An Analysis of Transformer Raw Materials Planning by Using Lot Sizing Technique (A Study Case of PT. XYZ Indonesia)

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Abstract: ***Global market of world electrical equipment has increased year by year. However, the fluctuated cost of raw materials can become an obstacle for the market development. PT. XYZ as one of electrical equipment companies needs a strategy of raw materials planning to meet the market demand which is expected to continue to grow. This study aims to analyze the raw material planning one of the company's products, namely transformer, which is able to save the total cost of inventory using lot sizing techniques. The method used is descriptive quantitative research. This study illustrates and compares several lot sizing techniques and its compliance with the conditions of the company. The conducted analysis shows among several lot sizing techniques mentioned, namely Lot for Lot (LFL), Economic Order Quantity (EOQ), Least Total Cost (LTC), Least Unit Cost (LUC), Part Period Balancing (PPB), and Wagner Within algorithm, lot sizing techniques which can be implemented in a company are lot for lot and Wagner Within algorithm. The research result shows that Wagner Within algorithm is the most suitable lot sizing technique in the transformer's raw materials planning. Wagner Within algorithm is able to produce the lower inventory cost compared to lot for lot technique can do and save total cost saving ranges from 12 until 62 percent.***

Keywords: Inventory Cost, Lot for Lot (LFL), Lot Sizing Technique, Wagner Within Algorithm

1. Introduction

The liberalization of markets around the world has caused the enhancement of competition, especially among the manufactures which produce goods and services. The competitiveness of companies in the future will inevitably depend on how they respond the customer's need in the last chain of supply, which is better than their competitors (Thogori, 2014). The global market of electrical equipment has increased in numbers of mergers and acquisitions. However, the fluctuated cost of raw materials can become an obstacle for the market development (Research and Markets, 2013). In 2014, based on the data of Central Bureau of Statistics, the manufactures' performance in Indonesia is increasingly better; this case is supported by the enhancement of the sectors production, primarily the electrical equipment industry which grows by 13.21 percent (CNN Indonesia, 2014).

PT. XYZ in its business development has participated in the national economic establishment in a real sector, especially manufacture industry which produces exported products empowering many labours as well as performing the partnership program with the small industries. PT. XYZ until now has not owned a system in controlling the inventory of raw materials yet to meet the customer's demand. The "make to order" system makes the company only planning the production based on the order. Moreover, the company does not store the finished goods in a warehouse. It causes the raw materials control does not become the focus of the company in minimizing the inventory cost.

In order to respond the customer's demand, the detailed production scheduling is needed to operate the "make to order" so that the strict delivery commitment is met. Therefore, the problem is when and how many products will be produced in some periods (Zhongping, 2011). The problem of lot sizing on a material requirement system is a central issue in the system planning. Selecting the right lot sizing method will minimize the total set up and the inventory cost (Ismail, 2011).

2. Theory

2.1 Inventory Management

Inventory, based on Jacobs (2008:312), is storage from goods or resources used by the company. The manufacture inventory refers to the goods which contribute to a part of output product of a company. The manufacture inventory is classified into raw materials, finished goods, component parts, supply, and works in process. According to Balakrishnan (2011:12-1), inventory is stored resources which are used to meet today's needs or in the future. The raw materials, work-in-process, and the finished goods are examples of inventory. Each organization has different planning and inventory system.

2.1 Lot Sizing Technique

Lot sizing technique, based on Heizer (2009:176), is a process or a technique which is used to determine the lot size. Jacobs (2008:361) stated that most lot sizings are related to how we balance between the set up cost or the order cost and the holding cost to meet the requirements of raw materials planning. There are several techniques of lot sizing, they are Lot for Lot (LFL), Economic Order Quantity (EOQ), Least Total Cost (LTC), Least Unit Cost (LUC), Part Period Balancing (PPB), and Wagner Within algorithm.

LFL is the most common technique. This technique produces precisely what is needed. EOQ model is preferred when there is an independent demand which is now relatively fixed when this demand is discovered. LTC method is a dynamic lot sizing technique which calculates the order quantity by comparing the carrying cost and the set up cost (or order) with various lot sizes. LUC method is a dynamic lot sizing technique which adds the order cost and the storage cost for the size lot experiment and which divides them by numbers of unit in each lot, and then which selects the lot size with the lowest unit cost. PPB is a more dynamic approach to balance the set up cost and the storage cost. The procedure of Wagner Within is a dynamic programming model which adds some complexities on the calculation of the lot size. This procedure assumes that a horizon in a limited time is beyond a situation where there is no additional requirement.

