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THERMAL-HYDRAULIC ANALYSIS OF A 600MW SUPERCRITICAL CFBC BOILER WITH LOW MASS FLUX

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ABSTRACT: Heavy industrialization & modernization of society demands in increasing of power, cause to research & develop new technology and efficient Utilization of existing power units. Variety of sources available for power generation are, thermal, hydro, nuclear and renewable sources like wind, tidal, biomass, geothermal & solar. Out of these most common and economical way for producing the power is by thermal power stations. Various industrial boilers plays an important role to complete the power generation cycle such as CFBC (Circulating Fluidized Bed Combustion), FBC (Fluidized Bed Combustion), AFBC (Atmospheric Fluidized Bed Combustion Boiler), CO Boiler, RG & WHR Boiler (Waster heat recovery Boiler). In this thesis, The coal combustion in circulating fluidized bed Combustion and the k–ϵ two-phase turbulence model was used to describe the gas–solids flow in a CFBC. The analysis of coal combustion is done by discrete phase model (DPM) and non pre mixed combustion in species model .Predicting the performance of large scale circulating fluidized bed boilers requires reliable and efficient modelling tools. In a CFB furnace, the fuel, air, and other input materials are fed locally and the mixing of different reactants is limited. . As a result of analysis, the variation in mean particle diameter and superficial velocity, does affect the temperature, pressure and turbulence kinetic energy in different mean fractions in the combustion zone. In this project the thermal analysis is done through finding the heat flux and temperature distribution and taking required thermal results through the CFD analysis. Finding the pressure, velocity, mass flow rate ,heat transfer coefficient and heat transfer rate of cyclone circulator and 600mw super critical CFBC boiler at low mass flux.

Key words: CFBC boiler, CFD analysis, CREO

1. INTRODUCTION

A boiler is a closed vessel in which water or other fluid is heated. The heated or vaporized fluid exits the boiler for various processes or heating applications including water heating, power generation, cooking, and sanitation. 'Getting rid of waste' was the ultimate goal when the fluidized bed combustion (FBC) technology was introduced This goal evolved over time to 'clean energy for the future'. Since its introduction in the 1970s the technology has gained acceptance in various industrial applications..

BOILER TYPES AND CLASSIFICATIONS:. A fuel-fired hot water heater because of its similarities in many ways to a steam boiler it is also called as "hot water boiler". Hotwater boilers that have temperatures above 250° F or pressures greater than 160 psig are called "high temperature hot water boilers". Hotwater boilers that temperatures not crossing 250° F are called low temperature hot water boilers.

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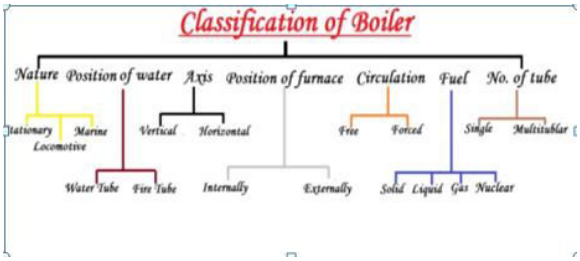
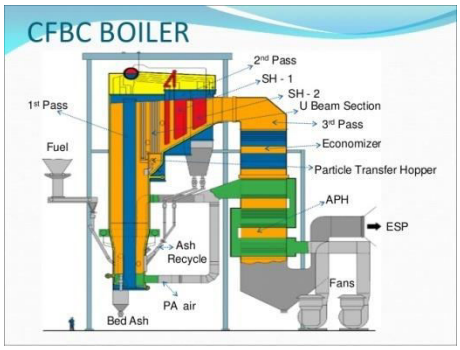


1.2 WORKING PRINCIPLE OF CFBC BOILER: CFBC stands for circular fluidized bed combustion. Here ash leaving with flue gas is recirculated to combustion zone. This ash reduces combustion temperature. Due to recirculating of ash unburnt carbon get burnt. CFBC boilers are very usefull particularly for Indian coal which has high percentage of ash. CFBC boilers give unburnt coal percentage as low as .5 %. Ash which isunburnt can be used in cement kiln.Circulating Fluidized Bed combustion has given boiler and power plant operators a great flexibility in burning a wide variety of coal and other fuels.



