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USE AND APPLICATIONS OF OPTIMIZING SELECTIVE INVENTORY CONTROL TECHNIQUES OF SPARES FOR A CHEMICAL PROCESSING PLANT

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ABSTRACT

This paper presents the implementation of an improved inventory management and control system of a chemical processing industry. Inventory management system involves the procurement, stocking, and issue of materials to the maintenance department as and when required. Inventory management is the main area in which many process industries are suffering. The work is concentrated with the inventory management problems of a chlor-alkali industry. The aim of this work is to design inventory models for such a system in a process industry. The effort of an effective inventory strategy is to optimise usage of materials while minimizing cost. The existing system of inventory control of spares reveals that past data cannot be taken as the major decision criteria. The important decision making criterion related to spares is criticality, lead time and consumption value which need to be accounted for effective control of inventory management in the organization. Data are collected from various sources like log books, ledgers, annual financial statements and published articles of the company. Interview method is used to collect primary data regarding the existing inventory management system. Selective treatment is done based on ABC and VED analysis which were then combined to give a two dimensional picture and stocking policies are suggested for each category. As an extension of the above analysis, the other parameters called lead time and service level are incorporated in order to obtain 3D models and suggestions were given to improve the inventory management of spares. The key performance indicators were also established to give benchmark operations. Simulation technique is used to obtain the probable lead time and demand, optimum re- order quantity and optimum re- order level, minimum total cost which are also analyzed in this paper.

Keywords: ABC, MUSIC-3D, Re-order level and Re-Order Quantity, Selective inventory control, , VED, Simulation,

I. INTRODUCTION

The present study is conducted in a chemical industry named as Travancore Cochin Chemicals Limited, located at Ernakulum district. This company has a history of more than 60 years. The chemical industry plays a vital role in the production of many manufacturing goods. The industry provides a tremendous variety of materials to other manufacturers of textiles, rayon's, plastics, detergents, drugs, fertilizers, food preservatives, aluminium and paper producing industries. It also produces chemical products that benefits people directly. The Indian chlor-alkali industry is driven by the demand for caustic soda and chlorine is considered as a by-product. Many changes in technology have been taking place in the processing of chemicals. Today, chemical processing industries in India are facing certain challenges that will be tackled for the survival of these organizations in the era of globalization. Inventory

is often a company's largest current asset and the single largest contributor of working capital requirements. If inventory is properly managed, working capital requirements are reduced and cash flow is increased, enhancing the organization's chances to prosper and grow. Proper planning and control of spare parts inventory is a critical component of an effective asset management program. In this analysis a systematic approach has been adopted to identify the inventory management problems of the chemical company and suggestions are recommended to improve the inventory management system. ABC, VED, and MUSIC (3D) analysis and their combination along with lead time and reorder level and re order quantity are used to analyze the inventory problems. The major problem related to inventory problem is uncertainty in demand and lead time, which are considered in the present study. The objectives are (1) To study the existing inventory control of spares, (2) To identify appropriate selective inventory control tool, (3) To study and model selective inventory control of spares, (4) To analyze the three-dimensional approach for multi-selective inventory control (MUSIC-3D), (5) To suggest optimum re order level and re order quantity for such a item using simulation

