Inventory Optmization through Safety Stock Schemata

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ABSTRACT

In the complex business environment and stiff competition, inventory optimization in an industry's supply chain has gained tremendous significance. It has become business imperative to optimally tune the supply chain and save lot of working capital by reducing inventory levels; this can surely be done while increasing the customer service level and utilizing the internal capacities optimally. Stock out costs and stock surplus costs both impact businesses badly, the former in the form of opportunity loss and resultantly causing customer annoyance and later in high financial markups and increasing cost and reducing margins accordingly. So inventory optimization can essentially help to reduce costs, which results in a considerable improvement of the company performance indicators. Traditional IMS (Inventory Management System) followed in a selected manufacturing industry has been examined for all types of inventories, i.e. raw materials; WIP (Work In Process), and finished goods as a case study. The paper suggests an optimized inventory model for an organization to provide the best possible customer service within the restraint of the lowest practical inventory costs. The safety stock optimization was implemented in a complex business environment and considerable savings were realized thereof.

Key Words: **Complex Business Environment Stiff Competition, Working Capital, Inventory Optimization, Safety Stock Schemata, Increased Customer Service Level**

1. INTRODUCTION

Inventory is life blood of SCM (Supply Chain Management). Properly managed inventory plays a significant role in efficient functioning of SCM. So inventory management becomes one of the critical tasks in efficient SCM system. For the industrial managers and executives, it becomes imperative to design a supply chain model, which requires optimized level of inventories and where supply chain cost is kept at the lowest level. According to Aberdeen's survey of supply chain professionals [1] most of the organizations fail to manage their valuable assets effectively. Majority of the manufacturers and distributors are reluctant to update their out-of-date inventory policies. This negligence in the current competitive business environment resulting in tie up of working capital, harm customer retention and hurt the interests of the stack holders. The paper aims to

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identify the emerging practices for supply chain management with a view to suggest framework by which readers could assess their capabilities in relation to supply chain inventory practices. The paper provides some basic guidelines on what is required for inventory optimization, how it is accomplished and tradeoffs between different approaches. The paper also outlines the important steps to inventory management excellence by utilizing current efficient inventory practices.

2. LITERATURE SURVEY

2.1 Inventory Optimization Defined

Micro Inventory Management Ltd, UK [2] has defined inventory optimization: "Balancing inventory to meet customer demand". International Business Systems [3] elaborates this term more adequately, "The core objective of good inventory management system is to provide the best possible customer service within the restraint of the lowest practical inventory costs". Efficient service is achieved by ordering the right items and quantities at the right time. Reducing the inventory stock held at a given time has a significant impact on the working capital of that organization.

Cornacchia, [4] presents another definition, "Inventory optimization is an emerging practical approach to balancing investment and service-level goals over a very large assortment of SKUs (Stock Keeping Units)". Inventory Optimization not only provides greater and much faster benefits but is also a powerful way of spotting the residual inefficiencies so that continuous improvement process can be driven effectively.

Buffet, [5] suggests that the better strategy for keeping optimized inventory may be by delaying ordering to the last moment. A realistic estimate of the optimal quantity is critical since an inventory shortage may result in lost sales while excessive inventory will lead to more cost.

Rügge, [6] quotes economic scientist who have estimated and validated a realistic inventory reduction by 15-25% by applying modern inventory management techniques. He suggests three steps for achieving inventory management excellence:

Firstly companies should create awareness on the potential which emerges from the application about the modern inventory management approaches in order to improve the current performance. Secondly, obsolete procedures must be replaced with optimized replenishment concepts. The third step is to ensure the inventory availability through execution of a proactive and dynamic inventory planning to avoid shortage. These steps are also depicted in Fig. 1.

