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# Analysis of E-Flute Raw Material Inventory Control using the Material Requirement Planning (MRP) Method in a Cardboard Packaging Company

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**Abstract:- Cardboard packaging companies are companies thatproduces various types of packaging products including Master Boxes, Archive Boxes, Mosnon Boxes, Small Cartons, Big Cartons). Cardboard packaging companies have not implemented good inventory management when purchasing E-Flute raw materials, soInventory control in these companies often experiences problemsnamely ordering and using inappropriate raw materials, sometimes in excess and sometimes in shortage. Optimum material requirements planning is carried out using the Material Requirement Planning (MRP) method. This method begins by forecasting the number of requests for the future. This forecasting is carried out using the Moving Average, Exponential methodSmootingand Linear Regression. After knowing the price of raw materials, data on material requirements, and costs for inventory and material storage, then a comparison of inventory planning costs is carried out using the Lot For Lot (LFL) method.AndEconomic Order Quantity (EOQ). From the calculation results of the two methods, the method that produces the minimum inventory costs is selected. The Lot For Lot (LFL) technique produces the lowest total inventory costs, namely Rp4.800.000,-**

***Keywords:-*** *Lot Sizing, Material Requirement Planning (MRP), Forecasting.*

## I. INTRODUCTION

In the midst of increasingly varied and competitive competition, an industry operating in the manufacturing sector is required to provide all production needs quickly and accurately, including the provision of raw materials. The process of procuring raw materials and their availability can support the smooth production process[1]. The main goal is to obtain optimal profits so that the company's activities can continue, that is what is expected by all companies, both businesses operating in the service and production sectors.[2]. Therefore, good analysis is needed in determining the quantity and time of ordering raw materials.

Cardboard packaging companies produce various types of products including Master Boxes, Archive Boxes, Mosnon Boxes, Small Cartons, Big Cartons). This company orders raw materials from suppliers using a pre-order system. This kind of ordering system results in companies not being able to control raw material supplies optimally due to uncertainty in the stock held by suppliers.

The process of purchasing raw materials at the Cardboard Packaging Company is carried out based on the same quantity as the previous purchase, without any adjustments or changes in quantity in each purchase transaction. Companies are expected to be able to estimate the use of raw materials in order to anticipate stockouts of material inventory which could cause disruption to the production process. Disruptions in the production process cause delays in sending orders to customers.

Every month the factory experiences an average shortage of 1.81% during the period 2022 - 2023. The thing that causes the shortage to occur is because the average production output is more than the previously determined production plan. An increase in production quantities is usually influenced by increased market demand in a certain period. Therefore, the thing that must be considered is how to carry out appropriate forecasting methods for planning future production needs to increase inventory cost efficiency and reduce production shortage costs. The Material Requirement Planning (MRP) method controls inventory so that the components needed can be determined so that the production process is not hampered and is in accordance with the master production schedule that has been determined.

Material Requirement Planning (MRP) Method Takes lead time into account in planning material requirements, ensuring raw materials arrive on time to meet the production schedule. This is very important for primary raw materials that are bound in nature which require proper planning so as not to disrupt production. The Material Requirement Planning (MRP) approach is the right approach to help companies schedule material inventory.[3]Defining MRP as a plan in production management that discusses the appropriate way to plan the raw material requirements needed during the production process, so that the raw materials needed by the company can be available as planned.

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## II. LITERATURE REVIEW

### A. Supply

[4]defines inventory as a general term that includes everything or organizational resources that are stored as a way of anticipating the fulfillment of demand. This request can be in the form of raw materials, goods in process, finished goods, or final products (finished products). The term inventory has different meanings, but basically the aims and objectives are the same.

### B. Inventory Control

According to[5]Material stock management is a method for monitoring the volume or composition of inventory and production materials, enabling companies or manufacturers to effectively and efficiently ensure the smooth running of the production process. Herjanto[6]adding that the amount of inventory that needs to be maintained (safety stock) and when to reorder (reorder point) are regulated by a series of policies or control rules.

### C. Forecasting

Forecasting in demand management is predicting the demand for independent demand items in the future, which is then combined with definite order service, so that we can know the total demand for an item or product, making it easier to manage production and inventory[7].

➢ *Forecasting Models*

The choice of forecasting model will depend on the data pattern and the time horizon of the forecast. There are a number of forecasting models that have been developed currently. Several forecasting models according to[7]are as follows :

- *Moving Average Model (Moving Average)*

The moving average model uses a number of new actual demand data to obtain forecast data for future demand. This model assumes that market demand for the product will be stable over time.

- *Trend Line Analysis Model (Trend Linear Analysis)*

The trend line analysis model is used as a forecasting model if the historical pattern of actual demand data shows an upward trend over time.

- *Exponential Smoothing Model (Exponential Smoothing)*

The exponential smoothing model is used when the historical pattern of actual demand data is volatile or unstable over time

- *Weighted Moving Average Model (Weighted Moving Averages)*

The weighted moving average model is more responsive to changes, because data from new periods is usually given greater weight.

### D. Forecasting Model Testing

Testing of the forecasting model needs to be carried out to determine the extent of the reliability of the selected forecasting model. Here are several ways to test forecasting models according to[7]:

➢ *Mean Absolute Deviation(MAD)*

Mean Absolute Deviation(MAD) measures forecast accuracy by the average forecast error (the absolute value of each error). MAD is useful for analyzing or measuring forecast errors in the same units as the original series. The following is the formula for calculating MAD.

$$\text{MAD} = \frac{\sum(\text{Absolute dari forecast errors})}{n}$$

Where :

MAD = Mean Absolute Deviation

n = forecasting period

Absolute forecast error = absolute value of the difference between actual demand and forecast.

