

RAW MATERIAL INVENTORY PLANNING TIRE RETREADING WITH SILVER HEURISTIC METHOD MEAL IN CV. XYZ

Muhammad Zakaria^{*1}, Syukriah², Muhammad Yasir³

^{1,2,3}Department of Industrial Engineering, Malikussaleh University, Lhokseumawe, 24352, Aceh, Indonesia

*Corresponding Author : irmuhammad@unimal.ac.id

ABSTRACT

This study aims to do the planning of raw material inventory at optimal Tire Retreading industry with Silver Meal Heuristic methods optimally. Planning includes penentuan safety stock, reorder point and Economic Order Quantity and Total Cost of Inventory. The results were obtained 706.44 kg of safety stock, reorder point 2283.76 kg and 8356 kg economic order quantity and lead time of 5 days for a total of Rp. 4,020,778,592.6. While based on the existing condition of the total cost of raw material inventory Rp. 4,061,927,100. This shows the efficiency of Rp. 41,148,507.4 or 1.01% per year.

KEYWORDS: Heuristic Silver Meal, Lot size, Inventory

INTRODUCTION

Raw materials are one of the factors that are vital for the ongoing process of production. Inventories of raw materials that exceed needs will cause extra costs or high storage costs. While the amount of inventory that is too little will cause loss costs, namely the disruption of the production process and also result in a loss of opportunity to obtain profits if it turns out that demand in actual conditions exceeds the expected demand.

Planning the right inventory is not an easy thing, if the amount of inventory is too large resulting in a large amount of idle funds, increased storage costs, and a greater risk of damage to goods. But if the inventory is too little, the risk of inventory shortage is caused because often the material / goods cannot be brought in suddenly and as much as needed, which causes the production process to stop, the sale is delayed, even the customer is lost [1].

CV. XYZ is a manu-invoicing company engaged in tire retreading, which is processing used tires by replacing the outer tire layer with a new layer through several stages, so that the tire or the whole tire flower like a new tire returns. The main raw material used in the tire retreading process is rubber tire. In carrying out the tire vulcanization production process, raw materials such as rubber tread tires are ordered directly from PT. Rubber Deli Industry, North Sumatra.

So far, the company in ordering raw materials is only based on estimates because the inventory of raw materials is not determined and the reorder point is ordered. To solve the inventory problem in the company, the right contribution is needed by using the Heuristic Silver Meal method.

The purpose of this research is to determine the optimal supply policy, which is to minimize the total inventory costs so as to increase the efficiency of the company.

LITERATURE REVIEW

1. Inventory

Inventory is an idle resource waiting for the next process, what is meant by a further process is in the form of production activities in the manufacturing system, marketing activities in the distribution system or food consumption activities in the household system. Inventory is an important component in a company's production and distribution activities. Inventory is used as a safekeeping or security deposit for products that require uncertain procurement times.

Inventory Costs

Based on the understanding of the above inventory, we can see that to maintain smooth production or sales activities costs are needed. There are four types of costs in inventory, namely:

1. Purchase costs (purchase cost) The purchase cost is the purchase fee for each product purchased from an outside party which includes the cost per product and transportation costs.
2. Procurement or order costs (set-up cost / order cost). Procurement or ordering costs are fees for each order and receipt of the product ordered.
3. Storage costs (holding cost / carrying cost). Storage costs are costs related to product storage costs which include embedded capital in costs, warehouse rental costs, taxes, electricity, depreciation costs, and other costs incurred to maintain inventories.

4. Cost of inventory shortages (stockout costs / shortage costs). The cost of inventory shortages is the cost incurred as a result of a shortage of inventory.

2. Forecasting

Forecasting is a process of estimating events that will occur in the coming period with a relatively long time and by using data in the past. The function of forecasting is seen when making decisions. A good decision is a decision based on consideration of what will happen when the decision is made. If the forecast is not correct, the forecasting problem is also a problem that we always face. Forecasting has the following objectives:

- a. To study the current and past corporate policies and see how far the influence will be in the future.
- b. Forecasting is needed because of timelag or delay between when a company policy is determined by implementation.

