



Application of the Min-Max Stock Method in the Inventory Control of the Raw Materials for the Cement Production at PT XYZ

Iqbal Abdurrahman Hasan*, Farida Pulansari

Department of Industrial Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Jl. Rungkut Madya No.1, Gunung Anyar, Surabaya 60294 Indonesia

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A B S T R A C T

PT XYZ is the largest cement manufacturer in Indonesia that produces cement with different types of cement, namely OPC, PCC, and PPC. The implementation of its production process, starts with the mixing of raw materials, processing, and packaging to the finished product, namely cement. PT XYZ has a problem in the form of raw material inventory that has not been well controlled because the raw materials are often placed outside the storage area provided by the company due to overloading, thus taking up space that should not be used as a raw material storage area. In this study, the minimum-maximum method is applied to 4 types of raw materials, silica sand, gypsum, trass, and fly ash. By determining the amount of safety stock, minimum stock, maximum stock, reorder point and order quantity, companies can effectively determine the raw material inventory policy to avoid overstock or stockout. The study uses a 99% service level with a 1% risk of out-of-stock products. The results of the study obtained the safety stock value of silica sand 3,854 tons; gypsum 4,405 tons; trass 10,456 tons; and Fly Ash 511 tons. Then, the minimum inventory calculation is carried out, it is known that the minimum inventory results are in Fly ash raw material of 776 tons while the results for maximum inventory are in Trass of 34,613 tons. After the min-max calculation, the ordering policy for each material can be obtained, silica sand 5,255 tons, gypsum 9,111 tons, trass 22,534 tons, fly ash 776 tons.

Corresponding Author

Iqbal Abdurrahman Hasan

E-mail: iqbal.abdurrahman76@gmail.com

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1. INTRODUCTION

Competition among companies has become increasingly fierce as Indonesia's industrial world has developed rapidly (Setiawan et al., 2020). With increased competition and challenges, manufacturers need to compete for

survival. New brands and product variants emerge in the market, constantly researching survival strategies (Indrawan et al., 2022). One of these efforts is aimed at improving the company's ability the supply sector (Bunga & Rinawati, 2019). Therefore, the inventory area

or supply sector needs to be controlled by the company as efficiently and effectively as possible (Chamidah & Auliandri, 2019).

Inventory management is an activity carried out by a company that is needed in making decisions so that the need for materials or goods for company activities both production and sales can be met optimally with the least possible risk, the purpose of this inventory management is to control the amount of inventory so that it does not exceed and cause additional material handling costs and it is also expected not to experience shortages for the production process or other business activities. Industry cement and concrete is one of Indonesia's major industries as cement is a necessary material in development. In addition, the cement industry is a source of income for those involved in producing and distributing cement products. As such, this raw material for cement manufacturing plays an important role in the acceleration of infrastructure development throughout Indonesia, particularly in the new capital city of Indonesia in East Kalimantan.

PT XYZ is the largest cement producer in Indonesia. The company was established in 1957. Since then, it has grown into a leading company in the Indonesian cement industry. PT XYZ has several cement plants located in different regions of Indonesia and produces various types of OPC, PCC, and PPC cement to meet the needs of domestic and international consumers. Excerpts from some of the researcher's previous journals are the basis of this study's success in using the Min-Max Stock Method, including the following: Rachmawati & Lentari (2022) by applying the min-max inventory method shows that the min-max method can avoid stockouts and overstocks of O-ring and diaphragm retainer raw materials. Indarti et al. (2019) by controlling the drug inventory using the minimum-maximum inventory method, the following results obtained by applying this method can have a positive impact on the efficiency of the medicine stock, namely reducing the inventory value and the ITOR (Inventory Turn Over Ratio) value. Suseno & Siswoko (2022) confirmed that using the min-max method, he obtained cost-optimal results for the calculation

of the level of orders for 9 months. Mail et al. (2018) research into raw material supply control using the minimum-maximum stock method. The aim is to enable the company to avoid raw material overstocks or stockouts. Humaidy (2022), researched by designing a sponge recipe raw material inventory system with the min-max inventory method, and it was obtained that the condition of raw material inventory in 2019 is normal or there is no shortage.

The calculations in this study were performed on 4 types of raw materials, namely silica sand, gypsum, trass, and fly ash. The method used to control raw material inventory in this study is the minimum-maximum inventory method, which is a control method to determine safety stock, minimum stock, maximum stock, reorder point, and order quantity to avoid overstocking or stockouts. As for the service level value, which shows the company's ability to meet its needs, in this case, the raw material for making cement, it uses a service level value of 99%.

