INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Emerging Trends in Mechanical Engineering Proceedings of the International Conference, ETME-2017, 27 & 28 December, 2017, Pg: -93-101

MODIFICATION OF STAND OF LPG STOVE TO OPTIMIZE ITS THERMAL EFFICIENCY BY VARYING THE DISTANCE BETWEEN THE BURNER AND THE UTENSIL HEATED

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Abstract

Energy conservation has become an important need of our times. Population is steadily increasing and conventional energy sources are steadily depleting. The developments in the renewable energy alternatives have been slow and are not yet economically viable. Hence, it is important to look for the ways and means to reduce the consumption of energy from conventional sources. About 40% of the total energy consumed in the developing world (population more than 4 billion) is used for cooking. The large population size explains this astonishing figure. Out of the total energy consumed for cooking, 31% comes from commercial fuels such as gas, kerosene, or coal; the remaining 69% is from non-commercial fuels such as firewood, dung cakes, and agricultural waste. Because of its increased availability, economy, and convenience, the use of liquefied petroleum gas (LPG) is increasing at a faster rate. It may be noted that cooking is also a physico-chemical process, like any other process in the Chemical Process Industry (CPI) , and hence, there is a possibility of applying conservation strategies in CPI to cooking practices. LPG plays a pivotal role in the transition towards a more secure, sustainable and competitive energy model. Considering the limited fossil fuels resources, energy conservation, environmental issues, increasing in the demand on LPG in the near future, it is necessary to explore the ways to further improve the thermal efficiency. In the present work, modified gas stand has been developed to check the thermal efficiency of the gas stove by varying distance between the burner and the utensil heated. This has proved to be more efficient than the existing gas stand and it is observed that 1.24% of fuel can be saved by using this modified gas stand.
Keyword: LPG, physico-chemical process, Chemical Process Industry (CPI), Thermal efficiency, energy conservation.

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INTRODUCTION

The term Liquefied Petroleum Gas (LPG) is applied to those hydrocarbons, the chief components of which consist of propane, propylene, butane, butylene and iso-butane or mixture thereof in any

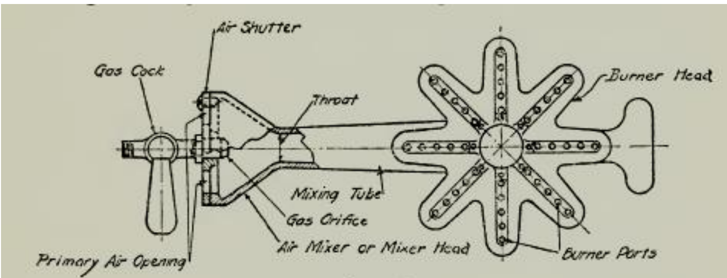

FIGURE 1

ratio. These hydrocarbons can be liquefied under moderate pressure, at normal temperature, but, they are gaseous under normal atmospheric condition. LPG is a colourless liquid which readily evaporates in to gas. It has no smell, although it will normally have an odour added (Ethyl Mercaptan) to detect the leakage. It can burn when it is mixed with air and when it meets a source of ignition. It is heavier than air, so, it tends to sink towards the grounds. Its net calorific value is 44000 KJ/kg. For any given distance between burner and utensil ,the higher the gas rate that can be safely used, the shorter will be the time. Over the years Liquefied Petroleum Gas has become very popular as a domestic fuel compared to other fuels, because, it is convenient, smokeless, time saving and economical. This is the reason it has created a demand of LPG utilization in domestic sector for cooking. In the recent past, it has created a demand in industrial and automobile sector also. At the same time, it requires great attention to safety while using it, because, the gas forms an explosive mixture and may be dangerous in case of leakage from the appliance.

OPERATION OF A GAS BURNER

Nearly all gas burners employed in domestic appliances are of the Bunsen or -" blue flame" type and are commonly referred to as " atmospheric" burners.
Figure 1 shows a sketch of a commonly used range burner. The different parts of the burner are indicated according to the nomenclature commonly used, and a description of the operation of this burner will be applicable to all others of the Bunsen type. The gas, after passing through the controlling “cock,” issues from the “orifice” with high velocity and enters the “mixing tube” (also called “mixer” and “injecting tube”), the elongated portion of the burner which leads to the

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"burner head" in which the "ports" are situated. The constricted portion of the mixing tube is distinguished as the "throat" and the enlarged portion, which the gas and air first enter, as the "mixer head.

