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AN OPTIMAL ORDER QUANTITY OF SPARE PARTS TO MINIMIZE TOTAL INVENTORY COST USING PERIODIC REVIEW APPROACH (R,s,S) METHOD IN PT XYZ BANDUNG

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Abstract— The availability of spare parts is very crucial thing for manufacturing company in order to support the continuity of production activities. PT XYZ is a manufacturing company which produces thread into fabric. In this case, inventory control of spare part is not properly managed. Inventory position of spare parts in warehouse is always more than inventory policy of the company itself or called overstock which causes total inventory cost is always high. Company only consider on the order fulfillment of spare parts to prevent downtime on the machine that increase performance of production. Hence, order quantity of spare parts is always excessive or not optimal. In this research, global inventory policy conducted in order to minimize total inventory cost is periodic review approach (R, s, S) method. This inventory policy will be calculated using power approximation and obtained total saving cost of holding cost by 31 % while total saving cost of order cost decreased by 7 %. Overall, total inventory cost minimized
by 7 % or equal to Rp138.902.742.

Keywords—Inventory, Overstock, Spare Parts, Periodic Review, Power Approximation

I.INTRODUCTION

PT. XYZ is a manufacturing company which runs in textile industry located in Bandung. It produces raw material in the form of thread to become finished goods in the form of fabric. There are five main steps to produce it. By managing production, it will increase performance of company and reduce failures. The crucial thing to ensure the production is the availability of spare part itself to do preventive and corrective [13]. The total active machine for every process can be seen in Table 1.

TABEL 1
TOTAL ACTIVE MACHINE FOR EVERY PROCESS

Name of Process (Department)	Number of active machine
Texturizing	17
Twisting	130
Weaving	144
Sizing	13
DF	38
Total	342

Every spare parts demand of machine has a unique phenomenon in which there are no demand in some months in of the year to do corrective or preventive machine. This phenomenon also shows there are zero demand of spare part in long term. For example of the phenomenon of spare parts Bearing 6002 ZZR C3 FAG can be seen in Table 2.

TABEL 2
DEMAND PHENOMENON OF BEARING 6002 ZZR C3 FAG IN 10 MONTHS

Name of Spare Part	Month									
	1	2	3	4	5	6	7	8	9	10
Bearing 6002 ZZR C3 FAG	6	9	0	0	4	0	5	0	7	16

The company always consider the fulfillment of spare parts for each machine in order to ensure the continuity of production and fulfilling customer demand. On the other hand, the company does not consider inventory of spare parts, the company only estimates the needs of each spare part per month by looking at the number of machine damaged. Hence, inventory of spare parts in warehouse tends to be much more than the use of spare parts. This can be seen on Figure 1 that shows comparison between stock and demand.

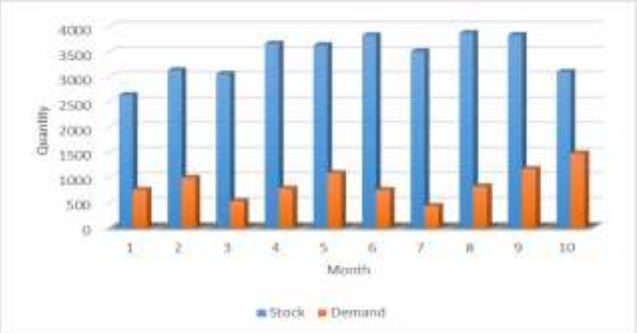

Fig. 1 Graph of Comparison between Stock and Demand

The phenomenon of fluctuative demand is a major cause of overstock spare parts inventory in this

company. This can be seen from the inventory of spare part are always greater than the company's inventory policy itself which is 25% of stock in the company. Figure 2 will show the comparison between inventory and inventory policy of company to indicate that the inventory of spare parts has been overstock.

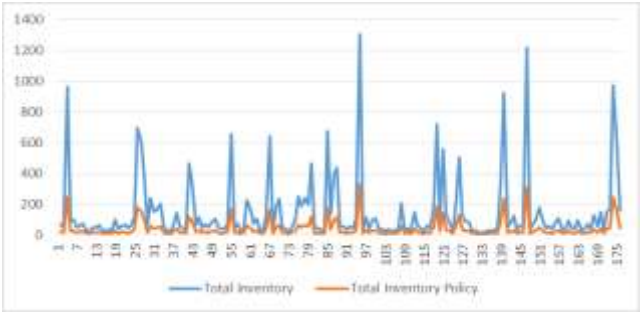

Fig. 2 Graph of Comparison between Inventory and Inventory Policy

According Huang (2011) [9] inventory of spare parts are always excessive which leads to increase total investment of spare parts while if spare parts are stock out, the performance of machine will decline. Therefore, spare parts inventory is very important. Inventory spare parts of company are overstock every month and the amount of total investment of company due to the inventory can be seen in Figure 3 which shows that every month the company must invest more than 200 million to almost 600 million.

