Performance Analysis of Gas Burner Using Producer Gas For Application of Small Boiler of 1 TPH Capacity Using ANSYS Software.

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Abstract - This paper presents the software analysis of 1 TPH boiler in which producer gas used as fuel. The analysis is done by using ANSYS FLUENT 15.0 software. The analysis includes flame distribution, flame temperature distribution and distribution of gas components inside the boiler after ignition. The study reveals that the flame temperature inside the furnace is evenly distributed and it decreases gradually till it reaches the stack inlet. As the percentage of producer gas component like carbon dioxide and methane is less the temperature of flame after ignition is in the range of 1300-14000C. Flue gases temperature remains static inside the furnace and decreases after first pass.

Key Words: Burner, Producer gas, Flame distribution, Temperature distribution, ANSYS FLUENT Software.

1. Introduction

It is observed that in Small and Medium scale textile industry clusters of developing countries, wood is burned as a fuel for boilers. The industry uses primary non commercial energy source as well as bio mass and electricity for their final product. The process of burning wood is robust and leads to inefficiencies in system. The steam is used for processing the cloth at various stages.

Majority of the cluster units are of integrated type, where the raw material yarn is processed in-house to the final product. The energy cost is second to the raw materials cost. Majority of the units in the cluster are dependent on local / run of the mill technologies of low end and with little investment initiatives and technology up-gradation.

The main energy forms used in the cluster units are grid electricity, wood, and small quantity of coal. Effort are required to conserve the energy and convert wood firing in to efficient alternate energy technologies for climate change mitigations.

1.1 Producer gas-Producer gas is a derived gaseous fuel, which is obtained by gasification of various primary fuels like coal, lignite, charcoal, and biomass.

Conversion of primary fuels into producer gas by gasification broadens the range of applications of these fuels. The primary advantage of gasification technology is that it enables the substitution of expensive fuels with cheap solid fuels. Also it increases the firing efficiency in the furnace/boiler and achieve energy conservation. The research work has analyzed the possibility of use of producer gas instated of wood or coal as a fuel using ANSYS simulation tool using real time data of producer gas for a given existing boiler of 1 TPH in textile process industry at Ichalkaranji, ,India and verifies the firing efficiencies vis-à-vis wood as a basic fuel.

Producer gas is the mixture of different gaseous components and the percentage of gas components vary according to the biomass used in the gasifier. The components of gas and its properties in the gas which is used as fuel in the burner is given in the following table 1.

Table 1: Producer gas components and there properties.

Component	Percentage (%)	Molecular weight (mole/kg)	Density (kg/m^3)
H_2	20	2	0.089
CO	15	28	1.165
CO_2	15	44	1.842
CH_4	2	16	0.668
N_2	48	14	1.165

The quantity of biomass and producer gas is calculated according to the boiler capacity and enthalpy of steam at the pressure at which it is to be produced.

1 Kg of biomass produces approximately 2.5 m3 of producer gas. Primary and secondary air requirement of the burner is calculated by the indirect method. Primary air is required for the gasification purpose of the biomass in the gasifier and secondary air is used for the complete combustion of the fuel in the furnace.

Table2. Gives information about specification of all the input materials and their quantities required for 1 TPH capacity boiler using producer gas as fuel.

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Table -2: 1 TPH capacity boiler input specification.

Sr no.	Parameters	Quantity
1.	Biomass feeding rate	170.78 kg/hr
2.	Producer gas generation	444.04 kg/hr
3.	Primary air mass flow rate	344.97 kg/hr
4.	Excess air mass flow rate	594.78 kg/hr
5.	Volumetric flow of excess air	0.137 m^3/sec
6.	Volumetric flow of producer gas	0.118 m^3/sec
7.	Diameter of gas tube	0.095 m
8.	Diameter of excess air tube	0.190 m
9.	Area of gas outlet	7.08×10^{-3} m^2
10.	Area of excess air outlet	2.8×10^{-2} m^2
11.	Velocity of excess air through tube	4.8 m/sec
12.	Velocity of producer gas through tube	16.6 m/sec
13.	Enthalpy of producer gas	1310.24 kcal/kg
14.	Enthalpy of biomass	3000 kcal/kg
15.	Temperature of producer gas	450^0C
16.	Temperature of excess air	32^0C
17.	Heat release through burner	674.84 kW
18.	Feed water temperature	80^0C

The above calculated quantities are used in ANSYS software for the simulation purpose.

