Analysis Of Raw Material Cement to Minimize Inventory Costs Using the Material Requirement Planning Method at PT. XYZ

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Abstract

PT XYZ is one of the cement producing companies in Indonesia. To produce cement, it is necessary to pay attention to the amount of raw material supply that must be provided. This is due to variable demand, the amount of inventory is not excessive, cost savings, and adjustment of the amount of inventory to the capacity of the warehouse. Currently PT XYZ has not been able to meet all consumer demands. This is because there is no method of controlling the inventory of raw materials that is not appropriate. This study aims to determine a good inventory model used in determining the order quantity, ordering time and safety stock taking into account the minimum total cost. Based on the analysis and calculation results, in this case, the use of the MRP method with the lot-sizing Least Unit Cost (LUC) technique will produce the lowest cost compared to the Economic Order Quantity (EOQ) method and wagner within algorithm. By using Least Unit Cost, the cost of ordering and storing raw materials will save Rp 1.096.019 with a percentage of 18% of the total costs incurred by the company.

Keywords
Inventory Theory, Material Requirement Planning, Forecasting, EOQ, LUC

1. Introduction
Every company has many goals that they want to achieve, for example, to get as much profit as possible and maintain smooth operation. In companies that produce products in the form of goods, efforts to earn profits are carried out by processing raw materials into finished goods or semi-finished goods (Handoko, 2015). This means that the procurement of raw materials is very important to achieve these goals for the smooth running of the production process. The smoothness of the production process itself is influenced by various factors. One of the important factors is the procurement and inventory control of raw materials to be processed in the production process. This production factor is often referred to as raw material inventory (Maharani, 2015).

Inventory is stock of materials used to fulfill customer demand or to support the production of goods or services. Inventory planning and control is an important concern for managers in a company. Inventory that is too large (overstock) can reduce profitability, because it will increase ordering and storage costs. Too little inventory can affect sales, because it will cause inventory voids that disrupt the production process and can damage customer trust. Based on these 3 things, managers need to think about how to manage inventory effectively within the company (Krajewski, et al. 2015).

PT. XYZ is one of the cement producing companies in Indonesia. The cement products produced are very diverse. One of them is OPC cement. OPC cement is a new innovation for PT XYZ which was introduced in 2019. OPC cement was born to increase consumers' choice of quality cement at a more affordable price, which is around Rp.

10,000 with the main cement. PT XYZ already has staff who control inventory calculations, but, the available OPC cement stock cannot meet customer demand, so it can hamper a production process within the company. Congestion of the production process will cause production to be reduced so that the company loses the opportunity to get the benefits that should be obtained. So, this is a problem for PT XYZ.

Many companies have similar problems that can be solved by using the material requirements planning method as in the research conducted by Prisikila Abigail Gunawan et al with the title Production Planning and Capacity Control with Demand Forcasting using Artificial Neural Network (Case Study PT. Dynaplast) for Industry 4.0. This study tested with LFL, EOQ, POQ, Silver Meal, AWW and LUC techniques. The resulting Wagner Within algorithm method is the most optimal method for determining the cost of raw materials. In the research of Muhammad khoilil, Hendir, Saiful Munajat with the title Analysis of Inventory Control Planning for P-200 Chip (Semi Dull) using Material Requirement Planning (MRP) Method at PT. Indonesia Toray Synthetic which solves problems using the LFL, EOQ, FOQ, and FPR methods produced by the EOQ method can minimize the total inventory cost more efficiently by 50% than the company's method.

Therefore, this study applies the method of material requirements planning (MRP). With the right design, it is hoped that there will be no over stock and stock out. So, the company gets the maximum possible output with the minimum possible input. Forecasting methods used in this study are constant methods, linear regression, exponential smoothing and exponential smoothing with a trend. The lot sizing technique used in this research is Least unit Cost and Economic Order Quantity (EOQ).

