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Development of Mamdani FIS for Flow Rate Control in a Rawmill of Cement Industry

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Abstract— This paper presents the mamdani type fuzzy inference system (FIS) for water flow rate control in a rawmill of cement industry. Fuzzy logic can be used for imprecision and nonlinear problems. The fuzzy controller designed for flow rate control is two input and one output system. It is essential to control water flow rate efficiently to produce high quality cement. Rawmill is a mill which is used to grind the raw materials which are used to manufacture cement. In this paper, the system is designed and simulated using MATLAB Fuzzy logic Toolbox. The experimental results of the developed system are also shown.

***Index Terms*—FIS, *flow rate control, mamdani, process value, rawmill, setpoint*.**

I. INTRODUCTION

After being mostly viewed as a controversial technology for two decades, fuzzy logic has finally been accepted as an emerging technology since the late 1980s. This is largely due to a wide array of successful applications ranging from consumer products, to industrial process control, to automotive applications [1]. The term "fuzzy logic" was introduced by Lofti A. Zadeh in 1965. Fuzzy logic is a form of many-valued logic. It deals with reasoning that is approximate rather than fixed and exact. In contrast with traditional logic they can have varying values, where binary sets have two-valued logic, true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. [2] This is a methodology to represent and implement human's knowledge about how to control a system.

FLC is a non-linear controller that can be viewed as an artificial decision maker that operates in a closed loop system in real time. To design the FLC, information must be gathered on how the artificial decision maker should control the system. This information can either be collected from a human decision maker who performs the control task or by directly understanding the plant dynamics then formulate a set of rules about how to control the system. Fuzzy systems have been in a wide variety of applications in engineering, science, business, medicine, psychology, and other fields [3]. Mamdani is given by Ebrahim Mamdani in 1975 [4].

The cement production is one of the most fundamental industries. The cement can be found almost everywhere in the everyday life and the industrial society cannot be imagined without it. The Indian cement industry is the second largest producer of cement in the world, just behind China but ahead of the United States and Japan [6]. Cement is typically made from limestone and clay or shale. The cement manufacturing process consists of broadly of mining, crushing and grinding, burning, and grinding with gypsum. Two basic processes, the wet process and the dry process, are used for cement manufacturing [5].

The quality of the produced cement depends on the raw materials and also on the processing operations. The control system of the cement production controls these operations to produce the maximum quantity of the cement with prescribed quality and minimum cost. Due to increasing population, various constructional activities are increasing day by day. As a result the market demand of cement is also increasing continuously [6]. Our interest is to control raw grinding systems. Conventional control design method requires the development of mathematical model of the control system. This being the advantage of fuzzy logic control which does not require mathematical modeling for the design of the controller. It has the ability to deal with non linear systems. Fuzzy logic controller (FLC) uses the qualitative knowledge of a system to design a controller. FLC deals with the uncertainties in the process of control by collecting human knowledge and expertise. Fuzzy logic controllers provide better control than conventional controllers. The use of fuzzy logic controllers also reduces energy consumption [7]. The rest of the paper is organized as follows: Section 2 shows the implementation of fuzzy controller using mamdani FIS with results in section 3, and section 4 reports the conclusion of this paper.

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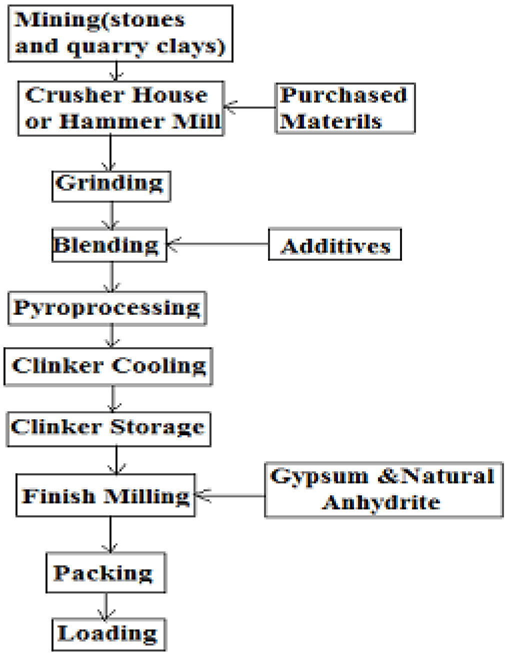

Fig1. Plant Process Flow Diagram [6]

II. IMPLEMENTATION OF MAMDANI FIS

Fuzzy controller for flow rate control system is developed using MATLAB Fuzzy logic Toolbox. Fuzzy inference system for the system is generated with two inputs and one output. First input is variation in required temperature i.e. difference between present and previous setpoint (i.e. required temperature) and denoted by 'dSP'. Its units are ˚C. Second input is difference between actual and required temperature i.e. difference between process value (i.e. actual temperature) and setpoint and denoted by 'dT'. Its units are also ˚C. Output is flow rate of water measured in m^3/h and denoted by 'Flow Rate'.The two inputs and output each have four triangular membership functions. The ranges of dSP and dT are from -4˚C - 6˚C and 0˚C - 2˚C respectively as shown in Fig. 2 and Fig. 3. Flow Rate is taken in the range of 4 m^3/h - 15 m^3/h as shown in Fig. 4.

