Consumable Material Spare Part Management Control in Electricity Transmission System

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***Abstract*—Overstock spare part in the Electric Power Transmission System will affect the inefficiency in the asset management of the company. While the spare part stockouts in the company will disrupt the maintenance process of the electric transmission system, which then lead to power outages. Overstock spare parts are caused by several factors, such as forecasting errors in material requirements, intermittent requests, so it is difficult to determine the optimal order quantity. On the other hand, the unavailability of spare parts will affect the reliability of the electrical energy transmission system, which has the potential in causing a massive power outage. Monte Carlo simulations help to show the more concrete picture of the spare parts inventory condition using a periodic review (R, S) system approach. Divination of the combination of S and R parameters is very influential on the success of spare part control. Spare part classification is used for understanding the demand characteristics and the level of criticism. Moreover, the analysis of simulation results will show the information on supply fulfilment strategies to overcome the problems of either spare parts availability or spare parts overstock.**

***Keywords*—Periodic Review, (R, S) Model, Monte Carlo, Overstock, Stockout.**

I. INTRODUCTION

THE Main Unit of Transmission Y (UIT Y) is one of the units in PT X, which has a strategic role as the manager of transmission systems in the electricity business of Java and Bali systems. Transmission Unit is responsible for transmitting electrical energy from generation to medium voltage 20 kV. UIT Y's working area includes 6 Transmission Service Units (UPT). Each UPT accommodates 15 Units of Transmission Services and Substations (ULTG) which is a unit that performs equipment maintenance functions in East Java, Madura and Bali.

UIT Y has three missions, such as developing transmission assets and managing transmission assets, controlling investment and transmission logistics, and carrying out the maintenance of transmission assets effectively, efficiently, reliably, and environmentally friendly. UIT Y maintenance activities are essential as the manifestation of the management of transmission assets. Maintenance activity types include preventive, predictive, corrective, and breakdown. Asset maintenance activities include routine maintenance, replacement of spare parts, to replacement of assets that no longer have benefit value. Such maintenance activities must be supported by the availability of spare parts or inventory materials that are always ready to be used when needed.

The arrangement of spare part inventory is fundamental to create reliability and efficiency in the distribution of electric power. Besides, to support spare parts availability, the provision of spare parts should be performed selectively. Other aspects such as the criticality level, procurement lead-time, and the value of use are not resulting inefficiencies for the company. It is essential to establish a method for grouping spare parts which are very important to maintain their availability to maintain the highest possible service level. However, at the same time, this is not an inefficiency for the company.

Table 1.
Initial Material Balance January 2020

No	Material	Initial Material Balance (IDR)
1	UPT Surabaya	578.889.987
2	UPT Malang	43.450.000
3	UPT Madiun	29.458.000
4	UPT Probolinggo	2.979.972.066
5	UPT Bali	367.260.398
6	UPT Gresik	235.652.560

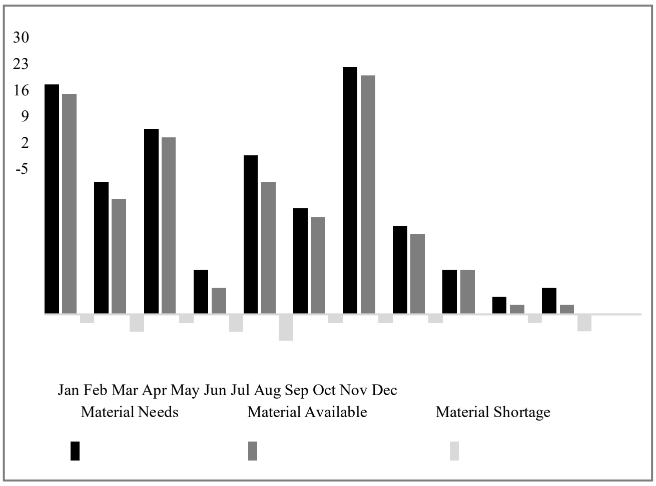

Figure 1. Material requirement CT150kV.

Costs incurred for the purchase of spare parts and materials are very high, it has not become a concern for companies to calculate the cost of using materials accurately and efficiently, which has not considered the existence of stock out or overstock.

The idea is how to control spare part inventory by determining the number of order quantities, top stock and reorder points by considering inventory costs and can recommend the right inventory model policy with service levels and inventory costs optimally.