1.1 Objectives

The purpose of this study is to find out the best forecasting for the company so that it can be seen the most optimal lot sizing method to be applied at PT XYZ to minimize total inventory costs

2. Literature Review

2.1 Forecasting

Forecasting is an estimate of future needs which includes needs in terms of quantity (amount), quality (quality), time, location needed to meet demand for goods or services. The most suitable forecasting method is the method that has the smallest error. Knowing future demand can help companies decide which strategy is most suitable for the next planning period (Gozali et al., 2013).

1. Regression Line

$$y = a + bx$$

Remarks:
Y = predictable variable
X = independent variable
a = intercept
b = slope

2. Exponential Smoothing

$$D_t = A_{t-1} \text{ x } \alpha + (1 - \alpha) D_{t-1}$$

Remarks:
D_t = predicted variable
$A_{t-1} + (1 - \alpha)$ = independent variable
A = constant between 0 and 1

3. Double exponential smothing

$$S'_t = aX_t + (1 - \alpha)(S'_{t-1} + t_{t-1})(1)$$
$$t_t = \beta(S'_t - S'_{t-1}) + (1 - \beta)t_{t-1}$$
$$F_{t+m} = S'_t + t_t m$$
$$S'_1 = X_1$$
$$t_1 = \frac{(X_2 - X_1) + (X_4 - X_3)}{2}$$

Remarks:
X_t = Data demand in period t

S_t' = value of single exponential smoothing
t_t = Trend value in period - t
α , β = smoothing parameters between 0-1
F_{t+m} = forecast m period to be forecast
m = number of future periods to be forecast

2.2 Safety Stock

Safety Stock (SS) is an existing inventory to reduce the risk of running out of goods if there is a customer demand because there is uncertainty in both customer demand and the company's production (Tersine, 1994). The larger the safety stock will reduce the possibility of running out of goods, as well as when the safety stock is small, it will increase the possibility of shortages of goods, large and small, the safety stock is directly proportional to the costs incurred by the company

$$SS = Z \textit{ (service level)} \times \sigma$$

Remarks:
SS = Total safety stock
Z = normal table value
σ = Standard deviation of demand

2.3 Material Requirement Planning

MRP (Material Requirement Planning) is an approach technique that aims to increase company productivity by scheduling material and component requirements to assist companies in overcoming the minimum requirements of components whose needs are dependent and ensuring the achievement of final production.
The formula that are used in this calculation are as follows

1. Economic Order Quantity (EOQ)
   EOQ is an inventory level that minimizes the total cost of storing inventory and ordering costs with fixed lot size (Herjanto, 2009).

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

   Remarks:
   D = raw material quantity needed
   S = order costs
   H = storage costs
2. Least Unit Cost (LUC)

   LUC is a lot-sizing technique that choose the lowest cost per unit from certain periods by adding up total storage cost to ordering cost and then finding out the period with the lowest unit cost (Nisa, 2016). In the LUC technique, the size of the order quantity is determined by trial and error, namely by asking whether the lot size in one period should be the same as the net size or it is added to the next period. In the end, the decision is determined as per the lowest unit cost (sum of order and storage cost per unit) of each proposed lot size to be selected.

$$V(L) = \frac{s + (h \sum_{t=T}^{L} (t - dT) dt}{J}$$

   Remarks:
   s = order costs
   h = storage costs
   dt = quantity needs in t period
   T = the first period the cumulative lot has been calculated
   L = the last period which needs to be cumulative lot included
   l = a cumulative lot each period
   t = N period

3. Wagner Within Algorithm
   AWW is a lot-sizing technique that minimizes inventory costs by using a variable cost matrix step. This technique aims to obtain the optimal solution for a deterministic number of ordering units over a predetermined time horizon (Tersine, 1994). The optimization procedure of this technique is based on a dynamic program to obtain the optimal order size of the entire required schedule by minimizing the order and storage total costs. Basically, this technique tests all possible ordering methods to meet the net needs of each period that is on the planning horizon so as to provide the optimal answer. (Heizer and Render, 2011)

3. Methods

First of all, observations are made by conducting field studies to find out the real problems that occur. On the other hand, a literature review was also carried out. After determining the problem, the research objective is identified. After that, the data was collected to be processed afterwards, then analyzed the research results. (Figure 1)

