Analysis of cement raw material control using the min-max stock method in the PT semen bosowa maros

Arfandi Ahmad*, Nur Ihwan Safutra, Yan Herdianzah, Muhammad Dahlan, Mutmainnah

Department of Industrial Engineering, Universitas Muslim Indonesia, Makassar

*Corresponding author: arfandi.ahmad@umi.ac.id

History: Received 18th January, 2023; Revised 01st August, 2023; Accepted 05th September, 2023

Abstract. *Inventory of raw materials is one of the crucial problems in the company. Errors in determining the size of raw material inventory is very influential for the smooth production of the company. PT Semen Bosowa Maros is a private company that focuses on cement production. This study aims to avoid excess and shortage of raw materials by calculating the amount of raw material inventory at PT Semen Bosowa Maros. This study uses the Min-Max Stock method. The research data was obtained from the company's annual data with related parties. The results of the study obtained safety stock values of Silica Sand 166.46 ton's, Gypsum 1482.96 ton's, Fly Ash 33.71 ton's, and Trass 30.76 ton's. Then, the minimum inventory calculation is carried out, it is known that the minimum inventory results are found in Trass raw materials of 260.18 ton's while the results for maximum inventory are in Gypsum of 22117.18 ton's. After calculating the min-max, an order policy can be obtained for each material, Silica Sand 1074.85 ton's, Gypsum 9575.63 ton's, Fly Ash 217.68 ton's, and Trass 198.65 ton's.*

Keywords: inventory, raw material, min-max stock, safety stock.

1. Introduction

In the company's activities, inventory is needed. Inventory is a reserve needed in a company to ensure the smooth running of its business processes (Fatma et al., 2019). Another meaning is where a stored inventory has the aim of fulfilling production activities both assembling and for resale (Pradana & Jakaria, 2020). Inventory is an important element in a production carried out by companies to produce products (Kinanthi et al., 2016). In the manufacturing industry, raw materials are assets with high value, where 30% of the assets of the manufacturing industry come from raw materials

Inventory of raw materials is a crucial problem in the company. Determining how much raw material inventory will affect company activities. Small inventory will have an impact on production activities because there will be stock outs resulting in delays in meeting consumer demand (Dahlan et al., 2022). Meanwhile, if the inventory is too large it will have an impact on accumulation and excess storage costs. Therefore the need for proper inventory management so that the company's performance can run optimally (Rizky et al., 2016).

PT Semen Bosowa Maros is the main company for Bosowa Cement whose marketing area is outside of Indonesia but has penetrated the international market. The production stage starts from the raw material mining process, the second is processing, and finally the packaging until it becomes finished good, namely cement that is ready to be marketed. PT Semen Bosowa Maros produces its own clinker (Muthalib et al., 2020). Based on the data obtained, cement production in 2019 amounted to 1,591,331.64 tons, where the demand for and use of raw materials for PT Semen Bosowa Maros shows that the total supply of raw materials is greater than the amount of use, where the raw material is Gypsum with an inventory of 57,398.32 tons and consumption of 55,696.61 tons, Trass raw materials with inventories of 29,888.43 tons and usage of 26,575.24 tons. If the amount of inventory exceeds the use of raw materials, there will be excess or overstock. However, for Fly Ash raw materials with an inventory of 28,699.45 tons and usage of 29,121.37

tons, it shows that the total supply of raw materials is smaller than the amount used, which means there is a shortage of raw material supplies .

From these problems it is necessary to have inventory planning and control. Inventory management is an issue that is so important to pay attention to, because inventory management will affect production activities as well as the effectiveness and efficiency of a company (Setiawan et al., 2022; Taufik et al., 2021).

The purpose of this study is to analyze the application of the min-max stock method to control inventory and find out how much safety stock and re-order points are. the application of the Min-Max method from the research results of (Goldiantero et al., 2020), namely: "if the supply has exceeded the minimum brick and approaches the safety stock limit, it is necessary to do a Re Order, meaning that it has reached the re order limit level, the maximum limit is the limit of the company's or management's willingness to invest their money in the form of raw material inventory. This study uses the min-max method because the situation is fluctuating, which means that consumer demand and raw material needs are uncertain (Padhil et al., 2021).