Measuring Accuracy of Forecasting Results.

Measuring accuracy of forecasting results which is a measure of error is a measure of the level of difference between the results of forecasting and actual demand. The results of the forecasting are usually used, namely [2]:

- 1) *Mean Absolute Deviation (MAD)*
 MAD is an average absolute error over a certain period regardless of whether the forecasting result is greater or smaller than the reality.
- 2) *Mean Square Error (MSE)*
 MSE is calculated by summing the square of all forecasting errors in each period and sharing them with the number of forecasting periods.
- 3) *Mean absolute percentage error (MAPE)*
 MAPE states the percentage of forecasting errors against actual times is always a certain period that will give information on the percentage of errors that are too high or too low.

3. Heuristic Silver Meal Method

One of the Heuristic methods is Silver Meal, which is a method with an easy-to-use approach, and from the workmanship it will get good results when compared to other heuristics. The execution of the Silver Meal method has similarities with the calculation of Economic Order Quantity (EOQ), which is used as a request as a basis for repeating variables in subsequent periods, then the total demand is above the planning limit.

The steps in using the Silver Meal Heuristic Method are as follows:

Step 1:

Calculates the total cost for ordering the 1st time period, calculating the costs for ordering the first two time periods. If this second fee is higher than the first

fee, then the order is concluded for the first time period. But, if the second cost is not greater than the first cost or the second cost is less than the first cost, then proceed to calculating the total cost for ordering the first three time periods. If this third fee is higher than the second fee, then the order is concluded for the second time period. But, if the third cost is not greater than the second or the third is less than the second, then proceed to the total cost of ordering the first four time periods. So on, until conditions are obtained where the total cost for the next order is higher than the total cost for the previous order. Step 2:

If there is still a period of time that has not been calculated, then step 1 is repeated for the remaining periods of time.

The general formulations that can be used are as follows:

$$K(m) = \frac{1}{m} (A + hD_2 + 2hD_3 + \dots + (m-1)hD_m)$$

Count

$$K(m), m = 1, 2, 3, \dots, m,$$

and stop counting if,

$$K(m+1) > K(m)$$

where is :

$$D_m = \text{Purchases in the period to-} m (D_1, D_2, D_3, \dots, D_m)$$

$$K(m) = \text{Average inventory cost per unit of time}$$

$$m = \text{Period}$$

$$A = \text{Ordering cost}$$

$$h = \text{Holding cost (unit / period)}$$

4. Safety Stock

Safety stock is an inventory that must exist in the company that is useful to maintain the possibility of a material shortage (stock out). General Safety Stock formula for variable demand levels and constant lead times, namely:

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

Where is ::

$$SS = \text{Safety Stock}$$

$$z = \text{Service Level}$$

$$\dagger d = \text{Demand standar deviation}$$

$$LT = \text{Lead Time}$$

5. Reorder Point (ROP)

ROP or commonly referred to as the limit / point of the reorder number, including requests that are desired or needed during the grace period, for example an additional / extra stock. Reorder point models:

- a. The number of requests and the grace period are constant.

- b. The number of requests is variable, while the grace period is constant.
- c. The number of requests is constant, while the grace period is variable.
- d. The number of requests and the grace period are variable
- a. Jumlah permintaan maupun masa tenggang adalah variabel

The general formula Reorder Point (ROP) to the level of the variable demand and the lead time constant, namely:

$$ROP = \bar{d}LT + SS$$

Where is :

- \bar{d} = average purchase rate
- LT = lead time constant
- SS = Safety Stock

METHODOLOGY OF STUDY

The problem solving methodology in this study is as follows:

1. Calculating the *safety stock*.

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

2. Calculating the order size (lot size), In this study, to determine the lot size, the Heuristic Silver Meal method is used. The general formulations that can be used are as follows:

$$K(m) = \frac{1}{m}(A + hD_2 + 2hD_3 + \dots + (m-1)hD_m)$$

3. Calculate the reorder

$$ROP = \bar{d}LT + SS$$

4. Interpretation and Implementation of inventory for next periode.

RESULT AND DISCUSSION

1. Raw Material Purchase Data at 2017 year.

This data is used as a basis for carrying out the demand forecasting process for the period January 2018 - December 2018. These data come from reports on the use of rubber tire raw materials on the CV. XYZ table 1 follows

