REVIEW ON METHODOLOGY OF FURNACE BURNER DESIGN FOR THERMAL POWER PLANT USING CFD AND IT'S OPTIMIZATION

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Abstract - The furnace burner is designed and analysis is done to perform for different key parameters like burner velocity, burner angle, burner size and its configuration. The analysis of the above parameters are combined for the best combination of parameters with the objective function to maximize mixing efficiency in the burner which ultimately produces efficient combustion and reduces the losses in the mixing stage. The efficient combination of parameters produces cost saving design for better performance of overall plant.

The base design can be studied for different design parameters with objective function of increasing the turbulence intensity which may directly enhances the flame stability for proper mixing of fuel and air which leads to better combustion efficiency

***Key Words*: Boiler, Furnace Computational fluid dynamic, efficiency, burner**

1. INTRODUCTION

Thermal power plants are one of the most important process industries for engineering professionals. Over the past few decades, the power sector has been facing a number of critical issues. However, the most fundamental challenge is meeting the growing power demand in sustainable and efficient ways. Practicing power plant engineers not only look after operation and maintenance of the plant, but also look after a range of activities, including research and development, starting from power generation, to environmental assessment of power plants.

In thermal power plant, the chemical energy stored in fossil fuels such as coal, fuel oil, natural gas is converted successively into thermal energy, mechanical energy and finally electrical energy for continuous use and distribution across a wide geographic area. In the Rankine cycle, high pressure and high temperature steam raised in a boiler is expanded through a steam turbine that drives an electric generator.

It is a competitive resource of energy amongst the other sources of fossil fuel and renewable energies. On the other hand, it has a major contribution to the greenhouse gases (GHGs) emissions and global warming. Based on this disadvantage from the brown coal utilization, innovations and research on the brown coal combustion in tangentially-fired furnaces can play an important role to develop this economical energy source.[1]

In order to design such efficient, clean, and economical brown coal combustion systems, the understanding of the brown coal reactivity and behavior under different operating conditions is required. Generally, brown coal has a number of advantages such as abundance, low-cost, high reactivity, and low sulphur content. In despite of these benefits, a high moisture content (about 60-70% wt.) is the major disadvantage of brown coal.

However, in the existing pulverized brown coal (PC) tangentially-fired boiler, a large amount of the hot exit flue gas, typically 50% of the total flue gas generated is reused to dry the brown coal within the mill-duct system. During that drying process by the hot gas off-takes (HGOTs), a large amount of water vapor is reproduced as well In order to avoid any flame stability problems inside the combustion chamber, due to that evaporated steam, a fuel-rich mixture (mainly pulverized coal) is passed through the main burner ducts. Whilst a fuel-lean mixture, including water vapor, inert gases, and remaining of PC, is delivered to the inert burner ducts (upper burners).

Computational fluid dynamics (CFD) modeling studies can comprehensively provide a wide range of information for the design of furnace and burner that can reduce the cost of time-consuming experimental investigations. The CFD has the ability to predict well the flame structure, gas temperatures distributions, chemical species concentrations, radioactive heat transfer etc., under different combustion conditions.

Pulverized coal tangentially fired furnaces are used extensively in power generation worldwide due to a number of their advantages, like uniform heat flux to the furnace walls and NO_x emission lower than in other firing types. Further study of the furnaces is needed by both experiments and simulations. While full-scale measurements are restricted by considerably high expenses, numerical simulation provides a cost-effective and powerful engineering tool, complementing experimental investigations.

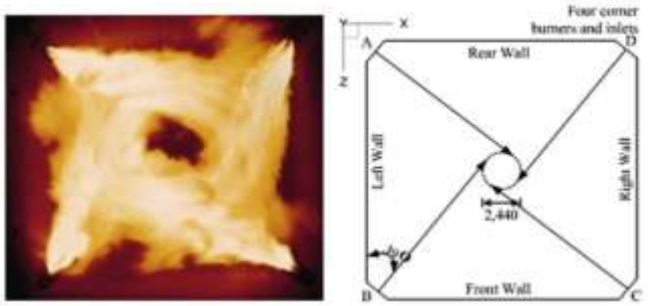

Figure -1 Central vortex & four corner burner's furnace configuration

Because of the peculiar aerodynamics of the tangentially fired furnaces, the flow inside the furnaces, as well as the combustion processes were found to be complicated for modeling. Still, comprehensive combustion large-scale tangentially fired furnaces, based on numerical solution of three-dimensional differential conservation equations, have been the subject of many investigations. The majority use variations of the SIMPLE algorithm and the k–e gas turbulence model, or some derivatives, like RNG k–e model or k–e–kp two phase turbulence model. Gas phase conservation equations are mostly time-averaged. A two-phase flow is usually described by Eulerian– Lagrangian approach and PSI-Cell method for coupling of phases, with some exceptions using Eulerian–Eulerian approach, or two-fluid trajectory model. Most of the combustion submodels given in treat particle devolatilization, char oxidation and additional gas phase reactions separately. Thermal radiation in the furnace is modeled by means of various approaches, like discrete transfer method, discrete ordinates method, six-fluxes method, Monte Carlo method and P-1model. Although commercial codes are applied successfully, research efforts are still given worldwide to specially developed comprehensive models of the furnaces.

2. MOTIVATION

The performance of the Burner affects the overall performance of the combined-cycle power plant. An accurate simulation of the performance of the Burner is required to study its effect on the entire system. Use of computational fluid dynamics (CFD) as a tool to analyze the flow in different designs, it is clear that CFD has the potential to become a useful tool to validate the performance of the tangentially fired burner, and to make some design changes to it. The successful utilization of CFD as a tool in the design of the Burner also performance on flame stability. This can be done only when the CFD tools are appropriately appli ed and validated using approaches and experimental results that accurately represent the flow and physics in the components of the equipments being modeled.

3. PROBLEM DEFINITION

- To design and optimize the furnace burner for 600MW plant
- To investigate the vortex strength of tangentially fired boiler, sustains the flame propagation for efficient combustion
- To investigate the effect of the following important parameters on vortex formation
  - Burner Angle
  - Inlet Velocity
  - Burner Size

4. METHODOLOGY

1. Modeling- Mathematical and numerical model
2. Turbulence Modeling
3. Burner model- geometrical and flow parameters of burner
4. Preprocessing- Grid generation
5. Experimental validation with numerical data
6. ANSYS Fluent- for CFD analysis of PC fired furnace

5. EXPECTED OUTCOME

The furnace burner will design and analysis will perform for different key parameters like burner velocity, burner angle, burner size and its configuration. The analysis of the above parameters will combine for the best combination of parameters with the objective function to maximize mixing efficiency in the burner which ultimately produces efficient combustion and reduces the losses in the mixing stage. The efficient combination of parameters may produce cost saving design for better performance of overall plant.

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