ABC Analysis and Diminution of Inventory Level through Forecasting Technique in a Medium Scale Manufacturing Industry

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Abstract

In a global market scenario inventory is one of the most significant possessions in a manufacturing trade. ABC analysis is a technique for inventory categorization which is most extensively used in manufacturing industries. The aim of this research is to deal with assignment of minimizing excess inventory by means of ABC classification and forecasting technique in a medium scale manufacturing industry. The main reason for the excess inventory is due to not following proper forecasting technique based on their original demand. The forecasting technique is used by simple moving average method for the previous three months production which leads excess inventory. This excess inventory is in the form of raw material, work in process, semi-finished product and finished product. Initially, the products need to be classified for inventory optimization and inventory forecasting. In this study ABC classification was used for optimizing the inventory level of the industry. Forecasting error time series method based on actual demand was used for predicting the future demand for reducing the current inventory level. From the results it was observed that, the percentage of forecasting error in actual demand and future prediction was reduced to 15.6%.

Keywords
Forecasting, Forecasting Error, Inventory, Optimization, ABC Analysis

Introduction

Inventory tool is used to direct and control the order, storage and machines usage of manufacturing industries since the majority of industries are applying the policy of minimizing their investment in fixed assets; which still highlights the proposition of minimizing the inventory level. Demand and sales forecasting are the most significant functions of manufacturers, distributors and business organizations. Keeping demand and supply in balance, the manufacturers reduces excess and shortage of inventories to improve their profitability. When the manufacturer's aim is to fulfill the overestimated demand, excess production results in extra stock - keeping which ties up excess inventory. On the other hand, underestimated demand causes unfulfilled orders, lost sales, foregone opportunities and minimizes service levels which lead to inefficient supply chain. Thus, the accurate demand forecast is a real challenge for participant in supply chain. The ability to forecast the future based on past data is a key tool to support individual and organizational decision making. In particular, the goal of Time Series

Forecasting (TSF) is to predict the behavior of complex systems by looking only at past patterns of the same occurrence.

Literature Review

Inventory management system is one of the ongoing processes of planning, organizing and controlling the inventory level at the manufacturing industries to reduce the capital investment in inventory whereas balancing supply and demand [1-3]. Spare parts (as inventories) are very essential in most industrial organizations. Therefore companies tend to analyze their spare parts' demand and try to estimate their future consumption. In a research it was explained about comparison between five forecasting methods based on three statistical tools such as Mean Square Error (MSE), Mean Average Deviation (MAD) and Mean Error (ME). Studies were made to determine how inventory lead time, inventory control and inventory control practices affect competitive advantage of companies [4-6]. Inventory lead time is a very important competitive tool. In an earlier research forecasting method was applied to analyze the production demand in plastic industry. The data were analyzed using double exponential smoothing and other methods to see if the products were going to either decrease or increase in future demand [7-9]. This technique will help during production planning. Theanalysis and discussion of the results have made us to understand the current status and problems of the company.

In the ABC analysis, data collection is mainly done through the interviews with the officers and technical staff involved in inventory control operations. Identifying items for potential consignment to have a greater impact on investment; those would be the best inventories to consider the potential for alternative stocking arrangements that would reduce investment liability and associated carrying costs [10-12]. To achieve optimum inventory replenishment is significantly difficult due to inherent uncertainties in demands and supply which results in loss of sales or keeping excessive inventories. In order to compete with invariably erratic demands, it is not only challenging to develop an intelligent system to maintain and control an optimum level of inventory [13-15]. To control inventory, manufacturing industries are using ABC and other selective control techniques likeFNSD (Fast, Normal, Slow and Dead items) , VED (Vital , Essential and Desirable) etc. Forecasts are evaluated to improve models to achieve better policy and planning outcomes. Statistical time series modeling techniques like moving average, simple exponential smoothing and least square methods are used for the study and their performance evaluated in terms of MAD and MSE [16-18].

