INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE

ISSN: 2057-5688

CFD ANALYSIS OF WASTE HEAT BOILER

D GEETHA SREE[a], Ms. M DEEPIKA[b]

M.Tech in mechanical engineering at Holy Mary Institute of Technology & Science

Assistant Professor at Holy Mary Institute of Technology & Science

A B S T R A C T

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.

Key words: Waste heat boiler, CFD analysis, CATIA software, Ansys Workbench, etc.

I INTRODUCTION

INTRODUCTION OF WASTE HEAT BOILER

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

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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 costly.

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 controlsthe 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 Water tube boilers. In a Fire tube boiler, hot gases of combustion flow through a series of tubes surrounded by water. Alternatively, in Water tube boiler

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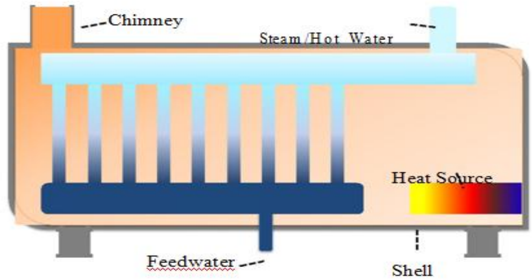

Figure 2: Watertube Boiler

Cast iron sectional boilers (figure 3) are another type of boiler commonly used in commercial space heating applications. These types of boilers don't use tubes. Instead, they're built up from cast iron sections that have water and combustion gas passages. The iron castings are bolted together, similar to an old steam radiator. The sections are sealed together by gaskets. They're available for producing steam or hot water, and are available in sizes ranging from 35,000 to 14,000,000 BTU inputs (2). Cast iron sectional boilers are advantageous because they can be assembled on site, allowing them to be transported through doors and smaller openings. Their main disadvantage is that because the sections are sealed together with gaskets, they are prone to leakage as the gaskets age and are attacked by boiler treatment chemicals.

Best Practices for Maintenance

Keep the Boiler Clean

As mentioned previously, any residue, such as soot or scale, that coats the heat transfer surfaces of the boiler will reduce its efficiency and also increase the likelihood of equipment failure. Cleaning this surface according to manufacturer's recommendations is important to maintaining optimum boiler performance and equipment life. Residue that coats the tubes of a boiler will interfere with heat transfer and elevate the flue gas temperature. If incomplete combustion occurs, the resulting soot accumulates on the combustion side of the tubes. Similarly, poor water treatment practices can result in scale accumulation on the water side of the tubes.

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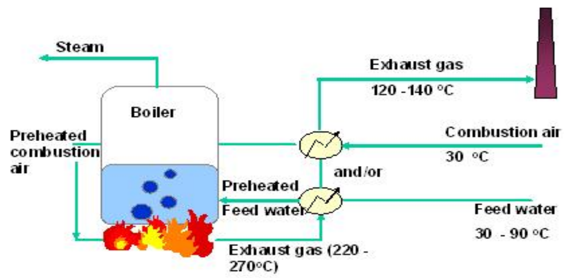
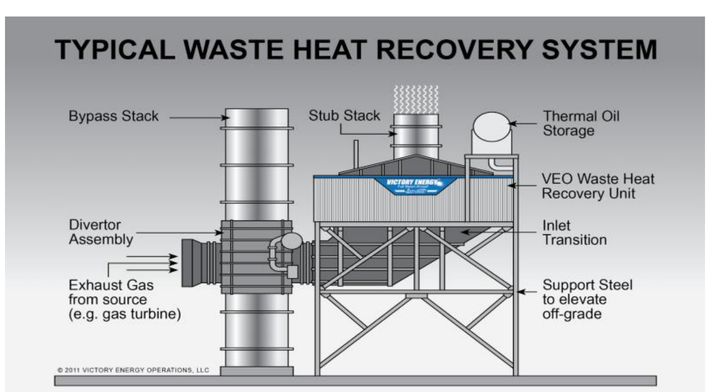


Rising energy costs and legal requirements for reductions in CO2 emissions demand efficient solutions, particularly in applications that consume a large amount of energy. One solution that can be effective is the recovery of energy from waste heat. Our innovative waste heat recovery systems utilise existing energy sources in order to efficiently generate thermal heat, process heat or electricity. The result: High efficiency, low emissions, cost reductions and lower consumption of resources.

Waste Heat Boilers

- the UL-S and UT-H boiler series can also be used purely as waste heat boilers
- for use in combination with combined heat and power units or gas turbines

Utilization of waste heat for generating steam or hot water



Typical components

- Containerisation
- Safety equipment
- Control panel
- Control systems
- Insulation
- Exhaust gas bypass
- Pumps

Advantages:

- Direct benefits: The recovery process will add to the efficiency of the process and thus decrease the costs of fuel and energy consumption needed for that process.
- Indirect benefits:

1. Reduction in Pollution: Thermal and air pollution will dramatically decrease since less flue gases of high temperature are emitted from the plant since most of the energy is recycled.
2. Reduction in the equipment sizes: As Fuel consumption reduces so the control and security equipment for handling the fuel decreases. Also, filtering equipment for the gas is no longer needed in large sizes.
3. Reduction in auxiliary energy consumption: Reduction in equipment sizes means another reduction in the energy fed to those systems like pumps, filters, fans...etc.

