BOILER CONTROLS & INSTRUMENTATION

PRESENTED AT
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MAJOR CLOSED LOOP CONTROLS IN BOILER

- DRUM LEVEL CONTROL
- PUMP ON-OFF CONTROL (USED ON PACKAGED SATURATED STEAM BOILERS)
- SINGLE ELEMENT DRUM LEVEL CONTROL (USED IN SMALL & PACKAGE BOILERS WITH ECONOMISERS OPERATING AT LOW PRESSURE)
- THREE ELEMENT DRUM LEVEL CONTROL (USED IN HIGH PRESSURE LARGE CAPACITY BOILERS)
ON-OFF LEVEL CONTROL

SIGNAL TO START THE PUMP

SIGNAL TO STOP THE PUMP

MOTOR

FEED PUMP
IN A SINGLE ELEMENT CONTROL, THE LEVEL TRANSMITTER ON THE STEAM DRUM WILL TRANSMIT THE LEVEL SIGNAL TO THE CONTROLLER. LEVEL CONTROLLER COMPARES THIS SIGNAL WITH THE SET POINT AND SENDS AN OUTPUT SIGNAL TO THE FEED WATER CONTROL VALVE TO OPEN OR CLOSE TO INCREASE OR DECREASE THE FEED WATER FLOW TO THE BOILER.
WHY THREE ELEMENT CONTROL?

- In high pressure boilers, when the steam demand of the boiler increases suddenly, the withdrawal of steam from the steam drum will be higher than the steam generation as combustion control will take some time to react and increase the fuel heat input to the boiler. This will result in drum pressure falling temporarily. This loss of pressure will result in the formation of steam bubbles in the drum water due to the enthalphy difference between the two pressure levels.

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WHY THREE ELEMENT CONTROL?
CONTINUED

- This bubbling in the drum water will result in foaming and increase in the volume leading to the level going up spuriously. The level transmitter will transmit this increase in drum level to the controller leading to reduction in feed water flow instead of increasing the feed water flow due to higher demand on boiler. To avoid such a wrong control 3 element drum level control is required.
THREE ELEMENT DRUM LEVEL CONTROL

- IN THIS THE DRUM LEVEL CONTROLLER IN ADDITION TO RECEIVING THE DRUM LEVEL SIGNAL, WILL ALSO RECEIVE THE STEAM FLOW AND FEED WATER FLOW TRANSMITTER SIGNALS. HENCE WHENEVER THERE IS A DIFFERENCE BETWEEN THE STEAM AND WATER FLOW, THE CONTROLLER WILL APPLY SUITABLE CORRECTION TO ITS OUTPUT SIGNAL TO THE FEED CONTROL VALVE. THIS TYPE OF CONTROL WILL KEEP THE DRUM LEVEL CONTROL TO FUNCTION CORRECTLY EVEN WHEN THE BOILER LOAD CHANGES.
3. ELEMENT DRUM LEVEL CONTROL
FLOW COMPENSATIONS

- In case of flow measurements for compressible fluids (steam, gas), the density will change due to change in pressure and temperature of the medium. In such cases both the pressure and temperature of the fluid also shall be measured to apply the density correction for the flow measurements. For example in a three element drum level control, the controller will also need the steam pressure and temperature signals to correct the steam flow. Without this the control will go wrong.
SUPER HEATER STEAM TEMPERATURE CONTROL

IN BOILERS WITH HIGH SUPER HEAT TEMPERATURES IT IS NECESSARY TO PROTECT THE DOWN STREAM EQUIPMENT LIKE STEAM TURBINE FROM LARGE VARIATION IN TEMPERATURES. ALSO WITHIN THE BOILER CONTROL RANGE (NORMALLY 60 TO 100 % MCR), THE STEAM TEMPERATURE LEAVING THE BOILER IS REQUIRED TO BE MAINTAINED CONSTANT IN MANY APPLICATIONS. IN INDUSTRIAL BOILERS THE SUPER HEATERS ARE GENERALLY CONVECTIVE TYPE AND HENCE ITS HEAT ABSORPTION WILL GO DOWN WITH BOILER LOAD AND THUS GAS FLOW.
SUPER HEATER STEAM TEMPERATURE
CONTROL-CONTINUED

HENCE THE SUPER HEATER WILL BE SIZED TO GIVE
REQUIRED STEAM TEMPERATURE AT THE MINIMUM
OF THE CONTROL LOAD AND AT FULL LOAD, IF NOT
CONTROLLED, THE SUPER HEATER OUTLET
TEMPERATURE WILL BE MUCH HIGHER THAN
REQUIRED. HENCE SUPER HEATER STEAM
TEMPERATURE CONTROL IS REQUIRED
ESSENTIALLY. THE SUPER HEATER OUTLET
TEMPERATURE IS SENT TO THE CONTROLLER BY
THE TEMPERATURE TRANSMITTER. THE
CONTROLLERS COMPARES THE SAME WITH THE SET
POINT AND GIVES A RESULTANT SIGNAL TO THE
SPARY CONTROL VALVE TO CHANGE THE SPRAY
WATER QUANTITY.
BALANCED DRAFT CONTROL

IN BOILERS PROVIDED WITH BOTH FD AND ID FANS IT IS NECESSARY TO MAINTAIN THE FURNACE DRAFT AT NEAR ZERO PRESSURE. (BETWEEN –5 TO –10 MMWC TO PREVENT FLAME FROM COMING OUT AND INJURING OPERATING PERSONNEL) THIS IS DONE BY THIS CONTROL. THE FURNACE DRAFT TRANSMITTER SENDS THE FURNACE DRAFT SIGNAL TO THE CONTROLLER. CONTROLLER ON COMPARING THE SAME WITH THE SET POINT SENDS AN OUTPUT SIGNAL TO THE PNEUMATIC POWER CYLINDER OF THE ID FAN DAMPER TO OPEN OR CLOSE THE SAME AND THUS CONTROLS THE FURNACE PRESSURE WITHIN LIMITS.

