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Design and Analysis of Portable Cartridge Stove

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ABSTRACT:

In the present work a stove which is portable in size was designed and fabricated and also investigated the performance analysis of Cartridge stove. The performance parameters, thermal efficiency and the emission characteristics was done experimentally according to IS 4246:2002 (Domestic Gas Stoves for use with Liquefied Petroleum Gases), IS 5116:1996 (Domestic and Commercial Equipment for use with LPG General Requirements) and IS 11482:1985 Specification for Portable Liquefied Petroleum Gas Appliances Operating At Vapour Pressure.Liquefied petroleum gas (LPG) is a popular fuel for domestic and commercial cooking as it offers clean cooking environment as well as high heat content. Large increases in the demand of LPG in developing countries like India, it is a necessary to explore the ways to further improve the thermal efficiency LPG cooking stoves.The Cartridge stove is a cooking stove specially designed to be portable and lightweight, used in camping, picnicking, backpacking, or other use in remote locations where an easily transportable means of cooking is needed. This stove has less maintenance and can be easily assembled whenever required. Portable stoves can be used in diverse situations, such as for outdoor food service and catering and in field hospitals.The Thermal Efficiency of the Cartridge Stove was experimentally done according to IS 4246:2002 found to be 68.56% and the rate of heat generated by burner is 1.62 KW. In the emission test, the combustion ratio CO/Co2 is 0.018.

INTRODUCTION:

Energy importance in our daily lives derives simply from the fact that it provides essential human services, such as lighting, cooking, motive power, space heating and cooling, water pumping and so on. Liquefied petroleum gas (LPG) is one of the commonly used conventional fuels for domestic applications. The fuel of LPG finds very wide application in a large variety of domestic, industrial, commercial and leisure uses.

A LPG cooking stove reported by Central Petroleum Research Association, India, In view of huge consumption of LPG in India, there is a need to look at different modifications for improving performance of the stove. Normally a burner plays an important role in any combustion system. Since proper efficient modifications of a burner often leads to an efficient combustion and possibility to produce less pollutant formation. Its consumption in domestic cooking is increasing every year at the rate of approximately. The total domestic consumption of LPG in India is almost comparable with other petroleum products used in industrial applications. The Overall efficiency of stove depends upon different conditions such as temperature, pressure, wind speed, specific heat capacity of the vessel, overall shape of vessel, weight of vessel, and size of vessel.A portable cartridge stove is a cooking stove specially designed to be portable and lightweight, used in camping, picnicking, backpacking, or other use in remote locations where an easily transportable means of cooking or heating is needed. Portable stoves can be used in diverse situations, as outdoor food service and in field hospitals.Since the invention of the portable stove in the 19th century, a wide variety of designs and models have seen use in a number of different applications. Portable stoves can be broken down into several broad categories based on the type of fuel used and stove design.

1. Unpressurized stoves that use solid or liquid fuel placed in the burner before ignition,
2.Stoves that use a volatile liquid fuel in a pressurized burner
3.Bottled gas stoves and
4.Gravity-fed “spirit” stoves

Prior to their use, the usual practice when backpacking was to build an open fire for cooking from available materials such as fallen branches. The fire scar left on the ground would remain for two or three years before the vegetation recovered. The accumulation of fire scars in heavily travelled areas detracted from the pristine appearance that backpackers expected, leading to more widespread use of portable stove.

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LITERATURE SURVEY

Many of the studies have been carried out on the design and fabrication of cartridge stove.

IS 11241: 1985 SPECIFICATION FOR PORTABLE LIQUEFIED PETROLEUM GAS APPLIANCES OPERATING AT VAPOUR PRESSURE

This standard Specifies construction, operation, safety requirements and tests for portable liquefied petroleum gas appliances, such as cooking appliances, lights, space heaters and blow torches intended for operating at the direct vapour pressure of the gas in refillable and non-refillable gas containers. This standard excludes liquid feed burners and equipment having integral containers refillable by user as they may constitute a hazard.

