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Experimental Investigations on the Performance and Efficiency of a Typical Domestic LPG Gas Stove

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Abstract* — Industrial, commercial and domestic gas appliances cover an extremely wide range of requirements with regard to flame stability, flame temperature, shape, size and aeration which need to be satisfied for optimum performance. With the wide spread use of LPG in industrial, commercial and domestic appliances, it should be our endeavor to design efficient burner systems not only to conserve fuel but also to keep our environment clean and green. In atmospheric burner primary air is entrained by momentum sharing between the gas and the surrounding air. The amount of air induced in this way is generally about 50 to 70 % of the stoichiometric air requirement. Two types of atmospheric burners may be distinguished, those in which the gas issues at normal supply pressure and those in which the gas is supplied from a compressor or high pressure supply. The importance of the former type, e.g., the Bunsen burner type heralded a new phase in gas utilization development when it was first introduced. Low-pressure atmospheric burners are restricted to industrial appliances, however they have been adopted on a limited scale. The present experiment consist of measuring the thermal efficiency of a LPG gas stove without wire mesh with varying heights of the vessel above the stove head: the height at which the thermal efficiency is maximum is noted for two burners i.e. BIG BURNER and SMALL BURNER for two gas input rates, i.e., the SIM (LOW) Flame and HIGH Flame position.

***Index Terms*— Domestic Lpg Gas Stove, burner, flame.**

I. INTRODUCTION

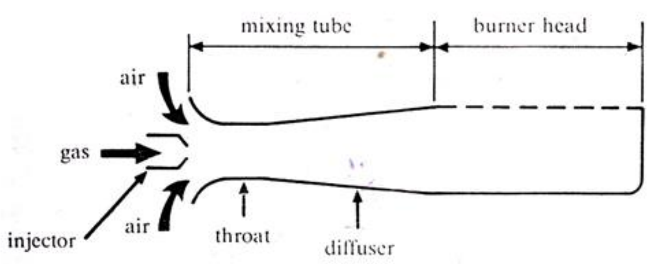

Fig. 1 General layout of an Atmospheric Aerated Burner

Figure 1 shows a general layout of an atmospheric aerated burner. Gas emerges from an injector nozzle consisting of one or more holes. On leaving the injector the gas entrains primary air by momentum sharing process between the emerging gas and the ambient air. The gas /air mixture enters a mixing tube, which may be shaped in the form of a tapered venture or may have parallel sides. As its name suggests, the mixing tube is designed to ensure thorough mixing of gas and air such that a constant air/gas ratio is maintained throughout the burner head. The mixture must then be distributed uniformly to the burner ports. Thus the four main aspects of the aerated burner are the injector, air entrainment, mixing tube design and burner port geometry. Optional features include an aeration shutter or mixing tube restrictor, which controls primary air entrainment, and baffles, or gauze within the burner body, which aids good mixing and prevent lint from clogging the burner ports.

During the operation of an appliance, the burner will become heated, which in turn will pre-heat the gas air mixture as it passes through the burner assembly. There are 2 effects, both of which are slight but beneficial. The burning velocity of the gas air mixture increases with temperature. This leads to better flame stability at high aeration and high port loading. As the gas air mixture rises in temperature, it expands and flow resistance in the burner increases, thereby decreasing air entrainment by as much as 10%. Consequently the flame will become more stable as the appliance warms up. This effect will be absent at ignition and will decrease if the injector also is subjected to a rise in temperature. Clearly, satisfactory (lift free) ignition must be provided, so, although increased burning temperature is beneficial, it can be ignored by the designer with respect to flame lift. The maximum satisfactory primary aeration for a particular burner is generally determined by its susceptibility to flame lift [1-5]. The minimum primary aeration is determined by the onset of incomplete combustion and sooting, which are accompanied by emissions of carbon monoxide and yellow tipped flames. Incomplete combustion is an indication either that primary or secondary air supply (or both). Is insufficient or that the flame is being quenched by impingement on a cool surface, or that there is aerodynamic quenching by surrounding air. This can be caused by bad design or such factors as vitiation of the air supply, linting and changes in gas composition.

II. EXPERIMENTAL WORK

The thermal efficiency of a given LPG stove is measured under the following conditions:

The distance of the heat exchanger (Z) is varied from the burner head and thermal efficiency is quantified for BIG burner and SMALL burner under HIGH flame and SIM flame positions.

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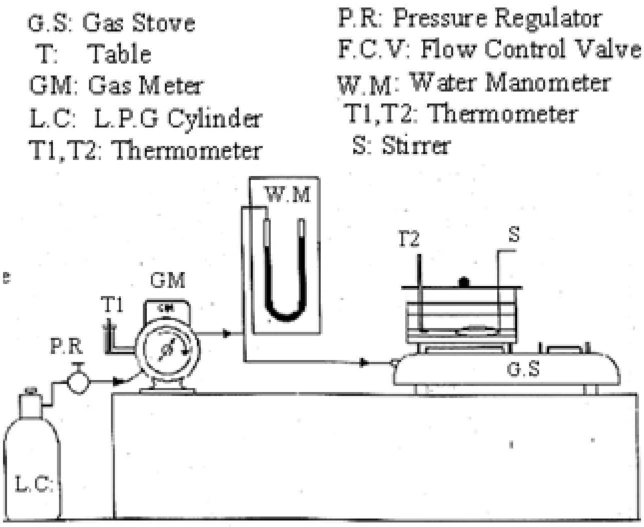

Fig. 2 Schematic Diagram of gas Stove Testing Apparatus

Figure 2 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. A wet type of gas flow meter (Flow range: 2-200 dm^3/h, max pressure: 50 mbar gauge) is used to meter the gas flow. A standard vessel of diameter 216 mm is used in the thermal efficiency test. The water equivalent of the heat-exchanger is estimated to be 786.55 J/K.

