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Enhancement of Heating Surface Area In Steam Boiler: A Review

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Abstract : *This review paper reveals that, capacity of steam generation of steam boiler is mainly depends upon heating surface area and heat transfer rate. For enhancement of boiler steam generation capacity, it is required to redesign boiler furnace. This review summarizes the previous work done on different geometries of tubes in steam boiler for enhancement of heating surface area. Also researchers focused on size and shape of boiler furnace for increasing boiler steam generation capacity. Helical coil structure, Multi lead rifled tubes or spiral type tubes are commonly used for enhancing heat transfer rate and increasing efficiency of boiler.*

Keywords : *Capacity of steam generation, Efficiency of boiler, Geometry of boiler tubes, Heating surface area, Heat transfer rate.*

I. Introduction

A steam boiler or steam generator is a device used to generate steam from water by applying heat transfer philosophy. This has many applications. The form and size is depends upon application such as steam powered road vehicle, mobile steam engines such as locomotive uses a small boiler; Industrial and power station installation will usually have a separate steam generation facility with big size boilers. The sources of generation of heat energy are from burning of any of several fuels such as coal, oil, wood or natural gas. Bagasse is also used for generation of heat energy in sugar producing industry. Then these produces heat energy is used to convert water into steam. The composition of solid fuel plays important role in assessing with its calorific value and efficiency calculation of boiler. Steam generation capacity of any boiler using solid fuel is mainly depends upon its heating surface area, grate area, furnace volume and draft system. To enhance the boiler steam generation capacity it is required to increase heating surface area in boiler.

There are mainly two types of boiler, water tube boiler and fire tube boiler. Mostly in industry water tube boiler is used where water flows inside the tube and it is more efficient than fire tube boiler. Due to economic and environmental demand of electric energy, engineers mostly working on improving efficiency of boilers. It is done by improving heating surface area and heat transfer rate. For enhancement of heating surface area many researchers working on geometry of water tubes in boiler. In real condition the boiler with water tube are plane walled so flow is laminar. They focused on turbulence flow in tubes using helical ridging or transverse ribbing to enhance heating surface area. Some researchers are also done with change in dimensions of water tube for improving heat transfer rate.

II. Researcher's Approach

The study is performed on changing geometry of tube in boiler furnace to increase the heat transfer rate. They used helical ridging for water tube and found that geometry of boiler tube that enhance the heat transfer rate as well as boiler efficiency which reduces emissions [1].

The performance is carried out for heat transfer enhancement in super heater tube. By changing inner diameter of tube with keeping thickness constant, this increases the surface area in contact and causes increase in heat transfer rate. Increase in inner diameter causes reduction of steam velocity in tube [2].

Sreesankar et al. are analyzed the efficiency and enhancement of heat recovery steam generator of combined cycle power plant with additional tube in economizer. The major heat loss in steam generator is caused by hot stack gases outlet. For improvement of efficiency is required to install horizontal heat recovery steam generator in economizer. Economizer extracts more heat from flue gases if incorporated of baffle tubes in it [3]. Calculation of efficiency is carried out with different gross calorific value (GCV) of coal and they found that efficiency of boiler changes with change in calorific value of fuel to be burnt. Also ash and moisture content inside the fuel will affect the efficiency. Authors also talked about opportunities of efficiency improvement such as proper water treatment, proper fuel selection and fuel preparation [4].

Sreepradha et al. are performed mathematical modeling for coal fired thermal boilers. Modeling is done for furnace, economizer, drums and superheater with certain assumptions such as: all parallel pipes in economizer, riser, superheater are considered as single pipe; pressure and water flow rate are uniformly

distributed. They considered formulation of simple mathematical models for integrated boiler and are validate with real time data from 210 MW power plant [5].

The study has performed for combination tube boiler where various heat losses in two pass boiler is observed and prepared the balance sheet. The losses due to unburnt content in the fly ash are very less but losses due to unburnt fuel in bottom ash is present in considerable amount for this type of boiler [6].

A review is carried out for boiler maintenance and enhancement of reliability study. It deals with the possible causes responsible for the breakdown of the boiler and the potential impacts of such breakdown that could occur in the system of which boiler is a part [7].

III. Enhancement of Heating Surface Area

As we know boiler steam generation capacity is depends upon heat transfer rate and heating surface area in it, so heating surface area is directly proportional to steam production rate or capacity. Heating surface area of boiler is nothing but the total area of tubes and drums in all components of boiler which is in contact with flue gases produced after burning of fuel. Usually water tube boiler is used in industry for production of steam. That water tubes content plan wall for transfer of heat from flue gases to water. Due to that plane wall flow of water inside tubes is considered as laminar flow [1]. Heat transfer rate is also varies with flow of fluid, so many researchers focused on turbulent flow. For that purpose they did studies on geometry of tubes which will affect on heat transfer rate, heating surface area and also on flow of fluid inside it.

They introduced corrugated geometry of tubes obtained from roughened surface like internal helical ridging or transverse ribbing or multi lead rifled tubes to enhance heating surface area as well as heat transfer rate [1]. Rainieri et al. experimentally performed on plane wall and corrugated wall as shown in fig. 1, they found that thermal performance of corrugated wall is often maximum over a straight section.

