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Design of LPG Refrigeration System

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ABSTRACT:The issue of ozone layer depletion has led to the consideration of hydrocarbons (HC) refrigerant such as liquefied petroleum gas (LPG) as working fluid in refrigeration. The hydrocarbons as refrigerants have several positive characteristics such as:-very low cost, nontoxic, zero ozone layer depletion potential, good compact ability. LPG is the best refrigerant to replace existing ozone layer depletion and global warming. It works on the principle that during the conversion of LPG into gaseous form expansion takes place and there will be a pressure drop and increase in volume of LPG. This results in drop of temperature and a refrigerating effect is produced. This refrigerating effect can be used for cooling purpose.

KEYWORDS:High Ozone Depletion Potential, Global Warming Potential, Zero Ozone Layer Depletion Potential.

I. INTRODUCTION

The general consensus for the cause of this event is that free chlorine radicals remove ozone from the atmosphere, and later, chlorine atoms continue to convert more ozone to oxygen. The presence of chlorine in the stratosphere is the result of the migration of chlorine containing chemicals. The chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are a large class of chemicals that behave in this manner. Hydrofluorocarbon (HFC) such as R134a have zero ODP, but it has relatively high ozone depletion potential. The issues of ozone layer depletion and global warming have led to consideration of hydrocarbon (HC) refrigerants such as liquefied petroleum gas (LPG) as working fluids in refrigeration. The hydrocarbon as refrigerant has several good characteristics such as very low global warming, non-toxicity, zero ozone depletion potential, and good compatibility. The global warming potential value and for LPG is 11 over 100-year. To overcome the problems stated above, this study will evaluate LPG performance characteristic to the existing refrigerant. LPG is the best refrigerant to replace existing ozone depleting and global warming refrigerants like CFC and HFC. The climatic change and global warming demands accessible and affordable cooling systems in the form of refrigerators. LPG refrigeration the work designing and fabrication of a refrigerator based on liquefied petroleum gas (LPG) refrigerant has been carried out. This work studies replacement of conventional refrigerant (CFC or HCFC) by LPG as a cooling medium in a refrigerator i.e. evaporator and capillary tube according to the properties of LPG.

II. RELATED WORK

Mohammed Aasim Nazeer Ahmad (2014) [2], in his paper he presents an experimental study of isobutene (R-600a), an environment friendly refrigerant with zero ozone depletion potential (ODP) and very low global warming potential (GWP) for the replacement R-134a in domestic refrigerators. The COP and other results obtained in this experiment show a positive indication of using mixed refrigerant. The used mixed refrigerant properties like, 24.4% propane, 56.4% butane and 17.2% isobutene.

N. Austin (2012) [3], experimented a household refrigerator designed to work with R-134a was used as an investigation unit to assess the prospect of using mixed refrigerants. The recital of the refrigerator using mixed refrigerant was investigated and compared with the performance of refrigerator when R-134a was used as refrigerant. The effect of condenser temperature and evaporator temperature on COP, refrigerating effect was investigated. The energy

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consumption of the refrigerator during experiment with mixed refrigerant and R-134a was measured. The outcome shows the permanent running and cycling results showed that R134a with a charge of 100 g or mixed refrigerant with charge of 80 mg or more satisfy the required freezer air temperature of -12°C .

Prashant Sharma (2012) [1], his paper gives an analytical computation of the pressure in a capillary tube. Thereby we get a formula for evaluating the required length for capillary tube during the design.

III. DESIGN OF LPG REFRIGERATION SYSTEM

COMPONENTS

1. LPG Gas Cylinder:

Liquefied Petroleum Gas is combination of Propane (C_3H_8) and Butane (C_4H_{10}). LPG is used as a fuel for domestic purpose, drying can industrial, LPG be horticultural, to agricultural, another cooking, heating fuel.

2. Capillary Tube:

It is long length and it is coiled to refrigeration several turns so that it the capillary tube to 2.28 mm. They have small internal diameter. Internal diameter tube an application varies from 0.5 (0.020 to 0.09 inch). The capillary refrigerant enters through the capillary tube, its pressure drops down suddenly due to its small diameter.

3. Evaporator:

It's the evaporators where the actual cooling effect takes place in the refrigeration systems. The evaporators are heat exchanger surface that transfer the heat from the substance to be cooled to the refrigerant, evaporators refrigeration thus removing the heat from the cabin are used for wide variety and hence the available form of the substance.

4. Pressure gauges:

Instruments that are used to measure pressure are called pressure gauges or vacuum gauges. These gauges are available in 63mm, 100mm, and 150mm sizes and can be customized as per client. A Bourdon gauge uses a coiled tube, which, as it expands due to pressure increases causes a rotation of an arm connected to the tube.

5. Digital Temperature probe:

A digital temperature probe is a device that provides for temperature measurement through an electrical signal.

6. ON/OFF Valve:

A flow control valve is used to control the flow or pressure of a fluid.

