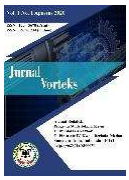
JURNAL ILMIAH TEKNIK MESIN, INDUSTRI, ELEKTRO DAN SIPIL



APPLICATION OF MIN-MAX STOCK METHOD IN THE OPTIMIZATION OF AUXILIARY RAW MATERIAL INVENTORY IN THE BIODIESEL INDUSTRY

Indrian Saputra Amta[1*], Masdania Zurairah Siregar[2], Muhammad Fiza Lubis[3]

[1,2,3] Industrial Engineering, Faculty of Engineering, Universitas Al Azhar Medan Jl. Pintu Air IV No.214, Kwala Bekala, Kec. Medan Johor, Kota Medan, Sumatera Utara 20143

Email: [*]amtaindriansaputra@gmail.com

Info Article

Historical Articles:

Receive: October 5, 2024

Accept and revise: October 10, 2024

Approved: October 13, 2024

Keywords: Inventory Control, Auxiliary Raw Materials, Min-Max Stock, Biodiesel, Cost Optimization

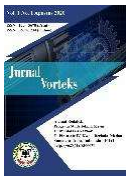
Abstract

Inventory is an aspect of manufacturing operations to ensure the availability of raw materials while minimizing costs. PT. Permata Hijau Palm Oleo Belawan, a biodiesel company, faces challenges in balancing the inventory levels of key auxiliary raw materials such as Methanol, Catalyst, NaOH, and HCl. Excessive inventory results in high storage costs, while inventory shortages can disrupt production continuity. This study aims to evaluate the effectiveness of the Min-Max Stock method in optimizing auxiliary raw material inventory at PT. Permata Hijau Palm Oleo Belawan, addressing its practical impacts on cost reduction and efficiency improvement in the palm oil-based biofuel industry. This study uses a quantitative approach, utilizing historical data on the purchase and usage of raw materials during the 2019-2020 period. The Min-Max Stock method is applied to determine the optimal inventory level, comparing the actual inventory level with the calculated minimum and maximum thresholds. The implementation of the Min-Max Stock method can save storage costs of around IDR 35 billion. The implementation of the Min-Max Stock method offers a solution that increases efficiency, reduces costs, and prevents production disruptions.

Abstrak

Persediaan merupakan aspek dalam operasi manufaktur untuk memastikan ketersediaan bahan baku sambil meminimalkan biaya. PT. Permata Hijau Palm Oleo Belawan, sebuah perusahaan biodiesel, menghadapi tantangan dalam menyeimbangkan tingkat persediaan bahan baku penolong utama seperti Methanol, Katalis, NaOH, dan HCl. Persediaan yang berlebihan mengakibatkan tingginya biaya penyimpanan, sementara kekurangan persediaan dapat mengganggu kelancaran produksi. Penelitian ini bertujuan untuk mengevaluasi efektivitas metode Min-Max Stock dalam optimizasi persediaan bahan baku penolong di PT. Permata Hijau Palm Oleo Belawan, menghadapi dampak praktisnya dalam pengurangan biaya dan peningkatan efisiensi di industri biofuel berbasis kelapa sawit.

JURNAL ILMIAH TEKNIK MESIN, INDUSTRI, ELEKTRO DAN SIPIL



Kata Kunci: *Pengendalian Persediaan, Bahan Baku Penolong, Min-Max Stock, Biodiesel, Optimasi Biaya*

Penelitian ini menggunakan pendekatan kuantitatif, menggunakan pendekatan kuantitatif, memanfaatkan data historis mengenai pembelian dan pemakaian bahan baku selama periode 2019-2020. Metode Min-Max Stock diterapkan untuk menentukan tingkat persediaan optimal, membandingkan tingkat persediaan aktual dengan ambang batas minimum dan maksimum yang dihitung. Implementasi metode Min-Max Stock dapat menghemat biaya penyimpanan sekitar 35 miliar rupiah. Penerapan metode Min-Max Stock menawarkan solusi yang meningkatkan efisiensi, mengurangi biaya, dan mencegah gangguan produksi.