II. LITERATURE SURVEY

The one common mistake in inventory control is identified by Institute of Financial Management and Research (1980) is to treat inventories in the same manner as costs and treat low inventories as desirable. It must be remembered that all costs the money to have inventories but so do stock-outs with inventories can be uneconomic as that of too high. The purpose of inventories is to allow for economic purchases and production quantities and to provide for uncertainties in the production process, market demand and sources of supply [1]. **Goal** said that inventories can also help to isolate or minimize the interdependence of each part of the organization, so that it may work more efficiently as becomes evident when many parts and subassemblies are purchased or manufactured, stored and used according to the needs [2]. **Horn** said as information of sales and inventory level has become more quickly obtainable the need for inventory to buffer information lag has been greatly reduced. Moreover there has been major improvement in inventory control transportation and warehousing [3]. **Gopalakrishnan** found in all cases company's working capital is tied up and hence the finance manager is way of servicing the idle working capital at 30% per annum on the contrary if the item is kept in the store, there will be stock out if the demand arrives [4]. Also the process industries are particularly vulnerable to plant process and product failures. Along with the main reasons are the complexities of technology involved in range of products and the often subtle nature of compositional changes, process shifts and hidden product flaws [5]. **Viale** said that objectives of inventory are minimizing investments while still providing a high level of customer service, maximizing profit, and providing for effectiveness in procurement and manufacturing [6]. **Chakraborty** opinioned that inventories are represent the major part of working capital management and an inventory has both physical and functional aspects. Accumulation of stock of finished goods except under conscious policies is very serious phenomenon, which has landed many companies in trouble [7]. **Viswanath** found inventory to be a simple insurance against uncertainty in demand, procurement lead time, quality and quantity of material supplied by the supplier. Inventory management is a looking forward activity in the sense that inventory is held in anticipation of future demand [8]. Maintaining an efficient inventory management strategy can help industrial plan managers improve and ensure the success of their operations [9]. VED analysis is most applicable to spare parts. The peculiarity about spare parts is that it does not follow a predictable demand pattern as in the case of raw materials [10]. The generally accepted 80:20 rule illustrates that approximately 80 percent of any storeroom's volume is associated with only 20% of the items in inventory. It is important to pay extra attention to that critical 20% items [11]. A survey carried out in India show that on an average 64% of the total cost of manufacturing is that of materials. This percentage however differs from industry to industry [12]. 'Spare part' refers to the part requirement for keeping owned equipment in healthy operating condition by meeting repair and replacement needs imposed by breakdown, preventive and breakdown maintenance. The spare part management function is critical from and operational perspective especially in asset intensive industries such as refineries, chemical plants and paper mills [13]. It is advisable to define maintenance or spares supply service policies specifying the levels of availability to be achieved first and then workout inventory policies for individual items to meet the service requirements with given procurement infrastructure. In this method inventories are optimized for service requirements [14]. Because of the complex structure of spare parts supply chain, the conventional approaches, which do not consider the relationships between decision factors globally and cannot, achieve the optimal performance. An enhanced fuzzy neural network (EFNN) based decision support system for managing automobile spares inventory in a central warehouse. In this system, EFNN is utilized for forecasting the demand for spare parts. However, without considering relevant domain knowledge, traditional neural networks are found to be suffered from the problem of low accuracy of forecasting unseen examples. First, it assigns connection weights based on the fuzzy analytic hierarchy process (AHP) method without painstakingly turning them. Second, by generating and refining activation functions according to genetic algorithm our EFNN can provide comprehensive and accurate activation functions and fit a wider range of nonlinear models. Last, but not least, an adaptive input variable is introduced to decrease the impact of the bullwhip effect on the forecasting accuracy [15]. Forecasting the required number of spare parts, based on technical characteristics and operating environmental conditions of a system, is one of the best ways to optimize unplanned stoppages [16]. The study reveals the need of inventory control and inventory reduction in the industries. A 2-D matrix of

the ABC-VED analysis has been constructed for inventory modelling to achieve high efficiency. These inventory control methods are based on the principles that it is impossible to manage and control every item in inventory holdings in the same way and skill so as to meet the two broad objectives of inventory control i.e. to reduce investment in inventories, and to avoid stock outs and shortages. Selective inventory control management therefore concentrates on those items whether it is justified either due to criticality or amount of money involved [17]. **Onwubolu** (2007) said that there are various inventory management tools like EFFN, AHP, COCOMOII, C#.NET, MATLAB and Visual Basic programs that enables the user to find the best way to manage inventory [8]. Based on the above literature an analysis lacks to find optimum ROQ and minimum total cost, probable demand and lead time a one item of critical, high consumption value with long lead time. Hence it is decided to design a model for simulation to find solution for the above.

