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"Numerical Analysis of Bagasse Direct Combustion in Boiler Furnace at Different A/F Ratio"

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***Abstract*-- The most common methods to obtain energy from solid biomass are direct combustion, gasification and pyrolysis, which are thermochemical processes. The biomass combustion is a widely used method for heat and power production due to its versatility and adaptability. Bagasse is the by-product of sugar industry and used as fuel in boilers of sugar industry.**

Thereby, this research aims to characterize the thermal behaviour of sugarcane bagasse, at different ratio of Air and Fuel. A numerical analysis to optimize the air fuel ratio have been carried out for the study.

***Keywords*-- Biomasses, Biomass Wastes, CFD, biomass combustion etc**

I. INTRODUCTION

A boiler is a steam generator that uses combustion as its primary heat source. The most common fluid used in heat engines, which convert heat to work, is water that has been transformed to steam. Steam production was first used in equipment meant to turn heat into the labour needed to pump water from mines. Heat from a steam generator can be used directly to serve the required process purposes in process applications (e.g., district heating by steam). The heat source, combustion, and working fluid are all separated in steam generation, usually by a heat-resistant material wall (e.g., steel tubes). One of the most common applications for steam generators with turbines is electricity generation.

Biomass-based Power Generation

Biomass is a renewable energy source produced from plants and animals. Wood and wood derivatives, a variety of agricultural and animal wastes, a portion of municipal garbage, and various industrial wastes and by-products are all examples of biomass. Biomass was once the most important source of energy for almost all regions of the planet, with communities relying almost entirely on wood and charcoal for heating and cooking. New types of energy, such as coal, oil, and finally electricity, were introduced during the Industrial Revolution, and these have largely replaced biomass in the developed world.

Types of Biomass

The vegetation on the Earth's surface is the global biomass resource. According to the World Energy Council, this equates to about 220 billion dry tonnes of energy, or 4500 EJ (45001018 J). Each year, photosynthesis regenerates between one-third and two-thirds of this (the proportion depending on the means employed to determine the amount of carbon fixed annually). As previously stated, around the turn of the century, biomass equivalent to 50 EJ was utilised annually to supply energy, primarily from wood fuel for heating and cooking. According to estimates, between 200 and 500 EJ could be used for power generation in the future. With primary energy demand anticipated to reach 600 EJ to 1000 EJ by 2050, biomass sources might offer a large fraction of overall demand, at least in theory. Biomass can be classified into two groups in terms of electricity generation: biomass wastes and energy crops.

II. LITERATURE REVIEW

César A. Bermdez et al., 2020, used an Eulerian fixed-bed biomass combustion model in conjunction with the CFD commercial package. The simulation of a large-scale moving grate biomass furnace will be done with ANSYS-Fluent. To adjust the model operation to the features of this scenario, new procedures must be established. The numerical results are compared to published experimental data. The novel approaches produce a bed morphology solution that is tested against experimental data.

These high-quality biofuels are primarily used as motor fuel in industrialised countries, whereas woody biomass is used for heat and power generation, as well as domestic heating, as alternatives to fossil fuels. Biomass can be a critical element in developing countries that lack access to or cannot afford alternative energy sources, particularly in rural regions where solid biomass is currently the primary source of energy.

Linjie Xu et al. (2018) developed a combustion model of a large-scale supercritical circulation fluidized bed (CFB) boiler for extensive computational fluid dynamics study. Gas–solid hydrodynamics, coal combustion, heat transfer on heat exchange surfaces in the furnace, and heat transfer between furnace and working media in heat transfer tubes are all included in the model. A 350-MW supercritical CFB boiler was successfully simulated using the model. In the boiler furnace, detailed distributions of solids content, oxygen, heat flux, and working medium temperature are provided.

The goal of ***Adeline Rezeaua et al(2018) .'s*** research was to create a numerical tool that could simulate biomass combustion in grate-fired systems and help improve these devices. Fluid patterns originating from combustion chamber operation and design, as well as the profiles of the most relevant variables, were all meant to be defined (fluid temperature and concentrations of gas species). In this way, the simulation was required to maintain the accuracy of the results while yet allowing for realistic development and computing demands.

III. RESEARCH METHODOLOGY

Computational Model and Methods

Since 2005, Porteiro et al. have been working on a fully integrated Eulerian model for the simulation of biomass combustion/gasification in the commercial CFD system ANSYS-Fluent, which can simulate fixed bed biomass boilers.

The model was initially zero-dimensional and consisted of a standalone code that was calculated using an external solver. The bed was modelled as an inlet boundary in the CFD simulation. The gas temperature, species, velocities, and particles were returned as inputs for the bed inlet after the radiation incident in this inlet was computed and supplied to the solver.

