

Essential Boiler Instrumentation and Controls

Abstract

Many of the low pressure, old sugar plant boilers are working negligible or no instrumentation. The modern day high pressure boilers which are provided with optimised heat transfer areas for its rated duty require some of the important operating parameters to be controlled closely to maintain a steady output. Though instrumentation is a very vast subject to be discussed, this paper highlights a few of the important instrumentation and control loops that are required for safe, economic and reliable working of the boilers.

Introduction

While it is theoretically possible to operate a boiler with manual control the operator must maintain a tedious, constant watch for disturbances and variations of parameters. Time is needed for the boiler to respond to a correction and this leads to over correction with further upset to the boiler. An automatic controller once properly tuned will make the proper adjustment quickly to minimise upsets and will control the system more accurately and reliably.

Instrumentation systems are provided for the boiler to achieve the following:

1. To measure the actual values of different parameters for which the boiler is designed.
2. Safe working range of the different parameters are maintained.
3. To monitor one or more variables at a time and provide input for automatic control.
4. In case of operator failure to take remedial action for an upset condition, it protects the boiler by alarms and trippings.
5. To provide data on operating conditions before failure of the equipment for analysing the failure.

Special care is required to be taken while selecting the instrumentation for the boiler. Simple auto control loops, avoiding duplication of instruments and selecting proven instruments with the correct operating range forms the basis of the reliable instrumentation. There are many instruments and control loops that are provided for a boiler. Based on the feed backs collected from various operating sugar plants a few of the important protection and controls which are essential are listed below:

Drum level high & low protection

The water level in the steam drum has to be maintained within the desired limits. The reduction of drum level below the low level mark will cause tube failures and level above the high level mark will cause water carry over to the turbine. Hence it is essential to have reliable direct level gauge on both ends of the drum. A low level trip to shut down the boiler in case the water level falls below the allowable limit and a very high level trip

/ alarm has been suggested for all boilers. At present it is noticed that these contacts for the indication / alarm has been taken from the drum level controller, which is not preferred. Due to many reasons if the controller is isolated during operation of the boiler the protection is not available. It is always recommended that a separate level switch be provided for water level low and high alarm and trip.

Furnace temperature probe

The new series of the boilers require controlled start up and loading programme. Most of the manufacturers provide a start up curve which generally gives the rate of pressure increase in the boiler to be followed.

During start up of the boiler adequate steam flow is not established through the superheater. Hence high rate of heat input if provided to the boiler furnace, will result in high furnace outlet temperature of the flue gas causing over heating and tube failure. It is advisable to control the rate of heat input into the boiler and maintain the flue gas temperature leaving the furnace at around 540o C.

A furnace temperature probe is a high temperature thermocouple surrounded by a jacket of a water. Cooling water can be circulate through the jacket to protect the thermocouple from over heating. Once adequate steam flow is established through the superheater there would not be any limitation on the rate of fuel firing.

Temperature probes without cooling water are also available, it requires the thermocouple to be withdrawn when the temperature of the flue gases exceeds 540o C. This thermocouple has an advance and retract mechanism similar to that of a long retractable soot blower. A protection to retract the furnace probe with alarm when the flue gas outlet temperature from furnace exceeds the allowable value, must be provided. This temperature probe is recommended to be installed to avoid, operator failure and ensure protection for super-heater during start-up and shut down. Fig 1 indicates a typical water cooled thermocouple without advance and retract mechanism. As a temporary measure mineral insulated, monel sheathed, 6 mm diameter thermocouple with sleeve capable of measuring maximum of 950o C temperature can be fixed in the furnace outlet zone to monitor the flue gas temperature.

Steam purity

Purity of steam indicates the extent of carry over of salts from boiler water with the steam. Sodium salts in boiler water gets carried over due to various reasons with the steam and deposits in the superheater inner surfaces and turbine blades causing reduction of equipment life and availability of the boiler.

Steam drums are provided with drier box arrangement to avoid carry over. Constant maintenance and inspection of these internals in an essential activity of the boiler operation. The purity of steam should be monitored periodically to improve the

availability of the boiler. The method of obtaining the steam sample plays a vital role in the measurement of its purity. It is recommended that the sampling lines should be of stainless steel and the cooling coils in the sample coolers should be located close to the sampling point to minimise settling and contamination from the sample line.