IS 5116: 1996 DOMESTIC AND COMMERCIAL EQUIPMENT FOR USE WITH LPG — GENERAL REQUIREMENTS

This standard specifies general requirements and methods of test relevant to these requirements, for domestic and commercial equipment, for households and other commercial catering organizations, using liquefied petroleum gases at 2.942 kN/m2 (30 gf/cm2) gas inlet pressure.

3. IS 4246:2002 DOMESTIC GAS STOVES FOR USE WITH LIQUEFIED PETROLEUM GASES — SPECIFICATION

This standard specifies construction, operation, safety requirements and tests for domestic gas stoves with metallic bodies intended for use with liquefied petroleum gases at 2942 kN/m2 (30 gf/cm2) gas inlet pressure.

THEORETICAL ANALYSIS – 20
LPG HISTORY

LPG is prepared by refining or "wet" natural gas, and is almost entirely derived from fossil fuel sources, being manufactured during the refining of petroleum (crude oil), or extracted from petroleum or natural gas streams as they emerge from the ground. It was first produced in 1910 by Dr.walter Snelling and the first commercial products appeared in 1912. LPG is used for cooking in many countries for economic reasons, for convenience or because it is the preferred fuel source.

According to the 2011 census of India, 33.6 million (28.5%) Indian households used LPG as cooking fuel in 2011, which is supplied to their homes in pressurised cylinders. LPG is subsidized by the government in India.

LPG range are propane (C_3H_8), Propylene(C_3H_6), normal and iso-butane (C_4H_{10}) and Butylene(C_4H_8). LPG vapour is denser than air: butane is about twice as heavy as air and propane about one and a half times as heavy as air. Consequently, the vapour may flow along the ground and into drains sinking to the lowest level of the surroundings and be ignited at a considerable distance from the source of leakage. In still air vapour will disperse slowly. Escape of even small quantities of the liquefied gas can give rise to large volumes of vapour / air mixture and thus cause considerable hazard. To aid in the detection of atmospheric leaks, all LPG's are required to be odorized. There should be adequate ground level ventilation where LPG is stored. For this very reason LPG cylinders should not be stored in cellars or basements, which have no ventilation at ground level.

SIMILARITIES FOR PROPANE AND BUTANE:

Both gases are derived from petroleum, either from oil or natural gas, but have different chemical structures. Each burns at similar temperatures and both release water and carbon dioxide as waste products. If the amount of oxygen available is limited when the gasses are being burned, they may also produce soot and carbon monoxide. In some cases, the gases may be used interchangeably, but people should always consult the manufacturer before attempting to substitute one for the other.The fire and hazard risks of both gases are quite similar. In North America, the gases are represented in the National Fire Protection Association (NFPA-704) classification system identically. The rating indicates high flammability, normal stability, a mild health hazard risk, and no special considerations such as an unusual reaction when mixed with water.Both gases burn cleanly and have high calorific value, giving similar flame shapes and heat outputs and in principle, appliances will burn equally well off either gas.

DIFFERENCES BETWEEN PROPANE AND BUTANE

The gas is drawn off from the cylinder and liquid turns back into gas, the liquid cools down causing the rate of change from liquid to gas to slow down.

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This effect is particularly marked for Butane which will not turn from liquid to gas below 0 °C, so that on cold days or when the gas is being withdrawn at a high rate, the liquid gets so cold that it delivers low amount of gas, or indeed no gas at all. Thus butane tends to be used for low pressure domestic appliances indoors, or outdoors in the summer only. Propane continues to turn from liquid to gas at much lower temperatures than butane and thus gives a high pressure of gas on the coldest days. Although propane cylinders can be used indoors on a temporary basis, they should not be stored indoors because of the higher pressures in them.