➢ *Mean Square Error(MSE)*

Mean Square Erroris another method for evaluating forecasting methods which is the average of the squared deviation values of the data. The MSE calculation formula is as follows:

$$\text{MSE} = \frac{\sum(\text{Absolute dari forecast errors})^2}{n}$$

Where :

MSE = Mean Square Error

n = forecasting period

Forecast error = the value of the difference between actual demand and the forecast

➢ *Mean Absolute Percentage Error(MAPE)*

Mean Absolute Percentage ErrorIt can also be used to compare the accuracy of the same or different methods in two very different series and measure the accuracy of the estimated model value expressed in the form of an average absolute percentage error. MAPE can be calculated using the following formula:

$$\text{MAPE} = \frac{\sum(\text{Absolute dari forecast errors})^2}{n\ (A)}$$

Where :

MAPE = Mean Absolute Percentage Error

n = forecasting period

A = actual demand Absolute forecast error = absolute value of the difference between actual demand and forecast

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*E. Material Requirement Planning (MRP)*

According to[7], in 2012 Material Requirement Planning (MRP) can be defined as a systematic technique or set of procedures in determining quantity and time in the process of controlling material requirements for interdependent demand components. (Dependent demand items).

*F. Economic Order Quantity (EOQ)*

According to[8]To calculate inventory control, the Economic Order Quantity (EOQ) method is used, which is a simple inventory method. This method aims to determine an economic order size that can minimize costs in inventory. The EOQ calculation is formulated as follows:

$$EOQ=\sqrt{(2AD)/H}$$

Where :

A = Order Cost

D = Average Demand

H = Holding Cost

*G. Lot For Lot (LFL)*

According to[9], the lot for lot (LFL) method, or also known as the minimum inventory method, is based on the idea of providing inventory (or producing) only what is needed, the amount of inventory is kept to a minimum. The number of orders corresponds to the actual quantity required (lot for lot) resulting in no inventory being stored. So the costs incurred are only in the form of ordering costs. The assumption behind this method is that suppliers (outside or on the factory floor) do not require specific lot sizes; This means that whatever lot size you choose will be fulfilled.

*H. Safety Inventory (Safety Stock)*

Definition of safety stock according to[10]is additional inventory held to protect or guard against the possibility of a shortage of materials (Stock Out).

[10]There are several factors that determine the amount of safety stock, namely the average use of raw materials, time factors, costs used. The general formula for Safety Stock for variable demand levels and constant lead times is:

$$SS = z(\sigma d)\sqrt{LT}$$

Where :

SS = Safety Stock

Z = Service Level

σd = Standard Deviation from the level of needs

LT = Grace Time (Lead Time)

*I. Reorder Point (ROP)*

Reorder point(ROP) answered the statement when it would start taking orders. The ROP model occurs when the amount of inventory in stock continues to decrease. Thus, we must determine how much the minimum inventory level must be considered so that there is no inventory shortage. The expected amount is calculated during the grace period. Maybe it can also be added to safety stock which usually refers to the probability or possibility of a stock shortage occurring during the grace period. ROP or what is usually called the reorder quantity limit/point includes requests desired or needed during the grace period, for example additional/extra stock[8]The general formula for Reorder Point (ROP) for variable demand levels and constant lead times is:

$$ROP = d\ LT + SS$$

Where :

D = Average level of demand

LT = Constant lead time

SS = Safety Stock

## III. RESEARCH METHODS

*A. Types of Research*

This research is a type of descriptive quantitative analysis research. This approach is rooted in theory, expert views and the author's personal experience, which is then applied to empirical data to verify the accuracy of the solution to the problem under study, as described by Tanzeh (2009:

*B. Time and Place*

The research was conducted at the Cardboard Packaging Company located at Jl. Kedaung BKKBN, Bekasi City. The object of this research is data on E-Flute raw materials at Cardboard Packaging Companies for the period January 2022 – December 2023

*C. Data Collection Technique*

This research applies three different integrated approaches, which include:

- *Interview*

In the context of this research, interviews are questions and answers from predetermined points.

- *Observation*

Observations were carried out in this research to determine and collect information regarding the existing conditions of the raw material inventory control system for packaging carton boxes in the field and ongoing processes.

- *Documentation*

In the context of this research, observation is used to identify and collect data about the real situation of the raw material inventory control system at the Cardboard Packaging Company and the ongoing processes.

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## IV. RESEARCH RESULTS AND DISCUSSION

### *A. Data on Production Plans and Use of Raw Materials*

This data is used as a basis for forecasting demand for E-Flute raw materials for the 2022-2023 period.

Table 1 Production Plan and Actual Production for the 2022-2023 period.

| No | Period | Production plan | Actual Production | Difference | % |
|---|---|---|---|---|---|
| 1 | Jan-22 | 9.339 | 8.816 | 523 | 0,94 |
| 2 | Feb-22 | 9.107 | 9.057 | 50 | 0,99 |
| 3 | Mar-22 | 9.750 | 8.537 | 1.213 | 0,88 |
| 4 | Apr-22 | 6.571 | 5.984 | 587 | 0,91 |
| 5 | May-22 | 8.661 | 7.928 | 733 | 0,92 |
| 6 | Jun-22 | 8.643 | 7.651 | 992 | 0,89 |
| 7 | Jul-22 | 4.214 | 5.149 | -935 | 1,22 |
| 8 | Aug-22 | 7.964 | 7.974 | -9 | 1,00 |
| 9 | Sep-22 | 10.875 | 10.543 | 332 | 0,97 |
| 10 | Oct-22 | 10.714 | 8.736 | 1.979 | 0,82 |
| 11 | Nov-22 | 7.125 | 6.657 | 468 | 0,93 |
| 12 | Dec-22 | 9.982 | 9.299 | 684 | 0,93 |
| 13 | Jan-23 | 7.625 | 7.899 | -274 | 1,04 |
| 14 | Feb-23 | 5.500 | 4.270 | 1.230 | 0,78 |
| 15 | Mar-23 | 10.518 | 9.664 | 854 | 0,92 |
| 16 | Apr-23 | 6.786 | 6.182 | 604 | 0,91 |
| 17 | May-23 | 9.732 | 9.899 | -167 | 1,02 |
| 18 | Jun-23 | 8.750 | 7.749 | 1.001 | 0,89 |
| 19 | Jul-23 | 5.804 | 6.348 | -545 | 1,09 |
| 20 | Aug-23 | 5.857 | 5.652 | 205 | 0,96 |
| 21 | Sep-23 | 5.411 | 5.578 | -167 | 1,03 |
| 22 | Oct-23 | 1.071 | 7.289 | -6.217 | 6,80 |
| 23 | Nov-23 | 893 | 9.369 | -8.477 | 10,49 |
| 24 | Dec-23 | 3.214 | 10.404 | -7.189 | 3,24 |
| | **Total** | **174.107** | **186.634** | **-12.527** | **40,57** |
| | **Average** | **7.254** | **7.776** | **-522** | **1,69** |