INTRODUCTION

The manufacturing sector, inclusive of the biodiesel industry, incorporates raw material inventory as a component of the production process.The maintenance of an efficient inventory can facilitate a more seamless production and reduce operating costs for the company [1].Conversely, inadequate inventory management has the potential to impede the production process due to a shortage of raw materials or result in excess inventory, which can lead to waste [2]. A further challenge faced by PT Permata Hijau Palm Oleo Belawan, a biodiesel producer, pertains to the optimal arrangement of auxiliary raw material inventory, including methanol, catalyst, NaOH, and HCl [3]. On the one hand, surplus inventory entails higher storage expenses, while on the other hand, insufficient raw material adversely impacts production, resulting in unfavorable outcomes for the firm.

The manufacturing sector, inclusive of the biodiesel industry, incorporates raw material inventory as a component of the production process [4].The maintenance of an efficient inventory can facilitate a more seamless production and reduce operating costs for the company [5]. Conversely, inadequate inventory management has the potential to impede the production process due to a shortage of raw materials or result in excess inventory, which can lead to waste [6]. A notable challenge faced by PT Permata Hijau Palm Oleo Belawan, a biodiesel producer, pertains to the optimal arrangement of auxiliary raw material inventory, including methanol, catalyst, NaOH, and HCl. On the one hand, surplus inventory entails higher storage expenses, while on the other hand, insufficient raw material adversely impacts production, resulting in unfavorable outcomes for the firm [7].

A variety of methodologies exist for the management of raw material inventories. These include the Economic Order Quantity (EOQ) method, Just-in-Time (JIT), and ABC analysis. Other common examples of inventory formulas include EOQ [8], or economic order quantity, which is used to determine the ideal order size that minimizes the total cost of ordering and storage [4][9]. However, this approach is particularly well-suited for applications in a production environment characterized by stable and periodic demand [10]. However, in industries characterized by dynamic demand within a supply chain, contingent on external suppliers, the implementation of just-in-time (JIT) methodologies, which are designed to minimize inventory based on just-in-time delivery, can result in challenges [11]. Conversely, the ABC analysis places greater emphasis on the classification of raw materials based on their value and frequency. While this approach is beneficial, it does not address the underlying problem of dynamically managing inventory levels.

With regard to biodiesel, the extant research is limited in its focus on auxiliary raw material inventory control, particularly with respect to the implementation of the Min-Max

JURNAL VORTEKS, Vol. 05 No. 02, October 2024 p-ISSN :2746-9778
Website : http://jurnal.alazhar-university.ac.id/index.php/vorteks e-ISSN : 2746-976X
DOI: 10.54123/vorteks.v5i2.407

Stock method. The Min-Max Stock method is a technique that establishes minimum and maximum inventory levels for a company to prevent shortages or overstocks over time [12]. The extant research has predominantly centered on this approach within the context of consumer goods manufacturing or products characterized by shorter production cycles [13]. This study, therefore, is significant in that it focuses on the biodiesel industry, where production is continuous and chemical feedstocks, which have highly variable market prices as inputs in an established industry, are utilized. To the best of our knowledge, the Min-Max Stock model has not yet been applied to this industry to provide outputs similar to those of other industries.

This research constitutes a novel contribution of the Min-Max Stock method to the management of auxiliary raw material inventory in the biodiesel industry, particularly at PT Permata Hijau Palm Oleo Belawan. While extant studies have primarily applied inventory control techniques to manufacturing, a few studies have analyzed these methods for the biofuel industry, which is characterized by certain raw material requirements and attraction of chemicals dependent on volatile prices and supplies. This research contributes to the existing body of knowledge by analyzing the costs of investments in inventory surplus and emphasizing the substantial savings that can be achieved by implementing Min-Max Stock [14]. Consequently, this study provides pragmatic guidance for biodiesel firms to optimize their inventory management, and it can be implemented across similar sectors worldwide [15].

