Performance of Super Heater on Waste Heat Recovery In A Co-Generation Plant

Sudarsun K[1], Hariharasudhan R[2], Pandiarajan R[3], Karthick R[4]

[1] *Assistant Professor, Department of Mechanical Engineering, Mangayarkarasi College of Engineering, Madurai.*

[2,3,4] *U.G Student, Department of Mechanical Engineering, Mangayarkarasi College of Engineering, Madurai.*

Abstract—

The world is facing problems of power Generation shortage, operational cost and high demand in these days. The main aim of this article is to know power generation methods, techniques and economical strategy which methods are suitable for individual country on the base its own natural resources, technical expertise and economy. However, Many industrial heating processes generate waste energy. Use of waste-heat recovery systems to produce the steam use heat from the exhaust gas temperature to develop the Electric Power Backup. Galvanized Steel is selected as exhaust pipe material and analysed. This paper presents case study of waste heat recovery of the exhaust flue gas with an average of 260^{o}C, here Wet Steam is converted into Dry or superheated steam by using economizer. This waste heat can be recovered by installing the super heater.Furthermore, the finite element analysis is performed on Ansys software and modeling is done using Solid works Software.

Keywords : *Economizer, Exhaust Flue Gas, Energy Saving, Waste heat recovery, Co - generation Plant, Exhaust Pipe*

I. INTRODUCTION

Boiler is an apparatus to produce steam. Thermal Energy released by combustion of fuel is used to make steam at the desired temperature and pressure. It is a closed vessel in which water or other fluid is heated. The fluid does not necessarily boil. (In North America the term “furnace” is normally used if the purpose is not actually to boil the fluid.) 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.

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.

II. METHODOLOGY

A. Boiler

A boiler is a closed vessel which is used to convert the water into high pressure steam. The high pressure steam so generated is used to generate power. Boilers are widely used in domestic and industrial applications such as:

- Thermal power plants
- Industrial processes
- Heating
- Sanitation
- Sterilizing equipment

The two primary types of boiler are:

- Fire Tube Boiler
- Water Tube Boiler

Fire Tube Boiler

A fire-tube boiler is a type of boiler in which hot gases from a fire pass through one or more tubes running through a sealed container of water. The heat of the gases is transferred through the walls of the tubes by thermal conduction, heating the water and ultimately creating steam.

Water Tube Boiler

A water tube boiler is a type of boiler in which water circulates in tubes heated externally by the fire. Fuel is burned inside the furnace, creating hot gas which heats water in the steam-generating tubes.

B. Air Pre heater

an air pre heater (aph) is a general term used to describe any device designed to heat air before another process (for example, combustion in a boiler) with the primary objective of increasing the thermal efficiency of the process. they may be used alone or to replace a recuperative heat system or to replace a steam coil. in particular, this article describes the combustion air pre heaters used in large boilers found in thermal power stations producing electric power from (e.g. fossil fuels, bio mass or waste.) the purpose of the air pre heater is to recover the heat from the boiler flue gas which increases the thermal efficiency of the boiler by reducing the useful heat lost in the flue gas. as a consequence, the flue gases are also conveyed to the flue gas stack or chimney at a lower temperature, allowing simplified design of the conveyance system and the flue gas stack. it also allows control over the temperature of gases leaving the stack (to meet emissions regulations, for example).

C. Turbine

A Steam turbine is a mechanical device that extracts thermal energy from pressurized steam and transforms it into mechanical work. because the turbine generates rotary motion, it is particularly suited to driving electrical generators – about 90% of all electricity generation in the united states (1996) is by use of steam turbines. sir Charles a. parsons invented the first modern turbine, a reaction turbine, in 1884. Connected to a dynamo, the turbine produced 7.5 kw of electricity. During parsons' lifetime, this generation capacity increased 10,000 times over. Steam turbines range from <0.75 kw units to 1.5 gw units. large turbines are used to generate electricity. as the name implies, a steam turbine is powered by steam. as hot, gaseous steam flows past the turbine' spinning blades, steam expands and cools, giving off most of the energy it contains. this steam spins the blades continuously. the blades thus convert most of the steam's potential energy into kinetic energy. the turbine is then used to run a generator, producing electricity.