As the gas leaves the orifice it possesses a considerable amount of "kinetic energy" or energy of forward movement. This energy is in part transferred to the air in the mixer head and throat, imparting a forward movement to it also. Air flows into the mixer head to replace that which has thus moved into the burner head.

HEATING EFFICIENCY:

Definition:

Efficiency may be defined as the ratio of the heat transferred to the contents of the utensil to the total heat produced by the combustion of the gas. Heat which may have been transferred to the utensil, but is lost through radiation or otherwise then by causing evaporation, is not included.

In addition to the factors which affect safety there are two conditions which every heating appliance must fulfil to be satisfactory to the user:

(1) It must have a high heating efficiency, and

(2) it must be capable of performing a given heating operation within a reasonable time.

DETERMINATION OF RELATIVE HEATING EFFICIENCY AND ITS VARIATION WITH CHANGES OF DISTANCE BETWEEN BURNER AND UTENSIL:

The present paper deals with the design of a burner for a specific application, "top burner" cooking, in which the utensils to be heated are supported by an open grate. The environment of the burner in this case is subject to one and only one important variation, the distance between the burner and the utensil heated.

The efficiency of heat transfer depends upon the size, shape, and material of the utensil. It would be possible, therefore, to obtain a considerable variety of numerical values for efficiencies, depending upon the conditions employed during the tests. We are primarily concerned, however, with comparisons between one appliance and another rather than with absolute values.

It is therefore sufficient for practical purposes to make the measurements of efficiency under a set of conditions chosen to approximate roughly the average service required of a range burner, and to reproduce carefully the same conditions in every test of a series that is to be inter compared. In the present study it is desired to determine how the efficiency is affected by variations in distance between burner and utensil. The method described below was selected because it is capable of giving the desired comparisons both accurately and with relatively few tests. An aluminium utensil of light weight having a capacity of 1 litre and a diameter of 165mm at the bottom is selected for

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these tests as being representative of the size and material most frequently used in the average family.

Procedure:

1. 0.5kg of water is heated to boiling.
2. Set the distance between burner and utensil
2. Gas meter reading taken to measure gas flow rate.
3. Note down temperatures t_i° c. and another at t_f° c.
4. Note down time required for the temperature to rise t_f° c.

A series of determinations of efficiency is made for each distance between burner and utensil. Results are tabulated and the curves are plotted against efficiencies Vs distance between burner and utensil.

Observation :

Mass of water used (M_w)	= 0.5 litre = 0.5kg
Gas flow rate (M_f)	= 1.2 kg/hr= 0.33×10^{-3} kg/s
Pressure (p)	= 5bar
Initial temperature of water(T_i)	=28^0C= 301 ^{0}K
Final temperature of water(T_f)	= 90^0C=363 ^{0}K
Material of utensil	= stainless steel 1865
Calorific value (C_v)	=44000 kJ/kg
Specific heated constant(C_p)	= 4.187 kJ/kg ^{0}K

Assumptions:

The following parameters are considered as a constant,
a. environmental condition, such as wind, temperature, pressure.
b. shape, specific heat capacity and weight of vessel, material of the vessel
c. burner size of stove and size of bottom face of cooking vessel.
d. energy content of fuel and quality of fuel
e. the amount of water evaporated was negligible, and the heat required for evaporation was therefore not considered.

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TABLE OF RESULTS

Distance between burner and utensil H (mm)	Time taken to rise temperature of water t(sec)	Rate of Heat input by combustion of LPG Q_{in}(kJ/sec)	Rate of heat added to water Q_{out} (kJ/sec)	Thermal efficiency (%)
15	268	14.667	0.4843	3.30
16	256	14.667	0.5070	3.45
17	245	14.667	0.5319	3.68
18	238	14.667	0.5453	3.71
19	242	14.667	0.5363	3.65
20	241	14.667	0.5080	3.38
21	240	14.667	0.5315	3.67
22	264	14.667	0.4916	3.35
23	234	14.667	0.5110	3.48
24	283	14.667	0.4586	3.12

CALCULATIONS

Rate of **Heat input** by combustion of LPG = mass of gas flow rate LPG x calorific value of the LPG

$Q_{in} = M_f \times C_v$

$= 0.000333 \times 44000$

$= 14.667$ KJ/s

Heat added to the water =mass of water in kg x specific heat capacity of water x temperature difference

