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FORECASTING PLANNING AND PROCUREMENT STRATEGY OF RAW MATERIAL USING MATERIAL REQUIREMENTS PLANNING METHODE

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Abstract: The research was conducted in the building material manufacturing industry. Research focus onplanning and controlling raw fiber roof fiber cement raw material using the Material Requirement Planning method. Problems that occur because of fluctuations in stock. By evaluating the planning process, calculating raw material requirements and then reviewing the most efficient Lotsizing techniques between Fixed Order Quantity, Economic Order Quantity, Lot for Lot, Period Order Quantity. Besides that, a strategy is also studied so that MRP can be applied. From the application of the lot sizing technique, the most efficient lotting method is obtained from the Lot for Lot method at a cost of Rp. 5.29 billion. The application of MRP also has an impact on improving inventory performance, changes in minimum and maximum stock changes that are adjusted to production activities. Efficient purchase costs from total raw material needs with an average value of Rp 8.33 billion.

Keywords: Material Requirements Planning, Forecasting, Lot Size, Bill of Material, Inventory

INTRODUCTION

Every company strives to continue to grow. Improvement of business processes on each line will grow the company and increase business profits. Research conducted in the building materials manufacturing industry with a focus on raw material planning and inventory management. Products with the main raw material in the form of a mixture of chrysotile fiber cement, cellulose fibers and some additives. From the data obtained by the inventory of raw materials is very volatile, high stock results in inefficient supplies, and lack of inventory can be the cause of companies unable to meet market demand.

As a basis for problem identification is the fluctuation of raw material stock in the period 2014 to 2019, the condition of raw materials is a prerequisite for the fulfillment of the needs of the product to be sold. The most important raw material to consider is Chrysotile fiber, which is an imported material with few sources. There are only a few countries that produce chrysotile, namely Russia, China, Brazil. The number of needs is quite large and long distances make the lead time quite high ranging from 4 weeks to 8 weeks, so that this chrysotile becomes a material that requires attention. Based on material inventory data, fluctuating availability one time has a very high stock number, but there are also times where stock shortage occurs. From sales data,The standard shows very high fluctuations. Picture 1 Graph of sales, production output and inventory

Picture 1. Graph of Sales Output and Stock End Inventory conditions for the period 2014 - 2018
(source: Departmental PPC data for 2018)

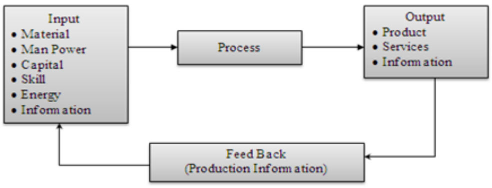
LITERATURE REVIEW

Good control of raw materials will ensure the availability of raw materials in optimum conditions, in order to avoid shortage of raw materials and excessive stock. Good control of raw materials will have a direct impact on the financial aspects. Meeting all needs and not accumulating costs only on material purchases that dominate the costs. If there is a shortage of raw materials, the company will face lost of opportunity for market opportunities, and if there is overstock, it will absorb very large cash flow and can disrupt operations for other needs.

Inventory along the supply chain has major implications for a company's financial performance. Many companies have an inventory value of up to 25% of the total value of assets owned (I Nyoman Pujawan, 2017)

Material Requirements Planning is a concept where in production management that discusses the right way in planning the needs of goods in the production process (Eddy Harjanto, 2018). The purpose of the MRP is to control inventory levels, determine priorities for each item by looking at production capacity or based on forecasting that is done. There are several factors that are taken into account for the successful implementation of MRP including ordering and arrival time of raw materials. So in this case it is very important to know the supply capacity of each supplier and leadtime to predict arrival near the expected time. Then the orientation of the application of MRP is the achievement of optimization of material requirements.

The production function or also commonly called the operation function is a function entrusted with the duties and responsibilities to carry out the activity of converting and processing production resources (assets of input) into outputs, goods or services, according as previously planned (Haming and Mahfud, 2014:4). The illustration as shown Picture 2.



Picture 2 General Model of Production Function
(Source: Haming and Mahfud, 2014)

Forecasting

Forecasting is an art and science in predicting future events. Forecasting will involve taking historical data and projecting that data into the future with a mathematical model (Heizer and Render, 2014)

Forecasting will have an impact on the organization

1) Scheduling: Efficient use of resources requires
2) Getting resources: Lead time
3) MeneDetermine resource requirements
4) technology

Forecasting Methods

Naive approach

The simplest forecasting model assumes that observations in the time period that has just passed (last year, last month and so on) are the best forecasting tools for predicting future conditions. These models are:

$$Y\,t + 1 = Yt \quad (1)$$

Simple Moving Average

Represents (n) current data for forecasting the period of forecasting methods using averages of future numbers

$$Mt = Yt + 1 = \frac{(Y1+Yt-1+yt-2+\cdots.+Yt-n+1)}{n} \quad (2)$$

Mt = Moving average in period t
Y t + 1 = Forecast value for the next period
Yt = Actual value in period t
n = Amount of data in a moving average

Simple Exponential Smoothing

The simple Exponential Smoothing method is used for approximate short distances, usually only one month in the future

$$St = \alpha.Xt + (1-\alpha).\ S\ t\text{-}1 \quad (3)$$

S t-1 = New data or actual Y value in period t
α = Smoothing constant
St = Forecast value for the next period
Xt = Long smoothing value

Linear Regression Method

Regression analysis is one of the causal methods. This approach is stronger than the time series method which only uses historical values for predictable variables (Heizer and Render, 2014).

$$Y = a + bx \quad (4)$$

Y = Dependent Variable
a = Interception y
b = Slope of the line
x = Independent variable

The degree of correlation is expressed by the size of the correlation coefficient (b), which is a number between –1 and +1. Correlation coefficients are generally calculated by the formula:

$$r = \frac{n\Sigma xy-(\Sigma x)(\Sigma y)}{\sqrt{(n\Sigma x^2-(\Sigma x))^2((n)\Sigma y^2-\Sigma y)^2}} \quad (5)$$

Evaluation of Forecasting Methods

There are several calculations that can be used to calculate total forecasting errors (forecasting cast errors),

Mean Absolute Deviation (MAD). An error calculation technique by adding up all absolute error values and then dividing by the number of forecasting periods.