IV. WORKING

This work replaces the conventional refrigerant by LPG as a cooling medium in a refrigerator. It works on the principle that during the change of LPG from liquid into gaseous form, expansion of LPG takes place. Due to this expansion pressure drop occurs and increase in volume of LPG. It results in the drop of temperature and a refrigerating effect is produced and it is used for cooling purposes. In this refrigeration system the high pressure LPG is passed through capillary tube and it expands, after expansion the phase change occurs and it convert from liquid to gas. Then it passes through the evaporator where it absorbs the latent heat of the stored product and produces the refrigerating effect

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Fig. 1: Basic setup

The basic components in this system are shown in set up diagram and the changes in thermodynamics properties of the fluid flowing (LPG). The figure consists of Lpg Cylinder, Evaporator, Capillary Tube, Pressure Gauges, Digital Temperature Probe, ON/OFF Valve.

V. EXPERIMENTAL OBSERVATIONS

Table .1: Experimental Readings

SL No.	Inlet Pressure (Bar)	Outlet Pressure (Bar)	Time (min)	Capillary Temp ⁰ C	Evaporator Temp ⁰ C	Water Temp ⁰ C
1	5.525	1.22	10	30	33	29
2	5.235	1.21	20	25	27	27
3	5.405	1.20	30	21	24	25
4	5.413	1.111	40	19	21	21
5	5.556	1.101	50	16	18	19
6	5.511	1.101	60	15	16	17

In the experimental reading inlet pressure gives the pressure at inlet, outlet pressure gives the pressure at outlet. The experiment is taken in a time interval of 10 min. Capillary temperature gives the temperature inside capillary tube. Evaporator temperature gives the temperature inside evaporator. Water temperature gives the temperature of water kept inside the refrigerator

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VI. CALCULATIONS

Size of refrigerator: - $335 \times 265 \times 135 \text{ mm}^3$
Initial temperature of water: - 30°C
Initial temperature of evaporator: - 33°C
Specific heat of LPG vapor is 1.495 kJ/Kg K

Refrigerating Effect

From propane table,
The properties of LPG at 5.525 bars are
Enthalpy $h_1 = 430.3 \text{ kJ/Kg}$.
The properties of LPG at 1.22 bars are
Enthalpy $h_f = 107.3 \text{ kJ/Kg}$.
 $H_{fg} = 375 \text{ kJ/kg}$

XLPG = Dryness fraction of LPG from graph = 0.5

$$\begin{aligned} h_2 &= h_f + X \cdot h_{fg}(1) \\ &= 107.3 + 0.5 \times 375 \\ &= 294.8 \text{ KJ/Kg} \end{aligned}$$

$$\begin{aligned} h_g &= h_f + h_{fg}(2) \\ &= 107.3 + 375 \\ &= 482.3 \text{ KJ/Kg.} \end{aligned}$$

$$\begin{aligned} h_3 &= h_g + C_p \cdot \Delta T \\ &= 482.3 + 1.67 \times 48 = 562.46 \text{ KJ/Kg} \end{aligned} \quad (3)$$

So the refrigerating effect is,

$$\begin{aligned} RE &= h_3 - h_2 \\ &= 562.46 - 294.8 \\ &= 267.66 \text{ KJ/Kg} \end{aligned} \quad (4)$$

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 = $40 \times 4200 = 168000 \text{ kWh}$
2. For lighting energy consumption = 227340 kWh
3. LPG compressor consumption = 153360 kWh

Total consumption for LPG pumps

One pump having 40 kW motor and 96 m head or 150 cubic meter /hour discharge

Annual operating = 4200 hrs

Annual energy 6 hrs /day in 350 days

$$\begin{aligned} &= 168000 + 227340 + 153360 \\ &= 548700 \text{ kWh} \end{aligned}$$

Per day consumption

$$\begin{aligned} &= 548700 / 350 \\ &= 1567.71 \text{ kWh} \end{aligned}$$

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500 cylinders are refilled every day, so per cylinder electricity consumption.

$$=1567.71/500$$

$$=3.1354\text{kWh}$$

For filling of 1 LPG cylinder of 14.5 kg the power input is

$$= 3.1354\text{kWh}$$

So 1 kg of LPG is

$$= 3.1354/14.5$$

$$=0.2162 \text{ kWh}$$

We run the set up for 1 hr

$$= 0.2162 \times 1000 / (9.45 / 10000) \times 3600$$

$$= 63.55\text{W}$$

Coefficient of Performance (COP)

$$\begin{aligned} \text{COP} &= (h_3 - h_2) / w & (5) \\ &= (267.66) / 63.55 \\ &= 4.2 \end{aligned}$$

After finding out the COP of the LPG refrigerator we found out the heat liberated by LPG after burning in the burner with the burner efficiency of 92 %

VII. CONCLUSION

In **LPG refrigeration**, LPG gases from the cylinder are used for the refrigeration effect. When the LPG gas is released pressure drop occurs and the weight of the gas decrease. Due to the pressure drop cooling effect develops. An LPG cylinder consists of pressure 12.41 bar and a weight of 14.5 kg equipped with a high pressure regulator. The pressure inside the cylinder is then reduced to 1.41 bar with capillary tube. The refrigerating effect changes in properties of LPG before and after the evaporator. It's with help of high pressure regulator. Therefore as a conclusion we can use LPG as refrigerant in refrigeration system. LPG will not harm the eco system. The potential of ozone layer depletion and global warming will be reduced due to usage of current refrigerant in the domestic refrigerators.

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