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Performance of Domestic LPG Cooking Stove with Porous Media

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Abstract

The world demand for energy is rapidly increasing. This demand for energy is increasing due to population growth and rising living standard. World population is doubling about every thirty five years. The combined effect of increasing need and diminishing supply constitutes the energy crises. Besides this, the use of biomass fuels like wood, dung cake and agro waste are used as a source of energy. The combustion of these fuels destructs the earth's atmosphere and directly affects the human life in forms of different ailments. This paper discusses the performance investigations of a conventional burner with different porous media used in LPG cooking stove. Thermal efficiency was found using the water-boiling test. The porous medium combustion test showed that a maximum thermal efficiency of about 61.86% was obtained with ball bearing, which was 10.71% higher than that of the conventional burners 51.15%. The thermal efficiency was found to increase by using porous medium combustion technique.

Keywords

LPG Cooking Stove, Porous Medium Combustion, Thermal Efficiency

Subject Areas: **Environmental Sciences, Mechanical Engineering**

1. Introduction

LPG gas burner is a simple device which is mostly used for domestic purpose. It is attached with gas cylinder. The main purpose of LPG burner is to produce concentrated flame to achieve maximum possible heat. Burner is usually made of brass which has good thermal conductivity. LPG is one of the commonly used conventional fuels for domestic applications. Its consumption in domestic cooking is increasing every year at the rate of approximately 10% [1]. The total domestic consumption of LPG in India is almost comparable with other petroleum products used in industrial applications. With some improvements in the existing LPG cooking stoves, a small saving in its consumption per family will lead to an enormous saving nationwide. Thus, there is a need for

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research in the LPG cooking stoves. In any combustion system, a burner plays an important role in combusting a fuel. An improper design of a burner often leads to an inefficient combustion and excessive pollutant formation. With the objective of improving the thermal efficiency of domestic LPG cooking stoves, experiments were carried out by incorporating porous media such as metal balls and metal chips in the mixing chamber of the conventional cooking stoves [2].

2. Porous Medium Combustion

A porous medium (or a porous material) is a medium containing pores. A porous medium is most often characterized by its porosity. Other properties of the medium e.g. permeability and electrical conductivity can sometimes be derived from the respective properties of its constituents (solid matrix and fluid) and the media porosity and pores structure, but such a derivation is usually complex. The concept of porous media is used in many areas of engineering. Fluid flow through porous media is a subject of most common interest and has emerged a separate field of study.

Combustion in porous media takes place in 3-D cavities of the inert porous matrix. These cavities, unlike the ports in the burner head of a conventional LPG cooking stove, are interconnected. Material of the porous matrix is chosen so as to have higher value of thermal conductivity and emissivity. Further, their extinction coefficients are also large so that they are radioactively highly participating in porous media combustion, flame can be stabilized over the surface or it can remain fully confined within the porous matrix.

Porous medium can to enhance the heat transfer hence it can be used in liquid and gaseous fuel combustion to improve the combustion process. Babkin (1991) were the first to do the experimental study of the porous medium usage in combustion. In their study, the combustion flame was directed to go through the porous medium in order to study the level of porosity that flame can pass through [3].

3. Objective of Present Work

As noticed, the premixed combustion system is quite complicated due to the system needs a proper mixer for the fuel and air. To be used as a home appliance, the system is quite high risk due to the high flammability of air-fuel mixture which can burn and explode instantaneously when the mixture is leaked at sufficient ignition temperature. From the past studies, most systems of porous medium premixed combustion are characterized as the ignition and reactions of gaseous mixture is occurred inside porous medium. This characteristic needs critical two different pore sizes and configurations of porous medium adjacent each other to support the mixture flow and flame quench processes and the flame propagation process. Therefore, the complex porous medium which is high precision of pore size and exact configuration are needed to obtain successful operation.

In the present experimental studied porous medium such as ball bearing, brass chips and mild steel chips will be used for evaluating thermal efficiency of LPG burner.