$$MAD = \frac{\Sigma|Actual-forecasting|}{n} \quad (6)$$

Mean Squared Error (MSE*).* Calculated by adding up the squares of all errors in each period and dividing by the number of forecast periods. Error is the difference between actual data and forecast results.

$$MSE = \frac{\Sigma|Actual-Forecasting|^2}{n} \quad (7)$$

Mean Absolute Percentage Error (MAPE). Is a relative measure of error, MAPE is generally more meaningful than MAD because MAPE states the percentage of errors resulting from forecasting the actual demand during a certain period.

$$MAPE = \frac{\sum_{i=1}^{n} 100|Actual\ i-Forecasting|/Actual\ i}{n} \quad (8)$$

Material Requirement Planning

MRP is a logical and easy-to-understand approach to solving problems related to determining the number of parts, components, and materials needed to produce the final product. The MRP also provides a detailed time schedule for when each component, material and part must be ordered or produced, (Nasution and Prasetyawan, 2009).

The purpose and benefits of Material Requirement Planning. that the objectives and benefits of the MRP can be explained as follows:

1 Reducing inventory.
2 Form a minimum requirement for each item.
3 Determine the implementation of the order plan.
4 Determine rescheduling or cancellation of a planned schedule.

Concluded that the implementation of Material Requirement Planning is the right solution to meet customer needs, better efficiency in monitoring production and avoiding excess and lack of inventory (Iasya and Handayati :2010)

MRP System Input

There are 3 inputs for the material requirements planning (MRP) :

Master Production Schedule (MPS)

Basically the master production schedule is a statement about the final product of a manufacturing industry company that plans to produce output related to the quantity and time period (Gaspersz: 2014).

Inventory State Records

The inventory state log illustrates the status of all items in the inventory. Each inventory item must be defined to ensure that planning does not go wrong. The recording must be kept up to date, by always recording the transactions that occur, such as receipts, expenses, failed products and so forth. Inventory records must also contain a timeline, lot size techniques used, reserve inventory and other important notes of all items.

Inventory control

Inventories are goods that are stored for use or sale in the future (Ristono, 2009).
Inventory is generally one type of current assets which is quite large in a company (Sartono, 2010)
inventory held from raw materials to finished goods is useful for:

1) Eliminating the risk of delays in the arrival of goods
2) Eliminating the risk of damaged goods
3) Maintaining the company's operational stability
4) Achieve optimal machine use
5) Provide the best service for consumers

Inventory Cost

There are three types of costs in inventory according to Heizer and Render (2014), including:

1) holding cost.
2) ordering cost
3) setup cost

There are 4 (four) types of inventory based on the manufacturing process according to Nasution & Prasetyawan (2008), as follows:

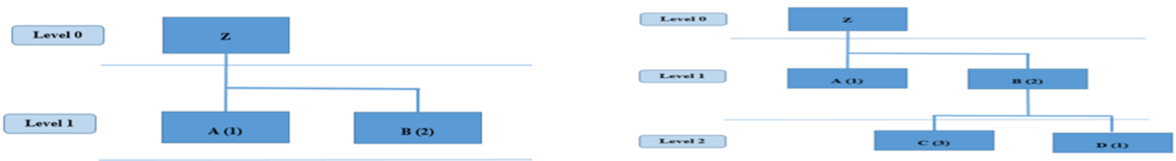
1) raw materials

2) work in process
3) finished goods
4) Auxiliary materials

Product Structure or Bill of Materials (BOM)

Bill of Materials identify the specific material used to make each item and the amount needed that can be arranged in the form of a product structure (product structure tree). There are 2 broad product structures, namely single level and multi level as in Picture 3

Single level product structure. The relationship between the final product that only requires 1 level to arrange it



(1) (2)

Picture 3. Single Level Product Structure (1) and Multi Level Structure (2)

(Source:Gaspersz, 2014)

Multi-level product structure. The product structure with its constituent components require other components with a structure underneath

MRP processing process steps

Some things that must be the basis for the implementation of the MRP are known to be information about lead time, order quantity, safety stock and gross requirements.

From this it can be calculated for the MRP stages as follows:

Netting is a calculation process to determine the amount of net need, the amount of which is the difference between the gross needs and the state of inventory, for the calculation of netting, what is needed is to know the gross needs, revenue plans, inventory levels owned.

Lotting or Lot Sizing is the process of determining the size of an order to meet the net needs of several periods, there are several types of lotting that are applied:

1) Fixed Order Quantity (FOQ), a method that uses the concept of a fixed order quantity by using trial and error.
2) Economic Order Quantity (EOQ), this method uses the concept of minimizing the cost of storing and ordering costs where the lot size remains based on the count of the minimization
3) Lot For Lot (LFL), this method aims to minimize storage costs per unit to zero, because the lot size is the same as the need
4) Period Order Quantity (POQ), this method is the development of the EOQ method for non-uniform requests for several periods.

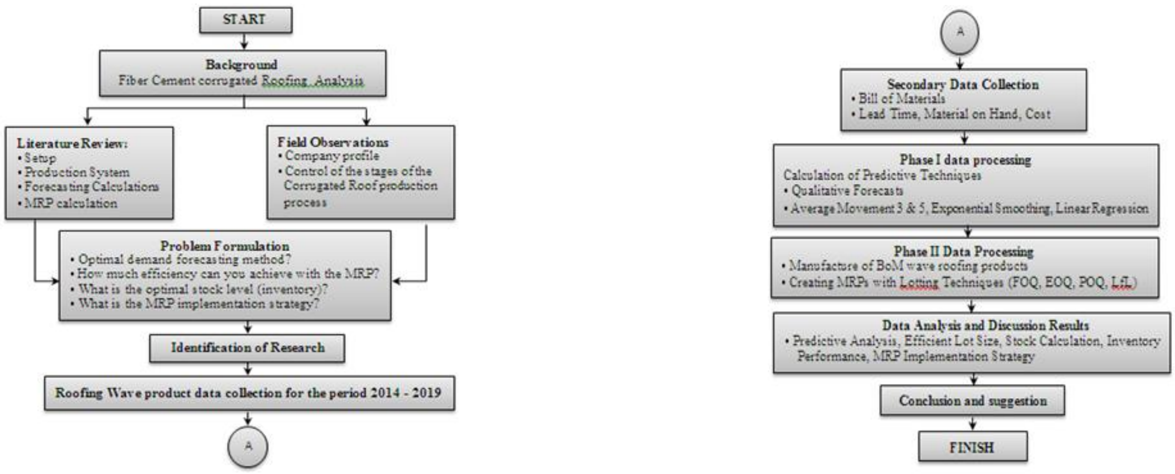
Research conducted by Jasorman Sinaga (2018) with the title "Analysis of Raw Material Inventory Planning in L-90D Products in Chemical Companies with Material Requirement Planning (MRP) Method" that by applying MRP makes raw material needs met properly. This study uses a batch reference in calculating the structure of raw materials. With the condition the company has not implemented a raw material inventory planning system and has not been well documented causing difficulties to get data as a reference on the company. Inventory planning and raw inventory control using LFL and POQ lot techniques were selected as the best lot technique out of the five lot techniques compared at the time of the study where 2 lot sizing produced the smallest total cost.