Sodium tracer technique permits measuring dissolved solids in steam to as low as 0.001 ppm. The operation of a flame photometer is illustrated in Figure 2. The condensed steam sample is aspirated through a small tube in the burner into the oxygen-hydrogen flame. The flame, at about 1700o C, vaporizes the water and excites the sodium atoms, which emits a characteristic yellow light having a definite wavelength. The intensity of the emitted yellow light is a measure of the sodium in the sample. The intensity of the light is measured with a spectrophotometer equipped with a photomultiplier attachment.

The light from the flame is focused by the condensing mirror and is directed to the diagonal entrance mirror. The entrance mirror deflects the light through the entrance slit and into the monochromator to the plane mirror. Light striking the plane mirror is reflected to the fiery prism where it is dispersed into its component wavelengths. The desired light wavelength is obtained by rotating a wavelength selector which adjusts the position of the prism. The selected wavelength is directed back to the plane mirror where it is reflected through the adjustable exit slit and lens. The light impinges on the photomultiplier tube, causing a current gain which registers on the meter. The amount of sodium in the sample is obtained by comparing the emission from the water sample to emissions obtained from solutions of known concentration.

Control loops

For the generation of steam to be continuous, it follows that the control also should be continuous and the needed adjustments for air flow, fuel flow, water flow, etc., should be adjusted simultaneously. Manual control of these variables depends much on the ability of the operator to judge and correct the parameters without too many trial and error operations. Automatic boiler control is the best course of maintaining a steady output from the boiler. Advancements in electronics has made electronic control systems more favourable when compared to pneumatic and other outdated systems. In case of cogeneration plants the complex interdependants of the turbo generator on the boiler to maintain a constant output when paralleled with state power grid would justify introduction of distributed data control system.

A few advantages of the electronic system can be listed as below:

- a. High speed of signal transmission and low time lag.
- b. Possibility for amplification of signal
- c. Easily adaptable to complex and integrated control.
- d. Greater accuracy due to fast response and feed back from more number of interdependent variables.

Electronic control system with final operating element either electric or pneumatic system is preferred as this results in high speed and high motive force. The following are

some of the vital control loops that are recommended for the modern high pressure sugar plant boilers.

Feed water control / drum level control

Maintaining drum level at the normal recommended operating level is very important. Too low a water level can cause starvation in boiler tubes and lead to failures. Too high a level will lead to carry over of boiler water and reduce the steam purity.

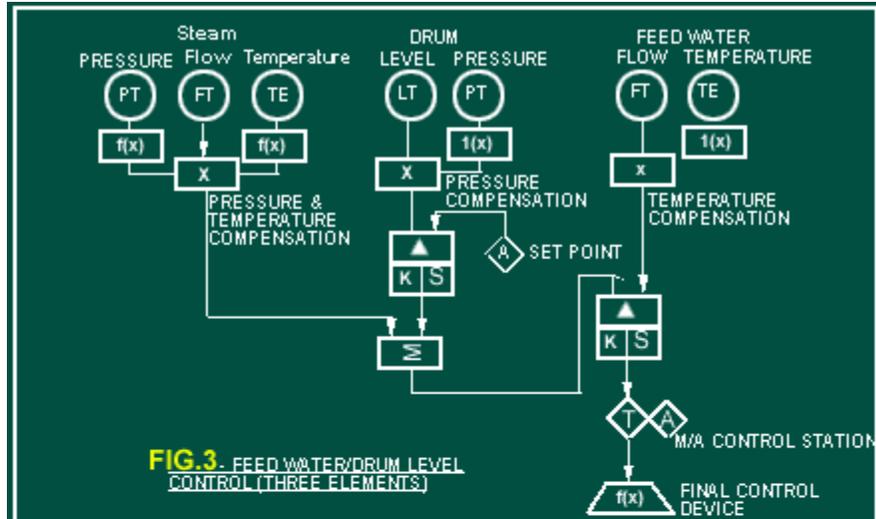


FIG.3. FEED WATER/DRUM LEVEL CONTROL (THREE ELEMENTS)