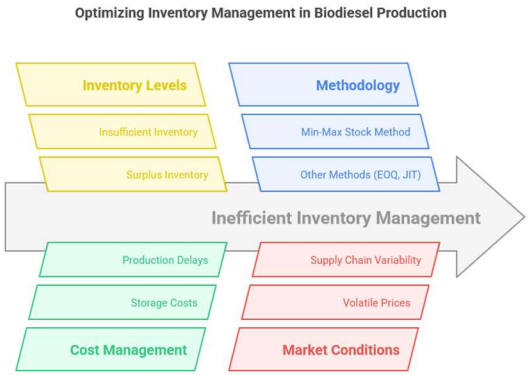


Figure 1 Optimizing Inventory Management in Biodiesel Production

The Min-Max Stock method, which was employed in this study, is a system for inventory control that involves the determination of the minimum and maximum inventory limits for each auxiliary raw material [16]. The calculation steps involved in this method are as follows:

1. Calculation of Safety Stock:
   Safety Stock = (Maximum Discharging -T) x C.....(1)
   Where:
   T = Average consumption of goods per period (kg).
   C = Lead time (bulan).
2. Minimum Inventory Calculation:P Minimum Inventory is calculated by the formula:
   Minimum Inventor = $(T \times C)+R$.....(2)
   where:
   T = Average consumption of goods per period.
   C = Lead time (bulan).
   R = Safety stock (kg).
3. Maximum Inventory Calculation:
   The maximum inventory is calculated by the formula:
   Maximum Inventory = 2 $(T \times C)$ .....(3)
   where:
   T = Average consumption of goods per period.
   C = Lead time (bulan).
4. Reorder Point Calculation:

JURNAL VORTEKS, Vol. 05 No. 02, October 2024 p-ISSN :2746-9778
Website : http://jurnal.alazhar-university.ac.id/index.php/vorteks e-ISSN : 2746-976X
DOI: 10.54123/vorteks.v5i2.407

The reorder point is calculated by the formula:
Q = Max – Min.....(4)
where:
Q = Restocking order rate (kg).
Max = Maximum setup.
Min = Minimum preparation.

RESEARCH METHODS

The objective of this study is to analyze the inventory control of auxiliary raw materials in the biodiesel production process at PT Permata Hijau Palm Oleo Belawan using the min-max stock method. The research method employed in this study is a quantitative approach with a descriptive analysis. In this approach, the data obtained will be systematically analyzed to obtain a clear picture of the existing conditions of inventory control of auxiliary raw materials. The following steps were taken in this research.
The data utilized in this study encompassed both primary and secondary sources.

1. Primary Data:Primary data was obtained through direct interviews with relevant parties involved in inventory management at PT Permata Hijau Palm Oleo Belawan, encompassing the production and raw material procurement departments.This data encompasses information pertaining to the inventory control process, raw material procurement policies, and information related to the demand and utilization of auxiliary raw materials.
2. Secondary data was obtained from company reports, including data on the purchase and use of auxiliary raw materials (methanol, catalyst, NaOH, and HCl) recorded during the 2019-2020 period. This data includes the amount of purchase, usage, and lead time for each raw material, as well as information related to storage costs and investment costs in inventory.

This research was conducted at PT Permata Hijau Palm Oleo Belawan, which is located in Medan, North Sumatra. The data collection period spanned from March to August of 2022. The data that was analyzed encompasses a two-year period, from 2019 to 2020, with the objective of obtaining a comprehensive overview of the management of auxiliary raw material inventory within the company.

The conceptual framework of this research focuses on the application of the Min-Max Stock method for inventory control of auxiliary raw materials in the biodiesel manufacturing process. The main concepts used in this study are

- Safety Stock: It is a reserve of raw materials prepared to deal with fluctuations in demand or delays in the delivery of raw materials.
- Minimum inventory: The amount of inventory that must be maintained to avoid a shortage of raw materials during a given period of time.
- Maximum Inventory: The maximum amount of inventory that can be held to avoid high storage costs.
- Reorder point: The point at which a reorder must be placed to replenish inventory to a predetermined level.
- Inventory Costs: Includes purchase costs, storage costs, and costs associated with unnecessary excess inventory.

RESULTS AND DISCUSSION

The following table presents data on the number of purchases and usage of auxiliary raw materials during the 2019–2020 period.

