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Spare Parts Management in Heavy Equipment Division (HED), Department of Roads, Kathmandu, Nepal

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ABSTRACT

Effective management of spare parts inventory system plays key role for successful execution of the maintenance plan of equipment and vehicles. This study is focused on spare parts management system of HED-Kathmandu. It is found that no effective spare parts management system is followed except to fulfill some formalities as prescribed by the financial rules and regulations. Study of spare parts of three major types of equipment shows that the unplanned spare parts expenditure is the major cause of high inventory level. It is also found that the warehouse is largely occupied by non moving parts.

Key words: Spare parts, Inventory management, Inventory classification, ABC, XYZ, FSN

INTRODUCTION

Inventory is often considered as idle resources in the form of physical resources, human resources and financial resources. Depending on the position of the items in supply-chain system, the inventory can be classified as: raw material inventory, work-in-progress (WIP) inventory, finished goods inventory, spare parts inventory and consumables inventory [1].

Major objective of the spare parts inventory is to fulfil the demand of preventive (planned) and corrective (unplanned) maintenance process. Spare parts inventory differs from other manufacturing inventories like WIP inventory and finished goods inventory. The purpose of WIP inventory is to stabilize the fluctuation in production flow rate and the purpose of finished goods inventory is to balance the irregular customer demand. But, spare parts inventory assists the maintenance division for keeping the equipment in running condition. Unlike WIP inventory and finished goods inventory, spare parts are not intermediate or final products. Major difference between spare parts inventory and other manufacturing inventory is that spare part inventory level largely depends on the equipment use pattern and level of maintenance [2].

Demand time of spare parts is usually unknown and irregular when corrective replacement method is used. The uncertainty and irregularity in demand pattern of spare parts make them slow moving items. Moreover, the intermittent demand makes the forecasting of spare parts difficult [3]. Even in the case of planned or preventive maintenance, the spare parts demand is irregular since defective but working parts may be identified during preventive maintenance [4]. Because of the specific purpose of the spare parts, they are purchased from the original manufacturer or their authorized representatives. The limited access of spare parts increases lead time and encourages bulk purchase. An organization should rely on the manufacturer recommended maintenance and spare parts replacement schedule for the purchase volume [5]. Sometimes lower inventory level of spare parts may lead to stock out and increased downtime which is a loss of production/service [6]. The unpredictable - demand, limited access and down time impact are the major constraints of management of spare parts. For efficient management of maintenance task, proper spare parts inventory management is important [7].

STUDY AREA

The Heavy Equipment Division (HED) is a large capacity maintenance workshop designed for repair and maintenance of heavy equipment and vehicles owned by Department of Roads (DoR), Nepal. Under the DoR, there

are six HEDs located at different locations of Nepal. The study is carried out in HED-New Baneshwor, Kathmandu, Nepal. Altogether, 91 numbers of equipment (26 types) is owned by HED-Kathmandu and about 85% of allocated budget of HED-Kathmandu is spent on procurement of spare parts [8]. Effective management of spare parts inventory in HED-Kathmandu is required not only to meet the desired level of repair and maintenance but also to allocate the budget effectively. The spare parts inventory should be governed by the demand of maintenance strategy but opposed to this, spare parts procurements system in HED-Kathmandu is found to be governed by the budget allocation. The record keeping practice is found to be merely fulfilling the formalities of financial rules and regulations. Instead of adopting systematic and optimized procurement strategy governed by maintenance demand, the existing tendency in HED-Kathmandu is to purchase bulk spare parts along with the new equipment. Bulk purchase of spare parts overcomes the equipment downtime issue but it also absorbs the significant amount of budgetary resources in the form of unused spare parts. It is found that some spare parts remain unused for more than 10 years.

A major problem related to spare parts management system in HED-Kathmandu is related to the absence of proper classification of spare parts. Because of uncategorized spare parts, there is not any clear scenario of spending pattern. Since spending pattern is unknown, there is not any control mechanism. The first step of defining an effective control mechanism is classifying spare part. The paper is focused on classification of spare parts in HED-Kathmandu and finding the spending pattern of the spare parts.

METHODS

Out of 26 types (91 numbers) of equipment owned by HED-Kathmandu, three types of equipment (wheel loader, motor grader and mini dumper) are chosen for the analysis. The equipment selection is made on the basis of higher average utilization hour, availability of records for at least ten years and more number of equipment in operation (Table -1 and Table -2) [9].