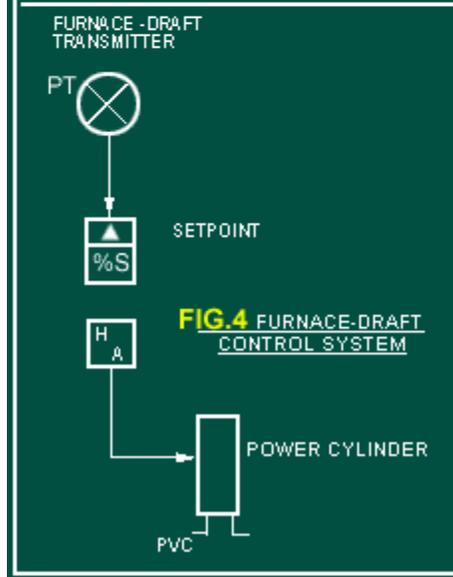


FIG.4 FURNACE-DRAFT CONTROL SYSTEM

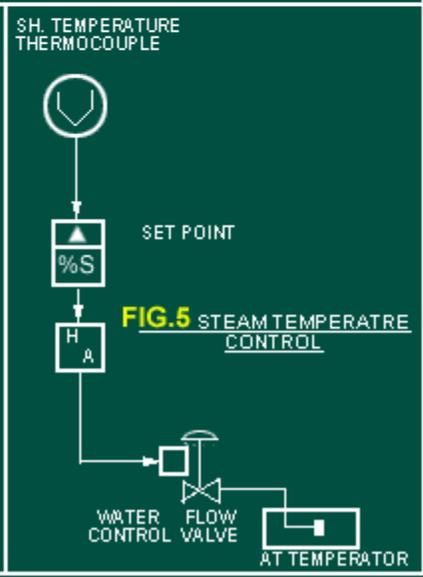


FIG.5 STEAM TEMPERATURE CONTROL

Three element system for drum level control:

Feed water flow to the drum should be continuous, failure of flow even for a brief period can cause serious and hazardous effect on the plant and operating personnel.

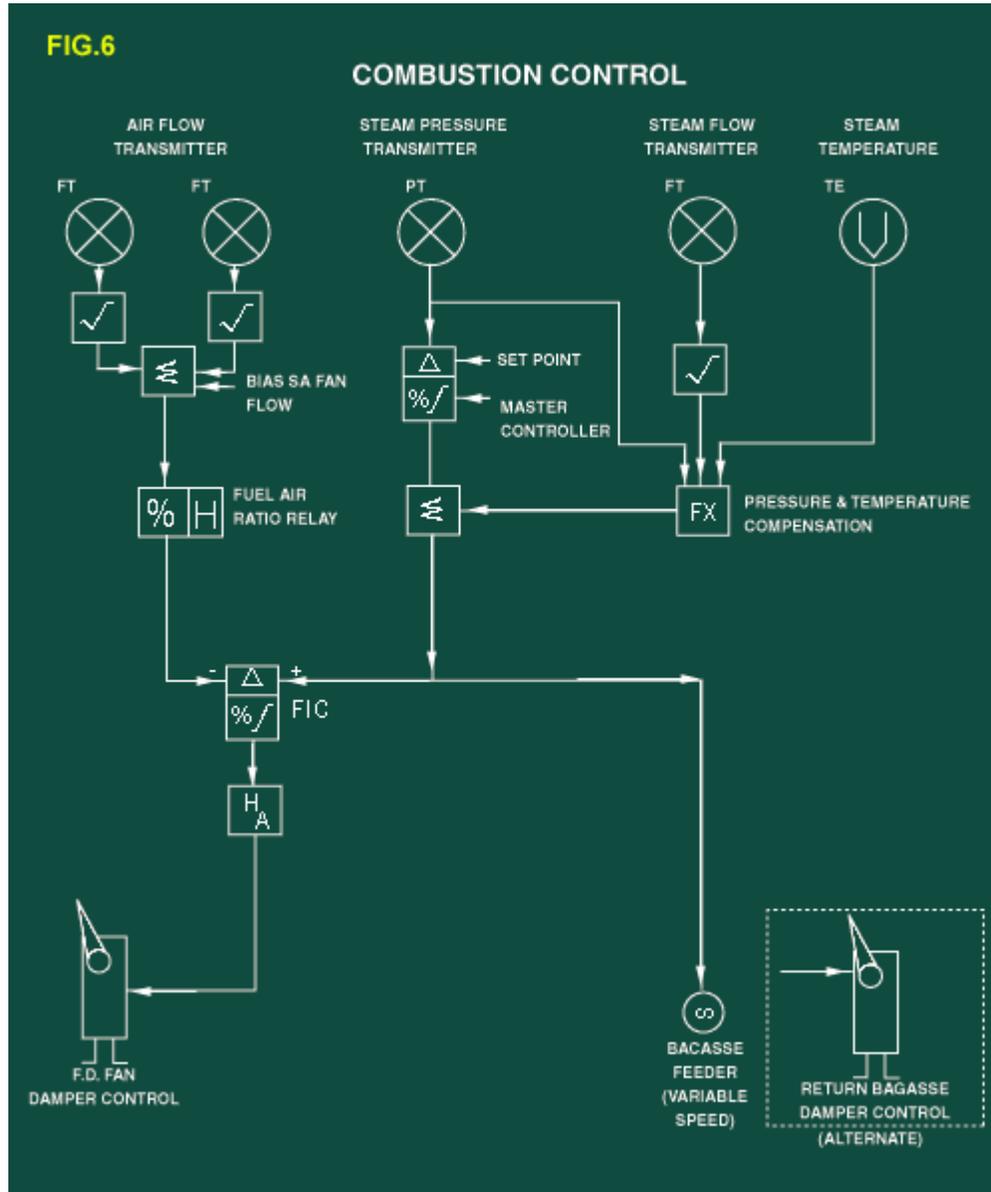
Many of the modern boilers today operate at steam temperatures near the maximum permissible metal temperatures and temperatures fluctuation as a result of poor feed water control can cause damage to the boiler tubes. In the design of the boiler advantage is taken of the high level of performance achieved by high steam release to water ratio. This high ratio calls for a highly reliable water level control.

