

EXPERT SYSTEM BASED PRESSURE CONTROL FOR THERMAL PLANT BOILER

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Abstract – The aim of the pressure controller in a thermal power plant is to regulate fuel and air to maintain constant pressure at the turbine inlet at all loads. This process is non linear and difficult tune the controller for efficient control action. This paper deals with the design of Real time Responses Based Pressure control Scheme to get the optimal parameters for PID controller. Many steady state and dynamic real time responses for different emergency conditions occurred in Power Plant were analyzed for different load conditions. Simulations were carried out to get optimum controller parameters in the fabricated lab scale set up. The outcomes were compared with existing controller and improvements of the proposed scheme are presented.

1. INTRODUCTION

In the boiler the fuel mixed with the air to produce heat energy. Water in the boiler tubes utilizes the heat energy to produce steam. In a thermal power plant the turbine is rotated with high pressure and high temperature steam. Steam turns the turbine which is coupled with generator, to generate electricity.

The steam Pressure to the turbine has to be maintained constant for all loads. The pressure control in a utility boiler is one of the most important control loops in a power plant. The pressure control system consist of airflow and the fuel flow control loops that are driven by the firing rate demand signal through master steam pressure controller. Existing PID (Proportional – Integral – Derivative) controller is simple in structure and dependable to certain

extent in performance. But they are not generally tuned for dynamic conditions which are not an easy task and are also time consuming.

Takao Sato et al [1] proposed a new design method of a pressure control system in a furnace of a thermal power plant boiler. To improve the control performance of the pressure control system in a furnace controlled by using self-tuning I-P controllers, a feed-forward compensator is introduced. Simulation results are illustrated to show the effectiveness of the method.

Geete.A et al [2] developed correction curves for power and heat rate are generated. The thermal power plants are designed based on required conditions, but actually inlet conditions are not as per the designed conditions. Variations in the power outputs from power plant are always a matter of disputes. So correction curves for power and heat rate are generated. In their paper, the thermodynamic analysis of 120 MW thermal power plant were done at particular inlet pressure (124.61 bar) and at different inlet temperatures (507.78 °C, 517.78 °C, 527.78 °C, 537.78 °C, 547.78 °C, 557.78 °C, and 567.78 °C). The correction curves for power and heat rate have been generated for combined effect of inlet pressure and different inlet temperatures.

Ma Su-xia et al [3] designed software for static behaviors of circulating fluidized bed boiler to provide precious technical support for optimization operation of the boiler, and provide technical methods for the development of

advanced circulating fluidized bed combustion technology.

Yinsong et al [4] introduced a nonlinear model combining boiler-turbine-generator dynamic characteristics for a thermal-power-generation unit. Based on the nonlinear model, a new coordinated control design was proposed using the backstepping method incorporating the coordinated passivation approach that considers the entire boiler-turbine-generator system as a whole.

Al-Awami et al [5] proposed Coordinated trading of wind and thermal energy to mitigate risks due to those uncertainties and they obtained the optimal trade-off bidding strategy that maximizes the total expected profits while controlling trading risks.

Yinsong et al [6] first introduced a nonlinear model combining boiler-turbine-generator dynamic characteristics for a thermal-power-generation unit. Based on the nonlinear model, a new coordinated control design is proposed using the backstepping method incorporating the coordinated passivation approach that considers the entire boiler-turbine-generator system as a whole.

Selwin Mich Priyadharson et al [7] proposed with the design of behavior response computation based approach to get the optimal controller parameters for the combustion control of utility boiler. A separate control scheme was developed for Fuel and Air system based on many steady state and dynamic behavioral responses.

At present there has been growing concern about the effect on the dynamic stability of thermal power plant. Some possible major changes are a fault in the equipment such as a generating unit, or sudden application of a major load. Performance of the boiler reduces[8-12],

due to poor combustion, heat transfer fouling and poor operation and maintenance. Hence it is necessary to obtain good performance which is also needed for energy conservation in power industries.

In order to enhance the performance, a responses based approach for pressure control and to get the optimal parameters for PID controller has been proposed.

The present paper is organized as follows: Section 2 deals with real time responses for deferent load conditions. Section 3 deals estimation of optimum parameters[13-18]. Section 4 describes the simulation studies of proposed controller. Section 5 presents the comparison of performances and gives the conclusions.

II. REAL TIME RESPONSES

For the present work, many real time responses for pressure control with respect to steady state and dynamic states were obtained from thermal power plant during real time operation[19-22]. When load increases, the turbine first stage pressure increases and turbine inlet pressure decreases. In order to keep the turbine inlet pressure at the desired value, corrective action for air and fuel flow is achieved smoothly by the controller.