Table 1 NaOH Purchase in 2019 – 2020

Moon	Year	
	2019(Kg)	2020(Kg)
January	41260	24910
February	32560	74860
March	16270	24850
April	76990	24910
May	16300	24970
June	24030	25010
July	49010	24970
August	16300	24840
September	49760	49880
October	50370	0

JURNAL VORTEKS, Vol. 05 No. 02, October 2024 p-ISSN :2746-9778
Website : http://jurnal.alazhar-university.ac.id/index.php/vorteks e-ISSN : 2746-976X
DOI: 10.54123/vorteks.v5i2.407

November	25180	0
December	25130	24890
Total	423160	324090
Average	35263,3333	27007,5

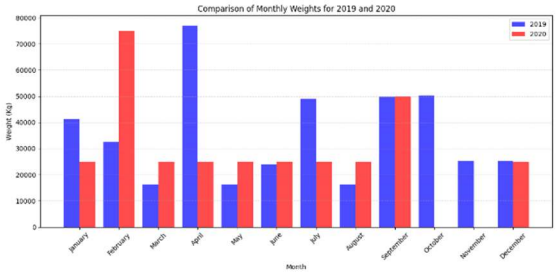


Figure 2 NaOH buying chart

Inventory control constitutes a pivotal component of a company's operational management, particularly within the manufacturing sector, which is contingent upon the accessibility of raw and auxiliary materials.The present study undertakes a meticulous examination and assessment of the inventory control mechanism for auxiliary raw materials, namely HCl (hydrochloric acid) and NaOH (sodium hydroxide), employing the Min-Max Stock method at PT. Permata Hijau Palm Oleo Belawan over the 2019 and 2020 timeframes.

Table 2 NaOH Inventory data 2019 – 2020

Tahun	Safety Stock (Kg)	Minimum Inventory (Kg)	Maximum Inventory (Kg)	Re-Order Point (Kg)	Persediaan Akhir (Kg)	Selisih dari Min-Max (Kg)
2019	6.236	13.959	27.906	13.947	153.387	**+125.481 (Overstock)**
2020	5.391	19.924	29.066	9.142	128.675	**+98.609 (Overstock)**

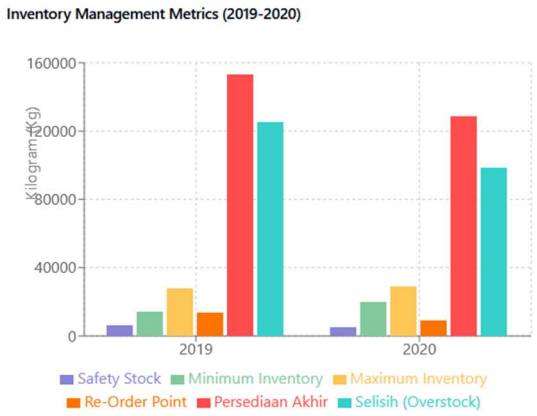


Figure 3 Inventory Chart 2019-2020 (NaOH)

The final inventory value far exceeds the maximum recommended value according to the Min-Max Stock method. In 2019, the final inventory total was 153,387 kilograms, whereas the recommended maximum value was 27,906 kilograms. This results in an excess stock of 125,481 kilograms, which leads to elevated storage costs. In 2020, while there was a modest decline in the final inventory, it remained well above the recommended maximum of 98,609 Kg.The investment costs associated with NaOH stocks in 2020 amounted to IDR 1,821,856,200, underscoring the need for enhanced inventory management to optimize efficiency.

Table 3 HCl Inventory data 2019 – 2020

Tahun	Safety Stock (Kg)	Minimum Inventory (Kg)	Maximum Inventory (Kg)	Re-Order Point (Kg)	Persediaan Akhir (Kg)	Selisih dari Min-Max (Kg)
2019	54.788	276.204	442.832	166.628	169.252	**-107.580 (Understock)**
2020	45.436	191.368	291.864	100.496	184.646	**-106.722 (Understock)**

JURNAL VORTEKS, Vol. 05 No. 02, October 2024 p-ISSN :2746-9778
Website : http://jurnal.alazhar-university.ac.id/index.php/vorteks e-ISSN : 2746-976X
DOI: 10.54123/vorteks.v5i2.407

