DESIGN AND FLUID FLOW ANALYSIS OF WASTE HEAT BOILER IN CFD

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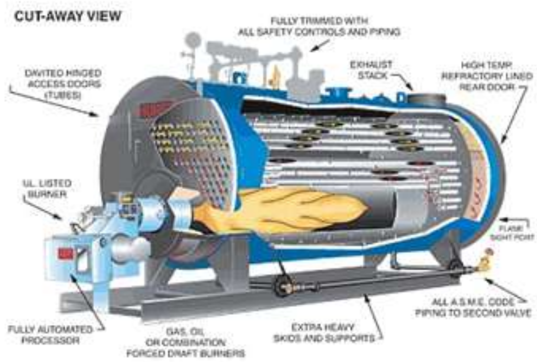
Abstract: Waste Heat boilers are used to recover waste heat from high temperature exhausts in chimney stacks. Waste heat boilers are typically water tube boilers which use large volume, high temperature waste heat streams as a heat source as opposed to conventional fuel. Typical heat sources include hot exhaust gases from such equipment as gas turbines, incinerators, furnaces and reciprocating engines. Should the waste heat in exhaust gases be insufficient for generating the required amount of process steam, it is sometimes possible to add the auxiliary burners. These systems burn fuel in the waste heat boiler or an afterburner may be added to the exhaust gas duct just ahead of the boiler.

Waste heat boiler were modeled in CATIA software and analyzing the heat boiler heat transfer rate with different mass flow inlets (337, 147 kg/s) with different fluids. Computational Fluid Dynamics is most commonly used tool for simulation and analysis. 3-D numerical CFD tool is used for simulation of the flow field characteristics inside the turbo machinery. CFD simulation makes it possible to visualize the flow condition inside heat boiler.

The present paper describes the heat transfer rate, mass flow rate, pressure drop, velocity and to evaluate the pump performance at different mass flow rates using the, a computational fluid dynamics simulation tool.

INTRODUCTION

Boilers are pressure vessels designed to heat water or produce steam, which can then be used to provide space heating and/or service water heating to a building. In most commercial building heating applications, the heating source in the boiler is a natural gas fired burner. Oil fired burners and electric resistance heaters can be used as well. Steam is preferred over hot water in some applications, including absorption cooling, kitchens, laundries, sterilizers, and steam driven equipment.
Boilers have several strengths that have made them a common feature of buildings. They have a long life, can achieve efficiencies up to 95% or greater, provide an effective method of heating a building, and in the case of steam systems, require little or no pumping energy. However, fuel costs can be considerable, regular maintenance is required, and if maintenance is delayed, repair can be cost



How Boilers Work

Both gas and oil fired boilers use controlled combustion of the fuel to heat water. The key boiler components involved in this process are the burner, combustion chamber, heat exchanger, and controls

Fire tube Boiler

The burner mixes the fuel and oxygen together and, with the assistance of an ignition device, provides a platform for combustion. This combustion takes place in the combustion chamber, and the heat that it generates is transferred to the water through the heat exchanger. Controls regulate the ignition, burner firing rate, fuel supply, air supply, exhaust draft, water temperature, steam pressure, and boiler pressure.

Types of Boilers

Boilers are classified into different types based on their working pressure and temperature, fuel type, draft method, size and capacity, and whether they condense the water vapor in the combustion gases. Boilers are also sometimes described by their key components, such as heat exchanger materials or tube design. These other characteristics are discussed in the following section on Key Components of Boilers.

Two primary types of boilers include Firetube and Watertube boilers. In a Firetube boiler, hot gases of combustion flow through a series of tubes surrounded by water. Alternatively, in a Watertube boiler,

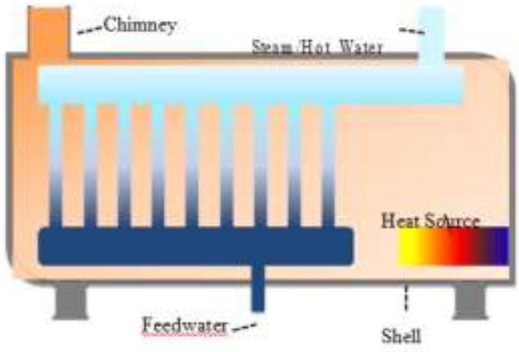
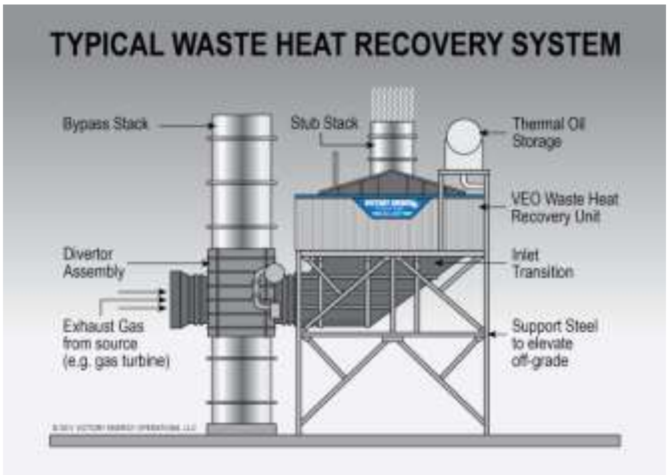