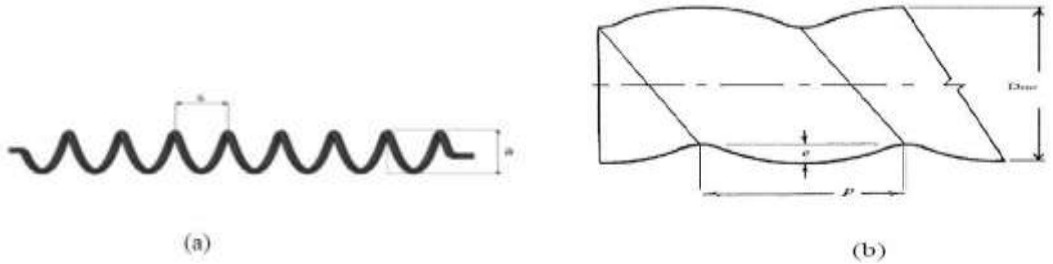

Fig. 1 Tube internal geometry (a) helical coil parameter (b) wall corrugation profile

Lixin et al. conducted an experiment on flow boiling heat transfer in vertical spirally internally ribbed tubes shown in fig. 2. They conclude that, flow boiling heat transfer coefficient in this are improved by factor 1.4 to 2 as compared with that in the plane wall tubes. From researcher's point of view, it is clear that geometry of water tubes in boiler will change the heat transfer rate as well as heating surface area [1].

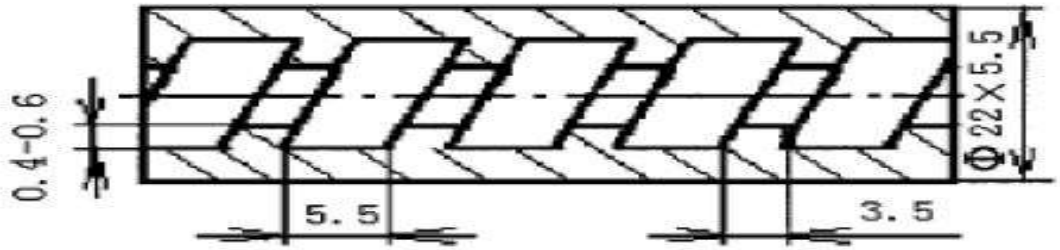

Fig. 2 Schematic diagram of spirally internally ribbing tube

Popat et al. are made changes in geometry of tubes for enhancement of heat transfer rate with improving heating surface area of tubes [2]. They varied diameter of tubes with keeping thickness 8mm constant. This variation of geometry of tubes is done in superheater. They found that, if mass flow rate of water is kept constant then heat transfer rate has increased by 20.68% [2]. So changing dimension of tubes also changes the heating surface area. And enhancement of heating surface area causes enhancement in heat transfer rate which will improves steam generation capacity.

Patro has used combination of tubes for enhancement of heating surface area in boiler [6]. It contain large furnace volume so it has large heating surface area. So steam generation is consistent and found that high thermal efficiency due to which it required less amount of excess air for combustion. The combustion zone of combined tube boiler is surrounded by water tubes, thus it has less radiation losses. Fig. 3 shows the pictorial view of a combination tube boiler.

Fig. 3 The pictorial view of a combination tube boiler

IV. Boiler efficiency calculation

Heating surface area of steam boiler affects boiler efficiency. So it is required to calculate the boiler efficiency. Boiler efficiency is calculated by two methods: 1) Direct method, 2) indirect method [4].

1) Direct method:

Boiler efficiency $= \frac{Heat\ output}{Heat\ input} * 100$

Boiler efficiency $= \frac{Q*(hg-hf)}{q*GCV\ of\ fuel} * 100$

2) Indirect method:

Boiler efficiency = 100 – total losses =100 - (L_1+ L_2+ L_3+ L_4+ L_5+ L_6+ L_7+ L_8)

Where L_1= loss due to dry flue gases ; L_2= loss due to hydrogen in fuel

L_3= loss due to moisture in fuel ; L_4= loss due to moisture in air

L_5= loss due to CO formation ; L_6= loss due to un-burnt fuel in fly ash

L_7= loss due to un-burnt fuel in bottom ash ;

L_8= loss due to surface area (radiation losses and convection losses)

From above equations it is clear that, efficiency of boiler is depends upon heating surface area and heat transfer rate. It is also depends upon gross calorific value of fuel which is to be burnt. Author conclude that, efficiency of boiler is directly proportional to GCV and it is shown in fig. 4

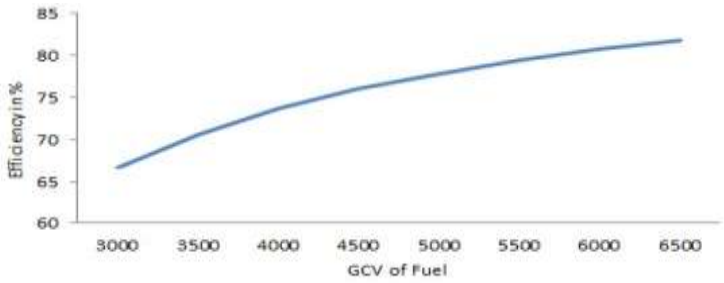

Fig. 4 graph of gross calorific value of fuel with efficiency of fuel.

V. Conclusion

A detailed study on the heating surface area of steam boiler reveals that, enhancement of heating surface area will improves steam generation of capacity of steam boilers. Many researchers focused on enhancement of surfaces as well as heat transfer rate for increase in boiler capacity and efficiency. Many are worked on characteristics of fuel which will lead to change in rate of heat transfer. We conclude form this study, geometry of tubes such as corrugated tubes like helical and multi lead rifled tubes will enhance heating surface area.

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