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Analysis of Inventory of an Automobile Dealer using Genetic Algorithm

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Abstract

Customer must continue to be satisfied & planners do not want to risk losing business because of a lack of or insufficient inventory. Within this challenging & delicate balance environment manufactures must, more than ever leverage advanced and proven technology to provide better, taster & more informed decision regarding inventory deployment. Inventory management is considered to be an important field in supply chain management (SCM). The supply chain is the best way of inventory mamagement, hence maintain lower cost of supply chain will enhance the services provided to the customers. To maintain lower cost of supply chain various factors are responsible . One of them is Inventory, so in this work we tried to optimized inventory level of an organization by using genetic algorithms in MATLAB7.6 on data obtained from a leading automobile dealer.

Keywords: MATLAB7.6, Genetic Algorithm (GA), Inventory management, Supply Chain Management (SCM)

Introduction

Customer must continue to be satisfied & planners do not want to risk losing business because of a lack of or insufficient inventory. Within this challenging & delicate balance environment manufactures must, more than ever leverage advanced and proven technology to provide better, taster & more informed decision regarding inventory deployment.

In most simplistic way the overall management of any supply chain requires the ability to manage three constantly changing variable, customer service needs, overall capacity & inventory. Inventory management remains a fundamental leg to this three legged stool.

Inventory management is considered to be an important field in supply chain management (SCM). The supply chain is considered as better option for management of inventory, service provided to the customer ultimately gets enhanced hence to ensure cost of supply chain should be minimum for minimizing supply chain cost for achieving this so many factors are responsible. One of them is Inventory so in this project we tried to optimized inventory level of an organization by using genetic algorithms in MATLAB7.6. In this paper we have take case study of leading brand of Automobile dear at Indore (INDIA) City. They were facing problem in inventory optimization because company has change policy at dealer level. The dealer cannot sales spare parts of vehicle in open market i.e. for counter sell of spare parts for customer they appointed separate dealer for the open market customer. Due to this dealer was trying to optimize the inventory level.

Inventory is the stock of any items or resource used in an organization Council of Logistics Management Consortium (1997). The objective of inventory management has to keep enough inventories to meet customer demand and also be cost effective. However, inventory has not always been provided as an area to control cost. There were fewer compititors and products are in a generally sheltered market environment, therefore companies have maintained “generours” inventory levels to meet long-term customer demand. Inventory is also defined as a list of movable goods which help directly in the production good for sale inventory is a service to production .it is just a short of investment in the form of raw materials like Tools, Gauges, supplies etc. Inventory may also be defined as a comprehensive list of movable item which are required for manufacturing the product and to maintain the plant facility in a working conditions.

In the United States the average cost of manufacturing goods inventory is approximately 30% of the total value of the inventory . The high cost of inventory has motivated companies to focus on efficient supply chain management & analytic management. Therefore the companies believe that reducing uncertainity at various points along the supply chain can reduce the inventory significantly.

Inventory optimization application organizes the latest techniques and technologies, thereby assisting the enhancement of inventory control and its management across an extended supply network. Some of the design objectives of inventory optimization are to optimize

inventory strategies, thereby enhancing customer service, reducing lead times and costs and meeting market demand Air material inventory optimization model based on genetic algorithm Liu, et al. (2000).
The design and management of the storage policies and procedures for raw materials, work-in-process inventories and typically, final products Supply chain design and analysis: Beamon, et al. (1998). Models and methods are illustrated by the inventory control. The costs and lead times can be reduced and the responsiveness to the changing customer demands can be significantly improved and subsequently inventory can be optimized by the effective handling of the supply chain A Taxonomic Review of Supply Chain. Ganeshan et al.(1999). The estimation of the exact amount of inventory at each point in the supply chain free of excesses and shortages are the main concerns of the inventory & supply chain managers, although the total supply chain cost is minimized.. Owing to the fact that shortage of inventory yields to lost sales, whereas excess of inventory may result in pointless storage costs, the precise estimation of optimal inventory is indispensable an algorithm for procurement in supply chain management Buffett et al. (2004).

