Applied Mathematical Sciences, Vol. 8, 2014, no. 83, 4115 - 4124
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/ams.2014.45375

The Calculation of Extra Carrying Cost (ECC) and Stock out Cost (SOC) to Determine the Raw Material's Optimal Arrival Lead Time

Haryadi Sarjono

Management Department, School of Business Management (SoBM)
Bina Nusantara University, Jl. KH. Syahdan No. 9
Kemanggisan, Jakarta Barat, Indonesia, 11480

Abstract

The purpose of this research is to determine how long is the arrival time of raw material needed by the company based on Extra Carrying Cost (ECC) and Stock Out Cost (SOC) calculation. The result of the calculation will be compared with company strategy and with theoretical calculation using Economic Order Quantity (EOQ). The research done in Rajalu Ltd. located in Surabaya, an aluminium smelter company, which smelting the recycle from all types of aluminium scraps or trashes. Research methodology in this research is qualitative research by observing the raw material requirements, ordering cost, holding cost, and working days within a year. The result of this research showed that between the comparison of the calculation based on company strategy and Economic Order Quantity (EOQ), the optimal lead time calculation was based on Economic Order Quantity (EOQ), which is 7 days with the lowest total cost IDR 22,809,436,-

Keyword: EOQ, inventory, lead time, order frequency, extra carrying cost, stock out cost.

INTRODUCTION

Background

One of management crucial function in a company operational is inventory control. Inventory is one of the important assets of many companies because total inventory representing as much as 40% of total invested capital. An operations manager should understand that inven-

tory is a very crucial issue, company always tries to reduce costs by decreasing inventory levels while keeping the quality of the product produced to satisfy the customers.
According to the situation above, inventory level control of raw material or finished good is needed to fulfilled both production process and the customer's needs. The main purpose of inventory control is to ensure that company always has the right inventory amount, in the right time, and match with the quality that has been determined so the continuity of the business does not be disturbed. In a production process, the inventory of raw material is important and related to the marketing strategy of the finished product.
One of the companies that applied inventory control is Rajalu Ltd., an aluminium smelter company that located in Gresik city, Mojo Tengah village, approximately 30 minutes from Surabaya, (East Java), is a sole proprietorship company formed in 2000 by Mr. Ferry Tantono and engaged in aluminium smelting, which is smelted the recycle from all types of aluminium scraps or trashes, for examples are drinks can, cooking utensil, car license plate, wire, and others. All those aluminium scrap is heated and printed as Ingot Aluminium and become raw material for new aluminium stuff, for examples door frame or window, new pot and pan, motor engine, and others. Along with the company growth, in 2008 the company started to penetrate in higher automotive industry as a first layer vendor in OIM company for Astra Otoparts Tbk., Honda Prospek Motor, Enkei Indonesia. In this situation, company is growing rapidly, in which all types of the product produces are increasing and the markets are penetrated to outside Java island.

Problem identification

The raw material lead time plan until it arrived at the warehouse is one of inventory control in overall operations management process in a company that can affect the production process in a bad way. This following are the problem identification that related to the explanation above:

1. How much is the lowest total cost of smelter company per year?
2. How long is the optimal lead time for raw material in the aluminium smelting company, based on Economic Order Quantity (EOQ) method?

Problem Scope

This research limits the research problem on raw material lead time cost, from the ordering time until the arrival in the warehouse, meanwhile the data needed for this research are raw material requirement, ordering cost, holding cost and working days within a year.

LITERATURE REVIEW

Several assumptions of EOQ according to Heiser and Render (2011):

1. Demand is known and constant.
2. The lead time, which is the time between the placement of the order and the receipt of the order, is known and constant.
3. The inventory from an order arrives is in one batch and completion.
4. Discount because of the quantity is not possible.
5. The only variable costs are ordering cost and holding or carrying cost.
6. Stockouts or shortage can be avoided completely if the order is placed at the right time.