Research on raw material inventory control has been carried out by (Kinanthi et al., 2016) using the Min - Max Stock method on CV. Adi Jaya Teknik to get CV information. Adi Jaya Teknik has been controlling its stock properly. CV. Adi Jaya Teknik is a company that has a business in the industrial machine spare parts section, especially lathes that have become a cast lead producer. The results obtained in the CV research. Adi Jaya with the Min Max Stock method has good results and is more efficient than the company's ending inventory. Then (Audina & Bakhtiar, 2021) has conducted research using the Min Max Stock method at PT. Mitsubishi Chemical Indonesia, where the company is engaged in the Polyester industry by producing the largest Purified Terephthalic Acid (PTA) product in Indonesia. The results obtained are able to determine the exact size of the order and the amount of safety stock for the raw materials Hydrobromic Acid and Soda Ash Dense which aims to reduce a fluctuation in demand and save the total cost of inventory. Based on previous research, this study can determine the amount of raw materials based on the minimum and maximum safety stock that can be prioritized in order to meet inventory above safety stock and raw material storage.

2. Methods

Research design

This research was conducted to control the supply of raw materials at PT Semen Bosowa Maros. Collect data on cement needs and lead time as well as supporting data related to demand and lead time. Then the data is processed using the min-max stock method, 1) Forecasting; 2) Determine safety stock; 3) Calculating minimum inventory; 4) Calculating the maximum inventory; 5) Determine the Reorder Point. This research was carried out for one month starting from June 16 to July 16 2022. This research was carried out at PT. Semen Bosowa Maros South Sulawesi Indonesia. Research design can be seen in Figure 1.

Data processing

The data that has been obtained from the results of data collection, will then be processed data to complete the objectives of this research. The steps in data processing are as follows:

a) Forecasting

Forecasting is an estimate of the amount of demand in the future based on forecasting variables (Oey et al., 2020). Forecasting has the goal of estimating future needs. Where forecasting is done has results that are less precise as expected. Solutions to solve these problems or minimize the process of failure (error) in forecasting, it needs to be solved by looking at data patterns so that you have the right forecasting method to use (Nivasanon et al., 2021; Rosyidi & Zabadi, 2019). According to (Jufriyanto, 2020) the forecasting steps are:

1. Conduct analysis using past data, to find out data patterns that occurred in the past
2. Using the right data
3. Projecting past data by using the right method to use

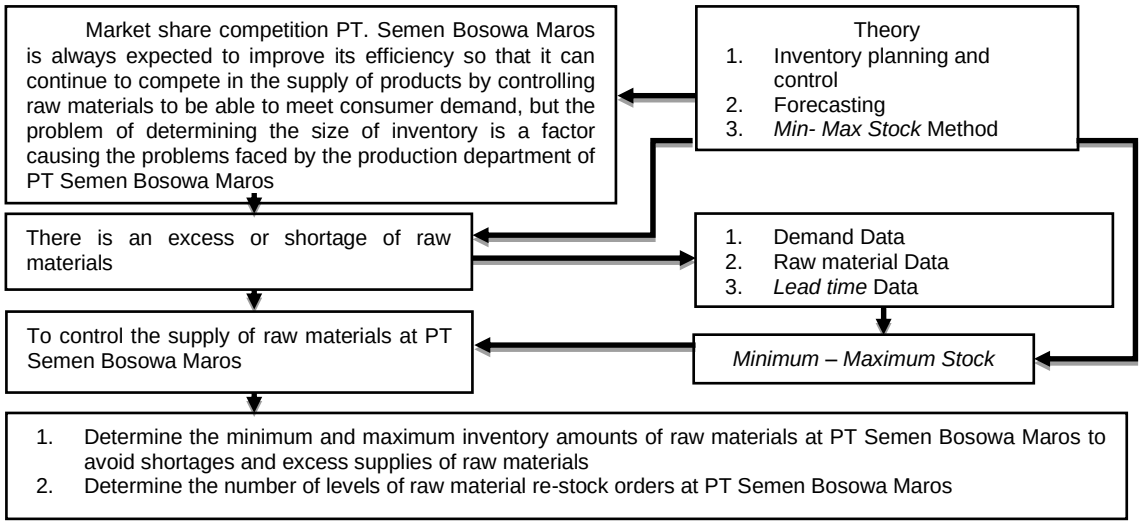

Figure 1 Research Concept Framework

b) Min-Max Stock Method

Min Max Stock is a method used to control the supply of raw materials with an assumption, where inventory exceeds the minimum limit and has a safety stock that is close to the limit, it is necessary to reorder or reorder raw materials. According to (Kinanthi et al., 2016), the Min Max Stock Method has the following stages :

1. Determine Safety Stock (Safety Stock)

   Safety Stock is a safety stock for when production activities experience additional raw materials and prevent delays in raw materials.