In other words, there is a cost involved in manufacturing any product in the factory as well as in holding any product in the distribution center and agent shop. More the products manufactured or held, higher will be the holding cost. Meanwhile, there is a possibility for the shortage of products. For the shortage of each product there will be a shortage cost. Holding excess stock levels as well as the occurrence of shortage for products lead to the increase in the supply chain cost. This study supplements the previous study that focuses only on a single product Inventory optimization in supply chain management using genetic algorithm Radhakrishnan et al. (2009). In this study, we are considering the position of multiple goods and multiple constituents of the provide string of links. Therefore the complexity of the difficulty has been increased. We have developed a novel and effective approach utilizing Genetic Algorithm to solve this complexity . In alignment to minimize the total supplied string of links cost, the proposed approach apparently works out the most probable surplus supply grade and lack grade that is required for inventory optimization in the provide string of links . In practice, the dynamic environment of the surplus stock grade and lack grade over all the time span is the usual difficulty happening in inventory management . The determination of the stock grade that occurs at a maximum rate is the crucial operation to be presented. Thus, the maximum occurrences of supply grade should be advised in alignment to optimize competently . The employed fitness function of the genetic algorithm is formulated in such a way that it will address the past time span to determine the essential supply grade. The proposed approach of genetic algorithm forecasts the optimum stock grades of the future by contemplating the supply grades of the past years such that the total supply chain cost will be sustained at a small.

Related Work

The entrepreneurs of the 21st century in the changing business conditions are confronting issue ranging from globalization, economic uncertainty to new technologies and increasing consumer demands. The decision making of entrepreneurs becomes more difficult as business environment of manufacturing firms is getting complex. The supply chain become more complex in the manufacturing companies with the threats that often occurred in the way of profitability & higher shareholder value such as long order-to delivery lead times, unreliable production schedules, excess inventory across the supply chain, lengthy demand planning cycles and lack of visibility of supplier.Therefore in today's competitive and challenging environment, the supply chain has become the potential source of competitive advantage and popular tool for improving the organizational competitiveness and innovation that combines distinctive competencies in a firm's supply chain. The companies are their competitive advantage maintaining by developing their capabilities to apply supply chain effectively for the acceptance of innovations. The innovations within supply chain related with the level of bonding made with the suppliers to build more valuable ways to serve either existing or new market, whether by employing existing knowledge or by creating new knowledge. We have proposed a strategic perfective to capture the substantial management capabilities of strategic supply chain innovation. This paper examines the framework how the supply chain management innovation concept directs entrepreneurs to tackle product competitiveness generic supply chain challenges & prospects and to respond to changing consumer demand Amit Mittal (2011).

A fresh Genetic Algorithm (GA) approach for the Integrated Inventory Distribution Problem (IIDP) has been projected by Abdel *et al.* (2006). They have developed a genetic representation and have utilized a randomized version of a formerly developed construction heuristic in order to produce the initial random population. Pupong *et al.*(1999) have put forth an optimization tool that works on basis of a Multi-matrix Real-coded Generic Algorithm (MRGA) and aids in reduction of total costs associated with in supply chain logistics. They have not only incorporated procedures that ensures feasible solutions such as the chromosome

