Experimental Investigation into an effect of material of Swiss role combustor on its thermal performance

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ABSTRACT— To produce heat energy by using small scale heat generator and then this heat energy is converted into electrical energy with the help of thermoelectric device is becoming general practice. To support the concept; experiment were conducted on different materials (i.e. Copper, Bronze, stainless steel 304 and Aluminum.).Dimensions of combustor were kept constant during all the tests. Parameters varied during tests were Equivalence ratio and flow velocity. Heat loss to atmosphere and temperatures in combustion chamber were measured. Temperature distribution and heat loss were compared for Copper, Bronze, stainless steel 304 and Aluminum. Heat loss to atmosphere was observed to be more for Bronze compared to other materials.

Keywords— Mesoscale, one turn Swiss role combustor, Materials

I. INTRODUCTION

The developments of small scale devices or miniaturized appliances like mobiles phones, laptops, PCs led to develop micro engines [T. Sakurai and S. Yuasa, 2009].Hydrocarbon fuels restrain extra energy per unit mass than lithium ion batteries and it is almost 20-50 times higher[P. D. Ronney, C. Hsienkuo, 2007] .For portable power generation; the small-scale devices which converts heat energy after burning fuel in to electricity with support of thermoelectric material are necessary.[I. C. Lee, 2009] Micro-combustors creates problems due to high surface area to volume Ratio, which increases heat loss through walls to surrounding and it lead to flame quenching. [Fernandez- pello, A. Carlos].Stable flame at the center of Swiss role combustor is a requirement to get a continuous heat transferred to the top plate from combustion region, which is required by thermoelectric devices. Present paper gives an idea about flame stability limits, combustion space temperatures and heat loss to surrounding at different equivalence ratio.

Experimental methodology

1. Experimental setup

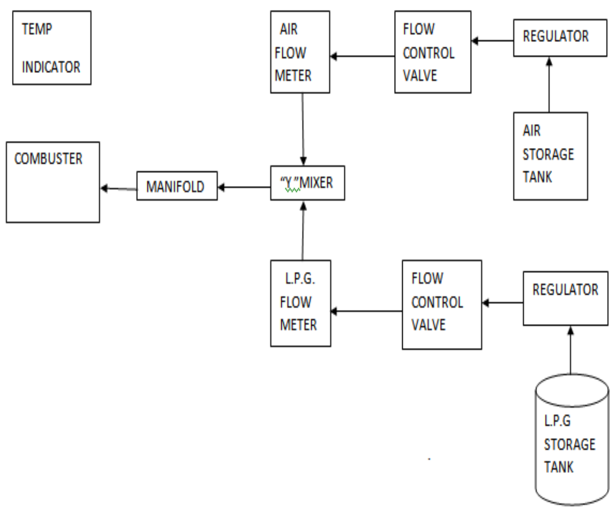

Fig 1 Experimental setup

Experimental Set up shown in fig.1 was prepared in which components like Air storage tank to store air, LPG tank to store LPG , 'Y' 'mixer; to mix the air and LPG. LPG flow Meter with range (0.23 to 2.3 LPM), air flow meter with range (0 to 25LPM) and gas manifold to supply mixture uniformly along the depth of combustor were arranged. Experiments were conducted at ambient condition. To sense the temperatures "K" type Thermocouple was placed in the combustion space. Surface temperatures were recorded by Thermal gun.

Fig 2 Actual Photo of Experimental set up

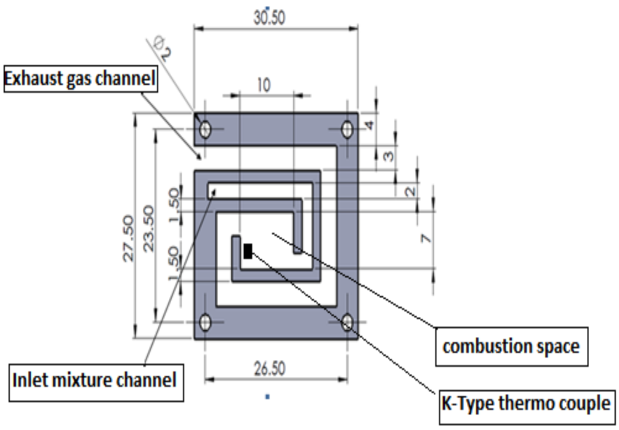

Fig 3 Dimension of one turn combustor

Figure 3 shows one turn Swiss roll combustor with actual dimensions. Combustors of Copper, Bronze, stainless steel 304 and Aluminum materials were fabricated by Electro Discharge Machining. Dimensions of combustor were sectional area equal to 10mm X 7mm, depth equal to 20mm. Inlet channel equal to 2mm and outlet channel equal to 3mm in dimension. Inlet channel dimension i.e. quenching dimension of LPG was less to avoid flash back. Exhaust channel dimension was kept higher than the quenching dimension to get easy push to exhaust gases.

Results and Discussions

All the tested models gave stable flame at center. Various parameters like Equivalence ratio, flow Velocity were varied and combustion chamber temperature and surface temperatures were measured. Heat losses through Top surface was calculated. .

