International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 14
October 2016

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 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 boilers and better material. And even CFD analysis is done for verifying the heat transfer in the CFB boiler.

INTRODUCTION

SUPERCRITICAL BOILER

A supercritical boiler is a type of steam generator that operates at supercritical pressure, frequently used in the production of electric power.

In contrast to a subcritical boiler, a supercritical steam generator operates at pressures above the critical pressure 3,200 psi or 22 MPa in which bubbles can form. Instead, liquid water immediately becomes steam. Water passes below the critical point as it does work in a high pressure turbine and enters the generator's condenser, resulting in slightly less fuel use and therefore less greenhouse gas production.

Technically, the term "boiler" should not be used for a supercritical pressure steam generator as no "boiling" actually occurs in the device.

Working of a Supercritical Boiler

A supercritical boiler burns pulverized coal and is a once-through boiler, meaning that it doesn’t require a drum to separate steam from water. Rather than boiling water to produce steam and then using that steam to turn a plant’s turbine, a supercritical boiler operates at such high pressure (3,208 psi/221.2 bar or above) that the fluid matrix in it ceases to be liquid or gas. Instead, it becomes what is known as a “supercritical fluid.”

This supercritical fluid turns the turbine that generates electricity. As it does so, it drops below the critical pressure point and becomes a mix of steam and water, passing into a condenser. In the process, less fuel is consumed than in a traditional drum boiler, making supercritical boilers more efficient than their subcritical counterparts.

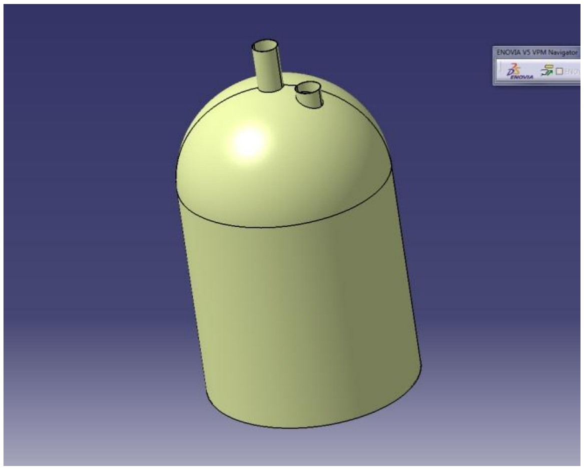
Benefits of Supercritical Boilers

It’s hard to believe, but supercritical boiler technology is almost 100 years old. Granted, it didn’t look anything like what it does today when Mark Benson first obtained a patent to convert water into steam at high pressure levels in 1922, but the drive to improve the power industry’s ability to burn coal through supercritical means has been constant throughout the history of modern boiler engineering.

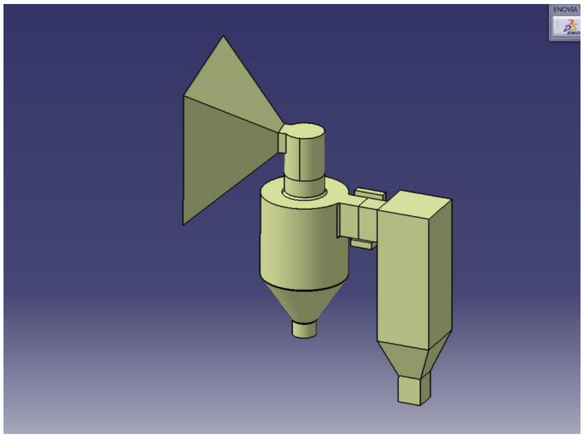
After some problems in the 1960s and 1970s, supercritical technology began to hit its stride in the 1980s and has been yielding better performance statistics ever since. With increasing government and industry pressures to reduce emissions and increase efficiency, supercritical boilers (or “steam generators,” since no actual boiling occurs in supercritical units) promise to be a part of the overall solution by using less fuel and helping coal-burning plants comply with more and more stringent emissions regulations.

Supercritical boilers offer benefits in the three interrelated areas that mean the most to plant owners and operators today: efficiency, emissions, and cost. While supercritical boilers cost more than comparably sized subcritical boilers, the larger initial capital investment can be offset by the lifecycle savings yielded by the technology’s improved efficiency, reduced emissions, and lower operating costs —all due to its higher steam temperature and pressure parameters.

