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A SIMULATION-BASED OPTIMIZATIONFRAMEWORK: A CASE STUDY ON INVENTORYMANAGEMENT

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Abstract:*The paper propose a simulation-based solution framework for tackling the inventory optimization problem. The goal is to find appropriate settings of reorder point and order quantity to minimize the average inventory level. Optimization of inventory management is a useful technique that can be used to decrease the lead time and cost incurred in any manufacturing company, while increasing the customer service level. The overall impact is a significant increase in the net profit of a company.*

Key words*: Selectiveinventory control, Reorder level, Reorder quantity*

I. INTRODUCTION

In the field of working capital, efficient management of inventory possess a challenging problem to the public sector organization particularly in India in the absence of any guiding principles from the government in this regard. The lack of conscious efforts by public units to control the growth of their inventory volume, and the diversity in the field of public industrial activities has added to the complexity of the problem. The relationship between inventory and working capital is very crucial, since inventory constitutes major part of working capital.

In Kerala majority of the public and private sector has established their own material management system. Mostly on the lines of well-established practices, with a view to control cost of production. Nowadays organizations are facing problems of survival because of acute competition. Only those organizations can meet the competitions effectively and can have a hold on the market, which are in a position to keep their cost minimum. Material is the first and most important clement of cost. In this context, it is worthwhile to make a comparative study of the theoretical aspect of purchase and inventory control system with practices in a manufacturing undertaking. With this end in view, it was thought desirable to undertake a case study of TCL which has been successful throughout its existence.This study analyses the inventory level and profitability position of a leading cement manufacturing company.

II. LITERATURE REVIEW

Inventory management is a basic part of any organization that produce a product or service of economic value. The basic objective and goals of inventory management is to obtain materials at the lowest possible price, which must go hand in hand with consistence in both quality and quantity of supply**.** The common mistake in inventory control is to treat inventories in the same manner as costs and treat low inventories as desirable and high inventories as undesirable. It must be remembered that all costs money to have inventories but so do stock outs with inventories there is an economic level and to low inventories can be uneconomic as those 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].As the information of sales and inventory level has become more quickly obtainable the need for inventory to buffer information lag has been greatly reduced. More over there has been major improvement in inventory control transportation and ware housing [2].The inventories can also helps 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 sub-assemblies are purchased or manufactured, stored and used according to the needs [3].The inventories are maintained basically for the operational smoothness, which they can affect by uncoupling successive stages of production whereas the monetary value to indicate the size of the investment made to achieve this operational convenience [4].In all cases company's working capital is tied up and hence the finance manager is wary of servicing the idle working capital at 30 percent per annum on the contrary if the item is kept in the stored, there will be stock out, if the demand arrives [5].Objectives of inventory are identified as minimizing investment while still providing a high level of customer service, maximizing profit and providing for effectiveness in procurement and manufacturing. Certain aggregate concerns regarding inventory on financial, objectives and measures such as return on investment and inventory turnover. Company strategy often uses inventory where product has seasonal demand or where hedging may be necessary to guard against anticipated supply disruptions [6].Inventories represent the major part of working capital management and inventories 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. Accumulated stock is such a grave matter that some people has graveyard, business have called stockyard of such business [7].

Inventory is simple insurance against uncertainty in demand procurement lead time, quality and quantity of material supplied by the supplier. Inventory management is a forward looking activity in the sense that inventory is held in anticipation of future demand or consumption depending on whether the item is the end product or an intermediate [8].Petrovic(2000)designed an expert system model for advising on spare part inventory control. The heuristic decision rules used in the model were based on several operational characteristics of spare parts: availability of required system, essentiality, price, weight, and volume of the part, availability of spares in the market, and efficiency of repair [9].Andersson and Marklund (2000) introduce a modified cost structure at the warehouse, and then multi-level inventory control problem can be decomposed to single-level problems. By applying a simple coordination procedure to them, the near optimal solution is obtained [10].Gajpal (2002)attends to projected needs for spares before searching for optimal solutions. His approach is to categorize the parts using a variety of partitioning techniques that complement the use of good forecasting procedures including ABC analysis, FSN analysis and VED analysis[11].Caglar, Li, and Simchi-Levi (2004)studied a spares inventory problem faced by a manufacturer of electronic machines with expensive parts that were located at various customer locations. Assuming that parts failed infrequently according to a Poisson process, he formulated a model to minimize the system-wide inventory cost subjected to a response time constraint at each field depot [12].Schultz (2004) demonstrated how the mean and variance of machine repair or down time affected cycle times at a given workstation and downstream workstations with existing closed-form approximation methods. Then, he presented a methodology for base stock parameters selection, while considering the trade-off between reduced cycle times and inventory investment [13].