From the literature review qualitative and quantitative methods are the two important forecasting techniques. Qualitative methods are based on the opinion of subject matter expert and are therefore subjective. Time series methods forecast the future demand based on historical data. Causal methods are based on the assumptions that demand forecasting is based on certain factors and explore the correlation between these factors. Demand forecasting has attracted the attention of many research works [19-21]. Many prior studies have been based on the prediction of customer demand based on time series models such as simple moving average exponential smoothing. Using simple moving average method for short period of time, forecasting error is high compared with long period time. MAD and Mean Average Percentage of Error (MAPE) are two terms used to identify forecasting accuracy between forecasting and actual demand of

forecasting technique. For achieving optimum inventory, replenishment is difficult due to inherent uncertainties in demands and supply which results in loss of sales or keeping excessive inventories. To control inventory, manufacturing industry are using ABC analysis [22, 23]. Based on the literature, an attempt was made to develop and implement a review policy for sustaining a better level of inventory in a small scale manufacturing industry which is the manufacturer of various types of welding electrodes.

Objective and Methodology

The main objective of the research is to reduce the current inventory level (excess inventory) to optimum level using forecasting technique through Group Method of Data Handling (GMDH) software simulation and ABC analysis. For predicting future demand, naive method is used for forecasting based on actual demand. This naive method is based on simple moving average method for twelve months to identify the future demand using actual customer demand through GMDH simulation. This GMDH shell software is predicting future demand based on actual customer demand.

Demand forecasting is the activity of estimating the quantity of a product or service. In this research the naive forecast method is used as the latest value of the variable of interest and as a best guess for the future value; which is one of the simplest forecasting methods. Also it is often used as a baseline method against which the performances of other methods are compared. The moving average forecast is calculated as the average of a defined number of previous periods. Trend-based forecasting is based on a simple regression model that takes time as an independent variable and tries to forecast demand as a function of time. Multiple linear regression model tries to predict the change in demand using a number of past changes in demand observations as independent variables.

Qualitative Forecasting Technique: It's a subjective based on the opinion and judgment of consumers, experts as they are appropriate when past data are not available. These are usually applied to intermediate- or long-range decisions.

Quantitative Forecasting Model: It is used to forecast future data as a function of past data as thisis appropriate when past data are available. These methods are usually applied to short- or intermediate-range decisions.

Naive Approach: Naive forecasts are the most cost-effective objective forecasting model and provide a benchmark against which more sophisticated models can be compared. For stationary time series data, this approach says that the forecast for any period equals the historical average. For time series data that are stationary in terms of first differences, the naive forecast equals the previous period's actual value. The comparison of different forecasting techniques are classified and given in Table 1.

Table 1: Comparison of Forecasting Technique

Methods	Inputs	Description	Mathematic Model	Innovative Features
Single exponential smoothing	Historical data Smoothing Constant	It adopts a smoothing constant of the real demands	Exponential smoothing	Adapt for low period forecasts Easy to compute
Moving average	Historical data Number of data to considerate	Mean of the past in demands	Arithmetic mean	Adapt for the constant demands Easy to compute
Weighted moving average	Historical data Number of data to considerate	Mean of past in demands with decreasing weights	Arithmetic mean	More weight applied to last demands Easy to compute

Analysis and Results

GMDH Numerical Algorithm: In the modern theory of predictive modeling it is well known that the model should provide a trade-off between simplicity and accuracy**.** GMDH is a family of inductive algorithms for computer based mathematical modeling of multi-parametric datasets that features fully automatic structural and parametric optimization of models. GMDH is used in such fields as data mining, knowledge discovery, prediction, complex systems modeling, optimization and pattern recognition. GMDH algorithms are characterized by inductive procedure that performs sorting- out of gradually complicated polynomial models and selecting the best solution by means of the so called eternal criterion. The idea of all GMDH type algorithms is to apply a generator of gradually complicating models and select a set of models that show highest forecasting accuracy at previously unseen data. Mathematically, GMDH is quite simple and at the same time it is well coordinated with the state of the art data mining techniques. The basic information one must gather to construct the Ivakhnenko polynomial is a set of 'n' observations like ones shown in below Table 2.

Where,

n - Number of observations and m - Number of variables

Step 1: The first step of constructing new variables z1, z2, z3….. zn is very simple. We take all the independent variables column of array x1, x2, x3… xm.

Table 2: GMDH Numerical Algorithm

Y1	X11 X12 ……. …X1m	Z11
Y2	X21 X22 …… …X2m	Z12
Y3	.	.
.	.	.
.	.	.
.	.	.
Yn	Xn1 Xn2 …….. …..Xnm	Zn1
Y	X	Z

Where,

Y = Y1+Y2+Y3…..Yn/n, X = X11+X12+X13…..Xnm/n, **Y** = Prediction based on company, **X** = Actual demand and **Z** = New array (future demand)

ABC Analysis: ABC analysis is an inventory categorization method which consists in dividing items into three categories, A, B and C. A represents the most valuable items and C represents the least valuable ones.

