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Lpg Refrigeration and its Perfomance Evolution

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ABSTRACT:- We know that the level of pollution is continuously increasing in today's world and because of this ozone layer is also continuously depleting. So the issue of ozone layer depletion has lead us towards the using of HC refrigerants such as LPG.
The working principal of LPG is that when expansion of LPG takes place there is pressure drop and increase in volume and because of that temp is also dropped and refrigeration effect is produced which is used for cooling purpose. In this project we analyzed a refrigerator using LPG as refrigerant.
Keywords:- ozone layer, HC refrigerants, pressure drop, refrigerent effect.

I. INTRODUCTION

With increase in demand of electricity in the entire globe we thought to utilize energy by secondary use which is already utilized in process of coking food. The climatic change and global warming has raised the need of alternatives in the form of refrigerators and air conditioners. Hence forth, we demonstrated ZERO COST cooling system though not effective as the former but yes can be a game changer. LPG is stored in liquefied state in cylinder at high pressure that is why compressor is not required for proposed system. However, the energy consumption of refrigerators has improved steadily year over year.The general cause of this ozone depletion event is that chlorine atoms is continuously removing ozone from the atmosphere and converted them to oxygen atoms. The HFC and CFC refrigerants have relatively high ozone depletion potential. So this reason leads us to using of LPG as refrigerant. It is the best refrigerant to replace existing refrigerants

Aim

- To calculate the COP of LPG refrigerator.
- To study and analyze the LPG Refrigeration system is our basic objective.

Properties of LPG

Colorless.
Odorless (It's normal to odorize LPG by adding an odorant prior to supply to the user, to the aid detection of any leaks).
Heavier than air.
Non-toxic.

Construction and equipments

1. **LPG Gas Cylinder :** LPG(Liquefied Petroleum Gas) is the combination of Propane (C3H8) and Butane (C4H10). It is stored in cylinders at a very high pressure of 5 bar/70psi. LPG is used as a fuel for domestic purposes as well as in automobiles and other manufacturing industries. LPG cylinder is connected to the capillary tub through a flexible pipe and by use of a suitable regulator LPG is sent into capillary tube.

2. **Dryer:-** filter-drier in a refrigeration or air conditioning system has two essential functions: one, to adsorb system contaminants, such as **water**, which can create acids, and two, to provide physical filtration. Evaluation of each factor is necessary to ensure proper and economical drier design.

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3. **Capillary Tube :** capillary tube is a long length copper tube of very small(36 gauge) diameter having length of 10-11ft. It is the most common throttling device used in domestic refrigeration system. It reduces the high pressure to the evaporator pressure. Capillary tube is the connection between the the LPG cylinder and the evaporator.

The length of capillary tube is greater when the evaporator pressure is lower. The capillary tube is a simple device with no moving part. However its small bore makes it necessary that a filter and drier is fitted before the capillary tube to prevent choking.

The size of the capillary= 36 no.
The length of capillary = 10-11ft

4. **Evaporator :** It's the evaporators where the actual cooling effect takes place in the refrigeration systems. Evaporator is a heat exchanger that exchanges heat form the substance to the refrigerant. The low pressure & low temperature LPG refrigerant enters the evaporator & transfer the heat from the substance to be cooled to the refrigerant.

Dimensions of the evaporator: 260mm *400mm *140mm

5. **Pressure and compound gauge:** Pressure gauges are the measurement devices that measure the gauge and vaccum preesure. Most commonly used pressure gauge is Bourden tube type. It uses a coiled tube, which, as it expands due to pressure increases causes a rotation of an arm connected to the tube.

6. **High pressure Regulators:** Regulators are used for regulate the flow of refrigerant. High pressure regulator sends the LPG from the cylinder.

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7. **Digital Temperature probe:** A digital temperature probe is a device that provides for temperature measurement through an electrical signal.

8. **High Pressure Tubes:** High pressure tubes are used for connecting the components and making the system leakproof where refrigerant flows.