D. Renewable Energy Sources

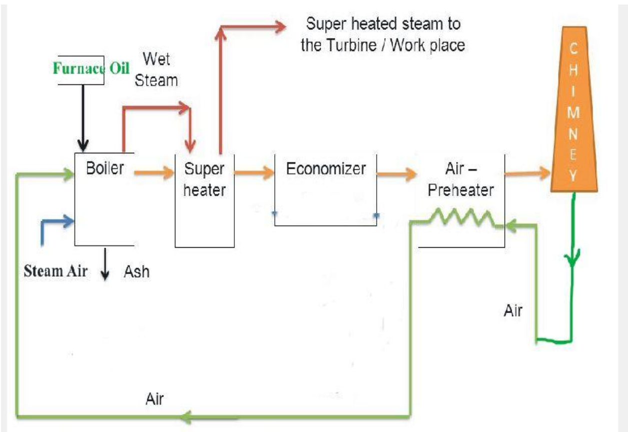
It has always been a goal to increase the energy transfer efficiency, within practical financial limits and operating specifications, of systems, which involve heat transfer. Examples of such systems include: steam boilers which typically burn fossil fuel to convert water to steam for use in heating, cooling, process manufacturing, or the driving of turbines to produce electricity oil refinery furnaces which burn fossil fuel to heat crude oil to produce various petroleum products; and food processing systems which use fossil fuel to heat. Vegetable oil to produce a variety of products. many of these systems burn millions of dollars of fuel per year, and thus small changes inefficiency can translate into large monetary savings therefore, it is essential to conduct a thorough investigation on boiler equipment, particularly on its type, characteristics, maintenance and fuel consumption to ensure better boiler efficiency boiler efficiency, in general, can be described as the difference between the input and output energy. a conventional boiler would require immense initial capital expenditure on fuel usage alone per year. therefore, slight improvement in boiler efficiency between units could provide significant amount of savings. the preheating of feed water in boilers is one of the most effective methods for increasing the efficiency of steam boilers if the temperature of feed water increase to above 100 degree Celsius, then less firing rate is needed for reaching to a specific horsepower therefore, a significant saving in fuel consumption is achieved and the efficiency be improved. the normal temperature of fuel gases in large boilers usually ranged from 230°c to 350°c. the heat produced from preheating of water can be recovered by using stack economizers that are available in a various sizes boiler stack economizer in general is a form of heat exchangers that separates between hot fuel gas and water. figure 1 shows the structure of economizer in fire-tube steam that allows the recycle usage of excess heat from exhaust.

E. Furnace Oil

Furnace oil is also known as fuel oil is a fraction obtained from petroleum distillation, either as a distillate or a residue. In general term furnace oil is any liquid fuel that is burnt in a furnace or boiler for the generation of heat or used in engine for the generation of power.

III. STEAM PRODUCING EXHAUST GASES

The Problem identified is to use the heat in the exhaust gas to develop the Electric Power Backup. The Exhaust gases temperature is 254^{o}C. Thus the heat is maintained to use as input to implemented Economizer and Pre heater. Economizer is also used for to convert the Wet steam into Dry steam or Super-heated steam. The steams are used in Particular temperature rotate on blades of turbine and to develop a power is help of Generator. But this process used for furnace oil method of power plant. This method is already used in Coal power plant but in this input energy is Coal. The power generation used in our system is similar to coal power plant. But its main disadvantages is initial cost is high.