2. LITERATURE REVIEW

Inventory is a company's ability to control all of its needs for goods, whether raw materials, work in process, or finished goods so that they are always available under both stable and fluctuating market conditions. (Purnama & Pulansari, 2020). The inventory control system is a control policy that is used to determine inventory levels that need to be maintained. Inventory shortages (stockouts) occur because goods often can't be brought in suddenly and in the quantity needed. This can stop the production process, delay sales, and even cause the loss of customers. (Pitriyani et al., 2021). Companies need to pay attention to inventory because inventory is an idle resource, when overstock becomes redundant, but when you experience a shortage it is difficult to anticipate other things that lead to inventory stockouts. (Suhartini & Basjir, 2018).

For a manufacturing company, the availability of a production line is essential for running the process of production. On the other hand, for a trading company, the availability of a trading company is essential for the business process to be able to continue. There are differences in the types of services provided between manufacturing companies and trading

companies. The main business of a trading company is to buy products and sell them to customers without making any changes, so the type of distribution that the company has is goods and services. While the manufacturing business is the processing of raw materials into finished goods, there are into finished goods, It is divided into three categories: raw materials, work in progress, and finished goods (Alynardina & Saifi, 2017). Inventory is essential to providing the flexibility needed to operate a system. Inventory can be categorized into inventory of raw materials, inventory of work in the process, and inventory of finished goods. Inventory of raw materials eliminates Dependencies between vendors and facilities. inventory of work in process removes the dependency between the machines of a product line, and inventory of finished goods removes the dependency between plants and customers/market (Kumari & Jagadeeswaran, 2018).

Minimum-maximum method. It determines the minimum and maximum inventory levels. The reason for determining the minimum stock level is to avoid a shortage of raw materials, and the maximum stock level is to avoid wasting storage costs. However, the cost incurred by the company can be quite high by using this method (Fithri et al., 2019). The minimum-maximum calculation method means that the replenishment of the stock will be done when the physical amount in the warehouse has touched the minimum amount of the item, and then it will be ordered as much as the maximum amount of the item. Determining the minimum and maximum stock levels in a company's warehouse is one way to control inventory (Wali, 2019). Base on this idea, the min-max stock formula for inventory replenishment came into being. In terms of inventory management, especially in terms of raw material inventory management, the min-max stock method has several stages, namely (Hendradewa & Aditiyana, 2022):

1. Safety Stock

Safety Stock is an additional inventory item that must be added to keep at any time there is an additional need or delay in the Arrival of the product. The safety stock formula is:

$$\text{Safety Stock} = Z \times S_d \times l \quad (1)$$

Where:

l = Lead time

S_d = Standard deviation of Usage

Z = Service Level Value

2. Minimum Stock

Minimum Stock is the lowest or smallest amount of inventory that must be available for a particular type of material or item. type of material or item. The Minimum inventory formula is as follows:

$$\text{Min stock} = (T \times LT) + SS \quad (2)$$

Where:

T = Average item usage per period (ton)

LT = Lead time (month)

SS = Safety Stock (ton)

3. Maximum Stock

The maximum stock level is the maximum quantity allowed to be kept in inventory. The Maximum inventory formula is as follows:

$$\text{Maximum Stock} = 2 (T \times LT) + SS \quad (3)$$

Where:

T = Average item usage per period (ton)

LT = Lead time (month)

SS = Safety Stock (ton)

4. Reorder Point

Reorder Point where there is an assumption that demand occurs continuously thereby reducing the level of existing inventory. The reorder point formula is as follows:

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

Where:

T = Average item usage per period (ton)

LT = Lead time (month)

SS = Safety Stock (ton)

5. Order Quantity

Order quantity is the order quantity for each order period. The order quantity formula is as follows:

$$Q = 2 \times T \times LT \quad (5)$$

Where:

Q = Order quantity (ton)

T = Average item usage per period (ton)

LT = Lead time (month)

6. Order frequency

Order frequency is the number of ordering periods in one year. The ordering frequency formula is as follows:

$$F = D/Q \tag{6}$$

Keterangan:

F = order frequency (times/year)

D = quantity of goods needed (ton/year)

Q = order quantity (ton/year)

Using the minimum-maximum inventory method will help the warehouse determine how much minimum stock is needed and needs to be available to meet the production quantity capacity and the maximum stock of spare parts in stock (Angelina et al., 2020).