Figure 2: Watertube Boiler

Firetube boilers are more commonly available for low pressure steam or hot water applications, and are available in sizes ranging from 500,000 to 75,000,000 BTU input (5). Watertube boilers are primarily used in higher pressure steam applications and are used extensively for comfort heating applications. They typically range in size from 500,000 to more than 20,000,000 BTU input.

Space to lower one:

1. Recuperators: This name is given to different types of heat exchanger that the exhaust gases are passed through, consisting of metal tubes that carry the inlet gas and thus preheating the gas before entering the process. The heat wheel is an example which operates on the same principle as a solar air conditioning unit.
2. Regenerators: This is an industrial unit that reuses the same stream after processing. In this type of heat recovery, the heat is regenerated and reused in the process.
3. Heat pipe exchanger: Heat pipes are one of the best thermal conductors. They have the ability to transfer heat hundred times more than copper. Heat pipes are mainly known in renewable energy technology as being used in evacuated tube collectors. The heat pipe is mainly used in space, process or air heating, in waste heat from a process is being transferred to the surrounding due to its transfer mechanism.
4. Thermal Wheel or rotary heat exchanger: consists of a circular honeycomb matrix of heat absorbing material, which is slowly rotated within the supply and exhaust air streams of an air handling system.
5. Economizer: In case of process boilers, waste heat in the exhaust gas is passed along a recuperator that carries the inlet fluid for the boiler and thus decreases thermal energy intake of the inlet fluid.
6. Heat pumps: Using an organic fluid that boils at a low temperature means that energy could be regenerated from waste fluids.
7. Run around coil: comprises two or more multi-row finned tube coils connected to each other by a pumped pipework circuit.



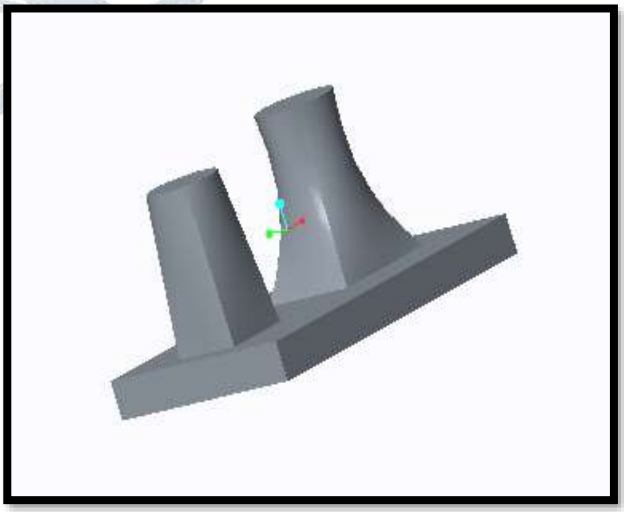
INTRODUCTION TO CAD

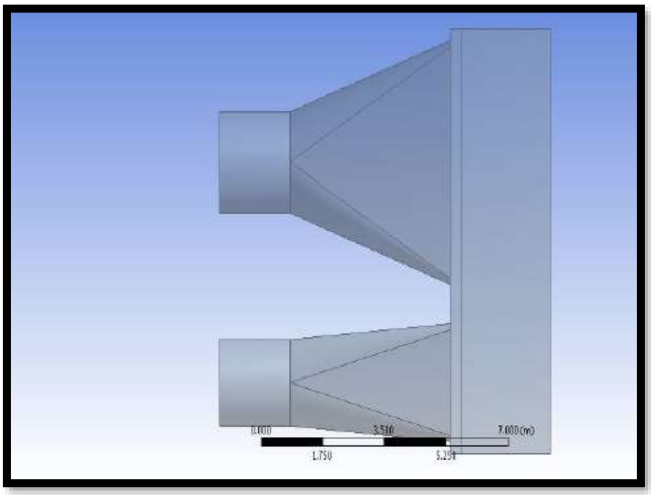
Computer-aided design (**CAD**) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term **CADD** (for Computer Aided Design and Drafting) is also used.