RESEARCH METHODS

This research was conducted at a building material manufacturing company, with one of its products a roof wave of fibersemen which was the object of research. The study uses a quantitative method with a descriptive approach, with a population of all recording results and calculations of raw materials used and samples of raw materials taken purposively are cement, chrysotile fiber, waste paper and scrap for the period 2014 to 2018.

Data analysis used descriptive analysis, through several research variable data in the form of demand for finished products, percentage of product defects, plans for production needs, plans for ordering raw materials, and costs needed for storage, procurement and control of raw materials with the MRP, LFL, and POQ methods.

The research process is as shown in Picture 4



Picture 4. Flow Process of Research

FINDINGS AND DISCUSSION

Determining forecasting by using sales data in the previous period, where the resulting sales data for the period 2014 to 2018 is in Table 1

Table 1. Sales Data for 2014 – 2018

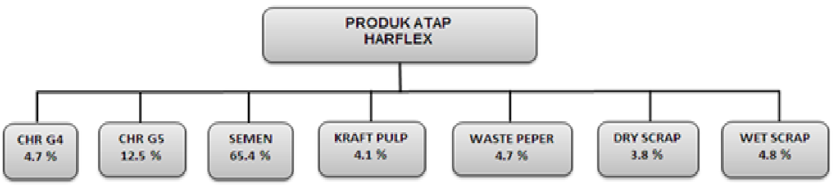
	2104	2015	2016	2017	2018
January	2,513,201	2,582,372	2,058,651	2,338,385	1,804,256
February	1,747,058	2,257,435	1,706,945	2,300,000	1,450,256
March	1,743,888	1,423,582	2,224,347	2,800,000	2,005,658
Aprl	1,753,171	1,666,380	1,808,138	2,800,000	948,789
May	2,160,812	1,362,674	1,622,231	2,200,000	2,056,345
June	1,692,843	2,184,948	1,773,353	2,000,000	1,365,216
July	1,411,131	1,074,631	1,096,450	2,048,658	2,800,000
August	2,193,478	2,234,098	1,846,362	1,200,000	2,200,000
September	2,539,749	2,052,322	2,270,268	2,100,000	2,100,000
October	2,636,488	3,093,838	2,339,386	1,800,000	2,897,897
November	1,815,423	2,017,136	1,400,789	2,168,250	2,805,654
December	2,123,958	3,368,520	2,339,676	1,200,000	770,678

From the data in Table 1, it was tested with several forecasting methods and compared to see the smallest deviation values. Qualitative methods that have been used are compared with several forecasting methods, namely moving average of 3 periods and 5 periods, exponential smoothing method with a value of α 0.4 and linear regression, and the results of comparison of these methods the value of the deviation of each method as in Table 2

Table 2. Error deviations from several forecasting methods

	QUALITATIVE	MOVING AVERAGE			EXPONENTIAL SMOOTHING α 0.4	LINIER REGRESION
		2 MA	3 MA	5 MA		
MAD	494,954.19	492,253.30	507,307.09	513,441.34	487,118.11	423,267.38
MSE	336,417,468,087.52	366,421,901,178.15	370,215,900,572.95	384,959,492,571.81	347,923,996,392.35	286,924,968,990.47
MAPE	28.68	29.37	29.76	30.12	28.89	25.08

From the comparison of forecasting methods the linear regression method has the smallest deviation value with a MAPE value of 25.08%, so that the linear regression equation is used to determine the forecast at MPS 2019. The intercept of the regression is y = 2,042,088 + (- 1,218 x). By calculating the setup factor and the percentage of damage, the total output amount is added by 2%. Total output becomes a reference for the calculation of bill of materials (BoM). Next is calculating the bill of material in the manufacture of products by basing on the mix composition of raw materials as shown in Picture 5



Picture 5. Product Structure and Material composition

From the composition of raw materials in Figure 5, the needs of each material for each period are as in Table 3

Table 3. Raw Material Requirements

No	%	Raw Materials	PERIODE												Total
			January	February	March	April	May	June	July	August	September	October	November	December	
GROSS (STDM)			2,007,127	2,005,884	2,004,641	2,003,399	2,002,156	2,000,913	1,999,671	1,998,428	1,997,185	1,995,942	1,994,700	1,993,457	24,003,502
NET (STDM))			1,967,771	1,966,553	1,965,335	1,964,116	1,962,898	1,961,680	1,960,461	1,959,243	1,958,025	1,956,806	1,955,588	1,954,370	23,532,845
1	4.70	CHR G4	566,010	565,659	565,309	564,958	564,608	564,258	563,907	563,557	563,206	562,856	562,505	562,155	**6,768,988**
2	12.50	CHR G5	1,505,345	1,504,413	1,503,481	1,502,549	1,501,617	1,500,685	1,499,753	1,498,821	1,497,889	1,496,957	1,496,025	1,495,093	**18,002,627**
3	65.40	SEMEN	7,875,965	7,871,088	7,866,212	7,861,336	7,856,460	7,851,583	7,846,707	7,841,831	7,836,955	7,832,078	7,827,202	7,822,326	**94,189,743**
4	4.10	KRAFT PULP	493,753	493,447	493,142	492,836	492,530	492,225	491,919	491,613	491,308	491,002	490,696	490,390	**5,904,862**
5	4.70	WASTE PAPER	566,010	565,659	565,309	564,958	564,608	564,258	563,907	563,557	563,206	562,856	562,505	562,155	**6,768,988**
6	3.80	DRY SCRAP	457,625	457,342	457,058	456,775	456,492	456,208	455,925	455,642	455,358	455,075	454,792	454,508	**5,472,799**
7	4.80	WET SCRAP	578,052	577,695	577,337	576,979	576,621	576,263	575,905	575,547	575,189	574,831	574,474	574,116	**6,913,009**
Total			**12,042,759**	**12,035,303**	**12,027,847**	**12,020,391**	**12,012,935**	**12,005,479**	**11,998,023**	**11,990,567**	**11,983,111**	**11,975,655**	**11,968,199**	**11,960,743**	**144,021,014**