Table 1 : Tires Raw Material Purchase

Period	Year	Raw Material Purchase (Kg)
January	2017	6.270
February	2017	9.750
March	2017	7.400
April	2017	7.380
May	2017	5.620

June	2017	7.780
July	2017	10.270
August	2017	9.640
September	2017	7.900
October	2017	10.170
November	2017	8.150
December	2017	9.290
Total	99.620	

Source: XYZ

2. Data on Raw Material Ordering

This tire rubber raw material was purchased from Medan, namely PT. Industri Karet Deli. The price of rubber tire raw material is Rp. 40,000 / kg.

While the Order Cost is all costs that occur starting from ordering goods until the availability of goods in the warehouse. Ordering costs incurred on the CV. XYZ is the cost of ordering, inspection and telecommunication costs. The company issues inspection fees of 20% of the booking fee of Rp. 2,650,000 / message. The details of the cost of ordering raw materials each time are as table 2 follows:

Table 2 : Ordering Cost

Information	Biaya (Rp)
Transportation costs	2.000.000
Inspection Costs	530.000
Telecommunication Costs	120.000
Total	2.650.000

Source: CV. XYZ

3. Raw Material Storage Data

Storage costs are costs incurred by CV. XYZ to storage of raw materials in storage. Based on the results of interviews with the head of the operational section, CV. XYZ costs warehouse administration, warehouse maintenance costs and material transfer costs. The amount of storage costs per kg on the CV. XYZ is as table 3 follows:

Table 3 : Storage Cost of raw materials /kg

Information	Cost (Rp)
Warehouse Administration Costs	110
Warehouse Maintenance Costs	125
Material Handling Costs	220
Total	455

Source: CV. XYZ

4. Ordering Lead Time

The lead time is the grace period between when ordering raw materials is carried out with the arrival of raw materials ordered. Based on the results of interviews with the head of the operational section CV. XYZ, the average lead time for rubber tire ordering from suppliers is for 5 days.

5. Forecasting

Based on data on the purchase of rubber tire raw materials in 2017, it appears that there is a fluctuation in the purchase of raw materials for each month. So, the forecasting used is forecasting with time series analysis, namely: Moving Average (MA), Weighted Moving Average (WMA) and Single Exponential Smoothing (SES).

To choose the best forecasting method from the four forecasting methods, errors can be measured between using Mean Absolute Deviation (MAD), Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE). The calculation method is compared to each forecasting method and the smallest (closest to zero) MAD and MAPE values are searched. The following is a third comparison in table 4 measuring errors by using Microsoft Excel:

Table 4 : Comparison of MAD, MSE and MAPE

Forecasting Method		Measurement of Forecasting Errors		
		MAD (Kg)	MSE (Kg)	MAPE (Kg)
Moving Averages	2-Monthly	1.351,00	2.667.770,0	16,56%
	3-Monthly	1.435,93	2.886.845,7	17,72%
	5-Monthly	1.194,57	2.290.614,3	12,53%
Weighted Moving Averages	2-Month Weighted	1.387,20	2.626.070,4	17,05%
	3-Month Weighted	1.436,44	2.695.020,0	17,65%
	5-Month Weighted	1.343,00	2.316.355,3	14,53%
Exponential Smoothing	= 0,1	1.545,17	3.742.776,5	17,24%
	= 0,5	1.349,54	2.845.164,9	15,86%
	= 0,9	1.596,14	3.529.820,7	19,04%

After obtaining the results of the measurement of the error forecasting of the 5-Monthly Moving Averages method, the forecasting data for raw material purchases for the next 12 periods or one year can be seen in the table 5 follows :

Table 5 :Results for forecasting raw material purchases in 2018

Year	Period	Raw Material Purchase (Kg)
------	--------	----------------------------

