International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 6, June - 2013

Performance Of Insulated LPG Burner Using Metal Chips As Porous Medium

Mohd. Yunus Khan[1] and Anupriya Saxena[2]
[1]Assistant Professor, Mechanical Engineering, University Polytechnic, A.M.U., Aligarh.
[2]Lecturer, Department of Mechanical Engineering,Mass College of Engineering and Management, Sasni (Hathras)

Abstract

The objective of this experimental work was to improve thermal efficiency of conventional LPG burner and to save LPG by utilizing the porous medium combustion technique. Further, improvement in thermal efficiency was achieved by insulating bottom base and the sides of the mixing chamber. By using porous medium combustion technique, thermal efficiency was found to improve. The maximum efficiency of 59% was obtained with brass chips as porous medium while minimum was obtained using aluminium chips. After insulating stove, the thermal efficiency increases from 49% to 54%. Thermal efficiency value for insulated stove filled was found to be highest with brass chips. This value is equal to 65%. While the lowest efficiency was obtained by using aluminium chips, it is 56%. These results show a better prospect for the use of porous medium in domestic LPG stoves.

1. Introduction

Fossil fuels reserves are depleting day to day and their usage is increasing considerably. To meet the impending fuel crisis, an extensive research is being carried out in the area of this area. The objective of this work is to help conserve energy to the maximum possible extent and thereby extend the availability of the conventional fuels.

Liquefied Petroleum Gas (LPG) is one of the commonly used conventional domestic fuel. The domestic consumption of LPG in urban India is quite high. LPG usage is important part of our life as 90% urban population uses it for cooking. With some changes in the existing LPG cooking stove, saving in its consumption can be made. Saving per family can result in enormous saving nationwide. Thus, any work related to thermal efficiency improvement and LPG saving is worthwhile. This experimental work is aimed at improving thermal efficiency of LPG stove using porous medium combustion technique.

2. Porous Medium Combustion Technique

A porous medium (or a porous material) is a medium containing pores. A porous medium is most often characterized by its porosity. Other important properties of the medium are permeability and electrical conductivity. Properties are much similar to properties of respective constituents (solid matrix or fluid). The media porosity and pores structure also plays significant role. This technique find wide applications in many areas of engineering such as geo-mechanics, soil-mechanics, rock-mechanics, petrochemical engineering, construction technology, hydrogeology, material science etc.

It has been seen that porous medium combustion technique enhances the rate of heat transfer. It also improves the combustion process. Combustion in porous medium takes place in 3-D cavities of the inert porous matrix. These cavities, unlike the ports in the burner head of a conventional LPG stove, are interconnected. In porous medium combustion technique, the flame can be stabilized over the surface or it can remain fully confined within the porous matrix. Thus, this process is also known as flameless combustion and it has found numerous applications. [1]

3. Experimentations

The line diagram of experimental setup is shown in Figure 1. The experimental setup consists of LPG stove, a 3 kg LPG cylinder, aluminium vessel and aluminium stirrer. A thermometer (0 to 100°C) was used to measure the water temperature during experimentation. A stirrer was used for stirring the water for uniform distribution of heat. An electronic balance (of least count 1g) has been used for weight measurement of water and LPG cylinder. The photograph of experimental setup is shown in Figure 2. Conventional LPG stove was used during entire testing. The value of thermal efficiency with conventional stove was taken as reference value.

ISSN: 2278-0181
Vol. 2 Issue 6, June - 2013

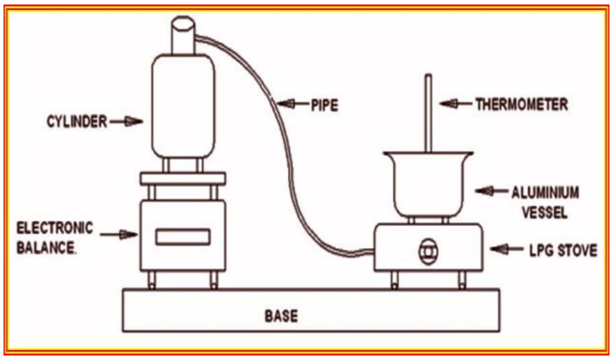

Figure 1 Line diagram of experimental setup

Figure 2 Photograph of experimental setup

The specifications of the LPG stove and electronic balance are shown in Table 1 and Table 2 respectively.

