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Experimental Investigations on the Efficacy Augmentation of a Domestic LPG Gas Stove using an Add-on Wire Mesh

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Abstract— There have been several attempts to improve thermal efficiency of gas stoves by improving various parameters like flame stability, flame temperature, shape, size and aeration etc. including the burner heads. The spacing of ports, inclination of the flame cones, port geometry are also important parameters which govern the flow pattern of hot gases impinging on the heat exchanger vessel. Several gadgets are displayed on the market, claiming that they can improve thermal efficiency of the gas stove. One such gadget is the wire mesh disc, which placed over the burner head is claimed to improve thermal efficiency of the stove. The mesh is made of durable special compound metal alloy to withstand vigorous LPG heat. Interwoven wires enable concentrated high flame. Also, the utensils do not get blackened as no unburned hydrocarbons are produced. This work aims at quantifying the effect of add-on disc holding wire-mesh above the burner head on the thermal efficiency of the gas stove and to determine its optimum location to further improve the thermal efficiency. The experiments suggest that the use of wire mesh on burner head improves gas stove thermal efficiency. Use of this gadget will be beneficial, as it leads to saving of LPG, however small, and on a global scale, it will be a major step towards energy conservation as millions of stove operate globally.

***Index Terms*: Efficacy Augmentation, Domestic LPG Gas Stove, Add-on Wire Mesh**

I. INTRODUCTION

The present experiment consisting of adding wire mesh disc and carrying out the thermal efficiency test subjected to changing the wire mesh disc positions with respect to the burner head and then varying the heights of the vessel bottom until the best efficiency value is attained.

Figure 1 shows the head of a simple big burner. The heat source of a gas stove could be Natural gas, propane, butane, liquefied petroleum gas or other flammable gas. Heat from the flame of gas stoves can be accurately and quickly adjusted. Gas stoves are difficult to install and require a gas line in the property. They pose the dangers of gas-leak related fire accidents.

A minor drawback is that the flames continuously consume fuel even when the stove is not in use. The burner head gets dust inside frequently and hence have to be cleaned frequently.

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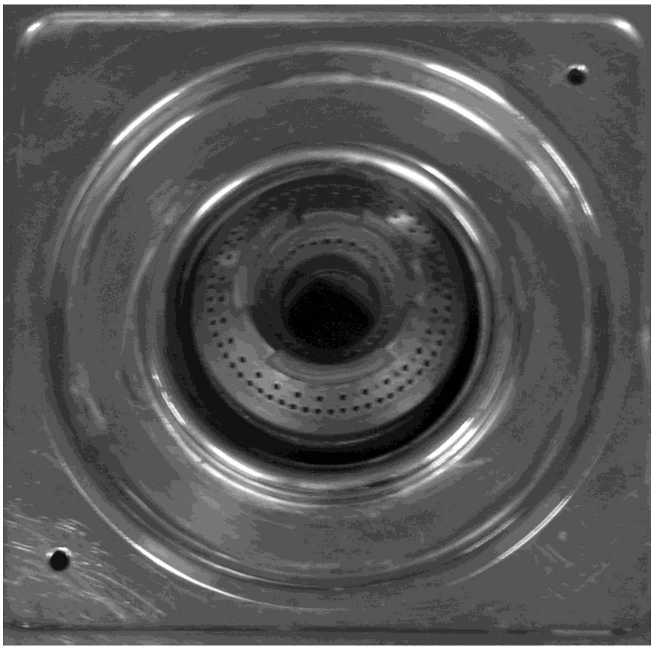

Figure1. Big Burner Head

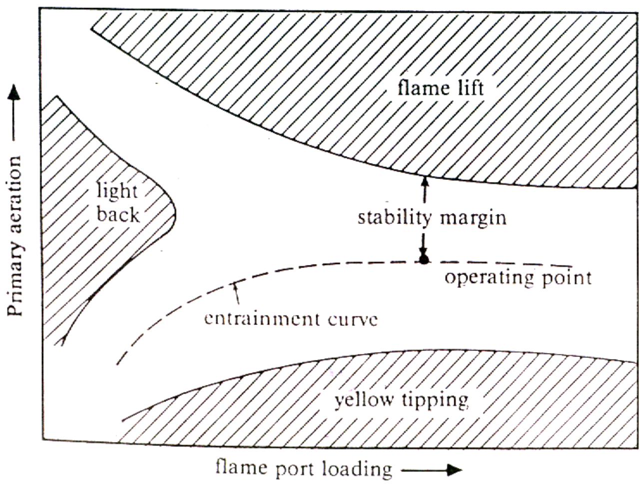

Fig. 2 Combustion diagram for a typical aerated burner

The flame stability diagram of a typical aerated burner is shown in Figure 2. The diagram shows qualitatively those three areas where unsatisfactory combustion results: a) Flame Lift: At high primary aeration, due to increased flow rate not being balanced by a similar increase in burning velocity. b) Light Back:

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At low heat input due to opposite of flame lift and c) Yellow Tipping: Incomplete combustion at low primary aeration due to oxygen starvation in the flame. In other words, the good burner designer will ensure that there is a large area of satisfactory operation and that the operating point is somewhere near the middle of that area.