The three elements employed are drum level, steam flow and feed water flow. In this system (fig 3) the basic control is from the relation of the steam flow to feed water flow. In closed system, under normal steady conditions, with the drum level at the correct value, the ratio of steam flow to feed flow will be 1:1. Any change in this condition will result in a control signal being applied to the feed water control valve. The signal from water level also will affect the readjustment of the feed water valve to trim the level back to its desired value, once stability is achieved. Water flow measurement signal enters the control system to position the regulating valve in the feed water line so that the water input equals the steam output from the boiler. Therefore any variations in feed water pressure ahead of the regulating valve, causing change in water flow will at once be detected by the flow meter and the regulating valve will react.

Furnace Draft Control System

In all the combustion control system, irrespective of the type, an independent control loop is provided to maintain a constant negative draft inside the combustion chamber. Any variation from the set value is detected by the controller, and the resultant output signal directly goes to regulate the position of the I.D fan damper.

Steam Temperature Control System



With the spray attemperation or desuperheater method, fine jets of water on steam condensate is sprayed through nozzles into the steam in its passage between the first and second stages of superheaters. In order to achieve this, the temperature of steam is measured and any variation from a desired value is detected by a controller. The latter then sends out a signal to the regulating valve in the injection line. The system as shown in Fig.5 is suitable for sugar plant boilers where the mass of the superheater and hence, thermal inertia time is small. This greatly minimises the time lag in the heat transfer.

Combustion Control System

The main object of automatic boiler combustion control is to regulate automatically, the heat input to a boiler in terms of fuel and air supplied in relation to heat output or steam demand. This should be implemented as efficiently as possible in terms of combustion quality and furnace stability. Combustion air supplies are to be adjusted with change in boiler loads. Steam pressure is taken as the indication for boiler load as the steam pressure is taken as the indication for boiler load as the steam pressure decreases in increasing load and vice versa. Hence variations in steam pressure is detected and the supply of the fuel and air adjusted accordingly. (Refer Fig.6)

The successful operation of the combustion control system depends upon the capability to vary the fuel supply to the furnace based on the signals from the control system.

To achieve this a system of bagasse storage and retrieval facility with about half an hour holding capacity, should be provided before the bagasse system.

Essential interlocks for Boiler

For safe operation of boiler and auxiliaries even in the event of a failure of the control system it is necessary to provide certain interlocks and trips in the control system.

Boiler trip protection

The sugar plant boiler should be provided with trip facility which will shut down the systems when it receives a trip command for the following conditions or if boiler trip push button provided in the panel is depressed.

- a. FD fan trip / shut down
- b. ID fan trip / shut down
- c. Cogeneration turbine trip
- d. Drum level low / high trip

Some of the essential interlocks recommended for start up of boiler auxiliaries are:

- a. Start ID fan when FD fan and SA fan are off.
- b. Start FD fan only if ID fan is on.
- c. Start SA fan only if both FD and ID fans are on
- d. Start bagasse feeder only if SA fan is on
- e. ID fan is of all fans shall trip.
- f. Trip bagasse feeders when SA fan is tripped.

General

While selecting the various elements for the instrumentation care should be taken to select the correct range. A well engineered system / configuration plays a major role in the availability of the instruments. Staffing of the sugar plant maintenance crew with trained and qualified instrument mechanics is essential for calibration and maintenance of the equipment.