DESIGN OF BASIC BOILER

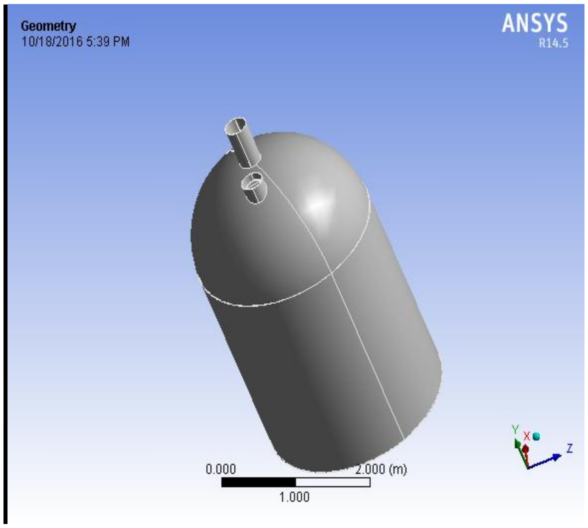


CFB BOILER DESIGN

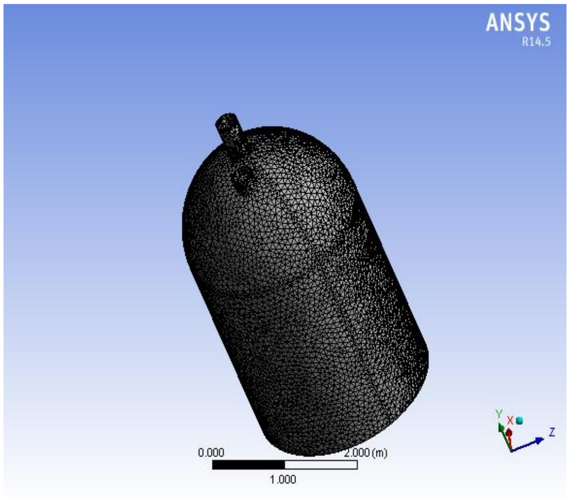


TRANSIENT THERMAL ANALYSIS OF BASIC MODEL OF BOILER MADE OF BRASS

IMPORTED MODEL



MESHED MODEL



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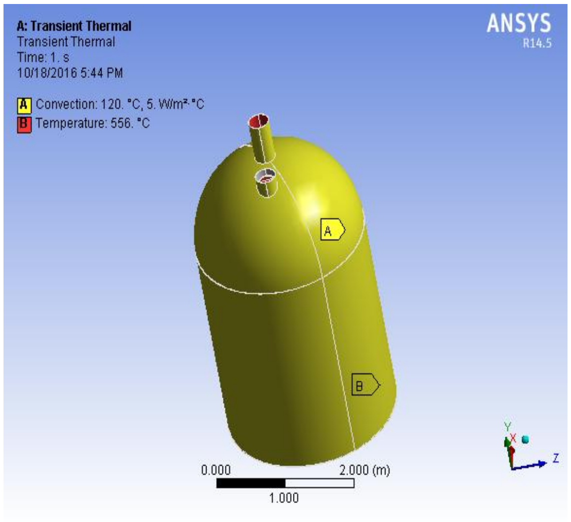

