DESIGN AND THERMAL ANALYSIS OF A SUPERCRITICAL CFB BOILER

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Abstract: **A boiler is a closed vessel in which water or other fluid is heated. The fluid does not necessarily boil. The heated or vaporized fluid exits the boiler for use in various processes or heating applications, including central heating, boiler-based power generation, cooking, and sanitation. Supercritical Circulating Fluidized Bed (CFB) boiler becomes an important development trend for coal-fired power plant and thermal-hydraulic analysis is a key factor for the design and operation of water wall. In this Paper, a simple boiler and a CFB boiler are compared for the better heat transfer performance. The 3D modeling of simple boiler and CFB boiler is done in Pro/Engineer and Heat transfer analysis is done in Ansys. The material used for boiler is steel. In this Paper, it is to be replaced with copper and brass. Thermal analysis is done to verify the better heat transfer rate by comparing simple and CFB boilers and better material.**

***Keywords*: Boiler, AutoCAD, Ansys CFD, steel, brass etc.**

INTRODUCTION:

The Kyoto Protocol, regardless whether it is fully ratified or not, has been the catalyst for a number of changes in the energy generation industry. Debate on future energy management for power stations and what types of energy should be used continues to be quite intensive, and has resulted in a lot of new research and development work. One focus of this debate has been on carbon dioxide (CO2) emissions and how to reduce them. As a result, coal remains somewhat unpopular, due to the perception that coal - fired plants pollute the atmosphere and generate higher emissions of CO2 than gas - fired technology.
Flue gas cleaning technologies have made major improvements here. The capture and sequestration of CO2 is not yet an economic technology when burning coal. The industry nevertheless needs to use coal as one of its fuel sources; and the only feasible method of reducing CO_2 in the near and medium term when utilizing coal is to emit as little CO_2 as possible, by increasing plant efficiency. Supercritical steam parameters have been applied as a first step to achieving these goals. Most of the large European thermal power plants fired on fossil fuels, such as coal and brown coal, that have been commissioned over the last decade have incorporated supercritical steam parameters In order to achieve even higher efficiencies, steam temperatures and pressures are being continuously increased as much as the metals used in boiler tubes and turbine blades allow.

The Foster Wheeler supercritical once - through boiler (OTU) employs a licensed application of Siemens' low mass-flux BENSON vertical once-through technology. It also employs the results of work performed under an EU-funded program aimed at further developing OTU CFB technology; that program known as High Performance Boiler (HIPE), began in 2002 under the Community's 5th Framework, and involves Foster Wheeler Energia Oy from Finland, Siemens AG from Germany, the Technical Research Center of Finland, and Energoprojekt Katowice from Poland. The BENSON system, together with some test results from the HIPE program, along with a design description of Foster Wheeler's 460 MW unit, are discussed below. The advantages of using low mass - flux OTU technology for a CFB boiler are described in general.

LITERATURE SURVEY

lkka Venäläinen and Rafał Psik., In this paper, the dynamic simulations of CFB boiler operations are discussed,Circulating fluidized bed (CFB) boiler technology has been growing in size and number over the past two decades and it has established its position as utility scale boiler technology. The paper describes the 460 MWe supercritical CFB boiler concept and presents the technical solutions of the boiler design with auxiliary equipment. The findings of the dynamic simulations of boiler operation are presented and discussed[1]

Ragnar Lundqvist, et.al., In this paper, the advantage of using of BENSON Low Mass Flux technology in supercritical CFB boiler is presented results of design analyses investigating the effects of varying furnace conditions, both steady-state and loss of fuel feed, on tube water/steam flow distributions and evaporator outlet temperatures[2].

Stephen J. Goidich and David E. Wagner., This paper presents the application of supercritical technology and boiler design to the proven combustion methods of Arch Fired Pulverized Coal and Circulating Fluid Bed for boiler sizes exceeding 600 MWe. The ability to successfully burn these low volatile fuels in an efficient manner, and within emission control standards is of critical importance to the future growth of the Chinese power generation industry[3].

Guangxi YUE and Junfu LU, They described A set of design theory for CFB boiler has been developed by the researchers at Tsinghua University, based on twenty-year research and development experience on CFB boiler. The theory couples the fundamental studies in the laboratory with the experiments on the commercial CFB boilers, and has been applied in designing more than 100 commercial CFB boilers[4].

Andreas Johansson et.al..,In this paper, the advantages of using loop seal in a 30MW circulating fluidized bed (CFB) boiler is high in heat transfer and low corrosive environmental effects[5].