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initialization procedure, crossover and mutation operations but also evaluated the algorithm with the aid of three sizes of benchmarking dataset of logistic chain network that are conventionally faced by mostglobal manufacturing. A technique to utilize in supply-chain management that supports the decision-making process for purchases of direct goods has been projected by Buffett, et al. (2004). The projection for future prices, demand and the quotes that optimize the level of inventory each day have been the basis of RFQs construction.. The problem was represented as a Markov Decision Process (MDP) that allows for the calculation of the utility of actions to be based on the utilities of substantial future states. The optimal quote requests and accepts at each state in the MDP. It were determined with the help of Dynamic programming. A supply chain management agent comprising of predictive, optimizing and adaptive components called the TacTex-06 has been put forth by Pardoe, et al. (2007). TacTex-06 functions by making predictions regarding the future of the economy, such as the prices that will be preferred by component suppliers and the degree of customer demand and then strategizing its future actions so as to ensure maximum profit. Beamon *et al*. (1998) have presented a study on evaluations of the performance measures employed in supply chain models and have also displayed a framework for the beneficial selection of performance measurement systems for manufacturing supply chains. In any supply chain performance measurement system, there are three kinds of performance measures have been recognized ad mandatory constituents. New flexibility measures have also been created for the supply chains. The accomplishment of beam-ACO in supply-chain management has been proposed by Caldeira, et al. (2007). To optimize the supplying and logistic agents of a supply chain, Beam-ACO has been used to optimization of the distributed system has assisted by a standard ACO algorithm. The local & global results of the supply chain has increased with the help of Beam-ACO.A beneficial industry case applying Genetic Algorithms (GA) has been proposed by Wang et al. (2008).In this case the total cost of a multiple sourcing supply chain system optimized with the aid of Gas. The system has been evinced by a multiple sourcing model with stochastic demand. A mathematical model has been implemented to portray the stochastic inventory with the many to many demand and transportation parameters as well as price uncertainty factors A genetic algorithm which has been approved by Lo, C.Y., (2008) deals with the production-inventory problem with backlog in the real situations, with time-varied demand and imperfect production due to the defects in production disruption with exponential distribution. In addition to optimizing the number of production cycles to generate a (R,Q) inventory policy,the total inventory cost can be minimized on the basis of reproduction interval searching in a given time horizon with the aid of an aggregative production plan. Yaman, B.*et al*. (1996) have developed a System Dynamics simulation model of a typical retail supply chain. Their simulation exercise suggested to build up inventory policies that raise the retailer's revenue and reduce costs at the same instant. Besides, the research was also aimed towards reckoning the implications of different diversification strategies. Lee *et al*. (1995). Have introduced a supply chain model working under periodic review base-stock inventory system to assist the manufacturing managers at HP to superwise or to control material in their supply chains. The search routine assisted in obtaining the invtorylevels across supply chain members.

Genetic Algorithm:

GA was 1st presented systematically by Holland the basic ideas of analysis & design based on the concepts of biological evolution can be found in the work of Rechenberg [1970]. Philosophically GA is based on drawing theory of survival of the fittest Singiresu S. Rao (1996).

The basic purpose of genetic algorithms (GAs) is optimization. Since optimization problems arise frequently, this makes GAs quite useful for a great variety of tasks. We have confronted(faced) the problem as occurred in all optimization problems, that of maximizing/minimizing an objective function f(x) over a given space X of arbitrary dimension. A brute force which consist in examining every possible x in X in order to determine the element for which f is optimal is clearly infeasible. GAs provides a Socratic way of searching the input space for optimal x that approximates brute force without enumerating all the elements and therefore bypasses performance issues specific to exhaustive search.

MATLAB

MATLAB is a effective language for computation of technical problems. It assimilates computation, visualization, and programming in an incomplicated or user friendly environment where problems and solutions are expressed in familiar(stated) in easy to understand mathematical notation. Typical uses include:

- Math and computation
- Algorithm development
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics

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- Application development, including Graphical User Interface building.

MATLAB is an user friendly system in which basic data element is an array that does not require dimensioning. It enables in solving many problems released to technical computing, especially those with matrix and vector formulations, in a possible time to write a program in a scalar no interactive language such as C or FORTRAN. The MATLAB refers to matrix laboratory. It was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects, which together represent the up-to-date software for matrix computation. MATLAB has emerged significantly with input from many users. It has become important tool has the standard instructional tool for various courses in mathematics, engineering, and science. Similarly, industry has also adopted it as a tool for high-productivity research, development and for analysis purposes. MATLAB provides one of the most important tool is toolboxes. Toolboxes are allows users to learn and apply specialized technology. Toolboxes are broad collections of MATLAB function also called as M-files that are responsible for MATLAB environment to solve particular classes of problems. Signal processing, control systems, neural networks, genetic algorithm, fuzzy logic, wavelets, simulation, and many others are the fields in which toolboxes are available.