3. Method

3.1 Descriptive Quantitative Method

The type of research is a descriptive quantitative research by comparing several lot sizing techniques and finding out which technique can generate the lowest inventory cost. Descriptive research according to Zikmund (2010:55) is study trying to draw a picture of a particular situation by answering the question of who, what, when, where, and how. Quantitative research according to Bryman (2007:26) is a research strategy that emphasizes the calculation in the collection and analysis of data. Quantitative research requires a deductive approach of the relationship between theory and research.

The lot sizing technique which will be used in this research is a lot sizing technique which is the most suitable with the situation of the company. Table 1 presented indicators of every lot sizing technique and situation of the company.

Table 1: Lot Sizing Technique Implementation

No	*Lot Sizing Technique*	*Indicator*	*Situation of the Company*
1.	Lot for lot (LFL)	a. Order plan based on the requirement. b. No storing the inventory. c. Having a high set up cost.	The situation of the company now describes that the company implements the LFL technique in raw material planning.
2.	Economic Order Quantity (EOQ)	a. The balanced storage cost and set up cost. b. The constant demand. c. Safety stock. d. The estimate of annual demand.	The sudden order demand of raw materials which is beyond the estimate is not suitable with the aim of EOQ which is used to calculate the cost with the constant demand.
3.	Least Total Cost (LTC)	a. The various lot sizes. b. Comparing the storage cost and order cost. c. Selecting the lot with the same comparison.	Based on the previous research, LTC technique is not the most optimum technique in minimizing the inventory cost so that will not be used as a comparison.
4.	Least Unit Cost (LUC)	a. The lot size experiment. b. The order cost. c. The storage cost. d. The selection of lot with the lowest cost.	Based on the previous research, LUC technique is not the most optimum technique in minimizing the inventory cost so that LUC technique will not be used as a comparison.
5.	Part Period Balancing (PPB)	a. Balancing the set up cost and order. b. Using the Equivalent Part Period (EPP) to convert the order cost.	The company does not have the standard EPP in planning the raw materials.
6.	Wagner Within Algorithm	a. Minimizing the storage cost and the order cost. b. The numbers of order and time of order are not fixed. c. The inventory in the last period of planning is always zero.	The sudden order demand of the raw materials which is beyond the estimate is suitable with the aim of Wagner Within algorithm which is used to calculate the cost. Based on the previous research, Wagner Within algorithm shows the most optimum result compared to other techniques.

Based on the table above, the lot sizing technique which will be used in this research is the technique implemented by the company, namely lot for lot, and the technique considered to be the most optimum, namely Wagner Within algorithm.

4. Result and Discussion

4.1 The List of Raw Materials Requirements

The raw materials which will be analysed in this research are five types' raw materials of transformer. The product structure data of transformer can be seen in figure 1

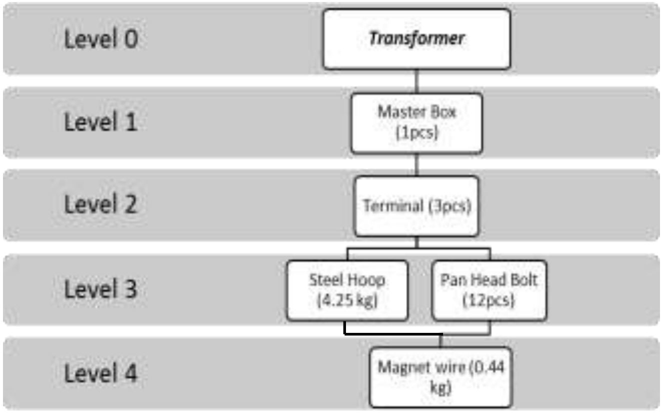

Figure 1: Product Structure of Transformer

4.2 Data of Net Requirement

The further step is to determine the master production schedule, the gross requirement, and the net requirement of the raw materials. Practically, PT. XYZ does not provide the data of master production schedule and the gross requirement of each raw material so that the used data are the data of net requirement. The data of net requirement which are used in this research are the data of net requirement of transformer raw materials during January – December 2014 as presented in table 2.

Table 2: Net Requirement of Transformer Raw Material (January – December 2014)

Month	*Net Requirement*				
	Master Box (pcs)	*Terminal (pcs)*	*Steel Hoop (kg)*	*Pan Head Bolt (pcs)*	*Magnet Wire (kg)*
January	130	5,000	7,183	2,000	1,029.3
February	320	5,000	3,289	2,000	0
March	100	0	1,882	7,500	503.9
April	200	0	1,916	3,500	0
May	250	10,000	2,160	3,000	503.1
June	547	5,000	1,407	5,500	0
July	0	5,000	2,762	3,500	503.1
August	980	0	3,617	3,500	499.6
September	0	0	1,918	4,000	533.6
October	1,040	5,000	3,776	4,000	0
November	0	10,000	3,394	4,000	1,001.4
December	690	5,000	767	1,000	490.4
Total	4,257	50,000	34,071	43,500	5,064.2
Average	355	4,167	2,839	3,625	422.02

4.3 Order Cost

Transformer raw material is originated from two sources, from domestic raw materials and imported raw materials. The domestic raw materials are two types: master box and pan head bolt.

