© May 2019 | IJIRT | Volume 5 Issue 12 | ISSN: 2349-6002

Externally Fired Biomass Boiler: 100kgphr flow rate

Shubham Shivajirao Patil[1,] Akash Azad Pawar[2], Vishwajeet Vijay Raorane[3], Rushikesh Suresh Sapate[4], M. T. Sawant[5]

[1,2,3,4] *Students, Department of Mechanical Engineering, SSPM'S College of Engineering kanakavli, India*

[5]*Professor, Department of Mechanical Engineering, SSPM'S College of Engineering kanakavli, India*

***Abstract*- Harmonization of environmental protection and the growing energy needs of modern society promote the biomass application as a replacement for fossil fuels and a viable option to mitigate the greenhouse gas emissions. For domestic conditions this is particularly important as more than 60% of renewable belongs to biomass. Beside numerous benefits of using biomass for energy purposes, there are certain drawbacks, one of which is a possible high emission of NOx during the combustion of these fuels. Thermal stresses in corrugated furnace tubes of different shape, i.e. with different corrugation pitch and depth, were analyzed first. It was demonstrated that the thermal stresses in corrugated furnace tube are significantly reduced with the increase of corrugation depth. Than deformations and stresses in the structure of a fire-tube boiler were analyzed in a real operating condition, for the cases of installed plain furnace tube and corrugated furnace tubes with different shapes. So if we place furnace outside the boiler then less thermal stress are acting on furnace because of furnace contact with atmospheric gasses. And also ash handling is easier in this case.**

I. INTRODUCTION

Externally fired boiler is a boiler whose furnace is neither wholly nor partly surrounded by water compared with internally fired boiler. In regular boiler there is problem of cleaning the furnace so we prefer externally fired boiler.

In regular boiler we generally use fossil fuel for boiler but they are costly so we use biomass as a fuel in our boiler. Biomass, the oldest form of renewable energy, has been used for thousands of years. However, with the emergence of fossil fuels, its relative share of use has declined in recent years. Currently some 13% of the world's primary energy supply is from biomass, though there are strong regional differences.

Fire tube boiler

A characteristic common element of fire-tube boilers is a cylindrical shell with endplates, which contains the working fluid. Fuel combustion is carried out in the furnace tube that is the boiler furnace. Flue gases from the furnace go into the reversal chamber, than into smoke tubes and exit at the stack, or depending on the flue gas pass arrangement turn around again in the second chamber and go into the next smoke tube bundle. The furnace tube could be performed as a flat cylindrical shell, with or without stiffeners, or as a corrugated cylindrical shell.

Due to theses disadvantages, the use of the steam to carry out the commercial cooking and heating processes becomes necessary. Thus, a steam boiler is required which will produce the steam that will be further used to carry out the heating process required for the cooking. Design of the steam boiler of the required size, results in the optimal production of the steam which overcomes all the disadvantages of the open furnaces and stove burners cooking processes. This minimizes the heat losses and thus, it reduces the fuel consumption and associated fuel cost. Hence, it improves the productivity of the plant. Steam is a convenient, reliable and cost effective energy required to carry out the process. Advantages of using steam for process heating are:

a. Fuel consumption is greatly reduced. Thus, cost associated with fuel consumption is reduced.
b. Productivity of the plant gets improved.
c. Uniform heating occurs in case of steam process heating.
d. Heat losses are greatly reduced.
e. Steam process heating does not have any harmful effect on environment or health of any worker.
f. Burnt flue gases can be filtered in dust collectors. Thus, air pollution is greatly controlled.

Convenient and reliable. Figure illustrates that the cost of energy consumption in a steam system is almost the entirely of the system's cost (based on the data for boilers with a high rate of capacity utilization over a 20 year life). It makes good business sense, therefore to run an energy efficient system.