A Category - 5% to 10% of the items represent 70% to 75% of the money value
B Category - 15% to 20% of the items represent 15% to 20% of the money value
C Category - The remaining number of the items represent 5% to 10% of the money value

The results of ABC classification are given in the following Table 3. From the results it was observed that, the contribution of product 1 and product 4 are high compared with other products. The results of ABC classification in individual product contribution and the cumulative percentage of product contribution are shown in the Figure 1. The company is using previous production data for predicting future demand based on simple moving average method for three months of data. For predicting future demand GMDH shell software is used to predict future demand. This software is simulating future demand based on naive method. Naive method is used to predict future demand based on actual demand of company for past 12 months. Now, the actual demand from January to December 2018 was calculated to predict the future demand.

Table 3: ABC Classification

Product	Demand	Annual Usage	Percentage of Contribution	Cumulative Percentage	Classification
1	657.15	104703805	47.70%	47.70%	A
4	637.41	64113729	29.30%	77.00%	A
3	519.52	41989775	19.20%	96.20%	B
2	519.23	8249008	3.80%	100%	C

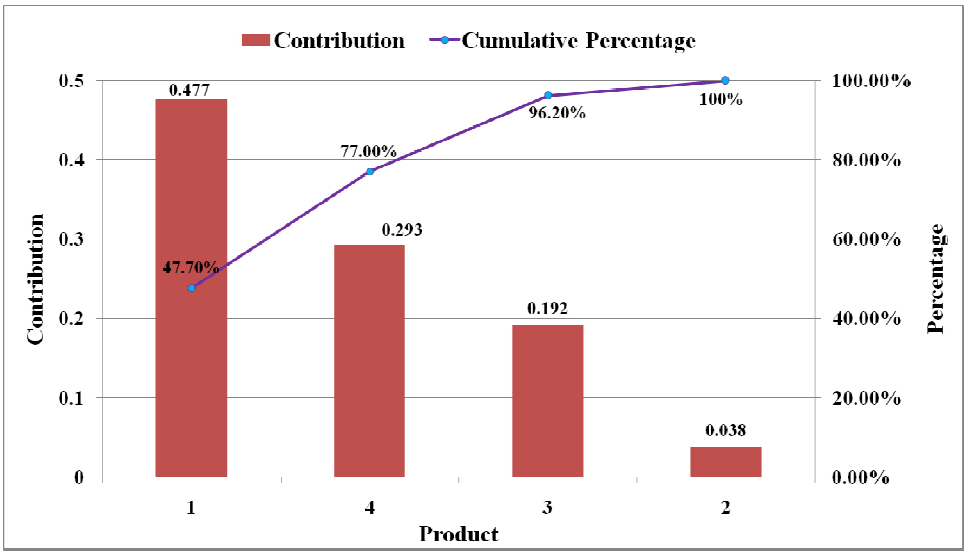

Fig. 1: Pareto ABC Classification

Table 4: Forecasting Error between Company Prediction and Actual Demand

Month	Company Forecasting Demand	Actual Customer Demand (in Tons)	Forecasting Error (MAD)	Forecasting Error (MAPE) in %
Jan-18	208.05	198.94	9.1	4.36
Feb-18	203.23	196.84	6.4	3.13
Mar-18	207.03	200.64	6.4	3.07
Apr-18	206.08	199.44	6.6	3.21
May-18	205.42	195.24	10.2	4.93
Jun-18	206.17	188.24	17.9	8.65
July-18	205.34	193.40	11.9	5.74
Aug-18	205.63	198.91	6.7	3.25
Sep-18	205.52	197.24	8.3	4.01
Oct-18	205.04	200.26	4.8	2.32
Nov-18	205.53	194.43	11.0	5.37
Dec-18	205.51	197.84	7.7	3.71
			MAD=107	MAPE=51.75

The forecasting error between company demand and actual demand is calculated as follows,

Forecasting error (MAD) = Company Forecasting-Actual Demand
Forecasting error (MAPEE)) = (Company Forecasting-Actual Demand /100)

The calculated values and reesults of forecasting error between company annd d actual demand are given in Table 4. From the reresults it was found that, the forecasting error haas been identified as 107 based on company and acctual demand. The percentage of forecasting error was identified as 51.75% based on company dedemand and actual demand. Figure 2 shows thee results of future

demand prediction through GMDH simulation software based on company and actual demand. Similarly, Figure 3 shows the comparison results of actual demand and company prediction.

