© 2017 IJSRSET | Volume 3 | Issue 2 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Design and Fabrication of Super Heater Used In Boiler

Patlola Rajender Reddy, Gaddam Arun Reddy, Doddigarla Prashanth Kumar, S Prasad Kumar

[1,2,3,] UG Final Year Student , Department of Mechanical Engineering , Vjdya Jyothi Institute of Technology , Hyderabad , India
[4]Assistant Professor , Department of Mechanical Engineering , Vjdya Jyothi Institute of Technology , Hyderabad , India

ABSTRACT

Super heater is one of the integral part of the boiler. Design of super heater is modified compared to previous super heater to improve steam output . In huge power plants super heater have two stages in between this two stages de-super heater are used. The main function of de-super heater is to control the temperature of the steam by sprinkling the water drops on its outer surface which gets contact to the flue gases . Thus temperature will be controlled without any losses. De-super heater can only be used in large power plants as it occupies huge space and also expensive. In this project according to design procedure , fabrication of damper in super heater chamber is made. Which works manually and acts as de-super heater. Which controls the direction of flue gases. This manual operation comparatively economical and occupies less space than de-super heater. The operation of the damper in super heater chamber is as follows : by inserting the damper in super heater chamber diverts the flue gases as this controls the heat from the flue gases touching the super heater tubes. By opening the damper flue gases are allowed to touch the super heater tubes . By this tube failure is controlled and efficiency of the super heater increases.

Keywords: Super Heater, Boiler, Fabricated, Damper Construction, Assembling or welding, MMAW, SMAW

I. INTRODUCTION

A. Boiler

In simple a boiler may be defined as a closed vessel in which steam is produced from water by combustion of fuel**.** The boiler system comprises of: feed water system, steam system and fuel system. The feed water system provides water to the boiler and regulates it automatically to meet the steam demand. Various valves provide access for maintenance and repair. The steam system collects and controls the steam produced in the boiler. Steam is directed through a piping system to the point of use. Throughout the system, steam pressure is regulated using valves and checked with steam pressure gauges. The fuel system includes all equipment used to provide fuel to generate the necessary heat. The equipment required in the fuel system depends on the type of fuel used in the system.The water supplied to the boiler that is converted into steam is called feed water. The two sources of feed water are: (1) Condensate or condensed steam returned from the processes and (2) Makeup water (treated raw water) which must come from outside the boiler room and plant processes. For higher boiler efficiencies, the feed water is preheated by economizer, using the waste heat in the flue gas.[1,2]

B. Boiler Types And Classifications

There are two general types of boilers: "fire-tube" and "water-tube". Boilers are classified as "high-pressure" or "low-pressure" and Steam boiler hot water boiler." Boilers that operate higher than 15 psig are called "high-pressure" boilers.A hot water boiler, strictly speaking, is not a boiler. It is a fuel-fired hot water heater. Because of its similarities in many ways to a steam boiler, the term "hot water boiler" is used.[3,4]

- Hot water boilers that have temperatures above 250° Fahrenheit or pressures higher than 160 psig are called "high temperature hot water boilers".
- Hot water boilers that have temperatures not exceeding 250° Fahrenheit or pressures not exceeding 160 psig are called "low temperature hot water boiler's.

C. Super Heater :

Super heater is one of the most important accessories of a boiler that improves thermal efficiency. It used in both fire tube and water tube boiler. Super heater is a device used to convert saturated steam or wet steam into super-heated steam or dry steam. Super heater is placed in the path of flue gases. It consists of a set of tubes through which steam passes and hot flue gases pass over the tubes the steam is further heated in the tubes by utilising the heat of the flue gases and due to this the temperature of steam is increased above the saturation temperature thus the function is to increases the temperature of steam by utilising the heat of flue gases . Super heating raises overall efficiency. and also reduces the initial condensation losses in steam engine One end of the tube is connected to inlet header and the other end connected to outlet header then steam passes through the super heater tube over which flue gases pass. Steam is superheated by receiving heat from flue gases and finally, the super-heated steam is supplied to steam engine or turbine through the stop valve.[5,6]

D. Types of Super Heaters:

Based on mode of heat transfer

- Radiant super heater
- Convective super heater
- Combined Radiant –Convective super heater.