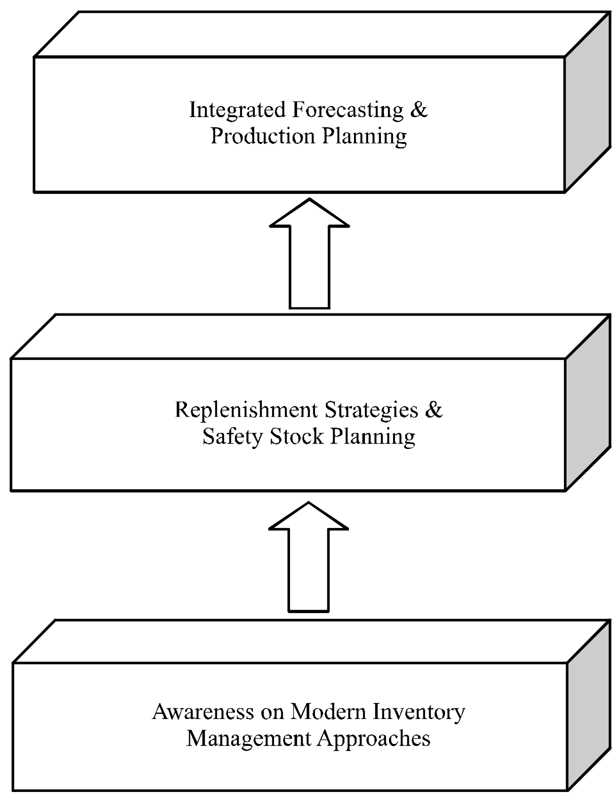

FIG. 1. STEPS TOWARDS INVENTORY MANAGEMENT EXCELLENCE

i2 professionals [7] emphasize organizations to integrate their systems, processes, techniques and services across inventory functions. Inventory policies should have ability to rapidly respond to demand fluctuation and supply changes.

According to Lewin, [8] manufacturing organization's capital investment pertains to 35-45% inventory. Economizing this investment without affecting service levels, provides management increasing return and freeing working capital for research and development.

2.2 Role of Inventory Optimization in SCM

Sharma, et. al. [9] have pointed out that for optimal benefits, integrated supply chain require integration of procurement, production and distribution, segments of SCM.

Williams, [10] is of the opinion that inventory optimization is about viewing inventory as an asset and maximizing the returns on that asset. The cost effective inventory level for each product is achieved when the payback from the associated increased service level cost is lesser than product holding cost.

Scheuffele, et. al. [11] defines inventory optimization as the application of latest techniques and technologies for the improvement of inventory visibility, control and management across an extended supply networks. He outlines rigorous and discrete analysis of inventory performance to identify product specific changes to inventory stocking and replenishment policies; to identify the supply network configuration, or to correlate inventory investment to revenue or profit generation.

Bursa, [12] explains inventory optimization as a mature supply chain discipline that saves tremendous working capital by reducing inventory and without negatively affecting service levels.

Benton, [13] identifies optimizing supply chain management optimizing the information flow across the chain as well as inventory in the supply chain to meet customer satisfaction.

Industry Directions Inc [14] claims that inventory optimization can provide both an enormous initial performance improvement for the supply chain and ongoing continuous improvement. In the present era, inventory optimization tool accounts for uncertainty and delivers a modeling capability to cope up with changes.

James, et. al. [15] highlight the importance of inventory in manufacturing business, as a single largest asset on the balance sheet. Inventory accounts for nearly 30% of the current assets of the manufacturing companies and 40-50% of the current assets in wholesaling and retailing industries. The categories of inventory are classified as:

(i) *Raw Material:* Components, sub assemblies or material that have been purchased and or waiting to be placed into production.

(ii) *Work in Process:* Parts or products in various stages of completion throughout the manufacturing operations including raw material that has been released for initial processing and partially processed units that have had labor and overhead added and are being stored for use at a later time.

(iii) *Finished Goods:* Completed goods that are being held for sale to customers.

(iv) *Maintenance Parts and Supplies:* Components used to maintain or repair processing equipment.

Persson, [16] states a total approach to all those activities involved in physically moving raw material, WIP inventory and finished goods inventory from point of origin to point of use or consumption. Firms are now realizing the potential for joint cost savings by working closely with suppliers and customers on improving the supply chain.

According to Teigen, [17] common pitfalls in inventory management are caused by no supply chain matrices, inefficient information systems and organizational barriers.

As indicated by Dolores, et. al. [18] the main decisions required for functioning of a manufacturing set up are, the production sites and quantities, the assignment of customers to facilities and the location and size of inventories.

2.3 Concept of Inventory Optimization

The balance between low inventory and high service level is the key point to supply chain success. With the combination of inventory policies and service level targets, there is theoretical curve where inventory is efficient enough in generating revenue and high service level. This is termed as Inventory Optimized Frontier depicted in Fig. 2. To reach the optimized frontier, safety stock level must be put right for each SKU in each location.

