DESIGN AND ANALYSIS OF WIND BOX SEGMENT IN TRAVELLING GRATE STOKER BOILER USING CFD

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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 main objective of the present work is to evaluate the turbulent air flow distribution in wind box channel of Travelling grate stoker boiler. The uniform air-flow distribution to burner is important to improve the optimum performance of boiler used in biomass power plant. This paper also examines the recirculation flow, at several locations of wind box channel, which aids to generate high pressures zones and severe turbulent flow. This effect in turn leads to unequal air-flow at exit. Computational fluid dynamics (CFD) modelling is the 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 O_2 level, and 80% of CO_2 level and there by temperature distribution in combustion bed is grown upto 40%.

Keywords--Travelling Grate Stoker Boiler; Wind box channel; Recirculation flow; Unequal air flow.

INTRODUCTION:

CFD simulations are an efficient tool for the design and optimisation of biomass grate furnaces to complement and reduce the extent of experimental investigations Ali shiehnejadhesar (2017). Polluting emissions from chain grate stoker furnaces may be as being caused by a poor combustion-air distribution to the fuel bed. Previous work showed that a better distribution of air is achieved by modifying the aerodynamic features of the individual grate links A.S.Green (2017). Wind box segment in boiler is used to supply the excess air to the combustion air is passed through wind box as primary air. Proper air distribution through the wind box segment to the burner is very important to the boiler optimum performance methodology adopted by Bhasker (2003). However, in order to individually validate the behaviour of the bed model, a simulation of an experimental burner operating under well-known controlled conditions Collazo et al. (2012) The model of the producing electricity by a difference of temperaturespower source accounts for all temperaturedetermined quality belonging of the materials and includes non linear fluid-thermal electric multi physical coupled effects and the model is validated Chenetal. (2011) Understanding the detail of the mixing stoking process on grate firing is crucial for the optimization of the combustion process in waste or biomass incineration plants. The discrete element method can help to obtain further information on the mixing process with a bed of fuel particles Sudbrock et al. (2011) A doubled vortex finder which was used for the investigations divides gas cleaned in the cyclone Krajowej et al. (2011). 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. Non uniform fuel size could be one of the reasons for incomplete combustion. In chain grate stokers, large lumps will burn incompletely, while small pieces and fines may block the air passage, thus causing poor air is spread over. The modelling results indicated that a substance which has the property of collecting molecules of another substance by sorptioninjected directly into the furnace through boosted over-fired air ports is more effective at removing SO_2, due to longer residence time and better mixing, relative to ports higher in the furnace with poor mixing by Shi et al. (2011) Environmental protection and stringent emission limits both require a significant reduction of nitrogen oxides (NOx) emissions from industrial boilers as well as waste incineration plants. [4] discussed about a disclosure which is made regarding a driving alert system which is designed in the form of a neck cushion which has the capability to sense the posture of the drivers neck position so as to identify whether the driver is alert and if he is dozing of. The system is made intelligent to obtain data from the movement so as to produce triggers to alert the user and to keep him/her awake to avoid accidents. The system is also linked to a mobile computing device so as to provide a report of the analysis done. The drivers location can also be tracked using the same.In recent years, the selective non-catalytic reduction (SNCR) technology, a flue gas treatment method for NOx emission control given et al. (2009) Finite element simulations incorporated with the iterative procedures may be used to estimate the increased temperature and decreased hardness values of the tube metal and development of oxide scale on the inner surface of boiler tubes over prolonged period of time sono et al. (2010). [10] discussed about a disclosure which is made regarding a gear blocking gear cover for the four wheeler vehicle where the protective cover has been with touch sensors and biometric sensors. Here in case of theft even if the car is started without a key the gear system is locked using biometric locks which can read the palm of the user to unlock the gear system thus protecting the vehicle against any form of theft. This device can be attached to any type of four wheeler vehicle.Approaches applied for reactor modelling, from black-box models to computational fluid-dynamic models, are described Barea et al. (2010) The air flow rate, particle size of the solids and air distributor type are considered to be the key parameters of the operation of a fluidized bed ash cooler (FBAC). Furthermore, the experiment reveals that the height of the weir in the FBAC does not affect the conveying of the of the ash flow Manetal. (2010).

MATERIAL AND METHODS:

For complete combustion of every 1 kg of fuel is needed 14.1kg of air is needed .In practice, mixing is never perfect, a certain amount of excess fresh air is needed to achieve complete combustion and ensure that release of the entire heat is observed by spraying the fuel on it. If too much of air is required for complete combustion, additional heat would be lost in heating the surplus air to the ambient temperature. This would result in increased stack losses. Less air would lead to the incomplete combustion, emission of various gases and smoke. Hence there is an optimum air level for each type of fuel. In a Travelling grate stoker boiler the wind box channel is used for air dampers, to ensure clean combustion. About 40% combusted air is passed through wind box as forced draft air. Burner air ports requires the proper air shared in the wind box channel. The recirculation of air flow and unequal air flow distribution of wind box causes the flow losses in forced draft air-inlet system of boiler.

