : 39727,73 Ton
Safety stock (SS) : 2669 Ton
Minimum Stock = (T x LT) + SS
= (39727,73 x 0,033) + 2669
= 3981 Ton

3. Maximum Stock

The following is an example of a maximum stock calculation using the Min-Max method for ammonia raw materials.

Rata-Rata Kebutuhan (T) : 39727,73 Ton
Safety stock (SS) : 2669 Ton
Maksimum = 2 x (T x LT) + SS
= 2 X (39727,73 x 0,033) +2669
= 5292 Ton

4. Reorder Point (ROP)

The following is an example of a Reorder Point calculation for ammonia raw materials.

Requirement Average (T) : 39727,73 Ton
Safety stock (SS) : 2669 Ton
Reorder Point = (T x LT) + SS
= (39727,73 x 0,033) + 2669
= 3981 Ton

5. Order Quantity (Q)

Based on the results of the minimum and maximum stock calculations, the required quantity of raw materials for each order can be determined. The following is an example of calculating the order quantity for ammonia raw materials in a single order.

Max stock : 5292 Ton
Min stock : 3981 Ton
Q = Max Stock – Min Stock
= 5292 – 3981
= 1311 Ton

6. Order Frequency (F)

The following is an example of a Order Frequency calculation for ammonia raw materials.

Total Requirement (D) : 476732,8
Order Quantity (Q) : 1311 Ton
F $= \frac{D}{Q}$
$= \frac{47632,8}{14581} = 363$ Times

Analysis of Data Processing

Following the application of the Min-Max method to the data set, the resulting outputs are the safety stock, minimum stock, maximum stock, reorder point, order quantity, and order frequency. The following section provides a summary of the data processing results presented in the table 4.

Table 4. Data Processing Summary

Parameter	Ammonia	Sulfuric Acid	Phosporic Acid	DAP	KCL	ZA	Urea
Total Demand (Tons)	476.732,8	1.002.340	802.100,1	171.930,8	805.312,1	1.027.952	20.367,28
Average Requirement (Ton)	39.727,73	83.528,33	66.841,675	14.327,56	67.109,34	85.662,67	1.697,273
Lead time (Month)	0,033	0,033	0,033	0,9	0,67	0,033	0,033
Safety stock (Ton)	2.669	5.634	3.831	3.684	19.896	6.658	57
Minimum Stock (Ton)	3.981	8.391	6.037	16.578	64.859	9.485	114
Maximum Stock (Ton)	5.292	11.147	8.243	29.474	109.823	12.312	169
Reorder Point (Ton)	3.981	8.391	6.037	16.578	64.859	9.485	114
Order Quantity (Tons)	1.311	2.756	2.206	12.896	44.964	2.827	55
Order Frequency (Times)	363	363	363	13	17	363	370

In the safety stock calculation, lead time (LT) data is required, which represents the time needed by the company to procure the raw materials. Additionally, the safety stock calculation is influenced by the service level value, where PT ABC applies a 99% service level, corresponding to a Z-table value of 2.226. Apart from lead time and service level, the safety stock calculation is also affected by the standard deviation of each raw material. Based on the calculations, the safety stock values are as follows: Ammonia (NH3) at 2,669 tons; Sulfuric Acid (SA) at 5,634 tons; Phosphoric Acid (PA) at 3,831 tons; DAP at 3,684 tons; KCL at 19,896 tons; ZA at 6,658 tons; and Urea at 57 tons.

To calculate the Minimum Stock, lead time (LT) data and safety stock based on prior calculations are required. Additionally, the average demand for each raw material is also needed. Based on the calculations, the minimum stock values are as follows: Ammonia (NH3) at 3,981 tons; Sulfuric Acid (SA) at 8,391 tons; Phosphoric Acid (PA) at 6,037 tons; DAP at 16,578 tons; KCL at 64,859 tons; ZA at 9,485 tons; and Urea at 114 tons.

After calculating the Minimum Stock, the next step is to calculate the Maximum Stock. The Maximum Stock calculation is similar to the Minimum Stock calculation, but after multiplying the lead time by the average demand, the result needs to be multiplied by 2. Based on the calculations, the Maximum Stock values are as follows: Ammonia (NH3) at 5,292 tons; Sulfuric Acid (SA) at 11,147 tons; Phosphoric Acid (PA) at 8,243 tons; DAP at 8,243 tons; KCL at 109,823 tons; ZA at 12,312 tons; and Urea at 169 tons.