3. MATERIALS AND METHOD: CASE STUDY

3.1 Optimized Safety Stock Schemata

The newly developed concepts on inventory optimization were applied in a Pump Manufacturing Industry. The industry has remarkably improved its stock management and replenishment with optimized inventory management system. The schemata applied is to reduce the stocks by optimizing its safety stock levels. The optimizing factors have been selected randomly after giving due consideration to the manufacturing environment. The schemata is worked out in Table 1 and explained as:

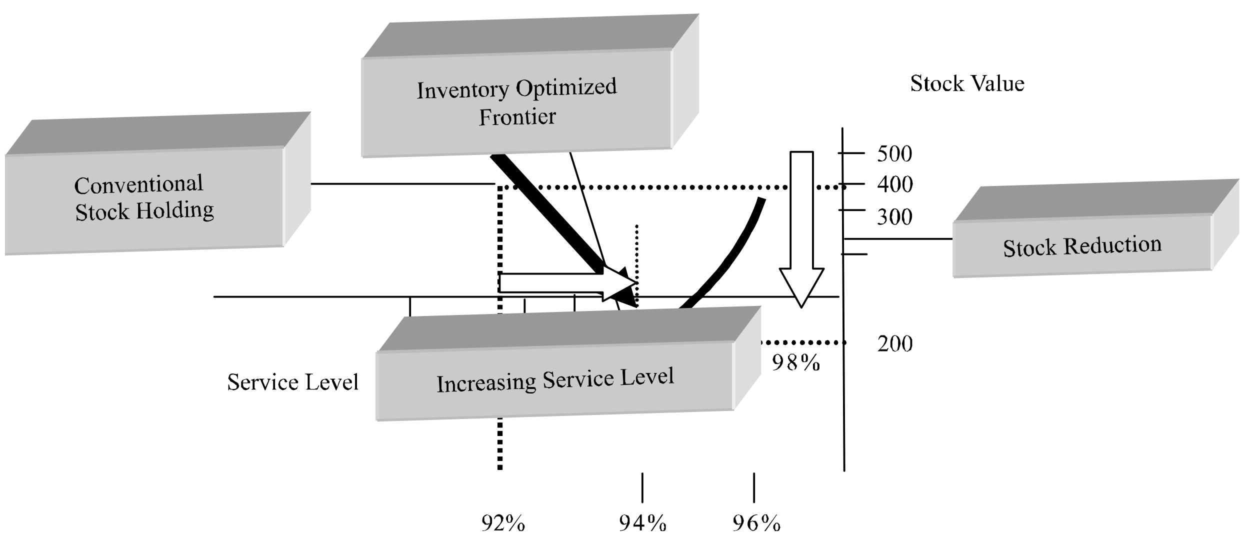

FIG. 2. CONCEPT OF INVENTORY OPTIMIZATION

TABLE 1. OPTIMIZATION SAFETY STOCK FACTORS

Description	Criteria	Optimizing Factors
Cost Factor		
Low Cost	1-500PKR	1.0
	501-1000PKR	0.9
	1001-3500PKR	0.8
High Cost	Greater Than 3500PKR	0.7
Common or Exclusive Factor		
Common	Common for more than 20 Products	1.0
	Common for 11 to 20 Products	0.9
	Common for 01 to 10 Products	0.8
Exclusive	Exclusive for Specific Product	0.7
Lead Time Factor		
Long Lead Time	3 to 4 Months	1.0
	2 to 3 Months	0.9
	01 to 2 Months	0.8
Short lead time	Within 01 Month	0.7
Historical Trend Factor		
Long History	Consistent trend for last 3 years	1.0
	Consistent trend for last 2 years	0.9
	Consistent trend for last 1 year	0.8
Short History	Consistent trend for last 06 Months	0.7
Number of Sales Point		
Continuous	100 to 80 % sale points	1.0
	80 to 71% sale points	0.9
	70 to 61 % sale points	0.8
Erratic	Less than 60 % sale points	0.7
Freight Cost Factor		
High Freight	Air freight 3 times higher than sea	1.0
	Air freight 2.5 times higher than sea	0.9
	Air freight 1.5 times higher than sea	0.8
Low Freight	Air freight comparable to sea	0.7
Bulky Factor		
Small Volume	Less than 1 cubic ft	1.0
	Greater than 1 and less than 1.5 cubic ft	0.9
	Greater than 1.5 and less than 2 cubic ft	0.8
Big Volume	Greater than 2 cubic ft	0.7

- *Cost Factor:* In order to ensure minimum amount of capital tied up in the inventory, items have been categorized from low cost to high cost with associated optimizing factors from 1.0 to 0.7 respectively.