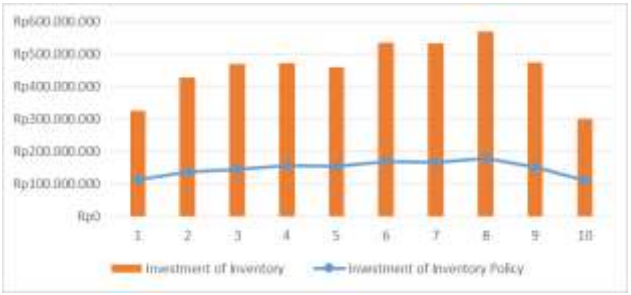

Fig.3 Graph of Comparison of Total Investment

Considering the large amount of total investment due to the excess inventory of spare parts, then the company must able to control inventory. It means the company have to know the maximum inventory level of spare parts and proper replenishment time to get optimal order quantity. Well-planned inventory will minimize holding cost, fulfill the demand and element that associated with supply chain operations [11]. In this research global optimum inventory will be conducted by using periodic review (R, s, S) in order to minimize total inventory cost.

II. THEORETICAL BACKGROUND

2.1 Definition of Inventory

According to Saxena (2009) [19] inventory is an asset or capital that has economic value. Inventory is exist to keep stock up to fulfill the demand fulfillment for production, maintenance, and so on or can called as idle resource. Controlling inventory is controlling the number of inventory itself to guarantee continuity of production, procurement and the amount of product order. The reorder point and reorder review should be done by inventory controlling [18].

2.2 Inventory Control of Spare Part

According Assauri (2004) [3] Inventory control is controlling inventory level, defining the inventory, and the optimal order quantity should be ordered. The goal are to avoid shortage and to prevent excessive cost [2]. Inventory cost are component is one of inventory types for manufacturing[8].In Spare parts are components using for keeping the availability of equipment or machine in order to ensure the operation can be done well in proper time[15]. One of the functions of controlling spare part itself is to control the stock or inventory of spare part [21]. Spare part classified by consumable parts, replacement parts and insurance parts [10].

2.3 ADI-CV Analysis

According to A. Regattieri (2005)[17] spare part has become an crucial issue for industry real case. Irregular demand for spare part can be categorized by intermittent. Irregular demand means that demand is not fluctuated consistent. Intermittent demand can be underlined by this features as, follows [7].

1. Slow moving demand : the demand does not have a big variation either the demand intervals nor the quantities
2. Strictly intermittent demand: there is no demand in many time periods or not having big variation of demand
3. Erractic demand is having great variable demand in scale
4. Lumpy demand is having no demand in many time periods with random variable.

The value of ADI and CV can be formulated as follows.

$$ADI = \frac{\sum_{i=1}^{n} ti}{N} \quad (1)$$

$$CV = \frac{\sqrt{\sum_{i=1}^{n}(\varepsilon i - \varepsilon)/n}}{\varepsilon} \quad (2)$$

Where Ɛa can be obtained with formulate:

$$\varepsilon = \frac{\sum_{i=1}^{n} \varepsilon ri}{n} \quad (3)$$

Where:
N is the amount of zero demand periods,
n is the addition of periods,
Ɛi is the item demand in period i,

Ɛ is average demand for all periods,
The cut-off values of the parameter are set as ADI = 1.32 and CV = 0.49.

According Fengyu (2015)[5] coefficient of variation (CV) can be classified to see the high influence of demand face to the inventory and operational in overall by the dispersion of demand itself In this research, the demand of spare part can be seen as "intermittent" in which is zero demand in many time periods in 10 months. So, the demand can be categorized by ADI-CV analysis to interpret the lumpiness of the spare parts demand pattern.