CHARCTERSTICS OF PROPANE:

Propane is used in North America as fuel for heating houses, and is also available in smaller portable tanks. Gas barbecues, camping stoves, and lanterns frequently can be used with propane fuel. Mixed with small amounts of other substances like butylene, propylene, and butane, it can be used as an automobile fuel known as liquefied petroleum gas (LPG). The odorless gas will often have ethanethiol, which has a strong odor, added to it so any leaks can be more easily detected. If the gas needs to be stored for a long time or in variable weather conditions, propane is usually a better choice than butane. It is relatively easy to liquefy and compress, and has a boiling point of -44°F (-42°C), which means that it turns into a gas as soon as it comes out of the tank at any temperature above this. Propane can easily be stored outside in almost all environments, since temperatures below freezing don't affect how it is stored or used

NICKEL PLATING:

Nickel deposits are usually sulfur-free, and matte in appearance. These deposits may be specified to improve corrosion and wear resistance, to salvage or buildup worn or undersized parts, to modify magnetic properties, to prepare surfaces for enameling or for organic coating, to function as diffusion barriers in electronic applications and for other purposes. Engineering applications exist in the chemical, nuclear, telecommunications, consumer electronics and computer industries. In a galvanic or voltaic electrochemical cell, the spontaneous reaction occurs and electrons flow from the anode (oxidation) to the cathode (reduction). In an electrolytic cell, a non-spontaneous reaction occurs using energy supplied by an external source.

In an electrolytic cell used for electroplating, the object to be plated is used as the cathode. Metal cations are reduced at the cathode and a layer of metal is deposited on the surface of the object. The anode is usually made of the same metal as the one being plated at the cathode. A concentrated solution of a very water-soluble ionic compound of metal being plated is used in the cell compartment as the electrolyte. This makes the solution very conductive and allows the plating to occur relatively quickly. The rate of electroplating and the amount of metal plated depend on the electrical current, in amps, and the time. A cell for plating copper is shown below.

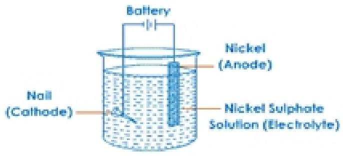

Fig 3.1: Principle of Nickel Plating

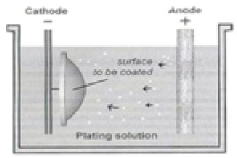

Fig : Deposition of Nickel on the surface

EQUIPMENT:

Manometer, Spirit Level, Gas Regulator, Thermometer, Stirrer,Alumimium pans as per table, Stop watch, Weighing Machine.

Fig: Ignition Test

Fig: Surface Temperature Test

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Fig: Test set up for Resistance to Draught

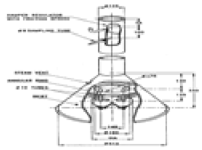

Fig: Hood for Burner

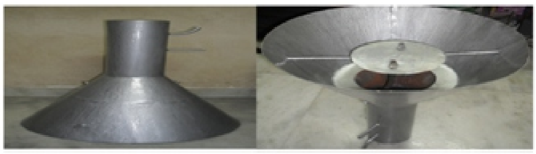

Fig: Experimental set up for Combustion Test

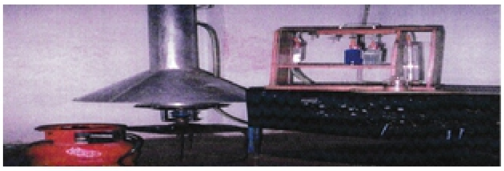

Fig: Test set up for Combustion Test

SELECTION OF ORIFICE:

For the above Routine and Type Tests we have taken the Orifice 0.24mm

Model Calculation for the Flow rate

Flow rate Q = Area X Velocity

Dynamic Pressure Equation $(P_d) = \frac{\rho V^2}{2}$

$$V^2 = 2\, P_d / \rho$$

Air at P_d = 5 bar is passed through 0.24mm Orifice.