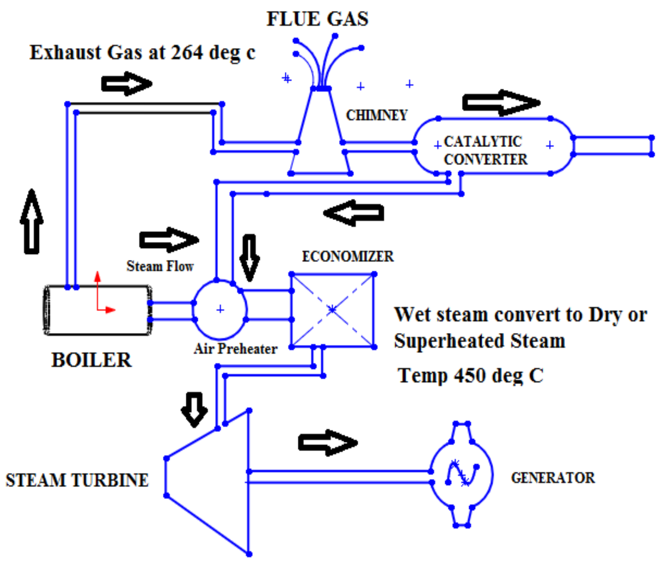


IV. PERFORMANCE TEST

The capacity of examined steam boilers are 6600 pounds (3000 kg of steam production per hour), this boilers were designed according to following standards of British Standard (BS) 2790, and ASME sec VIII and ISIRI 4231 The design pressure is 16 bar, the operation pressure is 10 bar, the pneumatic test pressure is 5 bar, and the hydro static test pressure is 16.5 bar. In first stage the steam boiler without using any equipment for increasing the efficiency (such as economizer) tested, the parameters were measured then the efficiency of the examined steam boiler will be calculated. In this study this boiler is called "Boiler 1". Another steam boiler has been made with the same specification as The boiler was started and same parameters as before measured, according the results that collected from the experiment the efficiency of this boiler is calculated. Table 1 shows the ultimate analysis and flue gas analysis in Boiler.

V. CO – GENERATION LAYOUT

Cogeneration plant (CHP) is installed in milk products plant production 2011., in order to reduce energy production costs. CHP is functioning as separate economic unit. Figure 1 shows the cogeneration plant (CHP) flow diagram in its basic form. Exhaust flue gas (EFG) is formed in natural gas combustion process in the gas engine. Constant temperature of the gas engine is held by cooling water. Amount of energy transferred to cooling water per time unit is 880 kW. Which heat power is 120kW. Electric generator is powered by the engine in order to produce 1415 kW of electrical power which is sold by the factory. And average EFG flow rate is 8100 kg/h. About 6.8% (550 kg/h) of this flow rate is water steam and non-condensing gasses arrest. Currently, EFG enters the shell and tube heat exchanger (STHE) which is used for steam production. EFG enters STHE tube side at 410˚C and exits at 165˚C.EFG which leaves STHE is removed from the process. The total nominal energy output of CHP is 1660 kW of thermal power and 1415 kW of electric power. In order to achieve maximum CHP plant capacity, EFG at 450˚C is considered for heating. Two possibilities were discussed: Economizer (ECO) installation to reduce EFG temperature to 120˚C Water vapour condensation can be done as exhausted gasses practically don't produce any sulphuric acid, hence there would be no harm to equipment by water. Position of ECO in the existing CHP plant is shown in figure 2. Of course, ECO design and consequently price is depending on its purpose and thermal performance (heat power). To use Galvanized Steel material is to reduce the stress cracking and life is more to balance on high temperature. So this material used and analysis of exhaust bend pipe below the given table.