APPLICATIONS OF BOILERS: Have you ever wondered why locomotives release steam? It is actually produced by the boiler which is responsible for the train to run. Boilers work by burning fuels such as oil, wood, coal or natural gas and the generated fire will heat up the water. Apart from fuel, nuclear reactor can also supply the heat. The water will transforms to steam which pressure drives the engine. During the early times, locomotive's engine was referred to as boilers way before the term steam generators was coined. Today, boilers are considered as part of bigger engine called steam generators.

CHARACTERISTICS OF ABOILER: The boiler should have maximum steam generation rate with minimum fuel consumption. It can be started or stopped quickly. Its initial cost, running and maintenance cost should not be high. Its erection time should be less and its parts should be easily dismantable.

2.0 LITERATURE REVIEW

KurapatiNageswaraRao, Mr.SanmalaRajasekhar, Mr. K. Mohan Krishna,. "Thermal Analysis of a Supercritical CFB Boiler" volume no: 2 (2015), issue no: 12 (December).,International Journal & Magazine of Engineering, Technology, Management and Research, 2015.

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

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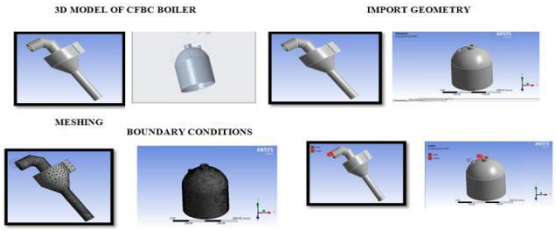
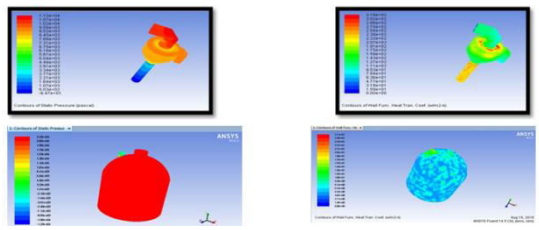
analysis is done in Ansys. The material used for boiler is steel

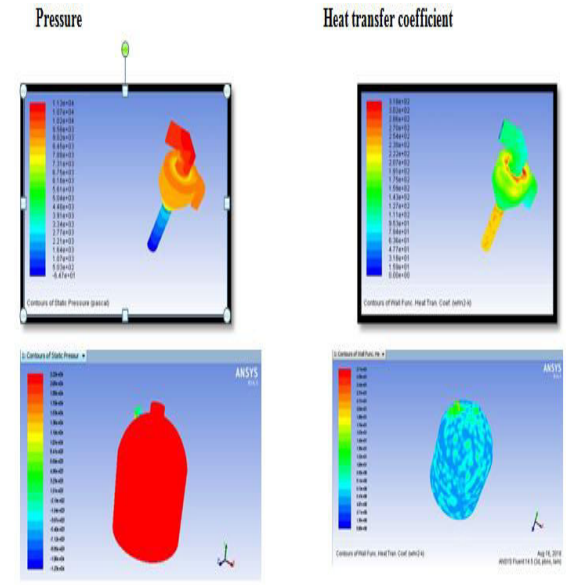
3. RELEATED STUDY

3.1 INTRODUCTION TO CREO: PTC CREO, in advance ask as Pro/ENGINEER, is 3-D modeling software bundled software cause to bear in mechanical touching, cartoon, up, and in CAD drafting jobholder firms. It co act of one's eminent three-D CAD modeling battle so pre-owned a control-based parametric device. Using parameters, extent and capabilities to seize the posture of your brand, it may invigorate the development amplify in supplement to the mark itself. The prescribe present within comprehend in against Pro/ENGINEER Wildfire to CREO. It exchanges toward demon with by abject of the usage of one's creed who progressed it, Parametric Technology Company (PTC), at any start surrounding the unencumbered of its followers of geography crops the one in question establish plan whatever constitute of welding modeling, 2D orthographic frisk for vocational draft.