The components of domestic order cost are:

a. Phone cost = Rp 1,200.-/min x 5 minutes = Rp 6,000.-
b. Administration cost = Rp 10,000.-
c. Transportation cost = Rp 14,200.-
d. Examination cost = Rp 50,300.-+
e. Total = Rp 80,500.-

Those costs are applied in every single time order.

The imported raw materials are three types: terminal, steel hoop, and magnet wire. The imported order cost is obtained by calculating the incoming custom and the import tax. The calculation is based on the formulation of custom tariff which is available on http://www.beacukai.go.id (2015) or http://www.bcsoetta.net/ (2015). The order cost of imported raw materials can be seen in table 3.

Table 3: The Order Cost of Imported Raw Materials

No	*Raw Materials*	*Order Cost (Rp)*
1.	Terminal	7,211,000
2.	Steel hoop	32,240,000
3.	Magnet wire	28,379,000

4.4 Storage Cost

Storage cost is the cost incurred relating to the supply of the raw materials. PT. XYZ provides the provisions by determining the storage cost with domestic raw materials by 0.5% of the raw materials price and with imported raw materials by 2.5% of the raw materials price. The storage costs of each raw material can be seen in table 4.

Table 4: Storage Cost of Raw Materials

No	*Raw Materials*	*Storage Cost/pcs (Rp)*
1	Master box	19.4
2	Terminal	109.2
3	Steel hoop	401.8
4	Pan head bolt	5.3
5	Magnet wire	2,500

4.5 Calculation of Lot for Lot Technique (LFL)

PT. XYZ practically implements the lot for lot technique in the raw materials planning. It is because the company does not store the supply of raw materials in a warehouse. The order is executed based on the net requirement needed by the company. The cost incurred from the lot is only the order cost and it does not have the inventory so that the inventory cost is zero. The example of the calculation of technique in master box can be seen in table 5.

Table 5: Results Calculation of Master Box Using Lot for Lot Technique

Month	*Net Requirement*	*Order Quantity*	*Inventory*	*Storage cost (Rp)*	*Order Cost (Rp)*	*Total Cost (Rp)*
January	130	130	0	0	80,500	80,500
February	320	320	0	0	80,500	161,000
March	100	100	0	0	80,500	241,500
April	200	200	0	0	80,500	322,000
May	250	250	0	0	80,500	402,500
June	547	547	0	0	80,500	483,000
July	0	0	0	0	0	483,000
August	980	980	0	0	80,500	563,500
September	0	0	0	0	0	563,500
October	1,040	1,040	0	0	80,500	644,000
November	0	0	0	0	0	644,000
December	690	690	0	0	80,500	724,500

The final results of calculation lot for lot technique from each raw material can be seen in table 6.

Table 6: Results Calculation of Lot for Lot Technique

No	*Raw Materials*	*Total Inventory Cost (Rp)*
1	Master box	724,500
2	Terminal	57,688,000
3	Steel hoop	386,880,000
4	Pan head bolt	966,000
5	Magnet wire	227,032,000

4.6 Calculation of Wagner Within Algorithm Technique

The aim of this method is to get the strategy of optimum order by minimizing the order cost and the storage cost. The number of order and the time of order are not fixed. The example of the calculation of Wagner Within algorithm in master box is:

a. Calculating the total inventory cost for all possibilities of order.

$O_{en} = A + h \sum_{t=e}^{n} [qen - qet]$ untuk $1 \leq e \leq n \leq N$ (1)

A= order cost = Rp 80,500,- h= storage cost = Rp 19,4

e= limit of beginning period n=maximum period

Table 7: Matrix of Calculation O_{en} Master Box

N	1	2	3	4	5	6	7	8	9	10	11	12
E												
1	80,500	86,708	90,588	102,228	121,628	174,687	174,687	307,771	307,771	489,355	489,355	656,601
2		80,500	82,440	90,200	149,719	147,197	147,197	163,222	261,269	422,677	422,677	556,537
3			80,500	84,380	94,080	125,915	125,915	220,975	220,975	362,207	362,207	482,681
4				80,500	85,350	106,574	106,574	182,622	182,622	303,678	303,678	418,766
5					80,500	91,111	91,111	148,148	148,148	249,028	249,028	342,730
6						80,500	80,500	118,524	118,524	199,228	199,228	279,544
7							80,500	99,512	99,512	160,040	160,040	226,570
8								80,500	80,500	120,852	120,852	174,396
9									80,500	100,676	100,676	140,834
10										80,500	80,500	107,172
11											80,500	93,886
12												80,500

b. Defining the lowest cost

Translating fn into lot size of f_N = min [Oen + fe-1], for e = 1,2,...,n and n = 1,2,.......,N (2)