As a preliminary data reference for the calculation of MRP, some data is needed, namely the price of raw materials, costs incurred as a basis for the calculation of Lot Sizing, Initial stock for the calculation of Netting, and Lead Time to determine the scheduling of arrival of raw materials, the data data can be seen in Table 4

Table 4. Cost Price and Raw Material Inventory Data

Raw Materials	Price (Rp/Ton)	*Ordering Cost* (Rp / Order)	*Holding Cost* Damage (Rp / Ton)	Electricity (Rp)	Forklift (Rp)	Administration (Rp)	*Delivery Cost* (Rp / Ton)	*Lead Time* (Hari)	Stok Akhir (Ton)	LEVEL
Chr G4 (Kg)	7,000,000	400,000	4,850	550	1,800	300	211,000	36	130	1
Chr G5 (Kg)	6,200,000	400,000	4,650	650	1,800	400	211,000	36	1500	1
Cement (Kg)	1,200,000	400,000	200	600	-	100		2	1000	1
Kraft (Kg)	6,000,000	400,000	5,300	800	2,500	400		6	200	1
Waste (Kg)	6,000,000	400,000	5,300	800	2,500	400		6	300	1
Dry (Kg)	500,000	400,000	200	7,600	700	500		4	50	1
Wet (Kg)	430,000	400,000	200	7,600	700	500		4	50	1

From the calculation of forecasting and the final stock available, the net requirement of each raw material for each period is calculated and in the MRP process this is stated as netting as in Table 5

Table 5. Netting of Raw Materials for Each Period

PERIODE	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
Unit (Kg)					**RAW MATERIAL Chr Grade 4**									
Gross Requirements		566,010	565,659	565,309	564,958	564,608	564,258	563,907	563,557	563,206	562,856	562,505	562,155	
Inventory on Hand	**130,000**													
Net Requirements		**436,010**	**565,659**	**565,309**	**564,958**	**564,608**	**564,258**	**563,907**	**563,557**	**563,206**	**562,856**	**562,505**	**562,155**	**6,638,988**
Unit (Kg)					**RAW MATERIAL Chr Grade 5**									
Gross Requirements		1,505,345	1,504,413	1,503,481	1,502,549	1,501,617	1,500,685	1,499,753	1,498,821	1,497,889	1,496,957	1,496,025	1,495,093	
Inventory on Hand	**1,500,000**													
Net Requirements		**5,345**	**1,504,413**	**1,503,481**	**1,502,549**	**1,501,617**	**1,500,685**	**1,499,753**	**1,498,821**	**1,497,889**	**1,496,957**	**1,496,025**	**1,495,093**	**16,502,627**
Unit (Kg)					**RAW MATERIAL SEMEN**									
Gross Requirements		7,875,965	7,871,088	7,866,212	7,861,336	7,856,460	7,851,583	7,846,707	7,841,831	7,836,955	7,832,078	7,827,202	7,822,326	
Inventory on Hand	**1,000,000**													
Net Requirements		**6,875,965**	**7,871,088**	**7,866,212**	**7,861,336**	**7,856,460**	**7,851,583**	**7,846,707**	**7,841,831**	**7,836,955**	**7,832,078**	**7,827,202**	**7,822,326**	**93,189,743**
Unit (Kg)					**RAW MATERIAL PULP KRAFT**									
Gross Requirements		493,753	493,447	493,142	492,836	492,530	492,225	491,919	491,613	491,308	491,002	490,696	490,390	
Inventory on Hand	**200,000**													
Net Requirements		**293,753**	**493,447**	**493,142**	**492,836**	**492,530**	**492,225**	**491,919**	**491,613**	**491,308**	**491,002**	**490,696**	**490,390**	**5,704,862**
Unit (Kg)					**RAW MATERIAL PULP WASTE PAPER**									
Gross Requirements		566,010	565,659	565,309	564,958	564,608	564,258	563,907	563,557	563,206	562,856	562,505	562,155	
Inventory on Hand	**300,000**													
Net Requirements		**266,010**	**565,659**	**565,309**	**564,958**	**564,608**	**564,258**	**563,907**	**563,557**	**563,206**	**562,856**	**562,505**	**562,155**	**6,468,988**
Unit (Kg)					**RAW MATERIAL DRY SCRAP**									
Gross Requirements		457,625	457,342	457,058	456,775	456,492	456,208	455,925	455,642	455,358	455,075	454,792	454,508	
Inventory on Hand	**50,000**													
Net Requirements		**407,625**	**457,342**	**457,058**	**456,775**	**456,492**	**456,208**	**455,925**	**455,642**	**455,358**	**455,075**	**454,792**	**454,508**	**5,422,799**
Unit (Kg)					**RAW MATERIAL WET SCRAP**									
Gross Requirements		578,052	577,695	577,337	576,979	576,621	576,263	575,905	575,547	575,189	574,831	574,474	574,116	
Inventory on Hand	**80,000**													
Net Requirements		**498,052**	**577,695**	**577,337**	**576,979**	**576,621**	**576,263**	**575,905**	**575,547**	**575,189**	**574,831**	**574,474**	**574,116**	**6,833,009**

For the next process is the offsetting process, which is a calculation to determine the right time to make an order plan, where the order plan is obtained by reducing the initial availability of desired net needs with lead time. In Table 6 Offsetting for CHR-G4 material

