Performance of Insulated LPG Burner with Ball Bearings as Porous Medium

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Abstract

The aim of this experimental work was to achieve improvement the thermal efficiency of LPG stove and to save fuel. Due to the shortage of petroleum resources and its high prices, it is the duty of each and every person to save it. Most of the families in rural areas use wood or cow-dung for cooking purposes but it is not possible in urban areas. In urban areas, 90% houses consume LPG, as its usage is effortless, time saving and less polluting. Porous medium combustion technique enhances the rate of heat transfer and improves combustion efficiency. In this paper, this technique was implemented to LPG stove. Further enhancing thermal efficiency and to minimize heat losses, the bottom base and the side of the mixing chamber were insulated. After insulating bottom base and sides of the mixing chamber of stove, the thermal efficiency value for conventional LPG stove increases from 49% to 54%. The thermal efficiency for insulated LPG stove filled with ball bearings was found to be 67%.

Keywords: LPG burner, thermal efficiency, porous medium combustion, fuel saving.

1. Introduction

Fossil fuels reserves are depleting day to day and their usage is increasing considerably. To meet the impending fuel crisis, therefore, an extensive research is being carried out in the area of non-conventional fuels. The objective of this experimental 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 most commonly used conventional fuels for domestic purposes specially for cooking. The total domestic consumption of LPG in urban India is quite high. With some alterations 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 fuel saving is very important. This work is focused to improve thermal efficiency of LPG stove using ball bearings as porous material.

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 play a 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. Experimental Methodology

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 line diagram of experimental setup is shown in Fig.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 Fig.2.

![Line diagram of experimental Setup](image1.png)

**Fig.1 Line diagram of experimental Setup**

![Photograph of experimental Setup](image2.png)

**Fig.2 Photograph of experimental Setup**

Conventional LPG stove was used during entire testing. The value of thermal efficiency with conventional stove was taken as reference value. The technical specifications of the test stove and electronic balance are shown in Table 1 and Table 2 respectively.

| Table 1 Technical Specifications of LPG Stove |
| Make of stove | Big Boss |
| Manufacture | Boss Home Appliances |
| Type | Single burner type |
| Thermal efficiency (designed) | 68% |
| Weight of burner | 0.5kg |
| Burner material | Brass |
| Design fuel | LPG |
| Weight of LPG cylinder | 3kg |

| Table 2 Technical Specifications of Electronic Balance |
| Make | Gold Tech |
| Manufacture | Precision Electronic Instrument Co., Delhi |
| Weighing machine type | Electronic |
| Range | Maximum 10kg; minimum 20g |
| Least court | 1g |
| Model | G. TET |

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 ($W_2 - W_1$) by time taken in heating gives fuel consumption rate. The thermal efficiency of the stove 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,
- $W_w$ 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),
- $CV$ is the calorific value of the test fuel (in kJ/kg).

For porous medium, the burner head was removed and the mixing chamber was completely with ball bearings. 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. Fig.3(a) and Fig.3(b) shows insulated LPG stove filled with ball bearings. The effect of insulation on thermal efficiency of LPG stove and stove with porous material were also studied.

![Insulated LPG stove filled with ball bearings](image1)

**Fig.3(a) Insulated LPG stove filled with ball bearings**

![Insulated LPG stove filled with ball bearings](image2)

**Fig.3(b) Insulated LPG stove filled with ball bearings**

### 4. Result and Discussions

Fig.4 shows the variation of thermal efficiency of the LPG stove under different conditions. The thermal efficiency conventional LPG stove was found to be 49%. This value was taken as reference value. It can be seen from bar graph that thermal efficiency improves by using technique of porous medium combustion. The thermal efficiency value with ball bearings was obtained to be 59.8%.

![Graph showing variation of thermal efficiency](image3)

**Fig.4 Variation of thermal efficiency (%) of LPG stove under different conditions**

The variation of thermal efficiency of insulated LPG stove can also be seen from this figure. The thermal efficiency improves by insulating the stove. The thermal efficiency conventional LPG stove with insulation was found to be 54%. Application of porous medium combustion technique further improves the thermal efficiency. It can be noted that the thermal efficiency found be 67% for insulated LPG stove filled with ball bearing.

### 5. Conclusions

Soaring prices of petroleum based fuels is a great bottleneck for the common people to use these resources. LPG is an important part of our life as 90% of population uses it for cooking purposes but shortage of fuel and high price are problem of concern. The porous medium combustion technique improves the thermal efficiency of LPG stove and thus saving in fuel can be achieved. This work focuses on improvement of thermal efficiency of LPG burner. From this experimental investigation, the following significant conclusions can be drawn.

1. The thermal efficiency of conventional LPG stove was found to be 49% whereas designed efficiency is 68%.
2. By employing porous medium combustion technique, improvement in thermal efficiency can be achieved. For LPG burner filled with ball bearing (as porous material), the thermal efficiency was found to be 59.8%.
3. After insulating the bottom base and sides of the mixing chamber of LPG stove the thermal efficiency value for conventional LPG stove increases from 49% to 54%.
4. The maximum thermal efficiency was found for insulated LPG stove filled with ball bearings. Its value was found to be 67%.

The technique is safe and secure. It can be implemented in domestic LPG stove quite easily for achieving improvement in thermal efficiency. Also, the technique requires lesser efforts and is cost effective.

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7. References