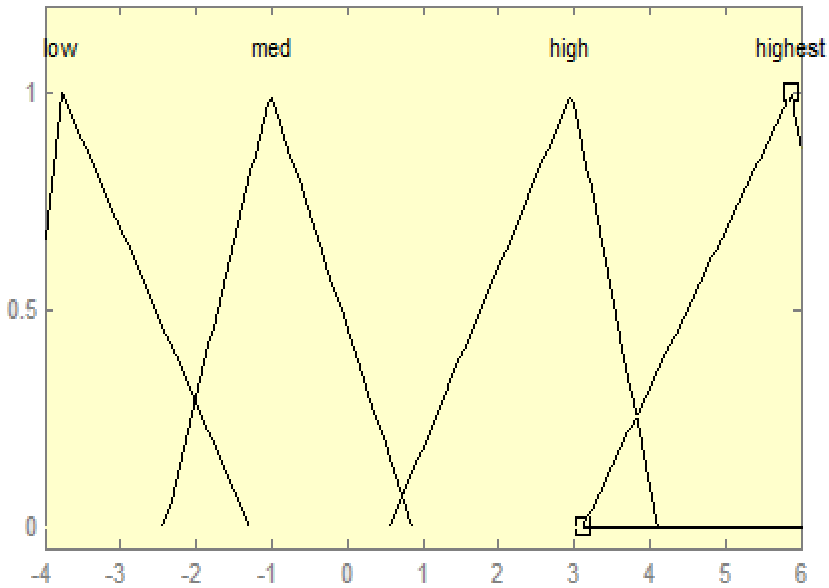

Fig.2. Membership functions of diff. between present and previous setpoint

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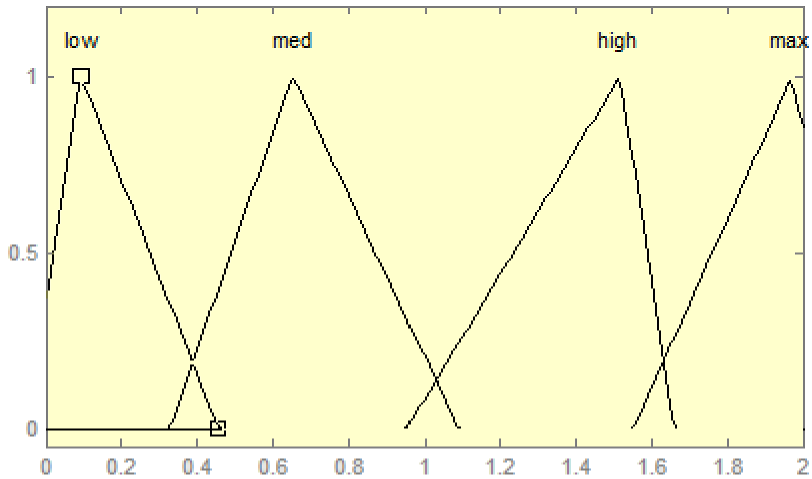

Fig.3. Membership functions of diff between process value and setpoint

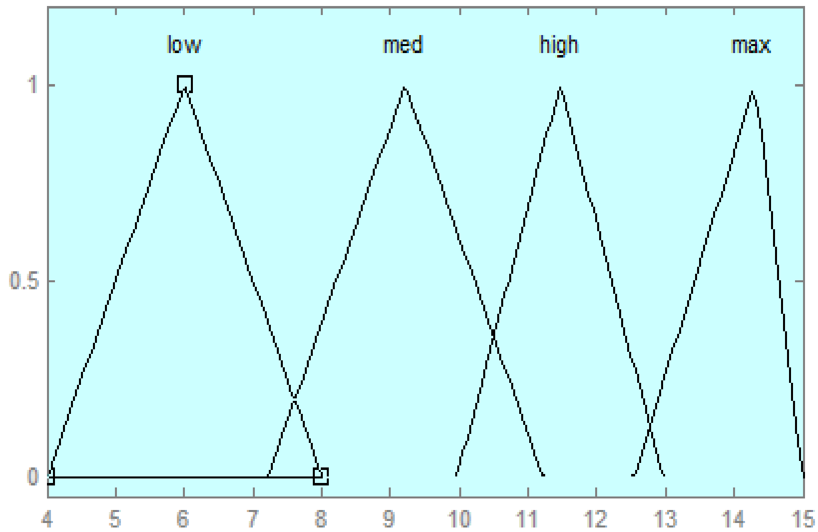

Fig.4. Membership functions of water flow rate

The rule base of the neuro-fuzzy controller is given in Table I.

