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Experimental Investigation on parametric study of gaseous fuel flow Parameters: Flame Length & Diameter

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Abstract— Flame is an important parameter for any combustion process which is responsible for either the complete or incomplete combustion process. There are certain factors which influence the flame length and diameter such as fire source diameter or nozzle diameter, equivalence ratio, quality of fuel, heat release rate etc. Investigation of flame length and diameter is more relevance in the rational design of combustion chamber, be it for an internal combustion engine or for a furnace. For this the numerical simulation and experimentation of flame structure and its parameters like flame length and flame diameter is done. Numerical simulation is done by using ANSYS 14.5, CFD tool and CFX solver. Different mass flow rate and air-fuel ratio added in boundary condition to get the results. The numerical simulation result shows that as the air-fuel ratio increases the diameter and length of flame also increases. During the experimentation it was found that as increases A/F ratio flame length and diameter increases. Air availability is enough so heat generation is more than the heat loss so flame length and diameter is longer.

Key words: Combustion; Flame; Flame Length; Flame Diameter; CFX; Combustion Chamber

I. INTRODUCTION

Combustion is a rapid oxidation generating heat and light and flame is the chemical reaction between one chemical substance called a fuel, and another chemical which is an oxidizer (or oxidant). The size and shape of flame depend on its type, namely, premixed or diffusion, laminar or turbulent and also on the burner dimensions. [1]

Flames may be of different types depending on the extent of mixing of fuel and oxidizer or how the mixtures reach the reaction zone. The flow patterns in the reaction vessel, such as well mixed and plug flows are the major tools to classify the flames in different types. The flame may be turbulent in a premixed flame the fuel and the oxidant are molecularly mixed before the combustion process takes place. The flames are mainly classified as: (i) Non -Premixed or Diffusion Flames and (ii) Premixed flames. These flames may be either laminar or turbulent types.

A. Non –Premixed Flame:

In such combustion process the fuel and air are often initially not mixed. The fuel and oxidizer are kept on either side of the reaction zone. The resultant flame is termed as diffusion flame. The diffusion flame occur at the interface of gaseous fuel and air with the progress of time as the flame propagates, the reaction zone increases. The non-premixed flame stoichiometric condition optimizes the flame temperature with a definite air fuel ratio.

B. Premixed Flame:

In this type, the fuel and oxidizer gas are mixed together as ambient condition before delivered to flame front. It is heated by conduction and radiation. Gradually the mixture is sufficiently heated at the chemical reaction take place. The turbulent premixed flame plays important role in the various practical application because it increases with reduce emissions. Turbulence actually results in reduction flame length. The turbulence can be increase by recirculation of fuel air mixture. [2]

The structure of the diffusion flame is determined mainly by the process of mixing of gas and air and not by the velocity of flame propagation. The mixing is achieved by either molecular diffusion or eddy diffusion, depending upon the laminar or turbulent condition of flame. A laminar diffusion flame is converted into the turbulent type by increasing the gas velocity beyond a critical value. A freely burning flame is considered stable when there is no flash-back or blow-off. The essential condition for flame stability is that the normal velocity of flame propagation is equal and opposite to the velocity of fuel-air mixture at a flame front. A consideration of all the factors affecting these two velocities is necessary for evaluating the condition of flame stability. [1]

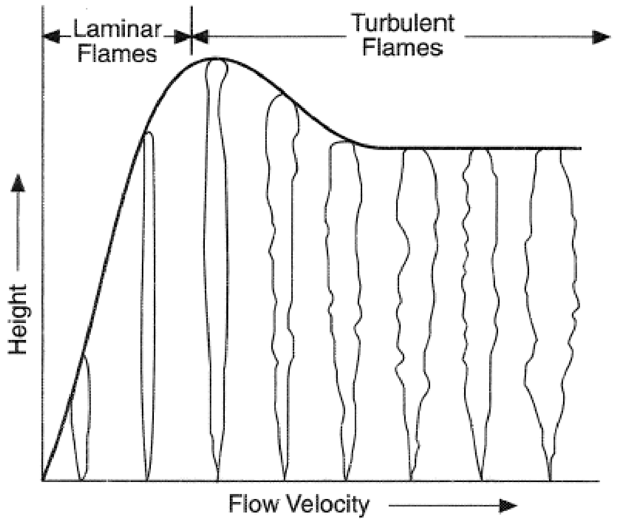

Fig. 1: Progressive Change in Flame Type with Increase in Jet velocity [1][2]

This is the transition stage. In the turbulent region the flame length remains practically constant with increasing jet velocity. Above a critical velocity the flame is lifted and finally it blown of when the jet velocity increases further.

II. EXPERIMENTAL SETUP

A. Components:

1) Air blower
2) Pipe
3) Gas nozzle
4) Chamber
5) Copper tube
6) Pressure regulator valve(PRV)
7) CNG cylinder