According to Table -2, selected equipment was run for 40.6% of total operation hours of all equipment. The analysis period is taken from the date of purchase of the equipment to the fiscal year 2010/11. Therefore, for all three equipment, the duration of the record is more than 10 years. Following information are recorded for each spare part from the Stock Ledger Book of HED-Kathmandu.

- Received quantity
- Issued quantity
- Purchase price
- Issuing date
- Purchase date
- Final stock level

After the collection of primary data; average unit price, average annual consumption, year-end stock level and average stay in year are calculated for each spare part with the help of the following calculation steps.

Annual consumption quantity = Issued quantity - Returned quantity
Av annual consumption = Total consumption during analysis period / Analysis period
Total spending = Σ(Purchased quantity × unit price) for analysis period
Av unit price = Total spending during analysis period / Total purchase quantity

Table - 1- Overview of Selected Equipment

Equipment	Purchase year (AD)	Availability of records (Years)	Total number of equipment available	Av. annual utilization for past five years (Hour)	Types of spare parts studied
Mini Dumper	1999	12	19	815	162
Motor Grader	1998	13	4	212	138
Wheel Loader	1999	12	4	318	61

Table - 2- Total Utilization Hours of Selected Equipments on Fiscal Year 2010/11

Descriptions	Types	Numbers	Total Utilization Hours
Running Equipment	26	91	21,886
Selected Equipment	3	27	8,896 (40.6%)

ABC Classification Based on Average Consumption Value

Average annual consumption value = Av annual consumption × Av unit price

Spare parts are shorted with decreasing average annual consumption value and corresponding cumulative percentage is calculated. The spare parts are then classified based on the following criteria:

First 70% of annual consumption value = A class
Next 20% of annual consumption value = B class
Last 10% of annual consumption value = C class

XYZ Classification Based on Final Stock

Year-end stock value = (Total current stock at the year-end × Av unit price)

Spare parts are shorted with decreasing year-end stock value for the year 2010/11 and corresponding cumulative percentage is calculated. The spare parts are then classified based on following criteria:

First 70% of year-end stock value = X class
Next 20% of year-end stock value = Y class
Last 10% of year-end stock value = Z class

FSN Classification Based on Average Stay and Average Consumption Rate

FSN analysis aims at classifying items on the basis of their movement from inventory. The items are classified as fast (F), slow (S) and non moving (N) items by considering average stay and consumption rate. Spare parts can be classified as fast moving if it has less average stay or high consumption rate. FSN analysis takes account of both average stay and consumption rate of spare parts.

The following steps are used for the analysis:

Step I: Calculation of average stay and average annual consumption rate of an item.

Average stay (in years) = Inventory holding years/Total purchase quantity
Inventory holding years = cumulative sum of closing balance of each year
Av. annual consumption = Total consumption during analysis period / Analysis period
Annual Stock Value = Closing Stock Quantity × Unit Purchased Price

Step II: FSN classification on the basis of average stay of the items
The spare parts are arranged in decreasing order of their average stay. Then, the cumulative average stay is calculated. The first 10% of the average stay are categorized as F Class, next 20% as S Class and last 70% as N Class.

Step III: FSN classification on the basis of consumption rate of the items
Spare parts are arranged on the basis of decreasing consumption rate and cumulative percentage is calculated. Then first 70% of cumulative consumption rate are categorized as F Class, second 20% as S Class and last 10% as N Class.

Step IV: Final classification of items into F, S and N Classes
The movement of the spare parts is defined by its consumption rate and the average stay in the inventory. For example, a group of spare parts can have high consumption rate (F class according to consumption rate) but longer stay in the stock (N class according to average stay) because of bulk purchase. In this case, rate of flow cannot be defined by consumption pattern or stock stay period alone. For clear picture, it is necessary to combine both consumption rate and average stay and develop a new classification. The single classification index that merges FSN index from consumption rate and FSN index from average stay is obtained from the guidelines given in Table - 3 [10].

Table - 3- Criteria for Combining Average Stay and Average Annual Consumption

FSN (Consumption Rate)	F	F	F	S	S	S	N	N	N
FSN (Average Stay)	F	S	N	F	S	N	F	S	N
Final FSN Classification	F	F	S	S	S	N	S	N	N

RESULTS

Comparative ABC and XYZ Analysis

As shown in ABC analysis (Table - 4), A class of spare parts (39 items) are found to cover NPR. 190,554. Similarly, B class (61 items) covered NPR. 54,444 and C class (152 items) covered NPR. 27,222.