- *Common or Exclusive Factor:* The parts and components required for assembling a product have also been categorized as common (applicable to most of the products) and exclusive (applicable to only a single product). Common and exclusive factors have been given the values from 1.0 to 0.7 respectively.

- *Lead Time Factor:* Lead time for various parts used in the assembling of products varies from 3-4 months to 1-3 weeks. Accordingly long lead time and short lead time have been divided into four shades i.e. from 1.0 to 0.7 respectively.

- *Historical Trend Factor:* The items of inventory which are consistently utilized have been grouped as long history (consistent for last 3 years) and no history (having activity for last 6 months only) have been assigned the factors from 1.0 to 0.7 respectively.

- *No of Sales Point:* The disposal of finished goods at sales points throughout the country has been analyzed. Continuous (100-81% sales points) and Erratic (less than 50% sales points) have been assigned factors from 1.0 to 0.7 respectively.

- *Freight Cost Factor:* There is a marked difference in freight cost of the inventory procured as compared to shipment by sea. High freight and low freight costs have been assigned factors from 1.0 to 0.7 respectively.

- *Bulky Factor:* In order to economize the storage capacity, small volume and big volume items have been characterized with correction factors from 1.0 to 0.7 respectively.

3.2 Safety Stock Calculation

The above optimizing factors have been utilized to calculate the optimized safety stocks as shown in Table 2.

3.3 Calculation of ROL and ROQ

ROL (Re-Order Level) and ROQ (Re-Order Quantity) for the existing model and optimized model have been reduced from 237-200 pieces and 75-60 pieces respectively as shown in Table 3.

TABLE 2. SAFETY STOCK CALCULATION

Average Sales per Month	Consumption Per Unit	Optimizing Factors							Safety Stock
		Cost	Common or Exclusive	Historical Trend	No. of Sales Point	Lead Time	Freight	Bulky	Optimized =a×b×c×d×e×f×g×h×i
a	b	c	d	e	f	g	h	i	j
50	1	1	1	1	1	1	1	1	50.0
50	1	0.9	1	1	1	1	1	1	45.0
50	1	0.8	1	1	1	1	1	1	40.0
50	1	0.7	1	1	0.8	1	1	1	28.0
50	1	0.7	1	1	1	1	1	0.8	28.0
50	1	0.7	1	1	1	1	1	0.8	28.0

4. RESULTS AND DISCUSSION

4.1 Inventory Movement

Based on current and optimized values of ROL and ROQ, Inventory movement during each month of the year and associated value of stock for existing model and optimized model has been depicted in Tables 4-5 respectively. The difference in the stock value of current and optimized value of ROL and ROQ in respective months is from 47000-17000 PKR.

4.2 Inventory Movement at Start of the Month

Inventory stocks for existing and optimized safety stock at the start of the month have been depicted in Fig. 3. The pattern shows considerable reduction in inventory stock.

TABLE 3. CALCULATION OF ROL AND ROQ

Inventory Data	
Average Consumption Per Month	50 pc
Lead Time	103 Days (3.4 Months)
Price	PKR 1000 Per pc
Existing Model	
Safety Stock	40 pc
Average Consumption Per Day: 50/26	1.92 per day
ROL= (Average Consumptions/Day x Lead Time Days + Safety Stock)	(1.92x103)+40=237 pc
ROQ = (Average Consumptions/Month x 1.5)	50x1.5=75 pc
Optimized Model	
Corrected Safety Stock	30 pc
Lead Time Demand = (Average Consumption/Month x	
Lead Time Months)	50x3.4=170 pc
ROL = (Lead Time Demand + Safety Stock)	170+30=200 pc
ROQ = (Safety Stock x 2)	30x2=60pc

TABLE 4 . INVENTORY MOVEMENT - EXISTING MODEL

Description	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Order	75		75	75		75	75		75		75	
Arrival				75		75	75		75	75		75
Opening Balance	237	187	137	87	112	62	87	112	62	87	112	62
Total Stock	237	187	137	162	112	137	162	112	137	162	112	137
Month Required	50	50	50	50	50	50	50	50	50	50	50	50
Balance	187	137	87	112	62	87	112	62	87	112	62	87
Value of Balance	187000	137000	87000	112000	62000	87000	112000	62000	87000	112000	62000	87000
Stock Month After Consumption	3.7	2.7	1.7	2.2	1.2	1.7	2.2	1.2	1.7	2.2	1.2	1.7
Value of Stock-A	237,000	187,000	137,000	162,00	112,000	137,000	162,000	112,000	137,000	162,000	112,000	137,000

The effect of stock reduction is more significant in 1st, 7th and 12th months.

