IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

DESIGN AND PERFORMANCE ANALYSIS OF LPG DUAL SYSTEM

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Abstract: This work investigates the result of an experimental study carried out to determine the performance of direct expansion of LPG in dual system, which comprises 24.4% propane, 56.4% butane and 17.2% iso- butene. The availability of electricity in most part of the India is not until continuous which interrupt the refrigeration process in household refrigeration system as well as in industrial one; as compressor is the main power consuming element in vapour compression refrigeration system. To check the feasibility for obtaining refrigerating (cooling) effect by directs expansion of LPG, with elimination of compressor; this system is build. This dual purpose LPG system in which main purpose of using LPG as a fuel for cooking and simultaneously use to obtain refrigerating (cooling) effect. Such type of system will be very effective in household applications as well as commercial one. Using the same concept car air conditioning will be achieving in future e scope. LPG is highly inflammable but use of strong design and standard equipment's can minimize the risks associated with LPG.

Index Terms – Dual system; LPG; direct expansion; cooling; open system; household refrigeration

I. INTRODUCTION

Glancing in future of refrigeration and air-conditioning field it is necessary to build the environmental friendly safe and cost effective alternative refrigeration systems and refrigerant for conventional domestic refrigeration system. LPG the fuel of new generation, with this scheme the main aim of this paper to check whether it is possible to achieve the refrigerating effect by direct expansion of LPG through the domestic LPG cylinder and feasibility of this concept in dual LPG system which uses LPG as fuel for cooking and for cooling also. In this system, condenser and compressor are skipped & doing direct expansion of LPG. LPG is a liquefied gas in the cylinder placed at lowest part of the cylinder. In conventional vapour compression system which comprises mainly four component condenser, compressor, expansion device, and evaporator. In such types of system the main source of power consumption is a compressor also the basic principle by which we get refrigerating effect is nothing but the heat exchange by means of phase change of refrigerant during the cycle. In vapour compression cycle when refrigerant comes out from compressor its temperature is so high & its pressure is also so high also when it enters into condenser coil it converts in to liquid form. Therefore, to compare with vapour compression refrigeration cycle this is a open system in which LPG comes from cylinder in liquid form and then it enters directly in expansion device without using compressor and condenser. As it enters into evaporator coil it absorbs the heat associated with the refrigerating space and converted into vapour state which cools the evaporator coils. Finally comes out from evaporator coils in gaseous state and this gas further we can use in burner for cooking purpose. Such type of system will be very useful in domestic kitchen, in hotels and restaurants, canteens, hostels mess, and the places where community food cooked. Use of strong and safe design will definitely make such dual system popular in India. Using same concept it will be possible to achieve air conditioning of LPG operated vehicles.

II. DUAL SYSTEM

Conventional LPG system is based on vapour compression system consists of process of compression, condensation, evaporation. In dual system compressor and condenser are absent because in household cylinder, LPG is stored at high pressure is about 8 bar. So compression processes is adapted by LPG cylinder. The second process of condensation in vapour compression cycle, high pressure and high temperature vapour converted into liquid form. In dual system as it uses LPG cylinder in which LPG it is stored in liquid form under high pressure (LPG is heavier than air), here at the outlet of cylinder the LPG is obtain in liquid form but it is possible when cylinder is in inverted position. The third & fourth expansion & evaporation process are same as the vapour compression cycle. The capillary tube is fitted after the flow control valve (Regulator) in which expansion of LPG takes place and pressure drops is obtain during the entire length of capillary. Further, the low temperature and low pressure LPG in liquid form enters in evaporative coil that is placed in a insulated box to form an isolated system. The low temperature LPG absorbs the latent heat from the isolated box i.e. from water with losing its cooling effect. At the outlet of evaporative coil, LPG obtains in heated vapour state as phase change takes place at the end of evaporative coil. Further, the connections made to burner, where vapour state LPG coming out from the evaporator coil is passes to the gas burner, where it burns & gives energy for cooking.

III. Experimental Work

3.1 Material and Component Arrangement

LPG cylinder : 14.2 kg domestic cylinder
Hose : ISI marked LPG hose.

Capillary Tube : Copper; Diameter: 0.5 mm (Neglecting Thickness), Length; 3000 mm
Evaporative coil : Material: Copper, Inner diameter:8 mm, Outer diameter: 10 mm, Length; 10000mm (STD)
Evaporative Chamber : Material, Aluminum, and Capacity 26 lit.
Insulation : Glass wool with wire net Packing.