Source: Company Data 2024

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Table 2 Data on use and Acceptance of E-Flute Raw Materials.

| No | Period | Receipt (Pcs) | Usage (pcs) | Difference | % |
|---|---|---|---|---|---|
| 1 | Jan-22 | 12.880 | 12.213 | 667 | 0,95 |
| 2 | Feb-22 | 12.555 | 12.550 | 5 | 1,00 |
| 3 | Mar-22 | 13.455 | 11.822 | 1.634 | 0,88 |
| 4 | Apr-22 | 9.005 | 8.248 | 757 | 0,92 |
| 5 | May-22 | 11.930 | 10.969 | 961 | 0,92 |
| 6 | Jun-22 | 11.905 | 10.581 | 1.324 | 0,89 |
| 7 | Jul-22 | 5.705 | 7.079 | -1.374 | 1,24 |
| 8 | Aug-22 | 10.955 | 11.033 | -78 | 1,01 |
| 9 | Sep-22 | 15.030 | 14.631 | 399 | 0,97 |
| 10 | Oct-22 | 14.805 | 12.100 | 2.705 | 0,82 |
| 11 | Nov-22 | 9.780 | 9.190 | 590 | 0,94 |
| 12 | Dec-22 | 13.780 | 12.888 | 892 | 0,94 |
| 13 | Jan-23 | 10.480 | 10.929 | -449 | 1,04 |
| 14 | Feb-23 | 7.505 | 5.848 | 1.657 | 0,78 |
| 15 | Mar-23 | 14.530 | 13.400 | 1.130 | 0,92 |
| 16 | Apr-23 | 9.305 | 8.525 | 780 | 0,92 |
| 17 | May-23 | 13.430 | 13.729 | -299 | 1,02 |
| 18 | Jun-23 | 12.055 | 10.719 | 1.336 | 0,89 |
| 19 | Jul-23 | 7.930 | 8.758 | -828 | 1,10 |
| 20 | Aug-23 | 8.005 | 7.783 | 222 | 0,97 |
| 21 | Sep-23 | 7.380 | 7.679 | -299 | 1,04 |
| 22 | Oct-23 | 1.305 | 10.074 | -8.769 | 7,72 |
| 23 | Nov-23 | 1.055 | 12.987 | -11.932 | 12,31 |
| 24 | Dec-23 | 4.305 | 14.435 | -10.130 | 3,35 |
| | **Total** | **239.070** | **258.168** | **-19.098** | **43,54** |
| | **Average** | **9.961** | **10.757** | **-796** | **1,81** |

Source: Company Data 2024

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*B. E-Flute Raw Material Demand Data*

This data is used as a basis for forecasting demand for E-Flute raw materials for the 2022-2023 period.

Table 3 Data on Demand for E-Flute Raw Materials for the Period 2022 - 2023.

| No | Period | E-Flute Request |
|---|---|---|
| 1 | Jan-22 | 12.213 |
| 2 | Feb-22 | 12.550 |
| 3 | Mar-22 | 11.822 |
| 4 | Apr-22 | 8.248 |
| 5 | May-22 | 10.969 |
| 6 | Jun-22 | 10.581 |
| 7 | Jul-22 | 7.079 |
| 8 | Aug-22 | 11.033 |
| 9 | Sep-22 | 14.631 |
| 10 | Oct-22 | 12.100 |
| 11 | Nov-22 | 9.190 |
| 12 | Dec-22 | 12.888 |
| 13 | Jan-23 | 10.929 |
| 14 | Feb-23 | 5.848 |
| 15 | Mar-23 | 13.400 |
| 16 | Apr-23 | 8.525 |
| 17 | May-23 | 13.729 |
| 18 | Jun-23 | 10.719 |
| 19 | Jul-23 | 8.758 |
| 20 | Aug-23 | 7.783 |
| 21 | Sep-23 | 7.679 |
| 22 | Oct-23 | 10.074 |
| 23 | Nov-23 | 12.987 |
| 24 | Dec-23 | 14.435 |
| **Total** | | **258.168** |
| **Average** | | **10.757** |

Source: Company Data 2024

*C. Fee Structure*

Information about the costs that must be incurred in procuring raw material supplies will be described as follows:

- *Order Fees*

Ordering costs for raw materials only include telephone costs and administration costs, which are Rp400.000,- for each order.

- *Saving Fees*

Cost coverage for raw materials consists of material handling costs and storage facility costs. The storage fee is Rp. 221.26,- per piece.

*D. Lead Time(Lead Time)*

Based on the results of interviews with the PPIC section, it is known that the lead time for raw materialsE-Fluteis 7 days.

*E. Product Structure Data*

For cardboard products that will be made for a count of 1 cardboard, you need 1 pc of E-Flute.