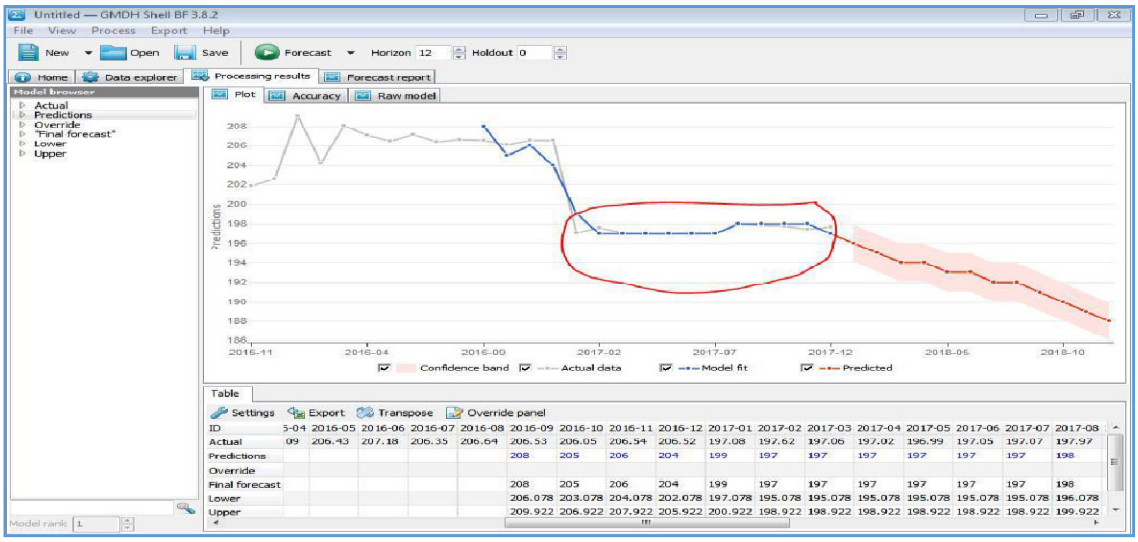

Fig. 2: GMDH Future Demand Simulation

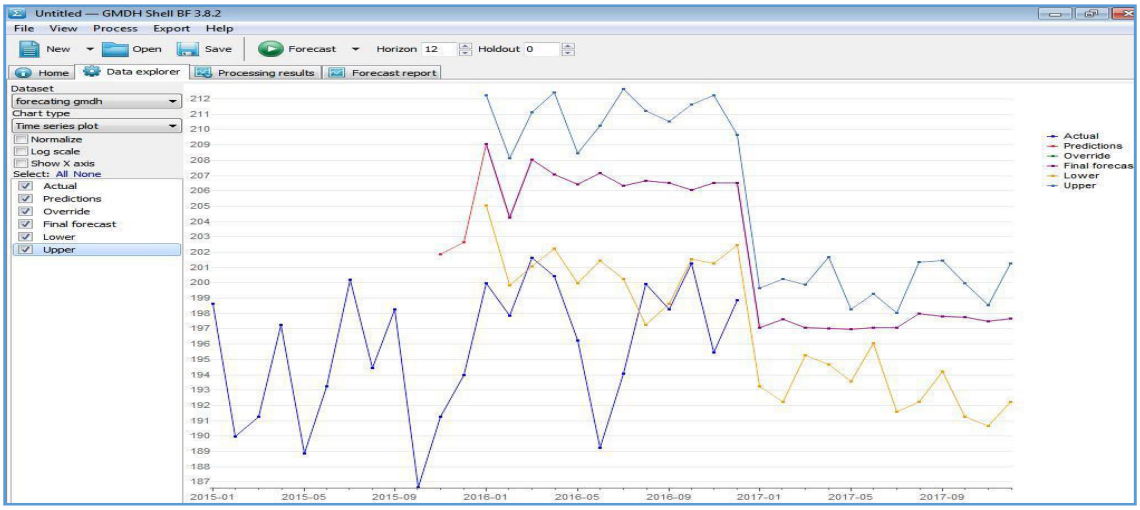

Fig. 3: GMDH Simulation Demand Comparison

The comparison results of forecasting error and percentage of forecasting error are given in Table 5. From the results forecasting error has been identified between actual demand and future prediction as 30.8. Similarly, the percentage of forecasting error has been identified as 15.6% based on actual demand and future prediction.