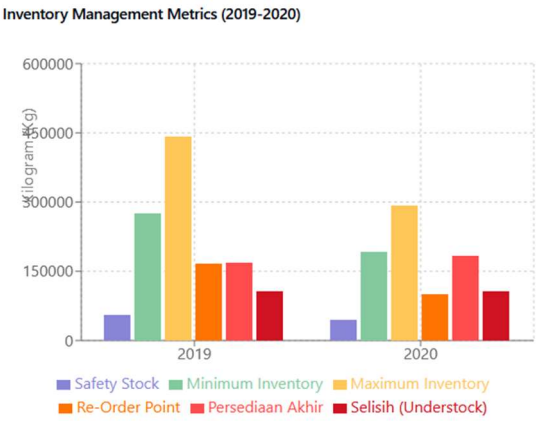


Figure 4 Inventory Chart 2019-2020 (HCl)

In contrast to NaOH, HCl is in short supply compared to the Min-Max Stock calculation.In 2019, the final inventory was only 169,252 kilograms, while the minimum recommended amount was 276,204 kilograms. This indicates a shortage of 107,580 kilograms. In 2020, a stock shortage of 106,722 kg was observed, indicating the potential for operational disruption due to raw material limitations.The investment cost allocated for HCl stock in 2020 was IDR 710,287,200, which is less than the investment cost for NaOH. However, the management of HCl stock requires further optimization.

Table 4 Comparison of NaOH and HCl Evaluation

Evaluation Factors	NaOH (2019-2020)	HCl (2019-2020)
Inventory Condition	**Overstock**	**Understock**
Difference from Min-Max	**98.609 - 125.481 Kg excess**	**106.722 - 107.580 Kg deficiency**
Impact on production	High storage costs	Risk of production delays
Investment Costs	**IDR 1.821.856.200 (2020)**	**IDR 710.287.200 (2020)**

CONCLUSION

1. This study assesses the efficacy of the Min-Max Stock method in optimizing the control of auxiliary raw materials in the biodiesel industry, with a particular focus on PT. Green Gem Palm Oleo Belawan. A comprehensive analysis of historical data from 2019 to 2020 revealed an imbalance in the management of NaOH and HCl raw material inventories.
2. The findings indicate that NaOH inventories are substantially overstocked, with final inventories significantly exceeding the recommended maximum limit. In 2019, excess stock reached 125,481 kilograms, and in 2020, while there was a reduction, there remained an excess stock of 98,609 kilograms. Consequently, the financial investment required for NaOH inventory in 2020 amounted to IDR 1.82 billion, suggesting the presence of inefficiencies in storage costs..
3. Conversely, HCl experienced a supply deficit, which posed a risk to uninterrupted production. In 2019, the inventory shortage amounted to 107,580 kilograms, while in 2020, the deficit reached 106,722 kilograms. This scenario heightens the probability of production disruptions due to inadequate raw materials. In 2020, investment in HCl inventory was recorded at IDR 710.29 million, which is lower than the investment in NaOH. However, this investment highlights the need for optimization of stock management.
4. The findings of the present study indicate that the implementation of the Min-Max Stock method can assist companies in identifying inventory imbalances and providing strategic solutions for optimization. To address excess NaOH stock, companies can implement a Just-in-Time (JIT) approach and adjust the number of orders. Conversely, for HCl, the

JURNAL VORTEKS, Vol. 05 No. 02, October 2024 p-ISSN :2746-9778
Website : http://jurnal.alazhar-university.ac.id/index.php/vorteks e-ISSN : 2746-976X
DOI: 10.54123/vorteks.v5i2.407

company must increase the number of orders to ensure stock stability and prevent production disruptions.

5. The implementation of a more optimal inventory control strategy is recommended for PT. This strategy is expected to enhance operational efficiency, curtail storage expenditures, and ensure the availability of raw materials to facilitate the uninterrupted biodiesel production.

BIBLIOGRAPHY

[1] H. Zhu, "A simple heuristic policy for stochastic inventory systems with both minimum and maximum order quantity requirements," *Ann. Oper. Res.*, vol. 309, no. 1, pp. 347–363, 2022, doi: 10.1007/s10479-021-04441-1.

[2] N. Yilmaz, A. Atmanli, M. J. Hall, and F. M. Vigil, "Determination of the Optimum Blend Ratio of Diesel, Waste Oil Derived Biodiesel and 1-Pentanol Using the Response Surface Method," *Energies*, vol. 15, no. 14, 2022, doi: 10.3390/en15145144.

