Optimization of Feed Rate in Cement Grinding Mill Using Electronic Ear based on CMAC-PID Algorithm

P. Gowri¹, J.A. Raviselvan Devadoss², S. Kalpanadevi³
¹PG Student ²Assistant General Manager ³Associate Professor
¹Department of Embedded System Technologies ²Control & Instrumentation ³Electrical & Electronics Engineering
¹,³Knowledge Institute of Technology, Salem, India ²India Cements Ltd, Sankari West

Abstract—Generally during the process of cement production, the processing takes place in cement grinding mill plays a vital role in determining the production rate of cement. This process consists of number of non-linearities like backlash, large lag and many time-varying model parameters. Therefore it is difficult to derive the exact mathematical model and hence obtaining satisfied results with traditional control algorithms is tedious. Even though PID controllers are used in almost all grinding mills for feedrate control, the performance is not up to a satisfactory level. In order to improve the performance of existing PID controller, this paper proposes an intelligent CMAC neural network algorithm for tuning the parameters of PID controller and thus it optimizes the feedrate control according to sound level in cement grinding mill. The results are simulated in proteus design software tool. Finally comparison is made between different control algorithms for improving the accuracy of control provided in cement grinding mill.

Key words: Cement Grinding Mill; Intelligent Control; PID Control; CMAC Neural Network

I. INTRODUCTION

The process taking place in cement-grinding mill becomes much important in producing good quality of cement. In order to maintain the stability in grinding mill and to increase production rate of cement, the study of control systems remains important. Since the characteristics like large inertia, delay, nonlinearity and so on is usually exist in the process of cement grinding mill, the traditional PID controller alone is not sufficient to achieve better performance[1].

Traditional PID controller is having its inbuilt drawbacks like it cannot satisfy the requirement of high precision control because of its tedious parameter adjustment and low accuracy. Hence due to the development in intelligent control theory such as expert system, fuzzy control and neural network, many intelligent techniques are now combined with PID controller which yields incomparable control effect. Especially neural network has ability of self-learning, self-organizing and better adaptability. One of such type of neural network such as back propagation neural network improves the control precision but the complexity of algorithm restrict optimization control speed. In this paper, a cerebellar model articulation control (CMAC) network with PID control is proposed to optimize the product flow rate in cement grinding mill. Here CMAC algorithm is used to tune the parameters of PID controller.

In cement grinding process, the raw materials like clinker, gypsum and fly ash are feed into grinding mill. The sound sensor is installed as near as possible to mill’s wall. The sound generated in grinding mill is given as actual input to comparator and desired input value is fixed based on fineness of cement.

The error rate from comparator is given to PID controller. If the grinding mill sound level is beyond the threshold, then the motor in weigh feeder which rotates to fill the raw material to grinding mill up to target value. If it is less than the threshold value, then the normal grinding process occurs. To improve the performance and response time of traditional PID controller, an intelligent CMAC-PID controller is proposed to increase the production rate.

II. LITERATURE SURVEY

1) Kong Ying describes that the cerebellar model articulation control (CMAC) with proportional integral derivative (PID) controller gives precise control effect on temperature of cement rotary kiln, when compared to traditional PID control method. Due to CMAC fast learning ability and the complicated working characteristics of rotary kiln system, PID controller parameters can be optimized real time by CMAC neural network. CMAC is a practical tool for improving existing nonlinear control systems. It can effectively reduce tracking error, but can also destabilize a control system, which is otherwise stable. The result shows that the control system can quickly reach steady state, which has small output error, good real time performance and strong robustness. The control approach has the very good control effect but mathematical model can’t be established accurately.

2) Jiangjiang Wang et al demonstrates that the hybrid CMAC-PID control system can achieve favorable tracking performance for the HVAC system with large inertia, pure lag and nonlinear characteristics and external disturbances. The controlled objects are modeled in heating, ventilating and air-conditioning (HVAC) system, mainly including the heat exchanger and the air conditioning space. The controller has been shown to have two obvious characteristic: one is the feedback control by using traditional PID controller to enhance the stability and reject the disturbance; another is the feed forward control by using CMAC neural network to increase the response speed and control precision in HVAC system.