Table 5: Forecasting Error and Percentage between Actual Vs Future Demand

Month	Company Forecasting 2018	Actual Demand 2018	Future Forecasting 2019	Actual Demand Vs Future Prediction (MAD)	Percentage of Actual Demand Vs Future Prediction (MAPE)
Jan	208.05	198.94	196.79	2.2	1.08%
Feb	203.23	196.84	196.61	0.2	0.02%
Mar	207.03	200.64	196.59	4.1	2.01%
Apr	206.08	199.44	196.19	3.3	1.62%
May	205.42	195.98	195.24	0.7	0.37%
Jun	206.17	196.04	188.24	7.8	4.12%
July	205.34	196.69	193.49	3.2	1.65%
Aug	205.63	198.91	196.69	2.2	1.11%
Sep	205.52	197.24	196.80	0.4	0.22%
Oct	205.04	200.26	196.76	3.5	1.70%
Nov	205.53	196.47	194.43	2.0	1.04%
Dec	205.51	197.84	196.64	1.2	0.60%

The comparison results of cocompany forecasting and actual demand are shhoown in Figure 4. From the results it was found tthat, the variation of company forecasting anndd actual demand forecasting error is high. Simimilarly, the comparison results of actual demmand and future prediction of the company is shhown in Figure 5. The variation of actual demmand and GMDH forecasting error is found to be hi high.