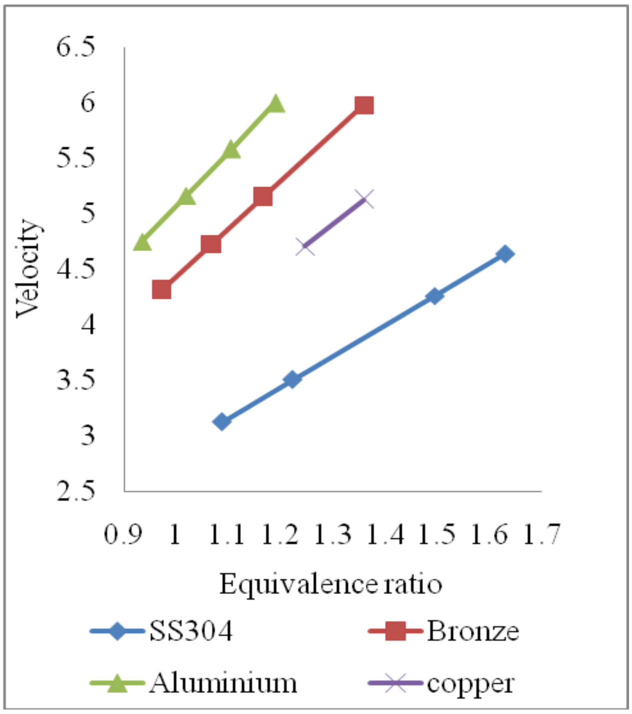

Fig.4 Velocity vs. equivalence ratio (optimum condition) without insulation

Figure 4 show that for Aluminum stable flame was obtained at higher velocities from 4.5meter/sec to 6 meter/sec, for equivalence ratio 0.9 to 1.2. Whereas for SS304 material stable flame was obtained at lower velocities 3meter/sec to 4.5 meter/sec for equivalence ratio 1.1 to 1.6

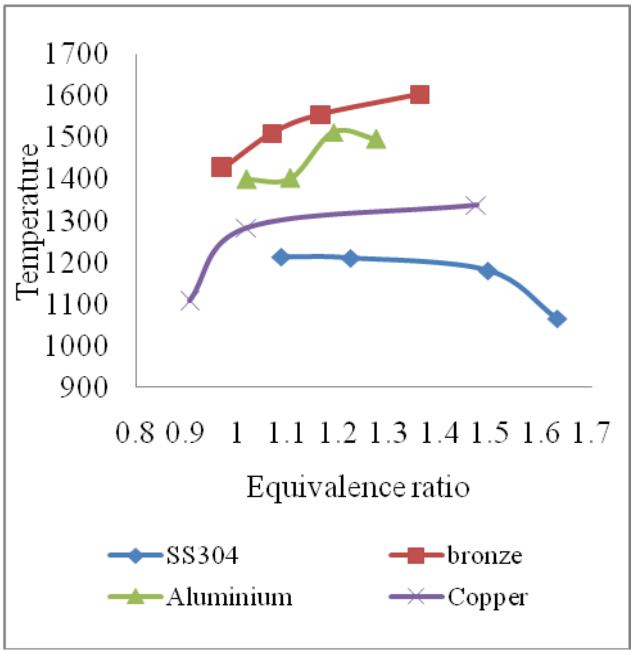

Fig 5 Combustion chamber temperature vs. equivalence ratio (optimum heat loss) without insulation

Figure 5 shows that without insulation maximum combustion chamber temperature for Bronze material was 1600 Kelvin for the equivalence ratio 1.4. and minimum combustion temperature for SS304 material was 1050 Kelvin for equivalence ratio 1.6.

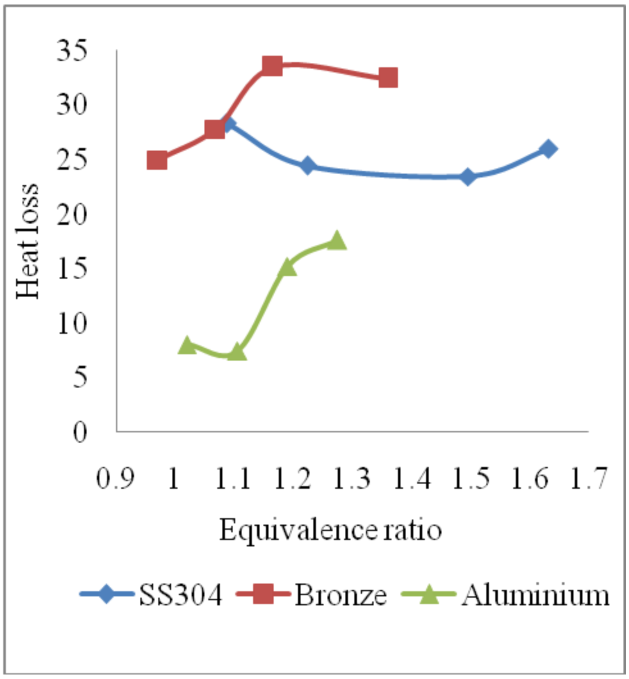

Fig 6 Heat loss vs. equivalence ratio(optimum condition) without insulation

Figure 6 shows that the maximum heat losses through top plate occurred in Bronze material 33watt for equivalence ratio 1.2 and minimum heat losses occurred in Aluminum material 17 watt for equivalence ratio 1.3 .

II. CONCLUSIONS

Stable flame was achieved only after proper mixing of air and LPG. Aluminum having higher thermal conductivity it leads to extinction and stable flame was achieved at higher velocities for equivalence ratio 0.9 to 1.2. As S.S. 304 has lower thermal conductivity which leads to lesser heat recirculation reactant by an axial heat conduction so stable flame was obtained at lower velocity for equivalence ratio 1.1 to 1.6

Combustion chamber temperature depends on thermal conductivity. Thermal conductivity of Bronze material is less so combustion chamber temperature for bronze material was highest 1600 Kelvin as compare to other tested materials.

Heat loss was maximum for Bronze material 33watt as compare to other materials for equivalence ratio 0.9 to 1.4

III. REFERENCES

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