



INVENTORY CONTROL OF BROWN PAPER RAW MATERIALS USING THE MATERIAL REQUIREMENT PLANNING METHOD IN PAPER COMPANY

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ABSTRACT

Inventory of raw materials is an essential element in the production process. The research was conducted in a paper company with different product demand problems each period, resulting in excessive raw material inventory in the warehouse and high inventory costs. Material Requirement Planning (MRP) is the right system to deal with uncertainty when planning raw material requirements. The lotting techniques used in this study are Lot For Lot (LFL), Economic Order Quantity (EOQ), and Fixed Period Requirements (FPR). For January 2021 - March 2022, the LFL lot size MRP method resulted in the smallest total inventory cost of Rp 92.228.707.169 and managed to save 9.2% of costs compared to the company's actual costs. Inventory control with LFL lot size for April 2022 – June 2023 requires 14 orders with the DSOCC raw material inventory 11.865.136,77 kg; OCC 5.256.037,55 kg; NDLKCA 4.262.881,19 kg; local box 3.340.998,93 kg and the total cost of inventory is Rp 110.075.072.816,14.

Keywords: Forecasting, Inventory, Material Requirement Planning, Raw Material

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1. INTRODUCTION

Inventory is an asset that includes goods belonging to the company to be sold within a certain period, an inventory of goods still in the production process, or raw materials waiting for users in a production process (Lahu and Sumarauw, 2017). Inventory is one of the riskiest decisions in logistics management. Proper inventory handling will cause serious problems in increasing revenue and maintaining customer relationships (Alam, 2018).

This raw material inventory is important because the production process can only occur if there are enough raw materials to produce the product. Otherwise, the production process cannot be carried out and must be postponed until there is sufficient stock of raw materials. Furthermore, the delay in the production process can lead to a decrease in the company's productivity and the possible inability to meet customer demands. Therefore, raw material inventory control is needed to continue the production process to run smoothly and under control, minimize damage to the material, and determine the optimal raw material inventory (Uyun, Indrayanto and Kurniasih, 2020).

Several raw materials produce brown paper products, including DSOCC, OCC, NDLKCA, and Local Box. The problem faced by the company is that the demand for products in each period is different, resulting in an excessive inventory of raw materials in the warehouse and high inventory costs. In addition, the demand for various products is related to the raw materials used by the company in the production process. Therefore, the company must be precise and fast in inventory control.

Following the problem description, the company should use a method to obtain optimal inventory costs. Many methods can be used to control inventory costs, one of which is the Material Requirement Planning (MRP) method. MRP is a system that is an arrangement of production plans and plans for ordering material components needed to support JIP (Syam, 2020). In general, it can be said that the purpose of MRP is to produce inventory information that can be used to support taking appropriate actions in production (Eddy and Jamudi, 2019). With the MRP system, the company's number of raw materials needed can be seen to complete the production process in the future. Therefore, the company can optimize the inventory of raw

materials needed so that the amount of inventory is not too much or too little.

Several lotting techniques are used, including Lot For Lot (LFL) is a simple approach to determining the order schedule for each period (Wardani and Siswanti, 2018). The second lotting technique is Economic Order Quantity (EOQ), which uses the concept of minimizing total inventory costs (Susmita and Cahyana, 2018). Finally, the third lotting technique is the Fixed Period Requirement (FPR), which determines lot sizes that place orders over a predetermined period, both empirically and intuitively (Uyun, Indrayanto and Kurniasih, 2020).

Production control defines forecasting as estimating the expected demand level for a product or several products in a certain period in the future. Therefore, forecasting is an estimate. It can be said that forecasting is a scientific estimate, although there will be some errors due to limited human abilities (Susmita and Cahyana, 2018). Forecasting paper demand is made to determine the number of raw materials needed. Quantitative forecasting methods are grouped into two types, namely time series methods and causal methods (Pratama *et al.*, 2020). In this study, several forecasting methods were used, namely Moving Average (MA), Weight Moving Average (WMA), and Single Exponential Smoothing (SES). The MA method is a forecasting method carried out by taking a group of observed values and looking for the average value as a forecast for the future period (Rachman, 2018). The WMA method is more responsive to changes because data from the new period usually gives greater weight (Awanda and Oktafianto, 2021). The SES method is a weighted moving average forecasting technique where the data is weighted by an exponential function (Samuel *et al.*, 2020).