In India, the Bureau of Indian Standards (BIS) has set guidelines for testing the thermal efficiencies for all types of cooking stoves. For LPG stoves, the thermal efficiencies are determined according to specifications provided by Indian Standards [2]. Following the guidelines, thermal efficiency of LPG stove in the present work is estimated by conducting the water-boiling test and the procedure followed is briefly described below [2,3].

The weight of vessel with its lid and the weight of water used in the vessel were noted. Initial temperature of water (T_1) was also noted. The weight of cylinder (W_1) was noted. The stove was lighted and water was warmed up to 80°C and stirred continuously for uniformity of temperature. When final temperature of water (T_2) has reached 80°C, the stove was put off. Again, the weight of cylinder (W_2) was recorded. The difference in the weight of cylinder (W_2-W_1) gives the mass of fuel consumed for heating water by temperature (T_2-T_1). By dividing the difference in the weight (W_1-W_2) by time taken in heating gives fuel consumption rate. The thermal efficiency of the stove is expressed as follows:

$$\eta_{th} = \frac{(W_w \times C_w + W_{Al} \times C_{Al}) \times (T_2 - T_1)}{(W_1 - W_2) \times CV}$$

Where, W_w is the quantity of water (in kg) in the vessel, W_{Al} is weight of the vessel (in kg), C_w is specific heat of water (in kJ/kg-K), C_{Al} is specific heat of aluminium vessel (in kJ/kg-K) and CV is the calorific value of the test fuel (in kJ/kg).

Table 1 Specifications of LPG Stove

Make of stove	Big Boss
Manufacturer	Boss Home Appliances
Type	Single burner type
Thermal efficiency (designed)	68%
Weight of burner	0.5 kg
Burner material	Brass
Design fuel	LPG
Weight of LPG cylinder	3 kg

Table 2 Specifications of Electronic Balance

Make	Gold Tech
Manufacture	Precision Electronic Instrument Co.,Delhi
Weighing machine type	Electronic
Range	Maximum 10 kg; minimum 20g
Least count	1g
Model	G-TET

The experiments were repeated three times and average of the three values was taken as final reading. For porous medium, the burner head was removed and the mixing chamber was completely filled with different types of metal chips (one by one) such as brass chips, copper chips, aluminium chips and mild steel chips. The test procedure as described above was followed for LPG stove with porous material. In second part of experimentation, the bottom base and the side of the mixing chamber were insulated. Figure 3 and Figure 4 shows insulated LPG stove filled with brass chips and mild steel chips respectively. The effect of insulation on thermal efficiency of LPG stove and stove with porous material were also studied.

Figure 3 Insulated LPG stove filled with brass chips

Figure 4 Insulated LPG stove filled with mild steel chips

4. Results and Discussions

Variation of thermal efficiency of LPG stove using different metal chips as porous medium is shown in Figure 5. Thermal efficiency value for conventional LPG stove was found to be 49%. This value was taken as reference value. Further, it can be seen from this figure that there is improvement in thermal efficiency of LPG stove using porous medium combustion technique. The maximum thermal efficiency value of stove is obtained with brass chips as porous medium. It is found to be 59%. While minimum thermal efficiency of 51% was obtained with aluminium chips as porous medium.