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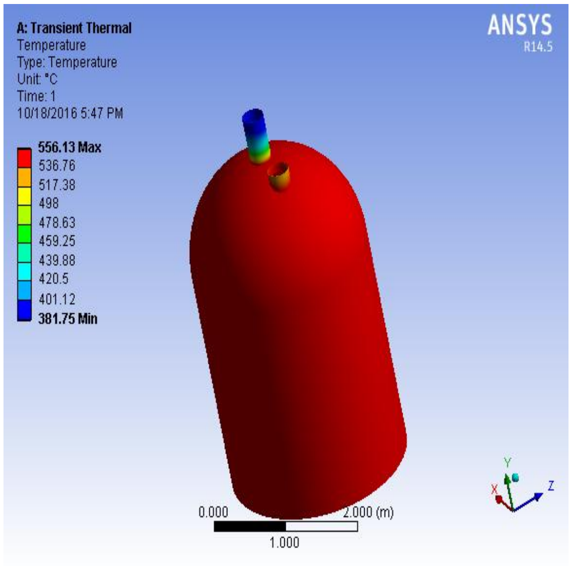
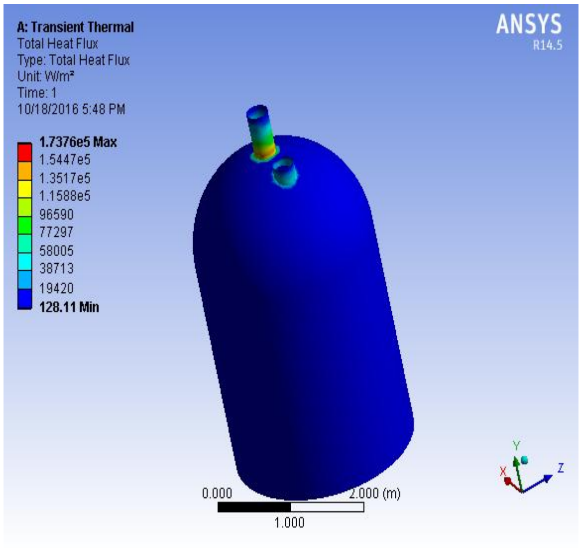
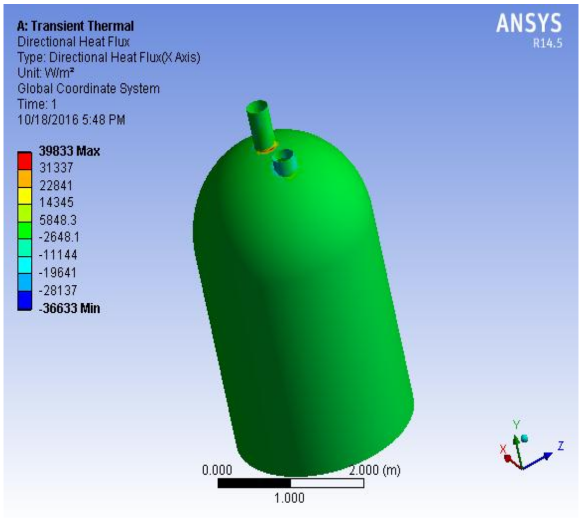


THERMAL FLUXES



DIRECTIONAL HEAT FLUX



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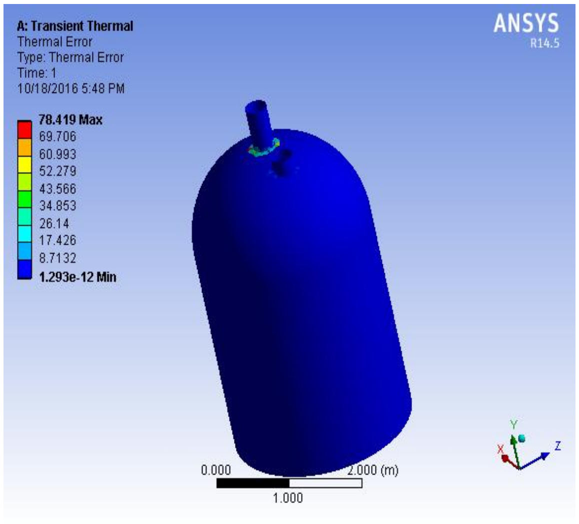
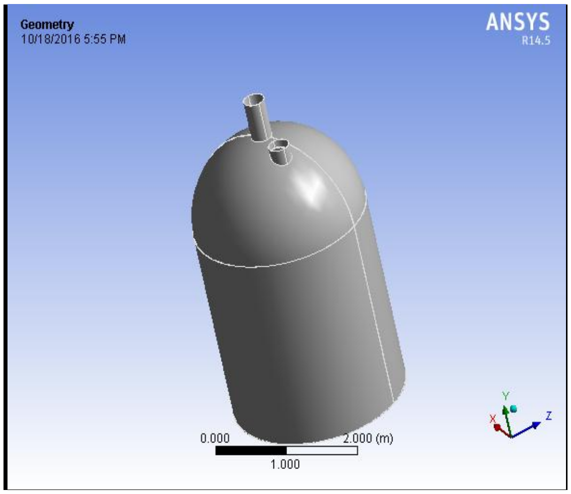


TRANSIENT THERMAL ANALYSIS OF BASIC MODEL OF BOILER MADE OF COPPER

IMPORTED MODEL



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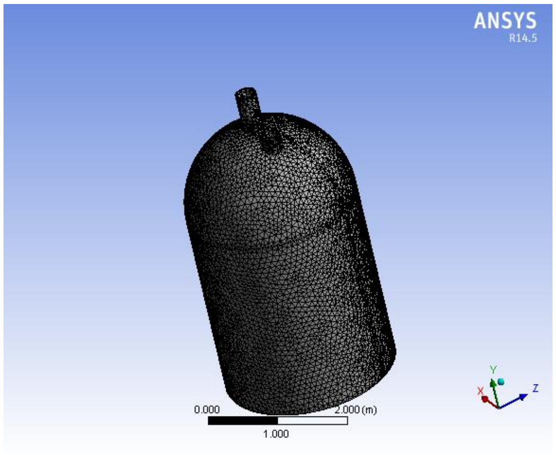

