Design of temperature and pressure control logic for coal fired fluidized bed boiler on DCS

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The paper deals with control logic's developed for compartments-1 and 2 according to temperature and pressure limits that exist in coal fired fluidized bed boiler-5 of captive power plant. The control logics have been implemented on-line by using the capabilities of TDC-3000 DCS supplied by Tata Honeywell, Pune, India. The ranges of temperature and pressure have been studied for the optimum utilization of the fluidized bed boiler. The operation of logics and its implementation are also discussed. This has helped in reducing the coal consumptions, which has improved the overall productivity.

Keywords: Coal fired fluidizer bed, Bed boiler, DCS

Introduction

In captive power plant coal-fired boilers are most widely used. It is summarized in the literature that the FBB will command more than 50 per cent of the new market for industrial boilers. To get the efficiency of the boiler and for the optimum utilization of fuel, a combustion strategy is most widely used. The combustion control basically involves the proper amount of fuel and air in order to generate tremendous amount of heat for producing steam especially today because of higher cost of fuel and tighter control on air emissions to check the pollution, efficiency in combustion control is an absolute necessity1. A case study on design and troubleshooting of the boiler has been given by Parthibanand and Jhunjhunwala2. Biggs et al.3 have developed a model to address optimization of overhauls by identifying the risk of failure associated with maintenance, operation, and engineering practices applied to steam turbines for pulp and paper industry.

For the past 50 y, rising labor costs and increasing global competition have demanded greater industrial efficiency and product quality. These demands fostered the development of complex processes that required distributed control system (DCS) to run them. Today, DCS has achieved the global acceptance and is essential for the success of any plant operation. Thus, DCS is used for controlling process variables which include combustion control in coal fired FBB because of its fast response, good controllability, and capability to handle complex problems.

In order to control the temperature and steam pressure by limiting the firing of the fuel and air control logics have been developed by using the capabilities of the TDC-3000 DCS supplied by Tata Honeywell, Pune,4. The process instrumentation (PI) diagram of combustion control for coal fired FBB is shown in the Figure 1. In the present scheme, if the bed temperature is within the normal bed limits, then the entire controlling is done by the pressure controller, while when the bed temperature exceeds this limit then temperature controller takes care of the control. For this purpose proportional-integral-derivative (PID) controller has been developed in the

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TDC-3000 DCS. The outputs of both (temperature and pressure) controllers are going in the selector switch, developed in DCS. The output of the selector switch controls the speed of the fuel feeder. The control logic to achieve the above conditions has been discussed earlier and is given below:

**Design of Control Logics**

The control logic's for combustion control has been developed for the boiler number-5 of the Century Pulp and Paper, Lalkua, Nainital, India. The boiler was supplied by Cethar Vessels Ltd. Some important parameters of the boilers are:

- **Evaporation:** 50 t/h
- **Super heater outlet pressure:** 62 kg/cm²
- **Super heater outlet temperature:** 480°C
- **Feed water temperature:** 170°C
The main fuel used for the boiler is bituminous coal with 50 per cent inert comprising of 45 per cent ash and 5 per cent moisture having a gross calorific value of 3675 kcal/kg.

