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Design and Analysis of Wind Box Segment in Travelling Grate Stoker Boiler using CFD

T. Sathish, D. Chandramohan

Abstract**:** ***In the current scenario energy demand plays a major role for which biomass technology meets global target on renewable energy. In which boilers performance evaluation is more essential. The major objective of this work is to evaluate the turbulent air flow distribution in wind box channel of travelling grade stoker boiler. In order to improve the optimum performance of the boiler used in the biomass power plant, the air should uniformly distributed to the burner. In this paper the sever turbulent flow and high pressure zones are generated by examining the recirculation flow at several locations in wind box channel. Due to these process the unequal air flow exits at exit valve. Computational fluid dynamics (CFD) modelling is the simulation tool used to determine the high pressures zones and turbulent flow of wind box segment. The results indicates that the design of wind box segment and combustion is more effective in increasing the performance of boiler and the amount velocity of air flow is decreased from around 30%. Increasing amount of the additive from around 90% of O2 level, and 80% of CO2 level and there by temperature distribution in combustion bed is grown upto 40%.***

Index Terms**:** ***Travelling Grate Stoker Boiler; Wind box channel; Recirculation flow; Unequal air flow.***

I. INTRODUCTION

The usage of cost effective biomass helps for industrial growths in terms of harvest production and conversion. In the process of plant growth during the conversion process it produces carbon as much as biomass produces [1]. However many of the current biomass combustion system is still need to be improving the combustion efficiency. Wind box segment in boiler is used to supply the excess air to the combustion air. Proper air distribution through the wind box segment to the burner is very important to the boiler optimum performance methodology adopted by [2]. A well-known controlled condition the burner operation is simulated to validate the bed model behavior [3]. All the temperature dependent characteristics of a material in considered in to an accounts for the thermoelectric power source model [4]. The additional information recording the mixing process with a bed of fuel particles can be obtained with the help of discreate element method [5]. The investigations divides gas with the doubled vortex finder by clean in cyclone [6]. The current scenario in the boiler interest has considerably increased in various publications, in Analysis, combustion, efficiency, performance, design, optimization, computational fluid dynamics and ash handling of boiler CFD analysis has consideration to elaborate the conceptual frame work to improve the performance of boiler used in power plants. Those researchers have shown considerable efforts on boiler used in power plants based on its performance characteristics and efficiency determination; very few papers were published on CFD analysis. And there is no consistent papers on Travelling grate stoker bed boiler. The non-uniform fuel size could be one reason for inadequate ignition. The displaying results showed that sorbent infused specifically into the heater through supported over-terminated air terminals is increasingly successful at evacuating SO2, because of longer habitation time and better blending, in respect to ports higher in the heater with poor blending [7]. Ecological insurance and stringent discharge limits both require a noteworthy decrease of nitrogen oxides (NOx) emanations from mechanical boilers just as waste burning plants. As of late, the specific non-reactant decrease innovation, a vent gas treatment strategy for NOx outflow control [8]. Limited component recreations by fused with the iterative techniques might be utilized to gauge the expanded temperature and diminished hardness estimations of the cylinder metal and advancement of oxide scale on the internal surface of kettle tubes over delayed timeframe [9]. Methodologies connected for reactor displaying, from discovery models to computational liquid unique models were depicted [10]. Besides, the investigation uncovers that the tallness of the weir in the fluidized bed fiery debris cooler (FBAC) does not influence the passing on of the of the slag stream [11].

II. 2MATERIAL AND METHODS

In order to complete the combustion 14.1 kg of air required for every 1 kg of fuel. But in practice an excess air may require to complete combustion and the excess air may require to ensure the release of contained heat fuel oil [12]. If too much air than what is required for completing combustion were allowed to enter, additional heat would be lost in heating the surplus air to the chimney temperature. This would result in increased stack losses. Less air would lead to the incomplete combustion and smoke [13]. Hence there is an optimum excess air level for each type of fuel [14]. In a Travelling grade stoker boiler the wind box channel is used for air dampers, to ensure clean combustion. About 40% combustion air is passed through wind box as forced draft air. Burners and over fire air ports requires the proper air distribution in the wind box channel [15]. The recirculation of air flow and unequal air flow distribution of wind box

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causes the flow losses in forced draft air-inlet system of boiler [16].