The calculation of the Material Requirement Planning (MRP) method with the Lot Sizing technique showed that the Fixed Order Quantity (FOQ) method had a lower total cost of Rp 6.208.100 compared to other Lot Sizing techniques (Desy and Fadhlurrahman, 2019). Using the EOQ model from October 2014 to April 2015 provided savings of Rp 311.612.769 compared to the company's inventory control policy (Susanti, Machfud and Hasbullah, 2015). This research was strengthened by (Arief, Supriyadi and

Cahayadi, 2017) by getting the profits from Rp. 6.096.088.915,00 or 25% higher than the method applied by the company.

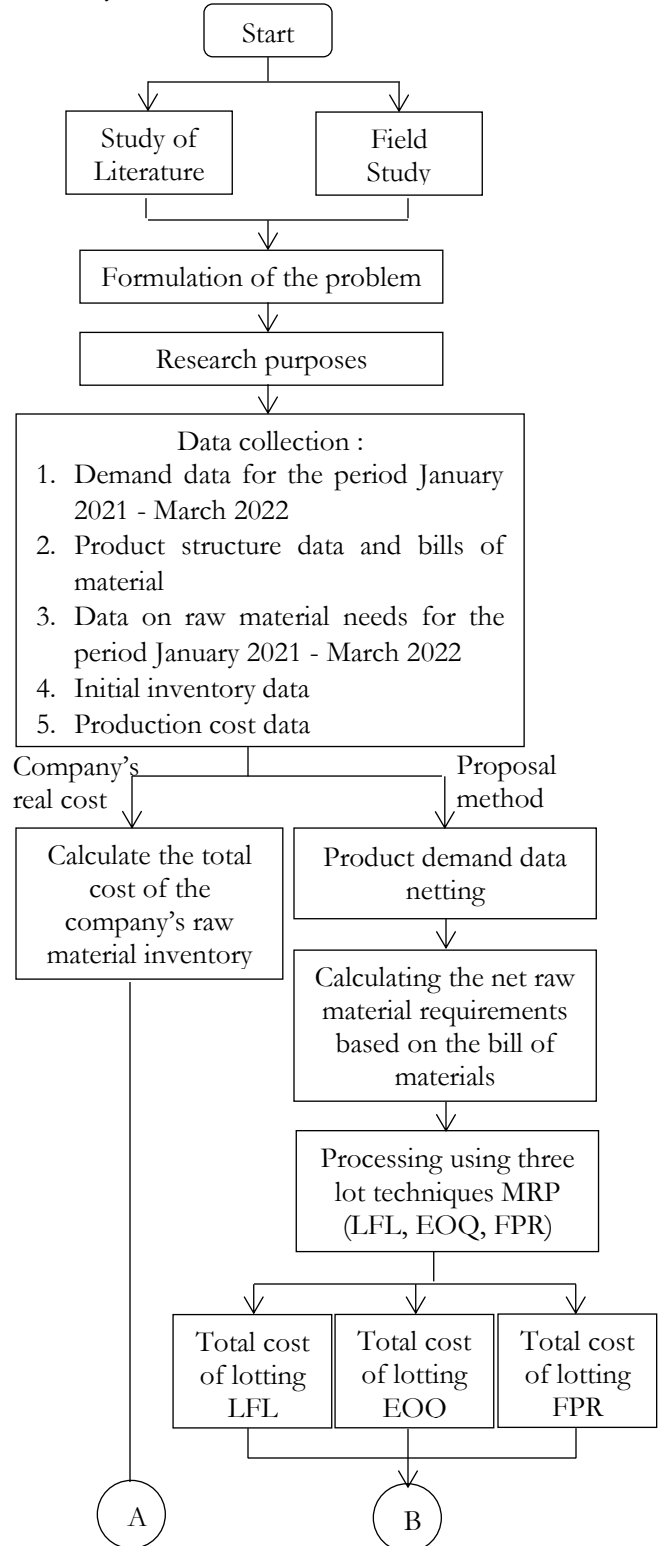
Raw materials, better known as raw materials, are raw materials that will be processed into finished goods as the company's main product (Kurnia, Bastuti and Istiqomah, 2018). Improvement of the raw material inventory control system is needed to overcome the problems encountered. Inventory control by performing analytical calculations is expected to improve an effective and efficient production work system. Inventory control significantly impacts the company in the ongoing production process. The MRP method that will be applied is expected to provide a raw material inventory control plan to produce optimal costs.