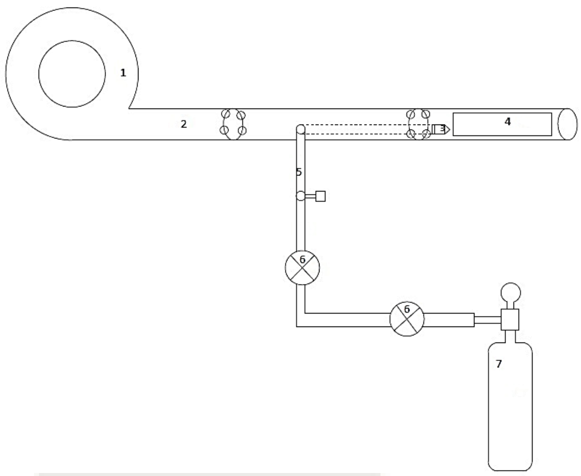

Fig. 2: Line Diagram of Experimental Setup

Fig. 3: Actual Experimental Setup

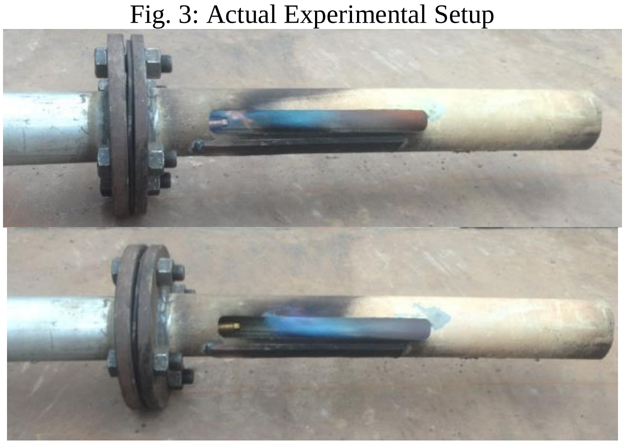

Fig. 4: Flame Lengths

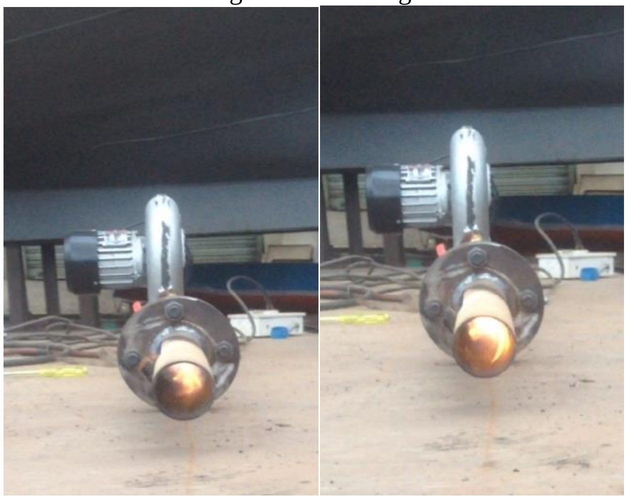

Fig. 5: Flame Diameter

III. RESULTS AND DISCUSSION

A. Results from Experimentation

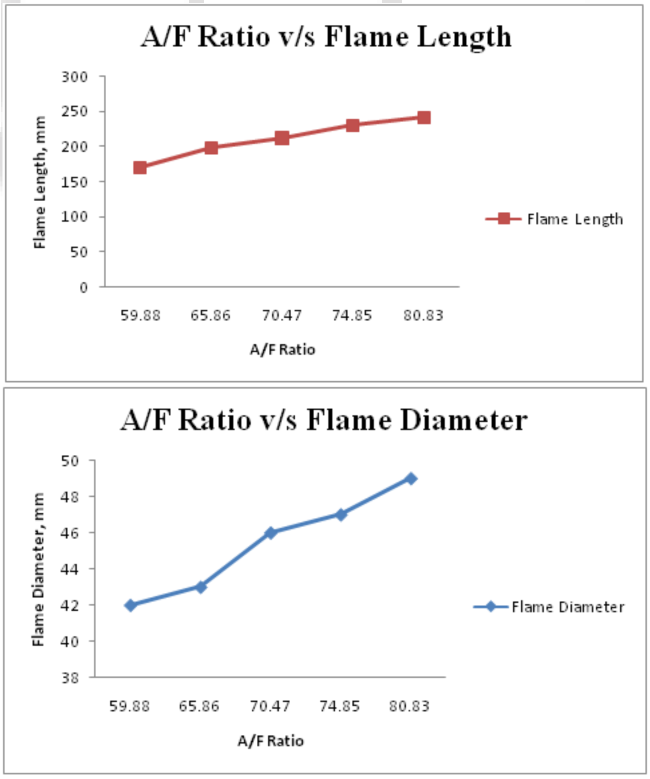

Fig. 6:

During the experimentation it was found that as increases A/F ratio flame length and diameter increases. Air availability is enough so heat generation is more than the heat loss so flame length and diameter is longer. When the A/F ratio is Minimum then the flame length is 170 mm and flame diameter is 42 mm and when it's maximum then flame length is 241 mm and flame diameter is 49 mm.

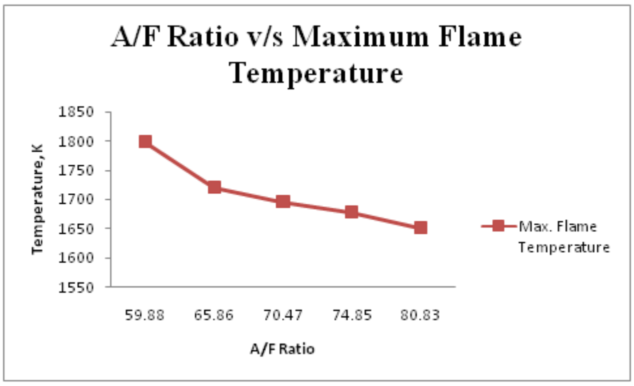

Fig. 7:

Figure shows the different value of flame temperature with respect to the A/F ratio. The flame temperature is decreased with the increased A/F ratio because of more heat loss during the combustion process.

IV. CONCLUSION

The numerical simulation shows that as A/F ratio increases the flame length and diameter increases. Flame length and diameter is longer because air availability is enough so heat generation is more than the heat loss. But if not enough air is available for combustion of fuel then heat losses is more than the heat generation so flame length and diameter is smaller. Same behavior of flame length and flame diameter has found during the experimentation.

From experimentation work when the A/F ratio is Minimum then the flame length is 170 mm and flame diameter is 42 mm and when it's maximum then flame length is 241 mm and flame diameter is 49 mm.

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