Radiant Super Heater:

- They are placed exposed to the heat source which requires the improvement of metal temperatures.
- The radiant type of super heater receives its heat by radiation in the furnace area of the boiler. An increase in load on a boiler increases the rate of steam flow through the super heater tubes.
- To maintain a constant super heater temperature the heat input to the super heater must also increase.
- Radiation ^{is} proportional to T^4_f-T^4_w where T_f and T_w are the flame and tube wall absolute temperature. T_f is greater than T_w so radiation is mainly dependent on the flam temperature. As the steam flow rate increases the exit temperature become lower as T_w goes up.
- Therefore, with an increase in load with a radiant type super heater, the outlet steam temperature decreases.

Convective Super Heater:

- The convection type super heater is located in the path of the combustion gas flow and receives its heat from the convective flow of these hot combustion gases pass the tubes. With an increase in the load the rate of steam flow through the super heater increases.
- To support the load increase more fuel is burned and more air is used, increasing the amount of combustion gases, and increasing the convective flow of heat to the super heater.
- This increase in the convection air flow is greater than the increase in steam flow, hence the amount of heat entering the super heater per pound of steam increases

II. METHODS AND MATERIAL

1. Design of Super Heater In Boiler

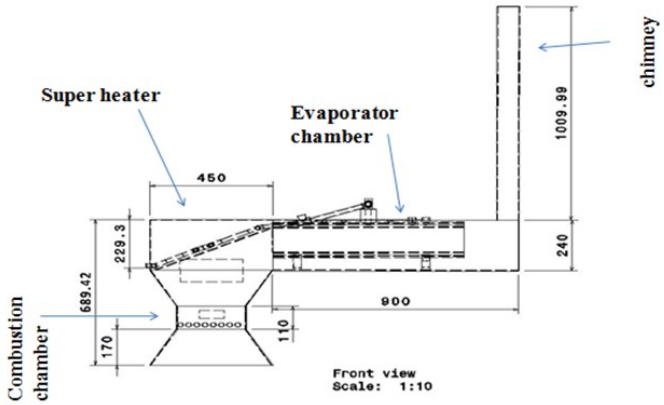

Figure 1. Design of super heater

2. Fabrication

Manufacturing process in which an item is made (fabricated) from raw or semi-finished materials instead of being assembled from ready-made components or parts. To fabricate the super heater tubes different types of materials can be used such as carbon steel, alloy steel and stainless steel etc. For each and every material having different properties. To produce steam up to 300*c temperature and 2bar pressure from super heater. For this any type of material can be used. Because carbon steel can bare up to 300*c temperature maximum, alloy steel can bare up to 450*c and stainless steel can bare up to 600*c and also their costs are different between each other. Here, carbon steel can get

in low cost and stainless steel can get in the highest cost. Therefore, to fabricate the super heater tube within low cost and to get efficient super-heated steam, carbon steel should take.[7]

A. Material used :

Carbon steels are steels with carbon content up to 2.1% by weight. The term "carbon steel" may also be used in reference to steel which is not stainless steel; in this use carbon steel may include alloy steels. As the carbon percentage content rises, steel has the ability to become harder and stronger through heat treating; however, it becomes less ductile. Regardless of the heat treatment, a higher carbon content reduces weldability. In carbon steels, the higher carbon content lowers the melting point.[8]

B. Fabrication Process:

1. Cutting of material,
2. Bending of tube,
3. De-rusting of tube,
4. Assembling or welding
5.Damper Construction

✓ **Cutting**

Cutting is the separation of a physical object, into two or more portions, through the application of an acutely directed force. Implements commonly used for cutting are the saw and knife. However, any sufficiently sharp object is capable of cutting, if it has a hardness sufficiently larger than the object being cut, and if it is applied with sufficient force.