III. RESULTS AND DISCUSSION

This modelling methodology has been developed for the complete simulation of biomass boiler. In order to individually validate the behavior of bed model is compared with Existing system of the travelling grate stoker boiler and proposed system of the travelling grate stoker boiler. The following figures 1 to 4 indicates the 3D modelling of wind box segment of traveling grate stoker boiler source from SRIRAM BIOMASS POWER PLANT, sempatti.

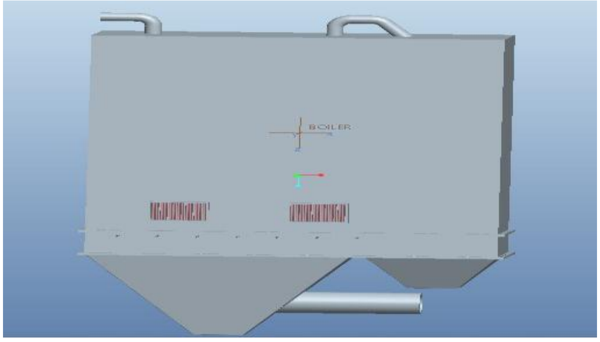

Figure 1: 3D Modelling of wind box segment of Travelling grate stoker boiler and

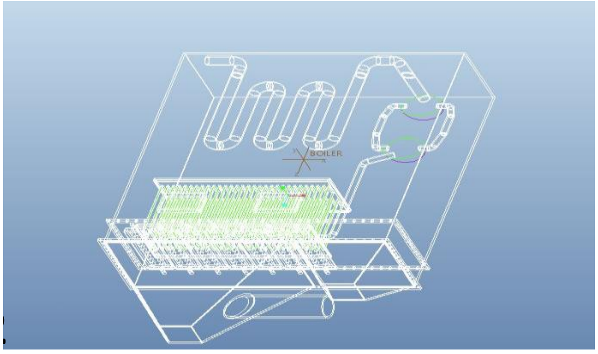

Figure 2 3D Wireframe view of wind box segment in Travelling grate stoker boiler

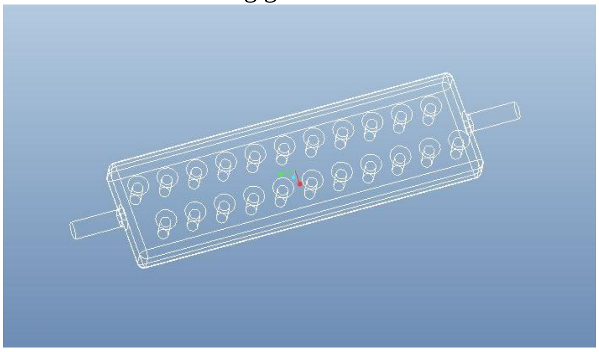

Figure 3. 3D Wireframe view of proposed model in Traveling grate stoker boiler.

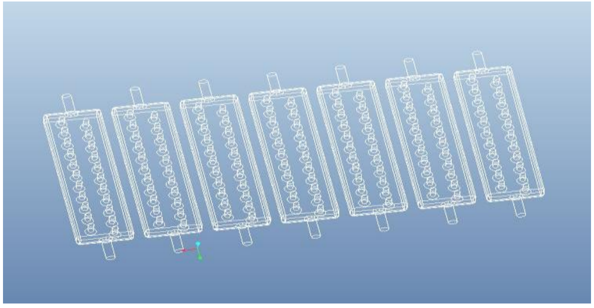

Figure 4. Proposed Design in Combustion Bed Chamber

Traveling Grate Stoker Boiler.

Table 1.Operation Parameters of the CFX analysis

Inlet Parameter	Combustion Parameters	Mass Flow Rate (Kg/S)	Temperature (C)	Pressure (atm)
Combustor Inlet	NO	0.000712	800	1
	CO_2	0.4314		
	O_2	0.6072		
	N_2	3.6210		
Atomizing Air Inlet	Atomizing air parameter	Mass Flow Rate (kg/s)	Temperature (c)	
	O_2	0.030	100	
	N_2	0.042		

Table 1 shows the Operation parameters of the travelling bed stroke boiler used in biomass power plant source from the SRIRAM BIOMASS POWER PLANT sembbati.