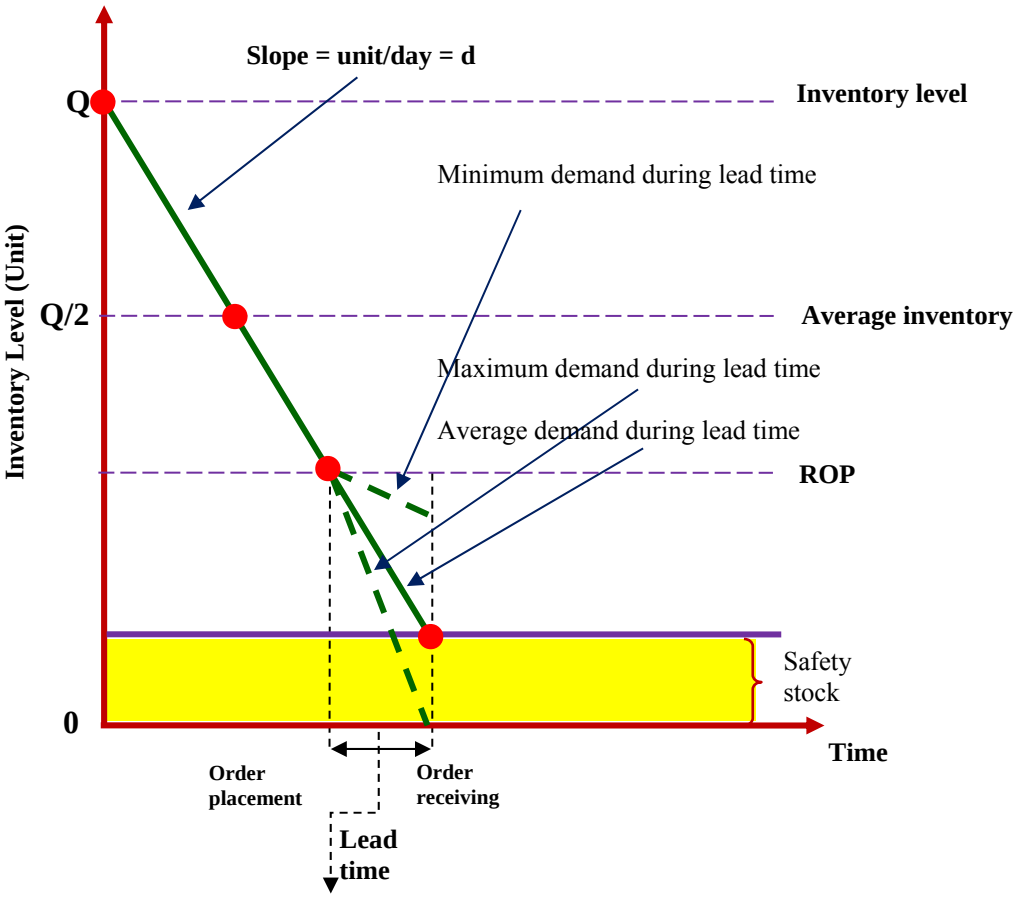

Figure 1. EOQ Inventory Model

RESEARCH METHODOLOGY

Research methodology in this research is qualitative research by observing the data using EOQ method, supporting data from company, such as the raw material requirements, ordering cost, holding cost, and working days within a year.

Unit Analysis

Unit of analysis that will be examined in this study are sales data, as well as the purchase of raw material inventory stock data from the marketing department, warehouse and corporate purchasing department

RESULT AND DISCUSSION

Before calculate lead time, other calculations needed are **a**). Total inventory cost and **b**). Optimal raw material order frequency.

Tabel 1. Table Percentage of Raw Material Supplies

Types of Raw Material	Persentase
Machine, drum, drill (Hard)	40%
Frying Pan, plate, elbow (Soft)	40%
Cans	5%
Abu, Taen, Gram	5%
Pure Aluminum	10%
Total	**100%**

A. Comparison of the total cost of inventories according to the company's calculations and according to the calculation of EOQ in 2012.

Comparative analysis to find out the cost of supply of the raw material that the company implemented more efficiently or not compared to the calculation according to the formula EOQ.

1. The total cost of the inventory quantity according to the company

- Raw materials needs in 2012 = 2,070,465 Kg
- Marketing frequency = 48 kali
- Quantity / Ordering = 2,070,465 / 48 = 43,135 Kg
- Ordering Cost
  - Telephone charges = IDR. 30,000,000
  - Transportation cost and loading and unloading have been entered into the cost of raw materials.

- Holding cost per-kg: 10% of the calculated per-kg price of items per-type of goods
  - Machine; etc (Hard) = 40% x 1,600 = IDR. 640
  - Pan; etc (Soft) = 40% x 1,600 = IDR. 640
  - Cans = 5% x 1,350 = IDR. 68
  - Abu, taen, Gram = 5% x 1,000 = IDR. 50
  - Pure Aluminum = 10% x 2,200 = IDR. 220 +

  Total save cost per-kg = **IDR. 1,618**

With the cost of supplies, safety stock calculation at least is some 50% of the per order.