   $$Safety\ Stock = (\text{maximum usage} - T) \times C \quad \text{.....(1)}$$

2. Determine Minimum Stock (Minimum Stock)

   Minimum Stock is the amount of raw material usage during the lead time or order time in each period and the average usage in days/weeks/months with the addition of safety stock.

   $$Minimum\ stock = (T \times C) + R \quad \text{.....(2)}$$

3. Determine Maximum Stock (Maximum Stock)

   Maximum Stock is the maximum amount that can be stored.

   $$Maximum\ stock = 2 \times (T \times C) \quad \text{.....(3)}$$

4. Determine Reorder Point

   Reorder when the quantity approaches the order point.

   $$Q = Max\ stock - Min\ stock \quad \text{.....(4)}$$

Remark:
T = The average amount of usage per period (ton)
C = Lead Time is the waiting period (month)
R = Safety Stock (ton)
Q = Inventory order level (ton)

3. Result and Discussion

Demand for cement

Table 1 presents a recapitulation of demand for cement products for the period January to December 2021.

Table 1 Cement Data Demand 2021

No	Month	Demand (ton)
1	January	148.882,07
2	February	160.159,70
3	March	140.788,45
4	April	150.474,32
5	May	160.039,45
6	June	157.039,45
7	July	148.611,93
8	August	142.339,62
9	September	146.085,26
10	October	160.824,36
11	November	122.469,17
12	December	118.474,84
	Amount	1.756.188,62

Cement Demand Forecasting

Historical data on demand for cement products for the period from January to December 2021 listed in table 1 is used to obtain forecasts for 2022 using the POM QM software so that you can choose the right forecasting method as follows Figure 2.

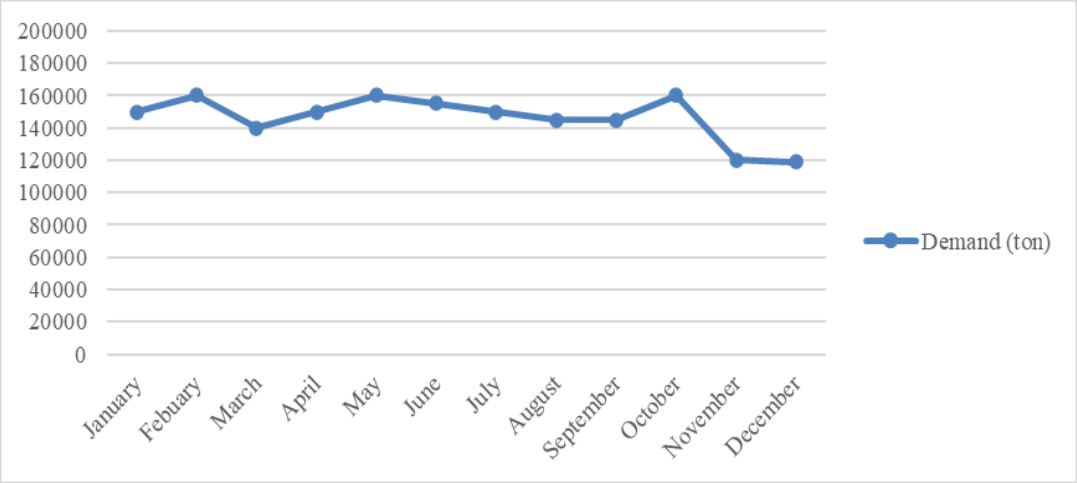

Figure 2 Plot of Cement Data

The graph above illustrates the pattern of data that has a horizontal/constant pattern. So that the methods that can be used are Moving Average, Weight Moving Average, and Exponential Smoothing. After forecasting, the selected method can be seen from the error value that is owned with the lowest value. The result is the Exponential Smoothing method. Recapitulation of error forecasting of cement forecasting results 2022 can be seen in Table 2.

Table 2 Recapitulation of Error Forecasting of Cement Forecasting Results 2022

Forecasting Method	Error Forcasting		
	MAD	MSE	MAPE
Moving Average	12.171,59	238.123.800	8,95%
Weight moving Average	11.819,60	224.749.700	8,66%
Exponential Smoothing (n=0.6)	11.257,53	199.630.300	8,17%

Based on data on the number of requests from January 2022 to December 2022. The results of a comparison of production forecasting systems show that the application of a forecasting system using the Exponential Smoothing (ES) method provides better results. compared to the Moving Average (MA) and Weight Moving Average (WMA) methods. This can be seen from the results of the MAPE error obtained for cement demand with ES obtained by MAPE of 8.17%, while the MAPE method is 8.95% and the WMA method is 8.66%. So that the exponential smoothing method that is suitable for forecasting cement demand is the exponential smoothing method. Cement Forecasting Results 2022 can be seen in Table 3.