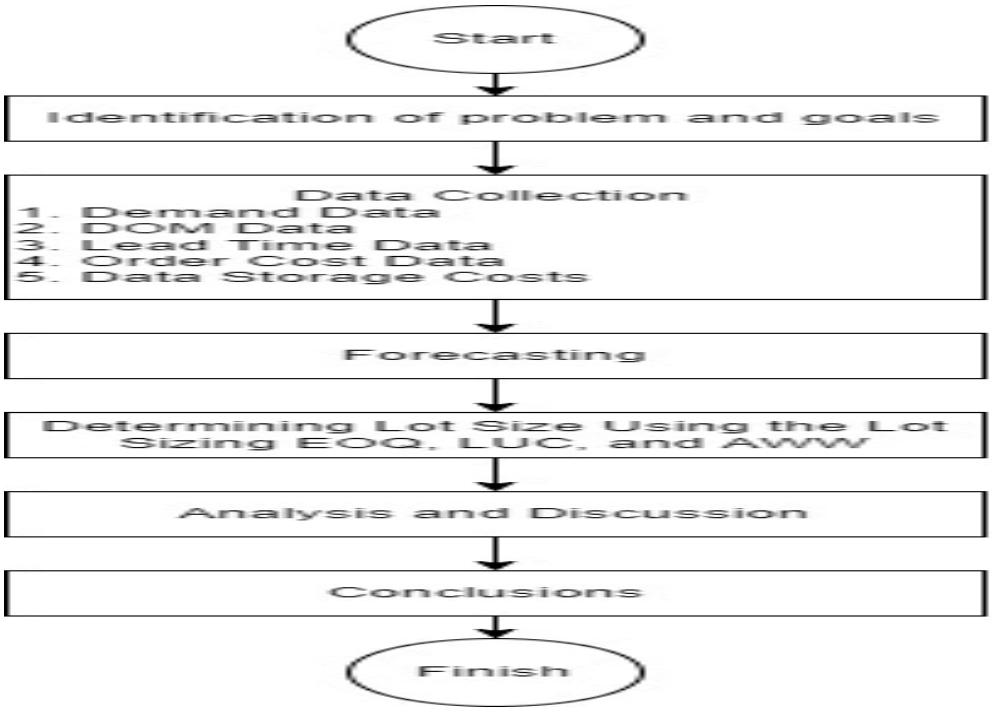

Figure 1. Research Methodology Flowchart

The methods used to obtain a suitable production plan for PT XYZ are forecasting, safety stock, and Material Requirement Planning. In determining the forecasting method according to the time series method, it is necessary to determine the type of data pattern. Constant (stationary), seasonal, and trend are three well-known data patterns. A constant pattern is found when the values fluctuate around a constant mean. This type is one in which the sales of the product do not increase or decrease over time. A seasonal pattern is found when the series is influenced by seasonal factors. When there is a tendency for the data to go up or down, a trend pattern will be found. Forecasting is done by using linear regression forecasting methods, exponential smoothing, exponential smoothing with trend and double exponential smoothing. The best forecast method is determined based on MAD (Mean Absolute Deviation) and Tracking Signal

The lot-sizing technique for planning material requirements used in this observation is Economic Order Quantity and Least Unit Cost. The research methodology flowchart is shown in Figure 1.

4. Data Collection

The data used in this study are product demand data from February 2021 to January 2022, order lead time and cost components, namely ordering costs and storage costs. All data that has been collected from PT. XYZ is shown in Table 1 and Table 2.

Table 1. OPC Cement Demand Data (tons)

Period	1	2	3	4	5	6	7	8	9	10	11	12
Quantity	23691	29406	25931	21705	31191	32101	37379	37788	40496	43355	47222	51758

Table 2. OPC Cement Cost Components

No	Raw Material	Order Cost	Storage Cost	Lead Time (Week)	Buying Description
1	Trass	Rp 60,000	Rp 485,000	2	ton
2	Cooper Slag	Rp 79,000	Rp 87,500	4	ton
3	Silica Sand	Rp 200,000	Rp 49,700	1	ton
4	Gpysum	Rp 609,000	Rp 98,950	3	ton

5. Results and Discussion

5.1 Forecasting

The most suitable forecasting method can be done by calculating the error of each method and selecting the one with the smallest error. Based on the calculation of the forecasting error, the smallest error for the production of OPC cement at PT XYZ is the Linear Regression method. All forecasting error calculations for OPC cement products are summarized and shown in Table 3.