UIT Y does not have a standardized schedule related to the purchase of material supplies, such as the calculation of order quantity, safety stock, and reorder point. Therefore, it is necessary to apply standardization of material inventory control, which is determined based on needs, inventory cost and lead time.

This condition is because of no methods for determining, reorder quantity (ROQ), reorder point (ROP) and safety stock in the company hence that the spare part stock runs out of control.150kV CT material needs for all UIT Y, yet almost every month, there is a material shortage which causes UIT Y to request materials to other UITs in Indonesia as seen in Figure 1.

Table 2.
Previous Research Results

Writer, Method & Results
A.A. Ghobbar, C.H. Friend (2002) - Method: Classification of material using Coefficient of variation (CV2) and the average inter-demand interval (ADI) *Provide a clearer picture of the material in the company to managers regarding the conditions of existing material demand in the company*
Anisa Nur Farida, I Nyoman Pujawan - Method: continuous review simultaneous, Periodic Review (R,s,S) *The continuous review simultaneous method, the Periodic Review Method (R, s, S) can reduce the cost of procuring materials that are fast-moving & intermittent. From the conclusions and suggestions in this thesis, it is also suggested that in calculating the inventory control parameters of inventory, it is better to simulate first to get results in the form of optimal inventory costs and service levels.*
Adhi Putra Mahardika, Muhammad Nashir Ardiansyah, Efrata Denny S. Yunus - Method: Periodic Review (R, s, S) Power Approximation *Periodic Review policy (R, s, S) produces a service level higher than the service level generated by the existing inventory system.*
Edi Triono, Nyoman Pujawan - Method: Coefficient of variation (CV2) and the average inter-demand interval (ADI), Periodic Review (R, s, S) *The approach using the method (R, s, S) is better than the existing policy because there is a very significant increase in service levels. The value of the simulation value results in a total inventory cost that is lower than the total cost of the existing conditions. It is recommended to use the reorder point parameter in the process of supplying spare parts so that inventory control is more optimal than the current policy.*
Imam Trio Utama, Nurhadi Siswanto - Method: Monte Carlo Simulation & Economic Order Quantity *The results obtained from planning an inventory system using the Monte Carlo and EOQ methods, the company can make an efficiency of 951 million for a year compared to the current company policies.*
Wirawan Aditya S.P, Nyoman Pujawan, and Nani Kurniati - Method: Periodic review (R,s,S) and Monte Carlo Simulation *By increasing the parameter s (reorder point), it will result in the increased service of the actual level*
Dian Kurniawati, I Nyoman Pujawan, Niniet Indah Arvitrida - Method: Continuous Review (s, S), Periodic Review (R, s, S), Material Requirement Planning (MRP). *From the calculation, it is concluded that materials with continuous wear patterns can use MRP method as a control strategy and results in lower costs compared to the control method, which uses the reorder point.*
Yadrifil, Wijana Nugraha - Method: MRO, Continuous Review System, Monte Carlo Simulation *The results obtained from the MRO inventory policy with a continuous review for 15 types of inventory material obtained a total order of 565 units, 900 units of safety stock, and the point of reordering reached 1467 units. This policy also succeeded in reducing the total cost of inventories by 31%*

On the contrary, UIT Y also often experiences overstock on lumpy & intermittent spare part materials. This problem resulted in an increase in the spare part material balance at UIT Y. The excess stock of the material balance will affect the company's balance sheet and inventory turnover.

In this journal, the calculation of spare part material control will be performed to reduce the cost of spare part supplies. The purpose is to find a method for the material supplied selectively and focus on other aspects such as the level of criticality, procurement lead-time and the value of use. The method to be implemented is the Periodic Review (R, S) method by performing a Monte Carlo simulation that can analyze the propagation of uncertainty.

In brief, the expected results are: create a grouping of consumable spare parts following the characteristics of the electric power transmission system; determine the value of the parameter values (R, S) of the spare part, safety stock, reorder point, max stock and the number of orders for each item of goods in consumable material at an economical cost; propose improvements to the management of spare parts in the electric voltage transmission system industry.

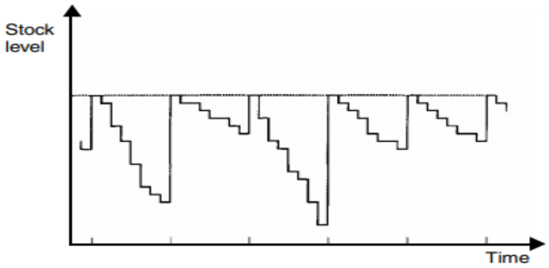

Figure 2. Periodic review.