2. METHODS

Identification of research needs describes the various stages of research that have been carried out. Starting with a field study conducted with a direct visit to the company and interviews with the parties concerned to understand the problem better. Literature study to determine methods and ways to solve problems. Determine the formulation of the problem followed by determining the objectives so that the research carried out has the direction and goals to be achieved. The data needed consists of 5 variable data: demand data for January 2021 - March 2022, product structure data and bills of material, data on raw material needs for January 2021 - March 2022, initial inventory, and production cost data.

Data processing begins with calculating safety stock, calculating the total cost of inventory using the Material Requirement Planning (MRP) lot size Lot For Lot (LFL), Economic Order Quantity (EOQ) method, and Fix Period Requirement (FPR). Choose the MRP with the lot size that produces the smallest total cost and compare it to the company's total actual cost. Next, plotting demand data to see data patterns as the basis for selecting forecasting methods. Next, determine the forecasting method and, with the help of POM-QM software, calculate each forecasting method's error value (MSE). Forecast verification test with moving range chart (MRC) to see deviations from forecasting data. Determine the need for raw materials for April 2022 – June 2023, which will be used as input

for data processing using the MRP method with the selected lot size to calculate the total cost of raw material inventory for April 2022 - June 2023. After carrying out the data processing process, a discussion is conducted to conclude this study.