2.4 Inventory Policy

In Statistical Inventory Control (SIC), the phenomena of inventory consist of deterministic inventory, probabilistic inventory and stochastic inventory. In probabilistic inventory model, the demand must be probabilistic with the distribution of probabilistic is known, order cost is constant and not depends on quantity of order and holding cost is constant. [6]

2.5 Periodic Review Approach (R, s, S) Method

Periodic Review is a probabilistic inventory which is combination between (R,S) and (S,s) system. Periodic Review (R,s,S) is a inventory control that make a decisions in inventory with three decision parameters namely reorder point (s), maximum level of inventory (S) and interval review(r). Reorder point(s) is the point where the ordering will be made when the inventory has reached or is below the reorder point itself. Maximum inventory level (S) is the maximum amount of inventory that can be stored in warehouse. When the spare parts supply decreases to reach the reorder point to fulfill the order, direct ordering is made to replenish the inventory up to the maximum inventory amount of S. However this only occurs in the continous review replenishment system where the ordering will be made immediately when the inventory is less than the reorder pount. In the periodic review system, replenishment are only made during the review period in order to make the frequency of ordering can be suppressed with the aim of minimizing the holding cost and procurement cost.

According Scarf (1960)[20], periodic review (R,s,S) are the best system based on the demand pattern and cost factors. It can produces a lower total replenishment, carrying, and shortage cost. In the other side, defining the value of there parameters itself are highly difficult. So for periodic review(R,s,S) itself have been developed the heuristic approach. Power approximation is the best algorithm that suggested by Ehrhardt(1979) and developed by Ehrhardt and Mosier (1984).
Here is the algorithm formulation for calculating these parameter.

Step 1. Compute the value of Qp and Sp

$$Qp = 1.30\ \hat{x}^{\frac{0.494}{R}}\left(\frac{A}{vr}\right)\left(1+\frac{\sigma^2_{R+L}}{\hat{x}^2_R}\right) \quad (4)$$

$$Sp = 0.973\ \hat{x}_{R+L} + \sigma_{R+L}\left(\frac{0.183}{z} + 1.063 - 2.192\ z\right) \quad (5)$$

Where,

$$Z = \sqrt{\frac{Qp\ R}{\sigma R+L \quad B3}} \quad (6)$$

$$\hat{x}_R = D.R \quad (7)$$

$$\hat{x}_{R+L} = D\ (R+L) \quad (8)$$

With B3 in $/$ short at the end of a review interval; r in $/$/review interval; D in units/year; and R and in years.

Step 2

If $\frac{Qp}{\hat{x}R} > 1.5$ then,

$$s = Sp \quad (9)$$

$$S = Sp + Qp \quad (10)$$

Step 3 Compute

$$So = \hat{x}_{R+L} + k\ \sigma_{R+L} \quad (11)$$

Where,

$$Pu\geq (k) = \frac{r}{B3+r}$$

So, obtained the value of parameter as follows.

$$s = \text{minimum } \{Sp, So\} \quad (12)$$

$$S = \text{minimum } \{Sp + Qp, So\} \quad (13)$$

Where:

R	= Interval review
D	= Demand
L	= Lead Time (day)
r	= Holding cost (unit/10 months)
B_3	= Shortage cost (unit/10 months)
A	= Ordering cost (unit/10 months)
V	= Unit price (unit)
Qp	= Perspective of ordering quantity (unit)
Sp + Qp	= Maximum limit number of inventory (unit)
So	= Minimum limit point (unit)
Pu≥ (k)	= Probability of shortage cost

These parameters can be defined under minimizing cost or service level constraint. All the parameters can be evaluated by the mean and variance of demand

distribution. Power approximation itself has been developed for assuming that demand is poisson distribution. According Lyer and Schrage (1992) [4], a deterministic (R, s, S) model has been discussed in term of stock level with the deterministic static of lead times (constant) and a shortage cost in a certain time

1.1 Demand Distribution

Distribution tests will be done to see whether the demand distribution is distributed or not. Distribution test consists of normal distribution, poisson distribution, uniform distribution and exponential distribution. In this case, all the demand are poisson distribution.

TABLE 3
POISSON DISTRIBUTION TEST RESULT WITH KOLMOGROV-SMIRNOV TEST

Name of Spare parts	N	The value of Asymp .Sig	Decision
Adapter_Bearing_A_2307_X	10	0,732	Reject Ho
Air_Regulator_AC_30	10	0,316	Reject Ho

Table 3 shows that all decision are reject Ho means that value of Asymp.Sig.(2-tailed) ≤ 0,05 so it can be concluded that demand data of spare parts are poisson distributed.

1.2 Demand Characteristic

Spare parts classification conducted based on the pattern of arrival demand and homogenity of demand. This classification will be conducted for determining the method selection in this research. Table 4 will show the recapitulation of the three characteristic of demand pattern of spare parts.