Methodology Adopted

- **Step1--** Tabulating spare parts as parts as per VED AND FMS analyses .In this case study is done for an automobile dealer.
- **Step 2** – In this case study time based inventory system is used so, forecasting of parts for inventory is done by writing an algorithm.
- **Step 3 –** To optimize inventory written algorithm is solved by GA in MATLAB 7.6.

Classification of parts as per price range

There are almost 42000 parts in used in cars manufactured by TATA. For our convenient categorization of parts done as per Table no. 3.1 by this categorization verity of parts could be understand in better way. It could help for study.

Table 3.1 Categorization of parts

S.NO.	Price range	No. of parts
1	*1 to 500*	*24319*
2	*500 to 1000*	*4468*
3	*1000 to 1500*	*2416*
4	*1500 to 2000*	*1643*
5	*2000 to 2500*	*1224*
6	*2500 to 3000*	*902*
7	*3000 to 3500*	*720*
8	*3500 to 4000*	*655*
9	*4000 to 4500*	*522*
10	*4500 to 5000*	*442*
11	5000 to 5500	388
12	5500 to 6000	341
13	6000 to 6500	317
14	6500 to 7500	562
15	7500 to 8500	391
16	8500 to 9500	316
17	9500 to 10500	238
18	10500 to 15000	672
19	15000 to 20000	464
20	20000 to 30000	323
21	30000 to 50000	224
22	*50000 to 80000*	*109*
23	*80000 to 100000*	*98*
24	*100000 to 150000*	*115*
25	*150000 to 200000*	*184*
26	*200000 to 300000*	*164*
27	*300000 to 400000*	*13*
28	*400000 to 500000*	*2*
29	*500000 to 600000*	*2*
30	*600000 to 800000*	*4*
31	*800000 to 1200000*	*2*

Classification of parts as per VED& FMS

All the parts have been categorized as par their price range. To optimize inventory of preventive maintenance vehicles it is necessary to classify parts according to Vital, Essential, Desirable (VED) & Fast, Medium, Slow (FMS) criteria. Table 3.2 shows matrix of VED and FMS.

Table 3.2 FME- VED Matrix Classification

	V	E	D
F	FV	FE	FD
M	MV	ME	MD
S	SV	SE	SD

In the table 3.3 parts are classified for the preventive maintenance of vehicle. They are classified as per VED & FMS categorization. For example, Oil Filter is a changed in all the service of vehicle except the second free service. So it is fast moving part (as per consumption) and it is to be changed in all the preventive services (Except second free service), because a choked filter may damage engine so it cannot be reused as per the norms of the TATA, and hence it is vital part also.

Table 3.3 Classification of parts as per VED & FMS

S.NO.	Name of Part	Classification
1	Oil Filter	F/V
2	Spark Plug	F/V
3	Fuel Filter	F/E
4	Air Filter	F/E
5	Brake Pad	F/V
6	Coolant	F/E
7	Brake Oil	F/V
8	Suspension Arm	F/D
9	Bushing	F/E
10	Ball Joints	M/E
11	Shock Up Buffer	M/D
12	Studs	M/D
13	Clutch Plate	M/V
14	Front Axle	M/D
15	Bearing(Wheel)	S/E
16	Point And Condenser	S/V
17	Fastener(Nut & Bolt)	F/V
18	Door Knob	S/V
19	Handel	S/V
20	Front Wind Shield	S/D
21	Rear Wind Shield	S/D
22	Fan Belt	S/V
23	Piston	S/D
24	Cylinder	S/D
25	Connecting Rod	S/V
26	Head Gasket	S/D
27	Half Engine	S/D
28	Bulb head light	F/V
29	Indicator	F/V
30	Brake Light	F/V
31	Fuse	F/V

Fixed time period Model –In a fixed time period modal system, recorders are placed at the time of review (T), and the safety stock that must be reordered is

q= d (T+L) + Z σ_{T+L} – I

q= Quantity to be ordered

T= the number of day between reviews

L= Lead time in days

d= Forecasting average daily demand

z= Number of standard deviation for a specific service probability

Z σ_{T+L} = Safety stock

σ_{T+L} =Standard deviation of demand over the review and lead time

I= Current inventory level (included items on order)

Algorithm of GA for this Case Study:

In this case study for spare parts following are the factors will be used during GA in MATLAB 7.6.