Table 6. Ofsetting Process

PERIODE	-	1	2	3	4	5	6	7	8	9	10	11	12	Total
Unit (Kg)						RAW MATERIAL Chr Grade 4								
Gross Requirement		566,010	565,659	565,309	564,958	564,608	564,258	563,907	563,557	563,206	562,856	562,505	562,155	6,768,988
Inventory on Hand	130,000													
Net Requirement		436,010	565,659	565,309	564,958	564,608	564,258	563,907	563,557	563,206	562,856	562,505	562,155	6,638,988
Order Released	**436,010**	**565,659**	**565,309**	**564,958**	**564,608**	**564,258**	**563,907**	**563,557**	**563,206**	**562,856**	**562,505**	**562,155**		**6,638,988**
Unit (Kg)						RAW MATERIAL Chr Grade 5								
Gross Requirement		1,505,345	1,504,413	1,503,481	1,502,549	1,501,617	1,500,685	1,499,753	1,498,821	1,497,889	1,496,957	1,496,025	1,495,093	18,002,627
Inventory on Hand	1,500,000													
Net Requirement		5,345	1,504,413	1,503,481	1,502,549	1,501,617	1,500,685	1,499,753	1,498,821	1,497,889	1,496,957	1,496,025	1,495,093	16,502,627
Order Released	**5,345**	**1,504,413**	**1,503,481**	**1,502,549**	**1,501,617**	**1,500,685**	**1,499,753**	**1,498,821**	**1,497,889**	**1,496,957**	**1,496,025**	**1,495,093**		**16,502,627**

In addition to the Offsetting process for determining release orders related to leadtime is determining lots for an order or referred to as lot sizing, some lotting techniques are carried out as follows:

Fixed Order Quantity (FOQ) Method

It is lotting technique with a fixed order quantity for each period, from the material requirements of CHR-G4, the lotting results for FOQ are as shown in Table 7

Table 7. Lotting with Fixed Order Quantity Techniques

FOQ						RAW MATERIAL Chr Grade 4						Lead Time 36 Days		
PERIODE	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
Gross Requirement		566,010	565,659	565,309	564,958	564,608	564,258	563,907	563,557	563,206	562,856	562,505	562,155	6,768,988
Inventory	130,000	128,073	126,496	125,269	124,393	123,867	123,692	123,867	124,393	125,269	126,496	128,073	130,000	1,509,888
Net Requirement		**436,010**	**437,587**	**438,813**	**439,689**	**440,215**	**440,390**	**440,215**	**439,689**	**438,813**	**437,587**	**436,010**	**434,082**	
Planning Order Released	564,082	564,082	564,082	564,082	564,082	564,082	564,082	564,082	564,082	564,082	564,082	564,082	**6,768,988**	12X

Costs (Rp)						
Holding Cost			Ordering Cost			Total
Inventory (Ton)	Cost		N/O (Times)	Cost		
1,510	7,500	11,324,159	12	400,000	4,800,000	**16,124,159**

Economic Order Quantity (EOQ) Method

Orders are made if the amount of inventory cannot meet the desired needs

By using the equation:

$$Q = \sqrt{\frac{2DS}{H}} \quad (9)$$

Number of needs 1 year (D) = 6,768.98 Tons

Order Fee (S) = IDR 400,000 / Order

Save Cost (H) = Rp 7,500 / Ton

$$Q_{CHR\text{-}G4} = \sqrt{\frac{2DS}{H}}$$

$$QCHR\text{-}G4 = \sqrt{\frac{2\,(6{,}768.98)(400{,}000)}{(7{,}500)}}$$

$$QCHR\text{-}G4 = \sqrt{\frac{5{,}415{,}190{,}125}{(7{,}500)}}$$

$$Q_{CHR\text{-}G4} = \sqrt{722{,}025}$$

$$Q_{CHR\text{-}G4} = 849.72 \text{ tons}$$

In the calculation of needs in 1 year is 6,768.98 tons, then the order frequency in 1 year is:

$$N = \frac{Demand}{Order\ Quantity}$$

$$N = \frac{3{,}802}{849.72}$$

N = then the order frequency is 7.97 ≈ 8 times a message = 846,123 Tons

More details for the Sizing lot table for the EOQ Method are as follows as in Table 8

Table 8. Lotting with the Economic Order Quantity Technique

EOQ						RAW MATERIAL Chr Grade 4							Lead Time 36 Days	
PERIODE	-	1	2	3	4	5	6	7	8	9	10	11	12	Total
Gross Requirement		566,010	565,659	565,309	564,958	564,608	564,258	563,907	563,557	563,206	562,856	562,505	562,155	6,768,988
Inventory	130,000	410,113	(155,546)	125,268	406,433	687,948	123,690	405,906	688,473	125,266	408,534	692,155	130,000	4,048,241
Net Requirement		**436,010**	**155,546**	**720,855**	**439,690**	**158,175**	**(123,690)**	**440,217**	**157,650**	**(125,266)**	**437,589**	**153,972**	**(130,000)**	
Planning Order Released	846,123	-	846,123	846,123	846,123	-	846,123	846,123	-	846,123	846,127	-	**6,768,988**	8 X
		Cost (Rp)												
Holding Cost			Ordering Cost			**Total**								
Inventory (Ton)	Cost		N/O (Times)	Cost										
4,048	7,500	30,361,808	8	400,000	3,200,000	**33,561,808**								

Lot to Lot method

In the lot-to-lot method, the number of orders (lot size) will always be the same as the number of net requirements required as in Table 9

Table 9. Lotting with the Lot for Lot Technique

Lot For Lot						**RAW MATERIAL Chr Grade 4**							Lead Time 36 Days	
PERIODE	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
Gross Requirement		566,010	565,659	565,309	564,958	564,608	564,258	563,907	563,557	563,206	562,856	562,505	562,155	6,768,988
Inventory	130,000													130,000
Net Requirement		**436,010**	**565,659**	**565,309**	**564,958**	**564,608**	**564,258**	**563,907**	**563,557**	**563,206**	**562,856**	**562,505**	**562,155**	**6,638,988**
Planning Order Released	**436,010**	**565,659**	**565,309**	**564,958**	**564,608**	**564,258**	**563,907**	**563,557**	**563,206**	**562,856**	**562,505**	**562,155**	**6,638,988**	**12X**
		Cost (Rp)												
Holding Cost			Ordering Cost			**Total**								
Inventory (Ton)	Cost		N/O (Times)	Cost										
130	7,500	975,000	12	400,000	4,800,000	**5,775,000**								

Period Order Quantity (POQ) Method

The POQ technique is in principle the same as FPR. The difference is that the POQ ordering interval is determined by a calculation based on the modified classical EOQ logic, so that it can be used on discrete-period requests.