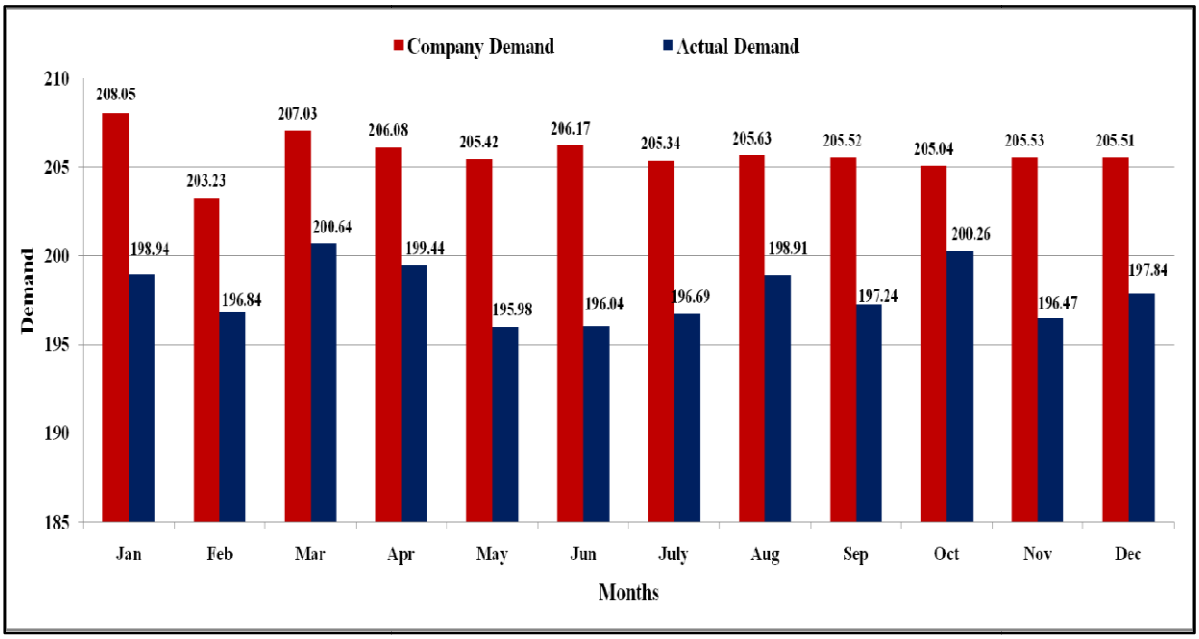

Fig. 4: Comparison Results of Company Forecasting Vs Actual Demand

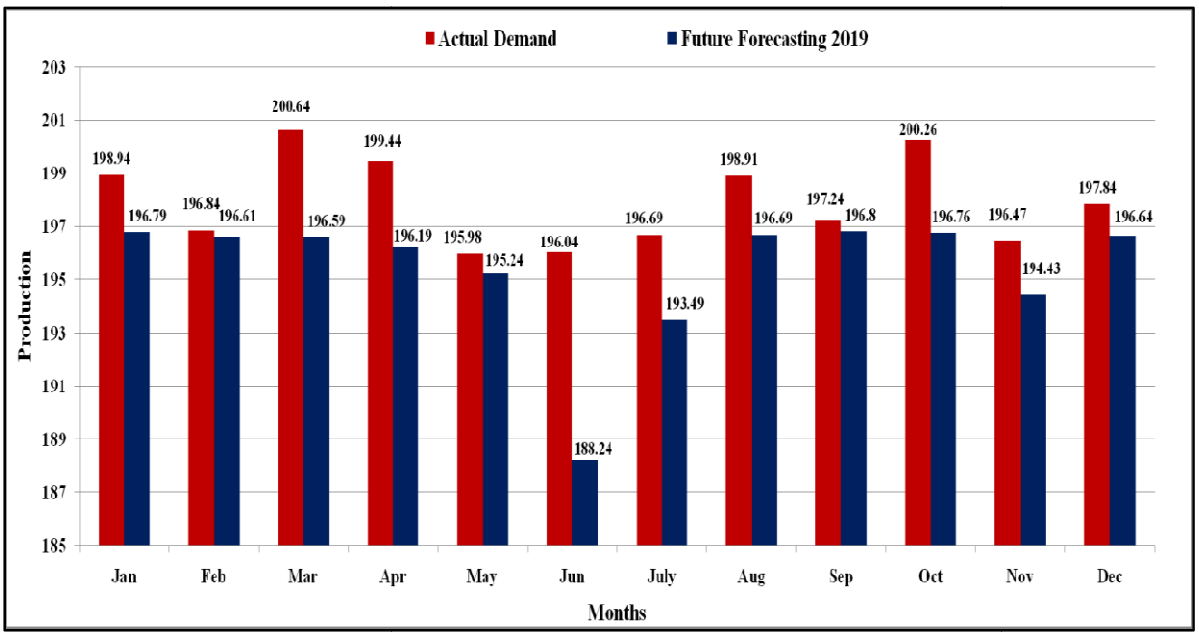

Fig. 5: Comparison Results os of Actual Demand of 2018 Vs Future Forecaassting of 2019

The forecasting error between coompany forecasting and future prediction resulttss were calculated and are shown in Figure 6. The f future prediction has been identified based on GMDH software simulation. From the results it w awas found that, the maximum error was occurredd in the month of June 2018 as 10.13 followed byy in the month of May as 9.44. Similarly, the f forecasting error between actual demand of 2018 aand the future prediction of 2019 were calculat teed and are shown in Figure 7. From the Figure it wwas found that, the maximum error was occurrinngg in the month of June as 7.8.