*F. Forecasting Raw Material Needs*

Based on data on demand for raw materials for the 2022-2023 period, it can be seen that there are fluctuations in demand for raw materials every month. So this research uses three forecasting methods, namely the Moving Average method, Exponential Smoothing method and Linear Regression method. Meanwhile, to choose the best forecasting method from totwoThis forecasting method can measure the error between actual demand for the 2022-2023 period and the forecast results using Mean Absolute Deviation (MAD), Measurement of Error (MSE) and Mean Absolute Percent Error (MAPE). The calculation methods are compared for each forecasting method and the MAD MSE or MAPE value is looked for the smallest (closest to zero) using Microsoft Excel, then the comparison of MAD values can be seen, MSE and MAPE for each forecasting method used.

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Table 4 Forecasting using the Moving Average Method

| Period | Actual | MA (2) | MAD (2) | MSE (2) | MAPE (2) | MA (3) | MAD (3) | MSE (3) | MAPE (3) | MA (5) | MAD (5) | MSE(5) | MAPE (5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan-22 | 12.213 | | | | | | | | | | | | |
| Feb-22 | 12.550 | | | | | | | | | | | | |
| Mar-22 | 11.822 | 12.382 | 560 | 313.600 | 4,74 | | | | | | | | |
| Apr-22 | 8.248 | 12.186 | 3.938 | 15.508.829 | 47,75 | 12.195 | 3.947 | 15.579.467 | 47,86 | | | | |
| May-22 | 10.969 | 10.035 | 934 | 873.057 | 8,52 | 10.873 | 96 | 9.184 | 0,87 | | | | |
| Jun-22 | 10.581 | 9.608 | 972 | 945.513 | 9,19 | 10.346 | 235 | 55.068 | 2,22 | 11.160 | 580 | 335.820 | 5,48 |
| Jul-22 | 7.079 | 10.775 | 3.696 | 13.663.188 | 52,22 | 9.933 | 2.854 | 8.145.316 | 40,32 | 10.834 | 3.755 | 14.102.654 | 53,05 |
| Aug-22 | 11.033 | 8.830 | 2.204 | 4.855.963 | 19,97 | 9.543 | 1.491 | 2.221.590 | 13,51 | 9.740 | 1.294 | 1.673.789 | 11,73 |
| Sep-22 | 14.631 | 9.056 | 5.575 | 31.079.231 | 38,10 | 9.564 | 5.067 | 25.670.267 | 34,63 | 9.582 | 5.049 | 25.491.391 | 34,51 |
| Oct-22 | 12.100 | 12.832 | 732 | 536.190 | 6,05 | 10.914 | 1.186 | 1.405.608 | 9,80 | 10.858 | 1.241 | 1.540.826 | 10,26 |
| Nov-22 | 9.190 | 13.365 | 4.175 | 17.430.625 | 45,43 | 12.588 | 3.398 | 11.544.139 | 36,97 | 11.085 | 1.894 | 3.588.562 | 20,61 |
| Dec-22 | 12.888 | 10.645 | 2.243 | 5.031.049 | 17,40 | 11.974 | 914 | 836.158 | 7,10 | 10.807 | 2.082 | 4.332.642 | 16,15 |
| Jan-23 | 10.929 | 11.039 | 110 | 12.073 | 1,01 | 11.393 | 463 | 214.755 | 4,24 | 11.968 | 1.039 | 1.079.833 | 9,51 |
| Feb-23 | 5.848 | 11.909 | 6.061 | 36.731.175 | 103,64 | 11.003 | 5.155 | 26.568.870 | 88,14 | 11.948 | 6.100 | 37.205.120 | 104,30 |
| Mar-23 | 13.400 | 8.389 | 5.012 | 25.116.385 | 37,40 | 9.888 | 3.512 | 12.332.973 | 26,21 | 10.191 | 3.209 | 10.298.965 | 23,95 |
| Apr-23 | 8.525 | 9.624 | 1.099 | 1.208.076 | 12,89 | 10.059 | 1.534 | 2.353.667 | 18,00 | 10.451 | 1.926 | 3.710.054 | 22,59 |
| May-23 | 13.729 | 10.963 | 2.766 | 7.650.065 | 20,15 | 9.258 | 4.471 | 19.987.606 | 32,57 | 10.318 | 3.410 | 11.630.828 | 24,84 |
| Jun-23 | 10.719 | 11.127 | 408 | 166.464 | 3,81 | 11.885 | 1.166 | 1.359.167 | 10,88 | 10.486 | 233 | 54.080 | 2,17 |
| Jul-23 | 8.758 | 12.224 | 3.466 | 12.014.023 | 39,58 | 10.991 | 2.233 | 4.987.406 | 25,50 | 10.444 | 1.687 | 2.844.620 | 19,26 |
| Aug-23 | 7.783 | 9.738 | 1.955 | 3.822.514 | 25,12 | 11.068 | 3.285 | 10.792.868 | 42,21 | 11.026 | 3.243 | 10.517.049 | 41,67 |
| Sep-23 | 7.679 | 8.270 | 592 | 350.168 | 7,71 | 9.086 | 1.408 | 1.982.229 | 18,34 | 9.903 | 2.224 | 4.946.398 | 28,96 |
| Oct-23 | 10.074 | 7.731 | 2.344 | 5.491.992 | 23,26 | 8.073 | 2.001 | 4.005.002 | 19,87 | 9.733 | 341 | 116.281 | 3,38 |
| Nov-23 | 12.987 | 8.876 | 4.111 | 16.899.293 | 31,65 | 8.512 | 4.475 | 20.028.608 | 34,46 | 9.002 | 3.985 | 15.879.030 | 30,68 |
| Dec-23 | 14.435 | 11.531 | 2.905 | 8.436.120 | 20,12 | 10.247 | 4.189 | 17.544.230 | 29,02 | 9.456 | 4.979 | 24.791.935 | 34,49 |
| **Total** | **258.168** | **231.133** | **55.857** | **208.135.592** | **575,70** | **219.391,25** | **53.078,42** | **187.624.178,41** | **542,68** | **198.991,90** | **48.270** | **174.139.875,22** | **497,60** |
| **Average** | | | **2.327,38** | **8.672.316,35** | **23,99** | | **2.211,60** | **7.817.674,10** | **22,61** | | **2.011,26** | **7.255.828,13** | **20,73** |