ADVANTAGES OF CATIA SOFTWARE

1. Optimized for model-based enterprises
2. Increased engineer productivity
3. Better enabled concept design
4. Increased engineering capabilities
5. Increased manufacturing capabilities
6. Better simulation

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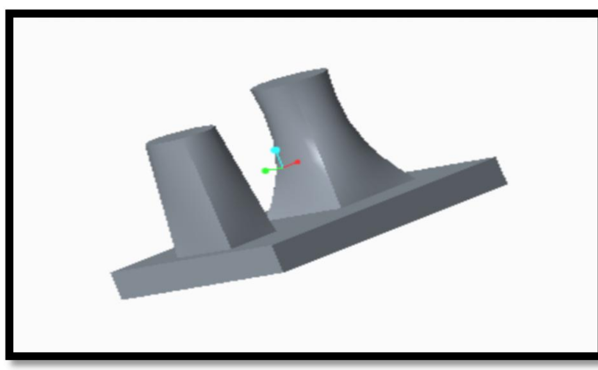
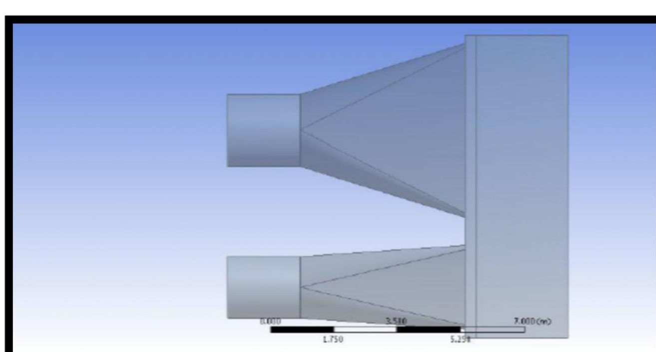
7. Design capabilities for additive manufacturing

CATIA parametric modules:

- Sketcher
- Part modeling
- Assembly
- Drafting

3D MODEL OF WATER HEAT BOILER





CFD ANALYSIS OF WATER HEAT BOILER

FLUID- FLUE GAS, COAL & AIR

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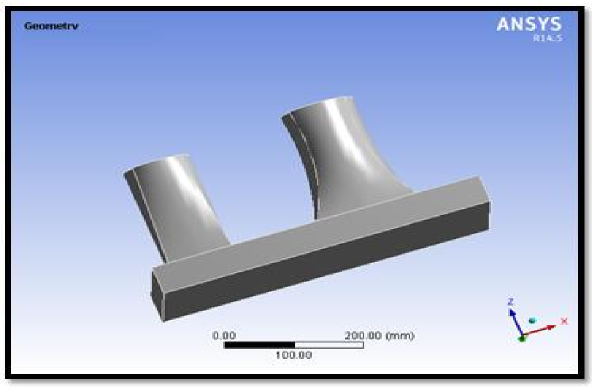
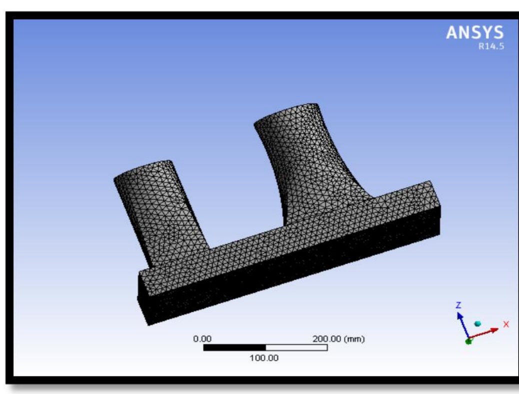
Mass flow inlet = 337kg/s, 147kg/s

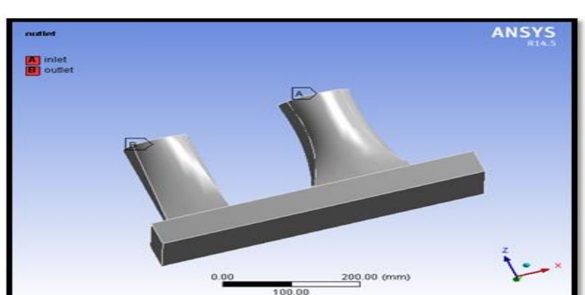
Import geometry



Meshed model



Boundary conditions



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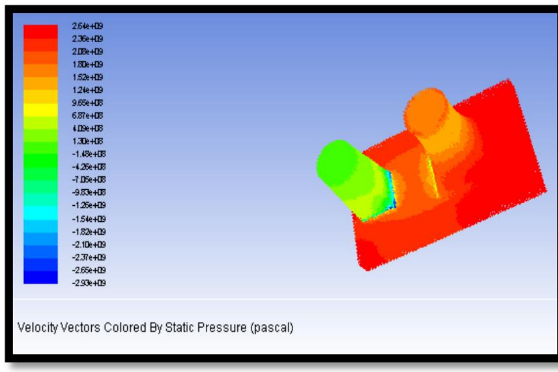
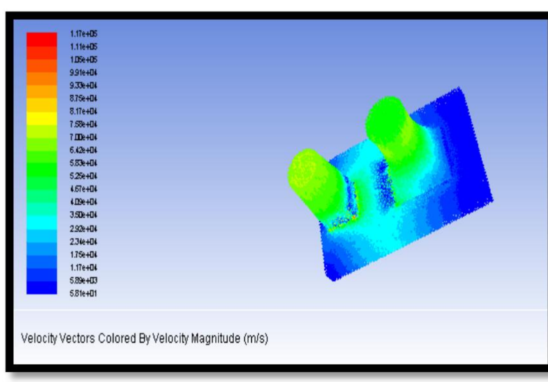
FLUID- FLUE GAS

MASS FLOW INLET = 337kg/s

PRESSURE



Velocity



Heat transfer rate

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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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