Table 3 Cement Forecasting Results 2022

No	Month	Forecasting (ton)
1	January	
2	February	148.882,10
3	March	155.648,60
4	April	146.732,50
5	May	148.977,60
6	June	155.614,70
7	July	156.469,50
8	August	151.755,00
9	September	146.105,80
10	October	146.093,50
11	November	154.932,00
12	December	135.454,30
Total		1.648.485,60
Average		137.373,80

Raw Material Needs Based on Cement Demand

The following below is the raw material requirements for cement manufacture from the results of cement demand forecasting. Raw Material Requirements can be seen in Table 4.

Table 4 Raw Material Requirements

Month	Raw Material			
	Silica Sand (ton)	Gypsum (ton)	Fly Ash (ton)	Trass (ton)
January				
February	22421,64	5210,87	2724,54	2486,33
March	23270,85	5408,23	2827,73	2580,50
April	22236,80	5167,91	2702,08	2465,83
May	22449,11	5217,26	2727,88	2489,38
June	23275,53	5409,32	2828,30	2581,02
July	23462,83	5452,85	2851,06	2601,79
August	22921,89	5327,13	2785,33	2541,80
September	22179,12	5154,51	2695,07	2459,44
October	22089,78	5133,75	2684,22	2449,53
November	23154,96	5381,30	2813,65	2567,65
December	20799,41	4833,86	2527,42	2306,44
Total	248261,93	57697,00	30167,29	27529,71
Average	20688,49	4808,08	2513,94	2294,14

Calculating inventory using the Min-Max Stock method

Calculation for Silica Sand raw material

It is known that the lead time is 0.06 months

1) Safety stock = (maximum usage – T) x C
   = (23.462,83 – 20.688,49) x 0,06
   = 166,46 ton
2) Minimum stock = (T x C) + R
   = (20.688,49 x 0,06) + 166,46
   = 1.407,77 ton
3) Maximum stock = 2 x (T x C)
   = 2 x (20.688,49 x 0,06)
   = 2.482,62 ton
4) Reorder Point = *Max stock – Min stock*
   = 2.482,62 – 1.407,77
   = 1074,85 ton

4. Conclusions and Recommendations

Conclusions

The results of the analysis and discussion that have been carried out, this study shows that each material has a different value from each material at the level of minimum inventory, maximum inventory, safety stock and the level of ordering. Based on the results of the previous study that there is a difference between the 2 raw materials and the 2 other raw materials, namely silica stone and iron sand are far above safety stock and lime stone and clay are below safety stock. Therefore cement production must present raw material inventories that are at a minimum inventory so as not to experience a shortage of raw materials and maximum limits so as not to experience excess raw materials and determine the reorder level to determine the amount ordered in one order is as follows 1) the minimum and maximum inventories of raw materials in the cement manufacturing process for the period January to December 2022 are for Silica Sand raw materials of 1407.77 tons and 2482.62 tons, for Gypsum raw materials of 12541.55 tons and 22117.18 tons , for Fly Ash raw materials of 285.11 tons and 502.79 tons, and for Trass raw materials of 260.18 tons and 458.83 tons. 2) the number of reorder points for raw material inventory in the cement manufacturing process for the period January to December 2022, namely for Silica Sand raw material was 1074.85 tons, for Gypsum raw material was 9575.63 tons, for Fly Ash raw material of 217.68 tons, and for Trass raw materials of 198.65 tons.

Recommendations

Suggestions For further research, it is expected to be able to obtain more optimal savings for each period. In addition, it is hoped that a formulation can be found to obtain the optimal inventory composition of each raw material needed by PT. Semen Bosowa Maros, so that the results obtained in planning future needs are more accurate.