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COMBUSTION CONTROL

THE STEAM DEMAND FROM BOILER VARY DEpending upon change in process requirement or power requirement. The fuel fed to the boiler should be controlled to give the necessary quantity of steam. The steam demand increase or decrease will be indicated by the boiler outlet pressure. Hence combustion control is essentially a control to keep the boiler outlet pressure constant. The steam pressure transmitter in the main steam line sends the signal to the controller which in turn sends an output signal to the feeder motors in the solid fuel fired boilers and to the fuel control valve in the case of oil and gas fired boilers.
COMBUSTION CONTROL FOR SOLID FUEL FIRING
COMBUSTION CONTROL IN OIL AND GAS FRIED BOILERS CAN BE VERY ACCURATE AS IT IS EASY TO MEASURE THE FUEL FLOW ACCURATELY. HOWEVER IN SOLID FUEL FRIED BOILERS, THE FUEL CONTROL IS MORE VOLUMETRIC AND NOT WEIGHT BASIS. IT IS ASSUMED THAT THE DENSITY OF THE FUEL IS CONSTANT AND THE FEEDER IS FULLY FILLED WITHOUT VACCUM. BOTH THESE ASSUMPTIONS ARE NOT EAXCTLY CORRECT. IN MANY SMALL SOLID FUEL FRIED INDUSTRIAL BOILERS THIS CONTROL IS NOT AUTOMATIC BUT MANUAL.
COMBUSTION CONTROL - CONTINUED

Even where the fuel control is automatic, the air flow control will be semi-automatic. The FD fan guide vane/damper will be controlled remotely manually by the operator to match the fuel flow. Only in very large boilers, the air flow control also will be automatic, with the same signal from steam pressure controller going to the actuator of the FD fan damper after getting corrected to the actual air flow signal received from the air flow transmitter.

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DEAERATOR CONTROLS

- DEAERATORS NORMALLY HAVE TWO CONTROLS:
  - PRESSURE CONTROL
  
  This is necessary to maintain the deaeration temperature at the required level to achieve the removal of gases from water. Since in saturated conditions both pressure and temperature are related, the deaerator pressure is controlled instead of the temperature.
  
- LEVEL CONTROL
  
  The deaerator level control is similar to the single element drum level control.
BOILER INTERLOCKS

- IN ADDITION TO CLOSED LOOP FULLY MODULATING CONTROLS REQUIRED FOR THE NORMAL OPERATION OF THE BOILER, INTERLOCK CONTROLS ARE REQUIRED FOR THE SAFE START-UP AND SHUT-DOWN OF THE BOILER.

- THE FOLLOWING ARE SOME OF THE INTERLOCKS USED FOR SOLID FUEL FIRED BOILERS.

1. FD fan can not start without ID fan
2. Fuel flow will not start without FD and ID fans are in operation
3. Standby feed pump will automatically come into operation when operating pump fails
4. Boiler will trip in case of steam drum low level trip switch is activated
5. Boiler will trip if Deaerator low low level switch is activated
6. Boiler will trip is ID fan trips
7. Boiler will trip if instrument air pressure fails.
BURNER MANAGEMENT SYSTEM

- NATIONAL FIRE PROTECTION ACT (NFPA), USA is widely used all over the world with regard to the interlocks required for safe start-up and shut-down of oil and gas fired burners.
- THESE INTERLOCKS ARE TO BE HANDLED BY A SEPARATE PROCESSOR IN THE PLC/DCS AS PER NFPA AND NOT BY THE SAME PROCESSOR WHICH HANDLES THE OTHER BOILER OPEN LOOP OR CLOSED LOOP CONTROLS.
SOME OF THE START-UP PERMISSIVES

1. Oil pressure is not low
2. Oil temperature is not low
3. Fuel gas pressure is not low
4. Fuel gas pressure is not high
5. Instrument air pressure is not low
6. Scanner air pressure is not low
7. Pilot gas pressure is not low
8. Combustion air pressure is not low
9. ID fan is running (Where applicable)
10. Steam drum level not low low
SOME OF THE TRIP INTERLOCKS HANDLED BY BMS ARE:
During the burner start-up, start-up will be aborted when any of the following occurs:
1. Pilot flame is not proved,
2. Main flame is not proved

During operation, the burner system will trip on any of the following occurrence:
1. Flame is not sensed
2. Failure of instrument air pressure
3. Failure of scanner air pressure
4. Drum level low
5. ID fan failure
6. FD fan failure
7. Fuel gas pressure low
8. Oil pressure low
PLC

- PROGRAMMABLE LOGIC CONTROLLER:
  - USED MORE FOR INTERLOCKS EVEN THOUGH CAN BE USED FOR CLOSED LOOP CONTROLS ALSO
  - FASTER AND HENCE MORE SUITABLE FOR INTERLOCKS
  - USED FOR CLOSED LOOP CONTROLS ALSO IF THE NUMBER OF CONTROLLERS ARE LESS.
DCS

- DISTRIBUTED CONTROL SYSTEM
- AS THE NAME ITSELF IMPLIES, THIS IS USED WHEN WHEN MANY INDEPENDENT PROCESSES IN A PLANT ARE TO BE CONTROLLED FROM ONE LOCATION
- MORE SUITABLE WHEN LARGE NUMBER OF CLOSED LOOP CONTROLS ARE INVOLVED
- SLIGHTLY SLOWER THAN PLC