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CFD SIMULATIONS OF A LAB-SCALE FLUIDIZED-BED REACTOR WITH AND WITHOUT SIDE-GAS INJECTION

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Abstract-Fluidizedbed reactors are widely used in the biofuel industry for combustion, pyrolysis, and gasification processes. In this work, a lab-scale fluidized-bed reactor without and with side-gas injection and filled with 500–600m glass beads is simulated using the computational fluid dynamics (CFD) code Fluent 6.3, and the results are compared to experimental data obtained using pressure measurements and 3D X-ray computed tomography. An initial grid-dependence CFD study is carried out using 2D simula-tions, and it is shown that a 4-mm grid resolution is sufficient to capture the time- and spatial-averaged local gas holdup in the lab-scale reactor. Full 3D simulations arethen compared with the experimental data on 2D vertical slices through the fluidized bed. Both the experiments and CFD simulations without side-gas injection show that in the cross section of the fluidized bed there are two large off-center symmetric regions in which the gas hold up is larger than in the center of the fluidized bed.

***Keywords* -** Fluidizedbed reactors ,glass beads, computational fluid dynamics.

I.Introduction

A boiler isaclosed vessel inwhich water orother 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 water heating, central heating, boiler-based power generation, cooking, and sanitation. fluidized bed combustion (FBC) is known for its ability to burn low-grade fuels with low calorific value, high ash content and high moisture content. Fluidized beds suspend solid fuels on upward-blowing jets of air during the combustion process. The result is a turbulent mixing of gas and solids. When a fluidized bed is operated above the terminal velocity of the particles, they are carried out of the bed. The system of a circulating fluidized bed (CFB) occurs when the particles are separated from the fluid by the use of cyclones and are recycled to the bed. The part of the system where the carryover of solids transpires is normally referred to as the riser. It is known for its ability to burn low-grade fuels with low calorific value, high ash content and high moisture content. In this paper, the gas (air) and solid (coal) is injected at the base with different velocities while taking coal particles of different diameters as solid bed. In the 2D CFB combustor have the 3 inlet points such as inlet for fluidizing velocity (primary air), inlet for coal particles and inlet for secondary air. The primary air is used for the fluidized of coal particle and secondary air for proper combustion in the combustor. The combustion processes is done by the discrete phase model and use the single injection system for burning of coal in the combustor. Aim & objective is to understand the cause of failure & serve the solution with technical aspects. This can be only achieved by using advance CAD/CAE/CFD tools available to demonstrate the actual boiler operation phenomenon virtually in to computers. Steps followed to achieve the simulation are Prepare individual equipments into CAD software Prepare the general arrangement of equipments of FLUIDIZED-BED REACTOR. To simulate the flow of flue gas inside the loop of FLUIDIZED-BED REACTOR by using CFD software to understand & address the failures

II.Material Selection

Brass is a metallic alloy that is made of copper and zinc. The proportions of zinc and copper can vary to create different types of brass alloys with varying mechanical and electrical properties. [1] It is a substitutional alloy: atoms of the two constituents may replace each other within the same crystal structure. In contrast, bronze is an alloy of copper and tin. Bronze and brass -in turn- may include small proportions of a range of other elements including arsenic, lead,phosphorus, aluminium, manganese, and silicon. The term is also applied to a variety of brasses, and the distinction is largely historical. Modern practice in museums and archaeology increasingly avoids both terms for historical objects in favour of the all-embracing "copper alloy".

Brass is used for decoration for its bright gold-like appearance; for applications where low friction is

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required such as locks, gears, bearings, doorknobs, ammunitioncasings and valves; for plumbing and electrical applications; and extensively in brass musical instruments such as horns and bells where a combination of high workability (historically with hand tools) and durability is desired. It is also used in zippers. Brass is often used in situations in which it is important that sparks are not struck, such as in fittings and tools used near flammable or explosive materials. Brass has higher malleability than bronze or zinc. The relatively low melting point of brass (900 to 940 °C, 1,650 to 1,720 °F, depending on composition) and its flow characteristics make it a relatively easy material to cast. By varying the proportions of copper and zinc, the properties of the brass can be changed, allowing hard and soft brasses. The density of brass is 8.4 to 8.73 grams per cubic centimetre (0.303 to 0.315 lb/cu in).