Reference

Audina, S., & Bakhtiar, A. (2021). Analisis Pengendalian Persediaan Aux Raw Material Menggunakan Metode Min-Max Stock Di Pt. Mitsubishi Chemical Indonesia. *J@ti Undip: Jurnal Teknik Industri*, *16*(3), 161–168. https://doi.org/10.14710/jati.16.3.161-168

Dahlan, M., Ahmad, A., Pawennari, A., & Alimuddin, W. (2022). Pengendalian Persediaan Bahan Bakar Solar Menggunakan Model Probabilistik pada SPDN Baji Pamai Maros. *Conference SENATIK STT Adisutjipto Yogyakarta*, *7*. https://doi.org/10.28989/senatik.v7i0.443

Fatma, E., Indriani, I., & Fitriana, M. (2019). Perencanaan Persediaan Komponen Pada Perusahaan Original Equipment Manufacturer Menggunakan Metode Persediaan Deterministik Dinamis. *Spektrum Industri*, *17*(1), 1–9. http://www.nber.org/papers/w16019

Goldiantero, Z., Rif'ah, M. I., & Sodikin, I. (2020). Optimalisasi Pengendalian Persediaan Bahan Baku Menggunakan Metode Min-Max Stock. *Jurnal Rekayasan Dan Inovasi Teknik Industri*, *8*(2), 23–28. https://ejournal.akprind.ac.id/index.php/rekavasi/article/view/3205/2811

Jufriyanto, M. (2020). Peramalan Permintaan Keripik Singkong Pada UMKM Difaa dengan Simulasi Monte Carlo. *Jurnal Teknik Industri: Jurnal Hasil Penelitian Dan Karya Ilmiah Dalam Bidang Teknik Industri*, *6*(2), 107. https://doi.org/10.24014/jti.v6i2.10452

Kinanthi, A. P., Herlina, D., & Mahardika, F. A. (2016). Analisis Pengendalian Persediaan Bahan Baku Menggunakan Metode Min-Max (Studi Kasus PT.Djitoe Indonesia Tobacco). *PERFORMA : Media Ilmiah Teknik Industri*, *15*(2), 87–92. https://doi.org/10.20961/performa.15.2.9824

Muthalib, I. S., Rusman, M., & Griseldis, G. L. (2020). Overall Equipment Effectiveness (OEE) analysis and Failure Mode and Effect Analysis (FMEA) on Packer Machines for minimizing the Six Big Losses-A cement industry case. *IOP Conference Series: Materials Science and Engineering*, *885*(1). https://doi.org/10.1088/1757-899X/885/1/012061

Nivasanon, C., Srikun, I., & Aungkulanon, P. (2021). Aggregate production planning: A case study of installation elevator company. Proceedings of the International Conference on Industrial Engineering and Operations Management, 5357–5365.

Oey, E., Wijaya, W. A., & Hansopaheluwakan, S. (2020). Forecasting and aggregate planning application – a case study of a small enterprise in Indonesia. *International Journal of Process Management and Benchmarking*, *10*(1), 1–21. https://doi.org/10.1504/IJPMB.2020.104229

Padhil, A., Chairany, N., Ahmad, A., Ramli, H., & Malik, R. (2021). Supply Chain Risk Analysis in Kub – Ik Mataram Macoa With House of Risk (Hor). *Journal of Industrial Engineering Management*, *6*(2), 51–60. https://doi.org/10.33536/jiem.v6i2.942

Pradana, V. A., & Jakaria, R. B. (2020). Pengendalian Persediaan Bahan Baku Gula Menggunakan Metode EOQ Dan Just In Time. *Bina Teknika*, *16*(1), 43. https://doi.org/10.54378/bt.v16i1.1816

Rizky, C., Sudarso, Y., & Sadriatwati, S. E. (2016). Analisis Perbandingan Metode EOQ dan Metode POQ dengan Metode Min-Max dalam Pengendalian Persediaan Bahan Baku Pada PT. Sidomuncul Pupuk Nusantara. *Admisi Dan Bisnis*, *17*(1), 78. http://kbbi.web.id/biolit

Rosyidi, M. R., & Zabadi, F. F. (2019). Perencanaan Produksi pada Produk Hollow dengan Ukuran 15 mm X 35 mm X 0.30 mm. Jurnal Rekayasa Sistem Industri, 8(1), 27–38. https://doi.org/10.26593/jrsi.v8i1.3099.27-38

Setiawan, I., Nurdiansyah, Tosin, M., Lusia, V., & Wahid, M. (2022). Aggregate Planning Implementation for Planning and Controlling the Materials in the Beverage Packaging Industry. *Spektrum Industri*, *20*(1), 95–104. https://doi.org/10.12198/spektrum.v20i1.25

Taufik, D. A., Setiawan, I., Wahid, M., Rochim, A., & Tosin, M. (2021). Integrasi Linear Regression dan Aggregate Planning untuk Perencanaan dan Pengendalian Produksi Leaf Spring Hino OW 190/200 di Industri Komponen Otomotif. *Operations Excellence: Journal of Applied Industrial Engineering*, *13*(2), 245. https://doi.org/10.22441/oe.2021.v13.i2.023