According to the XYZ analysis (Table - 5), total stock value occupied by three equipment is NPR 2,896,190.00. Out of that amount, X Class of spare parts (38 items) is found to cover NPR. 2,027,333.00 Whereas Y Class (56 items) covers NPR 579,238.00 and Z Class (153 items) covers NPR. 289, 619.00.

Average annual purchase and consumption amount of spare parts are compared in Table - 6. The result shows that in average 47% of spare parts expenditure is used for the storage of the spare parts and 53% of spare parts expenditure is used to fulfil the maintenance demand. In general, out of 100 rupees spent on spare parts, 53 rupees is used for maintenance requirements while 47 rupees is used for storing spare parts which, in turn, gets accumulated each year.

Table - 4- ABC Classification of Spare Parts

Machine	A Class % in %	No. of Items	Consumption value NPR	B Class in %	No. of Items	Consumption value NPR	C Class in %	No. of Items	Consumption value NPR
Motor grader	16	11	76,181.00	28	19	21,766.00	56	38	10,883.00
Wheel loader	19	6	79,255.40	29	9	22,644.40	52	16	11,322.20
Mini dumper	14	22	35,117.60	22	33	10,033.60	64	98	5,016.80
	Total	39	190,554.00		61	54,444.00		152	27,222.00
Total annual consumption for all three types of equipment								NPR 272,220.00	

Table - 5- XYZ Classification of Spare Parts

Machine	X Class in %	No. of Items	Current Stock Value NPR.	Y Class in %	No. of Items	Current Stock Value NPR.	Z Class in %	No. of Items	Current Stock Value NPR.
Motor grader	16	15	980,000.00	26	23	280,000.00	58	53	140,000.00
Wheel loader	29	13	793,630.60	25	11	226,751.60	46	20	113,375.80
Mini dumper	9	10	253,702.40	19	22	72,486.40	72	80	36,243.20
	Total	38	2,027,333.00		56	579,238.00		153	289,619.00
Total current stock value for all three types of equipment								NPR. 28,96,190.00	

Table - 6- Spending Pattern on Spare Parts

In NPR	Motor grader	Wheel loader	Mini dumper	Total
Av annual purchase	217,258.00	212,325.00	80,462.00	510,045.00
Av annual consumption	108,830.00	113,222.00	50,168.00	272,220.00 (53%)
Av annual left in stock *(Av annual purchase – Av annual consumption)*	108,428.00	99,103.00	30,294.00	237,825.00 (47%)

Table - 7- Beginning and End Stock of Spare Parts

	Motor grader	Wheel loader	Mini dumper
Purchased on	1998	1999	1999
Av year-end stock level (NPR)	1,480,520.00	801,254.00	460,112.00
Av annual consumption (NPR)	108,830.00	113,222.00	50,168.00
% annual consumption to average year-end stock level	7.4%	14.1%	10.9%

In order to determine how the inventory is getting accumulated, the comparison of average year-end stock level is compared with average annual consumption. The year-end stock accounts the stock for the year and stock transferred from the previous year. When average year-end stock and average annual consumption is compared, it is found that average annual consumption is about 10% of the average year-stock (Table - 7).

Comparative FSN Analysis

Table - 8 to Table - 10 shows the FSN-Class of spare parts for selected equipment. It is observed that F-Class items have least current stock value. The non-moving items (N-class) absorb the most current stock value.

Table - 8 FSN Classifications (F-Class) of Selected Equipment

Machine	F Class in %	No. of items	Consumption Value %	Consumption Value in NPR.	Current Stock %	Current Stock in NPR.
Motor grader	4	5	17	18,501.10	0.32	4,480.00
Wheel loader	5	3	42	47,553.24	5	56,687.90
Dumper	6	10	11	5,518.48	4	14,497.28
	Total	18		71,572.82		75,665.18

Table - 9 FSN Classifications (S-Class) of Selected Equipment

Machine	S Class in %	No. of items	Consumption Value %	Consumption Value in NPR.	Current Stock %	Current Stock in NPR.
Motor grader	46	63	62	67,474.60	22.68	317,520.00
Wheel loader	34	21	40	45,288.80	18	204,076.44
Dumper	48	77	71	35,619.28	62	224,707.84
	Total	161		148,382.68		746,304.28