Table I. Rule base

S. No.	dSP	dT	FlowRate
1	highest	low	low
2	high	low	low
3	highest	low	low
4	low	max	max
5	high	med	med
6	med	high	max
7	low	high	high
8	med	max	max

III. EXPERIMENTAL RESULTS

The model is simulated using MATLAB Fuzzy logic Toolbox. The plots obtained after simulating Mamdani-type of FIS are shown in Figs. 5, 6 and 7.

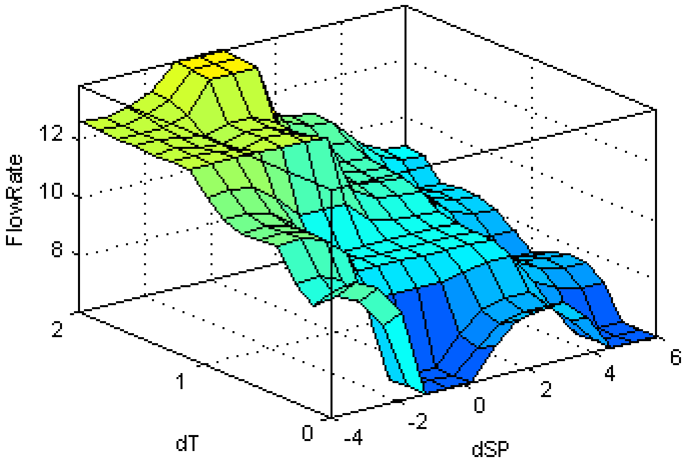

Fig.5. Surface view of Mamdani-type FIS

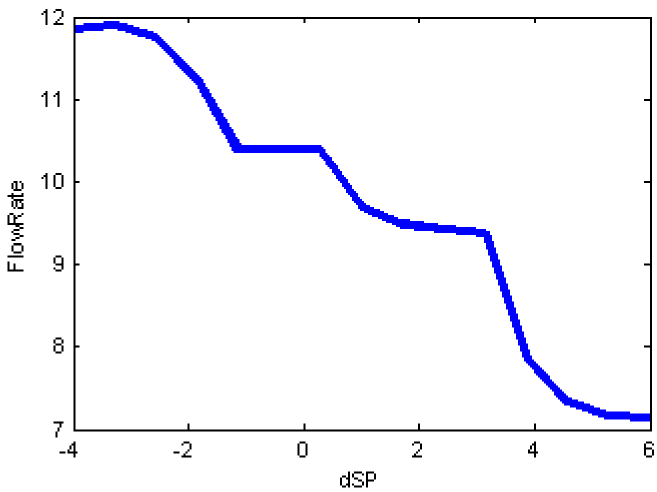

Fig.6. FlowRate with dSP (Input 1)

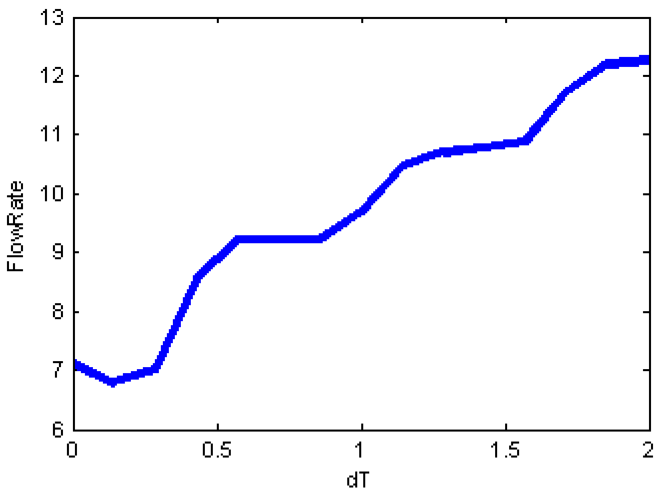

Fig.7. Flow Rate with dT (Input 2)

From these experimental results it can be deduced that using mamdani type FIS to design the controller for water flow rate control gives an efficient control. From the curve in Fig. 6 it is evident that flow rate of water decreases with increase in difference between present and previous setpoint temperature. Because as the setpoint (i.e. required temperature) increases then flow rate decreases. From curve in Fig. 7 it is evident that flow rate of water increases with increase in difference between actual temperature and required temperature i.e. if actual temperature is greater than the required temperature then flow rate should also be increased to maintain required temperature. Hence, the system can be easily and efficiently controlled with the usage of mamdani fuzzy inference system.

IV. CONCLUSION

In this paper, it is shown that mamdani type FIS provides an efficient control for water flow rate control system. Mamdani FIS uses centroid method to calculate output value. Therefore it is complex and time consuming. But fuzzy logic system is superior to conventional algorithms.

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