III. RESEARCH METHODOLOGY

Initially the inventory management system was understood from the stores manual of stores department and the discussions are made with the Manager (stores and inventory control) and stores officers to clarify the doubts and study the existing system of keeping inventory. Data are collected from the above said sources, ERP data and using questionnaire survey. Hand outs, registers are also made use of to collect secondary data. Reliability test of the questionnaire is analyzed, since a sample size of 62 from a population of 74, is selected and a questionnaire was distributed to 62 experts, out of which 58 responded. Using 55 valid responses, an analysis is conducted in SPSS 20 for testing the reliability. It is found that at 95% confidence level the Cranbach's Alpha is 0.82. The data collected are found to be good since the respondents responded to the questionnaire differently. ABC and VED analysis are done to categorize the spare parts on the basis of usage value and criticality. There are twenty three critical factors identified for equipment classification, based on the data collected from the AGC plant and opinion of the experts of operations and maintenance department out of which eight factors which are most important are selected. The factors are (1) %utilization of machine (2) Number of alternative machine (3) Effect on other machines due to break down (4) Age of machine (5) Ease of repair (6) Quality of work done on the equipment (7) Ease in procurement and (8) Maintenance history. Weight age are assigned to each factor such that total score is 100%. The most important factors are assigned higher weight age as compared to less important factors. Also with the help of questionnaire all the equipments in the plant are classified based on their criticality score obtained as follows.

Vital	- criticality score over 80%
Very important	- criticality score between 60% & 80%
Important	- criticality score between 40% & 60%
Least important	- criticality score below 40%

The analyses are then combined to give a control matrix which will provide better control of inventory. Lead time is incorporated in to the above control matrix in order to obtain a three dimensional picture and service level for items is also considered for building a model. The key performance indicators were also established to give benchmark to operations. Uncertainty in demand and lead time are also taken in to account and solutions are given with the help of simulation model. A computer programme is coded and a graphic user interface (GUI) is developed in MATLAB 2008 to calculate optimum ROQ with minimum total cost using simulation technique for most critical items.

A. ABC Analysis

A thumb rule known as 20-80 rules is applied here. It states that a small number of goods less than 20 % account for most of the stock value greater than 80%. These percentages may vary according to stock species. ABC classification is the most popular and it classifies inventory into three distinct classes. A- Class items are those which are found to be hardly 5% to 15% of total items with their consumption value being 70% to 75% of the total money spend on materials. B- Class items are generally 10% to 20% of the total items and their consumption amounts to 10% to 20% of the money spend on the materials. C- Class items are large number of items which are cheap and inexpensive and hence insignificant. They are large in number and running into hardly 5% to 10% of the total money spends on materials.

B. Control Matrix

ABC and VED analysis are combined together for better control of inventory. For different combinations, the treatments should be different. Suppose an item is found to be vital and it is an A class item, then constant control and regular follow-up is necessary. Similarly, suitable treatments should be given for AE, AD, BV, BE, BD, CV, CE, CD combinations. The treatments to be followed are specified in Table 4.1 given below.

Table 4.1 ABC - VED Matrix

	V	E	D
A	Constant control and regular follow up (AV)	Maintain at moderate level (AE)	Eliminate item or keep nil stock (AD)
B	Maintain at moderate level (BV)	Maintain at Moderate level (BE)	Low stock (BD)
C	Maintain at moderate level (CV)	Maintain at Moderate level (CE)	Low stock (CD)

C. Multi Unit Selective Inventory Control 3D (MUSIC 3D)

MUSIC 3D is a three dimensional approach, the three functions being finance, operations and materials. Based on ABC analysis, items are classified as high consumption value (HCV-80/20 Rule) and low consumption value (LCV-20/80 Rule). Based on VED analysis, we can classify items as critical and non critical. Long lead time (LLT) and short lead time (SLT) are based on SDE analysis.

Table 4.2 MUSIC 3 D

	HCV		LCV	
Critical	LLT	SLT	LLT	SLT
	1	2	3	4
Non- critical	5	6	7	8

Based on SDE analysis, HCV items that are 20% with annual consumption value of 80% remaining 80% of LCV items account for an annual consumption value of 20% are shown in Table 4.2. Cost reduction techniques are not used for items in cells 3, 4, 7, 8 since the cost of cost reduction method is likely to be greater than the cost of the item itself. It may be dangerous to apply cost reduction technique for highly critical items falling in cells 1& 2. Therefore cost reduction technique can be applied only to items in cells 5&6. This method ensures maximum plant availability with minimum working capital commitment.