III. METHODOLOGY

I)For the appraisal interpretation and review of the effectiveness of inventory management of TCL, the following ratios are worked out.

1. Inventory turnover ratio
2. Raw material turnover ratio
3. Stores and spares turn over
4. Raw material storage period
5. Stores and spares storage period
6. Percentage share of individual component of inventory to aggregate inventory.
7. Inventory conversion period
8. Net profit

A comparative study of the inventory management performance of different years (2012-2013 to 2016- 2017) is also undertaken. Various statistical tools have been used for this purpose such as percentages, bar charts, combined bar charts, line charts etc.

II) For getting proper control of materials, selective inventory control techniques are applied.

III) Due to the complex nature of distribution followed by demand and supply of spare parts, the problem cannot be solved analytically. It is however possible to get the solution by simulation techniques. The basic approach is to determine the quantities demanded the lead time and their frequencies. Run the inventory system artificially by generating the future observations with the help of random numbers. Software in MATLAB has to be developed to find out Re-order level and ordering quantity by entering the required data.

IV. ANALYSIS AND FINDINGS

Ratioanalyses wereconducted. The data presented in the below tables indicate the performanceofcompanyoverthe years.

Table 1: Ratios Analysis

		2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
Inventory turnover ratio		4.27	3.46	3.73	2.85	2.28
Raw material turnover ratio		2.67	1.69	1.39	2.06	1.96
Stores and spares turnoverratio		0.53	0.61	0.80	0.53	0.53
Raw material storage period (Months)		4.5	7.1	7.0	5.9	6.2
Stores and spares storage period(Months)		19.9	19.9	15.2	22.9	19.9
Percentage shareof individual component	**Raw Material (%)**	11	19	20	17	19.4
	Spare Parts (%)	58	49	51	56	59.6
	Finished Goods (%)	31	32	29	27	21
Inventory conversion period (Months)		13.5	13.8	14.2	14.6	15.8
Net profit (in crores)		11.56	10.29	10.08	9.83	9.02

From the table shown above it is found that there exist an inventory problem and company suffering loss due to it. The major problems faced by the company due to excess inventory are high storage cost, storage space problem, wastage of material, reduction in liquid assets, profit loss.

These factors show some predominance when compared to other factors. So it is necessary to control the inventories of the company. For that multi-dimensional selective inventory control is used. The table above shows the results of one dimensional selective inventory control.

One Dimensional Selective Inventory Control Analysis

Table 2: 1D- selective inventory control

Type of Analysis		**Number of items**
ABC Analysis	A Class	41
	B Class	85
	C Class	572
VED Analysis	V Items	26
	E Items	217
	D Items	474

FSN Analysis	F Items	43
	S Items	410
	N Items	264
HML Analysis	H Items	57
	M Items	105
	L Items	558
XYZ Analysis	X Items	71
	Y Items	96
	Z Items	550

Two Dimensional Selective Inventory Control Analysis

Table 3: 2D- selective inventory control

	V	**E**	**D**
A	9	13	9
B	15	40	5
C	64	568	16
	X	**Y**	**Z**
A	13	6	3
B	32	19	18
C	17	61	529
	F	**S**	**N**
X	28	20	10
Y	20	32	41
Z	22	277	257

Three Dimensional Selective Inventory Control Analysis (MUSIC 3D)

MUSIC 3D which stands for 'multi-unit selective inventory control' is a three dimensional approach. The three dimensions are being finance, operations and availability.

The three dimensions can be seen in Table 4

Table 4: 3D- selective inventory control

	High consumption value [HCV]		**Low consumption value [LCV]**	
	High Lead Time [HLT]	**Low Lead Time [LLT]**	**High Lead Time [HLT]**	**Low Lead Time [LLT]**
Critical	1	2	5	6
Non-Critical	3	4	7	8

Based on ABC analysis we get HCV or LCV items. Critical and non critical items are based on VED analysis.

HLT and LLT classification is based on availability. MUSIC 3D analysis can be taken as an extension of control matrix and can focus more effectively.

For cells 1 &2 - AV Class.

For cells 3 & 4 - AE &AD Classes.

For Cells 5 & 6 - BV & CV Classes.