4.3 Inventory Movement at End of the Month

Inventory stock for existing and optimized safety stock at the end of the month have been depicted in Fig. 4. The pattern shows considerable reduction in inventory stock. The effect of inventory stock reduction is more prominent in 1st, 7th, 10th and 12th months.

4.4 Inventory Value at the Start of the Month

Inventory stock values for the current and optimized safety stock at the start of the month have been plotted in Fig. 5. The trend shows considerable decrease in inventory stock value for the optimized inventory model. The graph for the optimized model is depicting much lower inventory stock values.

4.5 Inventory Value at the End of the Month

Inventory stock values for the current and optimized safety stock at the end of the month have been plotted in Fig. 6.

TABLE 5. INVENTORY MOVEMENT - OPTIMIZED MODEL

Description	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Order	60		60	60	60	60	60	-	60	60		60
Arrival				60		60	60	60	60	60		60
Opening Balance	200	170	120	70	80	30	40	50	60	70	80	30
Total Stock	200	170	120	130	80	90	100	110	120	130	80	90
Month Reqquired	50	50	50	50	50	50	50	50	50	50	50	50
Balance	150	120	70	80	30	40	50	60	70	80	30	40
Value of Balance	150000	120000	70000	80000	30000	40000	50000	60000	70000	80000	30000	40000
Stock Month After Consumption	3.4	2.4	1.4	1.6	0.6	0.8	1.0	1.2	1.4	1.6	0.6	0.8
Value of Stock-B	200,000	170,000	120,000	130,000	80,000	90,000	100,000	110,000	120,000	130,000	80,000	90,000
Difference (A-B)	37,000	17,000	17,000	32,000	32,000	47,000	62,000	2,000	17,000	32,000	32,000	47,000

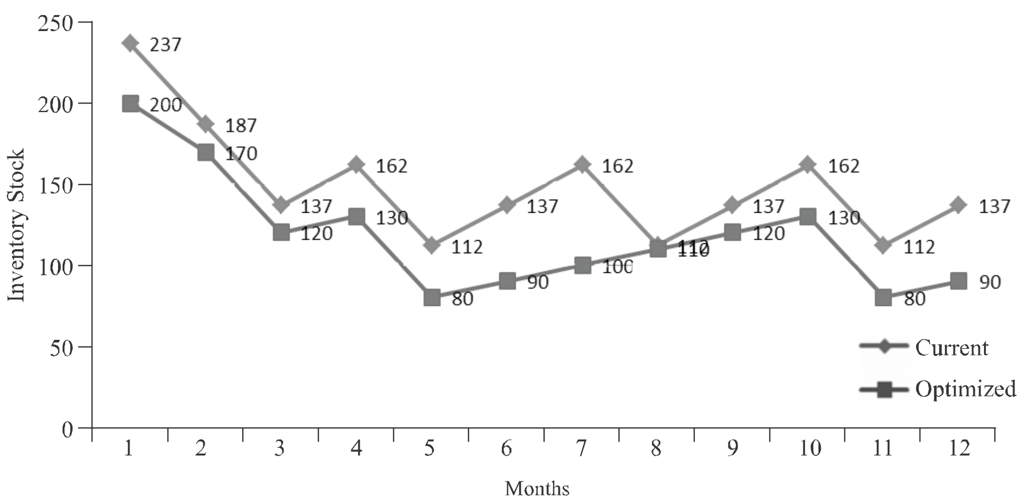

FIG. 3. INVENTORY MOVEMENT AT START OF THE MONTH

The trend shows considerable decrease in inventory stock value for the optimized inventory model. The inventory stock value at the end of the month is relatively more significant as compared to those at start of the month.