D. Inventory control systems

There are two inventory control systems commonly used—(i) continuous review system and (ii) periodic review system. An important parameter for installing an inventory control system is the service level, which is the percentage of orders that are received before a stock-out occurs in inventory control. When historic data exists, then the expected demand can follow the normal distribution pattern so that:

$$Z = (X - \mu) / \sigma \sim (0, 1)$$

where, mean = expected demand = μ , standard deviation, $\sigma \approx 10\%$ of μ , safety stock, $S = Z\sigma$, order point = X ; the parameter X is a normally distributed variable, i.e. has a mean of 0 and a variance of 1 and Z has what is called a standardised normal distribution, i.e. one with a mean of 0 and a variance of 1 [18].

E. Development of key performance indicators

Key performance indicators (KPI) are high-level snapshots of a business or organisation based on specific predefined measures. KPIs typically consist of any combination of reports, spreadsheets, or charts.

Table 4.3 K factor for MUSIC- 3D

Sl No	Category	Suggested K factor	Control action plan
1	Critical -High consumption value -Long lead time	1.8 To 2.0	1. Strict control on consumption norms 2. Expediting and follow up effort maximum 3. Multiple sources 4. Stock as low as possible 5. No stock out
2	Critical -High consumption value -Short lead time	1.5 To 1.7	1. Strict control on consumption norms 2. Expediting and follow up effort maximum 3. Multiple sources 4. Stock as low as possible 5. No stock out
3	Critical -Low consumption value -Long lead time	2.5 To 3	1. Large quantity to be ordered for annual or two years requirement 2. Adequate level of inventory(qty-plenty) 3. No stock out(100% service level)
4	Critical -Low consumption value -Short lead time	2.5 To 3	1. Order quantity may be quarter or six months being short lead time 2. Adequate level of inventory(qty-plenty) 3. No stock out(100% service level)
5	Non-Critical -High consumption value -Long lead time	0.8 To 1.0	1. All cost reduction techniques to be applied 2. Stock out possible 3. Low inventory level
6	Non-Critical -High consumption value -Short lead time	0.5 To 1	1. All cost reduction techniques to be applied 2. Stock out possible 3. Zero inventory or Low inventory 4. Service level minimum 5. Purchase on JIT basis
7	Non-Critical -Low consumption value -Long lead time	2.0	1. Moderate inventory level 2. Stock out Possible 3. Service level moderate
8	Non-Critical -Low consumption value -Short lead time	1.8	1. Moderate inventory level 2. Stock out Possible 3. Service level moderate

Source: Vinay sharaf P&IC Hand book

They may include global or regional sales figures and trends over time, personnel statistics and trends, real-time supply chain information, or anything else that is deemed critical to a company's success. The essence of developing key performance indicators (KPIs) are for TCC stores to carry on with their future work of benchmarking their operations using the KPIs. The standard formulae used are

Service level = (No: of requisitions serviced / Total number of requisitions) x 100%

Late service level

= (No: of requisitions not serviced on time / Total number of requisitions) x100%

This approach also provides a simple method of fixing ideal stock level of each item taking into account criticality, availability and consumption value as follows:

Ideal Stock Level = 1 + K * (Lead Time Consumption)

Where K is the safety factor varying from 0.5 to 3 is assigned to each of the eight groups based on its consumption value, criticality and lead time factor proposed to be used initially suggested in the MUSIC-3D Table 4.3. To arrive at the ideal stock level, safety factor is multiplied by lead time consumption & unit 1 is added to the above. Unit 1 is added to signify no stock out even if lead time is zero for an item. The safety factor (K) shall be subjected to periodic review.

F. Use and application of MUSIC-3D

Music-3D is used in cost reduction techniques selectively. Its application is

- Effective follow up and chasing,
- Powers of delegation to all levels,
- Lower inventory levels,
- Selective information by continuously monitoring of high consumption value items,
- Development of new sources of supply for high value critical items
- Different service levels for different categories,
- Development of consumption norms for high value items.