- Population size 20
- Number of generations 1,00
- Crossover type= Scattered
- Crossover rate of 0.6
- Mutation types= bit flip
- Mutation rate of 0.001

Data Analysis

"Analysis of data is a process of inspecting, cleaning, transforming, and modeling data with the goal of highlighting useful information, suggesting conclusions, and supporting decision making. Data analysis has multiple facets and approaches, encompassing diverse techniques under a variety of names, in different business, science, and social science domains." Alfonso sarminento (2011). In research, proper conclusion can only be achieved only when collected data are interpreted properly.The collected data must be arranged and tabulated into statistical form on the basis of responses (output) given by Genetic Algorithm. The collected data was then converted into tabular form, interpretation and analysis is done with the help of Genetic Algorithm in MATLAB in 7.6.In this research GA in MATLAB 7.6 is used for forecasting the demand. Here last three years consumption has been used as secondary data. Analysis has been done for selected parts only as par VED and FMS criteria.

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Analysis of Suspension arm

Table No. 4.1 Consumption of Suspension arm for Year 2009 to 2011

Month	Year		
	2009	2010	2011
January	58	70	68
February	59	69	69
March	58	65	71
April	62	69	75
May	58	63	82
June	62	65	81
July	64	63	73
August	62	68	62
September	68	63	81
October	71	62	88
November	76	67	86
December	73	71	83
Total	771	795	836

Figure 4.1 Shows consumption of suspension arm year wise. There is on fixed pattern in the consumption of ball joint for the year 2009 to 2011, so predicting the forecasting is very difficult. In august consumption is going down wards.

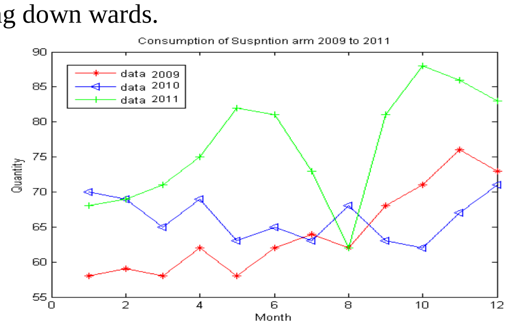

Figure 4.1 yearly Consumption pattern of Suspension arm.

Figure 4.2 shows consumption of suspension arm for the 36 months from 2009 to 2011. The pattern of this graph shows that demand of suspension arm is continuously increasing except some month. It is very necessary to maintain inventory of this part properly.

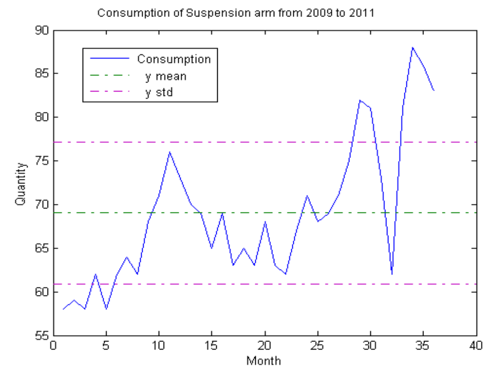

Figure 4.2 Consumption of Suspension arm for 36 months

Figure 4.3 showing forecasting curve as well as actual consumption of 36 months. Here green line shows actual consumption pattern and red line shows the Forecasting of Suspension arm. The forecasted curve is the result from Genetic Algorithm and MATLAB 7.6. This forecasting will help to keep optimum inventory level of service centre. In this study we considered fixed time period model. This forecasting will help to in deciding the order quantity for the particular period.