The flame stability diagram shows that the primary aeration at the onset of yellow tipping is virtually independent of port loading. Since the cross sectional area of the flame hardly varies as the gas flow is increased, the radial diffusion length for secondary air to the core of the flame remains roughly constant. Thus the primary aeration required just to prevent yellow tipping also remains approximately constant. At very low flow rate, where the flame length and width are almost equal, axial diffusion upstream from the flame tip also becomes important, so low primary aerations are attainable without the risk of sooting [1-5].

II. EXPERIMENTAL WORK

In the present work, the thermal efficiency of a given LPG stove is measured under the following conditions.

- The distance of the heat exchanger is varied from the burner head and thermal efficiency is quantified for BIG burner under HIGH flame and SIM flame positions.
- A disc shaped wire-mesh is inserted between burner head and heat exchanger such that the distance between mesh and the burner head is varied and the thermal efficiency is quantified for the BIG burner and SMALL burner under HIGH flame and SIM flame positions.

III. EXPERIMENTAL SETUP

Figure 3 gives the schematic diagram of the set up being used in the present work. The apparatus consist of a gas-flow meter, water manometer and a given LPG gas stove. A standard vessel is used for determining thermal efficiency measurement .The lid of the vessel is provided with two holes, one for stirring wire and the other for thermometer to measure water temperature.

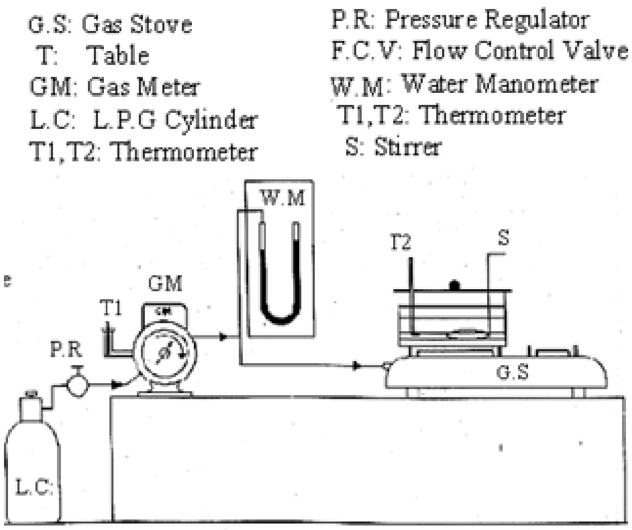

Fig. 3 Schematic diagram of gas stove testing apparatus

A wet type of gas flow meter (Flow range: 2-200 dm3 /h, max pressure: 50 mbar gauge) is used to meter the gas flow. The water equivalent of the heat-exchanger is estimated to be 786.55 J/K.

IV. DETAILS OF BURNER HEAD

Burner Head (Big), dp = 2mm and D = 84mm

Outer rows of holes, Do_1 = 71 mm with 60 holes

Middle row of holes, Do_2 = 65 mm with 30 holes

Inner row of holes, Do_3 = 38 mm with 30 holes

Burner Head (Small): dp = 1.8mm and D = 70mm

Outer rows of holes, Do_1 = 59 mm with 50 holes

Middle row of holes, Do_2 = 52 mm with 25 holes

Inner row of holes, Do_3 = 32 mm with 25 holes

V. FLOW RATE MEASUREMENT

The gas is allowed to flow through the gas stove .The gas flow rates involved in operating the gas stove in SIM and HIGH modes, for the small and big burners are determined. The time taken for 1 dm^3 of gas (one complete rotation of the pointer) is noted. From this flow rate in (liter/hr) is calculated. Experiments were performed 3 times and average is taken. Table 1 gives operating gas flow rates of the stove used in the present work.

Table 1. Operating gas flow rates

Gas LPG (commercial butane)	Volume flow rate (l/h)	
	SIM: Low Flame	HIGH: High Flame
Big Burner	22.64	83.50
Small Burner	19.35	62.53

VI. RESULTS AND DISCUSSION

While performing the tests, care is taken to assure the thermometer reads steady value of water before the start of the experiment. The room should be free from draught. The pressure and hence the flow rate of gas must remain constant throughout.

Tables 2 and 3 shows the thermal efficiency with one mesh (big burner – high flame position) and thermal efficiency with one mesh (big burner – SIM flame position).

