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Survey on Start-up Operation Procedure for Indian Fluidised Bed Combustion (FBC) Boilers/Heaters

Amit Goraksh Avhad

Lecturer at Indira Institute of Aircraft Engineering, Hadapsar, Pune, Maharashtra, India.

ABSTRACT

This article briefly discusses about the standard practices which have been followed for firing start-up operations for FBC Boilers by Engineers and Operators. These procedures have been practiced by the author personally while he operated several Atmospheric Fluidised Bed Combustion (AFBC) Boilers ranging from capacities 2 Tons per Hour (TPH) to 30 TPH. In addition, elaborated details on the reasons for clinker formation have also been accounted which forms one of the major difficulties encountered by Boiler Operators.

Keywords: AFBC, Operations, Indian, Boilers/Heaters.

1. INTRODUCTION

The methods of combustion employed in the boilers vary depending on factors such as fuel used, type of boiler, capacity of boiler in terms of TPH etc. Among the several methods are- Hand Fired over Static Grate or Mechanical stokers such as Low Ram, Chain Grate, Travagrate, etc. In boilers having large capacities, i.e. 30 TPH and over, pulverized fuel is combusted through a jet of air in specific burner. One of the popular and efficient method of combustion used in today's boilers/heaters is the concept of Fluidised Bed Combustion (FBC). A descriptive feature for the popularity of FBC technology is it can work efficiently with low grade coal quality for example Indian Coal, which generally has very high ash (up to 70%) and high moisture (up to 40%).

With the help of air jet, solid particles can be carried. The movement of solid particles depends primarily on the velocity of the stream of the air within the enclosure. Likewise, the air will just seep out through a bed of sand because of the porosity of sand bed when the velocity of the air stream is low, while, if the velocity is increased beyond the minimum fluidization velocity then the particles can be transported. Therefore, a specific velocity is determined – when the particles freely move in the bed as fluid behaves and frequent collision with each other. With this application, the sand bed particles are raised similar in appearance as of the bubble formation from beneath. This bubbling of air through sand causes mixing and thus the bed is recognized as bubbling bed or fluidized bed. The fluidized bed exhibits a few properties as liquids do-

- The bed levels itself within the compartment.
- Objects when placed in the bed will either stay over the top or sink in the bed depending on its density.
- Addition of solid powder material gets distributed uniformly.
- The heat gets uniformly transferred throughout the bed when generated within a specific part.

The technology of FBC has been used in the Chemical Engineering and processes for long time but its use in combustion has begun since last twenty years. While using the phenomenon of FBC in boilers and heaters, a fuel like coal, husk is continuously fed to the sand bed which is maintained at a temperature higher than required to ignite the fuel, which keeps the combustion self sustained. With control of air stream, velocity of air, its turbulence, feed rate of the fuel, high temperatures and efficiency can be achieved. This control of abovementioned properties if properly cared then the problem of clinker formation, fusing of sand and fuel to stones, can be avoided.

2. OPERATIONS

2.1. Start up/ Firing Procedure for AFBC boiler/heater bed.

2.1.1 Initially charge sand of size- 14 to 30 mesh, density-1200 to 1300 kg/m^3 in the furnace chamber. Make bed about 8 inches deep with uniform level. Let Forced Draft (FD) fan be ON in order to achieve levelling.

2.1.2 Later add up to 15 kg of charcoal per m^2 of bed area which is wetted with either kerosene or diesel. Repeat the addition process once again and let the charcoal be distributed equally.

