Global Journal of Researches in Engineering: G
Industrial Engineering
Volume 16 Issue 2 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Simulation of Cement Manufacturing Process and Demand Forecasting of Cement Industry

By Md. Irfan Uzzaman, Mohammad Shakilur Rahman, Md. Shafiul Alam & Sadman Alam

Ahsanullah University of Science & Technology

Abstract- Demand forecasts form the basis of all supply chain planning. This research is focused on the simulation of cement manufacturing process to find out the production loss of machines that will affect the production quantity, and analyzing different methods of forecasting to compare their errors so that appropriate forecasting method is identified to predict correct demand. Depending on the forecasting, the simulation process applied can aid to estimate amount of raw materials require producing particular amount of cement to fulfil the demand including the losses in various steps of manufacturing process. Moreover, seasonality of demand is considered where the same demand will repeat at a particular period. The longer horizon forecasts, using Holt-Winters method, are usually less precise than the shorter horizon forecast; that is, long horizon forecasts have larger standard deviations. This investigation on overall demand could facilitate the comparison between the futures forecasted demand and the overall customer demand.

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GJRE-G Classification: *FOR Code: 680302*

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Simulation of Cement Manufacturing Process and Demand Forecasting of Cement Industry

Md. Irfan Uzzaman [α], Mohammad Shakilur Rahman [σ], Md. Shafiul Alam [ρ] & Sadman Alam [Ѡ]

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I. Introduction

Simulation is the imitation of the operation of a real-world process or system over time. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors/functions of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time. Simulation is used in many contexts, such as simulation of technology for performance optimization, safety engineering, testing, training, education, and video games. Often, computer experiments are used to study simulation models. Simulation is also used with scientific modelling of natural systems or human systems to gain insight into their functioning. Simulation can be used to show the eventual real effects of alter-native conditions and courses of action. Simulation is also used when the real system cannot be engaged, because it may not be accessible, or it may be dangerous or unacceptable to engage, or it is being designed but not yet built, or it may simply not exist. Key issues in simulation include acquisition of valid source information about the relevant se-lection of key characteristics and behaviors, the use of simplifying approximations and assumptions within the simulation, and fidelity and validity of the simulation outcomes. Process simulation is used for the design, development, analysis, and optimization of technical processes such as: chemical plants, chemical processes, environmental systems, power stations, complex manufacturing operations, biological processes, and similar technical functions [12]. Process simulation software describes processes in flow diagrams where unit operations are positioned and connected by product or edict streams. The software has to solve the mass and energy balance to find a stable operating point. The goal of a process simulation is to find optimal conditions for an examined process. This is essentially an optimization problem which has to be solved in an iterative process. Process simulation always use models which intro-duce approximations and assumptions but allow the description of a property over a wide range of temperatures and pressures which might not be covered by real data. Models also allow interpolation and extrapolation within certain limits and enable the search for conditions outside the range of known properties. The development of models for a better representation of real processes is the core of the further development of the simulation software. Model development is done on the chemical engineering side but also in control engineering and for the improvement of mathematical simulation techniques. Process simulation is there-fore one of the few fields where scientists from chemistry, physics, computer science, mathematics, and several engineering fields work together.

Forecasting plays a crucial role in the development of plans for the future. It is essential for the organizations to know for what level of activities one is planning before investment in inputs. Forecasting is an estimate of future event achieved by systematically combining and casting forward in a predetermined way data about the past. To know the future demand of cement industry forecasting is an essential part.

II. Literature Review

In literature, different aspects of demand forecasting problems with unknown demand distributions and information updates have been studied. For seasonal demand forecasting, starting from the 1990s, a Quick Response (QR) policy was adopted by many researchers. This policy is intended to reduce manufacturers' production time to respond to retailers

Author α σ ρ Ѡ: Ahsanullah University of Science & Technology.
e-mails: shafiul078.aust@gmail.com, irfanzaman71@gmail.com
shakil1016@gmail.com, sadmanalam.ipe@gmail.com

order in a quicker way so that forecast can be improved by collecting more information about the future demand. Hammond (1990) and Fisher et. al. (1994) [5] studied the QR policy with ski apparel (ski suits, ski pants, parkas, etc), and showed that forecast accuracy can be substantially improved by adopting QR policy. Fisher and Raman (1996) [6] developed a forecasting model based on the sale trend using the early stage market sales data to reduce the uncertainty of the future demand under QR ordering system. Iyer and Ber-gen (1997) [7] studied demand forecast by collecting the demand information of a preseason product to forecast the actual demand of a seasonal product using Bayesian approaches. They proposed that the demand process of the fashion apparel follows normal distribution and presented the improvement of demand forecast due to Bayesian information update in forecasting process. Agrawal and Smith (1996) [1] used negative binomial distribution (NBD) for the demand model and suggested that NBD model provides a better fit than the normal or Poisson distributed data. They developed a parameter estimation method for the demand model in which sales are truncated at a fixed point. Time series forecasting models are increasingly applied to forecast demand and short-life product demand. Under an auto-regressive moving average (ARMA) assumption, Kurawarwala and Matsuo (1998) [8] estimated the seasonal variation of PC products demand using demand history of pre-season products and validated the models by checking the forecast performance with respect to actual demand. Miller and Williams (2003) [11] incorporated seasonal factors in their model to improve forecasting accuracy while seasonal factors are estimated from multiplicative model.