In this research, material data used is data for the last two years in the company taken from SAP MM (Material Management). This paper does not include transportation costs from the warehouse to the work location.

II. METHOD

Every company, both manufacturing and service companies, always have material supplies, companies require various types of goods for their industrial needs. These items in the form of raw, auxiliary materials, or other items used to maintain equipment and facilities, as well as those used for carrying out their operations [1]. Therefore, this paper method is based on data on inventory & related cost and inventory management.

A. Previous Research

Several previous types of research were completed with the purpose to compare and evaluate one study with other similar studies as seen in Table 2. Several previous types of research were completed with the purpose to compare and evaluate one study with other similar studies.

B. Probabilistic Inventory Method P (Periodic Review) for Inventory Control

The control system with the P system is an inventory control system where the time interval between two orders is fixed, as shown in Figure 2. Safety stock in this system is not only required to reduce fluctuation in demand during Lead Time, but also for the total consumption of supplies.

Every time the order is created, the quantity ordered is highly dependent on the remaining inventory during order period; hence placed order lot size is insufficient. Another issue is the possibility that the inventory will run out before the reorder period. As a result, the safety stock required is relatively more extensive.

The order interval (T) can be a period that adapts to needs. If there is no exact cycle, it may be possible to add up orders once a year or average order size within a year. A useful approach is to calculate EOQ, and then find the period that gives orders around this measure. The final decision is mostly a matter of corporate management judgment. As a result, there is a Lead Time during the decline in stock before the stock order arrives. Therefore, Actual stock will never accomplish the target stock.

The number of orders A is determined when the stock reached A1 level, but in fact, the stock orders at the A1 level

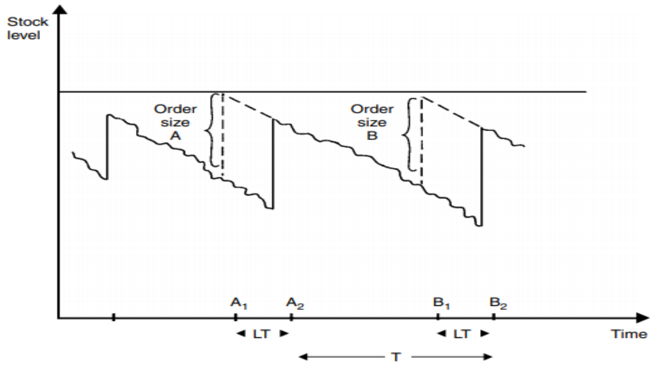

Figure 3. Timing order of periodic review.

only arrive when the stock starts dropping at the A2 level. This stock order must be able to meet the stock needs until the next level arrives, namely level B2. So the target stock level must be able to meet the demand for the stock from the period A1 to B2, namely T + LT. Stock requirements when T + LT are typically distributed with the mean of (T + LT) x D, the variance of σ2 × (T + LT) and the standard deviation of σ × √ (T + LT), so it can be concluded that:

$$Target\,Stock = Mean\,demand\,dari\,(T + LT) + SS \quad (1)$$

$$SS = Z\,x\,Standard\,deviation\,of\,demand\,dari\,(T + LT) \quad (2)$$

Z is the number of standard deviations from the average demand adjusted to the service level of service.

$$Target\,stock = D \times (T + LT) + Z \times \sigma \times (T + LT) \quad (3)$$

Where D is demand, LT is lead time, and Q is the period. The period for ordering materials is carried out within the same period. Thus, to determine the amount or lot of economic order (EOQ) at each T, and the amount will be different for each order as seen in Figure 3. The amount of safety stock is calculated together with the optimization of inventory costs and the level of service.

Method P has the characteristics of orders placed with a fixed interval of time
(T) and the order lot (qo). A shortage of inventory will occur during time T. The determination of the size of the safety message (ss) is calculated by balancing the service level and the cost of supplies. The inventory control mechanism, according to the P model, does not have to be monitored because orders are created with a scheduled time.

Safety stock serves to protect errors in predicting demand during the lead time [3]. The safety stock will be larger than the average demand so that the safety stock useful if the real demand in a period is larger than the average demand. The safety stock regulation is based on service levels and inventory investment.