Advantages of fire tube boiler

Fire tube boiler consists of boiler shell which is filled with water and perforated with tubes, there are different configurations of these tubes but horizontal configuration is the common one. Water is partially filled in the water tank and volume is left inside the tank to accommodate the steam. Long horizontal tubes arc called flues and these carry the hot combustion gases through the water tank and heating the water. . Heat from the products of combustion is transferred to the boiler water by tubes and it goes out from the smokestack. Fire-tube boilers are subdivided into three groups; horizontal return tubular (HRT) boilers typically have horizontal self-contained fire-tubes with a separate combustion chamber.

Scotch, scotch marine, or shell boilers have the fire-tubes and combustion chamber housed within the same shell. Firebox boilers have a water-jacketed firebox and employ at most three passes of combustion gases.

Most modern fire-tube boilers have cylindrical outer shells with a small round combustion chamber located inside the bottom of the shell.

Depending on the constructions details, these boilers have tubes configured in one, two, three or four pass arrangements, because the design of fire-tube boilers is simple, they are easy to construct in a shop and can be shipped fully assembled as a package unit. Fire-tube boilers typically have a lower initial cost, are more fuel efficient and are easier to operate. Advantages of fire tube boiler are:

a. Low cost.
b. Fluctuations of steam demand can be met easily.
c. It is compact in size.

II.WORKING

A boiler is an enclosed vessel that provides a means for combustion heat to be transferred into water until it becomes heated water or steam. The hot water or steam under pressure is then usable for transferring the heat to a process. Water is a useful and cheap medium for transferring heat to a process. When water is boiled into steam its volume increases about 1,600 times, producing a force that is almost as explosive as gunpowder. This causes the boiler to be extremely dangerous equipment that must be treated with utmost care.

The process of heating a liquid until it reaches its gaseous state is called evaporation. Heat is transferred from one body to another by means of radiation, which is the transfer of heat from a hot body to a cold body without a conveying medium, convection, the transfer of heat by a conveying medium, such as air or water and conduction, transfer of heat by actual physical contact, molecule to molecule.

Problems with conventional boiler

- Present commercial horizontal shell and tube boilers have the problem of cleaning of ash grate so in order to work overcome this problem we are going to design and fabricate externally fired horizontal boiler (with biomass fuel).
- Biomass combustion is related with potential problems concerned with the environmental pollution, even though they are less pronounced in comparison with the coal. The emission of nitrogen oxides (NOx) is one of the most important challenges in the field.

III.CALCULATION

All the calculation are done by considering the ideal case and 100% efficiency

Fuel required:

Calorific value of the biomass pallets ranges between 18 to 21 MJ

Taking 18000 KJ ………… for the worst case

At 7bar:

Specific heat = 697.07 KJ/Kg

Latent heat = 2064.92 KJ/Kg

Total heat required = specific heat + latent heat

Q = 687.07 + 2064.92

Q = 2761.99 KJ/Kg

For 100kg of water, Q = 276199 KJ/Kg

Q = m * calorific value ……………… m = mass of the fuel

Q = m * 18000

m = 15.34 Kg of fuel must burn in 1hour

1kg of biomass requires 4.76Kg of fresh air for complete combustion

Therefore, 15.34kg biomass will require 73.04kg of air for complete combustion
So, take a fan of capacity 200 m3/hr flow rate
Q = m * Cp * (T2 – T1) …………… Cp = 1.007 KJ/KgK for air
276199 = 245.8 * 1.007 * (T2 - 27)
T2 = 1142.86deg C ……. Maximum temperature obtained
Number of tube required
Given output conditions:
Steam flow rate = 100kgph
Considered pressure = 7bar
Tw = 165deg C …………….. Boiling point temp of water at 7bar
T1 = 1140deg C …………… temp obtained by burner at inlet
T3 = Tw + 50
T3 = 165 + 50
T3= 215deg C
T2 = (T1 + T2)/2
T2 = (1142 + 215)/2
T2 = 678.5deg C
(T2) flue = (T1 + T2)/2
(T2) flue = (1142+678.5)/2
(T2) flue = 910.25deg C
(T2') flue = (T3+T2)/2
(T2') flue = (678.5+215)/2
(T2') flue = 446.75deg C
Heat Transfer within steam boiler
Assumed values:
Heat transfer coefficient of water varies between 100 to 1000 W/m2K