RESULTS AND DISCUSSION:

Initially the model created CATIA V5 using modelling software was imported into the geometry to analysing software in the required format.There are four standard tool bars found in the Sketcher Work Bench. The individual tools found in each of the four tool bars are labelled to the right of the tool icon. Some tools have an arrow located at the right corner of the tool option. The arrow is an indicator that there is more than one variation of that particular type of tool. The tools that have more options that are sorted to the right of the default tool. To show the other tools menu you must select and hold the left mouse button . This will display the optional tools window. The desired tool now becomes the default tool. All you have to do is select the new default tool and double click on it. This is done by holding the right mouse button down, dragging it to the required location and releasing the mouse button. If you use several tools on one particular tool bar, you might want to expand and relocate the tool bar so that you don't have to select the different tool icons every time. Select arrow to expand tool options for additional tools.

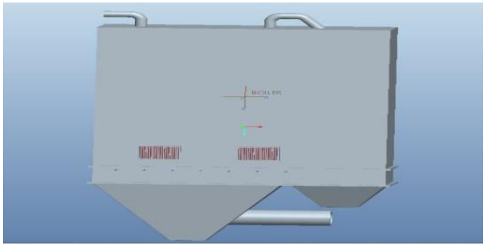
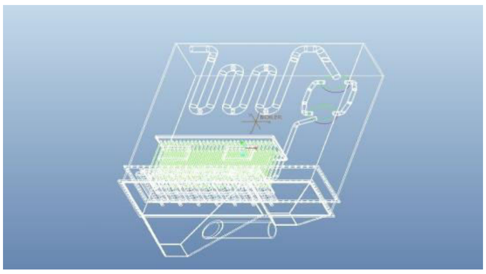


Figure-1.3D Modelling of wind box segment of
Travelling grate stoker boiler
Figure-.2**.** 3D Wireframe view of wind box segment in Travelling grate stoker boiler.

Solid Modelling of Proposed Design for Combustion Bed of TBS Boiler



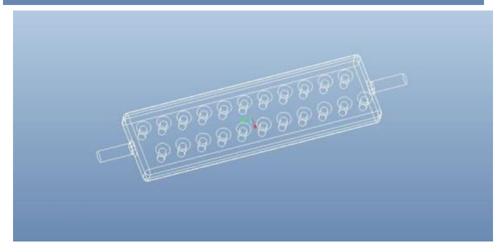


Figure- 3**.** 3D Wireframe view of proposed model in Travelling grate stoker boiler.

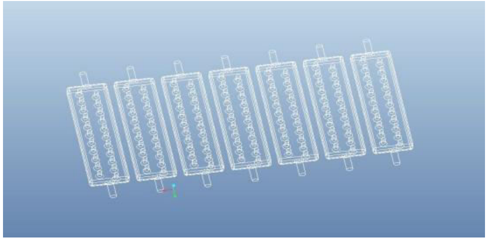


Figure- 4. Proposed Design in Combustion Bed Chamber Travelling Grate Stoker Boiler.

Table-1.Operation Parameters of the CFX analysis

Inlet Parameter	Combustio n Parameters	Mass Flow Rate (Kg/S)	Temperatur e (C)	Pressur e (atm)
Combusto r 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)**	**Temperatur e (c)**	
	O_2	0.030	100	
	N_2	0.042		

Operation parameters of the travelling bed stroke boiler used in biomass power plant source from the SRI RAM BIOMASS POWER PLANT, Sembatti.

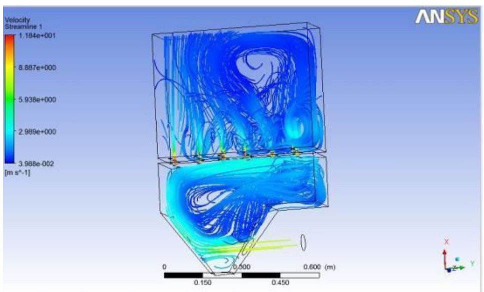


Figure- 5. Air Flow Distribution for TBS Boiler in Existing Design

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.

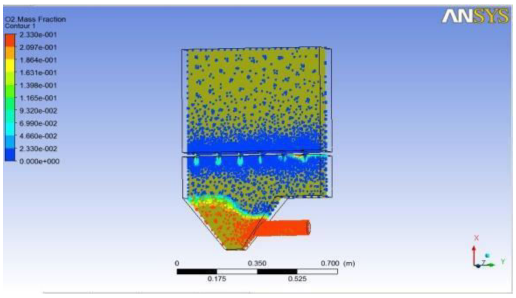


Figure- 6. O_2 mass fraction for TBS Boiler in Existing Design

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 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.

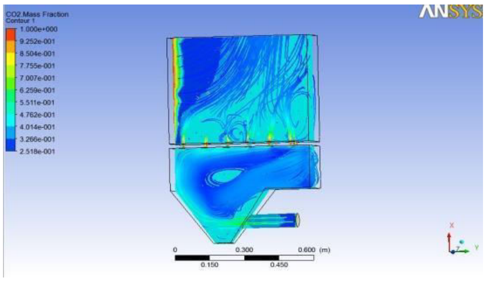


Figure-7. CO_2 mass fraction for TBS Boiler in Existing Design

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.