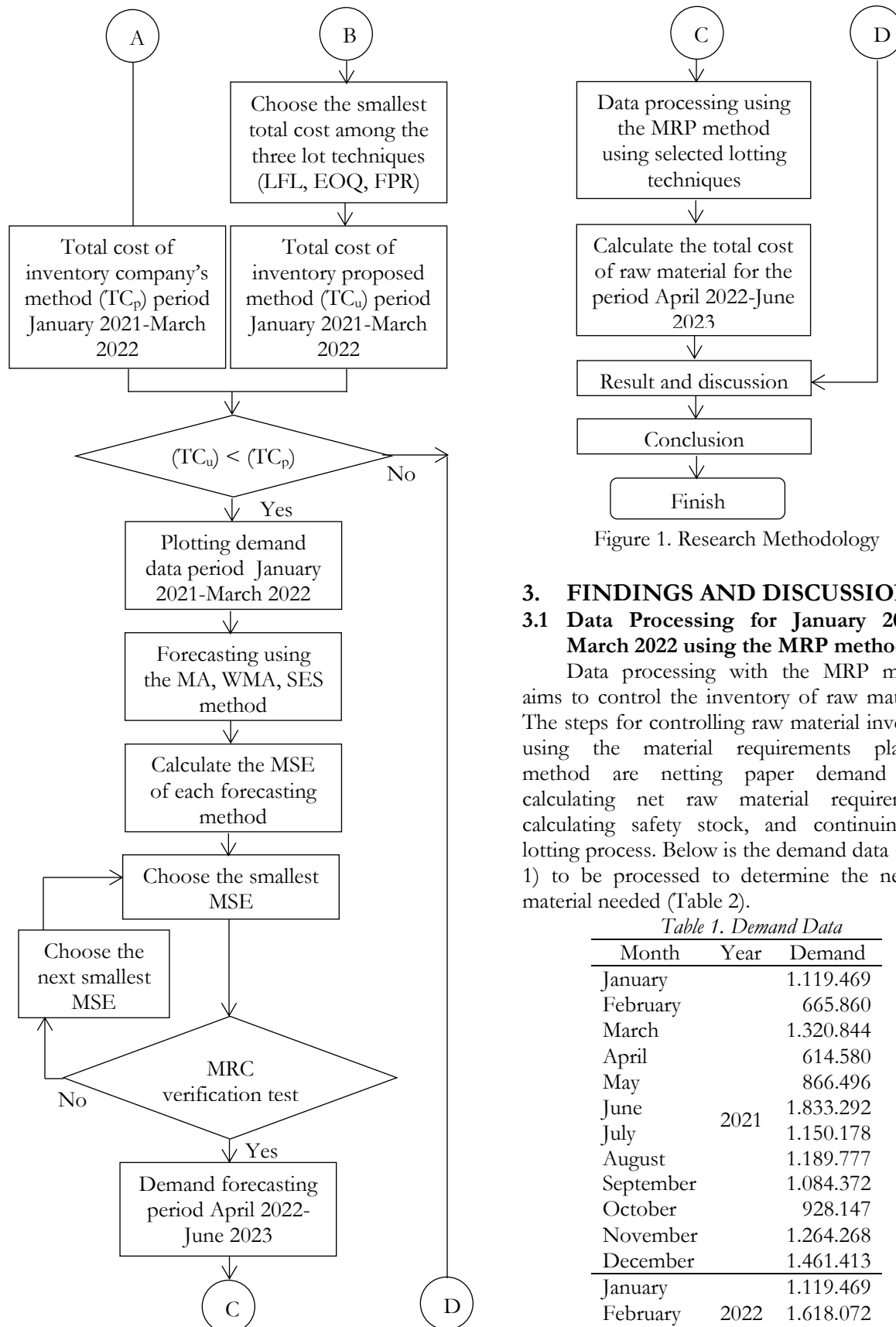


Figure 1. Research Methodology

3. FINDINGS AND DISCUSSION

3.1 Data Processing for January 2021 – March 2022 using the MRP method

Data processing with the MRP method aims to control the inventory of raw materials. The steps for controlling raw material inventory using the material requirements planning method are netting paper demand data, calculating net raw material requirements, calculating safety stock, and continuing the lotting process. Below is the demand data (Table 1) to be processed to determine the net raw material needed (Table 2).

Table 1. Demand Data

Month	Year	Demand
January	2021	1.119.469
February		665.860
March		1.320.844
April		614.580
May		866.496
June		1.833.292
July		1.150.178
August		1.189.777
September		1.084.372
October		928.147
November		1.264.268
December		1.461.413
January	2022	1.119.469
February		1.618.072
March		1.498.389

Table 2. Net Raw Material Demand for the Period January 2021 – March 2022

Month	Year	DSOCC (kg)	OCC (kg)	NDLKCA (kg)	Local box (kg)
January	2021	439.925,83	193.865,62	193.865,62	149.127,40
February		392.857,40	173.123,60	173.123,60	133.172,00
March		779.297,96	343.419,44	343.419,44	264.168,80
April		362.602,20	159.790,80	159.790,80	122.916,00
May		511.232,64	225.288,96	225.288,96	173.299,20
June		1.081.642,28	476.655,92	476.655,92	366.658,40
July		678.605,02	299.046,28	299.046,28	230.035,60
August		701.968,43	309.342,02	309.342,02	237.955,40
September		639.779,48	281.936,72	281.936,72	216.874,40
October		547.606,73	241.318,22	241.318,22	185.629,40
November		745.918,12	328.709,68	328.709,68	252.853,60
December		862.233,67	379.967,38	379.967,38	292.282,60
January	2022	660.486,71	291.061,94	291.061,94	223.893,80
February		954.662,48	420.698,72	420.698,72	323.614,40
March		884.049,51	389.581,14	389.581,14	299.677,80
Total		10.242.868,46	4.513.806,44	4.513.806,44	3.472.158,80