The safety stock quantity must cover more than regular demand during the lead time of replenishment [4]. There are several parameters that must be considered when calculating safety stock, such as demand requirements, lead time and target service level. Safety stock will be easier to obtain if the demand data during lead time is normally distributed.

The value of the safety stock depends on the uncertainty of supply and demand. Under normal circumstances, supply uncertainty is represented by the standard deviation of the supplier lead time. Meanwhile, the demand uncertainty is represented by the standard deviation of the amount of demand per period.

C. Analysis of Spare Part Characteristics Based On ADI - CV² and Spare Part Criticality Level. The initial stage in data processing is to analyze the characteristics of each spare part based on ADI (Average Demand Interval) & CV (Coefficient of Variation) from January 2018 to December 2019.

Determination of spare part characteristics is performed by classifying spare parts based on categories of demand patterns: smooth, intermittent, erratic, and lumpy. Material categorized as smooth demand if ADI <1.32 and CV^2 <0.49, material is said to be Intermittent demand if ADI> = 1.32 and CV^2<0.49, material is said to be Erratic demand if ADI <1.32 and CV^2> = 0.49 and material is said to be Lumpy demand if ADI> = 1.32 and CV^2> = 0.49 [6]

D. Selection of spare parts based on the characteristics of Demand (ADI-CV) and the level of criticality (High-Medium-Low)

Select spare parts in the lumpy, intermittent demand and erratic demand patterns; on the contrary, these materials are also materials with a high level of criticality.

The spare parts to be tested in this study are spare parts that are in the lumpy, intermittent demand and erratic demand patterns and have a high level of criticality or have the potential for power outages if spare parts are not available.

E. Determining the Spare Part Control Model

Considering the company's conditions of unstable demand, minimizing shortage, and availability of monthly basis data, the periodic review method is used for this research.

The analysis stage is continued by testing each spare part with the Periodic Review control method in the Monte Carlo Simulation. Material data is intermittent and lumpy, so it is necessary to simulate the demand pattern modelling that refers to historical data from previous material requests.

From the data resulting from the demand pattern, a prediction of what will happen next can be forecasted. This calculation simulation aims to simulate a policy with a periodic review approach as well as to calculate the total cost and service level resulting from the policy.

F. Simulation of Spare part Management using the Periodic Review Method (R, S)

The simulation is used by using randomly generated ordering data following the distribution of empirical data. The historical data on the use of spare parts is used as the basis for determining the distribution of demand which will then be used to generate demand figures with simulation.

This calculation simulation aims to simulate policies with the periodic review method as well as to calculate the total costs generated by the policy.

This simulation aims to evaluate the proposed policy so that later results can be obtained in the form of inventory and cost parameters.Orders in the inventory calculation simulation and ordering with the periodic review (R, S) system approach will be carried out within a specific time period (R) with a varying number of orders to reach the maximum stock (S).

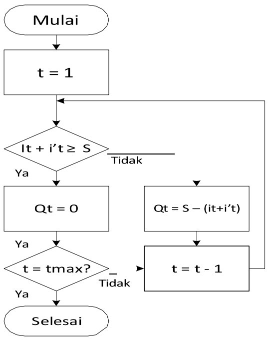

Figure 4. Ordering decision flowchart.

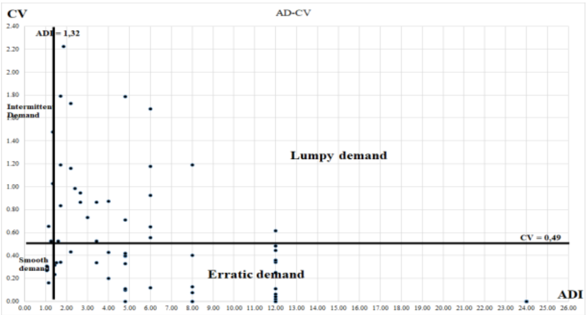

Figure 5. ADI calculation results.

The Periodic Review (R, S) method allows uncertainty and variation in the number of orders but in fixed time intervals. In doing this calculation, several steps will be used for making decisions about ordering. Ordering decision flowchart can be seen in Figure 4.

Where t is period, S is maximum stock, i_t is inventory period – t, i'_t is inventory in order period – t, Q_t is the number of orders in period t, ss: Safety Stock, and t_{max} is the final period (24th period in this study).

III. RESULT AND DISCUSSION

Data Normality Test from the demand data for two years, the normality test was performed using Minitab software. (Stat - Basic Statistic - Normal Test). Furthermore, the result is that the sample data does not follow a normal distribution, so the Monte Carlo simulation method is used to produce the optimal value of the inventory variable values.