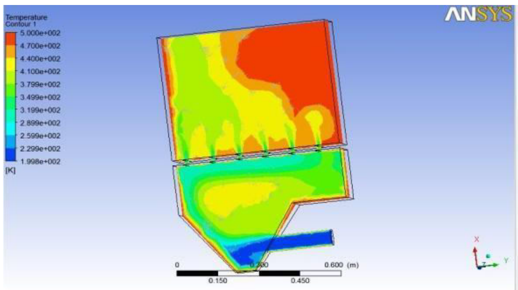


Figure-8. Temperature distribution in combustion bed for TBS Boiler in Existing Design

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

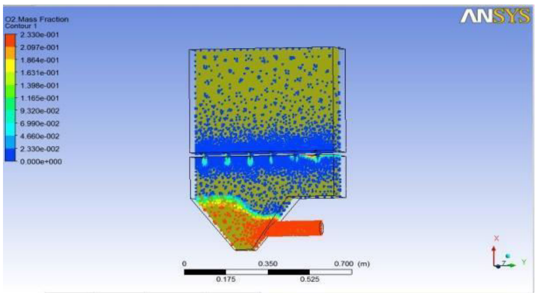


Figure-9. O_2 mass fraction for TBS Boiler in Existing Design

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.

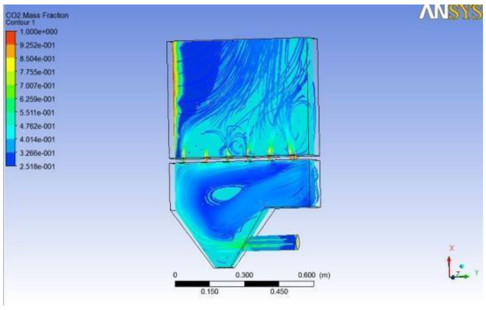


Figure-10. CO_2 mass fraction for TBS Boiler in Existing Design

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.

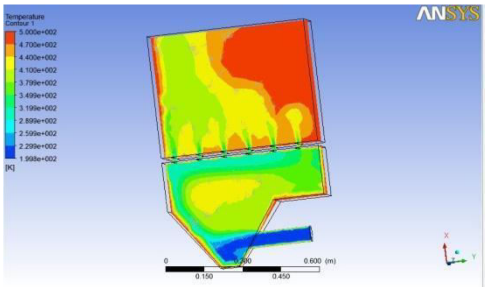


Figure-11. Temperature distribution in combustion bed for TBS Boiler in Existing Design

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

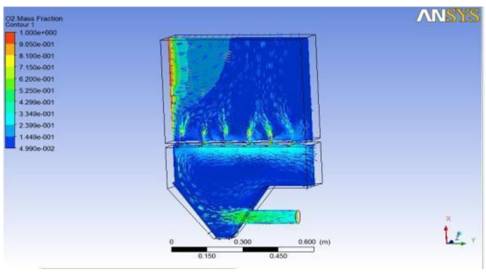


Figure-12. O_2 of TBS Boiler in proposed Design

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 $9.050e-^{001}$.

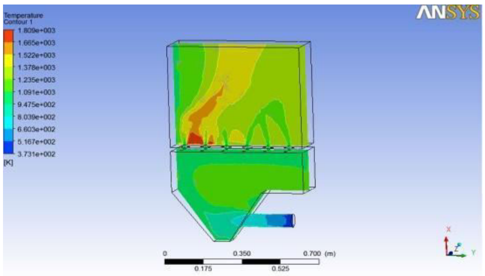


Figure-13. Temperature distribution in combustion bed for TBS Boiler in proposed Design

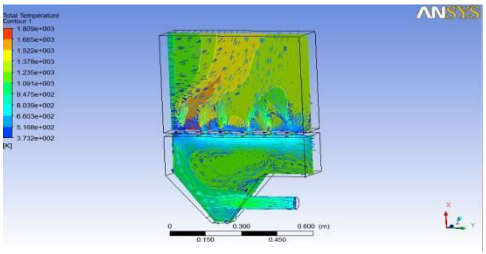


Figure-14. Temperature distribution in combustion bed for TBS Boiler in proposed Design

This figure-13 & 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 ^{0}C while compared with existing design. So it becomes on good chemical combustion process and it makes good burning process. And temperature is gradually increased.

Combustion Parameters	**Existing Design Of TBS Boiler**	**Proposed Design of TBS Boiler**
Air Flow Distribution	1.184×10^{001}m/s	9.305 m/s.
O_2 Mass Fraction	$9.252\times10-^{0.01}$	9.050×10^{000}
CO_2 Mass Fraction	$2.330\times10-^{002}$	$8.502\times10-^{001}$
Temperature Distribution	800 K	1235 K

Table-2 Validation

This modelling methodology has been developed for the complete simulation of biomass boiler. In order to individually validate the behaviour of bed model is compared with Existing system of the travelling grate stoker boiler and proposed system of the travelling grate stoker boiler.

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. 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^{0}C to 1235**^{0}C while compared with existing design. So it becomes on good chemical combustion process and it makes good burning process.

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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