Table 5 Forecasting using the Exponential Smoothing Method

| Period | Actual | α = 0.1 | α = 0.5 | α = 0.9 | MAD 0,1 | MSE 0,1 | MAPE 0,1 | MAD 0,5 | MSE 0,5 | MAPE 0,5 | MAD 0,9 | MSE 0,9 | MAPE 0,9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan-22 | 12.213 | | | | | | | | | | | | |
| Feb-22 | 12.550 | 12.213 | 12.213 | 12.213 | 338 | 113.906 | 2,69 | 338 | 113.906 | 2,69 | 338 | 113.906 | 2,69 |
| Mar-22 | 11.822 | 12.247 | 12.382 | 12.517 | 425 | 180.625 | 3,60 | 560 | 313.600 | 4,74 | 695 | 483.025 | 5,88 |
| Apr-22 | 8.248 | 12.204 | 12.102 | 11.891 | 3.956 | 15.651.914 | 47,97 | 3.854 | 14.851.389 | 46,72 | 3.643 | 13.273.271 | 44,17 |
| May-22 | 10.969 | 11.808 | 10.175 | 8.612 | 839 | 704.550 | 7,65 | 794 | 631.032 | 7,24 | 2.357 | 5.555.095 | 21,49 |
| Jun-22 | 10.581 | 11.724 | 10.572 | 10.733 | 1.144 | 1.308.021 | 10,81 | 9 | 80 | 0,08 | 153 | 23.274 | 1,44 |
| Jul-22 | 7.079 | 11.610 | 10.576 | 10.596 | 4.532 | 20.535.115 | 64,02 | 3.498 | 12.234.474 | 49,41 | 3.518 | 12.372.847 | 49,69 |
| Aug-22 | 11.033 | 11.157 | 8.827 | 7.430 | 124 | 15.292 | 1,12 | 2.206 | 4.865.816 | 19,99 | 3.603 | 12.981.605 | 32,66 |
| Sep-22 | 14.631 | 11.145 | 9.930 | 10.673 | 3.486 | 12.153.621 | 23,83 | 4.700 | 22.094.039 | 32,13 | 3.958 | 15.664.180 | 27,05 |
| Oct-22 | 12.100 | 11.493 | 12.281 | 14.235 | 607 | 367.944 | 5,01 | 181 | 32.683 | 1,49 | 2.135 | 4.559.164 | 17,65 |
| Nov-22 | 9.190 | 11.554 | 12.190 | 12.313 | 2.364 | 5.586.484 | 25,72 | 3.000 | 8.999.355 | 32,64 | 3.123 | 9.753.266 | 33,98 |
| Dec-22 | 12.888 | 11.317 | 10.690 | 9.503 | 1.571 | 2.466.574 | 12,19 | 2.198 | 4.830.341 | 17,05 | 3.385 | 11.461.257 | 26,27 |
| Jan-23 | 10.929 | 11.475 | 11.789 | 12.549 | 545 | 297.320 | 4,99 | 860 | 739.339 | 7,87 | 1.620 | 2.625.065 | 14,82 |
| Feb-23 | 5.848 | 11.420 | 11.359 | 11.091 | 5.572 | 31.047.110 | 95,28 | 5.511 | 30.373.040 | 94,24 | 5.243 | 27.491.886 | 89,66 |
| Mar-23 | 13.400 | 10.863 | 8.604 | 6.372 | 2.537 | 6.438.683 | 18,94 | 4.797 | 23.007.976 | 35,80 | 7.028 | 49.391.701 | 52,45 |
| Apr-23 | 8.525 | 11.117 | 11.002 | 12.697 | 2.592 | 6.716.077 | 30,40 | 2.477 | 6.135.125 | 29,05 | 4.172 | 17.409.403 | 48,94 |
| May-23 | 13.729 | 10.857 | 9.763 | 8.942 | 2.871 | 8.243.298 | 20,91 | 3.965 | 15.721.548 | 28,88 | 4.786 | 22.908.230 | 34,86 |
| Jun-23 | 10.719 | 11.144 | 11.746 | 13.250 | 426 | 181.261 | 3,97 | 1.027 | 1.055.201 | 9,58 | 2.531 | 6.406.592 | 23,61 |
| Jul-23 | 8.758 | 11.102 | 11.232 | 10.972 | 2.344 | 5.496.316 | 26,77 | 2.475 | 6.124.956 | 28,26 | 2.214 | 4.903.401 | 25,29 |
| Aug-23 | 7.783 | 10.867 | 9.995 | 8.979 | 3.084 | 9.514.018 | 39,63 | 2.212 | 4.892.645 | 28,42 | 1.196 | 1.430.264 | 15,37 |
| Sep-23 | 7.679 | 10.559 | 8.889 | 7.903 | 2.881 | 8.297.465 | 37,51 | 1.210 | 1.465.228 | 15,76 | 224 | 50.218 | 2,92 |
| Oct-23 | 10.074 | 10.271 | 8.284 | 7.701 | 197 | 38.702 | 1,95 | 1.791 | 3.205.951 | 17,77 | 2.373 | 5.632.746 | 23,56 |
| Nov-23 | 12.987 | 10.251 | 9.179 | 9.837 | 2.736 | 7.485.390 | 21,07 | 3.808 | 14.502.832 | 29,32 | 3.150 | 9.924.605 | 24,26 |
| Dec-23 | 14.435 | 10.525 | 11.083 | 12.672 | 3.910 | 15.290.834 | 27,09 | 3.352 | 11.236.770 | 23,22 | 1.763 | 3.108.287 | 12,21 |
| **Total** | | | | | **49.080** | **158.130.520** | **533,11** | **54.822** | **187.427.326** | **562,39** | **63.210** | **237.523.287** | **630,92** |
| **Average** | | | | | **2.133,89** | **6.875.240** | **23,18** | **2.384** | **8.149.014** | **24,45** | **2.748** | **10.327.099** | **27,43** |