3. RESEARCH METHOD

The research was conducted at a cement industry company in the city of Tuban, East Java. The analysis was based on raw material inventory data from January 2022 to December 2022. Data collection is the first step in research. There are two ways to collect data primary data and secondary data.

This survey describes the level of raw material inventory for each period. Primary data is information obtained directly from the company through collection and observation. Specific literature or references related to forecasts provide secondary data. The method used in this research is library research or searching for information in books and journals. The author uses the Min-Max Stock method for data processing. The following research methodology is shown in Fig. 1.

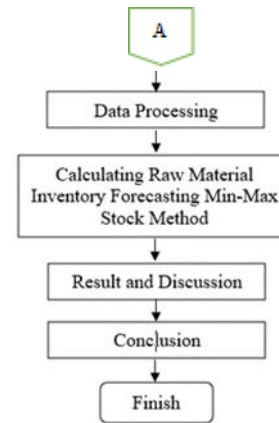
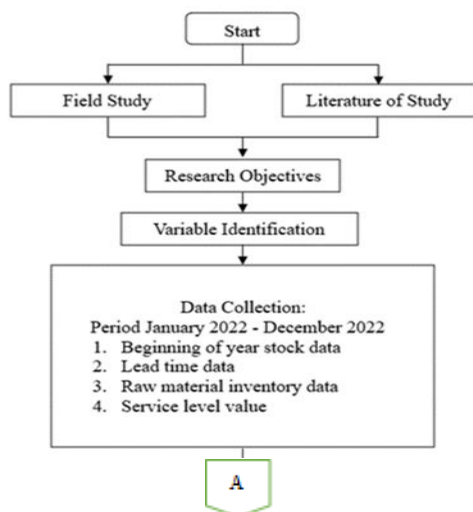


Fig. 1 Flow chart analysis stages (Source: processed data, 2023)

3.1 Beginning of the year stock data

The beginning of the year inventory is the total amount of raw materials for cement production available for use by PT XYZ.

Table 1. Beginning of year stock

Name of Material	Ton
Silica sand	10.505
Gypsum	36.995
Trass	18.630
Fly ash	3.004

(Source: beginning of year stock, 2023)

3.2 Lead Time Data

Lead time data obtained for each raw material (Table 2).

Table 2. Lead time raw material

Name of Material	Lead Time (Month)
Silica sand	0.066
Gypsum	0.233
Trass	0.33
Fly ash	0.033

(Source: lead time, 2023)

3.3 Raw material inventory data

Table 3. Raw material inventory Jan – Dec 2022

Month	Silica Sand	Gypsum	Trass	Fly Ash
January	24.498	23.772	33.458	6.487
February	28.123	22.988	33.655	8.847
March	19.640	23.906	34.078	9.145
April	27.151	22.572	42.400	11.066
May	10.581	9.907	19.788	6.971

June	13.489	15.222	23.422	9.425
July	27.848	20.203	38.352	7.592
August	34.451	21.869	39.151	9.362
September	30.726	23.066	43.583	9.997
October	18.194	19.494	42.643	9.453
November	20.603	20.071	43.171	8.030
December	24.941	22.474	45.508	9.645
Total	280.245	245.544	439.209	106.020
Average	23.354	20.462	36.601	8.835
Max	34.451	23.906	45.508	11.066
Min	10.581	9.907	19.788	6.487
SD	6.752	3.942	7.812	1.267

(Source: raw material inventory, 2023)

4. RESULT AND DISCUSSION

Based on data processing results using the Min-Max Stock method that has been carried out, several results can be obtained as in the subsections below:

4.1 Safety Stock

Several things affect the amount of safety stock, namely the level of inventory desired by the company and the lead time of each raw material. However, in this case, the calculation of the amount of safety stock is influenced by the standard deviation and lead time for each diverse raw material. The service level value set by the company is 99%. with a risk of unfulfilled products of 1%. then from the normal table a Z value of 2,33 is obtained. The equation used to calculate safety stock using equation number (1). In Table 4. presented the results of the safety stock calculation.

Table 4. Recapitulation of safety stock calculation

Serv. Lvl	Z	Silica Sand (Ton)	Gypsum (Ton)	Trass (Ton)	Fly Ash (Ton)
99%	2,33	3.854	4.405	10.456	511

(Source: data processing, 2023)

After calculating the safety stock, the safety stock value obtained at PT XYZ is 3.854 tons for silica sand, 4.405 tons for gypsum, 10.456 tons for trass, 511 tons for fly Ash. Safety stock is a part of the company's inventory used

for safety during the procurement process. With safety stock, it can avoid stockouts in the company so that the production process is not hampered and can run as it should.