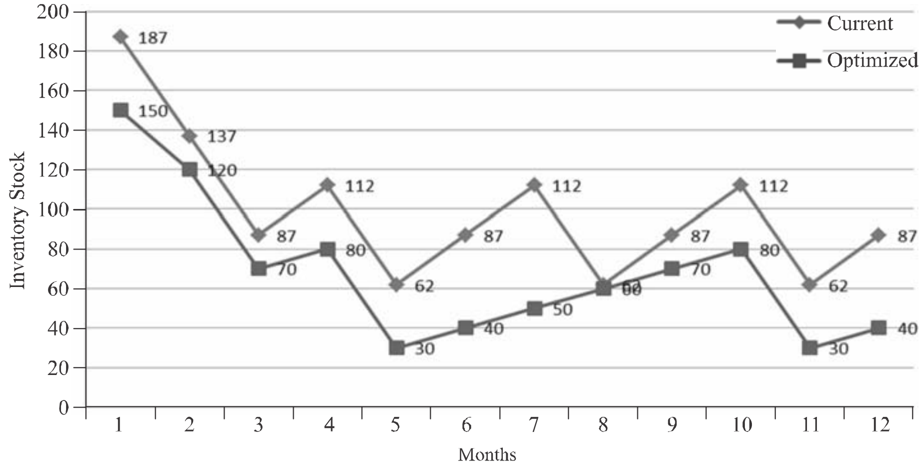

FIG. 4. INVENTORY MOVEMENT AT END OF THE MONTH

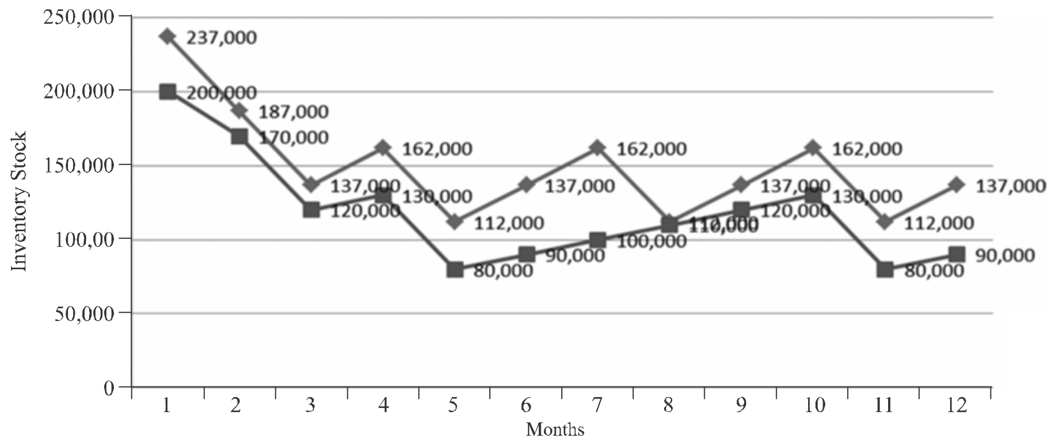

FIG. 5. INVENTORY VALUE AT START OF THE MONTH

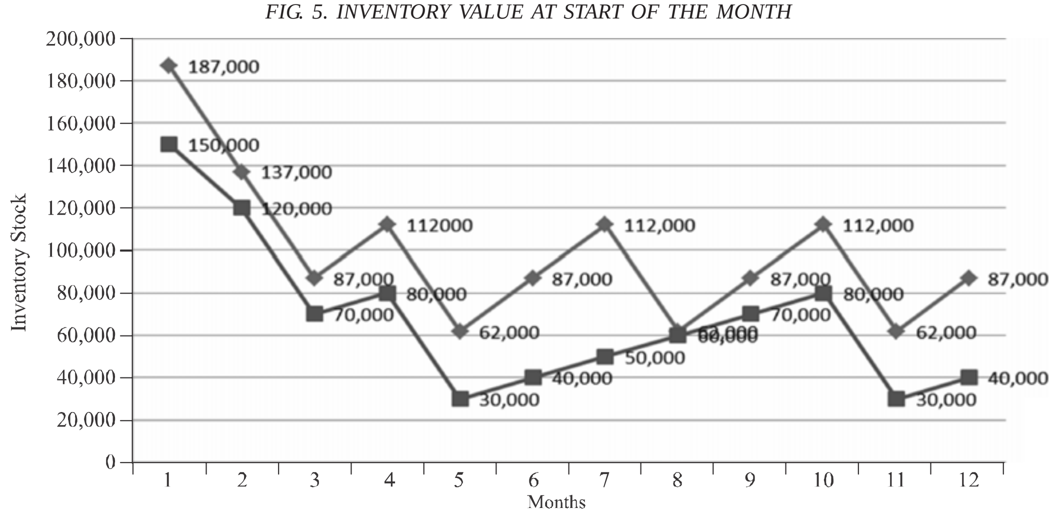

FIG. 6. INVENTORY VALUE AT END OF THE MONTH

5. BENEFITS OF OPTIMIZED SAFETY STOCK SCHEMATA

- Lesser financial exposure for the inventory.
- Cash flow available for modernization of the production facilities.
- Lower inventory levels facilitate tracking of quality issues and root causes.
- Optimized inventory levels will result in smooth and better inventory management at stores.
- Reduced risk for inventory obsolescence.
- The ultimate benefit will be in the form of getting the right things in the right quantities at the right moments at minimal cost as illustrated in Fig. 7. This will facilitate the important ingredients of flexibility, delivery, reliability for optimized inventory levels.

6. CONCLUSION

Inventory Optimization is one of the true indicators about organization's ability to understand the relevant scientific tools and its willingness to adopt these tools. The potential benefits accruing from application of these tools override the cost of innovation. The