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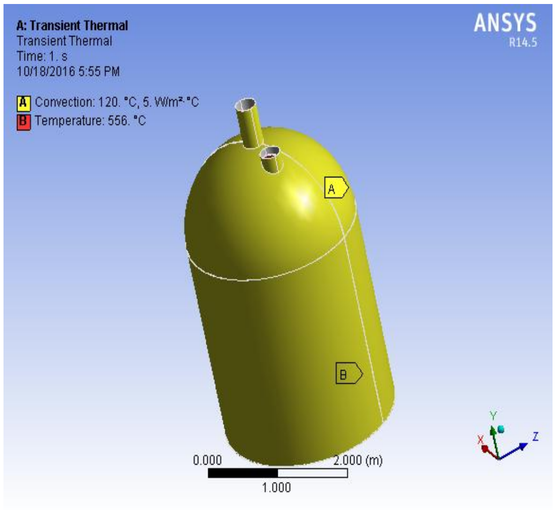

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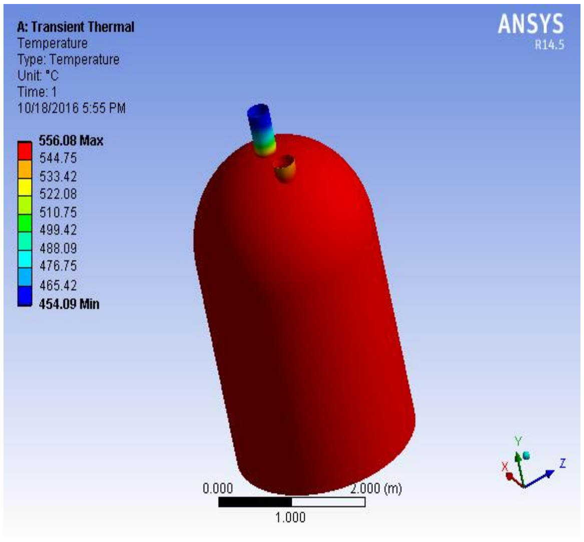

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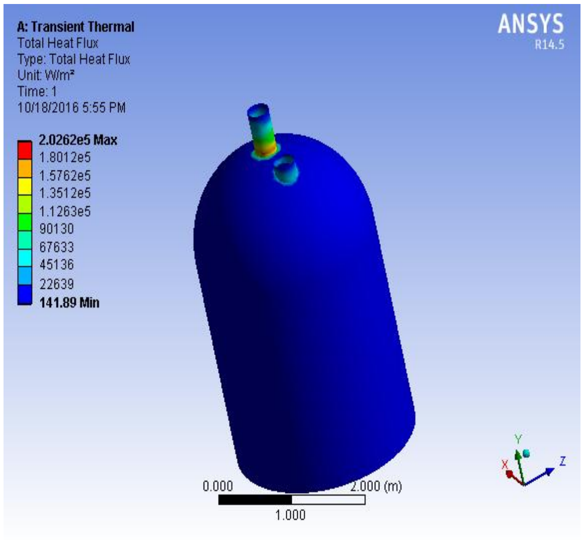

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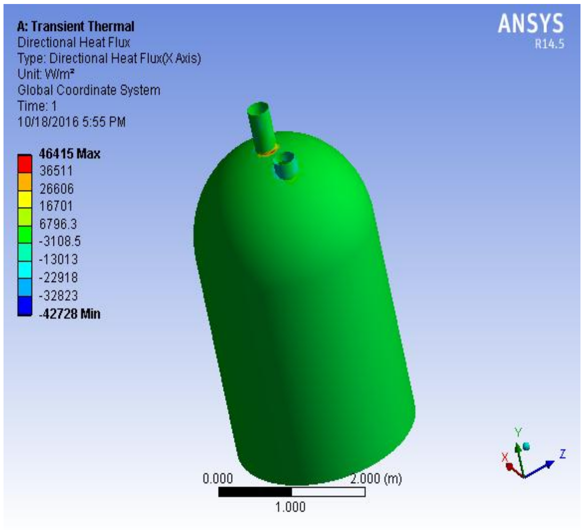