Before the simulation work three dimensional modeling of burner boiler assembly done with the help of 2013 Solidworks software. The boiler design is the three pass fire tube boiler with 48 no. of fore tube. The length of the furnace is 2.8m. Following fig. 1 shows 3-d transparent geometry of the boiler showing all components.

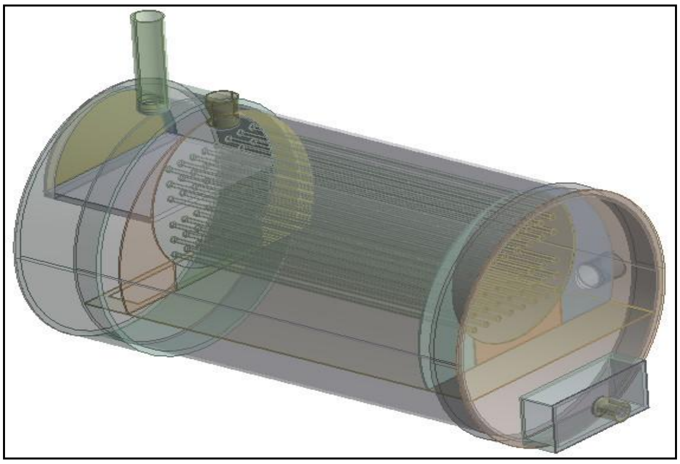

Fig. 1: 3-d transparent geometry of the boiler.

The analysis of combustion process and flow of the producer gas in a fire tube boiler have been discussed in the following section. It involves Pre Processor, Solver and Post Processor.

The Pre-Processor step involves geometry creation and grid generation and is shown in fig 2,

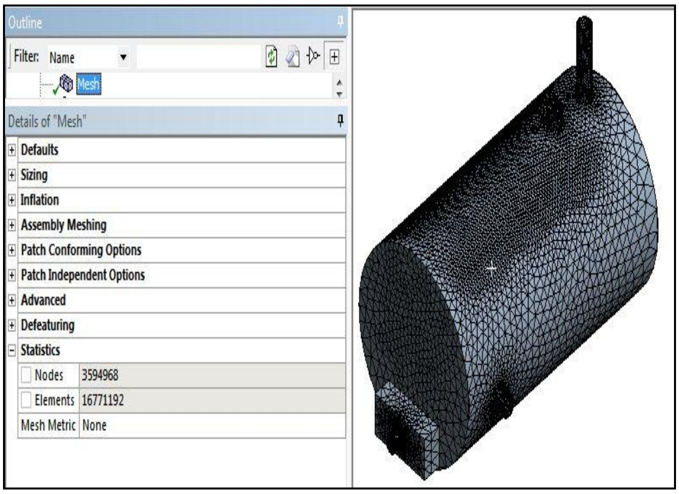

Fig. 2: Structured meshing of boiler assembly.

Boundary conditions are assigned to the boiler assembly and it gives the results according to the input and output conditions. Fig. 3 shows the boundary conditions assigned to boiler assembly.

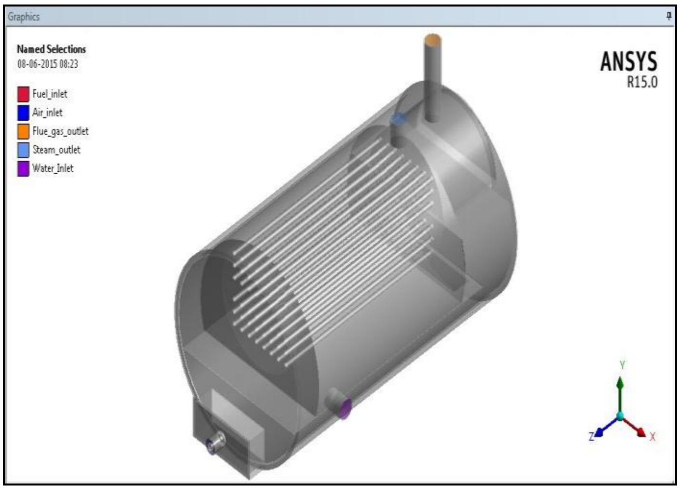

Fig. 3: Boundary condition assigned to the boiler assembly.

