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Review of various Parameters having Considerable Effect on the Design of Furnace Burner

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ABSTRACT

The furnace burner is designed and analysis has done to perform for different key parameters like burner velocity, burner angle, burner size and its configuration. The analysis of the above parameters is 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 is design 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. This paper work can be extend for finding out the distribution of temperature inside the combustion chamber and emission can be predicted like CO, NOx by solving chemical kinetics with the model.

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.

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 vapour 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 vapour, inert gases, and remaining of PC, is delivered to the inert burner ducts (upper burners). Computational fluid dynamics (CFD) modelling 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, radiative heat transfer etc., under different combustion conditions.

Co-firing is particularly appropriate for a country such as Greece, due to the high capacity of lignite-fired power plants and the large contribution of indigenous lignite in the gross energy production. However, instead of the usual, typically high quality, biomass feed stocks used in co firing projects, such as saw dust or wood pellets, co-firing initiatives in Greece will on agricultural biomass due to the overall economics of the biomass supply chains compared to the costs of lignite. Despite the high availability of agricultural residues in Greece, the lack of mechanization for residue harvesting, high costs and other competing uses have shifted attention to the exploitation of energy crops for power generation. One of the crops that are considered in Greece is Cynaracardunculus(cardoon) a perennial, herbaceous crop of Mediterranean origin well adapted to the xerothermic conditions of Southern Europe, with a potential for high yields. Cardoon is currently cultivated in the Region of Western Macedonia in the frame of a regional development program, with the aim to produce biomass for utilization in the nearby Kardia power plant.

While the effect of co-firing cardoon with Greek lignite in a 300 MW tangentially fired boiler is observed with taking into account the major physical and chemical differences in the combustion process for cardoon and lignite. The firing scheme and the fossil fuel utilized influences the particle trajectories and combustion conditions explain the value of cardoon as a co-firing fuel. The main parameters to be investigated relate to fuel burnout, temperature and gas concentrations and NO_x

formation. Results are evaluated on the basis of differences in the co-firing thermal ratio and the size of the biomass particles. However, co-firing studies with lignite on tangentially-fired boilers have been limited to solid-recovered fuels.[2]

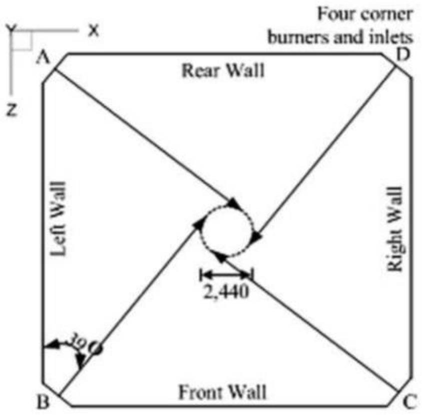

Figure 1.1: Central vortex &four corner burner's furnace configuration

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.

2. 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, Burner Mounting/configuration