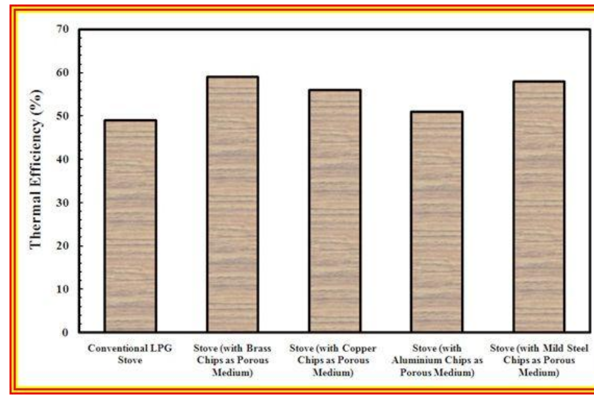

Figure 5 Variation of thermal efficiency (%) of LPG stove using different metal chips as porous medium

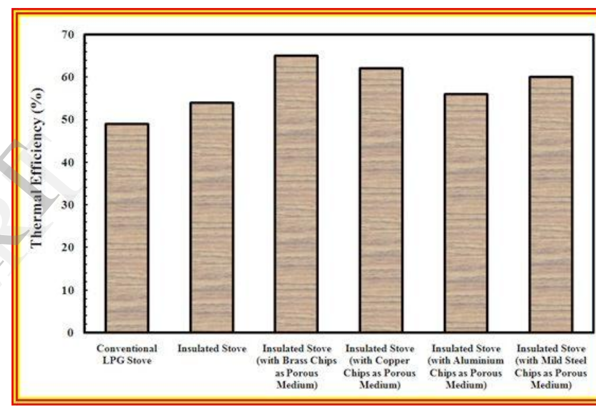

Figure 6 Variation of thermal efficiency (%) of Insulated LPG stove using different metal chips as porous medium

Figure 6 shows variation of thermal efficiency of insulated LPG stove using different metal chips as porous medium. For the sake of comparison, the thermal efficiency value of conventional LPG stove was also plotted. It can be seen from this figure that the thermal efficiency of LPG stove improves by insulating the stove. The thermal efficiency insulated LPG stove was found to be 54%. With further application of porous medium combustion technique thermal efficiency of insulated stove improves. It can be noted that the thermal efficiency value is maximum for insulated stove filled with brass chips. This value is equal to 65%. While the minimum efficiency is obtained by using aluminium chips as a porous medium, it is 56%.

5. Conclusions

From this experimental work, following significant conclusions can be drawn.

The thermal efficiency value for conventional LPG stove was found to be 49%. Improvement in thermal efficiency was observed by applying porous medium combustion technique. The highest thermal efficiency value was obtained with brass chips as porous medium which is found to be 59%. While lowest efficiency of 51% was observed with aluminium chips as porous medium. The thermal efficiency of LPG stove increases by insulating the bottom base and sides of LPG stove. For conventional LPG stove, efficiency increases from 49% to 54%. With application of porous medium combustion technique in insulated LPG stove, thermal efficiency further increases. The highest thermal efficiency for insulated stove was found to be with brass chips as porous medium. While the lowest efficiency was found using aluminium chips as a porous medium.

Porous medium combustion technique is safe and secure and can be applied in domestic LPG stove for achieving better thermal efficiency. Also, the technique requires fewer efforts and is cost effective.

6. Acknowledgements

The authors of this paper are grateful to the University Polytechnic, Aligarh Muslim University, Aligarh for kindly providing the test facilities.

7. References

[1] http://en.wikipedia.org/wiki/Porous_medium
[2] S. Kakati, "Effect of Heat Losses on Overall Performance of Kerosene Fuelled Capillary-Fed Wick Stove", *Proceedings of 1st National Conference on Advances in Energy Research (AER-2006)*, Department of Energy System Engineering, Indian Institute of Technology, 4-5 December 2006, Mumbai, India.
[3] V.K. Pantangi, A.S.S.R.K. Kumar, S. C. Mishra, and N. Sahoo, "Performance Analysis of Domestic LPG Cooking Stoves with Porous Media", *International Energy Journal*, 2007, 8, 139-144.