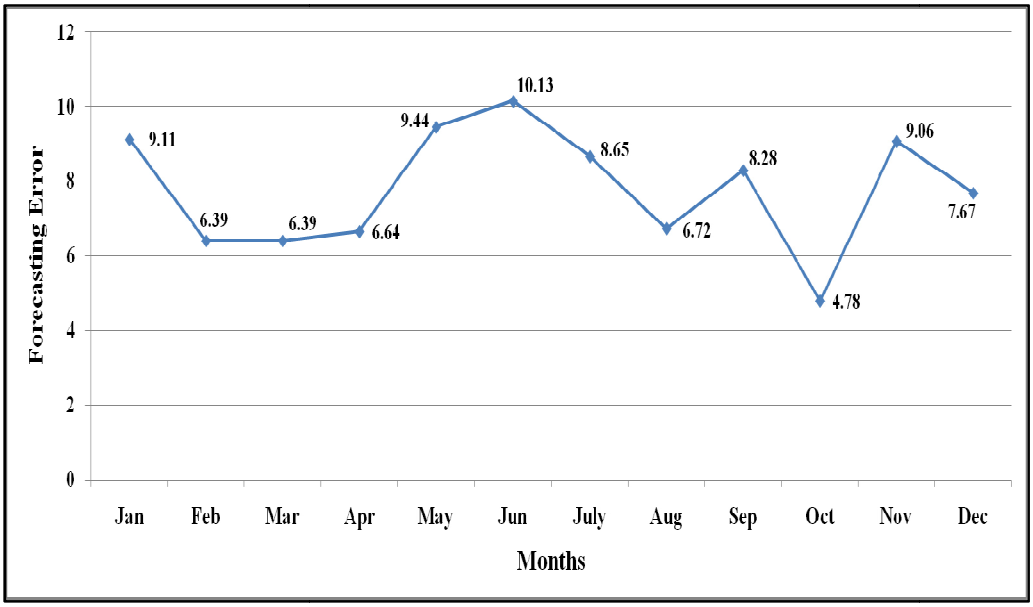

Fig. 6: Forecasting Error between Company Forecasting Vs Actual Demand

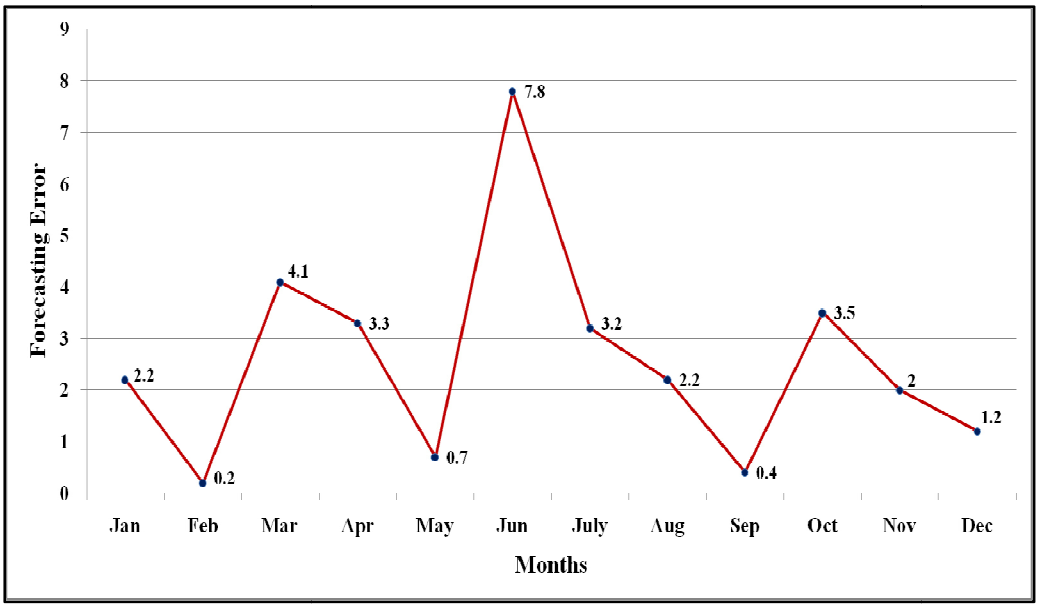

Fig. 7: Forecasting Error betwtween Actual Demand of 2018 Vs Future Preddiction of 2019

Conclusion

The objective of minimizing the inventory level through ABC analysis and forecasting techniques was carried out. Baseded on the observed results the following conclusions were made.

- The future demand was calculated based on actual demand of company, , instead of using company prediction techniqueue.
- The forecasting error between company prediction and actual demand was calculated and found very high which leads to inventory problem.
- By using actual demand through GMDH shell simulation to predict future demand forecasting error was found less.
- The variation between forecasting error and percentage of forecasting error of the company between prediction and actual demand was found to be 107 and 51.75% respectively.
- The variation between forecasting error and percentage of forecasting error actual demand of 2018 and future prediction of 2019 was found to be 30.8 and 15.6% respectively.
- Forecasting error was reduced to 15.6% by using GMDH software simulation based on actual demand and company prediction.

Further research may be viable by using naive method through GMDH shell simulation to predict the future demand with better accuracy.

References

[1] RaghadHemeimat, Lina Al-- Qatawneh, MazenArafeh and ShadiMasoud, FForecasting spare parts demand using statisticacal analysis, American Journal of Operations R Reesearch, 6 (2016) 113-120.