3. 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

4. Burner Model Description

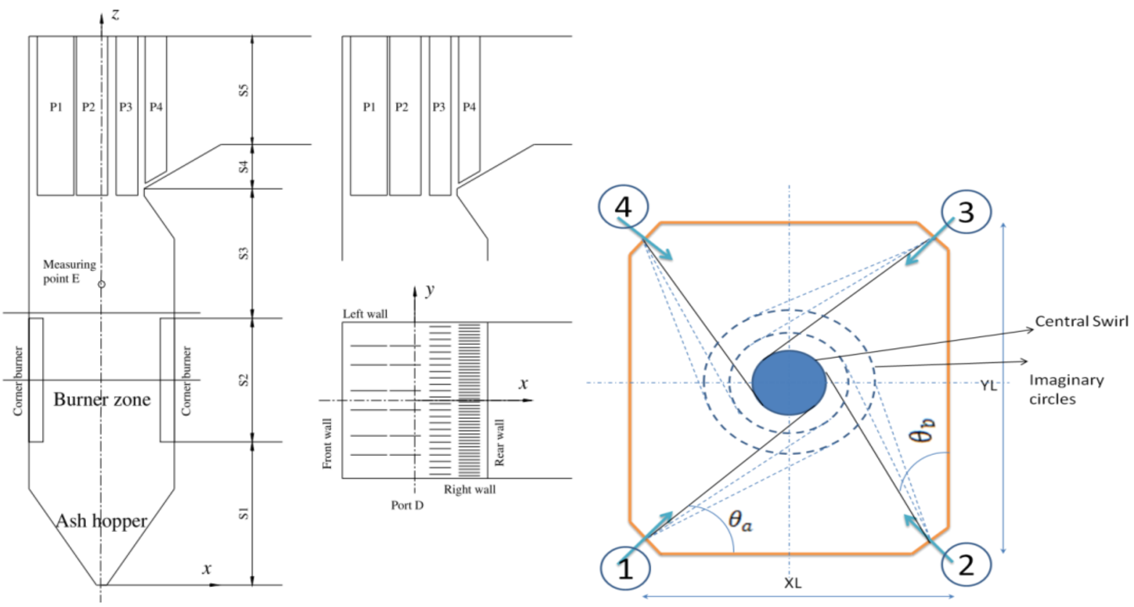

Figure1.2: Burner parameters with imaginary circles

Table No 1
Geometrical and Flow Parameters of the Burner

Parameters	Values
XL	0.657m
YL	0.741m
Θa	450
Θb	360
Inlet Velocity	14.1 m/s

5. Results

5.1 Effect of furnace burner velocity

Table No 2
Turbulence intensity(%) for different velocity

Velocity (m/sec)	Avg. Turbulence Intensity	Max(Circle region)	Total	%
10	2.07	215.54	991	0.217
12	2.52	265	1206	0.219
14	2.96	315	1418	0.222
16	3.42	365	1633	0.223

As the velocity increases of the flue gases, the momentum is increases which also increasing the pressure loss inside the furnace geometry but the increment in pressure is from 185 Pa to 200 Pa which is < 15% but the increase in the turbulence intensity in the middle core is from 315% to 365% i.e. >20%. Therefore the higher velocity is selected as the optimum parameter for enhancing the flame stability but beyond this range there is no appreciable change in the turbulence. Optimum Velocity =16 m/sec is selected.[14]

5.2 Effect of burner angle

Table No 3
Turbulence intensity(%) for different Burner Angles

SET	Burner Angle	Avg Turb Intensity	Max (Circle region)	Total
1	43_51	2.96	315	1418
2	33_61	3.46	366.9	1655
3	39_55	3.12	330	1494
4	46_48	2.92	305	1396

Increase or decrease in burner angle from the existing set up does not help in increasing in vortex strength as the change in burner angle is restricted due to the size of the furnace; the optimum vortex strength is achieved at set 1 i.e. existing set up which is kept fixed.

5.3 Effect of burner size

Table NO 4
Turbulence intensity(%) for different Burner Size

Size (mm)	Average Turbulence Intensity	Max. (Circle Region)	Total
56	3.2	216	929
75	3.32	245	1000
100	3.47	259	1394

Increase in burner size increases the average turbulence intensity but doesn't fetch better mixing in the center, due to which the intensity increases then decreases, optimum burner size is selected a 75mm which is also available in manufacture's range.[16]

Configuration 4 gives higher turbulence intensity compared to other configurations but the pressure loss (193Pa) is higher compared to the tangential fired case(170Pa). It is one of the favorable reasons for selection of tangentially fired furnace configuration compared to other different configurations.[17]

5.4 Effect of burner configuration

Configuration	Average Turbulence Intensity	Max(Circle Region)	Total	Pressure Loss (Pa)	%
1	3.46	335	1613	170	0.21
2	3.64	232	848	180	0.27
3	3.34	67	337	187	0.20
4	2.54	673	1453	192	0.46
5	2.57	221	2856	138	0.08

6. Conclusion

The following key points are concluded from the above analysis,

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

- The effect of different parameters are studied on the vortex strength formed at the middle of circle for tangentially fired boilers
- The optimum parameters are coupled and analyzed for the optimum configuration which gives better efficiency than the base case, the intensity i.e. efficiency increases from 22% to 27%.
- The above change in turbulence intensity makes the combustion process more effective and saves the cost of overall power generation process.

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