3. ANSYS software Result and Analysis

The temperature, pressure and velocity distribution (counters) inside the boiler obtained by the analysis are shown in following figures4,5 and fig 6 gives

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the material temperature distribution profile. The maximum temperature goes up to 1367° C in the red zone. The combustion is taking place in a circular ring manner near the region spark introduced, because small orifices in the burners which are actually required for the atomization of the air fuel mixture and its premixing are neglected for the simplification of the geometry. This does not have any effect on the chemical and thermal equilibrium of the reaction.

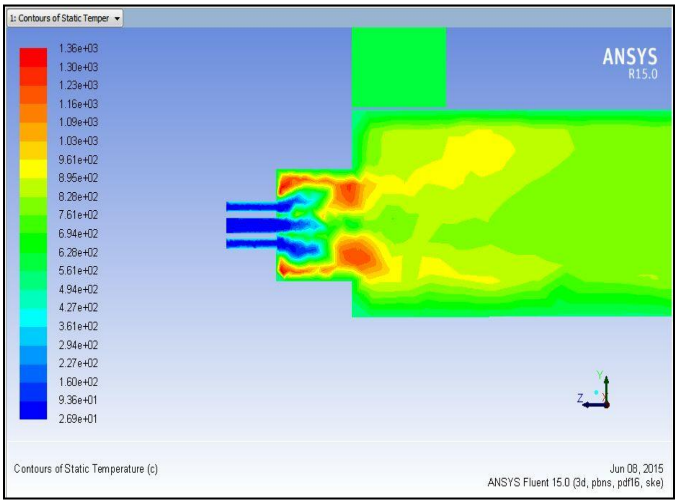

Fig. 4: Static distribution of flame temperature.

The actual stream line flow of the flame is shown in the figure 5 as follows. This shows that how the combustion flame is back propagated because of the turbulence nature of the fuel and air mixture. Hence to minimize this back propagation, proper swirl angle is provided in actual burner designed and fabricated to direct the flow and do enhance atomization of the mixture for premixing.

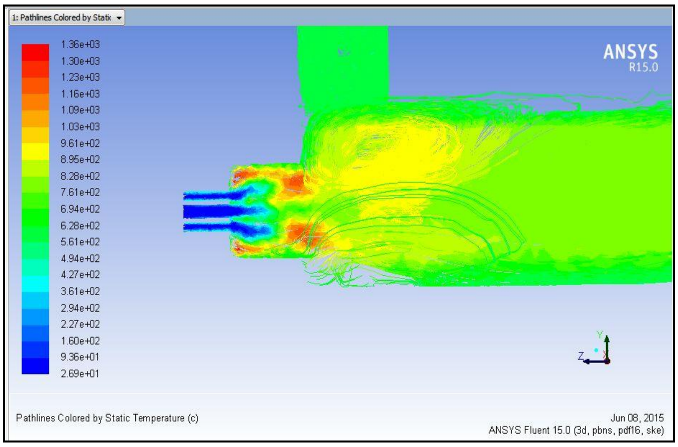

Fig 5: Actual stream line flow of the flame.

Figure 6 shows the overall temperature distribution inside the boiler. The outlet temperature at the stack is recognized by the blue and sky blue colour traces at the stack outlet. This is ranging about 160°C to 227°C.