Taking it as 500 W/m2K
h = hi * (di/d)
hi = tube side coefficient
h = 55 W/m2K ……………… taking the average
Heat transfer coefficient of fire tube material

Material used = mild steel
H = 11.3 W/m2K ………. Taking standard value
Thickness of the fire tube = 5mm = .005m
Heat transfer area:
Q/A = [(Tflue - Twater)/ {(1/hflue) + (ttube/Ktube) + (1/hw)}]
Where, tube = thickness of the fire tube
Ktube = heat transfer coeff. of fire tube material
For the second pass
Q2/A2 = {(678.5 - 165)/ [(1/55) + (.005/11.3) + (1/500)]}
Q2/A2 = 24897.82 W/m2
Q2/A2 = 24.89782 KW/m2
For the third pass
Q3/A3 = {(446.75 - 165)/ [(1/55) + (.005/11.3) + (1/500)]}
Q3/A3 = 13661.07 W/m2
Q3/A3 = 13.66107 KW/m2
Given mass flow rate of steam is 100kgph
m' = 0.0278kgps
Consider,
Water inlet temp = 25deg C
Therefore hf at25 deg C =104.86 KJ/Kg
(Specific enthalpy of water)
Considered pressure is 7bar
Therefore, hg = 2762 KJ/Kg
(Specific enthalpy of steam)
Total heat transfer
Q = m' (hg + hf) ……….. m' = mass flow rate
Q = 0.0278(2762 + 104.86)
Q = 79.69 KW

Consider,
70% heat transfer is done during second pass
30% heat transfer is done during third pass
Therefore,

For 2ed pass:
Q2 = 79.69 * 0.7
Q2 = 55.783 KW
Q2/A2 = 24.89782 KW/m2
A2 = 55.783 KW/24.89782 KW/m2
A2 = 2.24m2

For 3rd pass:
Q3 = 79.69 * 0.3
Q3 = 23.907 KW
Q3/A3 = 13.66107 KW/m2
A3 = 23.907 KW/13.66107 KW/m2
A3 = 1.75m2
Number of tubes required
………….Assume length of the fire tube as 1200mm
For 2ed pass:
A2 = n * π * l * d
Where, n = number of tubes, l = length of tubes, d = diameter of fire tube.
Therefore,

$2.24 = n * \pi * 1.2 * 0.045$ …………….. Taking dia. of fire tube = 2inches = .045m
$n = 13.2$
Taking it as **15** for symmetry
For 3rd pass:
$A3 = n * \pi * l * d$
Where, n = number of tubes, l = length of tubes, d = diameter of fire tube.
Therefore,
$1.75 = n * \pi * 1.2 * 0.045$ …………….. Taking dia. of fire tube = 2inches = .045m
$n = 10.31$
Taking it as **10** for symmetry

- 15 fire tubes of 1200mm length are required for 2ed pass
- 10 fire tubes of 1200mm length are required for 3ed pass

Volume of water present inside the vessel
= volume of vessel – volume of burner tube – 25 * volume of fire tube
$= (\pi/4 * .982 – \pi/4 * .52 – 25 * \pi/4 * .0452) * 1.2$
= 0.6218m3
Considering 15% space for the steam
Volume for steam = 0.15 * 0.6218
= 0.09327m3
Volume for water = 0.85 * 0.6218
= 0.5285m3
Volume of water present inside boiler vessel = 528.5 liter

Parameters:

- Overall length of the boiler vessel = 1500mm
- Diameter of the vessel = 1000mm
- Diameter of the burner tube = 500mm
- Diameter of the fire tubes = 45mm
- Thickness of the burner tube = 10mm
- Thickness of the boiler vessel = 10mm
- Thickness of the fire tube = 5mm
- Material used = mild steel
- Pressure = 7bar
- Total heat transfer required = 79.68 KW
- Inlet temperature of the flue gases = 1142.85deg C
- Heat transfer coefficient of the flue gases = 55W/m2K
- Heat transfer coefficient of water = 500W/m2K
- Heat transfer coefficient of fire tube = 11.3 W/m2K
- Number of tubes in 2ed pass = 15
- Number tubes in third pass = 10
- Water present inside vessel = 528.5 liter