A. Monte Carlo simulation results

From the inventory and ordering calculations that have been completed, the existing policy generates a high total cost with a low service level value. The high total cost is caused by the high costs that shall be incurred for storage and purchases. Meanwhile, the low service level value is caused by the absence of reasonable material requirements planning as an effort to meet material needs. Therefore, good material requirements planning is needed so that it is expected to increase the service level and a reasonable total material cost.

B. Inventory and Order Calculation Simulation Results with (R, S) System

From the results of the average similarity test between the history demand data and the replication data, it can be concluded that there is no difference in the average random generation results from the Monte Carlo simulation data.

Table 3.
Calculation Results

No	Item Number	D	Stdev	Q	SS	s (ROP)	S (Max Stock)
1	3050414	161	337	1237	554	716	1953

Table 4.
Periodic Review Results

Exp	Period R (mth)	S Value	Inventory Cost (IDR)	Order Cost (IDR)	Purchasing Cost (IDR)	Total Cost (IDR)	Service Level (%)
Hist	-	-	10.900.240	21.421.338	497.613.600	529.935.178	85
1	6	1,933	32,600,704	21,421,338	613,451,520	667,473,562	91.4
2	6	1,943	32,818,784	21,421,338	614,357,920	668,598,042	91.6
3	6	1,963	33,254,944	21,421,338	616,170,720	670,847,002	92.0
4	6	1,953	33,036,864	21,421,338	615,264,320	669,722,522	91.8
5	6	1,973	33,473,024	21,421,338	617,077,120	671,971,482	92.2
6	12	1,933	31,680,256	14,280,892	613,451,520	659,412,668	89.5
7	12	1,943	29,830,336	14,280,892	614,357,920	658,469,148	89.7
8	12	1,963	30,296,576	14,280,892	616,170,720	660,748,188	90.1
9	12	1,973	30,529,696	14,280,892	617,077,120	661,887,708	90.3
10	12	1,953	30,063,456	14,280,892	615,264,320	659,608,668	89.9
11	3	1,953	34,890,544	24,991,561	615,264,320	675,146,425	100.0
12	3	1,933	34,454,384	24,991,561	613,451,520	672,897,465	100.0
13	3	1,943	34,672,464	24,991,561	614,357,920	674,021,945	100.0
14	3	1,963	35,108,624	24,991,561	616,170,720	676,270,905	100.0
15	3	1,973	35,326,704	24,991,561	617,077,120	677,395,385	100.0

C. Material Category with ADI (Average Demand Interval)

Demand will be categorized into two types: fast-moving and intermittent. Material grouping is based on the time between requests or ADI (average demand interval) and coefficient variation (CV). Whereas ADI is less than 1.32, then the material is grouped into a continuous pattern, and if the ADI value is more significant than 1.32, then it can be grouped into the Intermittent pattern. ADI calculation results can be seen in Figure 5.

D. Analysis of Calculation Results

The calculation simulation results with the periodic review approach resulted in a decrease in total costs with an increase in service levels. The decrease in total costs is due to lower storage costs and purchasing costs, hence better for the company to order materials repeatedly in small quantities than to store large quantities of materials. With an increase in service levels, the company can minimize the occurrence of delayed maintenance processes due to material unavailability during maintenance or material replacement to be conducted. Besides, with a high service level value, the maintenance division can minimize delays in maintenance schedules due to the lack of material.

IV. CONCLUSION

The simulation value resulted in a lower total cost of inventory compared to the total cost of the existing conditions. From some material items used as data samples, it is found that the total cost of material 3050414 inventory increased by 21%.

Comparison of material policies using the Periodic review method with existing policies indicates that the company shall consider the periodic review policy and approach. It is expected to be the better policy since there is a significant increase in the value of service levels on material 3050414, which increased from the existing 84% to 100%.

It is recommended that companies to apply to reorder point and Maximum Inventory parameters in the material supply process so that inventory control can be optimized. The results of calculation and preiodic review can be seen in Table 3 and Table 4 respectively.

Additional suggestions as the result of this research for improvement in further research are as follows:

1. To create simulation models using tools or software to facilitate simulations so that the use of simulations should be maximized.
2. The company should use the reorder point and maximum inventory parameters in the process of supplying spare parts so that control can be optimized.

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