G. Inventory policy.

The objective of this simulation is to choose an inventory policy that will provide good customer service at a reasonable cost. A model is developed relating two output measures, total inventory cost and the service level, to probabilistic inputs, such as product demand and delivery lead time from vendors, and controllable inputs, such as the order quantity and the reorder point as shown in Fig 4.1.

Fig.4.1 Model for simulation

For each setting of the controllable inputs, a variety of possible values would be generated for the probabilistic inputs, and the resulting cost and service levels would be computed.

H. Simulation Model

The basic idea behind simulation is to model the given system by means of some equations and they determine its time-dependent behaviour. In a real life inventory management system, demand and lead time are uncertain. Hence simulation technique is used to optimize the re-order level and re-order quantity which yields the minimum total cost. Assumptions made in this model are 1) there should not be any replenishment order outstanding, when a new order is placed. 2) Backordering is not permitted. 3) Ordering cost is independent of the number of quantities ordered. The flow chart given in Fig 4.2 explains the logic of the program.

Fig. 4.2 Flow chart for the computer program

V. RESULTS AND DISCUSSION

A. Result of ABC Analysis

The result of ABC analysis is shown in Table 5.1 and in Fig. 5.1. From the graph plotted, it is clear that around 10.54% of items are contributing 70.19% to cumulative usage value. Therefore, such items are classified as class A. Around 19.23% numbers of items contributing to 24.84% cumulative usage value is categorized as class B. Remaining 71% number of items contributes only 4.73% to cumulative usage value is classified as class C items.

Table 5.1 Output of ABC analysis

Class	No. of Items	% of Items	Value of Usage (Rs)	% of total usage value
A (Above Rs 30000)	22	10.57	1162562	70.19
B Rs(2500-30000)	40	19.23	409741	24.84
C Below Rs 2500	146	71	77644	4.70

Fig 5.1 ABC Analysis

B. Result of VED Analysis

VED analysis is carried out for AGC plant. The criticality of spares is arrived by first finding the criticality of machines to which the spares belong. Based on the data collected from the plant with the help of questionnaire, all the machines in the plant are classified as vital, essential and desirable. This method was described in detail in Chapter 4. It has been found that 60 equipments are vital, 123 equipments are essential, and 52 equipments are desirable. The number of spares for vital, essential and desirable category is shown in Table 5.2. The corresponding graph is shown in Fig.5.2

Table 5.2 Output of VED analysis

Class	Number of items	% of No. of items	Usage value (In lakhs)	Criticality Scores
V	60	25.53	8.5	80-100%
E	123	52.34	8	40-80%
D	52	22.12	0.35	Below 40%

C. Discussion of VED analysis

The items in vital category are the critical spares whose shortage will result in production stoppage. Therefore such items should never be out of stock and policies that will provide enough stock should be adopted for this category of spares. Essential spares should be moderately stocked since its shortage affect production after some time. Tight control can be applied for desirable spares since their stock out will not affect the production.

D. Discussion of Control Matrix

The control matrix shown in Table 5.4 is a 3x3 matrix where each cell represents a combination of any of the two classes. Now it is possible to suggest suitable policy for items in each of these cells. There is no point in controlling

items in cell CD, since their consumption value and criticality are low. Items in cell AV should be given the greatest attention since their usage value and criticality are the highest.

Fig. 5.2 Criticality analysis

Combination of ABC and VED selective control helps to identify service levels which forms basis for inventory policies. The expert has given service levels based on criticality and consumption value is shown in Table 5.5. Using above equation and various service levels given in Table 5.3, the Table 4.1 can be re-calculated and shown in Table 5.4.