Foe Cells 7&8 - BE BD. CE & CD Classes.

High Lead Time means greater than 14 Weeks and Low Lead Time means, Lead Time less than or equal to 14 weeks.

Table 5: 3D- selective inventory control

	High consumption value [HCV]		**Low consumption value [LCV]**	
	High Lead Time [HLT]	**Low Lead Time [LLT]**	**High Lead Time [HLT]**	**Low Lead Time [LLT]**
Critical	1	3	7	16
Non critical	2	4	47	637

Cost Reduction by MUSIC 3D

Items in cell 1, 2, 3 and 4 number around 20% with an annual consumption of 80% while the remaining items in other cells numbering 80% account for an annual consumption of only 20%.There need not be any cost reduction techniques like value analysis for items in cells 5, 6, 7 and 8 as the cost of cost reduction methods is likelyto be greater than the cost of items itself. Items in the cells 1, 2, 3, 4 are potential candidates for applying cost reduction techniques. But it may be dangerous to apply cost reduction techniques for highly critical items falling in cell 1 and 2. Cost reduction can be applied on items grouped in cells 3 and 4.

Inventory control by MUSIC 3D

Inventory levels can be liberal for low value items in 5, 6, 7&.8. Items in cell 5 can be stocked more since they represent critical long lead-time items though with low consumption value. If possible avoid stocking items falling in cells 7 and 8 (especially 8. since they have short lead rime) Issue of materials falling in cell 1, 2, 3 and 4 should be verystrict, since they constitute high consumption value. If possible try to eliminate items falling in cell 3 and 4 (high value non critical)

For items in cell 1 and 2 rigorous monitoring and review is required. Service levels should be maximum for items under cells 1, 2, 3 and 4. Issue of items falling under cells 1 and 2 more sources are advisable.FSN analysis must be done once in 6 months for items in 1, 2, 3 and 4 to locate the slow moving, surplus and obsolete items. Physical verification should be done once in 3 months for items falling in cells 1, 2, 3 and 4.

Purpose of Classification

The V class of items by their extreme critical nature needs to be held in large quantity in the inventory. The stock out associated with such materials is very high and therefore, the service levels will be very high for this class of materials. The service levels for the subsequent E and D class of materials will be lower and lowest respectively. The D class of items is easily available in the market. They do not hold up production and may be substituted as well. Therefore, we can manage with small inventories of these items without drastic consequences on the running of the production line.

The A class of items incorporate a large turnover value in them. Naturally, the management attention must be focused on these items. This is possible as they are very few in number .Therefore A class of items are always under the scrutiny of the management. They are always monitored and followed up with respect to their stock levels.Their availability in the market, their substitutes if any etc. Since these are directly and constantly under the vision of the management. They can be kept in smaller quantities in inventory. Class C items contribute very little to the total annual consumption value and even if they are kept in large quantity in the inventory, it really doesn't significantly add to the inventory related cost. It is better that they be purchase and procured in large quantities, say once in a year and thus cut down the number of transactions and management follow up. Therefore the service levels of C class items will be high. B class items fall somewhere in between in terms of the service levels. The service levels of inventory therefore increase from D to V and from A to C. This suggests that the maximum service level will be for the CV class ofitems and the lowest service levels will be for the AD class of items. Others fall in between them. This has been illustrated in the Table

Next step is to develop simulation software to find the Re-order level and ordering quantity for these inventories. For that purpose a simulation program is developed in Mat lab which can be applicable to all inventories in the ABC-VED matrix. The results are:

Ordering quantity =14

Re order level = 26

Total cost = Rs. 13500

V. CONCLUSION

The study of the present inventory management system of the company gives a clearer picture about company's performance and efficiency in respected areas. Certain changes are necessary as given in the above section for betterment of the company as a whole. A clear attention can be given for efficiency of inventory. Even though there is an imbalance of sales compared to production and fixed expenses are growing up and also variable expenses are not in the control. On a random study on income and expenditure of the company, the above elements are some of the reasons for incurring loss. New measures should be taken for scientific and calculative approaches for increasing the efficiency of inventory and purchase control and distribution of products for increasing the sales**.**Travancore Cements Ltd is using old and outdated tools, techniques and procedures in Materials Management department. This is due to unavailability of funds and partial computerization. Company could not sustain with this outdated tools and techniques during the changing economic scenario of globalization and liberalization. The ratio analysis reveals that company is spending too much money in stocking inventories.

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