G. X. Yue, et.al..,In this paper, the development history and development status of the CFB boiler in China are introduced. The development history of the CFB boiler in China is divided into four periods and the important features of each period are given. Some latest research activities and important results on CFB boilers, and the typical achievements and newest development of the CFB boiler in China are also introduced. In addition, a few challenges and development directions including the capacity scaling up, SO_2 removal and energy saving are discussed [6].

THERMAL ANALYSIS OF CFB BOILER USING CFD:

CFD provides a qualitative (and sometimes even quantitative) prediction of fluid flows by means of:

a) Mathematical modeling (partial differential equations)

b) Numerical methods (discretization and solution techniques)

c) Software tools (solvers, pre- and post-processing utilities)

In this chapter, thermal analysis of different materials like steel, brass and copper performed.

MATERIAL – STEEL

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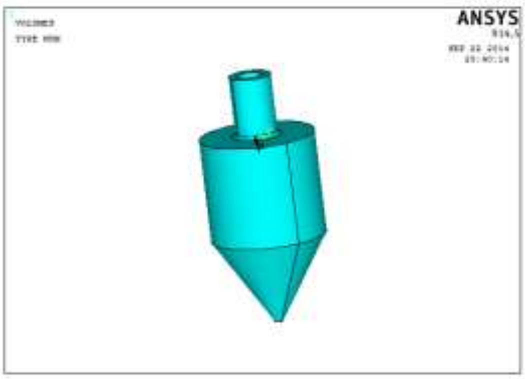</td>
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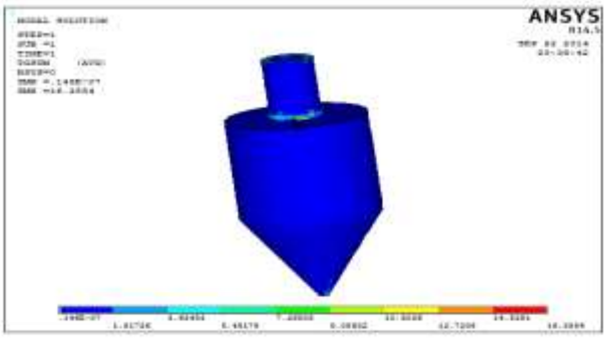</td>
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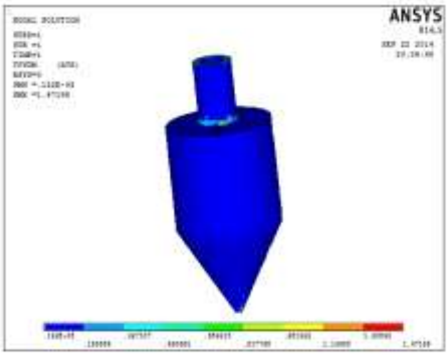
THERMAL FLUX
</td>
</tr>
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CFD ANALYSIS OF CFB BOILER:

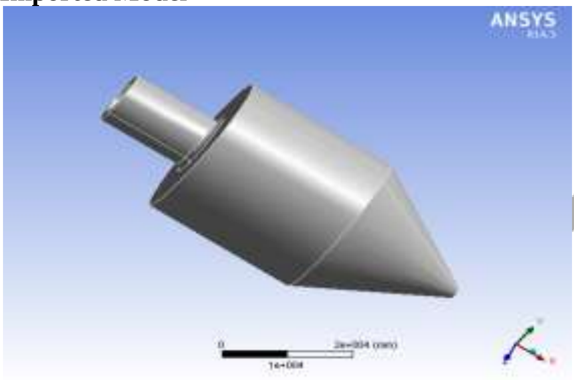
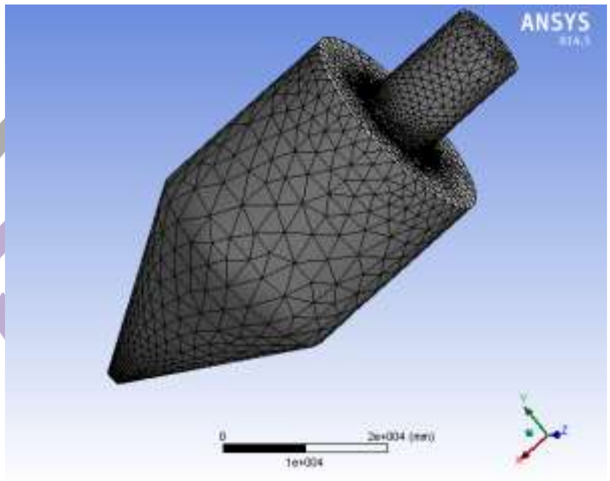
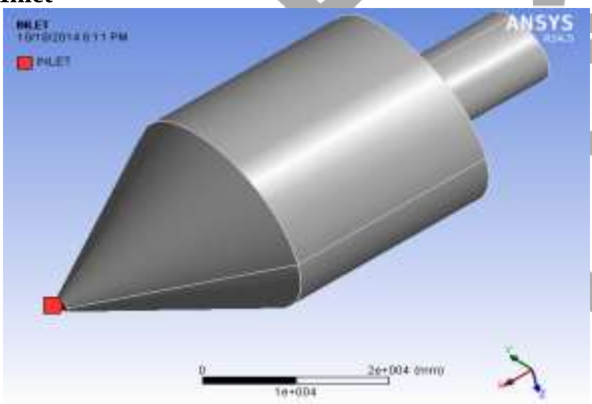
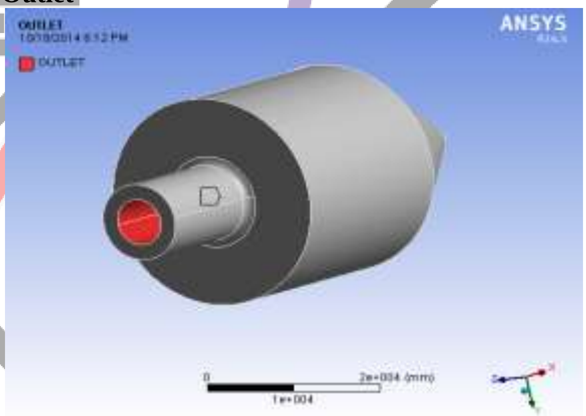
This chapter carried out different velocities for CFB Boiler like 4m/s, 5m/s & 6m/s.