Bill of Materials (BOM) contains information on what raw materials or assemblies are needed to be able to produce goods (Aziz and Suyatno, 2019). The raw materials needed to produce brown paper products can be seen in (Figure 2).

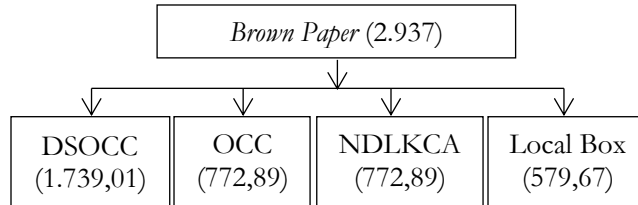


Figure 2. Product Structure Brown Paper

Based on the data structure, it can generate a Bill of Materials (BOM) (Table 3)

Table 3. Bill of Material

Level	Item	Amount	Unit	Description
0	Brown Paper	2.937	Kilo gram	Produce
1	DSOCC	1.739,01	Kilo gram	Buy
1	OCC	772,89	Kilo gram	Buy
1	NDLKCA	772,89	Kilo gram	Buy
1	Local Box	579,67	Kilo gram	Buy

Initial inventory data of raw materials records each material from products to raw materials stored in inventory. Initial inventory data includes the inventory and lead time taken

in December 2020 as initial data for input in the MRP process. Beginning inventory data can be seen in (Table 4).

Table 4. Beginning Inventory of Raw Materials

Item	Initial inventory (kg)	Lead times
Brown paper	373.832	-
DSOCC	1.225.120	1 month
OCC	565.440	1 month
NDLKCA	565.440	1 month
Local Box	131.079	1 month

Safety stock is held to anticipate unexpected stock-out conditions in the company's inventory control. Calculation of safety stock can be known by multiplying the safety factor by the standard deviation with the following formula (Efendi, Hidayat and Faridz, 2019):

$$SS = Z \times \sqrt{\text{lead time}} \times \sigma \quad (1)$$

The results of the safety stock calculation can be seen in (Table 5).

Table 5. Safety Stock

Raw Materials			
DSOCC (Kg)	OCC (Kg)	NDLKCA (Kg)	Local Box (Kg)
188.633,11	83.126,46	83.126,46	63.943,43

There are three types of lot-sizing used in data processing, including Lot For Lot (LFL), Economic Order Quantity (EOQ), and Fix Period Requirement (FPR), to get the minimum

cost. The total cost of inventory with LFL lot size can be seen in (Table 6).

Table 6. Total Inventory Cost of All Raw Materials with Lot Size LFL

Total inventory cost with lot size LFL	
Raw materials	Total cost
DSOCC	Rp 42.492.582.161,46
OCC	Rp 16.711.912.815,42
NDLKCA	Rp 19.282.473.675,53
Local Box	Rp 13.741.738.516,57
Total	Rp 92.228.707.168,98

To determine the economic order quantity (EOQ) can be calculated by the formula (Indah, Purwasih and Maulida, 2018):

$$EOQ = \sqrt{\frac{2.S.D}{H}} \quad (2)$$

The calculation results of the EOQ (Table 7) and the total cost of inventory with lot size EOQ (Table 8).