Table 9. Lotting with Period Order Quantity (POQ) Techniques)

POQ 2 PERIODE						**RAW MATERIAL Chr Grade 4**							Lead Time 36 Days	
PERIODE	-	1	2	3	4	5	6	7	8	9	10	11	12	Total
Gross Requirement		566,010	565,659	565,309	564,958	564,608	564,258	563,907	563,557	563,206	562,856	562,505	562,155	6,768,988
Inventory	130,000	663,990	98,331	733,022	168,064	803,456	239,198	775,291	211,735	748,528	185,673	692,155	130,000	5,449,443
Net Requirement		**436,010**	**(98,331)**	**466,978**	**(168,064)**	**396,544**	**(239,198)**	**324,709**	**(211,735)**	**351,472**	**(185,673)**	**376,833**	**(130,000)**	
Planning Order Released	1,100,000	-	1,200,000	-	1,200,000	-	1,100,000	-	1,100,000	-	1,068,988	-	6,768,988	6X
		Cost (Rp)												
Holding Cost			Ordering Cost			**Total**								
Inventory (Ton)	Cost		N/O (Times)	Cost										
5,449	7,500	40,870,826	6	400,000	2,400,000	**43,270,826**								

From the lotsizing calculations performed using FOQ, EOQ, LFL and POQ techniques, the technique that has the lowest cost is the LFL method as shown in Table 10

Table 10. Comparison of the costs of the Lotting Technique

No	Material	Quantity (Kg)	Price / Kg (Rp)	Amount (Rp)	Handling Cost Rp 211.304 / Kg	Ordering Cost, Handling Cost, Holding Cost (Rp)			
						EOQ	POQ	FOQ	LFL
1	Chr G4 (Kg)	6,768,988	7,000	47,382,913,592	1,430,314,168	1,463,875,976	1,473,584,993	1,446,438,327	1,436,089,168
2	Chr G5 (Kg)	18,002,627	6,200	111,616,285,818	3,804,027,042	3,942,827,465	4,010,838,812	3,942,827,465	3,820,077,042
3	Cement (Kg)	94,189,743	1,200	113,027,691,754		56,557,810	51,583,966	14,972,426	5,700,000
4	Kraft (Kg)	5,904,862	6,000	35,429,169,434		50,978,444	44,019,673	26,006,567	6,600,000
5	Waste (Kg)	6,768,988	6,000	40,613,925,936		45,702,472	69,804,991	36,748,991	7,500,000
6	Dry Scrap (Kg)	5,472,799	500	2,736,399,265		32,062,948	32,693,014	9,835,354	5,250,000
7	Wet Scrap (Kg	6,913,009	430	2,972,593,728		59,864,242	39,302,544	12,979,395	5,520,000
Total		144,021,014				5,651,869,357	5,721,827,993	5,489,808,524	5,286,736,209

From the lotting system applied where the lot for lot method has the least value in terms of cost for all raw materials. the application of MRP, performance evaluation and analysis are carried out

Optimization of the minimum maximum stock limit

The maximum and minimum stocks with stable fluctuations indicate the occurrence of a match between demand and demand, from the production data for 2018 and 2019, the maximum minimum stock conditions for CHR G4 material are as follows:

$$\text{Min Stock} = \frac{(D\ x\ L\ T)+Ss}{30} \qquad (10)$$

$$\text{Max Stock} = \frac{(2\ x\ Dx\ L\ T)}{30} \qquad (11)$$

$$\text{Ss} = \sigma \text{ x } Z \qquad (13)$$

For CGR G4 Raw Materials the calculation is as follows

Average usage $\overline{D}$ = 533,236.36 kg

Standard Deviation σ = 50,720.11 kg

Z 95% = 1.64

Then,

Safety Stock (Ss) = 50,720.11 kg x 1.64

= 83,427.15 kg

Min Stock $_{\text{CHR-G4}}$ $= \frac{(533{,}236.36\ Kg\ x\ 36\ hari)+83{,}727.15}{30}$

= **642,767.27 Kg**

Max Stock $_{\text{CHR-G4}}$ $= \frac{(2\ x\ 533{,}236.36\ Kg\ x\ 36\ hari)}{30}$

= 1,279,767.27 kg

Middle value $_{\text{CHR-G4}}$ $= \frac{Min\ Stok+Maks\ Stok}{2}$

$= \frac{642{,}767.27+1{,}279{,}767.27}{2}$

= 961,245.91 kg

Stability stock of raw materials

With the application of MRP the final stock of raw materials is relatively stable compared to the previous period as shown in Figure 6

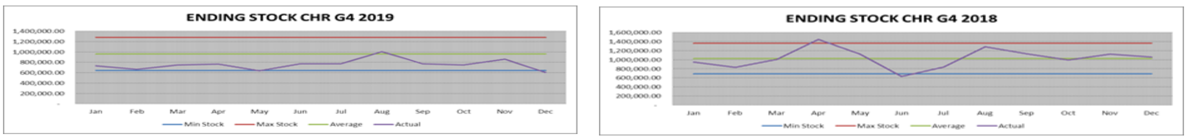


Figure 6. Graph of Final Stock of CHR G4 2019 and 2018 Raw Materials

Inventory Turn Over Ratio

In the application of MRP provides, improved performance on TOR, especially on CHR material which is the main raw materials that must be very attention to be controlled.
In this case the calculations for several periods are as follows:

$$\text{TOR jan2019} = \frac{564{,}000\ Kg}{431{,}600\ Kg}$$

$$\text{TOR}_{\text{Jan2019}} = 1.31 \text{ times}$$

$$\text{TOR}_{\text{jan2018}} = \frac{564{,}000\ Kg}{721{,}026\ Kg}$$

$$\text{TOR jan2018} = 0.94$$

So the 2019 TOR value is 0.37 times higher than the 2018 TOR. It means that CHR G4 Raw Material is faster to use in 2019

