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Investigation on circulating fluidized bed boiler tube with different external fin configuration

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Abstract — In present investigation numerical analysis is performed in CFB boiler tube with different mass flow rate, the observed value of exit temperature of water is compared with numerical model developed in CFD with optimization in CFB boiler tube fin profile pattern i.e. rounded wedge, perforated square and wedge shaped fin to predict effective temperature distribution further, In a Computational Fluid Dynamics (CFD), the trial has been conducted on the temperature, for a boiler water tube. In the CFD investigation it was assumed that, the flow of water is along length of tube. This investigation was carried out on a mass flow rate of 5, 10, 20, 30 kg/s.

Keywords— *CFD analysis, FLUENT, CFB boiler water tube, temperature distribution, heat transfer coefficient, water tube boiler external fin, mass flow rate.*

I INTRODUCTION

The development of fluidization technology as a widely used option for supplying clean, efficient energy has been made possible by concerns about global emissions. Despite the uproar regarding the concerning levels of global emissions and the necessity of switching to greener fuels, the dependence on coal for satisfying significant electricity demands persists. According to estimates, there is enough coal in the world to supply all the energy needed for the next 120 years. The energy industry has grown significantly in recent years. With a 195.6GW installed capacity, coal-based power plants remain in the lead. Thermal power has been allotted 72.3GW of the 12th Five Year Plan's total 88.5GW new capacity. Therefore, despite its bad reputation for producing hazardous emissions, coal will be around for a longer time. Although alternative fuels are beginning to show themselves to be more affordable options, their full potential has not yet been realised. The total installed capacity of both renewable and non-renewable power sources is shown in data released by the Indian Ministry of Coal in October 2015. The major sources of Green House gases (GHG), with CO2 as the main one, are outdated thermal power facilities with inadequate pollution control measures. NOx and SOx are two other major pollutants. SOx cause acid rain, while NOx causes respiratory diseases. If the increase in the global average temperature is not kept to within 2°C in the next 100 years, the International Panel on Climate Change (IPCC) has warned of negative consequences. Programs to renovate and extend the life of ageing thermal power plants haven't had much of an impact on emissions. Indian high ash coals worsen the situation and make disposal even more difficult. In addition to causing pollution, the influence of these pollutants on global warming has called for immediate action to undo the negative impacts created. To reduce GHG, policymakers have suggested the following measures: By absorbing and disposing of CO2 in deep wells or seas, carbon capture technology effectively reduces carbon emissions, but it has yet to demonstrate that it is an ecologically sound technology. Flue gas desulphurization and a switch from subcritical to supercritical pulverised fuel boiler technology have been shown to increase efficiency by at least 5%. Retrofitting appears to be the most well-liked solution among the aforementioned suggestions. By 1%, coal cleaning might increase the plant's efficiency even more. Fluidized bed combustion is one of the most well-liked new technologies. It has proven its worth when retrofitting traditional pulverised fuel burned boilers, and it is particularly suited for Indian coals. In a number of nations, cutting-edge technology such as the IGCC (Integrated Gasification Combined Cycle) and Ultra-Supercritical technology for pulverised fuel boilers have begun operating at varying levels.