Table 2. Thermal efficiency with one mesh (big burner – high flame position) V=83.5 l/h, T_2 =80°c

	Z, cm	T_1°C	τ (seconds)	η (%)
a	5.4	35	209.35	39.94
b	5.9	34.5	212.65	39.76
c	6.4	35	208.09	39.74
d	7.4	35	215.72	38.77

Z = Distance of the heat exchanger from the burner head in cm Distance of the mesh bottom face from the burner head = 2.7 cm

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Table 3. Thermal efficiency with one mesh (big burner – SIM flame position) V=22.64 l/h, T_2 =80°c

	Z, cm	T_1°C	τ (seconds)	η (%)
a	5.4	34	921.38	33.90
b	6.4	34	948.59	32.93
c	7.4	34	948.9	32.91

Figure 3 shows the thermal efficiency with mesh of the big burner at high flame position and Figure 4 shows the thermal efficiency with mesh of the Big burner at sim flame position

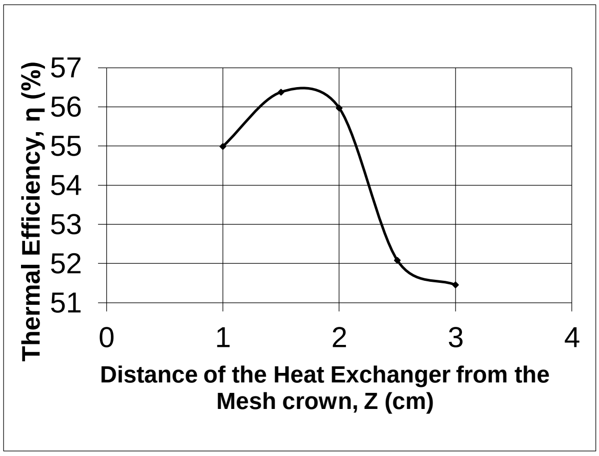

Fig.4 Thermal efficiency with mesh Big burner – high flame position

The data obtained in this work is presented in form of Tables and graphs. Table 2 gives the value of thermal efficiency variation with wire mesh by changing the distance of the heat exchanger from the burner head. It is observed that the value of thermal efficiency decreases with distance.

Adequate clearance was provided between the mesh crown and the heat exchanger vessel. In the HIGH flame position, the value of thermal efficiency decreased with the increase of distance.

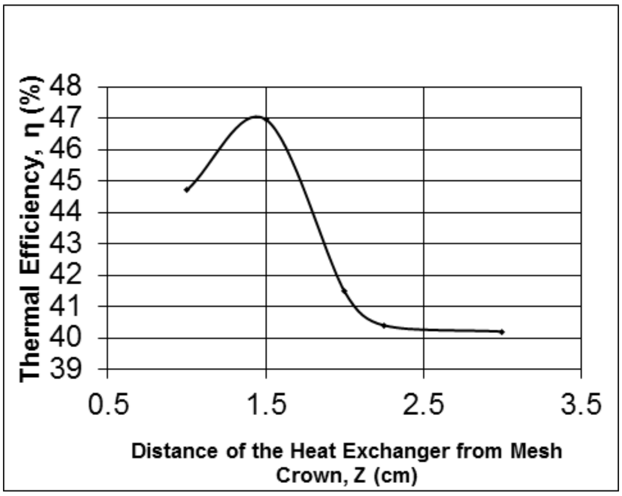

Fig. 5 Thermal efficiency with mesh Big burner – sim flame position

Table 4 indicates the best efficiency values for the gas stove with one mesh.

Table 1: Best efficiency values with one mesh

Burner	Flame Position	Maximum Efficiency (η_{Ref})
Big Burner	High	56.37
Big Burner	Sim	46.96

Table 3 gives the value of thermal efficiency when the mesh bottom face was lifted to 2.7 cm above the burner head and the distance of the heat exchanger vessel was varied from the mesh crown. In this experiment adequate clearance was given between the mesh and the bottom of the heat exchanger vessel. It was found that the value of thermal efficiencies obtained decreased with increase of distance.

Figure 4 gives the value of thermal efficiency when the mesh clearance (that is the distance between the mesh bottom face and the burner head top) was reduced to 0.8 cm in this set of experiments. Figure 5 gives the data when the mesh was placed on the burner head and the spacing between the crown of the mesh and the heat exchanger vessel was varied, in this case the clearance was varied between extreme values and the result obtained showed a particular trend. The value of thermal efficiency first increased, reached a maximum value and then further decreased with the increase of distance. Table 4 gives the best efficiency values with no mesh and corresponding locations. It is observed that the thermal efficiency value for BIG burner in SIM flame position is increased by 2.31 %. Thus, stove operation with one mesh as add-on gives improvement in thermal efficiency and saves LPG. The higher thermal efficiency is due to argumentation of heat transfer by radiation in addition to convective heat transfer of the hot gases to the vessel. If the mesh can be made to attain higher temperature level what it could with stand, then radiative mode can be made to be effective in transfer of energy to the vessel.

VII. CONCLUSIONS

- The thermal efficiency value for BIG burner in SIM flame position is increased by 2.31 %.
- It is found that the value of thermal efficiency increases, reaches a maximum value and then decreases. This trend was observed in high and sim flame position with mesh placed on the burner head.
- The best efficiency values with mesh were obtained in all the cases when the mesh was placed on the burner head.

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