3) Peilin Shi et al, describes that in the complex nonlinearity of electric power steering system, the actual current of motor can’t follow the tracks of
Optimization of Feed Rate in Cement Grinding Mill Using Electronic Ear based on CMAC-PID Algorithm

(IJSRD/Vol. 3/Issue 03/2015/140)

All rights reserved by www.ijsrd.com

Optimization of Feed Rate in Cement Grinding Mill Using Electronic Ear based on CMAC-PID Algorithm

The target current well with PID controller. A compound controller of CMAC and PID is proposed for it. This controller realized the feedback control with traditional PID controller to make the electric power steering system stable, and realized the feed forward control with CMAC neural network controller to increase the response speed and control precision. Simulation results showed that actual current of motor can follow the tracks of the target current very well with the compound controller. Moreover, the compound control system of CMAC and PID is less sensitive to the change of parameters than that in PID control system.

4) Chun-yuija et al studied the hydraulic roll bending control system which has the moving characteristics of nonlinearity, time dependent variance and and external disturbances during the rolling process and they find it difficult to predict mathematical model for controlling the system. So the authors came up with an novel idea to control the hydraulic roll bending control system by CMAC neural network and PID coupling control strategy. The mapping of theoretical and the practical functions of CMAC achieves the nonlinear relationship between them.

Improvement of anti jamming capability, tracking functions compared with the conventional PID control algorithm, showed better performance for hydraulic roll bending system the parallel control system using CMAC-PID coupling control strategy.

5) Guoqing Xia et al studied the hybrid CMAC based PID controller and measured the hydrodynamic parameters for the ship sailing at sea. PID controller law is of more adaptive nature for systems that accurate modeling can be resulted in mathematics. At the same time for complex nonlinear systems, they don’t yield proper outcome during ship dynamics. Combining neural network with PID controller, the simulation results we obtained are robust and can be applied to moving systems.

III. GRINDING BALL MILL IN CEMENT INDUSTRY

The Cement production is certainly the most important for all dry grinding applications around the world. For most of the twentieth century, the dry grinding circuits for the production of finished cement from cement clinker consist of two-compartment tube mills and the air separators. It is not uncommon to produce the cement in an open circuit. Advances in cement grinding technology are slow and these advances are limited to more developed countries. Approximately 95% of the feed to the cement grinding circuit are clinker and the rest of the feed are additives which includes grinding aids. The sequence of operation takes place in Cement grinding mill is as shown in figure 1.

Fig. 1: Process in Cement Grinding Mill

Raw materials like clinker, gypsum and fly ash are fed through the mill are crushed by impact and ground by attrition between the balls. The mill is usually divided into two chambers; first chamber is smaller than the second chamber. The coarse clinker is ground in the first chamber where larger balls (80, 60, 50mm) are used and the fine grinding is done in the second compartment where smaller balls (below 25mm) are used. A diaphragm separates the two compartments and allows only particles below a certain size to pass to the second compartment. Ground material exits the mill through the discharge grate which prevents grinding balls from leaving the mill. The final product is the fine fraction of the air classifier and the coarse fraction returns to the mill. The product of cement is stored in bulk storage called silo and then it goes into packing section for marketing the product.

To control the feed flow rate in grinding mill, PID controller is used in existing method by taking sound as input parameter. But the result obtained is not up to the satisfactory level due to high nonlinearity. Hence there is a need for optimization of controller to improve the production rate of cement. The proposed intelligent technique using CMAC algorithm is a practical tool for improving existing nonlinear control systems. CMAC can effectively reduce tracking error compared to other intelligent controllers.