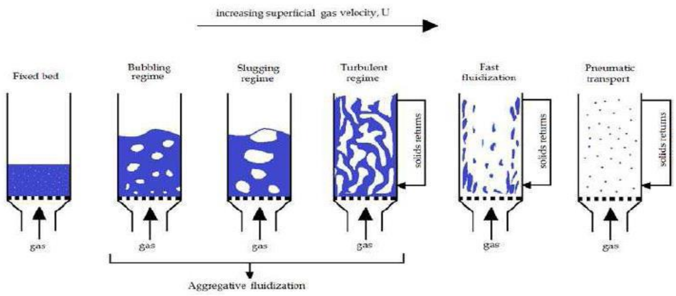

Figure 1.1: Fluidization Regimes

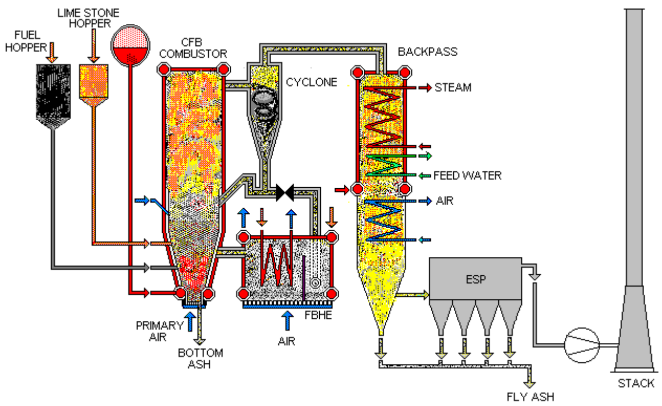

Figure1.2 A typical Circulating fluidized bed boiler

STEPS TO BE FOLLOWED

- Literature survey and problem identification.
- Study of CFB boiler and related process parameters.
- Study of mathematical model related to change in temperature inside the CFB boiler water tube.
- Identification of parameters that have influence on temperature gradient and optimum values.
- Study of thermal behavior of the proposed model of boiler water tube with different fin configurations.
- Validation of CFD model through numerical work measured temperature of water at exit of the CFB boiler water tube.
- Study and Optimize the value of variable mass flow rate at the different types of external fin configured tube of CFB boiler.
- Increase the temperature of the water at exit of CFB boiler water tube.
- Comparison of results and conclusion.
- Report preparation.

III OBJECTIVES

- To study input and output parameters and governing equations of CFB boiler tube.
- To develop a CFD model assisting with fluent flow of CFB boiler tube.
- To analyze the different mass flow rate of water (0.02 kg/s,0.04kg/s,0.06kg/s) inside the CFB boiler tube.
- To analyze the different types of CFB boiler tube (parallel flow, counter flow) and provide the temperature behavior of water at outlet.
- To analyze temperature profile of water using CFD approach and validation through experimental result.

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IV RESULTS

Developing the solid model of CFB boiler tube with external fins

Here the solid model of CFB boiler tube is developing based on the geometry of boiler water tube. Here the solid model of CFB boiler water tube is drawn inside the ANSYS and then it is analyzed in the fluent module. The workbench of the ANSYS is shown in the fig below.

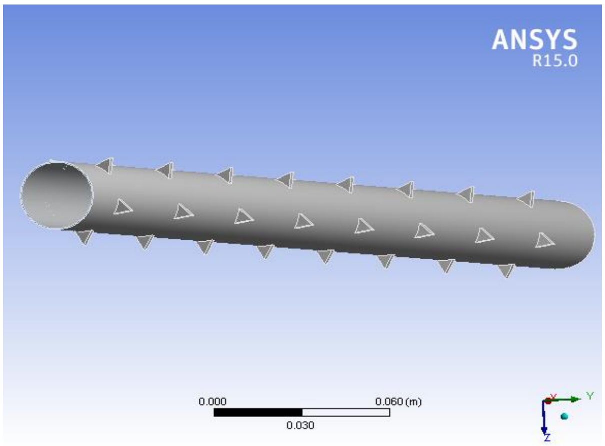


Fig.5.1 showing the development of the solid model of CFB boiler tube with wedge fin

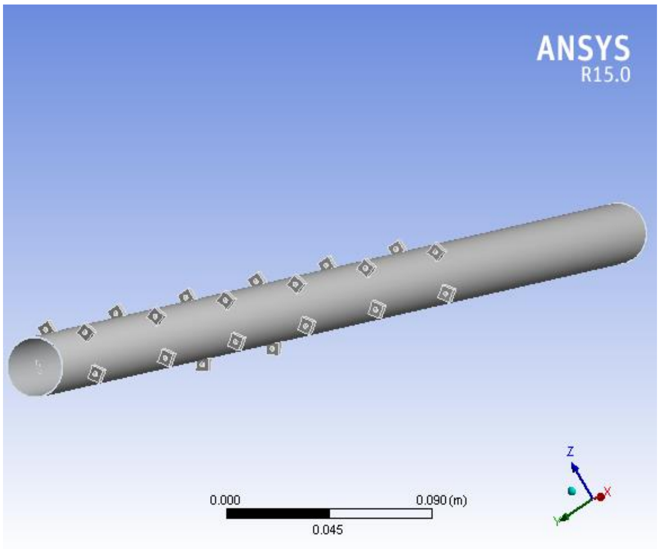


Fig.5.2 showing the solid model of the CFB boiler tube with perforated square fin