- Holding Cost = 1\2 x 43,135 x IDR. 1,618 = IDR. 34,896,215
- Ordering Cost = IDR. 30,000,000
- Raw Material Cost = IDR. 33,489,771,375 +

  = IDR. 33,554,656,806

Table 3. The number of each type of raw material needs

Type of raw material	%	Quantity (Kg)	Price / Kg (IDR)	Raw Material Cost (IDR)	Q/ Order (Kg)
Machine, drum, drill (Hard)	40%	828,186	16,000	13,250,976,000	17,254
Frying Pan, plate, elbow (Soft)	40%	828,186	16,000	13,250,976,000	17,254
Cans	5%	103,523	13,500	1,397,563,875	2,157
Abu, Taen, Gram	5%	103,523	10,000	1,035,232,500	2,157
Pure Aluminum	10%	207,047	22,000	4,555,023,000	4,314
Total	**100%**	**2.070.465**	**-**	**33.489.771.375**	**43.135**

2. The total cost of the inventory quantity according to the calculation of EOQ.

Where :

- Raw Material (2012) = 2,070,465 Kg
- Ordering Cost = IDR. 30,000,000/48 = IDR. 625,000
- Holding Cost = IDR. 1,618 / Kg

The value of the EOQ can be calculated as follows

So, the frequency of ordering is 52 times, then :

$$\mathbf{EOQ} = \sqrt{\frac{2(2{,}070{,}465)(625{,}000)}{1{,}618}} = \mathbf{39{,}994.45}$$

$$\mathbf{F}\ (\text{Frequency}) = \frac{2.070{,}465}{39.994.45} = \mathbf{51.8} = \mathbf{52}\ \text{times.}$$

$$\mathbf{Q} = \frac{2{,}070{,}465}{52} = \mathbf{39.817}\ \text{Kg}$$

With the cost of supplies :

- Holding Cost = 1\2 x 39,817 x IDR. 1,618 = IDR. 32,201,703
- Ordering Cost = 52 x IDR. 625,000 = IDR. 32,500,000
- Raw Material Cost = IDT. 33,489,771,375 +

= IDR. 33,554,473,07

Based on the calculation of EOQ above, the frequency of 52 times with quantity-per-order is the most efficient was 39.817 kg and the total cost of the inventory is **IDR. 33,554,473,078,-** When compared with calculations that have been done the company then found a difference of **IDR. 183,728,-**

Tabel 4. Cost comparison of the total cost of inventory according to company policy and eoq in year 2007-2012 (in IDR)

Year	Company Calculation	EOQ Calculation	Difference
2007	IDR. 39,832,553,333	IDR. 39,827,591,167	IDR. 4,962,167
2008	50,788,337,585	50,780,319,161	8,018,424
2009	16,935,183,076	16,934,951,428	231,648
2010	27,122,652,302	27,122,508,219	144,083
2011	24,684,075,427	24,684,058,836	16,591
2012	33,554,656,806	33,554,473,078	183,728

Note: EOQ calculations for 2007-2011, to do the same way with 2012.

Based on the data above, it is seen that there are many differences between the company's already done with calculation of eoq, seem that the equaition by the company only as 48 time turns out to be done difference amount for each year with a time of 5 days, this is due to a number of needs that are not the same each year depending on the end of product marketing.

B. The frequancy of purchases of optimal raw material.

1. **The frequency of purchases of raw material is optimum according to company policy.**
   From the results of the calculation of the total cost of the inventory quantity according to calculations the company obtained optimal company purchase frequency as much as 4 times in one year with a total cost of issued is amounting to **IDR. 33,554,656,806.**
2. **The frequency of purchase of raw materials according to the calculation of eoq.**
   Based on the calculation of the total cost of inventories according to the calculation above of eoq then come by the frequency of purchase quantity 52 times per-order is the most efficient 39,817 kg and the total cost of the inventory is IDR. 33,554,473,078. With the same method of calculating the frequency reservations has been calculated according to the company and the calculation of Economic Order Quantity (EOQ) start from year 2007 – 2012 the result can be seen in the following table:

Tabel 5. Comparison of the frequency of the company according to the company and the calculation of Economic Order Quantity (EOQ) year 2007 - 2012

Year	Company Calculation	EOQ Calculation	Difference
2007	48 times	73 times	25 times
2008	48 times	79 times	31 times
2009	48 times	43 times	5 times
2010	48 times	52 times	4 times
2011	48 times	47 times	1 time
2012	48 times	52 times	4 times

Note: method of calculating in years 2007-2011, same with the year of 2012

Lead Time Analysis

Lead time is the time between ordering raw material until it arrives at the warehouse. To determine the optimal lead time, company should bears several costs, such as:

1. Extra Carrying Cost (ECC) is cost that inquired if the arrival of raw material is earlier than the expected time.
2. Stock Out Cost (ECC) is cost that inquired if the arrival of raw material is longer than the expected time.