2.1.3 Ignite the bed and allow the fire to spread completely.
2.1.4 After there is complete fire, start the Induced Draft (ID) fan, with control damper of the ID fan positioned to maintain 100-150 mmWC to keep bed bubbling.
2.1.5 Charcoal burns thus heating the bed and raising the temperature. Add next charge of dry charcoal around 10 kg per m^2 of combustion bed area.
2.1.6 Let the temperature rise gradually. With rise in the temperature the sand bed starts appearing like red lava.
2.1.7 Similarly, raise (increase) Dampers for ID and FD Fan gradually in order to enhance combustion and balance the draught pressure in the furnace 0 to – 6 mmWC. Meanwhile, also have a note of O_2 level in the flue gas. Keep the O_2 level for flue gases below 8%.
2.1.8 When temperature rises to and above 500°C fuel through feeders can be further charged either by screw feeders, rotary feeders etc. During this whole time always inspect the bed condition for bubbling and proper fluidisation. If minor clinkers appear to form immediately remove them out as these may further continue grow bigger in size, thus making the complete bed inoperative.
2.1.9 Initially the fuel feeders must be operated at lower rate. Keep maintaining the draught pressure in the furnace and within the plenum chamber of the boiler.
2.1.10 At the time when temperatures reach 700°C, the FD fan and ID fan dampers need to be adjusted for a consistent and uniform operation ahead.
2.1.11 The adjustments of FD fan and ID fan dampers are to be made strictly based on furnace draught pressure and air flow quantity.
2.1.12 The bed temperatures needs to be maintained between 700- 800 °C for the normal operation.
2.1.13 There is a possibility that bed draught is low and also the O_2 in flue gas has fallen below 5%. At such times FD fan, which circulates the fresh air, needs increase in damper position. Furthermore, when O_2 level in flue gas is maintained around 8% then check bed plenum chamber draught pressure. Maintain this draught pressure up to 380 mmWC and if need arises charge or drain sand in bed to adjust the plenum chamber draught.
2.1.14 Major controlling factor at this stage is the fuel feed rate and then controlling must be for FD, ID, Secondary fan.
2.1.15 With daily shift wise maintenance tasks the boiler can run repeated for long duration like months. Operations parameters which are monitored and controlled need to be recorded on hourly basis.

2.2. Stopping of Boiler/ Heater

In order to stop the Boiler/ Heater always follow the sequence mentioned-

2.2.1 Stop the Fuel feeder.
2.2.2 Wait until the furnace temperature falls below 600°C. Switch OFF the ID, FD fan.
2.2.3 Furnace doors must be kept open to cool the furnace by natural circulation.

2.3. Clinker formation

Clinker forms in the boilers and heaters bed by the fusion of sand materials together into large blocks like stones. These impede the free flow of the air into the furnace and also the fuel remains un-burnt. The clinker once formed, no matter how small in quantity, keeps on adding and growing in size until all free sand is coagulated. Reasons for clinker formation are-

2.3.1 Nozzles through which FD air enters have blocked.
2.3.2 The ash softening or melting temperature limit is low.
2.3.3 The rate of fuel feed is high.
2.3.4 The fuel size is either more than 25 mm or there is very high percentage of powder (fines) fuel in the fuel.
2.3.5 When the fuel fed is not spread uniformly and there is concentration of fuel at certain area, then bed temperature rapidly rises at this location which further transcends softening temperature. The temperature sensors are not placed at proper position or damaged, thus giving incorrect data for operations control.
2.3.6 Inordinate usage of charcoal during start-up and less air supply.
2.3.7 As mentioned in the Start-up procedures earlier, if fuel feed rate initially isn't low then there is possibility that fuel gets aggregated due to slow combustion and lower temperature during start-up.
2.3.8 Initial smaller clinkers neglected.

When precautionary measures like regular inspection, control parameters record maintenance, bed material drain and charge and avoidance of abovementioned points are carried then the probability of clinker formation and breakdown can be avoided.

3. CONCLUSION

Comprehensive discussion on the Start-up procedures, Stopping, Clinker are very beneficial to amateur boiler/ heater operators and engineers looking forward to work with Fluidized Bed Combustion Boilers/ Heaters. These procedures have been developed by professional operators of AFBC boilers. Although in today's times, most high capacity boilers/heaters have advanced operations methods like SCADA, PLC which are programmed to automatically control many parameters based on current data, this basic knowledge is primarily important to understand the working of any FBC system. I have personally worked with several makes of FBC boilers and heaters all of which need this basic knowledge of operation apart from knowledge of boiler, heater, auxiliary equipments, instruments etc. found in the complete Heating system.

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AUTHOR

Amit G Avhad, completed B.E. Mechanical from Government College of Engineering & Re., Avasari, Pune in 2013. Has worked as Site Engineer, with Thermax India Ltd, where he Supervised the Operations & Maintenance activities at different sites having boilers ranging from capacity- 2 Tons per Hour to 30 Tons per Hour and Thermic Fluid Heaters of capacity 10 Lac kCal. Has expert knowledge of Boiler operations, specifically AFBC boilers. Currently he is lecturing Diploma students for subjects Thermodynamics, Theory of Machines, Fluid Dynamics, in the Indira Institute of Aircraft Engineering, Hadapsar, Pune.