IV. PROPOSED SYSTEM

Cerebellar model articulation control (CMAC) with PID can overcome the drawbacks of existing system. CMAC is a practical tool for existing nonlinear control
system and it can effectively reduce tracking error. It operates very fast when compared to other neural network and hence it is highly suitable for all real time adaptive control.

CMAC takes the audio signal as input from grinding mill. By using CMAC the PID parameters like $K_p$, $K_i$, and $K_d$ value can be dynamically adjusted to attain a target value.

![Fig. 2: Block Diagram of Proposed System](image)

The block diagram of the proposed system is shown in figure 2 which shows the PID control structure with CMAC parameter optimization. The block diagram consist of cement grinding mill, sound sensor(microphone), audio signal converter, CMAC neural network, PID controller and motor in weigh feeder. The comparator generates an error signal by comparing input sound signal with feedback signal from sensor. According to the error signal, PID controller gives a signal to control the feedrate input to grinding mill through weigh feeder. Weigh feeder is used to increase (or) decrease the feed flow rate. The sound level of grinding process is sensed in decibels by microphone and audio signal converter converts that to an electrical signal. An intelligent CMAC algorithm is used to tune the parameters of PID controller to optimize its performance.

![Fig. 3: CMAC Neural Network](image)

According to principle of CMAC, similar input mapped to A have some overlap and no relevant input are far apart. When the S is high-dimension, the conceptual memory A is very large. So the Hash Code is employed to compress A into smaller real physical memory $A_p$. Mapping $f: S \rightarrow A$ is fixed, that is that every $s_i$ in the input space is corresponding to C cells in A. The response cell sums the values of the weights attached to active C cells to produce the output vector $Y$ that is the mapping $g: A \rightarrow Y$.

Controller input is the difference between expectations and the actual output, while control outputs are the three PID parameters. According to the effect of three PID parameters in the adjustment process, the learning algorithm can be improved as follows. Based on the gradient descent method, the output weights of the three parameters $I$, $P$, $D$ can be respectively adjust as follows.

$$\Delta w_j(t) = -\eta \frac{\partial e(t)}{\partial w_j} = \eta \frac{\partial e(t)}{\partial w_j}$$

Where $\eta$ is learning rate and $\alpha_k$ is inertia coefficient of $I$.

$$w_j(t) = w_j(t-1) + \alpha_k (w_j(t-1) - w_j(t-2))$$

Where $\eta$ is learning rate and $\alpha_k$ is inertia coefficient of $P$.

$$\Delta w_j(t) = -\eta \frac{\partial e(t)}{\partial w_j} = \eta \frac{\partial e(t)}{\partial w_j}$$

Where $\eta$ is learning rate and $\alpha_k$ is inertia coefficient of $D$.

VI. SIMULATION RESULTS

The proteus design model for proposed system is as shown in figure 4. Proteus (Processor for text to use) is a fully functional, Procedural programming language created in 1998 by Simone Zanella. Proteus incorporates many functions derived from several other languages such as C, BASIC and Assembly language. CMAC-PID algorithm is done in Embedded C language and the program is executed in Arduino compiler. The design model consists of ATMega328P, LCD, Relay, Digital oscilloscope and RS 232 interface. CMAC-PID algorithm is coded in ATMega328P. By using VB.NET audio signal is given to controller via RS232. Depending on audio signal the motor in the weigh feeder can rotate to control feed flow rate.
The Comparison of cement grinding mill response using different control algorithm is shown in figure 5. The graph shows that the accuracy and speed of response of CMAC-PID control is better than traditional controller. Channel C shows CMAC-PID controller accuracy. Channel D shows PID control accuracy. It also yields a very good precision in control, improves the stability and rejects the disturbance in a better way when compared to traditional PID.

VII. CONCLUSION

The idea proposed is to control the feed rate based on the sound level of grinding mill using self-tuned PID controller combined with CMAC neural network algorithm. It best optimizes the sound level in cement grinding mill compared to that of conventional PID controller. The simulation result shows that the proposed control system increases the response time and production rate and thereby achieving good real time performance with small output error.

REFERENCES