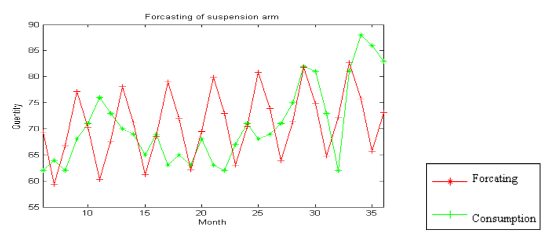

Figure 4.3 Forecasting of Suspension arm by GA.

In table 4.2 forecasting of suspension arm is done as per table in the month of April error is maximum i.e.29 and in December error is minimum i.e.19. In this part demand pattern is almost constant expect month of March & April. Life of suspension arm depends on the road condition on which car run that may be a one reason for uncertainty in demand. If suspension is damage little then also car can run so this part is kept in MD (Medium & Desirable). As per TATA preventive maintenance on 20000km or 18 month suspension should be replaced but as per the road condition this could vary.

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Table 4.2 Results of simulation calculation for Suspension Arm

S. No	Month/Year	Forecasting	Inventory $q = d(T+L) + Z_{\varsigma} - I$	Consumption	Error in forecasting and Consumption	Error in Inventory and Consumption
1	January	68.2181	69	70	2.5456	22
2	Feb	67.0415	68	69	2.8384	22
3	March	69.5039	70	65	6.9291	28
4	April	74.8508	75	69	8.4795	29
5	May	67.2993	68	63	6.8243	28
6	June	68.747	69	65	5.7647	27
7	July	65.4075	66	63	3.8214	26
8	August	68.8679	69	68	1.2763	24
9	Sep	67.9049	68	63	7.7856	28
10	Oct	61.5417	62	62	0.7392	23
11	Nov	63.2876	64	67	5.5408	20
12	Dec	66.5941	67	71	6.2055	19

Analysis of Clutch plate

Table No. 4.3 Consumption of Clutch Plate for Year 2009 to 2011

Month	Year		
	2009	2010	2011
January	91	98	105
February	89	97	103
March	92	98	106
April	84	96	101
May	86	98	106
June	82	95	109
July	78	93	115
August	92	96	102
September	96	104	106
October	99	103	108
November	102	105	115
December	105	101	112
Total	991	1083	1176

Figure 4.4 shows consumption of clutch plate year wise. There is no fixed pattern in the consumption of clutch plate for the year 2009 to 2011. It is clear from the graph that in the month of July consumption is decreasing in two years but in 2011 it is increasing to august consumption going down wards, and from august it starts increasing.

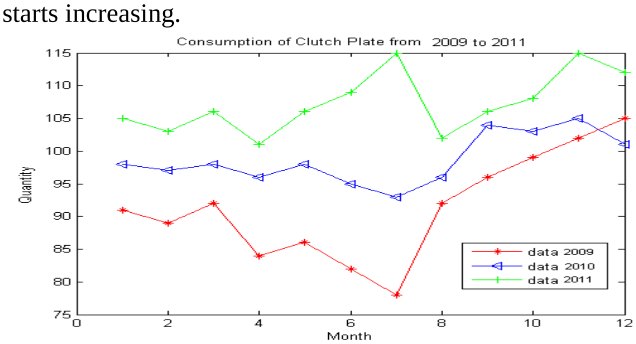

Figure 4.4 yearly Consumption pattern of Clutch Plate.

Figure 4.5 shows consumption of clutch plate for the 36 months from 2009 to 2011. The pattern of this graph shows that demand of clutch plate is continuously increasing. It is very necessary to maintain inventory of this part properly, if it is not done so, it will create worst condition in future.