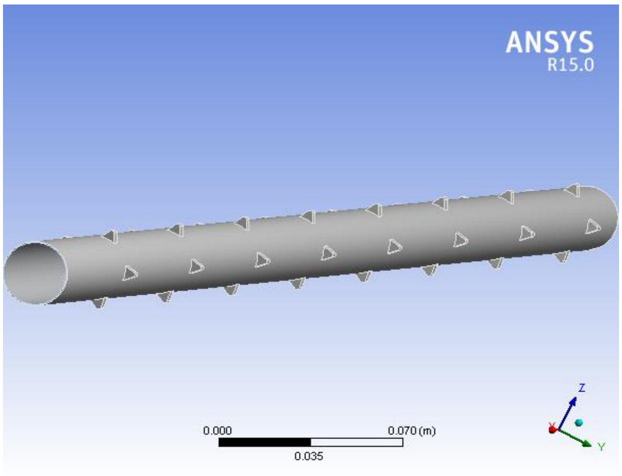


Fig.5.2 showing the solid model of the CFB boiler tube with rounded wedge fin

Table: 5.1 showing the geometric dimension of the CFB boiler tube

Parameter	values
Fin area	0.0515 m
Tube numbers	1
Tube length	1
Tubes centre	0.02 m
Tube diameter	0.03 m

Case 1- Wedge shaped fin

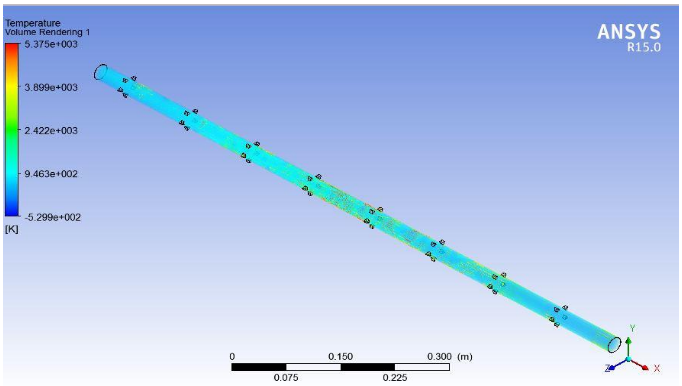


Fig 5.10 showing the contour of the temperature for the CFB boiler tube with wedge shaped fin

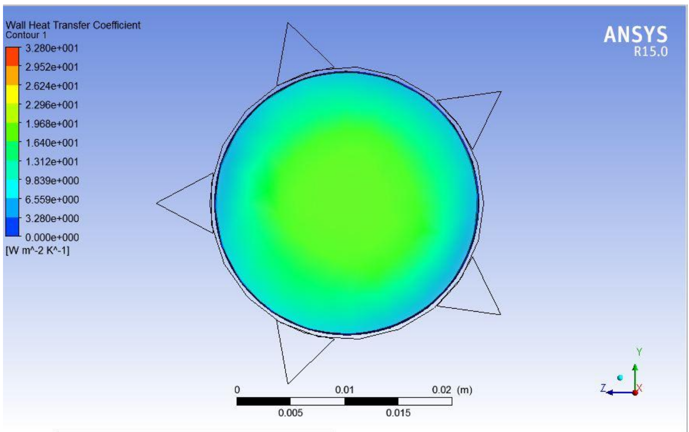


Fig 5.11 showing the heat transfer coefficient inside the CFB boiler water tube with wedge shaped fin

Table: 5.4 showing the values of the heat transfer coefficient

Wedge finned tube		
Mass flow rate (kg/s)	**Heat transfer coefficient of water at the exit of CFB boiler tube (W/m2K) (ANSYS) Wedge finned tube**	**Temperature of water at the exit of CFB boiler tube (K) Wedge finned tube**
5	154	318.85
10	152.66	315.66
20	150.85	312.85
30	147.96	310.55