4. Experimental Methodology

4.1. Experimental Setup

The experimental setup used for testing the performance of LPG burner as shown in **Figure 1**.

Conventional LPG stove was used for carrying out test. Stove consists of a burner and a knob driver. The knob driver control flow rates and air flow rate. The burner have combustion zone which is made by LPG and air mixture. Porous matrix is of 20 to 25 mm thickness. The LPG burner is made of brass. Specification of setup is given in **Table 1**.

An electronic balance (of least count 1 g) has been used for weight measurement of water and stove. The specifications of electronic balance are given in **Table 2**.

4.2. Test Procedure

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

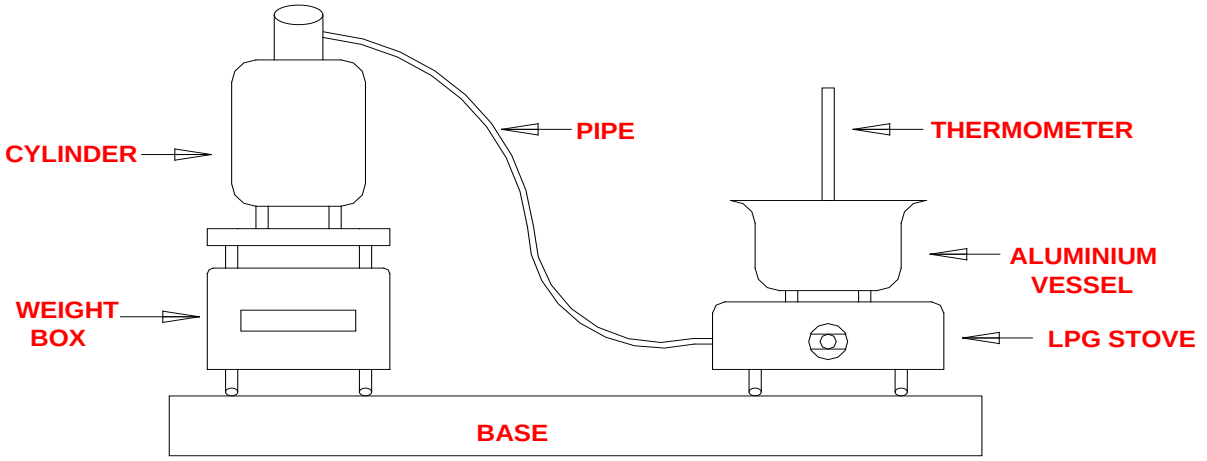

Figure 1. Line diagram of setup.

Table 1. Specification LPG burner.

Make	Big boss
Cylinder capacity	3 kg
Thermal efficiency (Designed)	68%
Weight	0.5 kg
Burner material	Brass
Design fuel	LPG

Table 2. Specification of electronic weighing machine.

Specification	
Make	Gold tech
Manufacture	Precision Electronic Instrument Co. Delhi-41
Weighing machine type	Electronic
Range	Maximum 10 kg; minimum 20 g
Least count	1 g
Model	G TET

The aluminum vessel was selected as the fuel consumption test. A thermometer (0 - 150) was used to evaluate the water temperature during experimentation. A stirrer made of aluminum has been made for stirring the water for uniform distribution of heat. The burner head is removed and the space in burner is filled with brass chips, aluminum chips and ball bearing. Thermal efficiency of burner with different porous medium was recorded and compared with the thermal efficiency of conventional burner.

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 along with fuel (W_1) was noted. The burner was lighted and water was heated up to 80˚C and stirred continuously for uniformity of temperature. When final temperature of water (T_2) has reached 80˚C, the cylinder 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 LPG consumed for heating water by temperature $(T_2 - T_1)$. The thermal efficiency of the cylinder is expressed as follows:

$$\eta = \frac{(W_W \times C_W + W_{Al} \times C_{Al}) \times (T_2 - T_1)}{(W_2 - W_1) \times CV}$$

where,

W_w = quantity of water in the vessel (kg),
W_{Al} = weight of the aluminum vessel (kg),
C_w = specific heat of water (kJ/kg-K),
C_{Al} = specific heat of aluminum vessel (kJ/kg-K),
T_1 = initial temperature of water (K),
T_2 = final temperature of water (K),
W_1 = weight of test cylinder before warming water (kg) and,
W_2 = weight of cylinder after warming water to 80˚C (kg).