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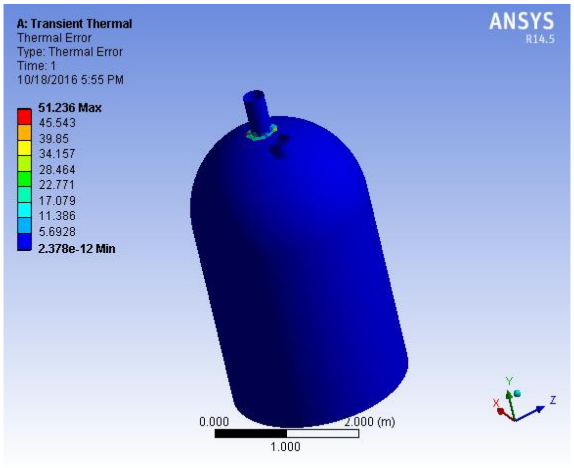
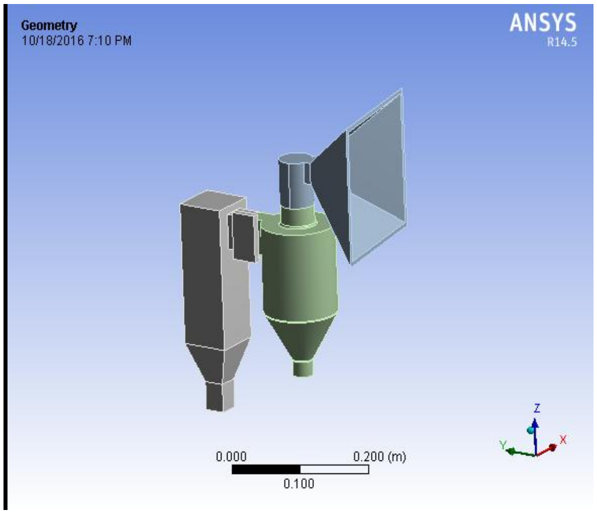


TRANSIENT THERMAL ANALYSIS OF CFB MODEL OF BOILER MADE WITH BRASS

IMPORTED MODEL



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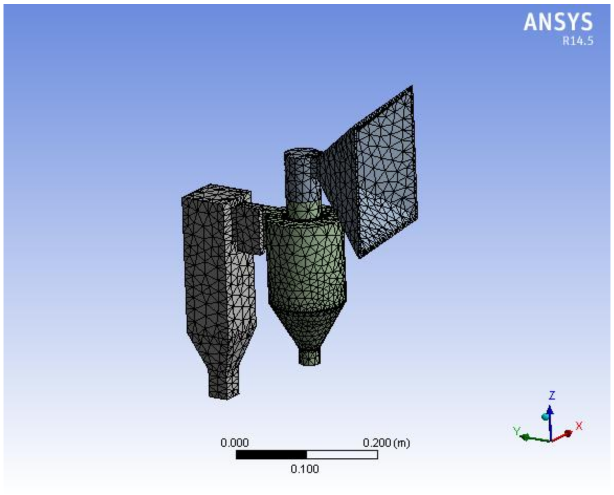

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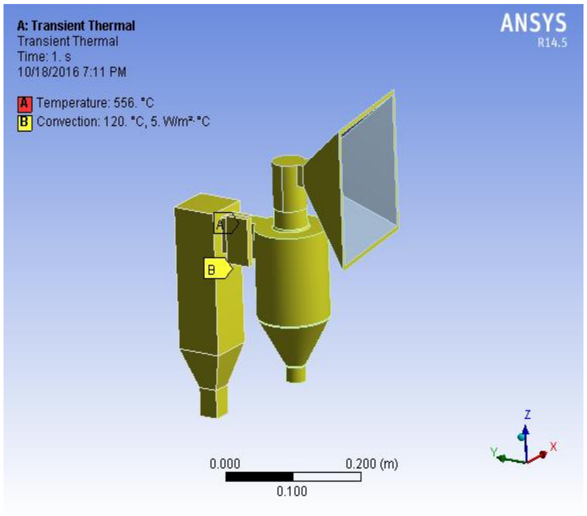