Table 7. EOQ Calculation Result

Raw material	D (kg)	RC (kg)	HC (Rp/kg)	EOQ (kg)
DSOCC	10.242.868,46	3.890.000	83,56	976.565,51
OCC	4.513.806,44	3.150.000	74,92	616.088,15
NDLKCA	4.513.806,44	3.575.000	84,47	618.120,63
Local Box	3.472.158,80	2.900.000	75,36	516.943,81

Table 8. Total Inventory Cost of All Raw Materials with Lot Size EOQ

Total inventory cost with lot size EOQ	
Raw materials	Total cost
DSOCC	Rp. 45.430.524.054,18
OCC	Rp. 18.112.865.412,40
NDLKCA	Rp. 20.915.798.432,84
Local Box	Rp. 15.246.013.520,16
Total	Rp. 99.705.201.419,59

The results of calculating the total cost of inventory using the lot size FPR can be seen in (Table 9).

Table 9. Total Inventory Cost of All Raw Materials with Lot Size FPR

Total inventory cost with lot size FPR	
Raw materials	Total cost
DSOCC	Rp. 42.846.157.572,87
OCC	Rp. 16.953.375.271,74
NDLKCA	Rp. 19.745.435.969,40
Local Box	Rp. 14.028.892.255,13
Total	Rp. 93.573.861.069,14

The next step is to compare the total cost of inventory using the MRP method with the company's total actual costs and calculate cost-efficiency (Table 10).

Table 10. Comparison and the Level of Cost Efficiency

Lot Size	Nominal	Company's real cost	Difference
LFL	Rp 92.228.707.169		Rp 9.308.378.078
EOQ	Rp 99.705.201.420	Rp 101.537.085.247	Rp 1.831.883.827
FPR	Rp 93.573.861.069		Rp 7.963.224.178

From the calculation of the total cost, raw material inventory was carried out from January 2021 to March 2022 using the company's actual and MRP methods. It can be seen that the company's actual method obtained a total cost of Rp 101,537,085,247. While the MRP method with lot size LFL obtained a total cost of Rp. 92,228,707,169, lot size EOQ obtained a total cost of Rp. 99,705,201,420, and lot size FPR obtained a total cost of Rp. 93,573,861,069. So it can be seen that the MRP lot size LFL method is a lotting technique that produces the smallest total cost of raw material inventory compared to other lotting techniques.

Calculate the level of cost efficiency in order to know whether the proposed MRP method can be used or not. As for how to

calculate the level of cost efficiency, it can be done by comparing the MRP lot size LFL (TC_b) method with the company's actual method (TC_a) as follows:

$$Eff = \frac{(TC_a) - (TC_b)}{(TC_a)} \times 100\% \quad (3)$$

Based on the cost-efficiency of raw material inventory, it can be seen that using the MRP lot size LFL method can save raw material inventory costs by 9,2%. Therefore, the proposed MRP method can control raw material inventory costs from April 2022 to June 2023.

3.2 Forecasting Period April 2022 – June 2023

Forecasting aims to estimate how much demand and need in the future. After plotting the demand data to find out the data pattern, it

is known that the demand data seems to fluctuate in parallel, which is called a horizontal pattern. Forecasting methods that match the horizontal pattern are Moving Average (MA), Weight Moving Average (WMA), and Single Exponential Smoothing (SES). After performing forecasting calculations according to the data plot, each forecasting method's Mean Square Error (MSE) value is obtained with the help of POM-QM software (Table 11).

Table 11. Comparison MSE

	MSE
Moving Average	120.319.200.000
Weight Moving Average	135.486.000.000
Single Exponential Smoothing (0,2)	122.798.600.000

Based on the MSE value, it can be seen that forecasting using Moving Averages has the smallest MSE value. Next, perform a data verification test to see whether the selected forecasting results can be used or not using the Moving Range Chart (MRC) in (Figure 3).