2018	January	9.030,00
	February	8.356,00
	March	8.726,00
	April	8.172,00
	May	8.018,00
	June	7.284,00
	July	7.586,00
	August	7.690,00
	September	8.138,00
	October	8.242,00
	November	9.152,00
	December	9.226,00
Total	99.620,00	
Average	8.301,67	
Standard deviation	628,17	

6. Calculation of Safety Stock

To reduce the risk of loss of inventory, the calculation of safety stock is held. So the safety stock stock of rubber tire supplies for the 2018 period is as follows:

Known :

$$LT = 5 \text{ days}$$

$$= 0,19 \text{ Month (26 average working days per month in 2017)}$$

$$z = 100\% - z = 100\% - 99,5\%$$

$$= 2,58 \text{ (From the normal curve)}$$

$$\uparrow d = 628,17 \text{ kg/month}$$

Then the value of safety stock is:

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

$$= 2,58\sqrt{0,19}(628,17)$$

$$= 706,44 \text{ kg}$$

This means that the company must have a minimum tire stock of 706.44 kg to anticipate a shortage of goods in production needs.

7. Calculation of Order Size (Lot Size)

Based on the raw material purchase data obtained from the forecasting of suitable methods, it is known that the level of demand for raw materials is random and experiencing a high enough demand variation. Therefore, to determine the lot size, the Heuristic Silver Meal method is used. For example, the calculation of Silver Meal Heuristic for order 1, 2.

Order 1

$$\text{Order Cost/order} = \text{Rp. } 2.650.000$$

$$\text{Storage Cost/kg} = \text{Rp. } 455$$

$$m = 1, A \text{ (order cost)} = 2.650.000$$

$$h \text{ (storage cost)} = 0$$

So, the average cost per month

$$= \frac{1}{1}(2.650.000 + 0)$$

$$\begin{aligned}
 &= \text{Rp. } 2.650.000 \\
 m = 2, A \text{ (order cost)} &= 2.650.000 \\
 D_2 \text{ (Period-2)} &= 8.356 \\
 h \text{ (storage cost)} &= 455 \times 8.356 \\
 &= 3.801.980
 \end{aligned}$$

So, the average cost per month

$$\begin{aligned}
 &= \frac{1}{2} (2.650.000 + (515) 8.356) \\
 &= \text{Rp. } 3.225.990
 \end{aligned}$$

Because the cost for $m = 2 >$ costs for $m = 1$ or Rp. 3,225,990 > Rp. 2,650,000 then taken $m = 1$. So the first amount of raw materials ordered is 9,030 kg.

Order 2

$$\begin{aligned}
 \text{Order Cost/order} &= \text{Rp. } 2.650.000 \\
 \text{Storage Cost/kg} &= \text{Rp. } 455 \\
 m = 1, A \text{ (order cost)} &= 2.650.000 \\
 h \text{ (storage cost)} &= 0
 \end{aligned}$$

So, the average cost per month

$$\begin{aligned}
 &= \frac{1}{1} (2.650.000 + 0) \\
 &= \text{Rp. } 2.650.000
 \end{aligned}$$

$$\begin{aligned}
 m = 2, A \text{ (order cost)} &= 2.650.000 \\
 D_2 \text{ (Period-2)} &= 8.726 \\
 h \text{ (storage cost)} &= 455 \times 8.726 \\
 &= 3.970.330
 \end{aligned}$$

So, the average cost per month

$$\begin{aligned}
 &= \frac{1}{2} (2.650.000 + (455) 8.726) \\
 &= \text{Rp. } 3.310.165
 \end{aligned}$$

Because the cost for $m = 2 >$ costs for $m = 1$ or Rp. 3.310.165 > Rp. 2,650,000 then taken $m = 1$. So the second amount of raw materials ordered is 8,356 kg.