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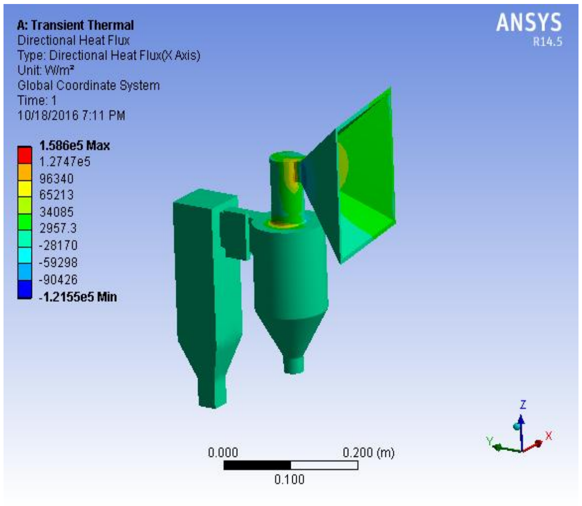

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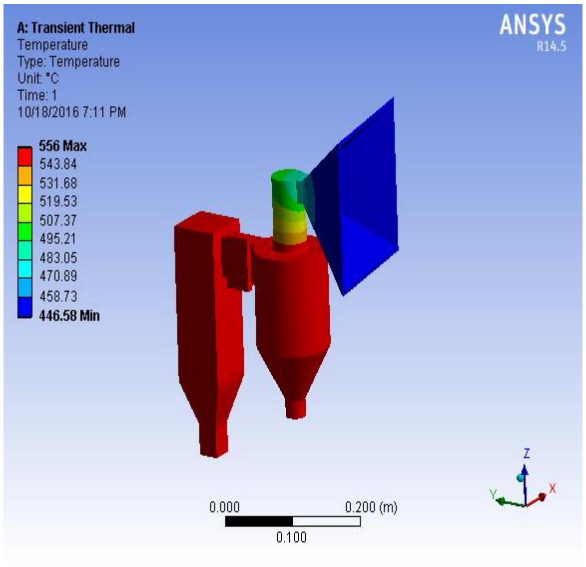

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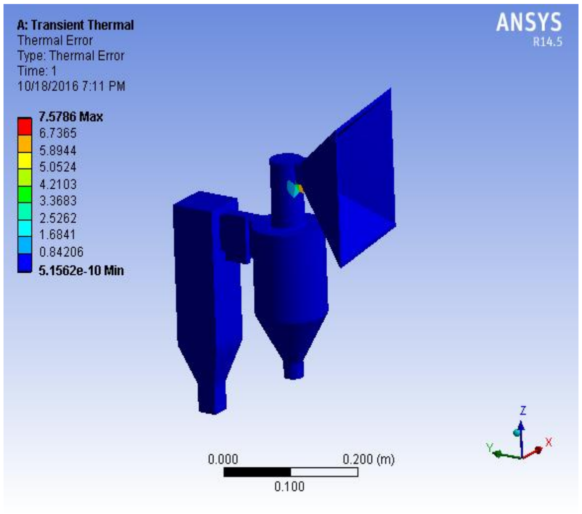

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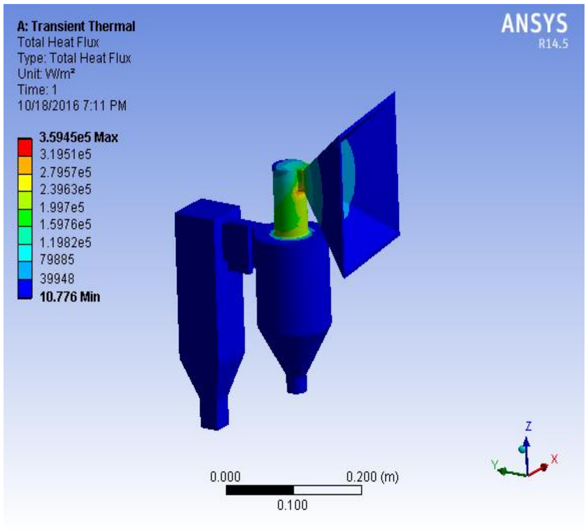
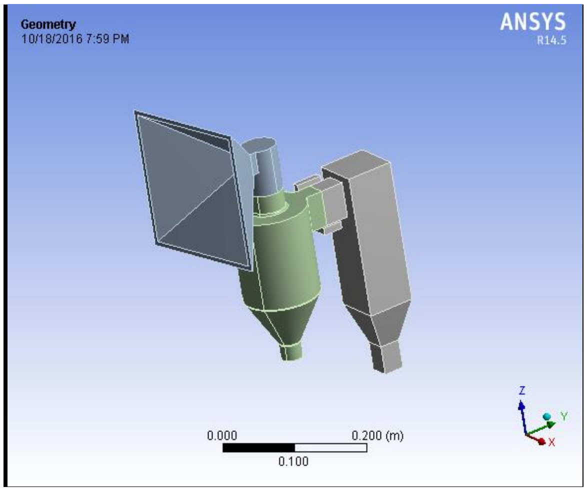