A. CFD Analysis of Existing Design of TBS Boiler

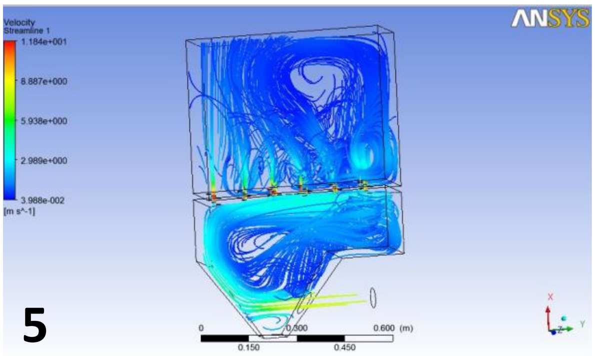

Figure 5. Air Flow Distribution for TBS Boiler in Existing Design

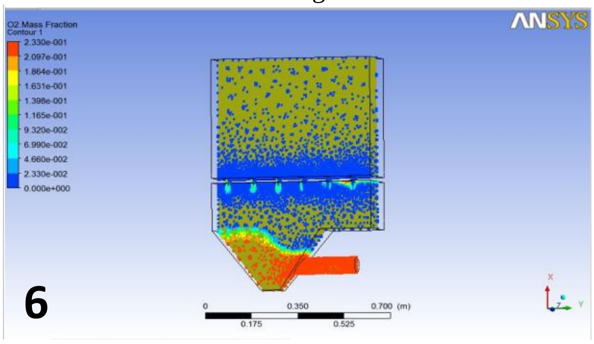

Figure 6. O2 mass fraction for TBS Boiler in Existing Design

This figure 5 indicates a recirculation of air flow distribution and unequal air flow distribution in the wind box segment to the burner in the existing system of the travelling grate stoker boiler used in biomass power plant. The velocity distribution is high in combustion bed is $1.184e^{001}$m/s .The analysis very clearly shown the air flow distribution it makes an incomplete combustion to the combustion process. This figure 6 indicates the O_2 mass fraction in combustion process the analysis shown that the mass fraction of O_2 level is very low $2.330e^{-002}$. So unequal and flow losses makes the poor chemical combustion process because every 1 kg of fuel

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is needed 14.1 kg air so very low level of O_2 mass fraction makes an incomplete combustion ,material losses and decreasing of O_2 level the chemical reaction forms an carbon monoxide ,and makes an heavy smoke.

This figure 7 indicates the CO_2 mass fraction in combustion process the analysis shown that the mass fraction of CO_2 level is very low $9.252e^{-001}$. So very low level of CO_2 mass fraction makes an incomplete combustion, material losses and decreasing of CO_2 level the chemical reaction forms a carbon monoxide CO, and makes a heavy smoke.

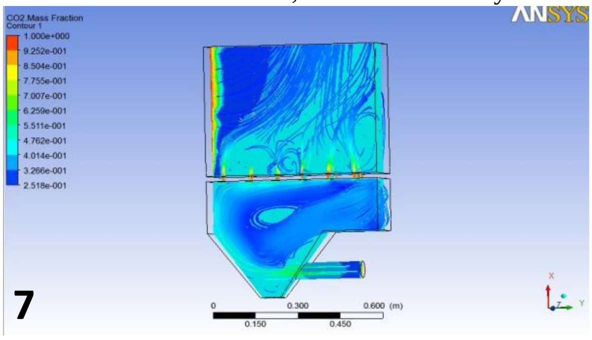

Figure 7. CO_2 mass fraction for TBS Boiler in Existing Design

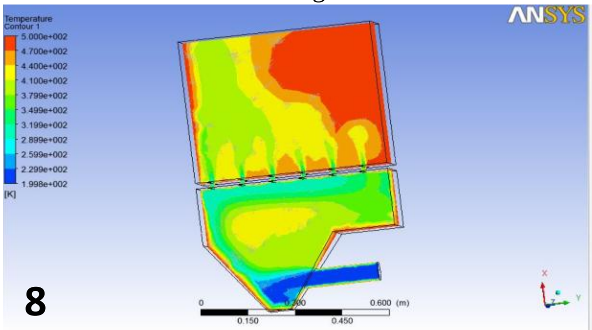

Figure 8. Temperature distribution in combustion bed for TBS Boiler in Existing Design