Lot size calculation of rubber treads with Heuristic Silver Meal at tabel 6 follows :

Table 6 :Lot Size Rubber Treads with Heuristic Silver Meal

Rubber Tire Tread		A	H
Trial Periods	Total Demand	Rp. 2.650.000	Rp. 455
		TC	TC/t
Period 1 *	9.030	2.650.000	2.650.000
Period 1, 2	17.386	6.451.980	3.225.990
Period 2 *	8.356	2.650.000	2.650.000
Period 2, 3	17.082	6.620.330	3.310.165
Period 3 *	8.726	2.650.000	2.650.000
Period 3,	16.898	6.368.260	3.184.130

4			
Period 4 *	8.172	2.650.000	2.650.000
Period 4, 5	16.190	6.298.190	3.149.095
Period 5 *	8.018	2.650.000	2.650.000
Period 5, 6	15.302	5.964.220	2.982.110
Period 6 *	7.284	2.650.000	2.650.000
Period 6, 7	14.870	6.101.630	3.050.815
Period 7 *	7.586	2.650.000	2.650.000
Period 7, 8	15.276	6.148.950	3.074.475
Period 8 *	7.690	2.650.000	2.650.000
Period 8, 9	15.828	6.352.790	3.176.395
Period 9 *	8.138	2.650.000	2.650.000
Period 9, 10	16.380	6.400.110	3.200.055
Period 10 *	8.242	2.650.000	2.650.000
Period 10, 11	17.394	6.814.160	3.407.080
Period 11 *	9.152	2.650.000	2.650.000
Period 11, 12	18.378	6.847.830	3.423.915

Not * = Optimal

So the quantity of raw material purchases using the Silver Meal Heuristic method is as much:

First Order	: 9.030 kg.
Second Order	: 8.356 kg.
Third Order	: 8.726 kg.
Forth Order	: 8.172 kg.
Fifth Order	: 8.018 kg.
Sixth Order	: 7.284 kg.
Seventh Order	: 7.586 kg.
Eighth Order	: 7.690 kg.
Ninth Order	: 8.138 kg.
Tenth Order	: 8.242 kg.
Eleventh Order	: 9.152 kg.
Twelfth Order:	9.226 kg.

8. Calculation of Reorder Points

In this study Reorder Point models are used where the level of demand is variable and Lead Time is constant.

Known:

$$d = 8.301,67 \text{ kg/month}$$

$$\bar{dLT} = 8.301,67 (0,19)$$

$$= 1.577,32 \text{ kg.}$$

Then the ROP value is:

$$ROP = \bar{dLT} + SS$$

$$= 8.301,67 (0,19) + 706,44$$

$$= 1.577,32 + 706,44$$

Thus the company must at least order a minimum return if the tire rubber stock is only 2,283.76 kg.

. Planning Raw Material Supplies

Then the planning of rubber tire raw material inventory at CV. XYZ in 2018 can be presented in the following MRP table:

$$Safety \ stock = 706,44 \text{ kg.}$$

$$Lead \ time = 5 \text{ days}$$

$$= 0,19 \text{ month.}$$

Inventory Planning for rubber tire treads at table 7 follows :

Table 7 : Rubber Tire Tread Inventory Planning

Rubber Tire Tread	Period												
	0	1	2	3	4	5	6	7	8	9	10	11	12
LT: 0,19 SS :706,44													
GR (KG)		9.030,00	8.356,00	8.726,00	8.172,00	8.018,00	7.284,00	7.586,00	7.690,00	8.138,00	8.242,00	9.152,00	9.226,00
SR (KG)		9.030,00											
POH (KG)	706,44	706,44	706,44	706,44	706,44	706,44	706,44	706,44	706,44	706,44	706,44	706,44	706,44
NR (KG)		8.323,56	7.649,56	8.019,56	7.465,56	7.311,56	6.577,56	6.879,56	6.983,56	7.431,56	7.535,56	8.445,56	8.519,56
PoRec (KG)			8.356,00	8.726,00	8.172,00	8.018,00	7.284,00	7.586,00	7.690,00	8.138,00	8.242,00	9.152,00	9.226,00
PoRel (KG)		8.356,00	8.726,00	8.172,00	8.018,00	7.284,00	7.586,00	7.690,00	8.138,00	8.242,00	9.152,00	9.226,00	

Heuristic Silver Meal Method:

- Order cost of Tire Tread Rubber/year
 = amount of order × storage cost
 = 12 × Rp. 2.650.000
 = Rp. 31.800.000
- Storage cost of Tire Tread Rubber/year
 = Storage cost OH + Storage cost SS
 = (455 × 706,44) + (455 × 706,44 × 12)
 = Rp. 321.430,2 + Rp. 3.857.162,4
 = Rp. 4.178.592,6
- Purchase cost of Tire Tread Rubber/year
 = purchase BB × cost BB
 = (9.030 + 8.356 + 8.726 + 8.172 + 8.018 + 7.284 + 7.586 + 7.690 + 8.138 + 8.242 + 9.152 + 9.226) × 40.000
 = 99.620 kg × Rp. 40.000
 = Rp. 3.984.800.000
- Inventory cost of Tire Tread Rubber/year
 = Order cost + Storage cost
 = Rp. 31.800.000 + Rp. 4.178.592,6
 = Rp. 35.978.592,6
- Total cost of Tire Tread Rubber/year
 = Purchase cost + Inventory cost

$$= \text{Rp. } 3.984.800.000 + \text{Rp. } 35.978.592,6$$

$$= \text{Rp. } 4.020.778.592,6$$

Company policy:

- Cost of Tire Tread Rubber/year un
 = amount of order × order cost
 = 12 x Rp. 2.650.000
 = Rp. 31.800.000
- Storage cost of Tire Tread Rubber/year
 = Storage cost OH × amount BB
 = Rp. 455 × 99.620 kg
 = Rp. 45.327.100
- Purchase cost of Tire Tread Rubber/year
 = purchase BB × cost BB
 = (6.270 + 9.750 + 7.400 + 7.380 + 5.620 + 7.780 + 10.270 + 9.640 + 7.900 + 10.170 + 8.150 + 9.290) × 40.000
 = 99.620 kg × Rp. 40.000
 = Rp. 3.984.800.000
- Inventory cost of Tire Tread Rubber/year
 = order cost + storage cost
 = Rp. 31.800.000 + Rp. 45.327.100
 = Rp. 77.127.100

- e. Total cost of Tire Tread Rubber/year
= Purchase cost + Inventory cost
= Rp. 3.984.800.000 + Rp. 77.127.100
= Rp. 4.061.927.100

Based on the results of calculations using the Silver Meal Heuristic method, the total cost of raw materials for Tire Tread Rubber is Rp. 4,020,778,592.6. While the results of calculations using the actual method of the company obtained the total cost of raw material inventory of Rp. 4,061,927,100. Of the two total costs compared to that obtained a difference of Rp. 4,061,927,100 - Rp. 4,020,778,592,6 = Rp. 41,148,507.4 shows that there is efficiency by using the Silver Meal Heuristic Method that is equal to 1.01%.

CONCLUSION

Based on the results of the research that has been done, a conclusion is obtained:

- a. From the calculation results obtained the safety stock of tire rubber raw materials as much as 706.44 kg, this means that the company must have a rubber tire stock of at least 706.44 kg to anticipate the occurrence of deficiencies in production needs. Whereas the reorder point obtained was 2,283.76 kg. This means that the company must make a re-order of raw materials if the minimum stock is 2,283.76 kg. So that the calculation with Silver Meal Heuristic method obtained the order size for 2018 Period which is 12 orders, namely in January Period = 9,030 kg, February = 8,356 kg, March = 8,726 kg, April = 8,172 kg, May = 8,018 kg, June = 7,284 kg, July = 7,586 kg, August = 7,690 kg, September = 8,138 kg, October = 8,242 kg, November = 9,152 kg, and December = 9,226 kg, with an order fee of $12 \times \text{Rp. } 2,650,000 = \text{Rp. } 31,800,000$.
- b. Inventory Planning for tire rubber raw material carried out in December 2017 the company orders 9,030 kg of raw material for January 2018 production with a lead time of 0.19 months. Then to anticipate the occurrence of material damage, the company provides safety supplies as much as 706.44 kg of rubber tires in the warehouse per month. The company re-orders in January 2018 for production in February 2018. Just like the previous order, the company must wait 5 days (0.19 months) until the raw material arrives and is ready to be used for production consumption.

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