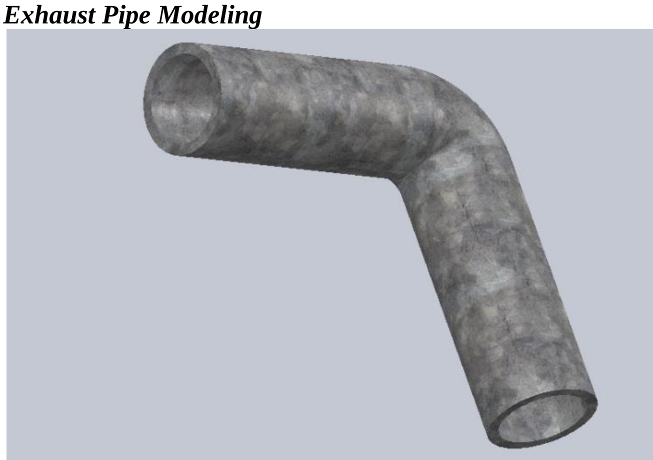


After Implementation of Layout

VI. RESULTS AND DISCUSSION

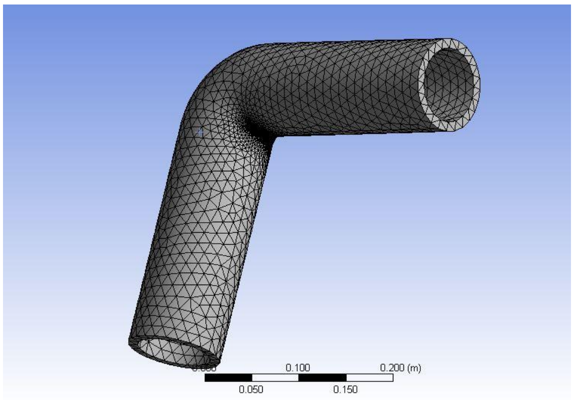
The calculations for efficiency in these experiments by using indirect Method show big differences between two boilers. In this stage the analysis of these discrepancies and the main reason is because of reducing in flue gas temperature that is declined around 103 degree Celsius. The following losses that related to the hydrogen and moisture in fuel do not show big gap between two tested boilers because these losses are mainly related to the specification of fuel and the fuel that used in these boilers is exactly the same (diesel), by using diesel as fuel in these experiments the losses due to fly ash(carbon) and bottom ash (carbon) do not exist that loss due to partial combustion is zero in two examined boilers.

Exhaust Pipe Modeling

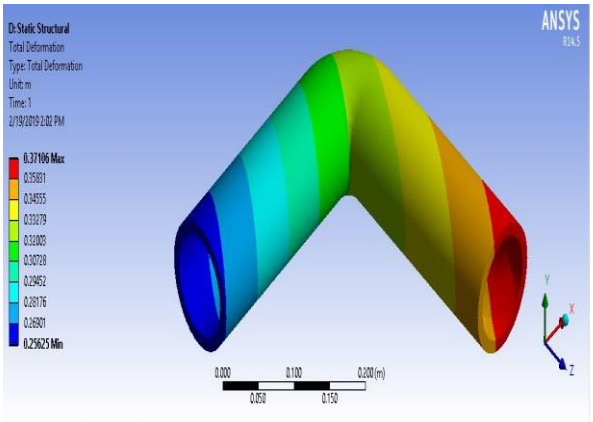


Analysis Values

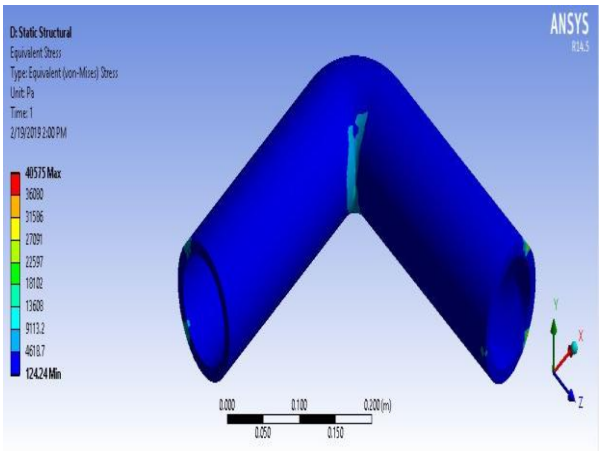
Equivalent (von Mises) stress (N/m^2)		Total Deformation (m)		Total Heat Flux (W/m^2)	
Max	Min	Max	Min	Max	Min
40575	124.24	0.37106	0.2565	3.7171 $x10^{-5}$	3.5941 $x10^{-5}$