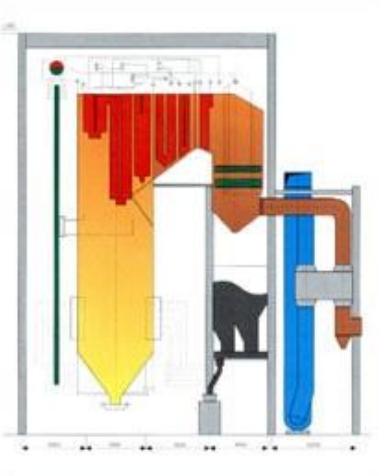

Figure 3.1 Boiler System

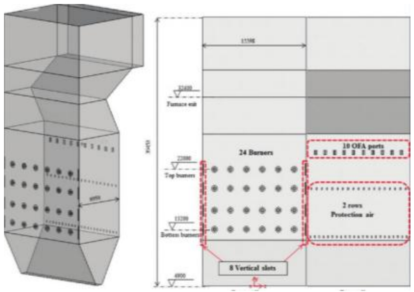

Figure 3.2 Geometry of boiler furnace considered for the study

Meshing

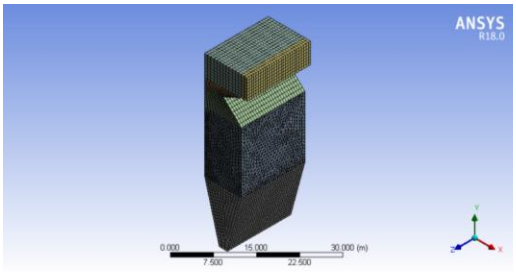

Figure 3.3 Meshed model of the furnace.

IV. RESULT ANALYSIS

The CFD results carried the contours of Temperature, Pressure, Velocity and different emission species variation with respect to different air fuel ratio followed by detailed discussion.

Results Considering A/F Ratio: 6.39 (Excess Fuel)

Figure 4.1 to 4.6 shows the Temperature, Pressure, Velocity, N_2 , H_2O and CO_2 Mass Fraction Contour for A/F Ratio: 6.39 (Excess Fuel).

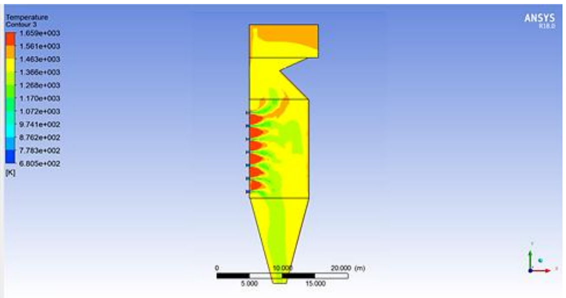

Figure 4.1 Temperature Contour for A/F Ratio: 6.39 (Excess Fuel)

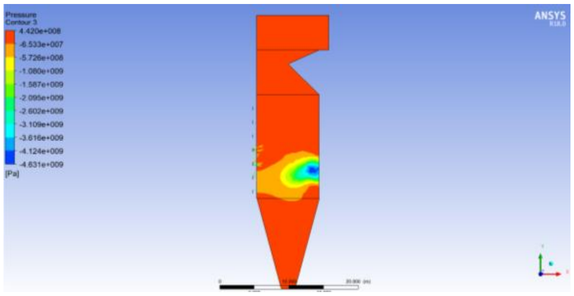

Figure 4.2 Pressure Contour for A/F Ratio: 6.39 (Excess Fuel)

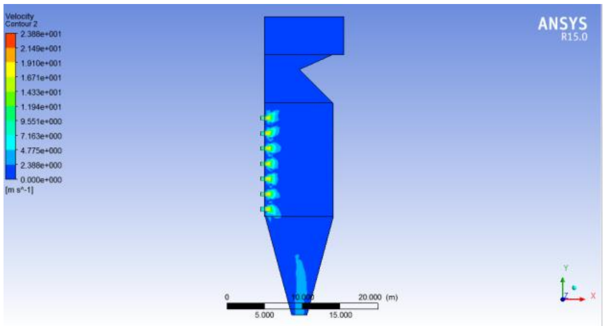

Figure 4.3 Velocity Contour for A/F Ratio: 6.39 (Excess Fuel)

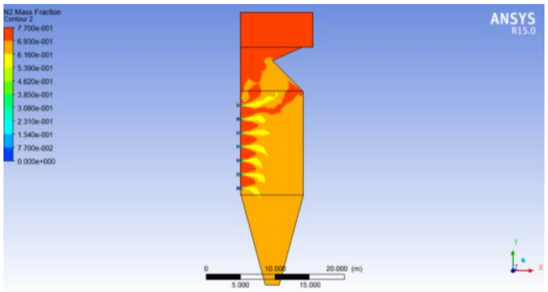

Figure 4.4 N_2 Mass Fraction Contour for A/F Ratio: 6.39 (Excess Fuel)