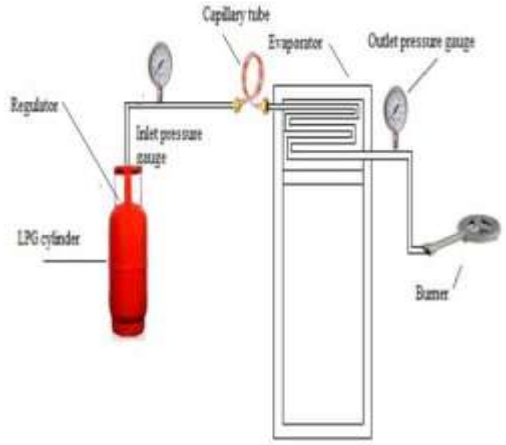
9. **Burner:-** At last a burner is required where combustion takes place and hence cooking can be done.

Working and application

Working

The basic idea behind LPG refrigerator is to use the LPG to absorb heat. The simple mechanism of the LPG refrigeration working is shown in the figure below.

1. LPG is stored in LPG cylinder at high pressure. When the valve of the of regulator opens, gas starts flowing through the pipe. Then this gas enters into the capillary tube.
2. When this high pressure LPG gas enters into the capillary tube its pressure drops and consequently its temperature also decreases but during this process the enthalpy of the LPG gas remains same.
3. After the capillary tube LPG gas enters into the evaporator. In the evaporator this low pressure and low temperature gas absorbs heat from the surrounding. Thus we get the cooling effect.
4. After the cooling effect is produced, then enters into the burning section where this low pressure gas is ready to get burn.



The principle of working of LPG refrigeration system is that when low temperature LPG enters into the evaporator it absorbs the heat

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from the surrounding. The pressure of LPG which is stored in cylinder is at about 5 bars. We are lowering this pressure of LPG up to pressure 1.03 bars by using capillary and so that cooling is done on surrounding by absorbing heat. Ideally this process of cooling is isentropic.

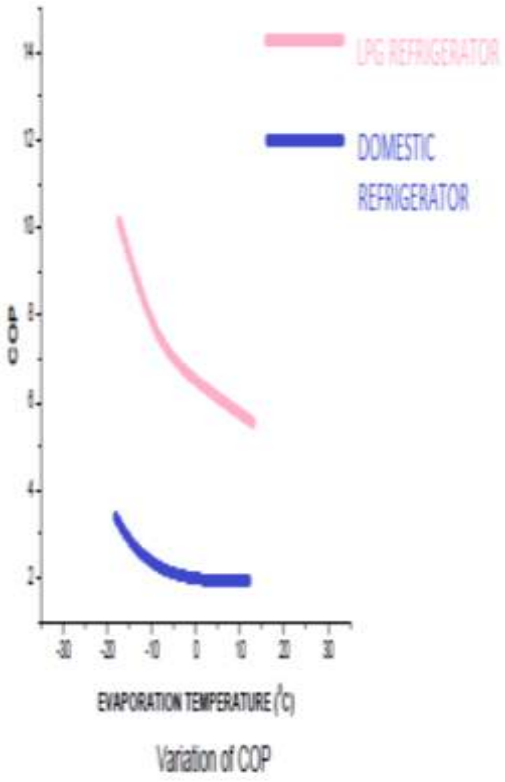
When the high pressure LPG enters into the capillary tube it expands which means the high pressure LPG is converted into the low pressure LPG. Due to the expansion of the LPG its temperature decreases. This low temperature LPG absorbs heat from the refrigerating space while passing through the evaporator coils.

Thus we can get refrigerating effect in refrigerator. After that the low pressure LPG from evaporator is passed to the burner through high pressure pipe and we can use this low pressure LPG for burning for further application In this way we can achieve refrigerating effect from this system.

Compare With Domestic Refrigerator

COP of a domestic refrigerator is normally up to 2.95. More moving parts in domestic refrigerator and not eco-friendly.

Domestic refrigerator requires more maintenance and operation is noisy.



Variation of COP

Brief Applications

- It can be used in large restaurants where continuous heating and cooling is required.
- It can be used in chemical industries for refrigeration purpose.
- It can be useful in remote parts where electricity is not available.
- It can be used in refineries where consumption of LPG is high.
- The system can universally be used in industrial central cooling and domestic refrigeration and air conditioning as well.
- It can be used in automobiles running on LPG or other Gaseous fuels for air conditioning.
- Cooling and storage of essentials in remote areas and in emergency vehicles, ;such as storage of essential bio-chemicals, injections, etc in an ambulance, is easily possible.
- It can be used for zero cost air-conditioning of spaces like airports, shopping malls, etc which have their own gas turbine power-plants.