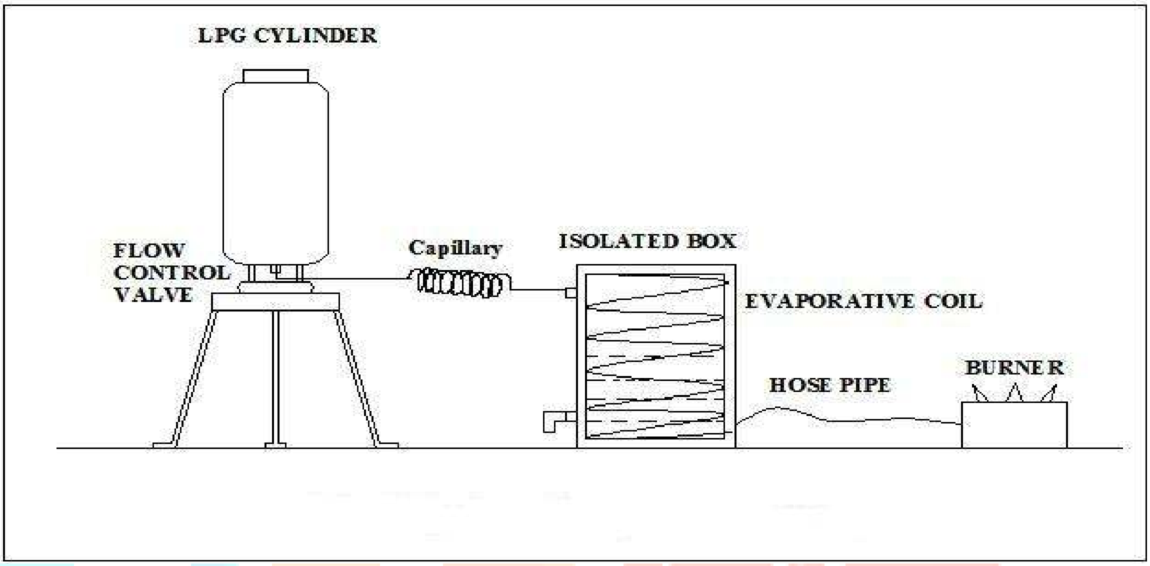

Fig.1 Experimental Set up of Dual System

IV. Test Performance

Test conducted for 30 minute for each observation. The experimental component arrangement is as shown in fig.1.Initially the position of LPG cylinder was upright with conventional LPG regulator; which was directly connected to the evaporative coil. With this arrangement there was no any temperature fall was observe hence in next observation the capillary tube was uncorrupted in the arrangement. One end connected to the regulator while other end connected to the evaporative coil. The flow of LPG through the evaporative coil and capillary were in the gaseous state. Later on the position of LPG cylinder made inverted so that it obtained in liquid state. With this arrangement, the temperature drop observed is mention in observation table no.1

4.1 Observations

Sr.No.	Cylinder Position	State of LPG	Atmospheric Temperature (T0)	Temp of Water Before Test (T1) ^0C	Temp of Water After Test (T2) ^0C	Evaporative Coil Temperature (T3) ^0C
1	Upright	Gaseous	30	29	29	27
2	Upright	Gaseous	32.5	32	31	26
3	Upright	Gaseous	33	32.5	31	26
4	Inverted	Liquid	33	32.5	29.5	24
5	Inverted	Liquid	33	32.6	25.4	21

Table No. 1 Observation Table

4.2 Calculations

4.2.1 Mass Flow Rate of LPG through System

Weight of LPG cylinder before trial (W1) = 15.400 kg Weight of LPG cylinder after trial (W2) = 15.275 kg Total LPG consumed during trial for 30 min. = 125gm

Hence,

Flow rate of LPG through system = 4.1667 gm/min

4.2.2 Heat Removed from Water (Q) or Cooling Effect Obtained

Here,
Refrigerating Effect (Cooling Effect) = Heat Removed from water

Therefore, the heat removed by water (Q) is calculate as

$Q = m.C_{pw}.\Delta T$... (4.1)

Where,

m = mass of water in Kg. (15 Kg)

Cpw = Specific Heat of water (4.187 KJ/ Kg-K)

Q = Heat Removed from water in KJ

ΔT = Total Decrease in Temperature in ^{0}C

V. Result And Discussion

Test was conduct for 30 minutes for each observation. For observation 1 to 3 the position of cylinder was upright. As LPG is heavier than air the flow of LPG at the outlet of regulator was in gaseous state. The result obtained from this arrangement i.e. when the cylinder in upright position had not shown any drastic fall in temperature of water. Also there was cooling of only 2 to 3 turn of evaporative coil. Table 2 shows the result obtained.