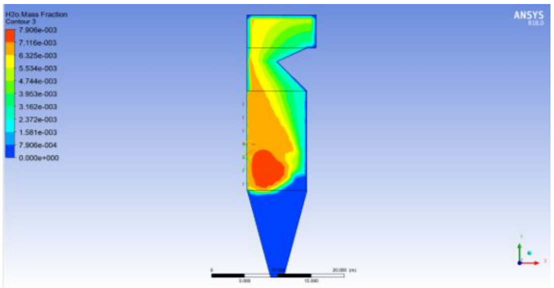

Figure 4.5 H_2O Mass Fraction Contour for A/F Ratio: 6.39 (Excess Fuel)

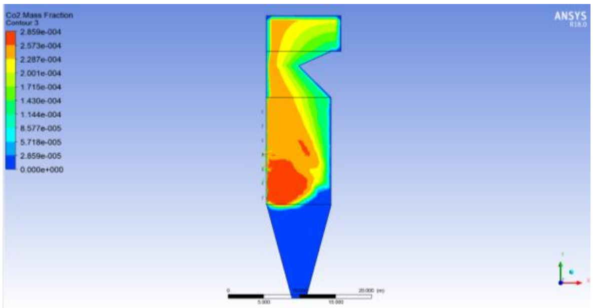

Figure 4.6 CO_2 Mass Fraction Contour for A/F Ratio: 6.39 (Excess Fuel)

The air–fuel ratio and its reciprocal, the fuel–air ratio, are two often used metrics that quantify the amounts of fuel and air in a given combustion process. Temperature, pressure, and velocity variations with regard to air/fuel ratio are shown in Figures. The maximum temperature has been observed when the air fuel ratio is increased up to 11.91 percent from the Stoichiometric ratio.

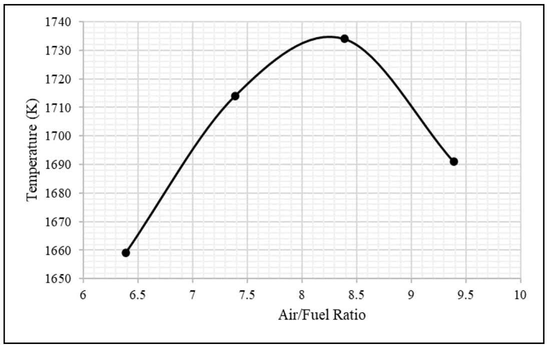

Figure 4.7 Variation of temperature with respect to air/fuel ratio

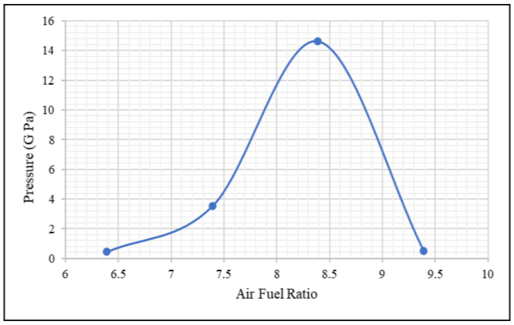

Figure 4.8 Variation of pressure with respect to air/fuel ratio

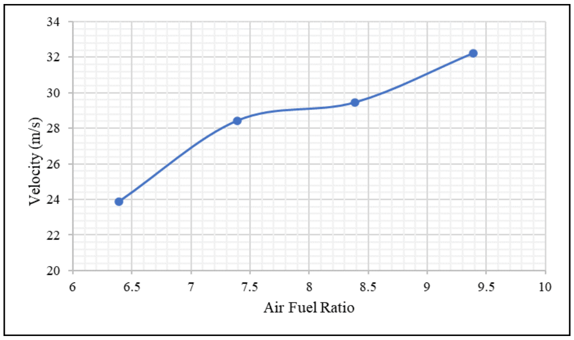

Figure 4.9 Variation of velocity with respect to air/fuel ratio

V. CONCLUSION

The responsibility of the combustion engineers should mainly be devoted towards the utilization of the energy sources in more efficient and economical mode.

The efficient combustion of fuel in combustion chambers and the efficient transfer of heat to water and steam in steam generators are essential for the economical operation of power plants.

In the present study, the bagasse is examined as fuel for combustion in boiler furnace. A CFD analysis has been carried out considering the A/F ratio.The following conclusion can be made from the study.

- It has been observed that as the air fuel ratio increases up to 11.91% from the Stoichiometric ratio, the maximum temperature is achieved.
- The pressure variation curve follows the same trends as the temperature.

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