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Inventory Control of Spare Parts for Operating Nuclear Power plants

Jong-Hyuck Park, Se-Jin Jang, Eui-Youp Hwang, Sung-Soo Yoo, Keun-Bae Yoo, Sang-guk Lee, Sung-Yull Hong
Korea Electric Power Research Institutes 103-16 Mun-ji- Dong Yusong-Gu Daejeon Korea, sunmin@kepri.re.kr
Korea Hydro & Nuclear Power Corp.167 Sam-Sung-Dong, Gang-Nam-Gu, Seoul Korea

1. Introduction

Inventory control of spare parts plays an increasingly important role in operation management. The trade-off is clear: on one hand a large number of spare parts ties up a large amount of capital, while on the other hand too little inventory may result in extremely costly emergency actions. This is why during the last few decades inventory of spare parts control has been the topics of many publications.

Recently management systems such as manufacturing resources planning (MRP) and enterprise resource planning (ERP) have been added. However, most of these contributions have similar theoretical background. This means the concepts and techniques are mainly based on mathematical assumptions and modeling inventory of spare parts situations

Nuclear utilities in Korea have several problems to manage the optimum level of spare parts though they used MRP System. Because most of items have long lead time and they are imported from United States, Canada, France and so on.

In this paper, we will examine the available inventory optimization models which are applicable to nuclear power plant and then select optimum model and assumptions to make inventory of spare parts strategies. Then we develop the computer program to select and determine optimum level of spare parts which should be automatically controlled by KHNP ERP system. The main contribution of this paper is an inventory of spare parts control model development, which can be applied to nuclear power plants in korea.

2. Model Development

EPRI has already presented several Technical Reports that support to optimization of inventory of spare parts in a nuclear utility[1,2]. But, It is difficult to apply for operating plants because of its depending on overseas inventory procurement conditions and available models can not apply directly without modification. In order to make optimize inventory control model for domestic nuclear utility, all the available models should be reviewed and modified properly to meet domestics conditions.

2.1 Typical Algorithm

Table 1 shows existing typical Algorithm.

- Annual Usage: Quantity of Items used for 1 year
- Lead Time: Time between ordering and entering
- DDLT: Demand quantity for lead time.

Table 1. Typical Algorithm

	Calculation
DDLT	Annual Usage * Leadtime /365
SS	Confidence Level * DDLT^(0.5)
EOQ	((2*Purchase Cost * Annual Usage) / (Carry Cost % * Unit Cost)) ^(0.5)
OQ Shelf-Life	Shelf Life * Annual Usage

- Safety Stock: Additional inventory held as a buffer against uncertainties in demand or in the supply chain.
- EOQ: Economic Order Quantity
- OQ shelf-Life: Order quantity for Shelf-Life.

2. 2 Application of EOQ

2.2.1 Materials Classification

Most of inventory of spare parts in store at operating nuclear power plants can be classified into one of three categories:

- <u>Engineered Spare Parts</u>
- Normal Operational Support Materials
- Construction Support Materials

Engineered Spare Parts can be classified into one of three categories considering Lead Time, FID(Functional Importance Determination), Usage Rates in order to calculate the appropriate quantity of inventory. The following diagrams shows different quantity level to the material classification.

- Materials of Max Quantity (figure 1)
- Materials of Normal Quantity (figure 2)
- Materials of EOQ (figure 3)