INTRODUCTION TO CATIA

CATIA (an acronym of **computer aided three-dimensional interactive application**) is a multi-platform software suite for computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), PLM and 3D, developed by the French company Dassault Systems.

3D MODEL OF WASTE HEAT BOILER





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. As such, it is a numerical rather than an analytical method. Methods of this type are needed because analytical methods cannot cope with the real, complicated problems that are met with in engineering. For example, engineering strength of materials or the mathematical theory of elasticity can be used to calculate analytically the stresses and strains in a bent beam, but neither will be very successful in finding out what is happening in part of a car suspension system during cornering.

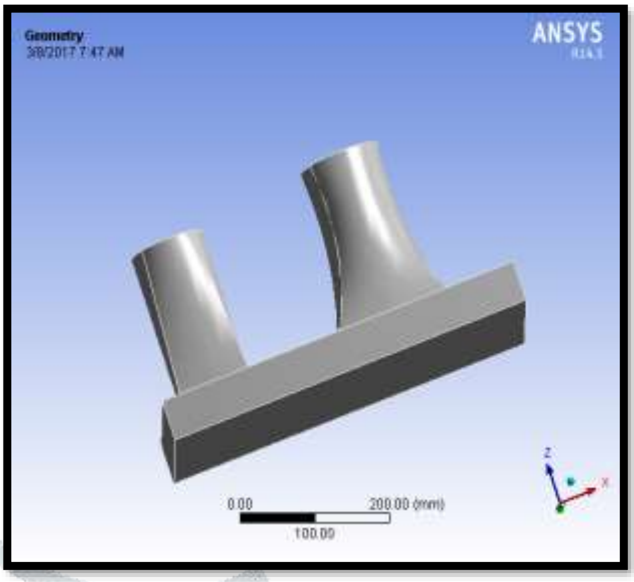
CFD ANALYSIS OF WASTE HEAT BOILER

FLUID- FLUE GAS, COAL & AIR

Mass flow inlet = 337kg/s, 147kg/s

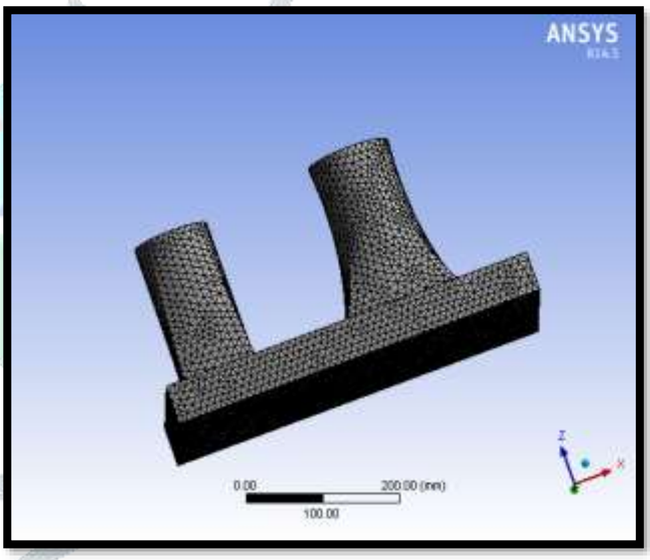
→→Ansys → workbench→ select analysis system → fluid flow fluent → double click

→→Select geometry → right click →new geometry

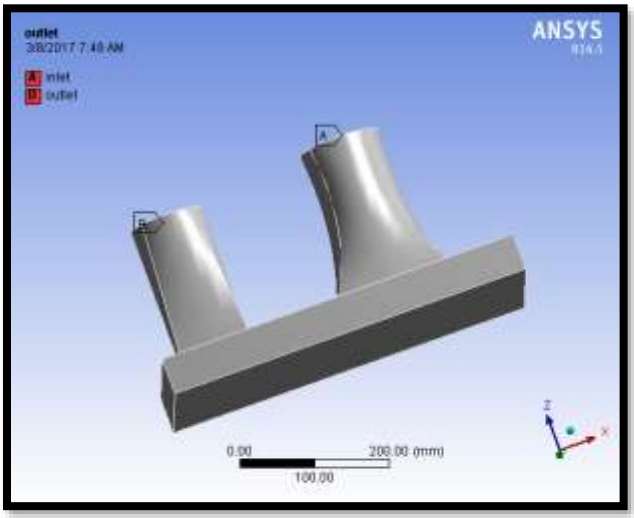


→→ Select mesh on work bench → right click →edit → select mesh on left side part tree → right click → generate mesh →