The Reorder Point calculation uses the same formula as the Minimum Stock calculation, resulting in identical values. Based on the calculations, the Reorder Point values are as follows: Ammonia (NH3) at 3,981 tons; Sulfuric Acid (SA) at 8,391 tons; Phosphoric Acid (PA) at 6,037 tons; DAP at 16,578 tons; KCL at 64,859 tons; ZA at 9,485 tons; and Urea at 114 tons.

Next, the Order Quantity (Q) is calculated by subtracting the Minimum Stock from the Maximum Stock based on the previous calculations. The Order Quantity results are as follows: Ammonia (NH3) at 1,311 tons; Sulfuric Acid (SA) at 2,756 tons; Phosphoric Acid (PA) at 2,206 tons; DAP at 12,896 tons; KCL at 44,964 tons; ZA at 2,827 tons; and Urea at 55 tons. With these Order Quantity results, the company can determine the amount to be ordered in each procurement cycle.

The Order Frequency calculation is performed by dividing the Total Demand (D) by the Order Quantity (Q) previously calculated. The Order Frequency for 12 periods is as follows: Ammonia (NH3) at 363 times; Sulfuric Acid (SA) at 363 times; Phosphoric Acid (PA) at 363 times; DAP at 13 times; KCL at 17 times; ZA at 363 times; and Urea at 370 times.

5. Conclusion

The Min-Max Stock method is an inventory control technique used to determine the minimum and maximum inventory levels that a company should maintain. The minimum stock represents the point at which backorders must be managed so that the arrival of new materials aligns with the timing when the inventory reaches the safety stock level. The maximum stock indicates the upper limit of inventory, beyond which storage costs may increase excessively. Based on the calculations that have been carried out, the minimum stock results for Ammonia (NH3) are 3,981 tons; Sulphuric Acid (SA) 8,391 tons; Phosporic Acid (PA) 6,037 tons; DAP 16,578 tons; KCL 64,859 tons; ZA 9,485 tons; and Urea 114 tons. While the results of the maximum stock calculation on Ammonia (NH3) are 5,292 tons; Sulfuric Acid (SA) is 11,147 tons; Phosporic Acid (PA) is 8,243 tons; DAP is 8,243 tons; KCL is 109,823 tons; ZA is 12,312 tons; and Urea is 169 tons.

References

Anjelica, M., Seran, A., & Luju, E. (2023). Analisis Pengendalian Persediaan Barang Dagang Dengan Menggunakan Metode EOQ (Economic Order Quantity) Pada PT. Sinar Fajar Mulia Yosefina Andia Dekrita Universitas Nusa Nipa. *Jurnal Penelitian Mahasiswa*, *1*(4), 100–112.

Darmawan, R., Sundari, S., & Nudin, B. (2023). Aplikasi Metode Min-Max di PT. T dalam Merencanakan Kebutuhan Persediaan Bahan Baku pada Proses Body Repair Mobil. *Industrika : Jurnal Ilmiah Teknik Industri*, *7*(3), 301–308. https://doi.org/10.37090/indstrk.v7i3.1146

Fadhilah, A. T., & Saifudin, J. A. (2023). *Pengendalian Persediaan Bahan Baku Menggunakan Metode Min-Max Stock*. *16*(2), 212–218.

Heizer, J. (2015). *Manajemen Operasi : Manajemen Keberlangsungan dan Rantai Pasokan*. Salemba Empat.

Manik, A., & Marbun, N. S. (2021). Analisis Pengendalian Persediaan Barang Dagang Menggunakan Model Persediaan Economic Order Quantity (Eoq) Pada Pt. Kimia Farma Apotek Cabang Iskandar Muda Medan. *Jurnal Global Manajemen*, *10*(2), 184. https://doi.org/10.46930/global.v10i2.1831

Manurung, H. R. N., Pondaag, J. J., Perencanaan, A., Bahan, K., Dalam, B., Mebel, P., Manajemen, J., Ekonomi, F., Manurung, H. R. N., & Pondaag, J. J. (2024). Pada Deebee Furniture Analysis Of Raw Material Planning In Furniture MANUFACTURING : AT DEEBEE Jurnal EMBA Vol . 12 No . 3 Juli 2024 , Hal . 1048-1059. *Jurnal EMBA*, *12*(3), 1048–1059.

Rachmawati, N. L., & Lentari, M. (2022). Penerapan Metode Min-*Max* untuk Minimasi *Stock*out dan Over*stock* Persediaan Bahan Baku. *Jurnal INTECH Teknik Industri Universitas Serang Raya*, *8*(2), 143–148.

Widiyanto, A. C. (2021). Analisis Pengendalian Persediaan Pekan Udang dengan Metode Min-Max Pada CV. Ikhsan Jaya. *Jurnal PENA*, *35*(1), 1–10.