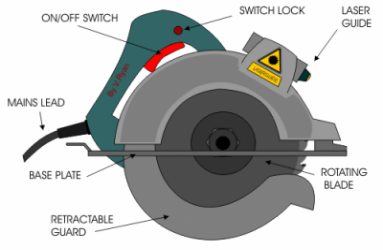

Figure 2 Circular Saw cutter

By using this circular saw tube is cut off the extra length than the required length. If the length of the tube is minimized then area is also minimized.

✓ **Bending**

Bending is a manufacturing process that produces a V-shape, U-shape, or channel shape along a straight axis in ductile materials, most commonly sheet metal. Commonly used equipment include box and pan brakes, brake presses, and other specialized machine presses. Typical products that are made like this are boxes such as electrical enclosures and rectangular ductwork. Usually bending has to overcome both tensile stresses and compressive stresses. When bending is done, the residual stresses cause the material to spring back towards its original position, so the sheet must be over-bent to achieve the proper bend angle. The amount of spring back is dependent on the material, and the type of forming. When sheet metal is bent, it stretches in length. The bend deduction is the amount the sheet metal will stretch when bent as measured from the outside edges of the bend. The bend radius refers to the inside radius. The formed bend radius is dependent upon the dies used, the material properties, and the material thickness. The U-punch forms a U-shape with a single punch.

Figure 3 Bending Equipment used

✓ **De-Rusting**

Rust or corrosion is initiated when atmospheric moisture (humidity) settles on metals. This moisture will act as a conducting medium for the flow of ions and electrons between high energy areas(cathode) and low energy areas (anode) on metal surfaces. This electrochemical process then results to as tarnish, corrosion or rust, depending on the metal. Despite being one of the most common and useful materials manufactured materials in the world, steel has always had one major flaw. It rusts. We often see the dark brown or red color and flaky material on old bridges, old buildings, and on steel that has just been left out in the open for too long. Steel isn't the only metal however that rusts. Just take a look at any pennies you

have laying around, any silverware you have, or pictures of the Statue of Liberty. Zinc, nickel, copper and aluminum and many more metals are also subject to the corrosion chemical reaction. Why steel rusts in the first place, why some steel rusts and not others, and why steel doesn't rust in certain situations makes for an interesting topic. If rusting is formed on the steel tube, then material gets failure or gives less efficient of steam. For this reason the tube or material should be de-rusted by grinding wheel. By removing this rusted or corrosion particles on super heater tubes, tube failures can be arrested and efficiency of steam also increases.

Figure 4 De-Rusting Tool

✓ **Assembling or Welding**

Arc welding is a process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals when cool result in a binding of the metals. It is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, or slag. Arc welding processes may be manual, semi-automatic, or fully automated.

Figure 5 Welding Operation

One of the most common types of arc welding is shielded metal arc welding (SMAW), which is also known as manual metal arc welding (MMAW) or stick welding. An electric current is used to strike an arc between the base material and a consumable electrode rod or stick. The electrode rod is made of a material that is compatible with the base material being welded and is covered with a flux that gives off vapors that serve as a shielding gas and provide a layer of slag, both of which protect the weld area from atmospheric contamination. The electrode core itself acts as filler material, making a separate filler unnecessary. The process is very versatile, requiring little operator training and inexpensive equipment. However, weld times are rather slow, since the consumable electrodes must be frequently replaced and because slag, the residue from the flux, must be chipped away after welding. Furthermore, the process is generally limited to welding ferrous materials, though specialty electrodes have made possible the welding of cast iron, nickel, aluminum, copper and other metals. The versatility of the method makes it popular in a number of applications including repair work and construction.By using this welding equipment, assemble the carbon steel material in the form of rectangular shape and also cover or fitted super heater tube completely in that rectangular box. By this super heater can be in safe position from exposing to environment. And also for flue gases there is no chance to escape from this rectangular box to the environment. By this flue gases, steam efficiency will increase to maximum. This covering of super heater tubes by this steel material is called ducting.