4.2 Min-Max Stock

After obtaining the safety stock results, the calculation of the minimum and maximum inventory amounts for the four materials. The equation minimum and maximum inventory using equations number (2) and (3). The results of the minimum and maximum stock calculations for all raw materials can be seen in Table 5.

Table 5. Min-max calculation recapitulation

Material	Min (Ton)	Max (Ton)
Silica Sand	5.255	6.656
Gypsum	9.111	13.818
Trass	22.534	34.613
Fly Ash	776	1.041

(Source: data processing, 2023)

Based on the calculation results obtained the minimum amount of inventory is 5.255 tons for silica sand, 9.111 tons for gypsum, 22.534 tons for trass, 776 tons for fly Ash. And results for maximum amount of inventory at PT XYZ is 6.656 tons for silica sand, 13.818 tons for gypsum, 34.613 tons for trass, 1.041 tons for fly Ash.

4.3 Reorder Point

The following results of the minimum and maximum stock calculations, the calculation of the amount ordered in one order (Q) for cement making raw materials is carried out in Table 6.

Table 6. Recapitulation reorder point

Material	Reorder Point (Ton)
Silica Sand	5.255
Gypsum	9.111
Trass	22.534
Fly Ash	776

(Source: data processing, 2023)

Based on the calculation obtained the reorder point is 5.255 tons for silica sand, 9.111 tons for gypsum, 22.534 tons for trass, 776 tons for fly Ash. With the results of this reorder point, PT XYZ should minimize or eliminate the occurrence of stockouts and overstocks.

4.4 Order Quantity

The following results of the minimum and

maximum stock calculations, the order quantity calculation is carried out where the order quantity is the order quantity for each period. Table 7. Presented the results of the recapitulation for the order quantity of raw materials.

Table 7. Recapitulation of Order Quantity

Material	Order Quantity (Ton)
Silica Sand	2.802
Gypsum	9.413
Trass	24.157
Fly Ash	530

(Source: data processing, 2023)

Based on the calculation results in Table 7, the results of the order quantity in each period are obtained if the stock in the warehouse has reached the minimum stock is 2.802 tons for silica sand, 9.413 tons for gypsum, 24.157 tons for trass, 530 tons for fly Ash.

4.5 Order Frequency

After obtaining the results of the order quantity calculation, the calculation of the order frequency is the number of ordering periods in one year. Table 8, presented the recapitulation results for the frequency of ordering raw materials.

Table 8. Recap order frequency

Material	Order Frequency (Times)
Silica Sand	100
Gypsum	26
Trass	18
Fly Ash	200

(Source: data processing, 2023)

After calculating the minimum inventory, it is known that the smallest result for the minimum inventory is in the Fly Ash raw material of PT XYZ for the January-December 2022 period of 776 tons. After calculating the maximum inventory, it is known that the results for the largest maximum inventory are in the Trass raw material at PT XYZ for the January-December 2022 period of 34,613 tons. The results of determining the minimum and maximum inventory can help PT XYZ in the decision-making process. One of the decision-making processes is the procurement of raw materials for cement production. It is necessary to know the amount of material in the warehouse in real-time and ensure that the goods are still within the minimum and

maximum control limits. PT XYZ rarely runs out of material, but minimum inventory determination is still needed to know when to order materials. to be made by the company. One way is to use the minimum inventory level as a reference for reordering the required material. This makes inventory control more in line with actual conditions.

5. CONCLUSION

The results of research that has been carried out on raw material inventory at PT XYZ using the Min-Max Stock method can be concluded following the objectives of the researcher, the results of the calculation show the minimum and maximum limits of raw material inventory. calculation results show the minimum and maximum stock, safety stock that is different for each raw material. This can happen because each raw material has a different lead time and demand for the availability of these raw materials. From the results that have been obtained, the authors provide several suggestions, namely, For more reliable and more effective results, storage capacity data must be known to check whether the calculation results with a method can be used or not. then, In its application, demand data, lead time, and other warehouse data must always be updated to facilitate the implementation of monitoring and inspection. and finally, can conduct periodic inspections and records of materials in the warehouse so that the amount and state of inventory are known. so that the amount and state of inventory are known and action can be taken

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