The best method in forecasting the OPC Cement product chosen is the Linear Regression method, therefore this method will be used to project demand for the coming year. The forecasting results above are shown in Table 4.

Table 3. Forecasting Error Summary for OPC Product

Forecasting Method	MAD	Tracking Signal	Deskription
Exponential Smoothing	3951.73	7.10	BIAS
Linear Regresion	2061.95	0.00	NO BIAS
Exponential Smoothing with Trend	2862.44	9.16	BIAS
Double Exponential Smoothing	2916.17	-4.25	BIAS
Company Method	2914.67	6.08	BIAS

Table 4. OPC Product Forecast Using Linear Regression Method

Period	13	14	15
Quantity	51306.61	53789.38	56272.15

5.2 Bill of Material (BOM)

The bill of materials shows a structured list and quantity of each component and material needed to produce an item. The OPC product BOM tree is shown in Figure 2. However, based on this BOM, the company only purchases Gpysum, trass, cooper slag, silica sand because the other raw materials are mined by themselves.

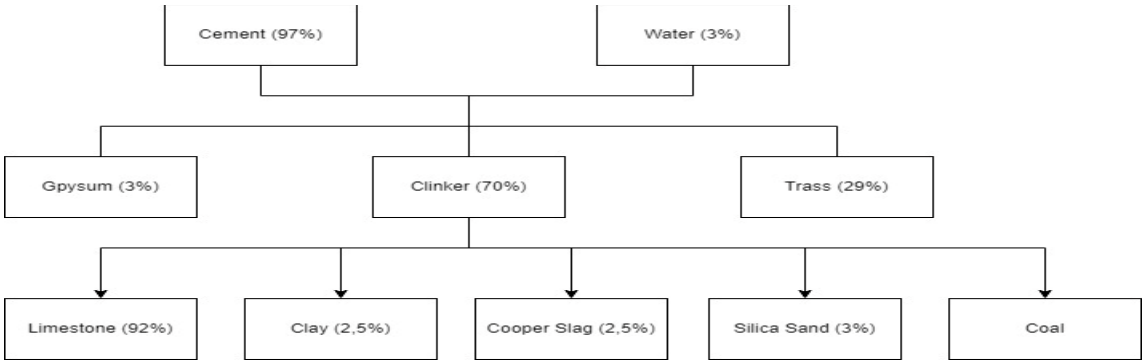

Figure 2. Bill Of Material

5.3 Safety Stock

Based on the 4 raw materials purchased by the company, safety stock analysis needs to be carried out to reduce the risk of running out of stock caused by uncertainty in supply and demand. Safety stock is carried out on all raw materials that will be used as stock and calculated by formula. The results of the safety stock for each raw material for OPC products are shown in Table 3. Where the largest safety stock is raw material trass

Table 3. Safety Stock for OPC Raw Material

Raw Material	Z-Table (99,9%)	Lead Time (Day)	Lead Time (Month)	Average Demand	Standard Deviation of Demand	Safety Stock
Trass	3.09	14	0.5	3900	146	308
Gpysum		28	0.9	403	15.1	45
Cooper Slag		7	0.2	262	9.8	15
Silica Sand		21	0.7	219	8.6	22

5.4 Material Requirement Planning

After determining the safety stock, the lot sizing technique was chosen, namely economic order quantity, least unit cost, and Wagner within algorithm. Based on the comparison of several lot-sizing techniques, Least Unit Cost is the best technique because it has the lowest cost required. Comparison of the costs required for each OPC raw material from all lot-sizing techniques is represented in a graph as shown in Figure 3 and Table 4.