[3] M. E. Arbabian and H. Rikhtehgar Berenji, "Inventory systems with uncertain supplier capacity: an application to covid-19 testing," *Oper. Manag. Res.*, vol. 16, no. 1, pp. 324–344, 2023, doi: 10.1007/s12063-022-00308-1.

[4] Q. Chen, I. Duenyas, and S. Jasin, "Optimal Use and Replenishment of Two Substitutable Raw Materials in a Stochastic Capacitated Make-to-Order Production System," *Manuf. Serv. Oper. Manag.*, vol. 24, no. 4, pp. 2274–2292, 2022, doi: 10.1287/msom.2021.1059.

[5] P. Luangpaiboon and P. Aungkulanon, "Hybrid Approach for Optimizing Process Parameters in Biodiesel Production from Palm Oil," *Key Eng. Mater.*, vol. 834, pp. 16–23, 2020, doi: 10.4028/www.scientific.net/KEM.834.16.

[6] K. Czajka, W. Kawalec, R. Król, and I. Sówka, "Modelling and Calculation of Raw Material Industry," *Energies*, vol. 15, no. 14, pp. 1–6, 2022, doi: 10.3390/en15145035.

[7] K. A. Umar *et al.*, "Optimization And Characterization Of Used Cooking Oil For Biodiesel Production Using Response Surface Methodology," *AT-TAWASSUTH J. Ekon. Islam*, vol. VIII, no. I, pp. 1–19, 2023, doi: 10.33003/fjs-2023-0706-2081.

[8] M. Andiana and G. Pawitan, "Aplikasi Metode EOQ dalam pengendalian persediaan bahan Bbku PT X," *J. Akunt. Maranatha*, vol. 10, no. 1, pp. 30–40, 2018, doi: 10.28932/jam.v10i1.926.

[9] M. J. Siregar, "Pengendalian stok spareparts mobil dengan metode EOQ dan Min-Max Inventory," *J. Serambi Eng.*, vol. 6, no. 3, pp. 2096–2101, 2021, doi: 10.32672/jse.v6i3.3121.

[10] M. K. Pasha, L. Dai, D. Liu, M. Guo, and W. Du, "An overview to process design, simulation and sustainability evaluation of biodiesel production," *Biotechnol. Biofuels*, vol. 14, no. 1, pp. 1–23, 2021, doi: 10.1186/s13068-021-01977-z.

[11] Z. H. Siregar, U. N. Harahap, and M. Zurairah, "Perencanan bahan baku menggunakan metode Min-Max pada PT Pacific Palmindo Industri," *Talent. Conf. Ser. Energy Eng.*, vol. 3, no. 2, pp. 756–764, 2020, doi: 10.32734/ee.v3i2.1073.

[12] P. Kumar, M. Ramprasad, and Sidharth, "Optimized Biodiesel Preparation from Waste Cooking Oil as a Fuel for Unmodified Diesel Engines," *J. Eng. Res.*, vol. 2021, pp. 1–18, 2021, doi: 10.36909/jer.ICETET.14989.

[13] R. Abdulla *et al.*, "Biodiesel Production from Waste Palm Cooking Oil Using Immobilized Candida rugosa Lipase," *Sustain.*, vol. 14, no. 20, 2022, doi: 10.3390/su142013632.

[14] N. L. Rachmawati and M. Lentari, "Penerapan metode Min-Max untuk Minimasi Stockout dan Overstock persediaan bahan baku," *J. INTECH Tek. Ind. Univ. Serang Raya*, vol. 8, no. 2, pp. 143–148, 2022, doi: 10.30656/intech.v8i2.4735.

[15] R. C. Nnamani, P. N. Okwu, B. John, and O. J. Abayeh, "Preliminary investigation of transesterified waste cooking oil (WCO) as a biodiesel R.," *J. Japan Acad. Nurs. Adm. Policies*, vol. 24, no. 1, pp. 164–174, 2020, doi: https://doi.org/10.46602/jcsn.v45i5.515.

[16] J. B. Bouvier and M. Ornik, "The Maximax Minimax Quotient Theorem," *J. Optim. Theory Appl.*, vol. 192, no. 3, pp. 1084–1101, 2022, doi: 10.1007/s10957-022-02008-z.