International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 09 | Sep 2021 www.irjet.net p-ISSN: 2395-0072

INCORPORATION OF LEAN TECHNOLOGY INTO MILK MANUFACTURING ORGANISATIONS

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ABSTRACT: Manufacturing wastes are virtually anything that does not add value to the final product. These wastes are everywhere in many different forms, ranging from over production to underutilization of manpower. The existing productivity level of the practiced manufacturing procedures was examined and production data were obtained. Time series (Auto regression: AR and Moving Average: MA) analyses were carried out on the econometric data obtained and forecast future losses and usage based on the practiced manufacturing procedures. The econometric linear transfer function (ELTF) model developed from the data obtained revealed that the present manufacturing practices at the powder factory had numerous associated losses of materials. The recorded values for actual usage of materials comprised of the waste incurred during the production process. The ELTF model operates a feedback system between the actual usage and actual loss which enabled it to predict the systemized values of losses and usage of materials. The ELTF modeled values based on lean manufacturing principles for actual loss (y_t), when t=61 was 11891.286 and actual usage (x_t) was 388661.0396. This was because the modeled system evaluated the losses and usage based on the presented records and generated modeled values which were based on the interaction between the two factors. The feedback process has filtered out the wastage in the production system and the lean production actual usage values were generated. The associated losses which the conventional practices at the factory incurred on powder materials, based on the ELTF model were also generated. The values are model-based and these could have their associated errors. The results of the multi variance analysis carried out on the monetary loss showed that a very small fraction of the actual usage had effect on the factory profitability. This supports the fact already established that the majority of the actual usage recorded were wastages in one form or the other.

***Keywords**: Lean Manufacturing, Moving Average, Time Series, Auto regression*

Introduction

Manufacturing wastes are defined as anything that does not add value to the final product. These wastes are everywhere in many different forms, ranging from over production to underutilization of employees. The waste associated with overproduction leads to high cost of inventory on finished product. Therefore, it is very important to categorize the wastes according to their availability. These are avoidable and unavoidable waste. Lean manufacturing is based on the continuous finding and removal of wastes which are the lean principles in manufacturing environments. Time series analysis is a powerful tool to determine dynamic models aiming at defining and controlling most relevant variables of a system (Clarke, 1973; Dooge, 1973). ARIMA models and procedures proposed by Box and Jenkins proved to be very efficient to generate sequences of time dependent variables. Businesses need to plan how they will generate and satisfy demand for their products and/or services. Sales promotions are a vehicle by which businesses increase the demand for and visibility of their products and/or services. These promotions cost money and these costs must be justified by structured analysis. Additionally, proposed sales promotions affect future demand, so increased resources must be allocated to satisfy the promoted demand. With the advent of e-commerce, customer expectations are much higher than in the past. Therefore, if a business promotes a product or service, it is expected to provide these in a timely fashion. Linear transfer function models (Box and Jenkins, 1976) have been extensively used to model the relationship between one 'output' time series and several other 'input' time series.

Literature

Milk powder manufacture is a simple process now carried out on a large scale. It involves the gentle removal of water at the lowest possible cost under stringent hygiene conditions while retaining all the desirable natural properties of the milk - colour, flavour, solubility, nutritional value. Whole (full cream) milk contains, typically, about 87% water and skim milk contains about 91% water. During milk powder manufacture, this water is removed by boiling the milk under reduced pressure at low temperature in a process known as evaporation. The resulting concentrated milk is then sprayed in a fine mist into hot air to remove further moisture and so give a powder. Approximately 13 kg of whole milk powder (WMP) or 9 kg of skim milk powder (SMP) can be made from 100 L of whole milk. Marco Polo in the 13th century reported that soldiers of Kublai Khan carried sun- dried milk on their expeditions. In more recent times, milk has been dried in thin films on heated rollers. The earliest patents for this process date from the turn of the century. Such roller drying was the main means of producing milk powders until the 1960s when spray drying took over. Milk powder manufacture is now very big business. Milk powder manufacture is a simple process now carried out on a large scale. It involves the gentle removal of water at the lowest possible cost under stringent hygiene conditions while retaining all the desirable natural properties of the milk - colour, flavour, solubility, nutritional value. Whole (full cream) milk contains, typically, about 87% water and skim milk contains about 91% water. During milk powder manufacture this water is removed by boiling the milk under reduced pressure at low temperature in a process known as evaporation. The resulting concentrated milk is then sprayed in a fine mist into hot air to remove further moisture and so give a powder. Approximately 13 kg of whole milk powder (WMP) or 9 kg of skim milk powder (SMP) can be made from 100 L of whole milk. The development and application of time series analysis in econometric forecasting has occurred rapidly during the past two decades. In recent years, the focus in this area has shifted from univariate or single equation to multivariate and simultaneous equation models. In particular, there has been a great deal of study on dynamic equation systems (Zeger and Diggle (1994)), rational structural form models (Whitman et al. (2001)), and vector autoregressive-moving average models (Tiao and Box (1981), Jenkins and Alarcón (1997)). Despite vast advancements in the development of econometric time series modeling, "classical" econometric models are still one of the major tools used by many commercial economic forecasting firms to provide national economic forecasts. Here they refer to the "classical" econometric models as the simultaneous equation systems originally proposed by Tinbergen (1949, 1951) and Klein (1950), and studied extensively by a number of econometricians. In typical applications of classical econometric models, a simultaneous equation system often consists of a set of linear lag regression equations with white noise disturbances.

