

Study of Various Processes Used In Coal Based Thermal Power Plants

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Abstract: Thermal power plants are used primarily to produce the electricity by using multiple types of fuels (Coal/Lignite/Naphtha and Gas based, MSW non-hazardous waste and other fuels except biomass). The study focuses on the various techniques used in the Coal-based Thermal Power Plants.

Here, the suitability of different methods of thermal power plants have been discussed along with their advantages, and disadvantages. For coal-based TPP, mainly two processes are there, i.e. Pulverized Coal Combustion and Fluidized Coal Combustion. It is found that in India most of the thermal power plants work on Pulverized Coal Combustion technique.

Keywords: Coal based, Power, Energy, Power Plants

1. INTRODUCTION

Energy and Power: Energy has been an indispensable part of our lives since the ancient times and in the future, our lives will even be more dependent upon energy.

Energy is of different variety, i.e., Mechanical, Electrical, Work, Heat, and Radiation. The thermal power plant uses thermal/heat energy to produce electricity from thermal energy.

Thermal power plants produce electricity using different types of boilers. Broadly, there are two technologies employed in the coal-based thermal power plants, i.e. Pulverized Coal Combustion and Fluidized Bed Combustion (FBC).

Pulverized coal combustion can be further categorized into Sub-critical, Super-critical, Ultra-super critical, Advanced Ultra-supercritical.

FBC can be categorized into Circulating FBC and Atmospheric FBC.

Suitability of these techniques can be decided on the basis of principles, as discussed later in this study.

2. THE OBJECTIVE OF THE STUDY

The objective of this study is to assess the applicability of various techniques of coal based thermal power plants operations and to arrive at the best suited method for the same.

The assessment criteria for the techniques are discussed here.

3. TYPES OF COAL COMBUSTION TECHNIQUES

There are mainly two types of coal combustion techniques, which are used in the thermal power plants.

These are:

1. Pulverized Coal combustion
2. Fluidized Bed Coal Combustion

3.1 Pulverized Coal Combustion

Pulverized coal combustion is the method in which pulverized coal (finely ground) is used in the boiler as a fuel and the powder is burnt in the combustion chamber.

In this technique, the pulverized coal is directly ingested into the boiler's burner. Here, it is mixed with the pre-heated combustion air and is thus, forced out of the nozzle.

The concept involved here is that the pulverized coal burns as smoothly and efficiently as a gas.

Pulverized coal power plants are further classified into four types:

- Subcritical Pulverized Coal (Sub-CPC) Plants,
- Supercritical Pulverized Coal (SCPC) Plants,
- Ultra-Supercritical Pulverized Coal (USCPC) Plants
- Advanced Ultra-Supercritical (Adv. USC).

Table 1: Classification of Pulverized boiler techniques

Plants	Main steam pressure, MPa	Main steam Temperature, °C	Reheat steam temperature, °C
Sub-critical	<22.1	Up to 565	Up to 565
Super-critical	22.1-25	540-580	540-580
Ultra-supercritical	>25	>580	>580
Advanced-ultra-supercritical	310	710	720

The four types of pulverized coal boilers are differentiated based on their operating temperatures and pressures. As the pressures and temperatures increase, the operating efficiency moves in the same way.

Subcritical plants operate at about 38.9% efficiency, super-critical plants at 40%, ultra-supercritical plants at

about 42-45% and advance USC plants operate at about 46% efficiency.

This can be better understood by a Real Rankine cycle as given below:

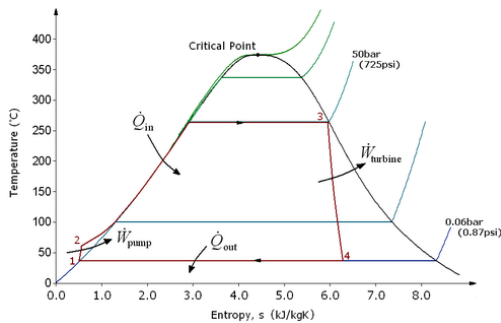


Figure 1: Real Rankine Cycle

Processes involved in Rankine cycles are as follows:

- Steam generation in the boiler at constant pressure.
 - Isentropic expansion in steam turbine
 - Condensation of steam in the condenser at constant pressure.
 - Application of Pressure to the condensate (up to boiler pressure) by isentropic compression.
- Pulverized fuel boiler can be employed to flame all grades of coal ranging from Anthracitic to Lignite. Moreover, it allows combination firing; hence there is a wide-ranging applicability of pulverized coal furnaces. However, there are some disadvantages involved in this process such as relatively high costs, the fouling and slagging of heat-transfer surfaces, and the need for expensive fine-particle-collection equipment.

3.2 Fluidized Bed Coal Combustion (FBC)

Apart from the Pulverized Coal combustion method, other method employed or coal thermal power plants' operations is Fluidized Bed Coal combustion (FBC).

The fluidized bed is made up of ash and other particular matter. A jet of air is blown from the lower side of fluidized bed over which the fluid particles remain in the suspended position. The jet of air provides oxygen required for the combustion of solid fuel. This results into fast and efficient mixing of gas and solid particles which promotes rapid heat transfer and the chemical reactions occurring inside the bed.

FBC is further classified into Atmospheric Systems (AFBC) and Pressurized Systems (PFBC).

AFBC beds use limestone or dolomite to arrest sulfur released by the coal combustion. During combustion, the sorbent and burning coal mixture are suspended by air streams. These types of boilers operate at atmospheric pressure.

AFBC is further divided into two types: Bubbling fluidized bed combustor and Circulating fluidized bed combustor. The differences between these two are given as below

Parameters	Bubbling Combustor	Circulating combustor
Fluidization regime	Bubbling bed	Fast bed
Carbon conversion	Relatively lower	Higher
Carbon loss	Low	Significant
Process control	Less complex	More complex

The second sub-category of FBC is Pressurized system (PFBC). This system operates at elevated pressure and produce a high-pressure gas stream at temperatures that can drive a gas turbine.

Merits of the PFBC system

- Efficient
- In-bed Desulphurization provision
- Less NO_x and carbon emission
- Compact

Though the working of Fluidized Bed Coal combustion (FBC) technique is stable, there are some intricacies involved in the process control, such as:

- The fuel particle size must be of less than 30mm.
- High-pressure drop is required here to fluidize the bed of granular particles.
- Flue gas carries a dust load, thereby possessing the capacity to pollute the surrounding air.

4. CONCLUSION

From this study, it can be concluded that the Pulverized coal combustion method for burning of fuel is better suited than Fluidized Bed Coal Combustion, owing to the merits of the former.

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