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Table 6 Forecasting Linear Regression Method

| Period | Period (x) | Actual (y) | xy | x^2 | y^2 | y "= | MAD | MSE | MAPE |
|---|---|---|---|---|---|---|---|---|---|
| Jan-22 | 1 | 12.213 | 12212,75 | 1 | 149.151.263 | 10.947 | 1.266 | 1.602.174 | 10,36 |
| Feb-22 | 2 | 12.550 | 25100,5 | 4 | 157.508.775 | 10.930 | 1.620 | 2.623.720 | 12,91 |
| Mar-22 | 3 | 11.822 | 35464,5 | 9 | 139.747.862 | 10.914 | 908 | 823.665 | 7,68 |
| Apr-22 | 4 | 8.248 | 32991 | 16 | 68.025.380 | 10.897 | 2.650 | 7.020.751 | 32,13 |
| May-22 | 5 | 10.969 | 54845 | 25 | 120.318.961 | 10.881 | 88 | 7.762 | 0,80 |
| Jun-22 | 6 | 10.581 | 63484,5 | 36 | 111.952.271 | 10.864 | 284 | 80.446 | 2,68 |
| Jul-22 | 7 | 7.079 | 49549,5 | 49 | 50.105.162 | 10.848 | 3.769 | 14.208.075 | 53,25 |
| Aug-22 | 8 | 11.033 | 88266 | 64 | 121.732.606 | 10.831 | 202 | 40.768 | 1,83 |
| Sep-22 | 9 | 14.631 | 131676,75 | 81 | 214.058.846 | 10.815 | 3.816 | 14.561.322 | 26,08 |
| Oct-22 | 10 | 12.100 | 120997,5 | 100 | 146.403.950 | 10.798 | 1.301 | 1.693.772 | 10,76 |
| Nov-22 | 11 | 9.190 | 101092,75 | 121 | 84.460.695 | 10.782 | 1.592 | 2.532.968 | 17,32 |
| Dec-22 | 12 | 12.888 | 154656 | 144 | 166.100.544 | 10.765 | 2.123 | 4.506.025 | 16,47 |
| Jan-23 | 13 | 10.929 | 142080,25 | 169 | 119.448.506 | 10.749 | 181 | 32.584 | 1,65 |
| Feb-23 | 14 | 5.848 | 81872 | 196 | 34.199.104 | 10.732 | 4.884 | 23.855.605 | 83,52 |
| Mar-23 | 15 | 13.400 | 201003,75 | 225 | 179.566.700 | 10.716 | 2.685 | 7.206.809 | 20,03 |
| Apr-23 | 16 | 8.525 | 136400 | 256 | 72.675.625 | 10.699 | 2.174 | 4.727.059 | 25,50 |
| May-23 | 17 | 13.729 | 233384,5 | 289 | 188.471.712 | 10.683 | 3.046 | 9.277.141 | 22,19 |
| Jun-23 | 18 | 10.719 | 192937,5 | 324 | 114.891.602 | 10.666 | 53 | 2.768 | 0,49 |
| Jul-23 | 19 | 8.758 | 166392,5 | 361 | 76.693.806 | 10.650 | 1.892 | 3.580.118 | 21,61 |
| Aug-23 | 20 | 7.783 | 155660 | 400 | 60.575.089 | 10.633 | 2.850 | 8.123.070 | 36,62 |
| Sep-23 | 21 | 7.679 | 161248,5 | 441 | 58.959.362 | 10.617 | 2.938 | 8.632.314 | 38,26 |
| Oct-23 | 22 | 10.074 | 221633,5 | 484 | 101.490.513 | 10.600 | 526 | 276.476 | 5,22 |
| Nov-23 | 23 | 12.987 | 298706,75 | 529 | 168.668.663 | 10.584 | 2.404 | 5.777.822 | 18,51 |
| Dec-23 | 24 | 14.435 | 346446 | 576 | 208.376.443 | 10.567 | 3.868 | 14.963.203 | 26,80 |
| **Total** | **300** | **258.168** | **3.208.102** | **4.900** | **2.913.583.438** | **258.168** | **47.117** | **136.156.415** | **492,66** |
| **Average** | **12,50** | **10.757** | **133.671** | **204** | **121.399.310** | | **1.963** | **5.673.184** | **20,53** |

Table 7 Comparison of MAD, MSE and MAPE Error Values

| | Moving Average | | | Exponential Smooting | | | Regresi Linear |
|---|---|---|---|---|---|---|---|
| | 2 Months | 3 Months | 5 Months | α = 0.1 | α = 0.5 | α = 0.9 | |
| MAD | 2.327,38 | 2.211,60 | 2.011,26 | 2.133,89 | 2.384 | 2.748 | 1.963 |
| MSE | 8.672.316 | 7.817.674 | 7.255.828 | 6.875.240 | 8.149.014 | 10.327.099 | 5.673.184 |
| MAPE | 23,99 | 22,61 | 20,73 | 23,18 | 24,45 | 27,43 | 20,53 |

From the table it can be seen that the forecasting method chosen is Linear Regression because it gives a smaller value than the Moving Average or Exponential Smoting method, and if we look at the smallest MAPE value, we will see that the forecast with the smallest deviation is Linear Regression because it gives the highest MAPE value. small (the value is closest to zero). Therefore to make forecastsOnenext year, the method used is the Linear Regression method.

$$Y = a + bx \quad = \frac{n(\Sigma xy) - (\Sigma x)\ (\Sigma y)}{n(\Sigma x^2) - (\Sigma x)^2}$$

$$b = \frac{24(76.994.448) - (300)(256.168)}{24(4900^2) - (300)^2}$$

b= -16.52

$a = - b\bar{Y}\bar{x}$

a = 10,757 - (-16.52)(12.5

a = 10,964

so Y(x) = 10.964 - (-16.52)X

Thus the forecast results for 2024.