TRANSIENT THERMAL ANALYSIS OF CFB MODEL OF BOILER MADE WITH COPPER

IMPORTED MODEL



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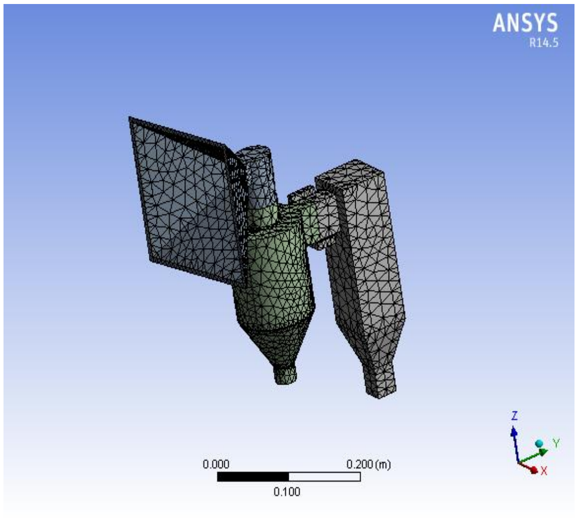

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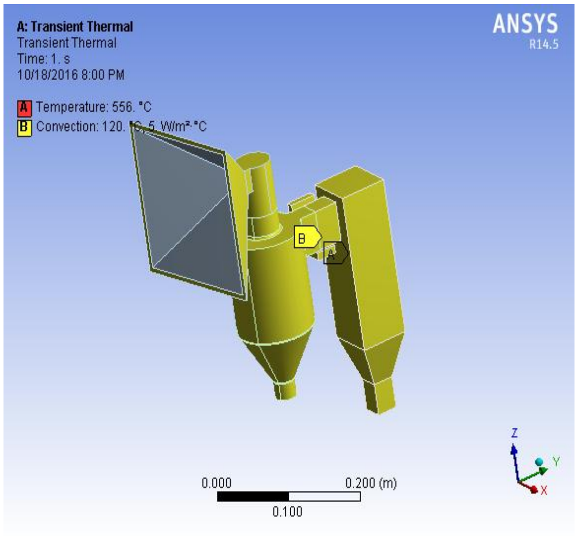

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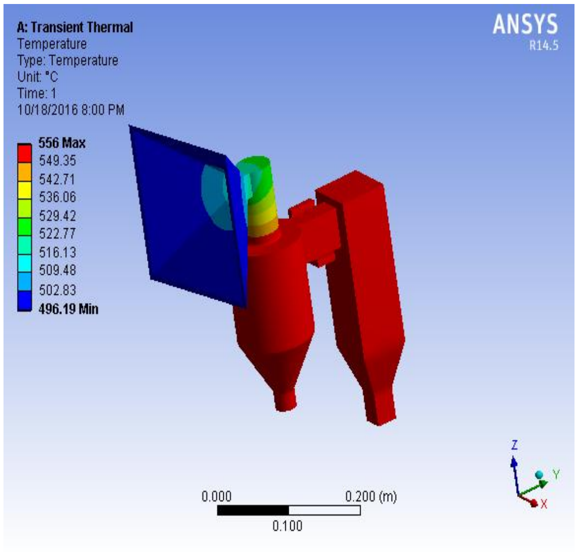