Table 5.3 Service level for different combinations

	V	E	D
A	90%	76%	60%
B	96%	86%	70%
C	99%	96%	80%

Table 5.4 Summary of ABC-VED Analysis

	V	E	D
A	Constant control and regular follow-up (AV)= $\mu_1=10$; (1/13) $Z_1 = 1.64$, $X_1 = 12$	Maintain at moderate level (AE)=6 $Z_2 = 1.18$, $X=7$	Eliminate item or keep nil stocks (AD)=6, $Z_3 = 0.82$, $X = 6$
B	Maintain at moderate level (BV)=15 $Z_4 = 2.06$, $X = 18$	Maintain at moderate level (BE)=47 $Z_5 = 1.48$, $X = 54$	Very low stocks (BD)=5 $Z_6 = 1$, $X=6$
C	Maintain at high level (CV) = 32 $Z_7 = 2.65$, $X=41$	Maintain at moderate level (CE)=70 $Z_8 = 2.1$, $X= 85$	Low stocks (CD)=14 $Z_9 = 1.29$, $X=16$

E. ABC-VED Groups matrix.

In case of spares, besides the criticality factor, the cost factor must also be taken into consideration, as can be seen from our study, where about 10% of the spares consumed about 70% of value. This is the group requiring greater monitoring as it has fewer spares consuming most of the money. It was noted that not all the spares in this group were vital or essential. It also had spares from the desirable category. Categorization of spares by the ABC-VED

Matrix model helps to narrow down on fewer spares requiring stringent control is shown in Table 5.5.

Table 5.5 ABC-VED Cumulative matrix.

Category	Groups	Total No. of items	% of No. of items	Usage Value (in Lakhs)
I	AV, AE, AD, BV, CV,	52	25	13.60
II	BE, CE, BD	142	68.26	2.7
III	CD	14	6.73	0.25

F. Result of 3D analysis

Items are classified on the basis of Usage value, Criticality and Lead time and then combined to give 3D matrix. Result of 3D analysis is shown in Table 5.6. The number of items in class A that is Vital and has long lead time is 4. Similar categorization is possible for items in each of the other cells.

Table 5.6 MUSIC 3D matrix

Class	HCV		LCV	
	LLT	SLT	LLT	SLT
Critical	(1) 4	(2) 6	(3) 8	(4) 36
Non-Critical	(5) 5	(6) 18	(7) 26	(8) 72

Using different K factor suggested in Table 4.3, each item in MUSIC-3D matrix can be calculated to get ideal stock level are shown in Table 5.7.

G. Discussion of 3 D analysis

Items in cells 1,2,5,6 number around 16 % with annual consumption value of 87%, and remaining 84% account for an annual consumption of 13%. Cost reduction techniques are not used for items in cells 4,5,7,8 since the cost of cost reduction method is likely to be greater than the cost of the item itself. It may be dangerous to apply cost reduction technique for highly critical items falling in cells 1&2. Therefore cost reduction technique is applied only to items in cells 5& 6, which are 23 items.

Table 5.7 Summary of MUSIC-3D Matrix

Class	HCV		LCV	
	LLT	SLT	LLT	SLT
Critical	(1.8-2) (1) 4 1.8	(1.5-1.7) (2) 6 1.5	(2.5-3) (3) 8 2.5	(2.5-3) (4) 36 2.6
Non-Critical	(0.8-1) (5) 5 0.8	(0.5-0.8) (6) 18 0.5	(1.5-2) (7) 26 2	(1.5-1.8) (8) 72 1.8

H. Results of Simulation Model

For the selected value of ROL and ROQ, the programs iteratively calculate the total cost for various demands and lead time to give the grand total cost. The maximum iteration permitted is 50. This procedure is repeated for each ROL and ROQ combination. The program then suggests the ROL and ROQ that gives minimum total cost as obtained from the simulation. This is the Optimum Re-Order Level and Re-order Quantity. The simulation model developed for the work is basically a MATLAB 2008 program that enables the user to find the best way to manage inventory. The graphic user interface (GUI) for the inventory management tool designed is shown in Fig.5.3. The output of simulation that is total cost versus order quantity graph is shown in Fig. 5.4. From the graph minimum total cost and optimum order

quantity is obtained, which can be used by the management for decision making. From the graph, the order quantity corresponding to minimum total cost is obtained for minimum and probabilistic lead time.