IV.CAD MODEL

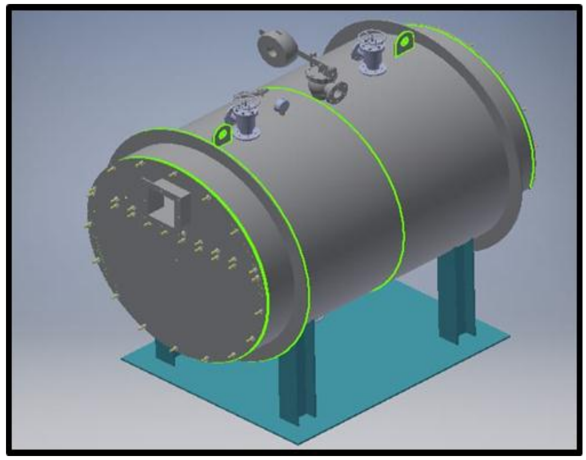


Fig: Isometric view

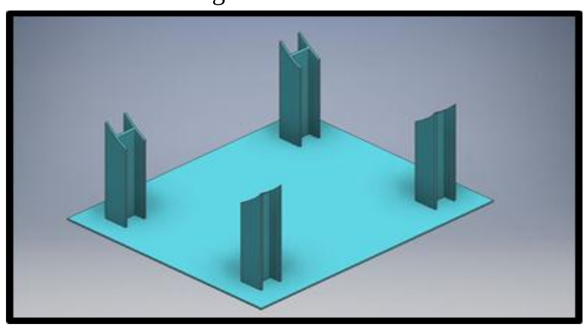


Fig: floor stand for the boiler

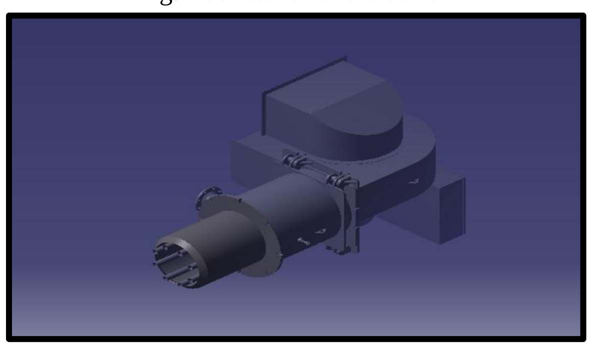
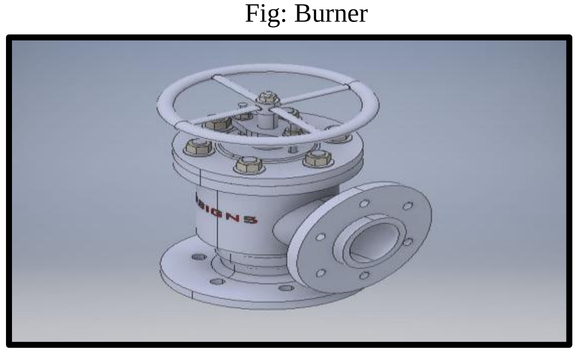


