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Boiler Furnace Pressure Excursion and Set Points

Poonam Tanwar,
Sr.Lecturer
Lingaya's Institute of Management &
Technology, Faridaba, Haryana

B.S. Tanwar,
Manager-Control & Instrumentation
ALSTOM Projects India Limited, Noida,
Uttar Pradesh, India

ABSTRACT
There are many important parameters to be monitored during any Power plant normal & emergency operations. Furnace pressure is one such very important parameter, which needs continuous control, protection & monitoring against any furnace explosion and implosion. The National Fire Protection Association (NFPA) codes, such as NFPA 85: Boiler and Combustion Systems Hazards Code are dedicated to fire and furnace explosion and implosion protection. The NFPA also requires some additional logic for the furnace pressure control loop to ensure adequate operating safety margins. There should be high and low furnace pressure logic to block the ID fan from increasing or decreasing speed, as is appropriate. A high furnace pressure signal the fan should be blocked from decreasing speed and on a low furnace pressure signal it should be blocked from increasing speed. A main fuel trip (MFT) there should be MFT kicker logic. An MFT occurs when the burner management system detects a dangerous condition and shuts down the boiler by securing the fuel per NFPA and boiler manufacturer requirements. This paper describe the Furnace explosion , Implosions, Furnace pressure set points, cause and remedies in Coal Based Utility Boiler keeping NFPA-8502 standard into consideration[2,5].

Categories and Subject Descriptors
[**Power Plant Instrumentation**]: Boiler Furnace Pressure Excursion and Set points

General Term
Measurement

Keywords
MFT-Master Fuel Trip

1. INTRODUCTION
Boiler is a major equipment in any Thermal Power Plant, need various control & protection for safeguard of big & complex mechanical component. While designing the boiler great care have to be taken for safety of each component. Control & protection system will take care of any operational mistake and process abnormality. Control system ensure the sequential & safe operation of the boiler. Important parameters to be monitored during any Power Boiler normal & emergency operations. Furnace Pressure is one such very important parameter, which needs continuous control, protection & monitoring. This is very important from safety of the boiler. Why to maintain furnace pressure ? Incase of very low and very high pressure the furnace may subject to explosion and implosion, which may result in Boiler Structure and pressure parts, tubes damage and furnace deformation[2,3].

2. FURNACE EXPLOSION
Furnace explosion is rare, but very severe in nature. This situation exists because furnace is supplied with explosive accumulation. Just a minute part of those explosive charges receive sufficient ignition energy to actually cause an explosion. The Furnace explosion requires both sufficient explosive accumulation and sufficient energy for ignition. The ignition requirements for an explosive charge are very small, making it possible to protect against all possible sources of ignition, such as electricity discharges, hot slag and hot furnace surfaces. So practical means of avoiding furnace explosion is the prevention of an explosive accumulation.
The factor determining the magnitude of furnace explosion (change in composition, mass and reaction time) are related in explosion factors[1].

Explosion Factor = (Mass/Furnace Volume) x Composition Change/Elapsed Time)

Each Furnace has a limiting explosion factor. If the conditions create an explosion factor exceeding this limit, a catastrophic explosion can result. Any lesser reaction will produce a furnace "puff" (sudden increase is pressure i.e nondestructive explosion.) or a temporary upset in furnace pressure. To protect furnace from such incidences a safety system must ensure a minimum reactive mass accumulation and with minimum available composition charges and with maximum reaction time required. Only control of the composition of the furnace atmosphere offers complete coverage in minimizing the explosion factor. After firing has begun, furnace always contain sufficient mass to have an explosion and control of time factor is not possible. Therefore , the composition change must be controlled to prevent furnace explosion.
The accumulation composition, which must be within the limits of flammability for that particular fuel, is formed in one or more basic ways. A flammable input into any furnace atmosphere (loss of ignition). A fuel rich input into an air rich atmosphere (fuel interruption) An air rich input into a fuel rich atmosphere (air interruption) For positive furnace pressure, a value which would be the lesser of either +35"wg or FD Fan test block capability at ambient temperature. For negative furnace pressure, a negative value whose absolute value would be lesser of either the absolute value of -35"wg or the absolute value of ID Fan test block

capability at ambient temperature. Generally following control system set points (‘wg) for furnace pressure are applicable for units with the above design pressure for utility Power Boilers.

- Alarm +3” wg
- Directional Block on FD/ID Fan controls +3”wg
- Master Fuel Trip (MFT) +6”wg
- Trip of FD/ID fans armed after 5-minutes post purge +6”wg

Incase of retrofit boilers projects these values revisited by Boiler manufacturer after RLA test of boiler structure and pressure parts[2,3,4].

The MFT set points are to be accomplished with pressure switches using 2 out of 3 voting logic. Pressure switches and logic should be verified for proper functioning. In accordance with the 1995 revision of the NFPA 8502 standard, it is equally acceptable or better to utilize the furnace pressure transmitters utilized for draft control to generate the set points as above. This also specifies a 2 out of 3 furnace pressure transmitter monitoring system.

The following control system set point for monitoring high excessive wind box/furnace differential pressure, is applicable for boilers with the above design pressure.

Open all the secondary air damper automatically at 9’wg DP.