Density of air $\rho_{air} = 1.225\ kg/m^3$

$$1bar = 10^5\ Pa$$

$$= 105\ N/m^2$$

$$= 105\ \frac{kg-m}{s^2} X \frac{1}{m^2}$$

$$V^2 = 2\, P_d / \rho$$

$$= \frac{2 X 5 X 105\ \frac{kg-m}{s^2} X \frac{1}{m^2}}{1.225\ kg/m3}$$

$$V = 903.5\ m/s$$

$$Q = Area\ X\ Velocity$$

$$= \Pi X \frac{(0.24)^2\ X\ 903.5\ X\ 1000}{4}$$

$$= 147069540mm^3$$

$$= 0.147m^3 \quad (1m^3 = 1000litres)$$

$$= 147\ liters$$

Therefore, flow rate for 0.24mm Orifice at 5bar pressure is 147 Liters.

RESULTS AND DISCUSSIONS :

The experiments were performed as per the procedure is given in. and IS 11482:1985 and IS 4246:2002 and prepare hood and to prepare the hood for proper measuring emission product.

ROUTINE TESTS:

1.The Gas soundness test was performed at 17kg/cm2 and 0.35 kg/cm2 .In both the cases there were no leaks find the valve is in closed condition.

2.Igntion and Flame Travel was performed on the stove and found that stove has easy and safe access for lightening with the help of a match stick.It is also found that that at fully open condition flame travel is complete.

3.Flame stability test was performed on the stove and found without the flame either extinguishing, blowing off or striking back

4. Stability test was performed on the platform which is of 15° when mounted on the cartridge with empty vessel on the stove found that container remained intact without falling down.Thermal Efficiency of the stove with Orifice 0.24mm is 68.56%

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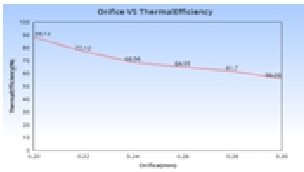

Fig: A Graph between Orifice VS Thermal Efficiency

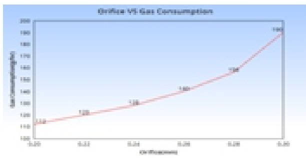

Fig: A Graph between Orifice VS Gas Consumption

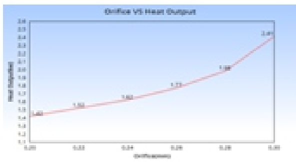

Fig: A Graph between Orifice VS Heat Output

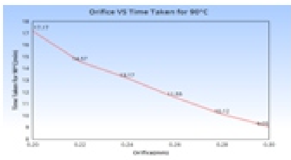

Fig: A Graph between Orifice VS Time Taken for 90°C (min

CONCLUSION :

The Cartridge stove was designed in such that it is very Portable and light weight which is easy to carry. The assembly and dismantle of stove is easy. The stove works with very less maintainenace. The stove burner was designed in such that it utilizes the fuel to produce maximum Thermal Efficiency with more heat rate and release less emissions to the surroundings. This stove is very useful for the bag packers camping, picnicking, field hospitals, or other use in remote locations where an easily transportable means of cooking is needed.

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[1] IS 4246:2002 Indian Standard Domestic Gas Stove for Use with Liquefied Petroleum Gases-Specification (Fifth Revision).

[2] IS 5116:1996 For general requirements of stove and selection of materials (Domestic and Commercial Equipment for use with LPG General Requirements)

[3]IS 11482:1985 Specification for Portable Liquefied Petroleum Gas Appliances Operating At Vapour Pressure.

[4]Walter M. Berry, I. V. Brumbaugh, G. F. Moulton, and G. B. Shawn "Design Of Atmospheric Burners" Technologic Papers Of The Bureau of Standards, September 6 1921.

{5}Mohd. Yunus Khan and Anupriya Saxena, "Performance Of LPG Cooking Stove Using Different Design Of Burner Heads" International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 7, July – 2013.