Fig: Burner



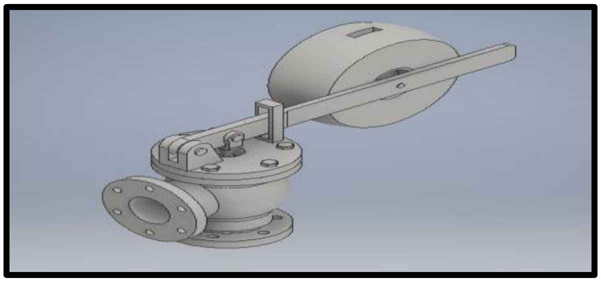


Fig: Mountings

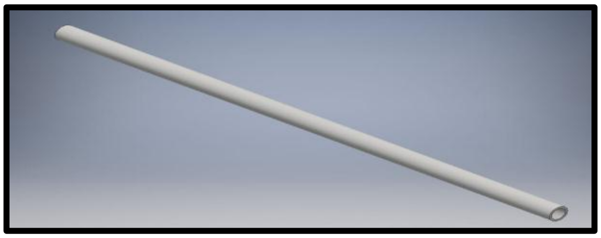


Fig: Flue gas fire tubes

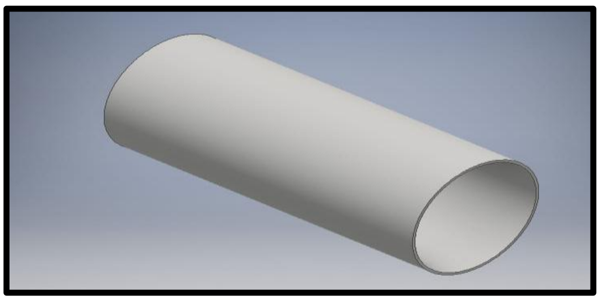


Fig: Burner flame tube

V.ANALYSIS

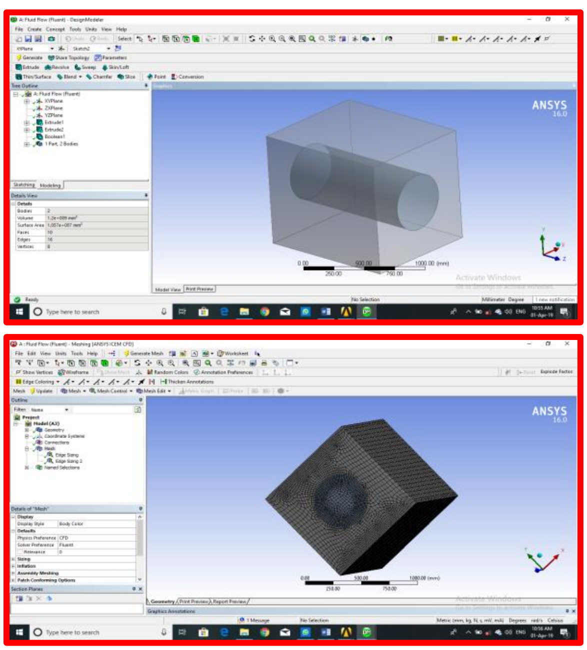


Fig: Geometry and Mesh of 1st pass and meshing

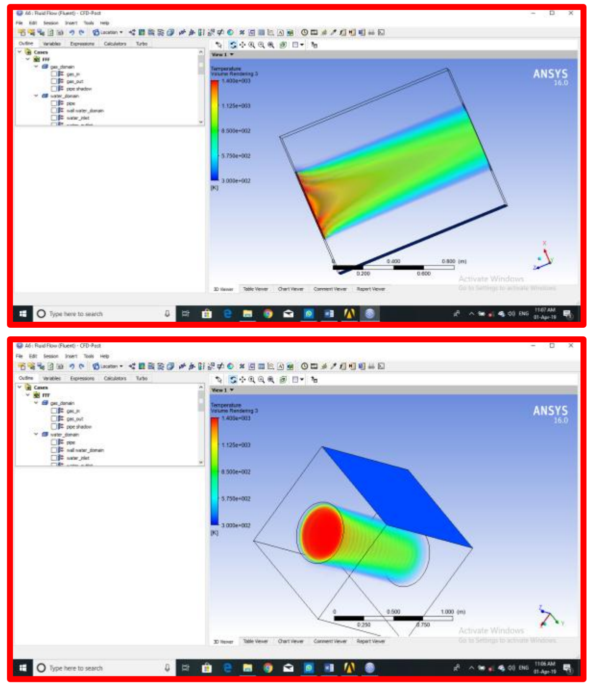


Fig: Results obtained for 1st pass

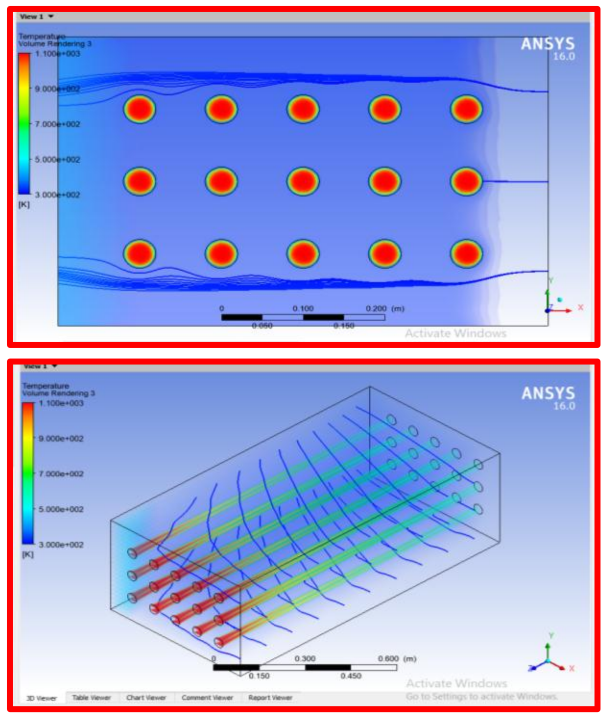


Fig: Result of 2ed pass

V.CONCLUSION

1. The research and development work was oriented towards designing and developing a modern, innovative burner for central heating boilers.

2. The scope of pre-implementation research and development work covered: development of the burner design, performance of tests of the prototype burner, development of the control system – burner automation, as well as preparation and filing of a patent application for the burner.
3. As a result of the conducted research and overall development work, a modern, innovative burner for central heating boilers was developed ensuring high quality combustion of pelletized biomass fuels.
4. The burner's compact design dimensions allow it to be installed in the majority of solid fuel boilers. 5. When operating with designed burner reaches parameters the of combustion class 5 according to the standard PN EN 303-5:2012. The fact boilers, the that the burner-boiler system meets the criteria of class