Advantages

- Coefficient of performance of this system is higher than many household refrigerator.
- The ozone depletion potential (ODP) of LPG is 0 and Global warming potential (GWP) is 8 which is significantly negligible as compare to other refrigerant.
- A part from environment friendly, use of LPG also gives us lot of cost advantages.
- There is 60% reduction in weight of the system due to higher density of LPG.
- This fridge works when electricity is off.
- The parts are effectively silent in operation.
- Running cost is zero
- Eliminates the compressor and condenser.

Disadvantages

- Leakage of LPG causes the blast.
- Repairing and servicing of the system is difficult.
- System is very bulky

Observation and Calculation

Observation table

TIME (MIN)	CAPILLARY INLET PRESSURE (BAR)	EVAPORATOR OUTLET PRESSURE(BAR)	EVAPORATOR TEMP(°C)
0	5.52	2.52	33

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15	5.25	2.54	28
30	5.35	2.62	24
45	5.12	2.11	21
60	5.48	2.50	18

Size refrigerator: -260mm*400mm*140mm mm³
Initial temperature of evaporator: - 33°C Specific heat of LPG vapor is 1.495kJ/Kg K

Refrigerating Effect

From propane table, The properties of LPG at 5.525 bars are Enthalpy
h_1 = 430.3 kJ/Kg.
The properties of LPG at 2.52 bars are
Enthalpy h_f = 152.1842 kJ/Kg.
h_{fg} =245.567 kJ/kg
XLPG = Dryness fraction of LPG from graph =0.5
$h2 = h_f + X.h_{fg}$ (1)
= 152.1842 + 0.5 x245.567
= 274.967 KJ/Kg
$h_g = h_f + h_{fg}$ (2)
= 152.1842 + 245.567
= 397.75 KJ/Kg.
$h_3 = h_g + C_p.\Delta T$ (3)
= 397.75 + 1.67 x 18
= 427.81 KJ/Kg
So the refrigerating effect is,
$RE = h_3 - h_2$ (4)
= 427.81 – 274.967
= 152.83 KJ/Kg
Work Input

For work input we have a LPG cylinder of 14.5 Kg. so the work input is amount of energy required for filling of 1 Cylinder.Some of the LPG bottling plants use a comprehensive monitoring technique for. Keeping track of energy / fuel Consumption on per ton basis. PCRA Energy Audit,

1. Consumption = 40×4200=168000kWh
2. For lighting energy consumption= 227340kWh
3. LPG compressor consumption= 153360 kWh

Total consumption for LPG pumps One pump having 40 kW motor and 96 m head or 150cubic meter /hour discharge Annual operating = 4200 hrs Annual energy 6 hrs /day in 350 days = 168000+227340+153360 = 548700kWh Per day consumption = 548700/350
=1567.71 kWh
500 cylinders are refilled every day, so per cylinder Electricity = 1567.71/500
=3.1354kWh
For filling of 1 LPG cylinder of 14.5 kg the power input is
= 3.1354kWh
So 1 kg of LPG is
= 3.1354/14.5
=0.2162 kWh
We run the set up for 1 hr
=0.2162×1000/(9.45/10000)×3600
= 63.55W
Coefficient of Performance (COP)
COP=(h3-h2)/w (5)
= (152.83)/63.55
= 2.40

II. CONCLUSION

It is concluded that refrigerating effect is produced with the use of LPG. From observation table, It is concluded that, evaporator temperature downs from 33°C to 18°C in 60 minutes. It is also concluded that, in the capillary tube pressure of gas 5.52 bar from the cylinder is reduced to 2.52 bar. The capillary tube is more suitable in LPG refrigeration system

It does not require an external sources to run the system and moving part is absent in the system. Henceforth, maintenance cost is less as well less silent operation. This system is most suitable for hotel, industries, refinery, chemical industries where consumption of LPG is very high. The COP of the demonstrated system is **2.40**.

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