Now days the MFT also functions to help protect against over pressurization that could be caused by the large fans on present day units. In addition, the MFT set point is now at +6”wg and also functions to indicate a major problem. However , the +6” wg MFT set point should be far enough away from the normal control set point of -0.5”wg so as not to cause nuisance trips.

Generally furnace design pressure is +26”wg for units with fans of less than +26”wg head at specified test block capability. For the units with fans of greater test block, the furnace design pressure is equal to fan test block up to a maximum of 35”wg.

3. FURNACE IMPLOSION

Boilers with both induced and forced draft fans may become unbalanced especially if the forced draft unit becomes tripped and the induced fan unit remains in full operation. The induced draft fan will produce an excessive draft in the furnace and create the real likelihood of furnace implosion. Negative pressure excursion of sufficient magnitude to cause structural damage.

Incase of ID Fan is capable of producing more suction head than the boiler structure is capable of withstanding. Control malfunction and / or operator error, establish such conditions.

The other process called flame collapse or flameout effect. The negative pressure excursion following a fuel trip and loss of furnace flame, in order to realistically evaluate pit falls and prevention techniques. The physical state of the gases in furnace can be described by the perfect gas law as given below.

$PV = MRT$

P = Absolute pressure
V = Volume of system under consideration
M = Resident mass (not mass flow)
R = The universal gas constant
T = Absolute temperature, all in consistent units.

V is fixed and R is approximately constant, so P is directly proposal to product of NT. Thus, for two differential conditions of pressure and temperature in a given boiler system.

$P2/P1 = (M2T2)/(M1T1)$

At steady state operation, P is held constant at approximately atmospheric pressure by balancing the resident mass M and the existing temperature T. Furnace temperature in a boiler is not directly controlled and depend on the thermal balance between the heat in (in the burning fuel and heated air) and the heat out (in the flue gas and heat transferred to the pressure parts). The resident mass is automatically balanced by controlling the flue gas flow out of the boiler to maintain a given furnace pressure. When the fuel input is terminated, this balance no longer exists. The flue gas being pulled out f the furnace by the ID fan is now being replaced only by preheated air rather than by the products of combustion in the firing zone. The average temperature of the gases resident in the furnace (or other subsystem) at any given time following fuel trip will decrease rapidly. Because of the temperature drop, the pressure in the furnace starts to decrease.

If M were to remain constant in quantity , the absolute pressure in the furnace will drop indirect proportion to the absolute temperature drop. The air flow through the wind box will increase because the lower furnace pressure appear to the FD fan to be reduced system resistance. The flue gas flow will decrease because of the lower furnace pressure appear to the ID fan to be an increased system resistance. This natural corrective action taken by the FD and ID fan is the key ingredient in the ability to contain furnace pressure excursion to values that are within tolerable limits [1,3,4,5]..

- Alarm -4” wg
- Directional Block on FD/ID Fan controls -4”wg
- Master Fuel Trip (MFT) -7”wg
- Trip of FD/ID fans armed 20-sec. after MFT -9”wg

There are high and low furnace pressure logic to block the ID fan from increasing or decreasing speed, as is appropriate. A high furnace pressure signal the fan should be blocked from decreasing speed and on a low furnace pressure signal it should be blocked from increasing speed. A main fuel trip (MFT) there should be MFT kicker logic. An MFT occurs when the burner management system detects a dangerous condition and shuts down the boiler by securing the fuel per NFPA and boiler manufacturer requirements[1,5]..

The MFT set points are to be accomplished with pressure switches using 2 out of 3 voting logic. Pressure switches and logic should be verified for proper functioning. In accordance with the 1995 revision of the NFPA 8502 standard, it is equally acceptable or better to utilize the furnace pressure transmitters utilized for draft control to generate the set points as above. This also specifies a 2 out of 3 furnace pressure transmitter monitoring system. The high furnace vacuum MFT set point of -7”wg is appropriate as it is far enough away from the normal control point of -0.5”wg to indicate a major problem (unless there is MFT with its resulting negative furnace pressure excursion, the furnace is not expected to be at -7” wg), but not to cause nuisance trips. The gap between the -7”wg and the yield point should be considered as additional margin which allow for correction of negative furnace pressure excursions that occur with MFT trip that are initiated at -7"wg[1,2,3]..

4. Advantages

- Saving in instrumentation as same pressure transmitters can be used for control and 2 out 3 voting by defining threshold values for furnace protection against pressure excursions.
- The gap between the negative and positive furnace pressure trip set point. which allow for correction of negative and positive furnace pressure excursions that occur with MFT trip.

5. CONCLUSIONS

It is essential therefore, that protective control system for large, high draft–loss boilers be properly designed, installed, tested and maintained, and the Boiler operation engineer should consider these control systems to be vital. Furnace pressure excursion can not be avoided fully but can be minimized by preventive or correct boiler unit operation. The set points depend upon the boiler manufacturer, boiler type, Fan selection and health of the boiler, if it is retrofit project[1,2,3]..

6. REFERENCES

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[2] M/s NTPC Tanda Project (4x110 MW) site visit and Retrofit project execution in year 2008-09

[3] M/s HINDALCO Industries-RPD (2x278 TPH) site visit and Retrofit project execution in year 2004-05.

[4] M/s APGENCO Boiler visit after furnace excursion in year 2003-2004.

[5] ALSTOM Power Inc. (Formerly known as Combustion Engineering USA), reference documents and learning from various projects.