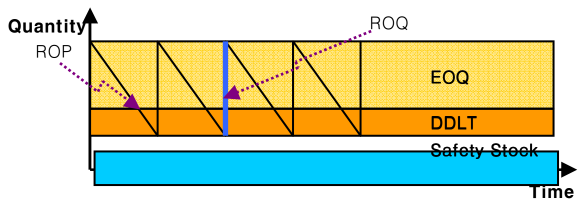

Figure 1. Diagram of inventory for Max. Quantity

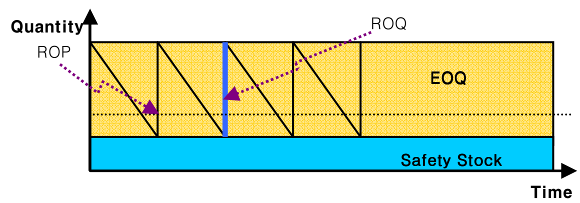

Figure 2. Diagram of inventory for Normal Quantity

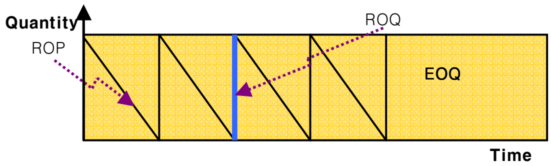

Figure 3. Diagram of inventory for EOQ

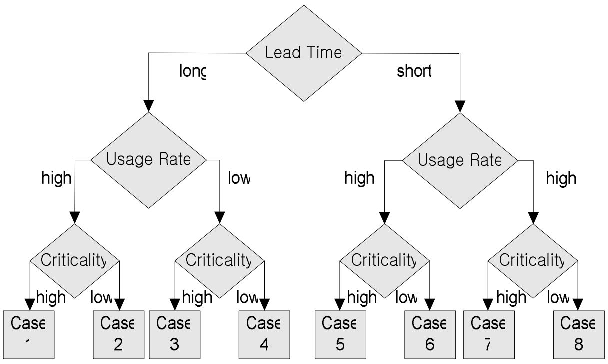

Figure 4. Materials classification flow chart

2.2.2 Application of calculation algorithm

According to the material classification flow chart (Fig. 4) inventory quantity is calculated as follows. Materials of max quantity just include Case 1. Materials of normal quantity include Case 2,3,4,5,7 and materials of EOQ include Case 6. Materials of case 8 classified by classification flow chart don't need to keep a inventory.

- Case 1 : SS+DDLT + EOQ
- Case 2 : SS+EOQ (DDLT <= EOQ)
  SS+DDLT (DDLT > EOQ)
- Case 3 : SS+EOQ (DDLT <= EOQ)
  SS+DDLT (DDLT > EOQ)
- Case 4 : SS+DDLT
- Case 5 : SS+EOQ (DDLT <= EOQ)
  SS+DDLT (DDLT > EOQ)
- Case 6 : EOQ (DDLT <= EOQ)
  DDLT (DDLT > EOQ)
- Case 7 : SS+DDLT
- Case 8 : Non-inventory

2.2.3 Work Process

In order to calculate inventory quantity in practice, it should be following process.

- Develop categorization strategy for filtering of target items.
- System development for inventory quantity by using EOQ applied model.
- Getting inventory data from KHNP ERP system
  - purchasing history(date, quantity)
  - Material information(lead time, moving price, shelf-life, etc)
- Data Conversion for system loading
- loading Data changed
- Inventory quantity calculation.

In the first place, Inventory calculation system should be developed by using EOQ algorithm applied and materials classification method. Inventory data from KHNP ERP system should be converted applicable data for loading into inventory calculation system.

3. Work results

We have classified inventory materials and non-inventory materials and calculated each inventory of spare parts' quantity according to work process. Table 2 shows the number of inventory items of KHNP operating plants and the number of items that we classified as an optimized inventory items for the quality class Q,T,R items(Quality class "S" is excepted). The total inventory of spare parts quantity which should controlled by KHNP ERP system is 11,527.

Table 2. Inventory of spare parts quantity for KHNP plants

	Target Item	KHPN	KEPRI
GoRi	**42,640**	**5,321**	**2,848**
WolSeong	**37,650**	**13,177**	**1,526**
YeongGwang	**42,070**	**3,205**	**3,296**
UlChin	**35,728**	**11,018**	**3,857**

4. Conclusion

In this paper, we have developed the effective inventory of spare parts optimization models which are applicable to operating nuclear power plant in korea. The developed methods and model is much more practical to apply operating power plants then the one currently in use by the other utilities and industries. We have confirmed the accuracy of the developed methods and model in reviewing the work results by KHNP field engineers. The developed computer program is very powerful to select and forecasting optimum level of spare parts which should be automatically controlled by KHNP ERP system in future.

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