III. Experimental Procedure

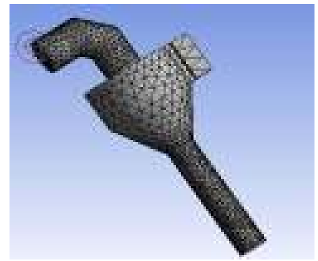
1) Cfd Analysis Of Fluidized-Bed Reactor

→→Ansys → workbench→ select analysis system → fluid flow fluent → double click

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

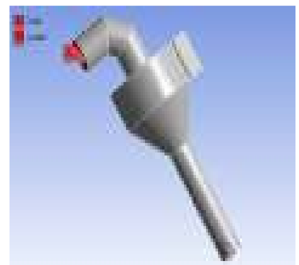
The model is designed with the help of pro-e and then import on ANSYS for Meshing and analysis. The analysis by CFD is used in order to calculating pressure profile and temperature distribution. For meshing, the fluid ring is divided into two connected volumes. Then all thickness edges are meshed with 360 intervals. A tetrahedral structure mesh is used. So the total number of nodes and elements is 6576 and 3344.

→→ select mesh on work bench → right click →edit → select mesh on left side part tree → right click → generate mesh →



Select faces → right click → create named section → enter name → water inlet

Select faces → right click → create named section → enter name → water outlet



Model → energy equation → on.

Viscous → edit → k- epsilon

Enhanced Wall Treatment → ok

Materials → new → create or edit → specify fluid material or specify properties → ok

Select air and water

Boundary conditions → select water inlet → Edit → Enter velocity → 25 m/s and Inlet

Solution → Solution Initialization → Hybrid Initialization →done

Run calculations → no of iterations = 50 → calculate → calculation complete

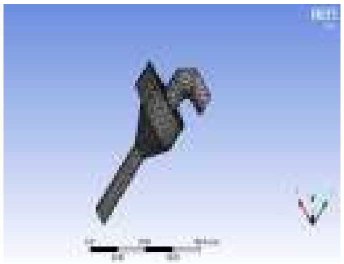
→→ Results → graphics and animations → contours → setup

2) Thermal Analysis Of Fluidized-Bed Reactor

Open work bench 14.5>select steady state thermal in analysis systems>select geometry>right click on the geometry>import geometry>select IGES file>open

Imported Model

Meshed Model

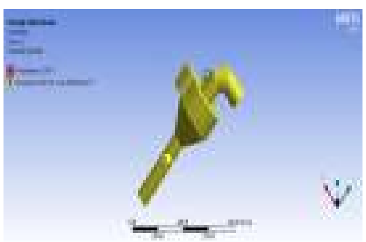


Boundary Conditions

T_1 =1370K

Select steady state thermal >right click>insert>select convection> enter film coefficient (from CFD analysis)

Applied temperature& convection



Select steady state thermal >right click>insert>select heat flux

Select steady state thermal >right click>solve

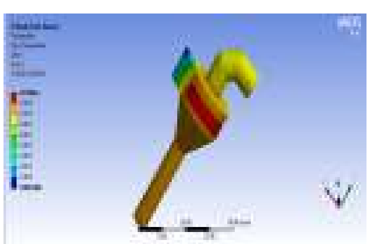
Solution>right click on solution>insert>select temperature

IV.Results

Material- brass

At velocity-25m/s

Temperature



Heat flux

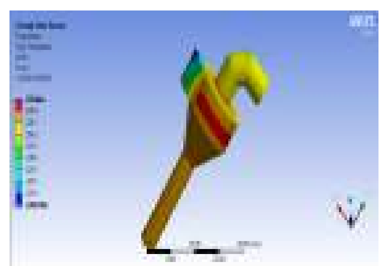
At velocity-30m/s

Temperature

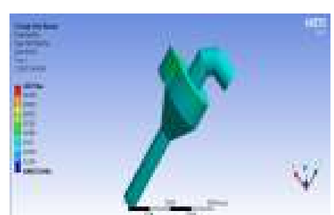
Heat flux

At velocity-35m/s

Temperature



Heat flux



At velocity-40m/s

Temperature

Heat flux

Material	Velocity (m/s)	Temperature (^{0}C)	Heat flux (w/mm^2)
Brass	25	1370	0.81994
	30	1370	0.95465
	35	1370	1.0277
	40	1370	1.1292

CFD Analysis Results Table

Velocity (m/s)	Pressure (Pa)	Heat transfer co-efficient (w/mm^2-k)	Mass flow rate(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

V.Conclusion

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 fluidized-bed reactor. 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 fluidized-bed reactor furnace, the fuel, air, and other input materials are fed locally and the mixing of different reactants is limited. By observing the CFD analysis the heat transfer coefficient, pressure drop values are increasing by increasing the inlet velocities. And the heat transfer rate & mass flow rate values are more at inlet velocity 35m/s. By observing the thermal analysis the heat flux values are more for brass material at a velocity of 40m/s.So it can be concluded the brass material is better material for fluidized-bed reactor.

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