MESHED MODEL



SPECIFYING THE BOUNDARIES FOR INLET & OUTLET



Update project>setup>edit>model>select>energy equation (on)>ok

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

Select fluid

Boundary conditions>inlet>enter required inlet values

Temperature=812K

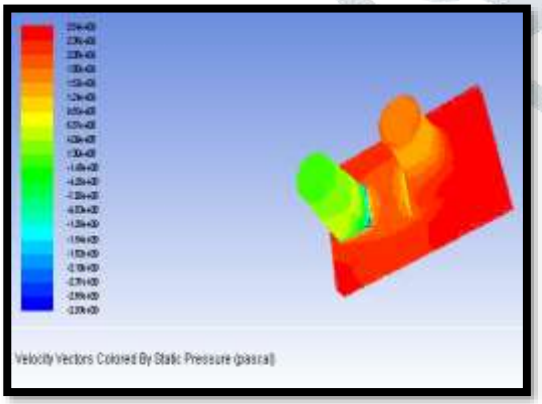
Solution > Solution Initialization > Hybrid Initialization >done

Run calculations > no of iterations = 10> calculate > calculation complete>ok

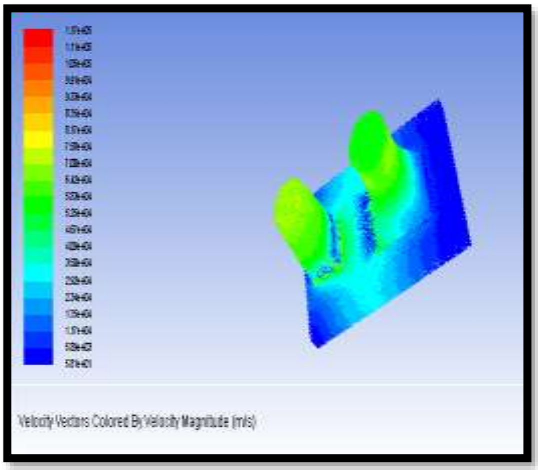
FLUID- FLUE GAS

MASS FLOW INLET = 337kg/s

PRESSURE



VELOCITY



HEAT TRANSFER RATE

```
Total Heat Transfer Rate                    (w)
-------------------------- --------------------
                     inlet        2.0714104e+08
                    outlet        -2.08356e+08
               wall-___msbr                   0
          ---------------- --------------------
                       Net             -1214960
```

MASS FLOW RATE

```
              Mass Flow Rate              (kg/s)
-------------------------- --------------------
                       inlet           336.99976
              interior-___msbr         761.15674
                      outlet          -338.97629
                 wall-___msbr                  0
          ---------------- --------------------
                         Net           -1.976532
```

RESULT TABLE

Fluid	Mass flow inlet (kg/s)	Pressure (Pa)	Velocity (m/s)	Heat transfer rate (w)	Mass flow rate (kg/s)
Flue gas	337	2.64e+09	1.17e+05	1214960	1.976532
	147	4.41e+08	5.08e+04	500128	0.8137207
Coal	337	1.15e+06	5.41e+01	799392	1.43045
	147	2.05e+05	2.36e+01	266728	0.47743225
Air	337	1.29e+09	1.88e+05	1393312	2.4769592
	147	2.27e+08	2.48e+04	137696	0.24482727

CONCLUSION

Waste heat boiler were modeled in CREO software and analyzing the heat boiler heat transfer rate with different mass flow inlets (337, 147 kg/s) with different fluids. Computational Fluid Dynamics is most commonly used tool for simulation and analysis. 3-D numerical CFD tool is used for simulation of the flow field characteristics inside the turbo machinery. CFD simulation makes it possible to visualize the flow condition inside heat boiler.

By observing the CFD analysis the heat transfer rate, mass flow rate, pressure drop and velocity increases by increasing the mass flow inlets of the waste heat boiler and increasing the heat transfer rate of the fluid air.

The waste-heat boiler is the common choice for heat recovery. According to the literature it is clear that successful operation of the boiler requires sufficient understanding of the process and its operating conditions. It was possible to identify and quantify the contribution of turbulence and radiation effects. However, most of the analysis was done qualitatively. Based on the findings obtained, the following significant conclusions can be made:

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