Fig. 1 shows the open loop behavior for change of fuel flow in the negative direction from 100% to 95%.

Drum pressure takes long time to reach steady state value than fuel and air flow[23-28]. This effect is because of shrinking and swelling action of the water inside the drum.

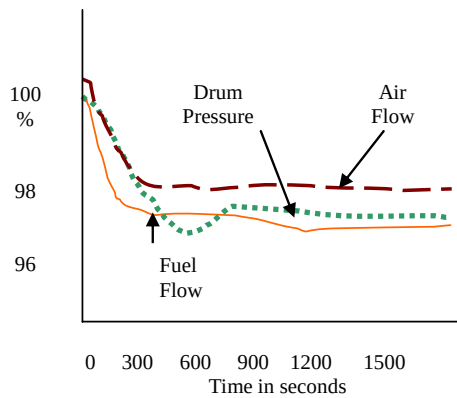
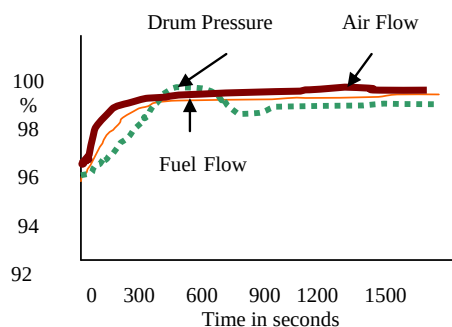
Fig.1. Open Loop (Δ fuel flow 100% to 95%)

Fig.2 shows the open loop behavior for change of fuel flow in the positive direction from 95% to 100%[29-34]. Airflow also follows the fuel flow to maintain required excess air for complete combustion.

Fig.2. Open Loop (Δ fuel flow from 95% to 100%)

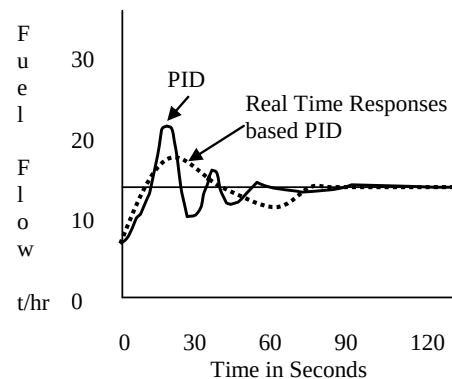
III ESTIMATION OF OPTIMUM PARAMETERS

After obtaining the real time responses from power plant, real time simulations were carried out, by imitating all the above-mentioned cases, on the lab scale experimental set-up for fuel and airflow[40-45]. Responses for different load conditions (10 to 20, 20to30,-----90-95 & 95-100MW Positive and Negative directions) were experimented in the lab. Finally, one average optimal PID controller parameter, which

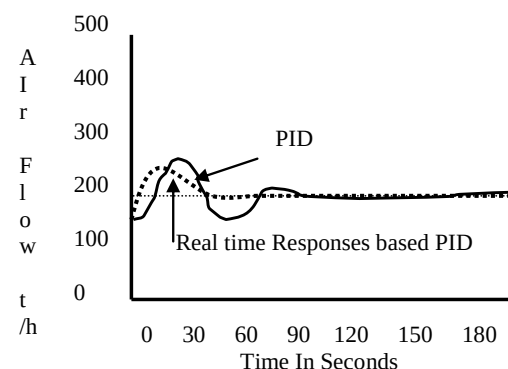
will mimic almost same way for all the types of real time dynamic behaviors was found out[35-39]. The average optimum PID parameters obtained for air and fuel flow controllers suitable for any kind of dynamic behavior is obtained as K_P , K_I & K_D for fuel controller are 1.85, 1.2 & 0.4 and K_P , K_I & K_D for air controller are 1.65, 1.1 & 0.4.

IV. SIMULATION STUDIES

Using the average optimum PID parameters obtained for air and fuel flow controllers suitable for any kind of dynamic behavior several experiments were conducted on the experimental set-up and the performances for all load conditions were studied.

Fig.3. Fuel flow response
LOAD 21MW-42MW

The responses obtained for positive and negative step change in load are shown in Figs. 3-4.

Fig.4. Air Flow Response
Load 21MW-42MW

V. CONCLUSIONS

Time-domain performance specifications were compared with conventional PID and the proposed method for different load behaviors. Proposed method shows better performance than existing and shows 45% improvement in settling time for low loads and 38% improvement in settling time for other loads.

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