The experiment was repeated three times and average of the three values was taken as final reading. The same procedure was followed for other porous medium [4].

5. Results and Discussions

Figure 2 shows the effect of thermal efficiency of the LPG cooking stove with different porous medium.

The designed thermal efficiency of conventional LPG burner is 68% but its practical value was found to be 51.15%. With the use of different porous medium such as brass chips, mild steel chips and ball bearing it was observed that the thermal efficiency was found to be different from each other and in all cases the thermal efficiency was found to be more than the conventional burner. The thermal efficiency in decreasing order is given as of ball bearing > mild steel chips > brass chips.

6. Conclusions

Thermal efficiency and performance of the conventional LPG burner have been compared with the thermal efficiency and performance of burner with porous medium. The following important conclusions from the present study that can be made are:

1) The maximum thermal efficiency was recorded to be 61.86% with ball bearing. This is about 10.71% more than the thermal efficiency of conventional LPG burner which was found to be 51.15%.

2) It was observed that the flame characteristics with different porous medium were different. The flame characteristics of burner with porous medium are found to be differing out from conventional LPG burner.

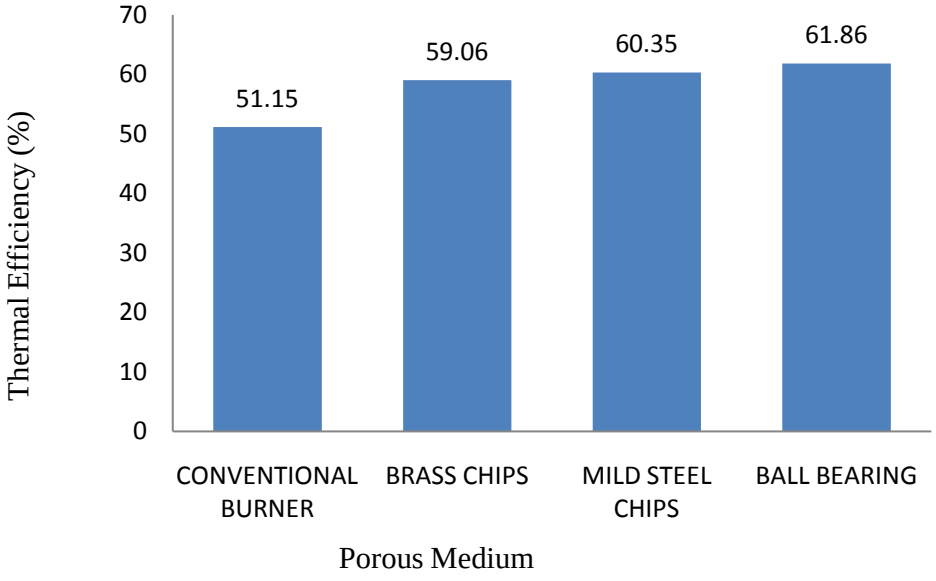

Figure 2. Effect of porous medium on thermal efficiency.

3) The thermal efficiency decreases in the order of ball bearing > mild steel > brass.

References

[1] Mishra, D.P. (2008) Introduction to Combustion. Prentice-Hall of India Private Limited, New Delhi.

[2] Muthukumar, P., Anand, P. and Sachdeva, P. (2011) Performance Analysis of Porous Radiant Burners Used in LPG Cooking Stove. *International Journal of Energy and Environment*, **2**, 367-374.

[3] Pantangi, V.K., Karuna Kumar, A.S.S.R., Mishra, S.C. and Sahoo, N. (2007) Performance Analysis of Domestic LPG Cooking Stoves with Porous Media. *International Energy Journal*, **8**, 139-144.

[4] http://en.wikipedia.org/wiki/Porous_medium