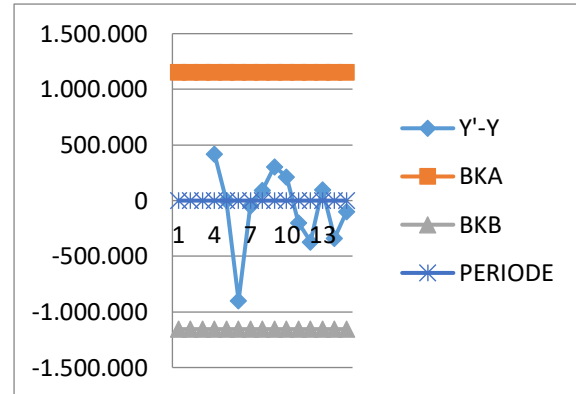


Figure 3. Demand Forecasting MRC Graph

The results show that all data are controlled so that the forecasting data using moving averages can be used to calculate inventory control for April 2022 to June 2023.

3.3 Calculation of Total Inventory Cost for the Period April 2022 – June 2023 using the MRP Method

After finding the chosen forecasting method, the next step is to calculate the cost of raw material for brown paper for the period April 2022 to June 2023 based on the demand forecasting data that has been done. Below (Table 12) is data on raw material requirements.

Table 12. Net Raw Material Demand Data for the Period April 2022 – June 2023

Month	Year	DSOCC (kg)	OCC (kg)	NDLKCA (kg)	Local Box (kg)
April	2021	624.674,69	275.280,37	275.280,37	211.754,13
May		888.168,76	391.396,40	391.396,40	301.074,16
June		847.636,68	373.534,81	373.534,81	287.334,47
July		849.009,76	374.139,89	374.139,89	287.799,92
August		856.290,56	377.348,38	377.348,38	290.267,99
September		861.605,07	379.690,37	379.690,37	292.069,51
October		850.979,00	375.007,69	375.007,69	288.467,46
November		855.635,13	377.059,55	377.059,55	290.045,81
December		856.291,54	377.348,81	377.348,81	290.268,32
January		856.073,06	377.252,54	377.252,54	290.194,26
February		854.301,89	376.472,02	376.472,02	289.593,86
March		855.999,91	377.220,30	377.220,30	290.169,46
April	2022	855.555,50	377.024,46	377.024,46	290.018,81
May		855.458,29	376.981,62	376.981,62	289.985,86
June		855.285,76	376.905,59	376.905,59	289.927,38
Total		12.622.965,58	5.562.662,80	5.562.662,80	4.278.971,38

Initial inventory data includes the inventory and lead time taken in March 2022 as initial data for input in the MRP process. Beginning inventory data can be seen in (Table 13).

Table 13. Initial Inventory of Raw Materials

No	Item	Initial inventory	Lead times
1	Brown Paper	353.206	-
2	DSOCC	812.460	1 month
3	OCC	330.700	1 month
4	NDLKCA	275.000	1 month
5	Local Box	149.679	1 month

The results of the safety stock calculation for April 2022 to June 2023 can be seen in (Table 14).

Table 14. Safety Stock

Bahan Baku			
DSOCC (Kg)	OCC (Kg)	NDLKCA (Kg)	Box Lokal (Kg)
54.631,45	24.074,87	24.074,87	18.519,13

After getting the data input results for the Material Requirement Planning (MRP) method, the next step is to process the MRP lot size Lot For Lot (LFL). (Table 15)