Case 2- Square perforated fin

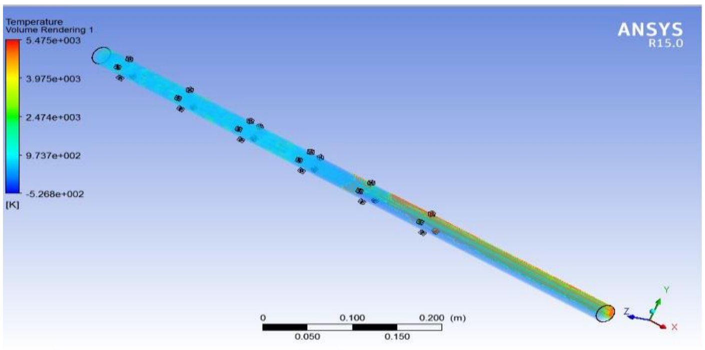


Fig 5.14 showing the contour of the temperature for the CFB boiler tube with square perforated fin

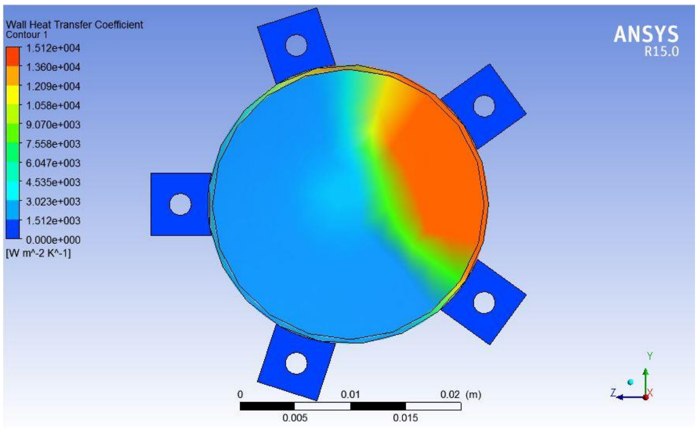


Fig 5.15 showing the heat transfer coefficient inside the CFB boiler water tube with square perforated fin

Square perforated finned tube		
Mass flow rate (kg/s)	**Heat transfer coefficient of water at the exit of CFB boiler tube (W/m2K) (ANSYS) Square perforated finned tube**	**Temperature of water at the exit of CFB boiler tube (K) Square perforated finned tube**
5	158.36	315.99
10	157.44	312.56
20	155.63	310.44
30	153.92	309.85

Case 3- Rounded wedge shaped fin

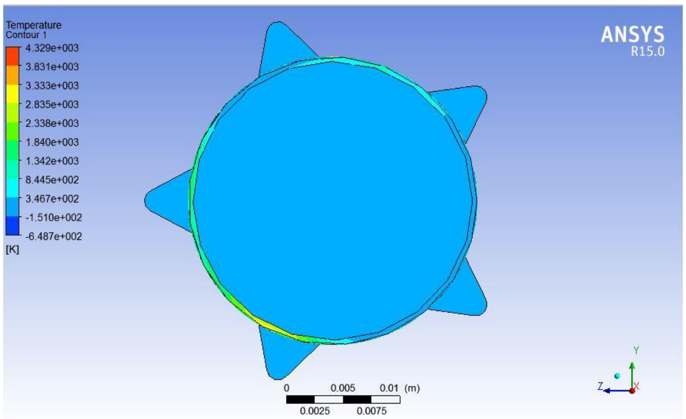


Fig 5.18 showing the contour of the temperature for the CFB boiler tube with rounded wedge shaped fin