Sr.No.	Temp of Water Before Test (T1) ^{0}C	Temp of Water After Test (T2) ^{0}C	Total Decrease in Temperature (ΔT)	Total Heat Removed (Q) KJ
1	29	29	0	0
2	32	31	1	62.805
3	32.5	31	1.5	94.207
4	32.5	29.5	3	188.415
5	32.6	25.4	7.2	452.196

Table No. 2 Total Decrease in Temperature (ΔT) ^{0}C and Total Heat Removed (Q) KJ

Fig. 2 shows the heat removed from the water at each observation with the mentioned component arrangement and corresponding cooling effect obtained. Here the cooling effect obtained is equal to the heat removed.

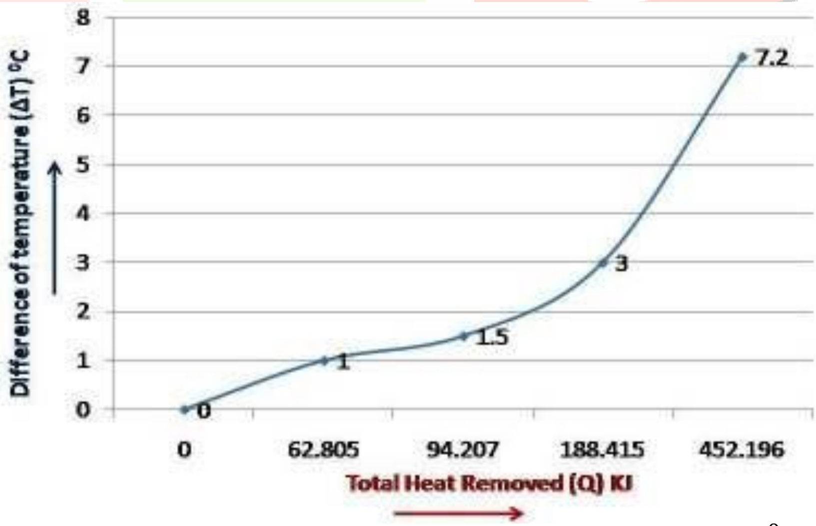

Fig.2 Heat Removed from Water (KJ) and Cooling Effect Obtain (^{0}C)

For observation, 4th and 5th the cylinder position made inverted. Now in this configuration of cylinder the flow of LPG at the outlet of regulator was in pure liquid state but it observed that there was freezing of LPG with ice formation on the discharge manifold. To overcome the problem of ice formation; regulator changed for further testing. The capillary tube was fitted immediate after the regulator outlet. It ob- served that there was drastic fall in temperature along the length of capillary.

For observation 4th and 5th, flow of LPG at the inlet of evaporative coil was found in low temperature liquid state. This is the state 3 as in vapour compression cycle. The cooling effect obtained in this state is calculated as the cooling effect obtained is equal to the heat removed from water. Heat removed from water for each observation was calculated as total decrease in temperature obtained from the difference of two temperatures T1 and T2 respectively. Further the phase change was observe in evaporative coil as the flow of LPG at the out let of evaporative coil was in high temperature gaseous state which was further supplied to LPG burner. The flow of LPG through the gas burner found uninterrupted.

VI. Conclusion

The outcome of the entire test shows that it is possible to obtain the cooling effect from expansion of LPG without the use of compressor and condenser as compared to the effect obtained in vapour compression refrigeration. Here one thing is important that cooling effect obtained only when the position of LPG cylinder is invert because the LPG is heavier than air. The regulator uses with domestic LPG cylinder is not suitable to supply gas in liquid state hence special design gas regulator is necessary. As the length of hose between flow control valve and evaporative coil, increase there is decrease in cooling effect. Too much short length of hose and evaporative coil leads to frosting of LPG in and on evaporative coil. In addition, it observe that if flow rate varied due to change in position of knob at burner, there is rise in pressure in entire system that is dangerous as system designed for dual purpose i.e. for cooking and cooling. To overcome this pressure rise due to backpressure in system there must be a gas receiver with non-return valve in between burner and evaporator i.e. isolated box. Use of strong and safe design will definitely make such dual system popular in India. Using same concept it will be possible to achieve air conditioning of LPG operated vehicles.

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