Table 15. Raw Material DSOCC using Lot Size LFL

Level: 1			Lead times: 1 month			
Raw material: DSOCC			Safety Stock: 54.631,45 kg			
Period	0	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022
Gross Requirement		624.674,69	888.168,76	847.636,68	849.009,76	856.290,56
Scheduled Receipt						
Projected on-Hand	812.460	187.785,57	54.631,45	54.631,45	54.631,45	54.631,45
Net Requirement			755.014,64	847.636,68	849.009,76	856.290,56
Planned Order Receipt			755.014,64	847.636,68	849.009,76	856.290,56
Planned Order Release		755.014,64	847.636,68	849.009,76	856.290,56	861.605,07
Period	Sep 2022	Oct 2022	Nov 2022	Des 2022	Jan 2023	Feb 2023
Gross Requirement	861.605,07	850.979,00	855.635,13	856.291,54	856.073,06	854.301,89
Scheduled Receipt						
Projected on-Hand	54.631,45	54.631,45	54.631,45	54.631,45	54.631,45	54.631,45
Net Requirement	861.605,07	850.979,00	855.635,13	856.291,54	856.073,06	854.301,89
Planned Order Receipt	861.605,07	850.979,00	855.635,13	856.291,54	856.073,06	854.301,89
Planned Order Release	850.979,00	855.635,13	856.291,54	856.073,06	854.301,89	855.999,91
Period	Mar 2023	Apr 2023	May 2023	Jun 2023	Total	
Gross Requirement	855.999,91	855.555,50	855.458,29	855.285,76	12.622.965,58	
Scheduled Receipt						
Projected on-Hand	54.631,45	54.631,45	54.631,45	54.631,45	1.765.086,08	
Net Requirement	855.999,91	855.555,50	855.458,29	855.285,76	11.865.136,77	
Planned Order Receipt	855.999,91	855.555,50	855.458,29	855.285,76	11.865.136,77	
Planned Order Release	855.555,50	855.458,29	855.285,76		11.865.136,77	

Table 16. Total Inventory Cost of All Raw Materials with Lot Size LFL

Total inventory cost with LFL	
Raw material	Total cost
DSOCC	Rp 54.378.165.090,44
OCC	Rp 21.616.497.504,42
NDLKCA	Rp 20.250.716.803,00
Local Box	Rp 13.829.693.418,28
Total	Rp 110.075.072.816,14

Inventory control of brown paper raw materials for the period April 2022 to June 2023 uses the Material Requirement Planning (MRP) lot size Lot For Lot (LFL) method, which requires a total order of 11.865.136,77 kg of DSOCC raw materials; OCC raw materials as much as 5.256.037,55 kg; NDLKCA raw materials as much as 4.262.881,19 kg; and Local Box raw materials as much as 3.340.998,93 kg with the number of orders for each raw material

14 times in 15 months. In comparison, the total cost of raw material inventory needed Rp 110.075.072.816,14.

4. CONCLUSION AND SUGGESTION

4.1 Conclusion

Based on the data processing results, the total cost of brown paper raw materials is calculated for January 2021 to March 2023. Using the company's actual and the Material Requirement Planning (MRP) method, the cost of raw materials includes the company's actual Rp 101.537.085.247; the proposed method is the MRP lot size LFL of Rp 92.228.707.169; lot size EOQ of Rp 99.705.201.420; and the lot size FPR is Rp 93.573.861.069. The smallest total cost of raw material inventory uses the MRP lot size LFL method of all the lotting techniques used. So the MRP lot size LFL method was chosen to control the brown paper raw materials inventory from April 2022 to June 2023 with a percentage savings of 9,2% or a cost difference of Rp 9.308.378.078.

Inventory control of brown paper raw materials for April 2022 to June 2023 uses demand forecasting with the moving average method, which gets an MSE value of 120.319.200.000. For the Material Requirement Planning (MRP) lot size Lot for Lot (LFL) method, a total order for DSOCC raw materials is 11.865.136,77 kg; OCC raw materials as much as 5.256.037,55 kg; NDLKCA raw materials as much as 4.262.881,19 kg; Local Box raw materials as much as 3.340.998,93 kg with the number of orders for each raw material as much as 14 times in 15 periods. Therefore, the total cost of raw material inventory needed is Rp 110.075.072.816,14.

4.2 Suggestion

Suggestions for companies that can be used to improve inventory control are

1. The company pays attention to controlling the brown paper raw materials inventory to avoid purchasing excessive raw materials, resulting in higher inventory costs.
2. Provide safety stock to anticipate a shortage of raw materials.
3. Consider the company to use the Material Requirement Planning (MRP) lot size Lot For Lot (LFL) in controlling raw material

inventory because it is proven that there are inventory costs.

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