immense amount released from savings in organization's working capital is incentive for Inventory Optimization. The paper recommends unconventional techniques for inventory optimization. These inventory techniques were applied in live manufacturing environment and resultantly, its impact was noted. The objective of the research was to minimize the working capital in a pump manufacturing industry tide up in the form of inventories. Optimized safety stock levels have been reduced from 75-60 by applying the optimized safety stock factors. Considerable advantage in terms of saving in inventory were observed without sacrificing the customer satisfaction level, rather the lean inventories offered other associated advantages like reduced stock keeping cost, lean operating costs, etc.

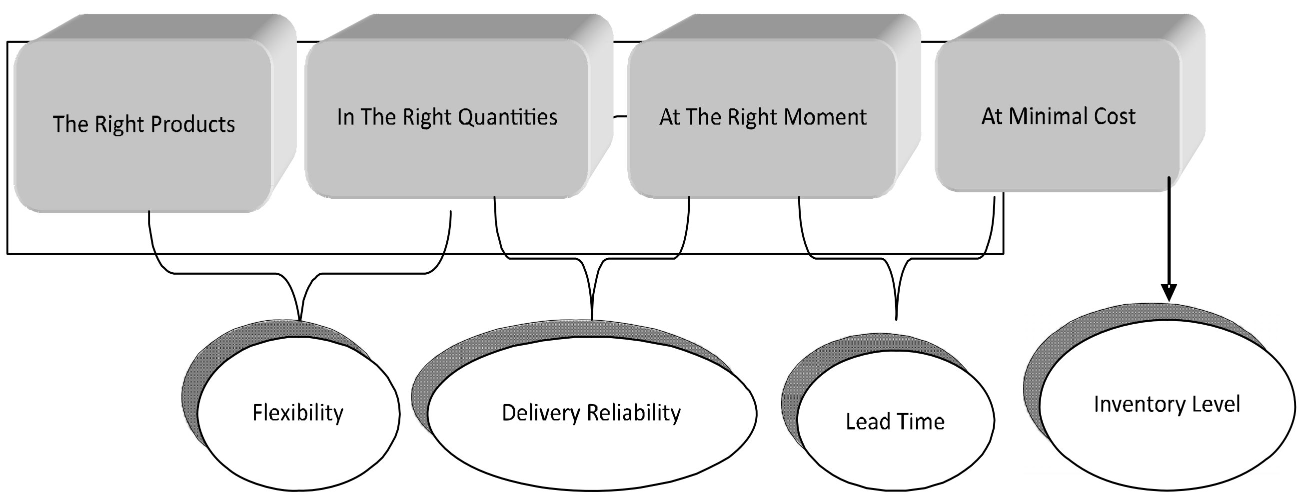

FIG. 7. BENEFITS OF OPTIMIZED SAFETY STOCK SCHEMATA

7. RECOMMENDATIONS

Careful monitoring and regular analysis of the achieved benefits will be subjected to continuous improvement cycle as shown in Fig. 8. The review cycle will help in better coordination between production, procurement and marketing departments for achieving further benefits of inventory optimization.