Here showing for velocity 4 m/s.

Inlet velocity – 4m/s

→→Ansys → Workbench→ Select analysis system → Fluid Flow (Fluent) → double click

→→Select geometry → right click → import geometry → select browse →open part → ok

Imported Model	**Meshed model**
 →→ select mesh on work bench → right click →edit Select mesh on left side part tree → right click → generate mesh →	
Inlet	**Outlet**
	

Specifying boundaries for inlet and outlet

Select edge → right click → create named section → enter name → inlet

Select edge → right click → create named section → enter name → outlet

File →export → fluent →input file(mesh) → enter required name → save.

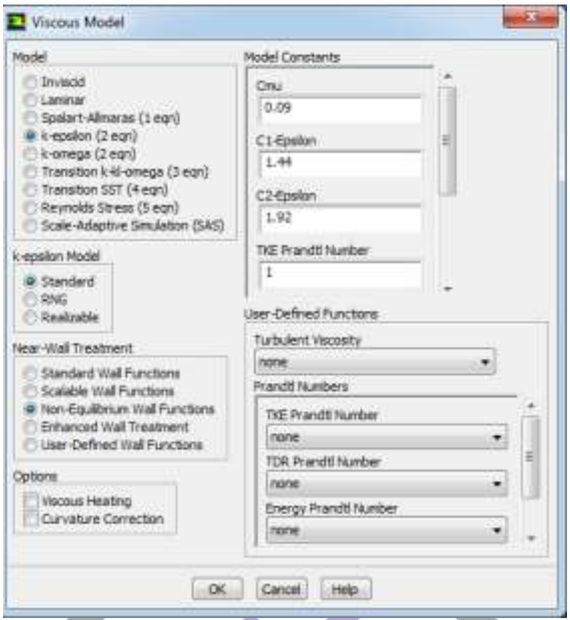
→→ ansys → fluid dynamics → fluent → select 2D or 3D → select working directory → ok

→→file → read → mesh → select file → ok.