Research Methodology

Moving Average Analysis

The moving average analysis was carried out on the actual usage data. The functional analysis for this moving average modeling was the computation of autocorrelation function (ACF). This ACF computation is carried out by taking three or four lags on the time series and thereby computes the r_k for each lag. The best three lags are rated as the best candidate for the moving average analysis. The formula for r_k is given as $r_k = \frac{\sum(x-\bar{x})(x_{t-k}-\bar{x})}{\sum(x_t-\bar{x})^2}$. And the detailed computation using Microsoft Excel software, is shown in Appendix 5. The second, third and fourth lags were selected and used for the moving average (MA) analysis. The detail of this MA analysis, using Microsoft Excel software, is shown in Appendix 6. The summing variables for the MA process were used to develop set of normal equations as shown in equations (1.0) to (1.10).

$$146588158 = 60b_0 + 140500671b_1 + 136623205b_2 + 132994737b_3 \quad (1.0)$$

$$370935846555212 = 140500671b_0 + 369752991451883b_1 + 354586958467409b_2 + 348099813194622b_3 \quad (1.11)$$

$$361175824689160 = 136623205b_0 + 354586958467409b_1 + 354718248870727b_2 + 340517697165321b_3 \quad (1.2)$$

$$353738008680098 = 132994737b_0 + 348099813194622b_1 + 340517697165321b_2 + 341552468843703b_3 \quad (1.3)$$

Likewise, the normal equations were represented in canonical form as shown in equations (1.4) to (1.5).

$$A = \begin{pmatrix} 146588158 \\ 370935846555212 \\ 361175824689160 \\ 353738008680098 \end{pmatrix} \quad (1.6)$$

$$B = \begin{pmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \beta_3 \end{pmatrix} \quad (1.7)$$

$$C = \begin{pmatrix} 60 & 140500671 & 136623205 & 132994737 \\ 140500671 & 369752991451883 & 354586958467409 & 348099813194622 \\ 136623205 & 354586958467409 & 35471824880727 & 340517697165321 \\ 132994737 & 348099813194622 & 340517697165321 & 341552468843703 \end{pmatrix} \quad (1.8)$$

The process parameters associate with these normal equations, $\beta_0 = 823214.886180650$ $\beta_1 = 0.426269183$ $\beta_2 = -0.006499655$ $\beta_3 = 0.287170479$ are obtained using MATLAB software as shown in Appendix 8. Thus the developed MA model for the actual usage data is shown in equation (1.9).

$$\hat{x} = 823214.886 + 0.426269 x_{t-2} - 0.0064997 x_{t-3} + 0.28717 x_{t-4} \quad (1.10)$$

The developed moving average model shown in equation (1.10) was used to predict for both in-sample and out-of-sample forecast.

Results of Moving Average (MA) computation

The data obtained for the actual record of milk powder factory usage or for a period of sixty (60) months is presented graphically in fig.1.1. The plot shows an upward trend and cyclical pattern which suggested that this actual usage did not follow a predetermined and controlled process. Moving average process was carried out and the results showed that the forecast value at t=59 has the least associated error. The plot of the actual and predicted moving average (MA) is shown in fig. 1.2.