TABLE 4
PERCENTAGE OF DEMAND PATTERN CHARACTERISTIC

Spare part Characteristic	Number of Spare parts	Percentage
Lumpy demand	156	89%
Erractic demand	15	9%
Intermittent	4	2%
Total	175	1

Table 4 shows that most of spare parts are lumpy demand counted by 89 % or 156 units. Intermittent demand is the lowest percentage by 2 % or just 4 units while erractic demand amounted by 9 %. Lumpy demand is zero random demand of spare part in long term.

1.3 Inventory Policy Result

The result of inventory policy using periodic review (R, s, S) approach method calculated by power approximation will determine the reoder point (s), maximum inventory level (S) by given interval review (R). Table 5 will show the value of s and S of 4 spare parts.

TABLE 5
RESULT OF PERIODIC REVIEW (R,S,S) CALCULATION

Name of Spare Part	D (unit)	S (unit)	S (unit)
Bearing 6002 ZZR C3 FAG	47	6	22
Bearing 6003	9	2	9
Bearing 6005	14	2	10
Bearing 6006	12	2	9

Table 5 shows that the value of s and S are directly proportional with the demand. It also depicts all of spare parts have value of s and S are different. It means that when period review (1 month), the replenishment will happen if inventory level has reached or below of the reorder point(s). The number of order quantity maximum is until the inventory level reach the point of the maximum inventory level(S). For example, Bearing 6002 ZZR C3 FAG. When the period review, the replenishment will happen if inventory level has reached or below of 6 units and the number of order quantity maximum until the inventory level reach 22 units.

1.4 Material Requirement Planning (MRP)

After s and S known, the total frequency of ordering and total inventory will be calculated by MRP(Material Requirement Planning). By using MRP, the total inventory, total order and shortage will be given in certain time [5]. Table 6 shows the calculation of MRP for spare part Bearing 6002 ZZR C3 FAG.

TABLE 6
CALCULATION OF BEARING 6002 ZZR C3 FAG

Item	Bearing 6002 ZZR C3 FAG	Periode										
Lot Size	-											
Safety Stock	7	0	1	2	3	4	5	6	7	8	9	10
Gross Requirement (GR)			6	9	0	0	4	0	5	0	7	16
Schedule Receipts (SR)												
On Hand Inventory (OH)		22	16	7	7	7	22	22	17	17	10	22
Net Requirement (NR)			0	0	0	0	19	0	0	0	0	28
Planned Order Receipts (PORc)			0	0	0	0	19	0	0	0	0	28
Planned Order Release (PORl)			0	0	0	0	19	0	0	0	0	28
Min			6	6	6	6	6	6	6	6	6	6
Max			22	22	22	22	22	22	22	22	22	22
Service Level			100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 6 shows that PORc and PORl are same because the lead time of all spare parts is less than 1 week. It also depicts that total frequency of ordering in 10 months are 2 times by seeing the value of PORl which is not zero order quantity per month and the total inventory is 169 units by calculting total on hand inventory in 10 months.

1.5 Total Inventory Cost

Total inventory cost are the addition of total order cost, total holding cost and total shortage cost in 10 months[14]. In this case, either actual condition or

proposal condition doesnot happen shortage condition in inventory of spare parts. It means that total inventory cost are just calculated by addition of total order cost and total holding cost.

Order cost is a cost that will be incurred by PT XYZ ordering the spare parts. Total order cost is multiplication of total frequency of ordering and unit price of spare part. Figure 4 will show the comparison between total actual order cost and total proposed order cost.

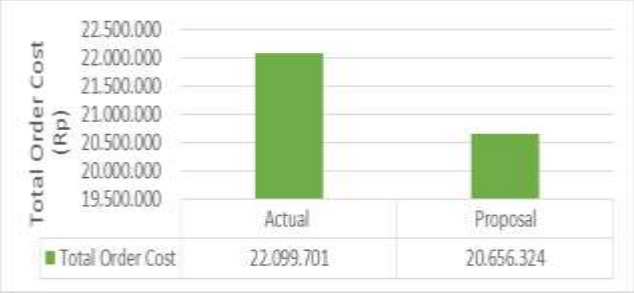

Fig. 4 Comparison of Total Order Cost

Figure 4 shows that the total order cost are decreasing. It can happen because in the proposal company order is less than actual condition. The more company order the spare parts so the more order cost will be incurred and vice versa. Additionally, optimal order quantity has known in proposal while in actual company does not know the optimal order quantity or just by estimation and feeling. Total order cost are decreased by 7 % or as much as Rp1.443.377.