This figure 8 indicates the temperature distribution in combustion bed from in combustion process the analysis shown that the temperature distribution level is very low.

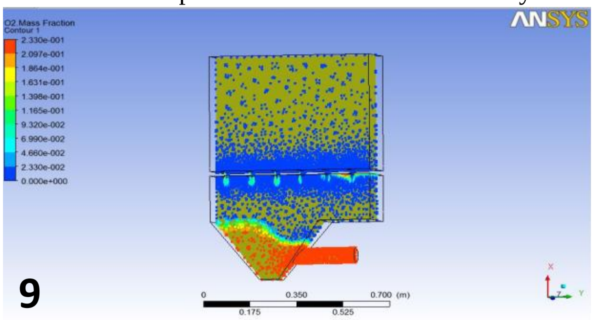

Figure 9. O_2 mass fraction for TBS Boiler in Existing Design

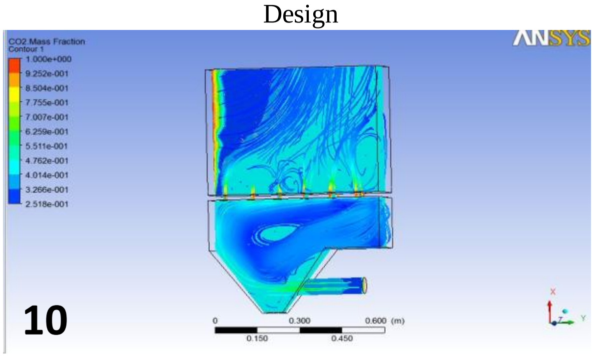

Figure 10. CO_2 mass fraction for TBS Boiler in Existing Design

This figure 9 indicates the O_2 mass fraction in combustion process the analysis shown that the mass fraction of O_2 level is very low $2.330e^{-002}$. So unequal and flow losses makes the poor chemical combustion process because every 1 kg of fuel is needed 14.1 kg air so very low level of O_2 mass fraction makes an incomplete combustion ,material losses and decreasing of O_2 level the chemical reaction forms an carbon monoxide ,and makes an heavy smoke.

This figure 10 indicates the CO_2 mass fraction in combustion process the analysis shown that the mass fraction of CO_2 level is very low $9.252e^{-001}$. So very low level of CO_2 mass fraction makes an incomplete combustion, material losses and decreasing of CO_2 level the chemical reaction forms an carbon monoxide CO, and makes an heavy smoke.

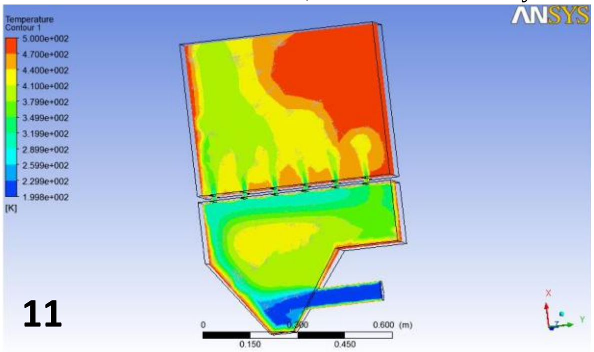

Figure 11. Temperature distribution in combustion bed for TBS Boiler in Existing Design

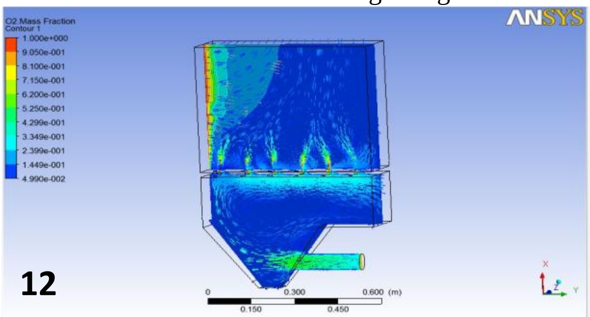

Figure 12. O_2 of TBS Boiler in proposed Design

This figure 11 indicates the temperature distribution in combustion bed from in combustion process the analysis shown that the temperature distribution level is very low.