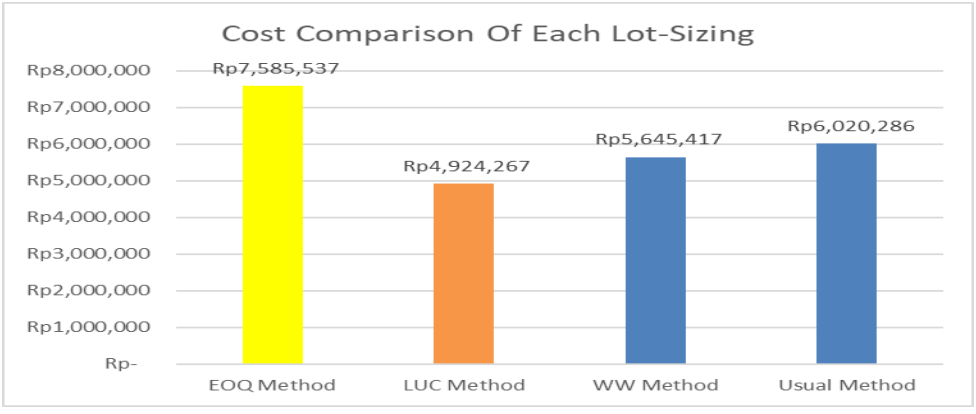

Figure 3. Cost Comparison of Each Lot-Sizing

Cost comparison based on lot sizing method consists of EOQ method, LUC, Wagner Within and company method

Table 4. Cost Comparison of Each Lot Sizing

No	Raw Material	Total Cost			
		EOQ Method	LUC Method	WW Method	Usual Method
1	Trass	Rp 5,890,572	Rp 3,662,152	Rp 4,147,152	Rp 4,519,421
2	Gpysum	Rp 754,333	Rp 562,283	Rp 661,233	Rp 589,324
3	Silica sand	Rp 443,457	Rp 313,152	Rp 362,852	Rp 432,971
4	Cooper slag	Rp 497,175	Rp 386,680	Rp 474,180	Rp 478,570
TOTAL		Rp 7,585,537	Rp 4,924,267	Rp 5,645,417	Rp 6,020,286
Selected Method		LUC Method			

So that by using lot sizing Least Unit Cost will save procurement costs of Rp. 1.096.019 with a percentage of 18% compared to the method of PT. XYZ is usually used. The results of the LUC calculation for each material are shown in Table 5 to Table 8.

Table 5. MRP of Trass Using LUC

MATERIAL REQUIREMENT PLANNING

LUC

No	Item :	Level :		Safety Stock :		Lead Time:		Jml Item :		On Hand :		End Inv :		Metode :	
1	**Trass**	1		308		2		0.97		0		4388		LUC	
		Periode													
		0	1	2	3	4	5	6	7	8	9	10	11	12	
	Gross Requirement		4028	4028	4028	4028	4208	4208	4208	4208	4388	4388	4388	4388	
	Scheduled Receipt		4028												
	Net Requirement		4028	4028	4028	4028	4208	4208	4208	4208	4388	4388	4388	4388	
	On Hand Inventory	0													
	Planned Order Receipt		8056	0	8056	0	8416	0	8416	0	8776	0	8776	0	
	Planned Order Release		8056	0	8416	0	8416	0	8776	0	8776	0	0	0	

Table 6. MRP of Gpysum Using LUC

MATERIAL REQUIREMENT PLANNING

LUC

No	Item :	Level :		Safety Stock :		Lead Time:		Jml Item :		On Hand :		End Inv :		Metode :	
2	**Gpysum**	1		45		2		0.03		0		467		LUC	
		Periode													
		0	1	2	3	4	5	6	7	8	9	10	11	12	
	Gross Requirement		430	430	430	430	448	448	448	448	467	467	467	467	
	Scheduled Receipt		430												
	Net Requirement		430	430	430	430	448	448	448	448	467	467	467	467	
	On Hand Inventory	0													
	Planned Order Receipt		1290	0	0	1326	0	0	1363	0	0	1401	0	0	
	Planned Order Release		0	1326	0	0	1363	0	0	1401	0	0	0	0	