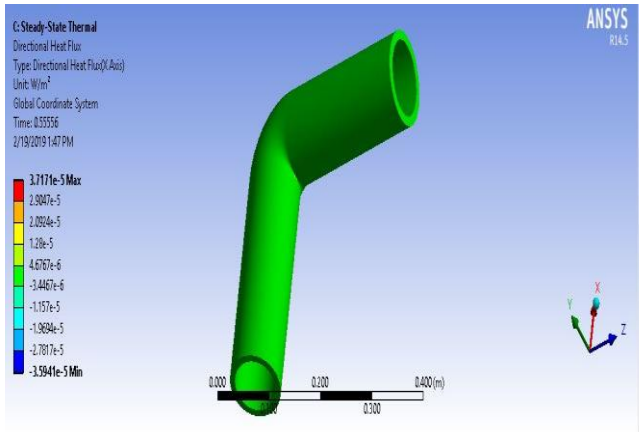
Meshing Stage



Total Deformation



6.6 Equivalent Von-Mises Stress



Total Heat Flux

Merits

- To reduces Emission Gases.
- Use Heat of Exhaust gas and steam gas combined to develop power generation.
- To withstand the high temperature on Galvanized Steel material..
- Maximum energy is steam power and combined gases.
- One more add than the required of steam used plant.

VII.CONCLUSION

Steam generation conditions in boiler manufacturing industries and institutions are at saturated steam pressure below 250 psig. Process of using waste heat is familiar from decades ago, but unlimited number of plants in the world does not utilize waste heat. Presented super heater in study or similar economizer design can be installed in every kind of plant: Power Plant, Oil & Gas Plant, Heating Plant, various production plant and etc.

The primary aim of this study is to use waste thermal energy from EFG at 264˚C and rise its temperature to 450˚C by using super heater. This high temperature of steam passed into the turbine through exhaust pipe which is made up of galvanized steel. It can produce Electric Power from a temperature of 450°C which can be stored with the help of a generator.

REFERENCES

[1] R K Kapooria, S Kumar, K S Kasana Vol 19 (2008) have carried out analysis of a thermal power plant working on a Rankine cycle – A theoretical Investigation.

[2] T Srinivas, A V S S K S Gupta, B V Reddy vol 10 (2007) have carried out Generalized Thermodynamic Analysis of Steam Power Cycles with 'n' Number of Feed water Heaters.

[3] M A Habib, S A M SAID, I Al- Zaharna Vol 17 - 34 (1999) have carried out Thermodynamic Optimization of Reheat Regenerative Thermal Power Plants in subcritical range.

[4] A.Srivastava [25] has discussed the energy analysis of various types of coal from major mines of the world. He concluded that the first law analysis gives only the quantity of energy

[5] F.J. Gutierrez Vol 16 (2011) have carried out A complete dynamic model of a full-scale fire-tube boiler has been developed based on the mass, energy, and momentum balances together with constitutional equations.

[6] Hasanuzzaman M, Rahim N, Saidur R (2011) Analysis of energy, energy and energy savings of a fire tube boiler. IEEE first conference on Clean Energy and Technology (CET).

[7] Kumar, C.R., Sonthalia, A., Goel, R.,Vol.14 (2011) Experimental study on waste heat recovery from an internal combustion engine using thermoelectric technology.

[8] Aljundi IH (2009) Energy and energy analysis of a steam power plant in Jordan. Appl Therm Eng 29: 324-328.