Time to Storage Raw Materials

Assuming the average number of working days is 30 days, the save time for the January 2019 and 2018 periods is as follows

$$T_{\text{storage 2019}} = \frac{30\ days}{1.31}$$

$$T_{\text{storage 2019}} = 22.96 \text{ days}$$

As for the same period of saving time in 2018 is

$$T_{\text{torage 2018}} = \frac{30\ days}{0.96}$$

$$T_{\text{storage 2018}} = 40.4 \text{ days}$$

Savings on Purchases for Inventory Decline

With a smaller DOI value, this affects the smaller number of purchases, this has a good impact on the company's cash flow.
As a comparison, the drop in the DOI value in 2019 compared to the 2018 DOI on the CHR-4 material

Variance = DOI 2019 - DOI 2018
= 32, 5 days - 40.60 days
= -8,10 days

Saving = Variance x Average usage x Price
= 8, 10 Days x 23,330 kg x Rp. 7000 / kg
= Rp. 1,322,811,000

The efficiency that occurs with the application of MRP

$$\eta \text{ Inventory} = \frac{DOI\ 2019 - DOI\ 2018}{DOI\ 2018} \text{ X } 100\%$$

$$\eta \text{ Inventory} = \frac{32{,}50\ days - 40{,}6\ days}{40{,}60\ hari} \text{ x } 100\%$$

$$\eta \text{ Inventory} = -19{,}951$$

Discussion

Forecasting method that has the smallest deviation value is a linear regression technique where the MAPE value is 25.08, and the deviation value of other methods ranges from 28 ÷ 30.12

Lot for Lot Technique is the most efficient technique seen from the costs incurred in the amount of 5.2 Billion Rupiahs while the other Lot Sizing Techniques are 5.4 to 5.7 Billion Rupiahs.

The implemented MRP affects the entire inventory performance, improving efficiency. compared to the period of inventory performance in 2018. On average the performance improvements are as follows

Turn Over Ratio in each CHR G4 raw material rose 0.18 times, CHR G5 0.07 times, kraft Pulp 2.8 times, Waste Paper 1.23 times, dry scrap 2.4 times and wet scrap 0.78 times. with the increase in the TOR, it shortens the shelf life which reduces the risk of damage to raw materials, and reduces the number of Day of Inventory of raw materials and decreases in ending stock in each period.

If efficiency is taken into account, improved inventory performance has resulted in an average efficiency in 1 year for each raw material CHR G4 21.65%, CHR G5 1.95%, kraft Pulp 74%, waste paper 26.11%, dry scrap 29.95% and wet scrap 6.58%

In Table 11 detailed differences in achievement of Performance Invetory in 2018 and 2019