[2] Naliaka V.W. and G.S. Namusonge, Role of inventory management on competitive advantage among manufacturing firms in Kenya: A case study of Unga Group Limited, International Journal of Academic Research in Business and Social Sciences, 5(5) (2015) 56-69.
[3] S. Nallusamy, R. Balaji and S. Sundar, Proposed model for inventory review policy through ABC analysis in an automotive manufacturing industry, International Journal of Engineering Research in Africa, 29 (2017) 165-174.
[4] EzelioraChukwuemeka Daniel, Application of forecasting methods for the estimation of production demand, International Journal of Science, Engineering and Technology Research, 3(2) (2014) 45-54.
[5] Shishir Kumar and Shailendra Kumar Singh, An ABC analysis of multiple component of compressor unit inventory management case study, International Journal of Current Engineering and Technology, 6(4) (2016) 1458-1463.
[6] RohanNadkarni and AsitaGhewari, An inventory control using ABC analysis and FSN analysis, International Journal of Engineering, Business and Enterprise Applications, 16(124) (2016) 24-28.
[7] Rakesh Kumar and DalgobindMahto, Application of proper forecasting technique in juice production: A case study, Global Journal of Researches in Engineering Industrial Engineering, 13(4) (2013) 75-86.
[8] Sri Lakshmana Kumar and S. Nallusamy, Development of multi bin inventory maintenance management system in lean manufacturing using ARENA, Journal of Engineering and Applied Sciences, 12(26) (2017) 7971-7980.
[9] AshvinKochak and SumanSharmademand, Forecasting using neural network for supply chain management, 4(1) (2015) 35-42.
[10] Ahmad Naufal, Ahmad jaffar, Noriahyusoff and NurulHayati, Development of Kanban system at local manufacturing company in Malaysia, Procedia Engineering, 41 (2012) 1721-1726.
[11] M.S. Akturk and F. Erhun, An overview of design and operational issues of kanban systems, International Journal Production Research, 37(17) (1999) 38-41.
[12] M. Apreutesei, I.R. Arvinte, E. Suciu and D. Munteanu, Application of kanban system for managing inventory, Bulletin of the Transilvania University of Brasov, 3(52) (2010) 161-166.
[13] S. Nallusamy, D. Sri Lakshmana Kumar, K.Balakannan and P.S.Chakraborty, MCDM tools application for selection of suppliers in manufacturing industries using AHP, Fuzzy Logic and ANN, International Journal of Engineering Research in Africa, 19 (2015) 130-137.
[14] Sheikh RizwanHussain, Design and implementation kanban controlled production system for job order production based organisation, 2(3) (2013) 50-58.
[15] D. Sri Lakshmana Kumar, S. Nallusamy and V. Ramakrishnan, Proposed inventory management model to improve the supply chain efficiency and surplus in textile industry, International Journal of Mechanical Engineering and Technology, 9(5) (2018) 675-686.
[16] Rudolf Kampfet. al., The application of ABC analysis to inventories in the automatic industry utilizing the cost saving effect, Journal of Marine Sciences, 63(3) (2016) 120-125.
[17] Carl Philip T. Hedenstiern and Stephen M. Disney, Inventory performance under staggered deliveries and auto correlated demand, European Journal of Operational Research, 249 (2016) 1082-1091.

[18] S. Nallusamy and GautamMajumdar, Enhancement of overall equipment effectiveness using total productive maintenance in a manufacturing industry, International Journal of Performability Engineering, 13(2) (2017) 01-16.
[19] Mitchell A. Millstein, Liu Yang and Haitao Li, Optimizing ABC inventory grouping decisions, International Journal of Production Economics, 148 (2014) 71-80.
[20] Smith, Inventory management and ABC analysis practices in competitive environments, International Journal of Procurement Management, 4(4) (2011) 433-454.
[21] K. Balakannan, S. Nallusamy, P.S. Chakraborty and GautamMajumdar, Performance evaluation of supply chain and logistics management system using balanced score card for efficiency enhancement in Indian automotive industries, Indian Journal of Science and Technology, 9(35) (2016) 1-9.
[22] Jichang and Wu Yue, Application of ABC analysis in inventory management, Advanced Material Research, 1030-1032 (2014) 2515-2518.
[23] P. Kumar and Mohd. Anas, An ABC analysis for the multiple- products inventory management - A case study of scooters India limited, International Journal of Research in Engineering and Advanced Technology, 1(5) (2013) 1-6.

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