Data that needed in the lead time calculation for 2012 are:

- Raw material requirement for 2012 = 2,070,465 Kg
- Ordering Cost = IDR. 30,000,000/48 = IDR. 625,000
- Holding Cost = IDR. 1,618/Kg
- Working days within a year = 300 days

Table 6. Company Lead Time Experiences

Lead Time (days)	Frequency (times)	Probability (%)
3	7	23.33%
4	6	20.00%
5	4	13.34%
6	7	23.33%
7	6	20.00%
Total	**30**	**100%**

$$\textbf{EOQ} = \sqrt{\frac{2(2{,}070{,}465)(625{,}000)}{1{,}618}} = \textbf{39,994.45}$$

$$\textbf{F}\ (\text{Frequency}) = \frac{2{,}070{,}465}{39{,}994.45} = \textbf{51.8} = \textbf{52}\ \text{times}$$

Raw material requirement per day = 2,070,465 / 300 = 6,902 Kg / days.

1. Extra Carrying Cost (ECC) Calculation for 2012

Extra Carrying Cost (ECC) calculation is = Holding Cost/Kg **x** (EOQ Quantity/working days)

= IDR. 1,618 x (39,994.45 / 300) = IDR. 215,703

This following are Extra Carrying Cost (ECC) for each lead time alternative:

- Lead time: 3 days → ECC = 0 x IDR. 215,703 = 0
- Lead time: 4 days → ECC = 1 x IDR. 215,703 x 23.33% = IDR. 50,330
- Lead time: 5 days → ECC = 2 x IDR. 215,703 x 23.33% = IDR. 100,660
  ECC = 1 x IDR. 215,703 x 20.00% = IDR. 43,146
  Total **IDR. 143,806**

- Lead time: 6 days → ECC = 3 x IDR. 215,703 x 23.33% = IDR. 150,989
  ECC = 2 x IDR. 215,703 x 20.00% = IDR. 86,292
  ECC = 1 x IDR. 215,703 x 13.34% = IDR. 28,778
  Total **IDR. 266,759**

- Lead time: 7 days → ECC = 4 x IDR. 215,703 x 23.33% = IDR. 201,319
  ECC = 3 x IDR. 215,703 x 20,00% = IDR. 129,438
  ECC = 2 x IDR. 215,703 x 13,34% = IDR. 57,556
  ECC = 1 x IDR. 215,703 x 23,33% = IDR. 50,330
  Total IDR**. 438,643**

2. Stock Out Cost (SOC) Calculation for 2012

This following are Stock Out Cost (SOC) calculation:

- Raw material requirement (2012) = 2,070,465 Kg / 300 days = 6,901 kg / day
- Purchase price difference (if forced to buy if shortage) called as shortage cost = IDR. 250.
- SOC per-days = (raw material requirement) (shortage cost)

= (6,901 kg) (IDR. 250) = IDR. 1,725,250 per-Kg

Stock Out Cost (SOC) calculation for each lead time alternative are:

- Lead time: 7 days → SOC = 0 x IDR. 1,725,250 = 0
- Lead time: 6 days → SOC = 1 x IDR. 1,725,250 x 23.33% = IDR. 402,500
- Lead time: 5 days → SOC = 2 x IDR. 1,725,250 x 23.33% = IDR. 805,001
  SOC = 1 x IDR. 1,725,250 x 20.00% = IDR. 345,050
  Total **IDR. 1,150,051**

- Lead time: 4 days → SOC = 3 x IDR. 1,725,250 x 23.33% = IDR. 1,207,502
  SOC = 2 x IDR. 1,725,250 x 20.00% = IDR. 690,100
  SOC = 1 x IDR. 1,725,250 x 13.34% = IDR. 230,148
  Total **IDR. 2,127,750**

- Lead time: 3 days → SOC = 4 x IDR. 1,725,250 x 23.33% = IDR. 1,610,003
  SOC = 3 x IDR. 1,725,250 x 20,00% = IDR. 1,035,150
  SOC = 2 x IDR. 1,725,250 x 13,34% = IDR. 460,296
  SOC = 1 x IDR. 1,725,250 x 23,33% = IDR. 402,500
  Total **IDR. 3,507,949**

From the calculation above, the optimal lead time probability table can be concluded as:

Table 3. Lead Time Probability and Projected Cost for 2012

Lead time	Extra Carrying Cost (ECC)		Stock Out Cost (SOC)		Total cost
	Per-Order	Per-year	Per-Order	Per-year	
3 days	-	-	3,507,949	182,413,348	182,413,348
4 days	50,330	2,617,160	2,127,750	110,643,000	113,260,160
5 days	143,806	7,477,912	1,150,051	59,802,652	67,280,564
6 days	266,759	13,871,468	402,500	20,930,000	34,801,468
7 days	438,643	22,809,436	-	-	**22,809,436**