Holding cost is a cost that will be incurred by PT XYZ stocking the spare parts in warehouse. Total holding cost is multiplication of total inventory and holding cost of spare part. The more inventory of spare parts in warehouse, the more holding cost will be incurred by company and vice versa. Figure 5 will show the comparison between total actual holding cost and total proposed holding cost.

Fig. 5 Comparison of Total Holding Cost

Figure 5 shows the total holding cost are decreasing. It means that total inventory in proposal is less than actual condition. It can happen because the optimal order quantity has known in proposal. Total holding cost are decreased by 31 % or as much as Rp137.459.365.

Total inventory cost can be obtained by addition of total order cost and total holding cost in advance. If the total inventory cost are decreasing means that the inventory policy using periodic review approach (R, s, S) method is effective for solving the problem of inventory in PT XYZ. Figure 6 will show comparison between total actual inventory cost and total proposed inventory cost.

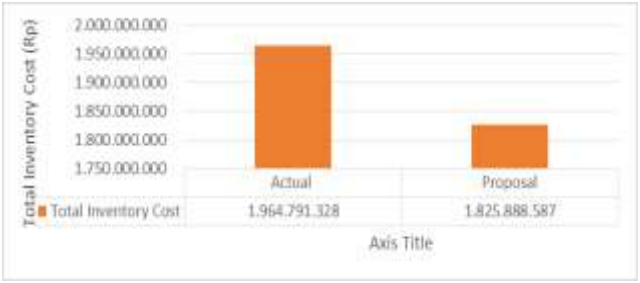

Fig. 6 Comparison of Total Inventory Cost

Figure 6 shows that total inventory cost is decreasing. Total actual inventory cost are calculated by Rp1.964.791.328 while total proposal inventory cost are counted by Rp1.825.888.587. It means this method can produce total saving cost of inventory counted by Rp138.902.742. This saving cost is contributed by the total holding cost and total order cost which has been explained previously. Total saving cost shows that inventory policy using periodic review approach (R, s, S) method is suitable in order to minimize total inventory cost as measured by 7 %.

1.6 Sensitivity Analysis

Analysis of sensitivity for total inventory cost has 3 paramaters, namely holding cost, shortage cost and order cost. These 3 parameters are the variable change of periodic review approach (R,s,S) method to change the value of objective function. Possibility of fluctuation of 3 variables are ranging in ±5%,±10%,±15%,±20 %, ±25 %. By knowing how much the sensitivity variable cost that influence total inventory cost [1]. It means company will prepar the action the fluctuation of the total inventory cost.

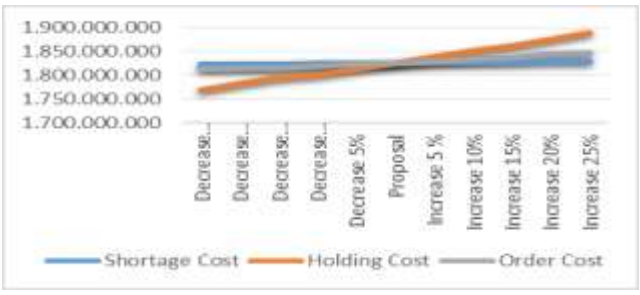

Fig. 7 Sensitivity Analysis

Figure 7 shows the sensitivity of all variables to the total inventory cost. It shows the change of the total inventory cost in decrease and increase. If all variables increase, so the total inventory cost will also increase and vice versa.

III. CONCLUSION

Selecting method is based on the demand distribution and characteristic of demand. All of spare parts demand are poisson distributed and most of demand are characterized by lumpy demand as much as 89 %. The lead time of spare parts are static deterministic, different but constant in a certain time. After using periodic review approach (R,s,S) method obtained that reorder point and maximum inventory level of each spare part. Reoder point and maximum inventory level of each spare parts is different. The greater amount of demand, the greater the reorder point of spare part itself. This indicates that the optimum order quantity of spare parts are different per period depends on the substraction of maximum inventory level and previous total inventory per review interval. Based on the calculation of MRP, either total holding or nor ordering cost is decreased. To sum up, total actual inventory cost is more than total proposed inventory cost or decreased by 7 % or equal to Rp138.902.742. As conclusion, periodic review approach (R,s,S) method - power approximation is suitable for solving the problem of inventory in PT XYZ.

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