Figure 6 Ducting

Therefore, by this process, super heater tube is fabricated according to required design. By this ducting we can stop escaping of flue gases into atmosphere and also super heater tubes absorbs flue gases very high amount.

✓ **Damper Construction**

When high amount of flue gases hits the super heater tubes, if there is no steam flow in the super heater tubes then tubes gets damaged or melted. So, to prevent this melting or corrosion of super heater tubes manual damper is used instead of de-super heater. The manual damper is chosen because its cost is less than de-super heater. And remaining properties are same as strong as de-super heater. Flue gases are allowed to flow from the combustion chamber to the super heater tubes directly because it is place exactly above the combustion chamber. If there is no steam flow in the super heater tubes, then damper is inserted into the super heater to cover entire super heater tubes. This damper is inserted from left side of super heater through a small hole.This damper is made up of mild steel material, because its capacity to handle the temperature of flue gases is more and also its cost is very less than other metals.

Figure 7 Damper Constructed

The final product super heater is showed below

Figure 8 Final Designed Super Heater

III. RESULTS AND DISCUSSION

1. Testing

Testing means to do experiment on manufactured item before it sells to an industry to meet its specified requirements.

A. Hydrostatic Testing

A hydrostatic test was conducted on super heater elements. 15kgs of pressurized water was applied to determine if there were any leaks. This water in the evaporator chamber gets converted into saturated steam by heating through flue gases. This saturated steam releases with 1200c from evaporator, it was known through temperature gauge, which was placed at saturated steam outlet. Steam engine Super heaters were engineered to increase efficiency by transforming saturated steam into dry steam. Saturated steam moves from the throttle valve through the dry pipe into the super heater header attached to the tube sheet in the smoke box. This steam then passes through elements which are housed in the super heater flues. Combustible gasses from the firebox move through the tubes and heat the water and the steam inside of the super heater element. By this saturated steam converted into super-heated steam with 1500c temperature and 2 bar pressure. At the end of it's cycle through the elements, it proceeds into a separate compartment of the super heater header into the distribution pipes, then on to the piston valves and then on to the main steam cylinders. Super heaters are more expensive and require extra maintenance however the benefits are reduced water and fuel consumption. Super heater reliability, safety and usability are crucial for power plants. Super heaters and channels have a limited lifespan; therefore, preventive condition monitoring is very important. For you to take the right action at the right time and to optimize the use of super heater means preventing leaks, accidents and interruptions − for the sake of safety, the environment and maximal uptime. In spectra helps customers to identify and detect potential failures early and to target replacement activities to the right places.

B. Calculations

HEAT SUPPLIED TO SUPER HEATER:

S.NO	DESCRIPTION	SYMBOL	VALUE	UNITS
1	Super heated steam outlet temperature	T_1	150	^{0}c
2	Saturated steam inlet temperature	T_2	120	^{0}c
3	Flue gases inlet temperature	T_{fi}	300	^{0}c
4	Flue gases outlet temperature	T_{fo}	180	^{0}c
5	Initial temperature difference=(T_{fi}-T_2)	ITD	180	^{0}c
6	Terminal temperature difference=(T_{fo}-T_1)	TTD	30	^{0}c

S.No	DESCRIPTION	SYMBOL	VALUE	UNITS
1	Steam flow considered	W	35	Kg/hr
2	Saturated steam inlet temperature	T_s	120	^{0}c
3	Super heated steam enthalpy	$\lambda 1$	686.6028	Kcal/kg
4	Enthalpy of saturated steam	$\lambda 2$	647.368	Kcal/kg
5	Heat to be supplied to super heater	Q	1373.205	Kcal/hr

1. Heat to be supplied to super heater $Q = (\lambda 1 - \lambda 2) \times W$

$= (686.6-647.36) \times 35$ kg/hr
$= 1373.2$ kcal/kg

TTD CALCULATION:

OVERALL HEAT TRANSFER COEFFICIENT" U" CALCULATION ON CLEANLINESS FACTOR:

S.NO	DESCRIPTION	SYMBOL	VALUE	UNITS
1	Uncorrected heat transfer coefficient	U_1	1674.873	Kcal/m^{2}h^{0}c
2	Inlet water temperature correction factor	F_w	0.823	
3`	Tube material &gauge correction factor	F_m	0.9	
4	Cleanliness factor	F_c	0.6528	
5	Overall heat transfer co-efficient= $U=U_1 \times F_w \times F_m \times F_c$	U	809.849	Kcal/m^{2}h^{0}c

SURFACE AREA CALCULATION OF SUPER HEATER:

S.NO	DESCRIPTION	SYMBOL	VALUE	UNITS
1	Heat to be supplied to super heater	Q	1373.205	Kcal/hr
2	Overall heat transfer co-efficient	U	809.85	Kcal/m^{2}h^0
3	Terminal temperature difference	TTD	30.00	^{0}C
4	Total area required=Q/(U×TTD)	A	0.06	m^2

TUBE DIAMETER AND AREA:

S.NO	DESCRIPTION	SYMBOL	VALUE	UNITS
1	Tube outside diameter	D_o	24	Mm
2	Tube inside diameter	D_i	18	Mm
3	Length of tube consider	L	1180	Mm
4	Area considered $A = \pi D_0 L$	A	0.09	m^2

Design margin considered =57.33 %

IV. CONCLUSION

The above experiment shows how tube failure can be arrested by using damper. In huge power plants tube failure in super heaters can be arrested by de-super heater, which controls the steam temperature by spraying water droplets through nozzle on surface. Here, damper controls the flue gases temperature further arresting tube failure. By increasing tube area tube failure can be arrested. Total tube area required 0.06 m^2 by considering some design margin 57.33% tube area increased to 0.09 m^2. So, therefore by increasing tube area and by using damper, tube failure can be arrested.

V. ACKNOWLEDGEMENT

The authors express their thanks to Head of the Mechanical Engineering Department, Principal, Director and Correspondent of Vidya Jyothi Institute of Technology, Aziz Nagar, Hyderabad for the help and support extended towards this work

VI. REFERENCES

[1]. Shaji Kumar K.R. - "An Investigation on Tube Temperature Distribution in a Water Tube Boiler" IOSR Journal Of Mechanical and Civil Engineering (IOSRJMCE) ISSN: 2278-1684 Volume 2, Issue 3 (Sep-Oct. 2012) PP 45-50.

[2]. Raja Saripally, Ting Wang and Benjamin Day. (2005) Simulation of combustion and thermal flow in an Industrial boiler, Proceedings of 27th Industrial Energy Technology Conference, New Orleans, Louisiana.

[3]. Rahimi Masoud, Abbas Khoshhal and Syed Mehdi Shariati, (2006) CFD modeling of boiler tubes rupture. Journal of Applied Thermal Engineering, 26, 2192-2200.

[4]. Mckenty. F., Gravel L., and Camarero.R. (1999) Numerical simulation of industrial boilers. Korean Journal of Chemical Engineering 16 (4) 482-488.

[5]. M.M.Rahman and Sukahar,(2008). Tube temperature distribution in water tube boiler – A parametric study by Finite element method. International Conference on Construction and Building Technology, ICCBT-2008, 14, 157- 170

[6]. Purbolaksono, J., Khinani A, Ali A.A., Rashid A.Z., and Nordin.N.F (2009) Iterative technique and finite Element simulation for supplemental condition monitoring of water-tube boiler. Journal of Simulation Modeling Practice and Theory, 17, 897-910.

[7]. Efim Korytnyi, Roman Saveliev, Miron Perelman and Boris Chudnovsky (2008) Computational fluid dynamic Simulation of coal fired utility boilers: An emerging tool, Fuel, Elsevier.

[8]. Khalil Ranjbar, (2007). Failure analysis of boiler cold and hot re-heater tubes. Journal of Engineering Failure Analysis, 14, 620-625