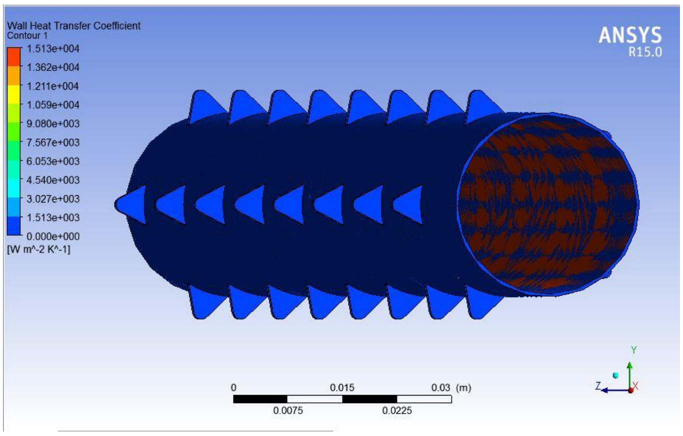
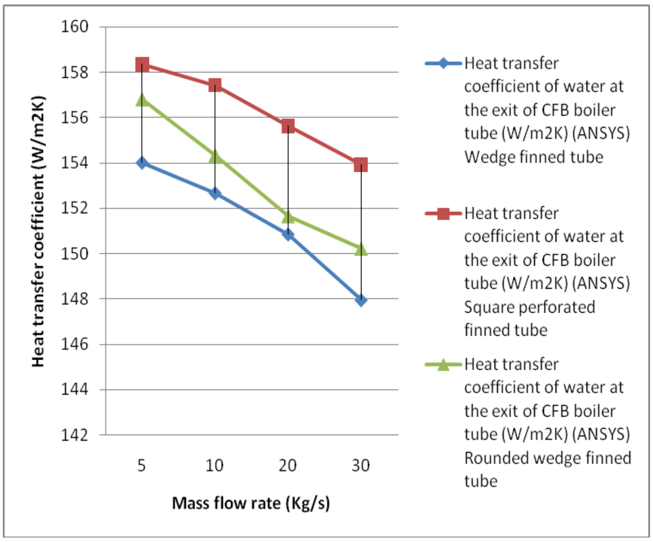
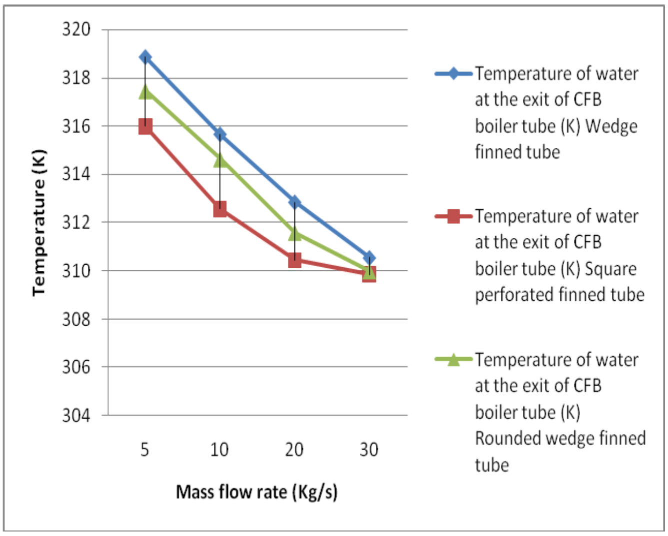


Fig 5.19 showing the heat transfer coefficient inside the CFB boiler water tube with rounded wedge shaped fin

Rounded wedge finned tube		
Mass flow rate (kg/s)	**Heat transfer coefficient of water at the exit of CFB boiler tube (W/m2K) (ANSYS) Rounded wedge finned tube**	**Temperature of water at the exit of CFB boiler tube (K) Rounded wedge finned tube**
5	156.79	317.46
10	154.33	314.63
20	151.66	311.58
30	150.23	309.98

Overall comparison





CONCLUSION

1. The CFD model was developed on ANSYS (design modeler) and analysis was done by Fluent 15.0.
2. The prediction of CFD model shows good relation with experimental result dictated in literature.
3. Simulated the CFB boiler tube having rounded wedge shaped fin and square perforated fin for different mass flow rate of (5, 10, 20, 30 kg/s) and found that square perforated shaped fin of pattern exhibits munimum temperature at outlet.

4. From the above result we have least temperature distribution square perforated fin configuration thus due to increased convection during flow which is related to optimum mass flow rate.
5. So, from the above It was concluded that the square perforated shaped fin of CFB boiler tube with different mass flow rate including external fin configuration having better temperature distribution, due to increase in surface area, thus heat concentration increase in surface area of CFB boiler tube.

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