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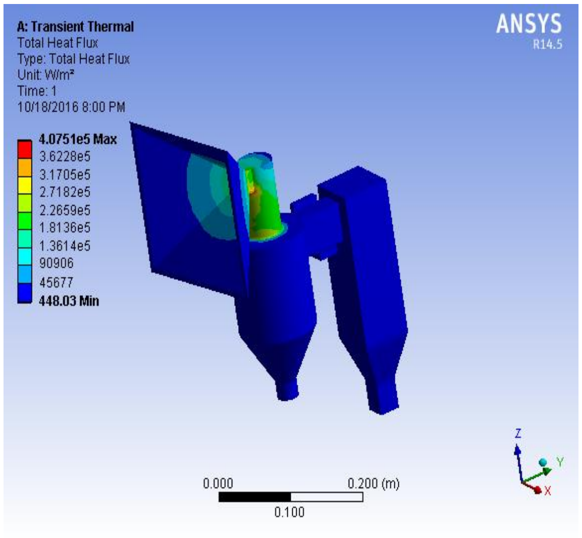
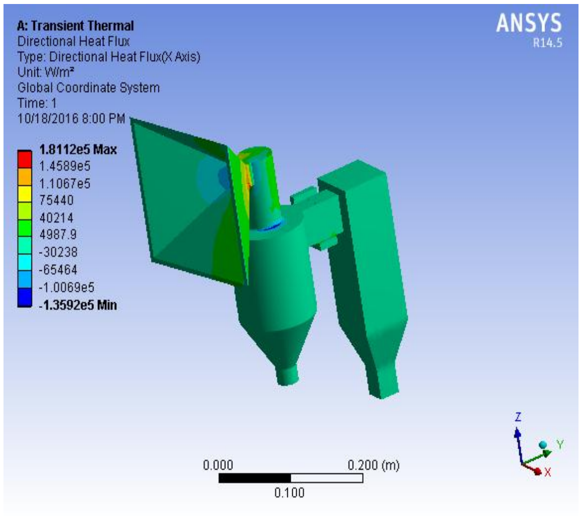


DIRECTIONAL HEAT FLUX



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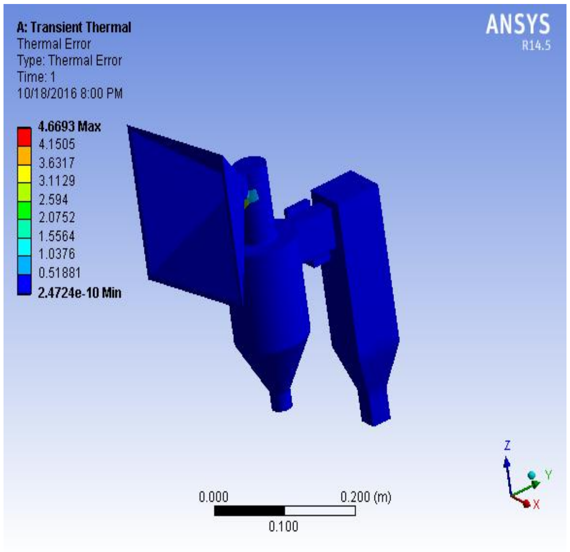

TABLES

THERMAL ANALYSIS TABLES

REGULAR MODEL	temperature		thermal flux		directional flux (x)		Thermal error	
	min	max	min	max	min	max	min	max
brass	381.75	556.13	128.11	1.7376e5	-36633	39833	1.293e-12	78.419
copper	454.09	556.08	141.89	2.0262e5	-42728	46415	2.378e-12	51.236

CFB BOILER	temperature		thermal flux		directional flux (x)		Thermal error	
	min	max	min	max	min	max	min	max
brass	446.58	556	10.776	3.55945E5	-1.2155E5	1.586E5	5.1562E-10	7.5786
copper	496.19	556	448.03	4.0751E5	-1.3592E5	1.8112E5	2.4724E-10	4.6693

cfd analysis report of SIMPLE BOILER

	min	max
sheer stress	0	8.86E+00
velocity magnitude	0	1.48E+01
temperature	2.95E+02	2.78E+03
static pressure	-1.57E+04	1.31E+04
density	1.23E+00	

Cfd analysis report of CFB BOILER

	min	max
sheer stress	0	1.42E+00
velocity magnitude	0	1.11E+01
temperature	4.43E+02	4.43E+02
static pressure	-3.43E+01	1.08E+02
density	1.23E+00	

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 boilers and better material.

As per the analysis done if we observe the results obtained for the simple boiler, we can find that the brass material is the best material for the simple boiler as the flux obtained is lees compared with the copper.

As in the other case a CFB boiler is considered and analysis is done, as if we compare the results of the CFB boiler we can see that the brass material CFB boiler is much better for the better life output as the stress is very minimum in this material. Her even CFD analysis is done to the CFB boiler to verify the stress and pressure and density values,

As if we compare both the results we can conclude that CFB boiler gives much better output for the material and even the temperature and the flux obtained is the best results for the boiler.

AUTHORS

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2. **GUIDE 1**