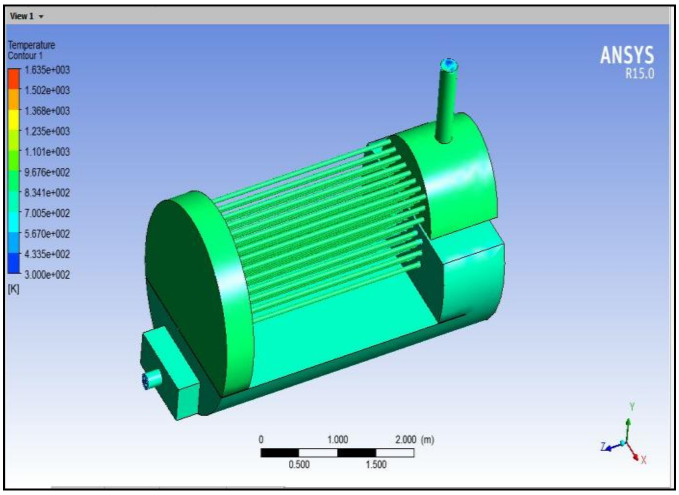

Fig. 6: The overall temperature distribution inside the boiler.

Figure 7 shows the flue gas temperature distribution at various section in the free region after combustion zone. This is somewhat uniform throughout the region and not having any considerable change up to the first pass.

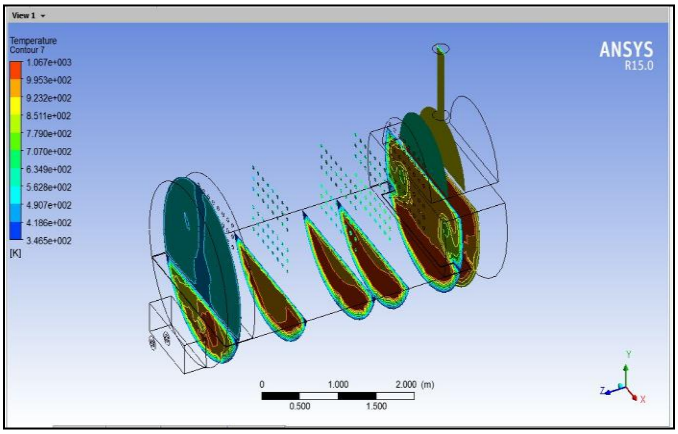

Fig. 7: Flue gas temperature distribution at various section in the free region after combustion zone.

Figures 8 and 9 show the mass fraction distribution from the burner to the stack. The CO_2 is present up to stack and it is the large quantity over the others. The CH_4 fractions are very less as compared to CO_2.

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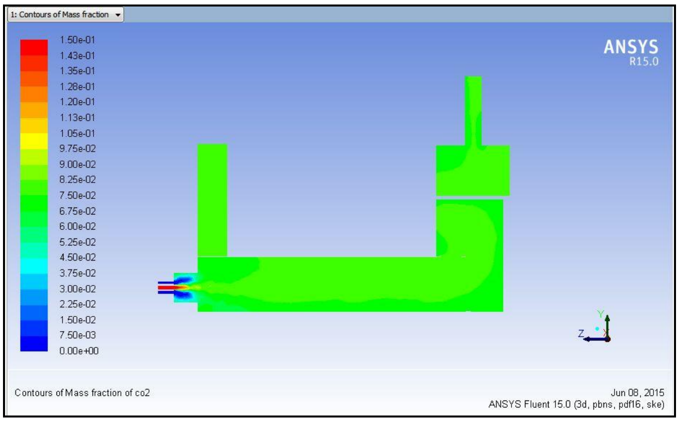

Fig. 8: Mass fraction of CO_2.

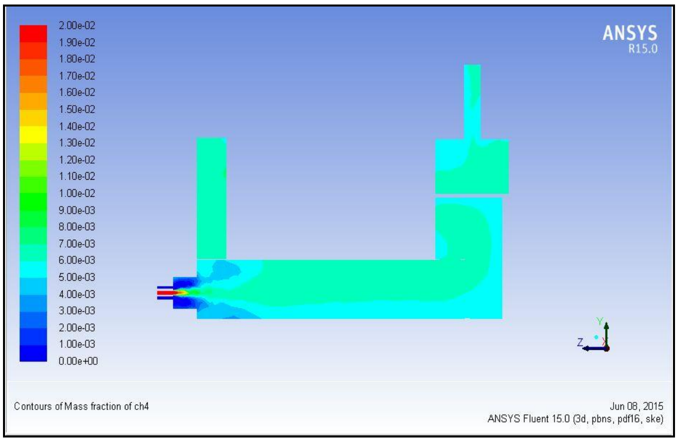

Fig. 9: Mass fraction of CH_4.