Table 11. Comparison of 2019 and 2018 Inventory Performance

	Inventory Performance 2018 Vs 2019												
CHR G4	**1**	**2**	**3**	**3**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**
TOR	0.37	0.30	0.09	0.20	0.13	0.03	0.20	0.13	0.04	0.22	0.25	0.16	0.18
Storage Time (Days)	(9.01)	(26.93)	(6.59)	(16.59)	(10.93)	(2.45)	(16.52)	(11.54)	(3.93)	(15.79)	(19.43)	(11.46)	(12.60)
Days 0f Inventory	(8.10)	(6.26)	(9.98)	(28.26)	(20.16)	7.06	(1.92)	(10.48)	(14.50)	(9.22)	(10.00)	(18.72)	(10.88)
Ending Stock Variance (Billion)	1.32	1.02	1.63	4.61	3.29	(1.15)	0.31	1.71	2.37	1.51	1.63	3.05	1.77
Efficiency (%)	(19.95)	(17.54)	(23.10)	(45.51)	(41.74)	26.01	(5.33)	(18.99)	(29.84)	(21.69)	(20.80)	(41.27)	(21.65)
CHR G5													
TOR	0.16	0.21	0.03	(0.01)	(0.07)	0.24	0.28	0.22	0.12	(0.25)	0.09	0.09	0.07
Storage Time (Days)	(7.95)	(16.93)	(1.77)	0.38	3.11	(18.12)	(27.18)	(20.45)	(7.33)	10.57	(8.57)	(7.26)	(7.12)
Days 0f Inventory	(0.13)	(2.42)	(5.63)	(1.14)	5.77	(4.00)	(33.93)	(17.31)	7.76	19.50	(3.15)	(41.52)	(6.82)
Ending Stock Variance (Billion)	0.05	0.95	2.21	0.45	(2.26)	1.57	13.30	6.80	(3.05)	(7.66)	1.23	16.32	2.68
Efficiency (%)	(0.37)	(7.82)	(16.29)	(3.58)	30.97	(9.33)	(50.31)	(36.63)	24.63	122.87	5.42	(53.40)	(1.95)
SEMEN													
TOR	(0.02)	1.64	(1.34)	(3.11)	(4.24)	(1.49)	2.18	0.87	(1.52)	0.08	0.90	(1.28)	(0.61)
Storage Time (Days)	0.01	(1.18)	0.75	1.24	1.77	0.82	(1.10)	(0.34)	0.82	(0.04)	(0.44)	0.59	0.24
Days 0f Inventory	-	0.30	0.30	1.11	(0.29)	0.65	(0.02)	(0.09)	0.08	0.11	0.18	0.08	0.20
Ending Stock Variance (Billion)	-	(0.12)	(0.44)	0.12	(0.79)	0.08	0.04	(0.04)	(0.07)	(0.04)	(0.13)	(0.03)	(0.12)
Efficiency (%)	-	10.42	9.65	52.61	(8.50)	29.28	(0.78)	(2.81)	2.40	3.54	5.81	2.60	8.68
KRAFT PULP													
TOR	0.24	0.28	0.51	3.93	2.45	2.03	2.70	2.96	3.05	5.34	6.21	3.87	2.80
Storage Time (Days)	(9.72)	(48.97)	(27.63)	(26.61)	(28.26)	(47.00)	(45.23)	(24.21)	(35.07)	(42.85)	(39.91)	(44.84)	(35.03)
Days 0f Inventory	(20.19)	(14.70)	(33.34)	(15.80)	(46.27)	(28.16)	(15.17)	(22.54)	(43.26)	(27.82)	(32.22)	(49.84)	(29.11)
Ending Stock Variance (Billion)	2.51	1.83	4.10	1.97	5.77	3.51	1.89	2.80	5.39	3.47	4.01	6.20	3.63
Efficiency (%)	(33.00)	(27.89)	(89.05)	(73.15)	(86.65)	(76.52)	(71.29)	(75.74)	(90.52)	(86.94)	(89.80)	(87.48)	(74.00)
WASTE PAPER													
TOR	(2.15)	3.03	5.19	2.57	(0.08)	0.47	3.04	3.21	0.38	0.37	0.49	(1.75)	1.23
Storage Time (Days)	5.57	(12.64)	(9.59)	(4.61)	0.17	(1.08)	(8.64)	(5.41)	(0.85)	(1.05)	(1.13)	2.04	(3.10)
Days 0f Inventory	0.25	(9.66)	(5.46)	(3.94)	(1.49)	(1.27)	(3.68)	(3.95)	0.42	(1.40)	2.20	(1.55)	(2.46)
Ending Stock Variance (Billion)	(0.03)	1.38	0.78	0.56	0.21	0.18	0.52	0.56	(0.06)	0.20	(0.31)	0.22	0.35
Efficiency (%)	3.46	(79.31)	(61.35)	(43.20)	(19.45)	(23.35)	(41.35)	(54.63)	5.41	(16.89)	44.72	(27.39)	(26.11)
DRY SCRAP													
TOR	1.89	2.69	2.45	2.84	1.12	2.09	4.19	4.00	3.41	1.90	1.10	1.10	2.40
Storage Time (Days)	(1.89)	(2.69)	(2.45)	(2.84)	(1.12)	(2.09)	(4.19)	(4.00)	(3.41)	(1.90)	(1.10)	(1.10)	(2.40)
Days 0f Inventory	0.00	(1.00)	(5.57)	(5.60)	(1.92)	(4.59)	(1.66)	(3.45)	(3.61)	0.96	(1.78)	(0.03)	(2.35)
Ending Stock Variance (Billion)	(0.00)	0.00	0.05	0.01	0.02	0.04	0.02	0.03	0.03	(0.01)	0.02	0.00	0.00
Efficiency (%)	0.00	(22.72)	(57.60)	(55.44)	(31.37)	(58.84)	(28.72)	(60.85)	(50.42)	29.82	(22.56)	(0.66)	(29.95)
WET SCRAP													
TOR	(0.19)	1.68	0.58	1.37	0.42	(0.38)	0.98	3.79	0.50	(0.66)	0.66	0.54	0.78
Storage Time (Days)	0.12	(4.72)	(2.02)	(4.30)	(1.33)	1.08	(1.91)	(4.01)	(0.82)	1.45	(1.25)	(0.92)	(1.55)
Days 0f Inventory	(1.99)	(1.19)	(4.47)	(7.29)	(2.93)	2.52	(0.56)	(6.89)	2.24	1.53	(1.63)	3.33	(1.44)
Ending Stock Variance (Billion)	0.02	0.01	0.05	0.08	0.03	(0.03)	0.01	0.07	(0.02)	(0.02)	0.02	(0.03)	0.02
Efficiency (%)	(27.75)	(12.22)	(34.30)	(50.48)	(24.88)	48.53	(8.69)	(71.08)	31.28	18.19	(22.12)	74.51	(6.58)

CONCLUSION AND SUGGESTION

Conclusion

From the results of data processing and analysis it can be concluded that the forecasting technique that has the smallest storage value is to use Linear Regression forecasting techniques with a MAPE storage value of 25.08%. The Lotting that provides the most cost efficient is a lot for Lot with a total cost of 5.3 billion. Impacts on the application of MRP have an impact on improving inventory performance and cost efficiency. For the purchase of raw materials, which can be seen in the final value of the stock, each period ranges from 0.02 billion to 3.63 billion. Inventory Turn Over Ratio increases between 0.18 to 2.8 times, and if calculated for the shelf life of raw materials decreases the shelf life from 1.5 to 35 days.

Maximum and minimum stock as inventory control for each raw material Min - Max stock (tons) CHR G4 642.66-1279.77, CHR G5 1805-35696, Cement 563.5 -1045, Kraft 100.9-196.57, waste paper 115.6-225.34, Dry Scrap 63.03 -121.33, Wet Scrap 79.64 - 153.29

Sugestion

suggestions for evaluations carried out, things need to be done as follows.

So that the application of MRP is more optimum where the appropriate Lotting method greatly affects the final results of the application of the MRP, the stability of the supply of raw materials must be increased, this is based on the fulfillment of the commitment between the two parties, namely the company where the research is conducted on the supplier.

The addition of facilities and technology to optimize the use of recycle materials so as to minimize the import of raw materials that have a higher risk of delays.

The scope of MRP can be developed for all functions in a company, therefore Enterprise Resource Planning (ERP) is the latest system that can be applied in the business world both manufacturing and services.

REFERENCE

Bower, Denise (2010). Management of Procurement. Thomas Telford Limited. London

Heizer, J & Render, B. (2015). Operations Management Edition 11, Salemba Empat. Jakarta

Herjanto, Eddy (2018). Third Edition, Revised. Operation management. PT Gramedia. Jakarta.

Jasorman. S (2018). Analysis of Raw Material Planning on L-90D Products . Thesis. UMB. Jakarta

Pujawan, IN and Mahendrawati (2017). Supply Chain Management. Third Edition. Andi. Yogyakarta

Ricky, Virona M. (2020). Fundamentals of Supply Chain Management. Earth Literacy. Jakarta.

Romain G., Caroline T., and Paweł. (2017). "Robust material requirements planning with cumulative demand under uncertainty". International Journal of Production Research, Vol. 55, No. 22, 6824–6845

Sunil, Chopra (2019). Supply Chain Management. 7th Edition. Pearson Education. London..

Ulewicz R., Nowakowsaka G., and Jelonel D. (2015). "Performance evaluation of the production control systems of push and pull type". Applied Mechanics and Materials Vol. 795