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Table 8 Results of Demand Forecasting using Linear Regression

| Period | y | a | b | x-b | a+b |
|---|---|---|---|---|---|
| Jan-24 | 25 | 10.964 | -16,52 | -413 | 10.551 |
| Feb-24 | 26 | 10.964 | -16,52 | -429,52 | 10.534 |
| Mar-24 | 27 | 10.964 | -16,52 | -446,04 | 10.517 |
| Apr-24 | 28 | 10.964 | -16,52 | -462,56 | 10.501 |
| May-24 | 29 | 10.964 | -16,52 | -479,08 | 10.484 |
| Jun-24 | 30 | 10.964 | -16,52 | -495,6 | 10.468 |
| Jul-24 | 31 | 10.964 | -16,52 | -512,12 | 10.451 |
| Aug-24 | 32 | 10.964 | -16,52 | -528,64 | 10.435 |
| Sep-24 | 33 | 10.964 | -16,52 | -545,16 | 10.418 |
| Oct-24 | 34 | 10.964 | -16,52 | -561,68 | 10.402 |
| Nov-24 | 35 | 10.964 | -16,52 | -578,2 | 10.385 |
| Dec-24 | 36 | 10.964 | -16,52 | -594,72 | 10.369 |
| **Total** | | | | | **125.516** |
| **Average** | | | | | **10.460** |
| **Standard deviation** | | | | | **59,56** |

*G. E-Flute raw material inventory planning using the Lot For Lot method*

Table 9 Raw Material Inventory Planning Lot For Lot method

| MRP E-Flute | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LT time = 7 days Lot size = 0 | | | | | | | | | | | | | |
| Method Lot For Lot | | | | | | | | | | | | | |
| | Jan-24 | Feb-24 | Mar-24 | Apr-24 | May-24 | Jun-24 | Jul-24 | Aug-24 | Sep-24 | Oct-24 | Nov-24 | Dec-24 | total |
| Gross Reqruitemnt | 10.551 | 10.534 | 10.517 | 10.501 | 10.484 | 10.468 | 10.451 | 10.435 | 10.418 | 10.402 | 10.385 | 10.369 | 125.516 |
| Schedule Receipts | | | | | | | | | | | | | |
| On Hand | | | | | | | | | | | | | 0 |
| Net Reqruitments | 10.551 | 10.534 | 10.517 | 10.501 | 10.484 | 10.468 | 10.451 | 10.435 | 10.418 | 10.402 | 10.385 | 10.369 | 125.516 |
| Planned Order Receipts | 10.551 | 10.534 | 10.517 | 10.501 | 10.484 | 10.468 | 10.451 | 10.435 | 10.418 | 10.402 | 10.385 | 10.369 | 125.516 |
| Planned Order Release | 10.551 | 10.534 | 10.517 | 10.501 | 10.484 | 10.468 | 10.451 | 10.435 | 10.418 | 10.402 | 10.385 | 10.369 | 125.516 |
| | | | | | | | | | | | | | 0 |

E-Flute ordering cost/Year = 12 x Rp400.000,- = Rp4.800.000,-

Inventory Costs = Ordering Costs + Holding Costs = Rp4.800.000,- + 0 = Rp4.800.000,-

*H. E-Flute raw material inventory planning using the Economic Order Quantity (EOQ) method*

Table 10 EOQ Inventory Calculation

| No | Period | Forecasting Results | Q Optimal | Ending Inventory | Order Fees | Storage Fee/Pcs | Saving Fees | Total cost |
|---|---|---|---|---|---|---|---|---|
| 1 | Jan-24 | 10.551 | 21.303 | 10.753 | 400.000 | 221,26 | 2379117,4 | 2.779.117 |
| 2 | Feb-24 | 10.534 | 21.303 | 10.769 | 400.000 | 221,26 | 2382772,6 | 2.782.773 |
| 3 | Mar-24 | 10.517 | 21.303 | 10.786 | 400.000 | 221,26 | 2386427,8 | 2.786.428 |
| 4 | Apr-24 | 10.501 | 21.303 | 10.802 | 400.000 | 221,26 | 2390083 | 2.790.083 |
| 5 | May-24 | 10.484 | 21.303 | 10.819 | 400.000 | 221,26 | 2393738,3 | 2.793.738 |
| 6 | Jun-24 | 10.468 | 21.303 | 10.835 | 400.000 | 221,26 | 2397393,5 | 2.797.393 |
| 7 | Jul-24 | 10.451 | 21.303 | 10.852 | 400.000 | 221,26 | 2401048,7 | 2.801.049 |
| 8 | Aug-24 | 10.435 | 21.303 | 10.868 | 400.000 | 221,26 | 2404703,9 | 2.804.704 |
| 9 | Sep-24 | 10.418 | 21.303 | 10.885 | 400.000 | 221,26 | 2408359,1 | 2.808.359 |
| 10 | Oct-24 | 10.402 | 21.303 | 10.901 | 400.000 | 221,26 | 2412014,4 | 2.812.014 |
| 11 | Nov-24 | 10.385 | 21.303 | 10.918 | 400.000 | 221,26 | 2415669,6 | 2.815.670 |
| 12 | Dec-24 | 10.369 | 21.303 | 10.934 | 400.000 | 221,26 | 2419324,8 | 2.819.325 |
| **Total** | | **125.516** | **255.637** | **130.121** | **4.800.000** | **2.655** | **28.790.653** | **33.590.653** |
| **Average** | | **10.460** | | | | | | |
| **Standard deviation** | | **59,56** | | | | | | |