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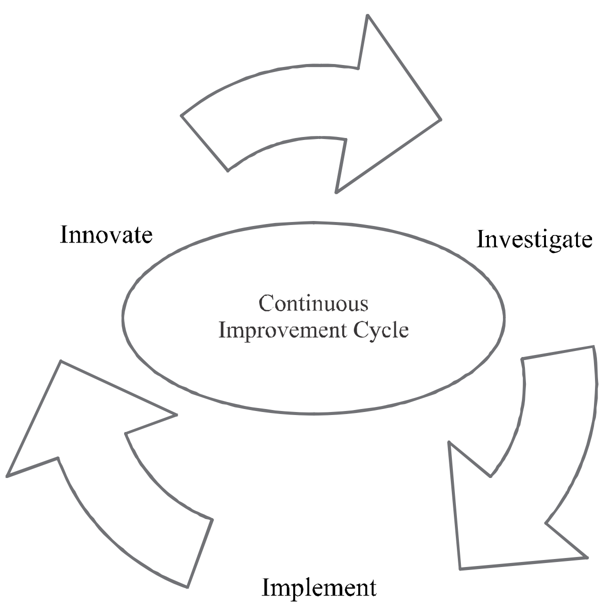

FIG. 8. CONTINUOUS IMPROVEMENT CYCLE

REFERENCES

[1] Beth, E., "Supply Chain Strategies Bench Mark Report, How Inventory Misconception And Inertia Damaging Companies, Service Levels and Financial Results", Aberdeen's Group Inc. Boston, Massachusetts, USA, December, 2004.

[2] Micron Inventory Management Ltd, "The Principles & Concepts of Inventory Optimization", University of Warwick Science Park, Coventry CV47E2, UK, December, 2004. www.micronim.co.uk

[3] IBS (International Business Systems), "Inventory Optimization can Increase Your Profitability", pp. 2 October, 2007 www.ibs.net.

[4] Eugenio, C., "Recent Trends in Inventory Optimization", Tools Group, pp. 3, UK, February, 2004.

[5] Buffet, S., "A Markov Model for Inventory Level Optimization in Supply Chain Management", 18th Canadian Conference on Artificial Intelligence, pp. 133-144, Victoria British Columbia, Canada, May, 2005.

[6] Stefen, R., "Advanced Inventory Management-The Path to Inventory Management Excellence", pp.2-3, Zeichen Inclusive Leerzeichen, February, 2008.

[7] i2 Total Inventory Management, "The Supply Chain Results Company", pp. 1, Dallas, Texas, USA, 2008 www.i2.com.

[8] Steve, S., "Inventory Planning and Optimization: Extending the Enterprise through the Supply Chain", pp. 4, Sourcetrix Corporation, USA, May, 2009.

[9] Dinesh, K.S., "Role of Supply Chain Management Decision in Effective Inventory Control", Journal of Academy of Business and Economics, Virginia State University, Petersburg, pp. 1, Virginia, March, 2004.

[10] Trevor, W., "Could Inventory Optimization be the Next Big Cost Cutting Move for the Logistic Industry?", pp. 3, Kelmic Consulting Inc, Canada, 2004.

[11] Greg, S., and Anupam, K., "Inventory Optimization: A Necessity Turning To Urgency", SET Labs Briefing, Volume 5, No, 3, pp. 1, September, 2007.

[12] Bursa, L.K., "What Do We Mean by Inventory Optimization", Vice President of Marketing Logility, pp. 2, December, 2011.

[13] Benton, C.W., "Inventory Chain Optimization: The Next Dimension of Supply Chain Management", GAIN Systems, pp. 126, Napervile, IL USA, May, 2009, http://benton.ascet.com.

[14] Industry Directions Inc., "Inventory Optimization: Improving Supply Chain Performance in an Uncertain World", pp. 12, USA, 2006, www.industrydirection.com.

[15] James, F.R., and Robert, L.D., "Managing Inventories: What is the Appropriate Order Quantity?", University of Virginia, Darden School Foundation, pp. 1-2, Charlottesville VA, 2001.

[16] Ulrika, P., "A Conceptual and Empirical Examination of the Management Concept Supply Chain Management", Licentiate Thesis, pp. 3, Lulea University of Technology, Sweden, September, 1997.

[17] Rune, T., "Supply Chain Management", Diploma Thesis, Enterprise Integration Laboratories, pp. 72, University of Toronto, May, 1997.

[18] Morales, M.D.R., "Optimization Problems in Supply Chain Management", pp. 259, Erasmus University Rotterdam, Netherlands, October, 2000.