**Conditions for Logic Design**

- The bed temperature of the operating compartment should be in the range of 800-925 °C.
- The combustion control loop should be bypassed during following conditions.
  1. During the boiler start-up until all the compartments are heated up to a minimum temperature.
  2. When the number of compartments in operation are less than or equal to two.
- During the turn down of compartments for the purpose of matching of the steam demand the combustion control loop should be limited to minimum two-compartment operation.
- For minimum and maximum heat output value (based on steam flow, pressure and temperature) the airflow value required is fixed and the same is taken from the literature supplied by boiler manufacturer.
- When the boiler heat output varies (between minimum and maximum), accordingly the airflow also varies. The rpm of the feeders is to be adjusted to maintain the bed temperature within the range of 800-925 °C, based on the signal from steam pressure controller. The bed temperature readings in the operating compartments may be averaged for this purpose. However, if the temperature difference between the readings of the thermocouple of the same compartment is more then 100 °C the reading of the thermocouple indicating lower temperature is not considered.
- Conditions of output selector switch are:
  1. When the bed temperature is above 950 °C, fuel feeder should trip.
  2. If bed temperature is less than 800 °C the speed of the fuel feeder increases by 10rpm repeatedly after every 30 s, until a bed temperature of 800 °C is attained.
  3. If bed temperature is above 925 °C the speed of the fuel feeder decreases by 10rpm repeatedly after every 30 s, until a bed temperature of 925 °C is attained.
  4. Output selector switch logic selects the maximum output when demand is high or bed temperature is between 600-830 °C or both the conditions exist.
- Under normal conditions, steam pressure controller controls fuel feeder and feeder speed depends upon steam pressure deviation.
- Airflow controller accept signal from the airflow transmitter, which acts as process value and heat output value (depends upon steam flow) as set point. The output of airflow controller is fed to power cylinder to open/close forced draft (FD) damper in order to match with required airflow.
- If the bed temperature exceeds 925 °C the airflow controller gets isolated and airflow selects the maximum flow in order to cool the bed.
- The slumping or reactivation of a compartment is done on the basis of airflow and steam flow. The reactivation of compartment is done automatically only if the temperature of the compartment to be reactivated is more then 600 °C, else the reactivation of compartment should be done manually.
- The slumping sequences of the compartments are:
  1. Reduce fuel feeder rpm to zero.
  2. After 1 min, close fluidizing air damper of the compartment to be slumped.
  3. Open the fluidizing air dampers.
  4. The coal feeders shall be switched on only after the bed temperature reaches 600 °C in the compartment during the compartment cut in logic. The feeder should be started from starter.

On the basis of above conditions control logic’s has been developed and implemented on DCS.

**Control Logic-1**

The control logic (Figure 2) for compartment-1 has been developed to control the speed of the fuel feeder according to variation in temperature and pressure conditions. After implementation of the logic-1, it has been observed that:

- If the temperature of the compartment is greater than or equal to 650 °C, but less then 785 °C and
compartment-1 is open then the selector switch will be in manual mode, otherwise it will be in cascade mode.

- If the temperature is greater than 925 °C then also selector switch is in manual mode. This shows that fuel feeding will be minimum, i.e., 200 rpm.
- If the temperature is < 800 °C or > 910 °C then temperature controller (05SW001.S2) controls the fuel feeding.
- If compartment temperature falls below 785 °C then SO6 will be high the speed of the fuel feeder (05SW001.OP) will become maximum, i.e., 70 per cent.
- If compartment temperature is between 800-925 °C then pressure controller controls the fuel feeding.

Control Logic-2

The control logic-2 (Figure 3) has been developed to control the speed of the fuel feeder according to the variations in the temperature and pressure conditions. After implementation of the logic-1, it has been observed that:

- If temperature of the compartment-2 is ≥ 650 °C but < 785 °C and compartment-2 is open then selector switch will be in manual mode otherwise it will be in cascade mode.
- If temperature of the compartment-2 is > 700 °C but < 785 °C than the fuel feeding will be maximum.
- If the temperature of the compartment exceeds 925 °C than the process engineer does the fuel feeding manually.
• If the temperature of the compartment is > 800 °C but < 925 °C then pressure controller controls the fuel feeding.

• If the temperature of the compartment-2 is between 650-785 °C then temperature controller controls the fuel feeder.

Results and Discussion

The control logic-1 and 2 have been implemented and tested online and it has been observed that the developed logics were able to control the compartment bed temperature within the normal limits, i.e., 800-925 °C. It is also observed that if the compartment 1 is open and temperature of the compartment 1 is below 800 °C then temperature controller controls the fuel feeding and as soon as the temperature exceeds 800 °C then pressure controller controls the fuel feeding. If the temperature is above 925 °C then fuel feeding is 200 rpm. Similarly, for compartment 2 if the bed temperature is below 785 °C then temperature controller controls fuel feeding and at this moment speed of the fuel feeder is maximum, i.e., 750 rpm. The above results indicate the successful implementation of the control logics for compartment 1 and 2.

Conclusions

From the above discussions on control logic for compartment-1 and 2, the following conclusions are drawn:

• The developed logics were able to maintain the temperature of the bed between 800-925 °C. Between 800-925 °C, pressure controller was able to control the fuel feeding.

Figure 3 — Compartment- 2 fuel feeder speed control logic
• If the temperature of the bed exceeds 925 °C, then temperature controller takes the charge and at this instant the speed of the fuel feeder reduces to zero, so that temperature of the compartment can come down.

• If the bed temperature is below 785 °C then fuel feeding is maximum, so that temperature of the compartment can increase. This has helped the engineer to maintain the bed temperature within the limit, thereby increasing the life of the boiler.

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References


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