Hyndman (2004) extended Miller and Williams' (2003) work by applying various relationships between trend and seasonality under seasonal autoregressive integrated moving average (ARIMA) procedure. In several articles, Liau and Lau (1997) [10], Eppen and Iyer (1997) [4], Choi et al. (2003, 2006) [3], inventory models were studied to determine the order quantity for a lead time and inventory cost of the seasonal demand. Liao and Shyu (1991) [9] first introduced the concept of crushing cost to variable lead time for a fixed or-der quantity, where crushing cost is the cost that increases if the procurement lead time is reduced. Ben-Daya and Raouf (1994) [2] extended Liao and Shyu's (1991) work by treating both order quantity and lead time as the decision variables.

III. Experimental Procedure

Simulate the simplified cement manufacturing process adding different input for each of the following stage

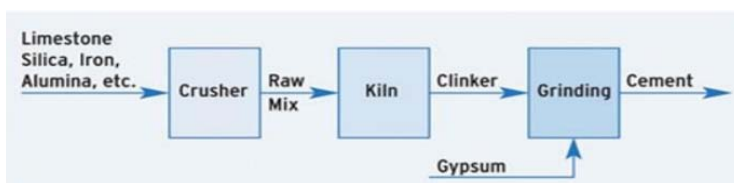

Fig. 1 : Simplified Cement Manufacturing Process

Analyzed one year sales data of a cement company and found forecasted demand as well as error by following 5 methods of forecasting which is:

- Regression Analysis
- Exponential Smoothing
- Moving Average
- Holt Method
- Holt-Winters' Model

IV. Results & Discussion

a) Process Simulation

Simplified process of manufacturing of cement, simulation process is done to find out the efficiency of overall process and final output of cement and the loss. For different loss of machine those parameters are calculated. Here the loss, output and efficiency is different for different batch production because for every batch machine variation of machine loss is not same. The below table shows the variation of output, loss and efficiency for the particular input of raw material. Here input raw material 50 tons are taken for every batch production.

Table 1 : Process Simulation

Batch No.	Output	Loss	Efficiency (%)	Batch No.	Output	Loss	Efficiency (%)
1	44.72	5.28	89.4	11	47.59	2.41	95.2
2	45.19	4.71	90.4	12	45.68	4.32	91.4
3	45.2	4.80	90.4	13	44.74	5.26	89.5
4	44.72	5.28	89.4	14	44.74	5.26	89.5
5	43.81	6.19	87.6	15	45.68	4.32	91.4
6	45.66	4.34	91.0	16	47.58	2.42	95.2
7	43.81	6.19	87.6	17	45.19	4.81	90.4
8	44.72	5.28	89.4	18	46.62	3.38	93.2
9	44.28	5.72	88.6	19	46.62	3.38	93.2
10	46.61	3.39	93.2	20	47.10	2.90	90.4

Fig. 2 : Graphical Representation of Process Simulation

Cement manufacturing process is simulated through Matlab in this research. For simulation, Fig 1. Simplifies cement manufacturing process is followed. At the initial stage, 50 ton/hr limestone is given into crusher machine as input and this input value is fixed for all 50 batch. In respect to the input of limestone, final output of cement per batch/hr is calculated as well as the loss per batch. From the Table 1, at the first batch output of final cement 44.72 and respective loss is 5.27. In Table 1, cement output varies from 43 to 48 ton/hr. Before coming out cement as output, loss occurs in all 3 machining stage. Some loss occurs due to attaching material with the machine surface, some amount of material are blown away and some amount of material came out as wastage

b) Forecasting

For the current amount of demands for 12 months that is316, 326, 373, 377, 315, 368, 318, 315, 319,315,320,392 (all are in thousands) in this paper different forecasting is done to find out which method is most appropriate to use for forecasting future demand by comparing their errors as shown in below table.

Table 2 : Error Comparison

		Mean Absolute Deviation	Mean Squared Error
Regression Analysis		7	64
Moving Average	For 3 months	20	906
	For 5 months	17	769
Exponential Smoothing	For $\alpha = 0.1$	28	904
	For $\alpha = 0.1$	27	1039
Holt Method		29	1342
Holt-Winter's Method		25	1048

Less Mean Squared Error (MSE) value gives better forecast. Therefore, in the error comparison table, Regression Analysis gives lowest MSE (value of 64) among. Holt Method and Holt-Winters Method can be compared also as future years demand can be forecasted by this two. Analyzing error comparison table, Holt and Holt-Winters MSE are 1342 and 1048 respectively. To conclude, Holt-Winters method is more appropriate than Holt method.

V. Scope of Future Research

Case studies in multiple cement manufacturing companies on sales data's to make accurate forecast Survey on several geographic areas for cement utilization based on random sampling. Application of hybrid Artificial Neural Network and Fuzzy Logic method in demand forecasting and process simulations [12]

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