Table7. MRP of Silica Sand Using LUC

MATERIAL REQUIREMENT PLANNING

LUC

No	Item :	Level :		Safety Stock :		Lead Time:		Jml Item :		On Hand :		End Inv :		Metode :	
3	**Silica sand**	2		15		1		0.03		0		289		LUC	
		Periode													
		0	1	2	3	4	5	6	7	8	9	10	11	12	
	Gross Requirement		265	265	265	265	277	277	277	277	289	289	289	289	
	Scheduled Receipt		265												
	Net Requirement		265	265	265	265	277	277	277	277	289	289	289	289	
	On Hand Inventory	0													
	Planned Order Receipt		795	0	0	819	0	0	843	0	0	867	0	0	
	Planned Order Release	795	0	0	819	0	0	843	0	0	867	0	0	0	

Table 8. MRP of Cooper Slag Using LUC

MATERIAL REQUIREMENT PLANNING

LUC

No 4 | Item : **Cooper slag** | Level : 2 | Safety Stock : 22 | Lead Time: 4 | Jml Item : 0.025 | On Hand : 0 | End Inv : 250 | Metode : LUC

	Periode												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirement		230	230	230	230	240	240	240	240	250	250	250	250
Scheduled Receipt		230											
Net Requirement		230	230	230	230	240	240	240	240	250	250	250	250
On Hand Inventory	0												
Planned Order Receipt		920	0	0	0	960	0	0	0	1000	0	0	0
Planned Order Release		960	0	0	0	1000	0	0	0	0	0	0	0

5.5 Proposed Re-planning

The design of the raw material procurement system is carried out by compiling a standard operating procedure (SOP) based on the proposed raw material requirements procurement process using the Material Requirement Planning method described in this study, where to: (Table 9)

1. Determine the need at the right time, determine exactly when the material must be available to meet the demand for the final product that has been planned in the master production schedule,
2. Determine the minimum requirements for each item, by knowing the final requirements, the MRP system can determine the scheduling system (priority) to meet all the minimum requirements for each item,
3. Determine the implementation of the booking plan, provide an indication of when an order for cancellation of an order must be made,
4. Determine rescheduling or cancellation of a planned schedule

Table 9. Difference Plan Proposal

Starting System	Proposal System
The forecasting method used has not been able to optimally meet consumer demand so that stock outs occur	The proposed forecasting method considers the pattern of historical data for the last 1 year
Safety Stock is determined by calculating about 10% of cement available in cement silos	Safety Stock is determined by taking into account the standard deviation of demand and lead time so that it shows the level of variability in demand
The ordering system and purchasing of cement raw materials are carried out when the remaining 50% inventory is in the storage warehouse	The ordering and purchasing system of raw materials can be broken down daily with the order quantity and time scheduled with MRP

Planning for material requirements is prepared requiring input in the form of a production schedule, product structure and bill of materials, as well as inventory reports using requirements planning. based on the lead time of each item, it can be seen the amount of material needed at each material level in the product structure, the state of the inventory will automatically continue to be monitored, because in the preparation of the purchase plan always look at the amount of inventory owned and the safety stock that must exist, so as to reduce possible shortage of inventory and a more accurate calculation of the use of raw materials, because it can know the gross needs and net requirements, not only for the end item, but also for each component or item at a low level

6. Conclusion

The best forecasting method in this study is linear regression with MAD of 80756.31 and tracking signal of 0.00. After calculating the lot sizing using Least Unit Cost (LUC), Economic Order Quantity (EOQ) and wagner within techniques. then recapitulate the results of the calculation of the entire cost of raw material inventory. The total inventory cost of the Least Unit Cost (LUC) method is Rp. 4.924.26, Economic Order Quantity (EOQ) method is Rp. 7.585.537 and wagner within method is Rp 5.645.417 while the actual costs incurred by the company are Rp. 5.141.508 with savings of Rp. 1.096.019 or 18%.

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Biography

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