$$EOQ = \sqrt{2DS/H}$$

$$EOQ = \sqrt{2 * 125{,}516 * 400{,}000 / 221.26} = 21{,}303$$

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Table 11 Raw Material Inventory Planning EOQ method

| MRP E-Flute | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LT time = 7 days Lot size = 0 | | | | | | | | | | | | | |
| Method Lot For Lot | | | | | | | | | | | | | |
| | Jan-24 | Feb-24 | Mar-24 | Apr-24 | May-24 | Jun-24 | Jul-24 | Aug-24 | Sep-24 | Oct-24 | Nov-24 | Dec-24 | total |
| Gross Reqruitemnt | 10.551 | 10.534 | 10.517 | 10.501 | 10.484 | 10.468 | 10.451 | 10.435 | 10.418 | 10.402 | 10.385 | 10.369 | 125.516 |
| Schedule Receipts | | | | | | | | | | | | | |
| On Hand | 10.753 | 10.769 | 10.786 | 10.802 | 10.819 | 10.835 | 10.852 | 10.868 | 10.885 | 10.901 | 10.918 | 10.934 | 130.121 |
| Net Reqruitments | 10.551 | 10.534 | 10.517 | 10.501 | 10.484 | 10.468 | 10.451 | 10.435 | 10.418 | 10.402 | 10.385 | 10.369 | 125.516 |
| Planned Order Receipts | 21.303 | 21.303 | 21.303 | 21.303 | 21.303 | 21.303 | 21.303 | 21.303 | 21.303 | 21.303 | 21.303 | 21.303 | 255.637 |
| Planned Order Release | 10.551 | 10.534 | 10.517 | 10.501 | 10.484 | 10.468 | 10.451 | 10.435 | 10.418 | 10.402 | 10.385 | 10.369 | 125.516 |

E-Flute ordering fee/Year = 12 x Rp400.000,- = Rp4.800.000,-

Saving Fees = Holding costs OH
=130,121 x 221.26 = Rp28.790.653,-

Inventory Costs = Order Cost + Holding Cost

= Rp4.800.000,- + Rp28.790.653,- = Rp35.590.653,-

*I. Calculation of Reorder Time (Reorder Point)*

In this research, the Reorder Point model is used where the demand level is variable and the Lead Time is constant. Lead time for E-Flute raw materials is 7 days. Before calculating the reorder point, first calculate the raw material usage per day. It can be known as follows:

$$d = = 402.29,-/ (pcs) \frac{125.516}{312}$$

So, the reorder point is:

ROP = raw material usage per day (d) x Lead time

= 402.29 x 7 days = 2816 (pcs)

Thus, the company must reorder if it has stock of E-Flute 2816 (pcs).

*J. Material Requirement Planning (MRP) Calculation Analysis*

The ultimate goal of MRP with different lot size calculations is to determine which lot size calculation technique will be used in planning and scheduling raw material requirementsE-Flutefor January 2022– December 2022. Lot size calculation is a technique for determining the optimal order quantity and determining when is the right time to place an order with the minimum total holding costs and ordering costs.

Table 12 Comparison of Order Costs and Holding Costs

| Method | Order Fees | Saving Fees | Inventory Costs |
|---|---|---|---|
| Lot For Lot | Rp4.800.000 | Rp0 | Rp4.800.000 |
| Economic Order Quantity | Rp4.800.000 | Rp33.590.653 | Rp38.390.653 |

Based on the processing results of the overall costs obtained from the lot size technique above, it can be seen that all ordering costs have the same total cost, namely Rp4.800.000,- this is because orders are made for all methods once a month. There is no charge for Lot For Lot (LFL) holding fees because there are no leftover items from the previous month to store, but for Economic Order Quantity (EOQ) there is a holding fee of Rp35.590.653,-

In the end, what produces the minimum material supply costs theoretically is the LFL method to be used in planning raw material supplies.

## V. CONCLUSIONS AND RECOMMENDATIONS

*A. Conclusion*

In this research, the following conclusions were obtained:

- The main influencing factors in planning and controlling E-Flute raw material inventory include market demand, lead time, inventory costs, and frequency of material use.
- For planning and controlling E-Flute raw material inventory, the MRP method with Linear Regression forecasting has proven to be effective and efficient, where this is shown by the error values for each MAD 1963, MSE 5.673.184 and MAPE 20,53 which are lower/smaller than using Moving Average and Exponential Smoothing forecasting,
- The correct Re-Order Point for E-Flute raw material requirements using the Linear Regression forecasting MRP method when raw material stock is less than or equal to 2,816 pcs.

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- The amount of storage costs using the MRP method of Linear Regression forecasting Lot For Lot technique is Rp4.800.000,- proven to be more efficient/lower than using other planning and control methods, for example EOQ

*B. Suggestion*

After discussing forecasting and Material Requirement Planning (MRP). Below are some suggestions that can be taken by the author to be taken into consideration as input for the company and for further research activities in improving the company's existing inventory system planning. This is of course intended so that the company's inventory planning can be carried out better for the smooth running of the production process. These suggestions include the following:

- Companies can pay more attention to the system currently running because as time goes by, a system needs improvement to suit industrial developments.
- Companies must always be able to see incoming demand or order data so that production can run well and can carry out inventory management appropriately.
- Companies should make other considerations in determining production forecasts, not just based on product demand at the end of the previous period. Companies can also consider sales for the past few years to serve as a basis for forecasting future demand.

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