This figure 12 indicates the O_2 mass fraction in combustion process the analysis shown that the mass fraction of O_2 level is improved $9.050e^{-001}$.

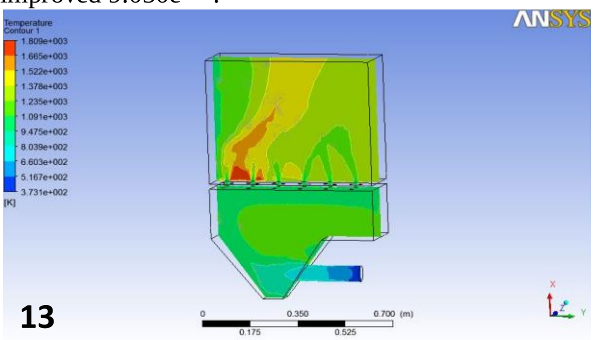

Figure 13. Temperature distribution in combustion bed for TBS Boiler in proposed Design

This figure 13 and 14 indicates the temperature distribution in combustion bed from in combustion process the analysis shown that the temperature distribution level is improved 800^0C to 1235^0C while compared with existing design. So it becomes on good chemical combustion process and it makes good burning process. And temperature is gradually increased as shown in table 2.

The analysis very clearly shown the air flow distribution it makes improved and the velocity is decreased from $1.184e^{001}$m/s to 9.305 m/s. the CO_2 mass fraction in combustion process the analysis shown that the mass fraction of CO_2 level is uniformly occurs in combustion bed $8.502e^{-001}$. So level of CO_2 mass fraction is improved makes a complete combustion.

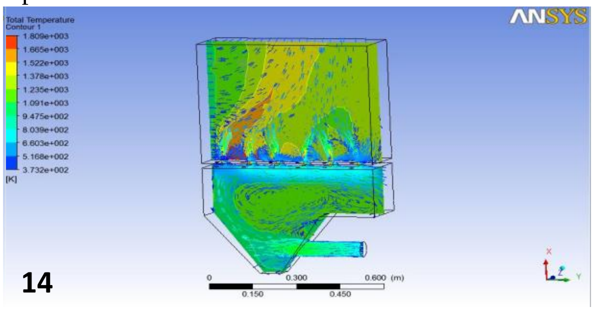

Figure 14. Temperature distribution in combustion bed for TBS Boiler in proposed Design

Table. 2 Comparison of combustion parameters

Combustion Parameters	Existing Design Of TBS Boiler	Proposed Design of TBS Boiler
Air Flow Distribution	$1.184e^{001}$m/s	9.305 m/s.
O_2 Mass Fraction	$9.252e\text{-}^{0.01}$	$9.050e^{000}$
CO_2 Mass Fraction	$2.330e\text{-}^{002}$	$8.502e\text{-}^{001}$
Temperature Distribution	800 K	1235 K

The O_2 mass fraction in combustion process analysis shown that the mass fraction of O_2 level is improved $9.050e^{-001}$. The temperature distribution in combustion bed from in combustion process the analysis shown that the temperature distribution level is improved 800^0C to 1235^0C while compared with existing design. So it becomes on good chemical combustion process and it makes good burning process.

IV. CONCLUSION

The Existing modelling results presented proved that while decreasing temperature, the combustion bed biomasses are burned with different air condition where the possibility of failure in experimental tube reaction is high. Hence in the present model the combustion bed is improved in the optimum performance of travelling grate stoker boiler. For which the recirculation of air flow in wind box segment was achieved by decreasing 30%. Hence the unequal air flow distributions are controlled and the temperature is improved from 800 K to 1235 K.

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