5. of this standard is a positive indicator of its efficiency and purity of combustion.
6. Implementation of the designed burner will result in savings on fossil fuels and limited emissions from burning of fossil fuels.
7. To secure the intellectual property rights – industrial property rights, a relevant patent application has been filed. The subject of the invention is a burner for central heating boilers utilizing a renewable energy source

REFERENCES

1. BOOKS:
Thermal and fluid power engineering by R.K.Rajpoot

2. RESEARCH PAPERS PUBLISHED IN JOURNALS:
[1] MODERN BURNER FOR CENTRAL HEATING BOILERS
[2] UTILIZING RENEWABLE ENERGY SOURCE - BIOMASS Example: Davis, William D., Thomas Cleary, Michelle Donnelly, and Samuel Hellerman. "Using Sensor Signals to Analyze Fires." *Fire Technology* 39 (2003): 295-308.
Here, all the papers from the literature survey should be listed in above format.
[3] INFLUENCE OF FURNACE TUBE SHAPE ON THERMAL STRAIN OF FIRE-TUBE BOILERS
[4] EFFICIENCY IMPROVEMENT OF BOILERS Sangeeth G.S.1, Praveen Marathur2
[5] Fabrication of Pilot Multi-Tube Fire-Tube Boiler Designed For Teaching and Learning Purposes in Mechanical Laboratory Gbasouzor Austine Ikechukwu, Member IAENG
[6] DESIGN OF THE HORIZONTAL FIRE TUBE BOILER FOR THE COMMERCIAL COOKING OF INDIAN FOOD Abhay Sharma, Prof. A.C. Tiwari

3 WEB SITE
1. www.google.com
2. www.Wikipedia.com