$Q = M_w \times C_p \times (T_i - T_f)$

$= 0.5 \times 4.187 \times (363-301)$

$= 129.797$ KJ

Rate of heat added to water=Heat added to the water/ Time taken to rise final temperature of water

$Q_{out} = Q / t_s$

$= 129.797/268$

$= 0.4843$ kJ/s

Thermal efficiency = Rate of heat added to water/ Rate of **Heat input** by combustion of LPG

$= (Q_{out} / Q_{in}) \times 100 = (0.4843/14.667) \times 100$

$= 3.3\%$

Thermal efficiency for standard height (20mm) $= (Q_{out} / Q_{in}) \times 100$

$= (0.5080/14.667) \times 100$

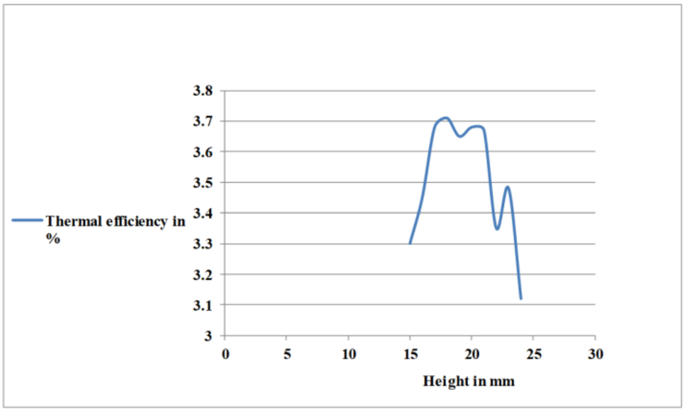
$= 3.38\%$

Thermal efficiency for the height (18mm) $= Q_{out} / Q_{in}) \times 100$

$= (0.5453/14.667) \times 100$

$= 3.71\%$

GRAPH OF HEIGHT V/S EFFICIENCY



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INFERENCE:

The relationship between the height and efficiency is as shown in the graph. As per the graph, as the height increases the efficiency also increases, at certain point efficiency reaches the maximum value and then it goes on decreasing with increase in height. From this graph, it is clear that the maximum efficiency is obtained at a height of 18mm. This height is different from the height specified by the supplier, i.e. 20mm. With this data, it can be proved that large amount of LPG consumed per day can be saved as shown below.

For standard height =20mm,

Mass of LPG consumed for 241 second is calculated as follows

$$M_{S1} = M_a x\ t_s$$

$$=0.33x10^{-3}x241$$

$$=0.07953\ kg$$

For height =18mm

Mass of LPG consumed for 238 second (experimentally found)

$$M_{S2}= M_a\ x\ t_s$$

$$=0.33x10^{-3}x238$$

$$=0.07854\ kg$$

$\therefore$ Mass of LPG saved= M_{S1}-M_{S2}

$$= 0.07953-0.07854$$

$$=9.9x10^{-4}kg$$

Therefore, percentage (%) of LPG saved.

$$= \left(\frac{9.9x10^{-4}}{0.07953} \right)$$

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= 1.24%

LPG gas consumed per day in India

=0.422 million barrels per day

1 barrel=158.9872972 litres

LPG gas consumed per day in India

=0.422x158.9872972

=67.09263944 million litres

1 litres = 0.502 kg

LPG gas consumed per day in India

=67.09263944x0.502

$=33.68050499 \times 10^6$ kg

LPG saved per day

=percentage of LPG saved x LPG gas consumed per day

$=0.0124 \times 33.68050499 \times 10^6$

=417632 kg

=417 tons

LPG saved per year throughout India

=417*365 days

=152205 tons

CONCLUSION

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 one and only one important variation, the distance between the burner and the utensil 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 is increased by 0.33%

2. By using this modified stand we can save large quantity of fuel as high as around 1.5lakh tons per year

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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.

REFERENCES

(1) Legros, G.; Havet, I.; Bruce, N.; Bonjour, S. The Energy Access Situation in Developing Countries. WHO and UNDP, 2009. http:// www.who.int/ indoor air/publications/ energy access situation/en/index.

(2) Wikipedia. http://wiki.answers.com/Q/What_percentage_of_ The world's_ population_ lives _in developing countries

(3) Center for Energy Studies Institute of Engineering Tribhuvan University Pulchowk, Lalitpur July 2001, "Efficiency Measurement of Biogas, Kerosene and LPG Stoves"

(4) Higher engineering mathematics by B.S grewal 43rd Edition 2015