3.2 INTRODUCTION TO FEA Finite element analysis is a method of solving, usually approximately, certain problems in engineering and science. It is used mainly for problems for which no exact solution, expressible in some mathematical form, is available. One of the first applications of FEA was, indeed, to find the stresses and strains in engineering components under load. FEA, when applied to any realistic model of an engineering component, requires an enormous amount of computation and the development of the method has depended on the availability of suitable digital computers for it to run on. The method is now applied to problems involving a wide range of phenomena, including vibrations, heat conduction, fluid mechanics and electrostatics, and a wide range of material properties, such as linear-elastic (Hooke's) behavior and behavior involving deviation from Hooke's law. In this theseis we see the analysis of cyclone circulator(coal feeder) & boiler of CFBC power plant





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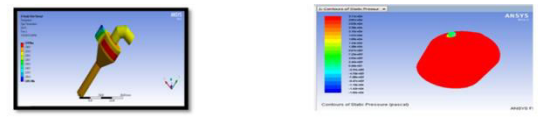
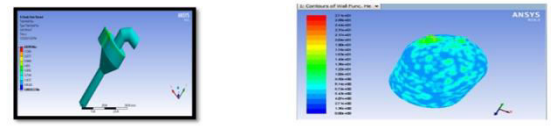
MATERIAL- BRASS At velocity-25m/s

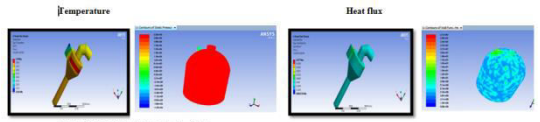
Temperature



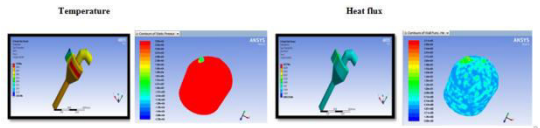
Heat flux



MATERIAL- BRASS At velocity-30m/s



MATERIAL- BRASS At velocity-35m/s



MATERIAL- BRASS At velocity-40m/s

MASS FLOW RATE

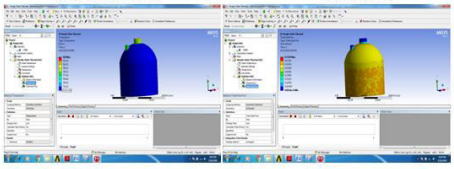
Mass Flow Rate		(kg/s)
interior-____msbr	inlet	0.36843044
	outlet	1.3986996
wall-____msbr		-0.36794347
		0
Net		0.00048696995

HEAT TRANSFER RATE

Total Heat Transfer Rate		(w)
wall-____msbr	inlet	27753.969
	outlet	-27801.289
		-995.25424
Net		-522.59089

THERMAL ANALYSIS OF MATERIAL-BRASS

TEMPERATURE **HEAT FLUX**



CFD Analysis Result Table At Different Velocites

Velocity (m/s)	Pressure (Pa)	Heat transfer co-efficient (w/mm²-k)	Massflowrate(kg/s)	Heat transfer rate(W)
25	$3.59e^{+03}$	$2.28e^{+02}$	0.0003222	133.9430
30	$5.89e^{+03}$	$2.68e^{+02}$	0.000257	115.23206
35	$6.19e^{+03}$	$2.92e^{+02}$	0.0011712	245.6123
40	$1.13e^{+04}$	$3.18e^{+02}$	0.0002809	207.46558

Comparison of Thermal results at different materials of Cyclone Circulator

Material	Temperature°C		Heat flux W/mm²
	Min.	Max.	
Steel	643.29	820	0.59752
Stainless steel	463.17	820	0.30392
Cast iron	625.31	820	0.56776
Brass	742.66	820	0.7559

Comparison of thermal analysis at different materials of Boiler

MATERIAL	Temperature°C		Heat flux W/mm²
	Min.	Max.	
Steel	34.3362	100	0.27352
Stainless steel	29.3362	100	0.10972
Cast iron	33.769	100	0.25306
Brass	56.09	100	0.43069

CONCLUSION

In this thesis, The coal combustion in circulating fluidized bed combustion and the two-phase turbulence model was used to describe the gas–solids flow in a CFBC boiler. The analysis of coal combustion is done by discrete phase model (DPM) and non pre mixed combustion in species mode. Predicting the performance of large scale circulating fluidized bed boilers requires reliable and efficient modelling tools. In a CFBC furnace, the fuel, air, and other input materials are fed locally and the mixing takes place in cyclone circulator and then transfer to boiler for combustion and production of steam in return to generate power. By observing the CFD analysis of both cyclone circulator and boiler the heat transfer coefficient, pressure drop values are increasing by increasing the inlet velocities. And the heat transfer rate &

mass flow rate values are better at inlet velocity 35m/s. By observing the thermal analysis the heat flux values are more for brass material in both i.e cyclone circulator and boiler analysis. So it can be concluded the Brass material is better material for CFBC boiler for better performance.

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