General →Pressure based

Model → energy equation → on

Model → Viscous → Edit



Materials → new → create or edit → specify Fluid material →steam

Specific heat(cp)=1220j/kgk

Thermal conductivity(k)=0.0454w/mk

Viscosity=1.72e^{-5}kg/ms

Boundary conditions → Inlet → Edit

Pressure=1×10^{5}Pa

Temperature=1573k

Velocity magnitude → 4m/s

Solution → Solution Initialization→ Hybrid Initialization →done

Run calculations → No of iterations = 10 → calculate → calculation complete

→→ Results → graphics and animations → contours → setup

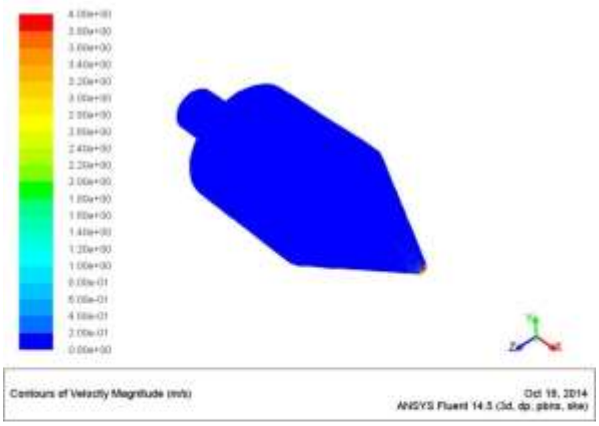


Fig: Velocity Magnitude

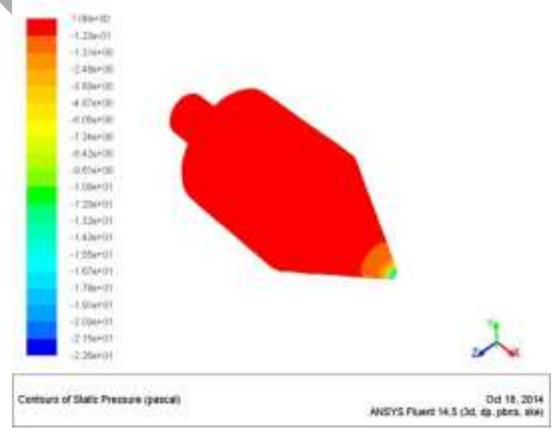


Fig:Static Pressure

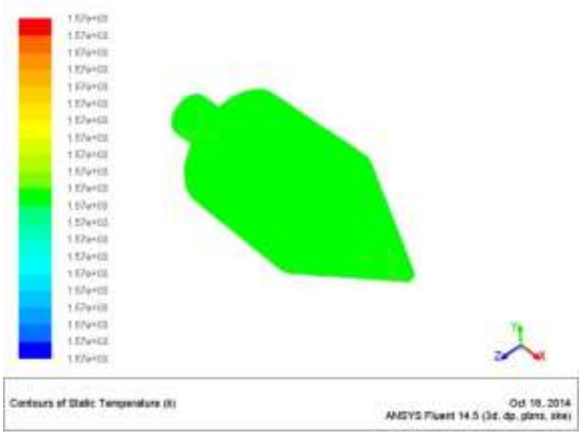


Fig: Temperature

Mass flow rate

```
  "Flux Report"

              Mass Flow Rate             (kg/s)
-------------------------------- --------------------
                  Inlet          39.813224
          Interior-____msbr            928.74986
                 Outlet         -40.278172
            Wall-____msbr                        0
          ---------------- --------------------
                   Net         -0.46494834
```

RESULTS:

SIMPLE BOILER

MATERIAL	STEEL	COPPER	BRASS
NODAL TEMPERATURE(K)	1123	1123	1123
THERMAL GRADIENT(K/mm)	22.0208	21.1724	21.8559
HEAT FLUX (W/mm^2)	1.10104	8.25724	2.40415

CFB BOILER

MATERIAL	STEEL	COPPER	BRASS
NODAL TEMPERATURE(K)	1573	1573	1573
THERMAL GRADIENT(K/mm)	16.3554	15.9157	16.2347
HEAT FLUX(W/mm^2)	1.47198	9.23111	3.57164

6.2 CFD RESULTS

	Inlet Velocity (m/s)	Results			
		Outlet Velocity(m/s)	**Pressure(Pa)**	**Temperature(K)**	**Mass flow rate (Kg/s)**
Simple boiler	**4m/s**	$2.067e^{+02}$	$1.36e^{+07}$	$1.12e^{+03}$	69.938379
	5m/s	$3.34e^{+02}$	$2.12e^{+07}$	$1.12e^{+03}$	87.881665
	6m/s	$4.01e^{+02}$	$3.05e^{+07}$	$1.12e^{+03}$	104.25339
CFB boiler	**4m/s**	$4.00e^{+00}$	$1.06e^{+00}$	$1.57e^{+03}$	0.46494834
	5m/s	$5.00e^{+00}$	$1.65e^{+00}$	$1.57e^{+03}$	0.42116011
	6m/s	$6.00e^{+00}$	$2.36e^{+00}$	$1.57e^{+03}$	0.48990058

CONCLUSION:

- In this thesis, a simple boiler and a CFB boiler are compared for the better heat transfer performance. The 3D modeling of simple boiler and CFB boiler is done in Pro/Engineer and Heat transfer analysis is done in Ansys.
- The material used for boiler is steel. In this thesis, it is to be replaced with copper and brass. Thermal analysis is done to verify the better heat transfer rate by comparing simple and CFB boiler and better material.
- By observing the thermal analysis results, by using CFB boiler, heat transfer rate is increased since thermal flux is more than that of simple boiler.
- By comparing the materials, using copper is better since thermal flux is more.
- So it can be concluded that using CFB boilers yields better results than simple boilers.

REFERENCES:

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