$f_0 = 0$

$f_1 = \min (O_{1\text{-}1} + f_0) = 80{,}500 + 0$

$= 80{,}500$ for $O_{1\text{-}1} + f_0$

$f_2 = \min (O_{1\text{-}2} + f_0 ; O_{2\text{-}2} + f_1) = \min (86{,}708 + 0 ; 80{,}500 + 80{,}500)$

$= 86{,}708$ for $O_{1\text{-}2} + f_0$

$f_3 = \min (O_{1\text{-}3} + f_0 ; O_{2\text{-}3} + f_1 ; O_{3\text{-}3} + f_2) = \min (90{,}588 + 0 ; 82{,}440 + 80{,}500; 80{,}500 + 86{,}708)$

$= 90{,}588$ for $O_{1\text{-}3} + f_0$

The calculation will continue until $f_{12.}$ The complete table of calculation can be seen in table 8.

Table 8: Calculation of Value of f_N Master Box

f_N	*Results (Rp)*
f_0	0
f_1	80,500
f_2	86,708
f_3	90,588
f_4	102,228
f_5	121,628
f_6	174,687
f_7	174,687
f_8	240,152
f_9	240,152
f_{10}	295,539
f_{11}	295,539
f_{12}	347,424

c. Explaining the optimum solution for the quantity of order. The optimum solution is determined by conducting an experiment to find out the order quantity with the lowest cost. The optimum solution for the order quantity:

$f_{12} = O_{10\text{-}12} + f_9$ which means that the order quantity by 1,730 units is executed in the 10th period to meet the requirement from the 10th period until the 12th period. Furthermore, it depends on the calculation in f_9 period.

$f_9 = O_{6\text{-}9} + f_5$ which means that the order quantity by 1,527 units is executed in the 6th period to meet the requirement from the 6th period until the 9th period. Furthermore, it depends on the calculation in f_5 period.

$f_5 = O_{1\text{-}5} + f_0$ which means that the order quantity by 1,000 units is executed in the 1st period to meet the requirement from the 1st period until the 5th period.

The last step of Wagner Within algorithm calculation is by inserting the optimum solution of the order quantity into a table of calculation.

The calculation results by using Wagner Within algorithm for master box can be seen in table 9.

Table 9: Results Calculation of Master Box Using Wagner Within Algorithm Technique

Month	*Net Requirement*	*Order Quantity*	*Inventory*	*Storage cost (Rp)*	*Order Cost (Rp)*	*Total Cost (Rp)*
January	130	1,000	870	16,878	80,500	97,378
February	320	0	550	10,670	0	108,048
March	100	0	450	8730	0	116,778
April	200	0	250	4,850	0	121,628
May	250	0	0	0	0	121,628
June	547	1,527	980	19,012	80,500	221,140
July	0	0	980	19,012	0	240,152
August	980	0	0	0	0	240,152
September	0	0	0	0	0	240,152
October	1,040	1,730	690	13,386	80,500	334,038
November	0	0	690	13,386	0	347,424
December	690	0	0	0	0	347,424

The calculation results of each raw materials planning by using Wagner Within algorithm can be seen in table 10.

Table 10: Results Calculation of Wagner Within Algorithm Technique

No	*Raw Materials*	*Total Inventory Cost (Rp)*
1	Master box	347,424
2	Terminal	18,790,000
3	Steel hoop	90,463,602
4	Pan head bolt	766,200
5	Magnet wire	70,596,850

4.7 Selection of Lot Sizing Technique

The lot sizing technique by using Wagner Within algorithm approach has much lower total inventory cost rather than lot for lot technique. The implementation of lot sizing technique by using Wagner Within algorithm is capable to save the total inventory cost which has been issued by the company when they use the lot for lot technique. The total inventory cost saving by using Wagner Within algorithm for each raw material can be seen in table 11.

Table 11: Total Inventory Cost Saving

No	*Raw Materials*	*Cost Saving*
1	Master box	35%
2	Terminal	51%
3	Steel hoop	62%
3	Pan head bolt	12%
4	Magnet wire	53%

5. Conclusion

The conducted research shows the comparison between the lot sizing technique which has been implemented by the company and the lot sizing technique which is proposed by the writer in the transformer raw materials planning. The research results shows that the lot sizing technique proposed, which is Wagner Within algorithm, produces the lower total inventory cost rather than the lot for lot technique which has been implemented by the company. The implementation of Wagner Within algorithm can save the total inventory cost from each raw material and save total cost saving from 12 until 62 percent. It is expected that by implementing the Wagner Within algorithm, the company can save the inventory cost of company's raw materials.

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