Figures 10 shows the velocity distribution of the gases. The velocities of the gases are dominant at only inlet section. As the flow goes away from the inlet section the velocity goes down rapidly. This causes the increase the pressure of the flue gases over the first pass of the boiler tube which need to be modify for the smooth flow of the gases.

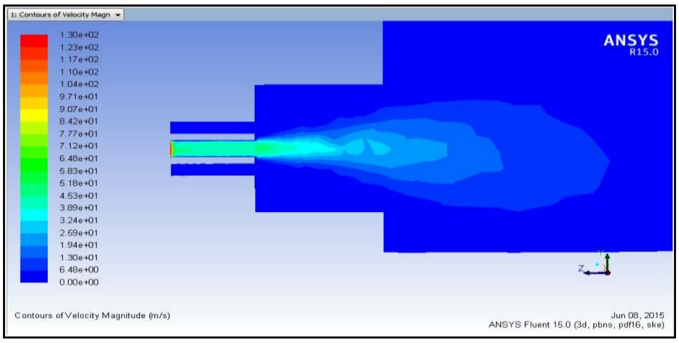

Fig 10: Velocity distribution of gases.

4. Conclusion

The results of simulation shows that, the maximum flame temperature is 1367⁰C and it gradually decreases up to 160 to 220⁰C at stack inlet. The velocities of the gases are dominant at only inlet section. As the flow goes away from the inlet section the velocity goes down rapidly. This causes the increase the pressure of the flue gases over the first pass of the boiler tube which need to be modify for the smooth flow of the gases. The CO_2 is present up to stack andits presence is on higher side . The CH_4 fractions are very less as compared to CO_2. The temperature distribution of flue gas is uniform throughout the region and does not show any considerable change up to first pass. The designs based on ANSYS simulation is thus recommended for modifications.

REFERENCES

[1] M A Choudhury, K. Mahkamov. Development of a Small Downdraft Biomass Gasifier for Developing Countries. Journal of scientific research Res. 3(1), 51-64 (2011). 29 November 2010.
[2] Anil K. Rajvanshi, Biomass Gasifcation, Alternative energy in agriculture, Chapter no-4, vol. 2, Ed. D., Yogi Goswami, CRC press 1986.
[3] Rajeev Jorapur, Anil K. Rajvanshi, Sugar leaf- bagasse gasifiers for industrial heating application. Biomass and bioenergy, Vol. 13, No. 3, pp 141-146, 1997.
[4] P.R. Bhoi, S.A. Channiwala, Emission characteristics and axial flame temperature distribution of producer gas fired premixed burner, Biomass and bioenergy 33, 469-477, 10 October 2008.
[5] N L Panwar, B I Salvi, V. Siva Reddy, Performance evaluation of producer gas burner for industrial application, Biomass and bioenergy 35 (2011) 1373-1377,11 January 2011.
[6] N. S. Rathore, N. L. Panwar, Y. Vijay Chiplunkar, Design and techno economic evaluation of biomass gasifier for industrial thermal application. African Journal of Environmental Science and Technology Vol. 3 (1), pp. 006-012, January 2009.
[7] O. A. Ighodalo, C. I. Ajuwa, B. R. Iredje, Development and performance evaluation of a high velocity burner for furnace operations. American journal of scientific and industrial research. pp. 049-053, 2011.
[8] Biogas stove design by Dr. David Fulford, Kingdom bioenergy Ltd, August 1996.
[9] Bureau of Energy Efficiency report on Detailed Project Report on Energy Efficient Boiler (200 kg/hr) Textile SME Cluster, Solapur, Maharashtra. Detail Project Report No. SLP/TXT/EEB/03.
[10] ANSYS Fluent 12.0 Theory guide by ANSYS, Inc. April 2009.
[11] ANSYS Fluent 15.0 software.

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