Table - 10 FSN Classification (N-Class) of Selected Equipment

Machine	N Class in %	No. of items	Consumption Value %	Consumption Value in NPR.	Current Stock %	Current Stock in NPR.
Motor grader	50	70	21	22,854.30	77	10,78,000.00
Wheel loader	61	37	18	20,379.96	77	8,72,993.66
Dumper	46	75	18	9,030.24	34	1,23,226.88
	Total	182		52,264.50		2,074,220.54

When the value of current stock absorbed by each class of spare parts is compared (Fig. 1), it is found that 72% of current stock worth is due to the N-class items.

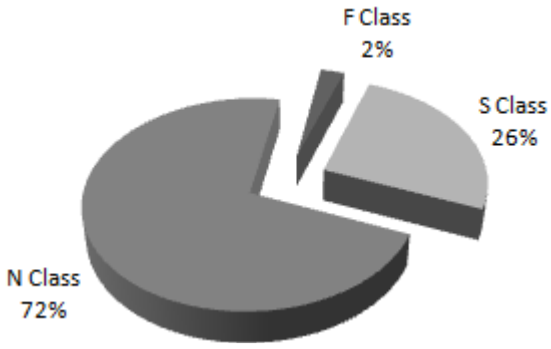

Fig. 1 Current Stock Value (NPR)

Key Findings

Besides the classification of spare parts, followings are the main findings extracted from the analysis:

- 53% of spare parts spending are used for fulfilling the equipment maintenance demand while 47% of spending is left for accumulation in inventory on annual basis.
- Because of bulk purchase and accumulated spare parts, the stock level is increasing on annual basis, as annual consumption is only about 10% of the average year-end stock.
- The maximum average stay is found to be 13 years for 43 types of spare parts.
- Out of the total current stock value, 72% is covered by non moving (N-Class) spare parts.

DISCUSSION

Spare part inventory system is not like other kind of inventory due to its unique characteristics like unpredictable - demand, specific use and higher lead time [2]. Because of such characteristics, the level of spare part inventory is often high. This fact is also justified by the study. According to the study, 47% of spare parts expenditure is done for just holding in the store. Spare part with higher irregular demand is termed as non-moving part [3]. It can be argued that higher the number of items with irregular demand, higher is the corresponding stock level. Since there is no specific definition and evaluation techniques of spare part demand pattern in HED-Kathmandu, it cannot be said that the higher stock of non-moving parts are due to the irregular demand pattern. Instead, it can be said that the higher stock of non-moving spare parts is due to lack of proper planning and control. Non-moving items in HED-Kathmandu is found to occupy 72% of the total stock value. Some of the non-moving parts are being stored since the time the equipment was purchased. It is common to have higher level of spare parts inventory [2] but there is always a limit and opportunity of improvement. Referring to the high level of non-moving items, significant percentage of accumulated spare parts and bulk purchase practice, there is a space for improvement by reducing the level of inventory.

CONCLUSION

In this study spare parts management system of HED-Kathmandu, is closely observed and found that no effective spare parts management system is followed. The existing practice is guided by necessity to fulfil formalities as prescribed by the financial rules and regulations.

For the study, all spare parts of all three equipment are analyzed using ABC, XYZ and FSN classification. From the ABC and XYZ analysis, it is found that about 47% of annual equipment maintenance budget is spent on procurement of spare parts that remain in stock for a long time.

A machine requires large number and variety of spare parts for its proper maintenance. It is very difficult to predict the exact time of demand. Also, some of the parts are not readily available in local market, as they have to come all the way from their OEMs (Original Equipment Manufacturers). Therefore, there is always a tendency to keep spare parts in stock to avoid the downtime cost and to increase availability of equipment. But the tendency of keeping the parts in stock triggers the accumulation of unnecessary spare parts. The scenario in HED-Kathmandu is found no different. According to the finding, the average annual consumption is only 10% of the average annual stock. Furthermore, FSN classification reveals that, 72% of the total stock value is accounted for non moving parts (N-Class). With critical analysis of the spare parts an efficient plan can be developed which helps to overcome the existing problem of over-stocking.

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