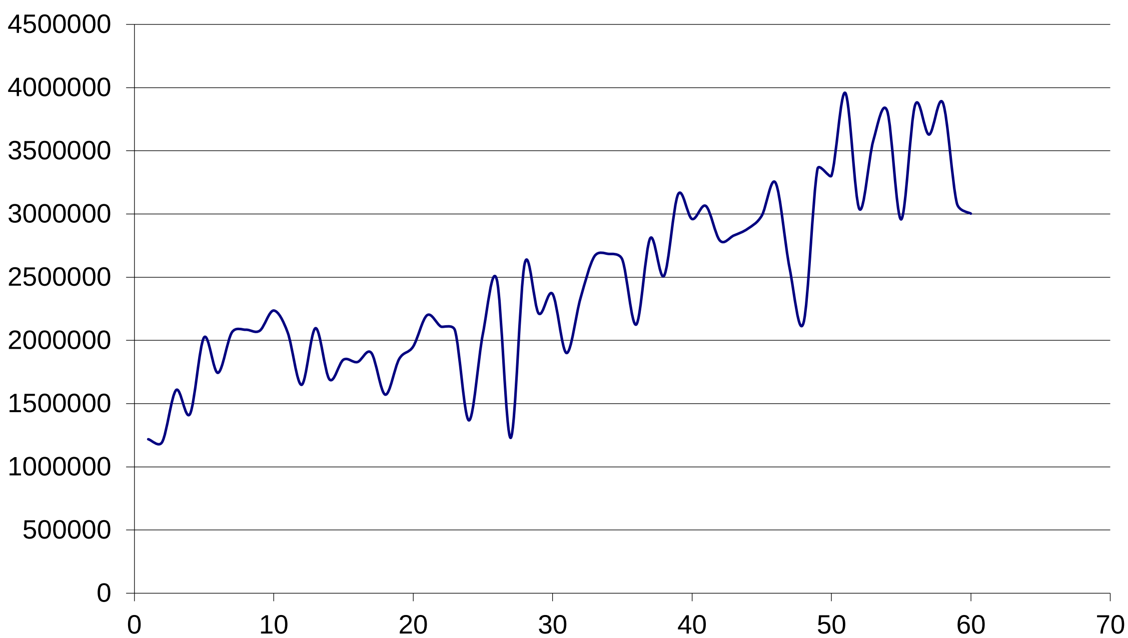

Figure 1.1: Plot of Actual Usage of Powder for sixty months

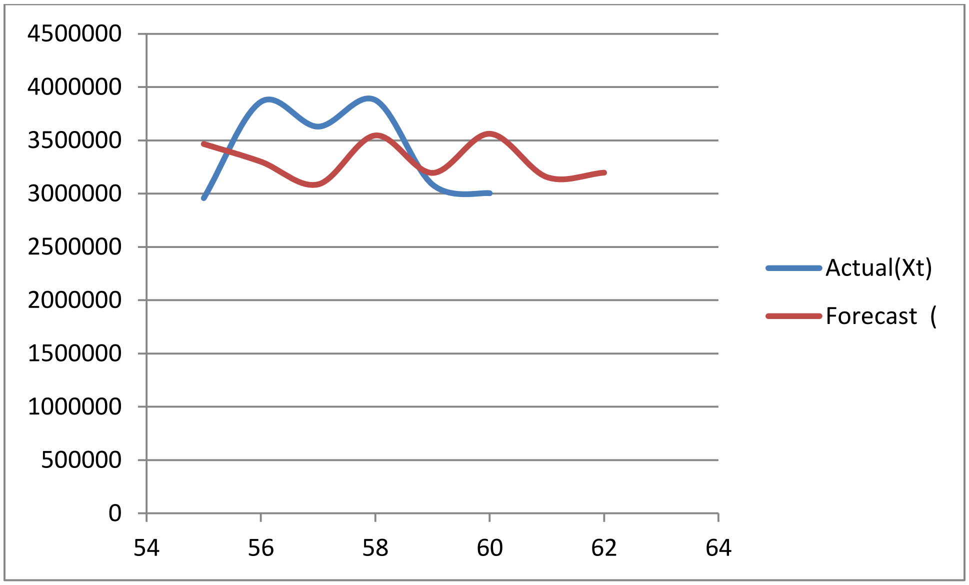

Fig.1.2: Plot of Actual usage and predicted MA usage

Conclusion

The lean manufacturing techniques that are applicable to the powder factory were highlighted in section of literature. The underlining principle of lean technology is elimination of waste in manufacturing processes. The moving average function technique applied to the actual usage and actual loss data obtained filtered the waste in the production process and generated forecast values for actual loss and usage. This revealed, probably, that there had been poor manufacturing practices in the factory. The research findings could be used to control future wastage in the production system.

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