The total lead time cost is the sum of extra carrying cost (ECC) and stock out cost (SOC). From the table above, known that the optimal lead time for 2012 is 7 days, this is because the total cost is the lowest compared to others, which is IDR 22,809,436/year. With the same way, the result of the optimal lead time calculation based on EOQ model with total minimum cost from 2007-2012 are:

Table 4. Lead Time for Raw Material based on Economic Order Quantity (EOQ)

Year	Lead time (days)	Total cost (IDR)
2007	7	26,811,732
2008	7	34,531,611
2009	7	11,434,474
2010	7	18,449,600
2011	7	16,768,566
2012	7	22,809,436

Tabel 5. Comparison according to the discretion of the company according to the Economic Order Quantity (EOQ) method year 2007-2012

Description	2007		2008		2009	
	Company	EOQ	Company	EOQ	Company	EOQ
Raw Materials need (Kg)	2.474.240	2.474.240	2.881.581	2.881.581	1.132.990	1.132.990
Ordering Frequency (time)	48	73	48	79	48	43
Inventory Cost (IDR)	39.832.553.333	39.827.591.167	50.788.337.585	50.780.319.161	16.935.183.076	16.934.951.428
Lead Time (days)	**5**	**7**	**5**	**7**	**5**	**7**
Total lead time cost(IDR)	**-**	**26.811.732**	**-**	**34.531.611**	**-**	**11.434.474**
Safety Stock (Kg)	0	29.755	0	29.625	0	20.716
ROP (Kg)	41.237	87.484	48.026	96.860	18.883	47.148

Description	2010		2011		2012	
	Company	EOQ	Company	EOQ	Company	EOQ
Raw Materials need (Kg)	1.815.266	1.815.266	1.584.014	1.584.014	2.070.465	2.070.465
Ordering Frequncy (time)	48	52	48	47	48	52
Inventory Cost (IDR)	27.122.652.302	27.122.508.219	24.684.075.427	24.684.058.836	33.554.656.806	33.554.473.078
Lead Time (days)	**5**	**7**	**5**	**7**	**5**	**7**
Total lead time cost (IDR)	**-**	**18.449.600**	**-**	**16.768.566**	**-**	**22.809.436**
Safety Stock (Kg)	0	21.923	0	24.104	0	21.743
ROP (Kg)	30.254	64.273	26.400	61.064	34.508	70.050

CONCLUSION

From the tables above, the conclusions that can be concluded only for 2012 are:

- Total lead time cost is the sum of extra carrying cost (ECC) and stock out cost (SOC). The lowest cost of lead time calculation is IDR 22,809,436.
- The optimal lead time based in Economic Order Quantity (EOQ) method is 7 days.

REFERENCES

[1] Candra, Sevenpri and Sarjono, Haryadi; (2011), Forecasting for inventory control, *Journal Supply Chain Management, Research and Pratice*, Assumtion University of Thailand, Vol. 6 June 2012, pp. 1-14., ISSN: 1905-9566.

[2] Mulyono, Sri; (2004), *Riset Operasi*, Edisi revisi, FEUI, Jakarta, Indonesia.

[3] Heizer, Jay and Render, Barry; (2011). *Operations Management*. 10th edition. New Jersey: Pearson.
[4] Render, Barry, Stair Jr., Ralph. M., and Hanna, Michael E.; (2012), *Quantitatif Analysis for Management*, 11th ed, Global Edition, Pearson.
[5] Render, Barry and Heizer, Jay; (2009); *Manajemen Operasi*, (terjemahan), Buku 1, Edisi 9, Salemba Empat, Jakarta, Indonesia.
[6] Taylor, Bernard W, III; (2010), *Introduction to Management Science*, 10th Edition, Global Edition, Pearson.
[7] Tri Pamungkas, Wahyu dan Susanto, Aftony; (2010), *Analisis Pengendalian Bahan Baku menggunakan metode EOQ* (Stud Kasus PT Misaja Mitra Co. Ltd)
[8] Wang, Chuanxu; (2008), Impact of Supply Chain Coordination for Deteriorating Goods with Stock-Dependt Demand rate, *Journal of Service Science and Management*, p. 123-127.
[9] Zaidi, S. A. H.; Khan, S. A. and Dweiri, F.; (2012), Implementation of Inventory Management System in a furniture company. *International Journal of Engineering and Technology*, 2(8):5-6.

Received: May 25, 2014