III. CONSTRUCTIONAL DETAILS

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

IV. 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.

V. RESULTS AND DISCUSSION

Table 1 to 4 shows the thermal efficiency with no mesh for big burner at high flame position, thermal efficiency with no mesh for big burner at SIM flame position, thermal efficiency with no mesh for small burner at high flame position and thermal efficiency with no mesh for small burner at sim flame position.

Table 1. Thermal efficiency with no mesh (big burner – high flame position) V=83.5 l/h, T_2 =80°c

	Z, cm	T_1°C	τ (seconds)	η (%)
a	2.4	31.5	181.97	50.02
b	2.6	32	173.53	51.41
c	3.1	31.5	185.12	48.69
d	3.6	31.5	202.53	44.51
e	4.6	34	201.56	40.22
f	5.6	34	220.25	38.82

Table 2. Thermal efficiency with no mesh (big burner – SIM flame position) V=22.64 l/h, T_2 =80°c

	Z, cm	T_1°C	τ (seconds)	η (%)
a	1.6	36	637.25	45.89
b	2.1	36	636.59	45.90
c	2.6	31.5	778.58	42.23
d	3.1	31	861.60	38.62
e	3.6	30.5	931.57	36.082
f	4.6	33	905.32	35.25
g	5.6	33	1008.64	31.64

Table 3. Thermal efficiency with no mesh (small burner – high flame position) V=62.53 l/h, T_2 =80°c

	Z, cm	T_1°C	τ (seconds)	η (%)
a	2.1	35	197.13	56.26
b	2.6	35	196.69	56.38
c	3.6	31.5	266.06	44.93
d	4.6	31.5	307.97	39.83
e	5.6	31.5	341.75	34.98

Table 4. Thermal efficiency with no mesh (small burner – sim flame position) V=19.35 l/h, T_2 =80°c

	Z, cm	T_1°C	τ (seconds)	η (%)
a	2.4	35	783.65	45.63
b	2.6	35	779.44	45.88
c	3.6	30.5	932.84	42.17
d	4.6	34	996.71	36.67
e	5.6	34.5	1123.72	32.17

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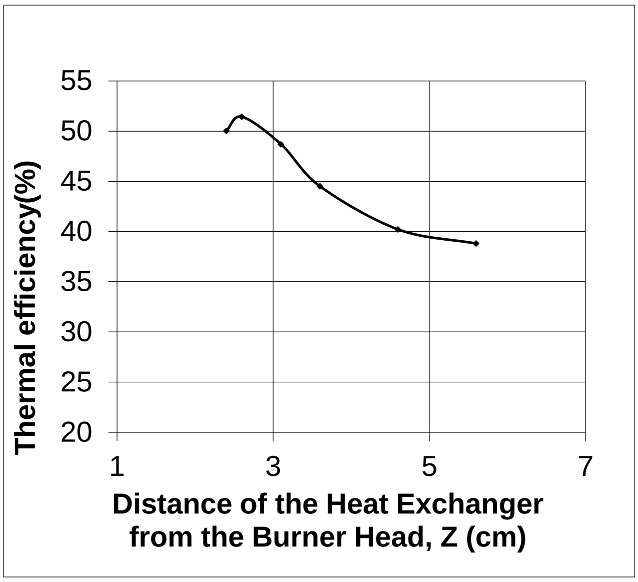

Fig. 3 Best efficiency values with no mesh

Table 5 Best Efficiency Values with no Mesh

Burner	Flame Position	Maximum Efficiency(η_{Ref})
Big Burner	High	51.41
Big Burner	Sim	45.90
Small Burner	High	56.38
Small Burner	Sim	45.63

The data obtained in this project work is presented in form of Tables and graphs. Table 4.1 gives the value of thermal efficiency variation without wire mesh by changing the distance of the heat exchanger from the burner head. It is observed that in all the 4 cases the value of thermal efficiency first increased, reached a maximum value and then decreased.

Table 4.2 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.

Table 4.3 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 (except one for small burner high flame position). Adequate clearance was provided between the mesh crown and the heat exchanger vessel. In all the cases except SMALL burner, HIGH flame position the value of thermal efficiency decreased with the increase of distance. In SMALL burner HIGH flame position when the clearance between the mesh crown and the heat exchanger bottom face was reduced the value of thermal efficiency obtained first increase, reached a maximum value and then further decreased with the increase of distance.

Table 4.4 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.

Figure 3 gives the best efficiency values with no mesh and corresponding locations. Table 5 gives the best efficiency values with mesh and corresponding locations. The data comparison of Table 5 shows that with the use mesh the value of thermal efficiency increased for SMALL burner in HIGH flame position to 17.24%. The corresponding value of BIG burner in high flame position is increased to 9.65%.

The thermal efficiency value for BIG burner in SIM flame position is increased to 2.31 % and the value of SMALL burner in SIM flame position is similarly increased to 2.02 %. 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.

VI. CONCLUSIONS

- It is interesting to note that thermal efficiency is higher for SMALL burner head in HIGH flame position whereas in SIM position BIG burner head has a marginal advantage.
- Thermal efficiency is enhanced by 17.24 % for SMALL burner in HIGH flame position and by 9.65% for BIG burner in HIGH flame position compared to 2.31 % in BIG burner SIM flame position and 2.02% for SMALL burner in the SIM flame position.
- It is found that the value of thermal efficiency increases, reaches a maximum value and then decreases. This trend was observed for 2 burners in HIGH and SIM flame position.

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