Fig. 5.3 The graphic user interface (GUI) for the inventory management tool

Fig 5.4 Output of total cost and order quantity curve graph

VI. FINDINGS

In the ABC analysis it was found that, around 10.54% of the items occupy more that 70.19% of the usage value and around 71% of the items give 5% of the usage value. Criticality of the spares is the most important decision making criterion for the inventory control of spares. In this factory, items are not classified on the basis of their criticality. Therefore if there is a shortage for a critical item, production will be stopped. In the VED analysis, it was found that above 25.53% of the items are vital and hence they are critical for the production continuity. It is also found that around 22.12% of the items are non –critical. In the Control Matrix it was found that there are 13 items in AV category which are vital as well as of high usage value and 32 items in CV category. From the MUSIC-3D analysis, it was found that it is not effective to apply cost reduction techniques to all the cells since the cost of cost reduction method is likely to be greater that the cost of the item in low consumption value cells and it may be dangerous to apply cost reduction technique for highly critical high consumption value items. Re-order level calculation does not consider lead time, since the internal lead time is very high and fluctuating. Therefore chances for stock-out situation are high.

VII. RECOMMENDATIONS

Items in class A should be tightly controlled so that total cost can be reduced. Items in class B should be moderately stocked and liberal policy should be adopted for items in class C. VED analysis may be done for evaluating and assigning criticality scores for spares. Vital spares should be there in stock in order to avoid production stoppage. It is found that analysis will give better result when two or more techniques are combined together. It is also found that ABC and VED are the two techniques which can be combined together for better control of spares. Constant control and regular follow-up should be made for 13 items in AV category. In MUSIC-3D analysis, cost reduction technique is recommended for 23 items in High consumption value, non-critical cells. ABC/VED matrix along with lead time may be used in replenishment of spares to incorporate the lead time uncertainty into the model. Simulation techniques have been used to handle the uncertainties in demand and lead time, and to obtain the Optimum Re-order Level, Optimum Re-order Quantity and minimum total cost. The total cost and optimum order quantity curve used to find minimum total costs and minimum order quantity with probable demand and lead time and corresponding values are useful for managerial decision making. The probabilistic demand and lead time can be calculated using simulation technique.

VIII. LIMITATIONS OF THE STUDY

In this study, lead time classification is not based on any of the conventional tool. The items that have lead time greater than 6 months are taken as high lead time and others as low lead time. Analysis will give better result if it is done on the basis of SDE (Scarce, Difficult, and Easy) analysis. The analysis was done for items that belong to only one plant.

IX. FURTHER SCOPE OF THE STUDY

Since the analysis was carried out for items in a single plant, this could be extended to other plants also. Similar analysis can be applied to other types of inventories like raw material. Technology used for the inventory management should be updated so that it can be made realistic. The information sharing programs and technologies will aid in inventory control system being more effective. The advantage of using MATLAB2008 programming language is that they offer greater flexibility in terms of being able to model more complex systems.

X. CONCLUSION

The paper explains the use and application of selective inventory control technique of spares of a chlor-alkali Industry. The study was conducted in a chemical industry located at Ernakulam district. Many changes in technology have taken place in the processing of chemicals. Nowadays, chemical processing industries in India are meeting various challenges which need to be identified for the survival of these organizations in the era of globalization. An intense literature survey has been conducted to study the inventory management problems of chemical processing industries. From the literature it is understood that many old chemical processing industries are facing serious inventory problems. The major problems are due to lack of adopting new technologies in the inventory management system. Since the technology is old, inventory problems are high. The present analysis reveals that a systematic approach has been adopted to identify the inventory management problems of the chemical company and few suggestions are recommended to improve the existing inventory management system. The existing inventory system of spares was analyzed and various selective inventory control tools are suggested. The selective inventory control of spares using 2D approach and 3D approach were also carried out and suitable model is suggested for each of them. Also, optimum re-orders level and re-orders quantity suitable for the spares was recommended with the help of simulation model. The computer program developed calculate probabilistic demand and lead time for a given re-order level. Thus, by using this method, we are able to calculate probable demand and probable lead time with optimum order quantity and minimum total cost.

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