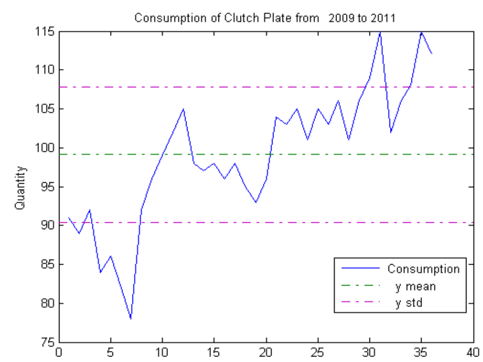

Figure 4.5 Consumption of Clutch Plate for 36 months

Figure 4.6 showing forecasting curve as well as actual consumption of 36 months. Here green line shows actual consumption pattern and red line shows the Forecasting of fuel filter. The forecasted curve is the result from Genetic Algorithm and MATLAB 7.6. This forecasting will help to keep optimum inventory level of service centre. In this study we considered fixed time period model. This forecasting will help to in deciding the order quantity for the particular period.

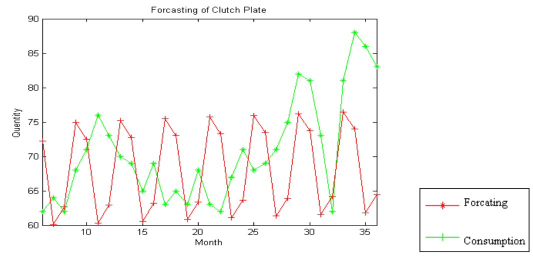

Figure 4.6 Forecasting of Clutch Plate by GA

In table 4.4 forecasting of clutch plate is done as per table. In the month of March error is maximum i.e.37 and in January error is minimum i.e.25. in this part demand pattern is not fixed. life of clutch plate depend on the driving condition and driver, so demand of clutch plate in not fixed but up to 20000km clutch plate should be changed. This part is kept in MV (Medium & Vital) category because frequency of demand of clutch is less and clutch not fails suddenly. As per TATA preventive maintenance is schedule on15000 km or 36month.

Table 4.4 Results of simulation calculation for Clutch Plate

S. No	Month/Year	Forecasting	Inventory $q = d\ (T+L) + Z_{\varsigma} - I$	Consumption	Error in forecasting and Consumption	Error in Inventory and Consumption
1	January	92.2721	123	98	5.8448	25
2	Feb	101.5834	132	97	4.7251	35
3	March	104.0827	135	98	6.2069	37
4	April	96.411	127	96	0.4281	31
5	May	98.0256	129	98	0.0261	31
6	June	95.4568	126	95	0.4808	31
7	July	96.2693	127	93	3.5153	34
8	August	95.6177	126	96	0.3982	30
9	Sep	98.0117	129	104	5.758	25
10	Oct	101.4342	132	103	1.5202	29
11	Nov	100.619	131	105	4.1724	26
12	Dec	98.5288	129	101	2.4467	28

Conclusion

The main aim of this research was to optimize inventory level of an automobile Service centre. The research was done by using Genetic Algorithm in MATLAB 7.6. Preventive maintenance vehicles are considered for this study in this study. By applying VED (vital, Essential, Desirable) and FMS (Fast, Medium, Slow) classification for categorizations for the parts only ten parts consider for the study. Last three year data i.e. 2009 to 2011 has been taken and try to optimize by genetic algorithm in MATLAB7.6. In this first predict the forecasting of the particular part and then try to maintain the inventory of this part.

In case of suspension arm error is maximum i.e.29 in month of April and in December error is minimum i.e.19. In this part demand pattern is almost constant expect month of March & April. Life of suspension arm depends on the road condition on which car run that may be a one reason for uncertainty in demand.

In case of clutch plate error is maximum i.e.37 in month of March and in January error is minimum i.e.25. The demand pattern of clutch plate is not fixed. life of clutch plate depend on the driving condition and driver, so demand of clutch plate in not fixed but up to 20000km clutch plate should be changed. This part is kept in MV (Medium & Vital) category

In this study one problem was very common that all the parts having a different consumption pattern in the same time period due to that forecasting of all parts having an error of 8 % to 15%. The proposed approach of inventory management has achieved the objectives which are the minimization of total supply chain cost and the determination of the products due to which the supplier endured either additional holding cost or shortage cost.

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