Design and Fabrication 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 compatibility. LPG is the best refrigerant to replace existing ozone layer depletion and global warming. It works on the principal 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 refrigerator effect can be used for cooling purpose.

Keywords-Coefficient of Performance, Global Warming, High Ozone Depletion, Hydrofluorocarbon, Liquefied Petroleum Gas, Refrigeration, Zero Ozone Layer Depletion.

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 hydro chlorofluorocarbons (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 11over 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 demand 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. LITERATURE REVIEW

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

Mohammed Aasim Nazeer Ahmad (2014) [2], presents an experimental study of isobutene (R-

600a), an environment friendly refrigerantwith zero ozone depletion potential (ODP) and very low global warming potential (GWP) for the replacement R-134a in domestic refrigerators. The COP and other result obtain in this experiment show a positive indication of using mixed refrigerator. The used mixed refrigerant properties like, 24.4% propane, 56.4% butane and 17.2% isobutene.

N.Austin (2012) [3], carried out experimentation 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 consumption of the refrigerator during experiment with mixed refrigerant and R-134a was measured. The outcome shows that permanent running of refrigerator and cycling results showed that R134a with a charge of 100g or mixed refrigerant with charge of 80mg or more satisfy the required freezer air temperature of −12°C.

III. OBJECTIVES

The objectives of our project work are as follows:

- To develop a refrigerator which has environmentally friendly nature with no Ozone Depletion Potential (ODP) and no Global Warming Potential (GDP). i.e. To use LPG as a refrigerant and eliminate the use of harmful CFCs in refrigeration cycle.

  To provide cost-effective refrigeration system to the high-end Hotel Industries. i.e. To utilize the energy of the high-pressure gas in the LPG cylinder for producing the refrigerating effect.

IV. COMPONENTS OF LPG REFRIGERATION SYSTEM

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, used for drying purpose in industries, LPG is used for horticultural purpose, cooking, heating fuel.

2. Capillary Tube:
It is long lengthy copper tube and it is coiled to refrigeration in several turns so that the capillary tube be of 2.28 mm for better performance. They have small internal diameter. Internal diameter tubes 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, thus removing the heat from the cabin.

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 customer requirement. 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.

V. 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.

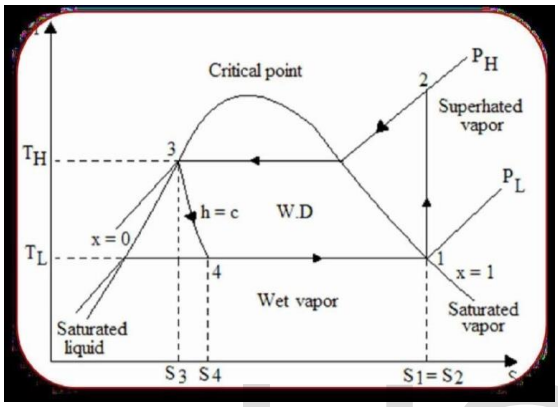

Fig1. T-S diagram of simple vapor compression refrigeration cycle

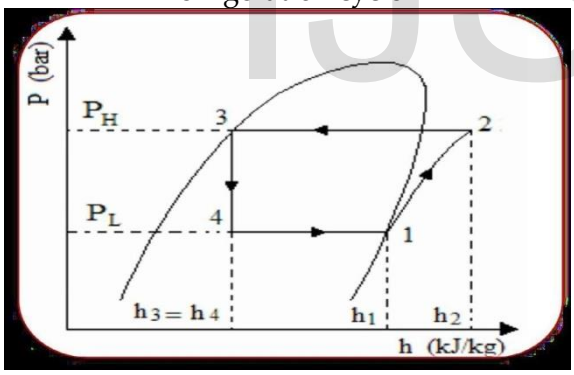

Fig2. P-h diagram of simple vapor compression refrigeration cycle

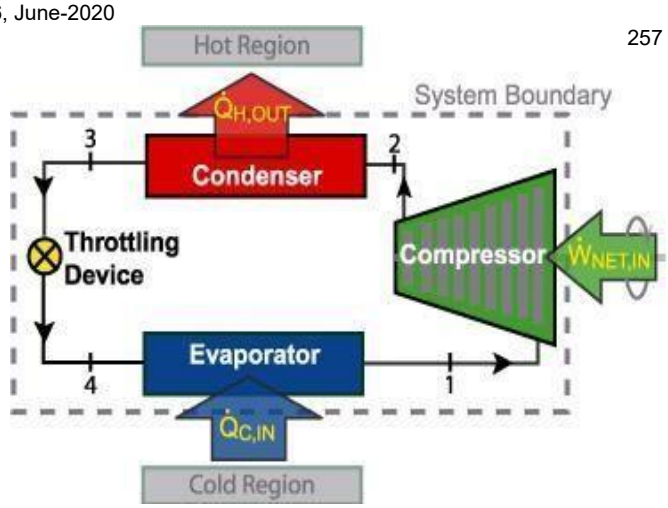

Fig3. Components of a simple vapor compression refrigeration cycle

VI. ADVANTAGES

Use of LPG as a refrigerant also improves the overall efficiency of by 10 to 20%.

- The ozone depletion potential (ODP) of LPG is 0 and Global warming potential (GWP) is 8 which is significantly negligible as compare to another refrigerant.
- Apart 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.

VII. DISADVANTAGES

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

Fig 4. Basic setup

The basic components in LPG Refrigeration system are shown in the set up diagram of Fig. 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.

VIII. CALCULATIONS

Determination of refrigerating effect

Size of refrigerator: - 335×265×135 mm^3

Initial temperature of water: - 30^0C

Initial temperature of evaporator: - 33^0C

Specific heat of LPG vapor is 1.495 kJ/Kg K

From Propane table [4],
The properties of LPG at 5.525 bars is:

Enthalpy, h_1 = 430.3 kJ/Kg.

The properties of LPG at 1.22 bars is:

Enthalpy h_f = 107.3 kJ/Kg.

Latent heat of evaporation h_{fg} = 375 kJ/kg.

Dryness fraction of LPG from graph x = 0.5

$h_2 = h_f + x.h_{fg1}$ = 107.3 + 0.5 x 375 = 294.8 KJ/Kg
$hg = h_f + h_{fg2}$ = 107.3 + 375 = 482.3 KJ/Kg
h_3 = hg + Cp. ΔT = 482.3 + 1.67 x 48 = 562.46 KJ/Kg.

So the refrigerating effect is,
R.E = $h_3 - h_2$ = 562.46 – 294.8 = 267.66 KJ/Kg

Determination of COP [4]

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

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For filling of 1 LPG cylinder of 14.5 kg the power input is = 3.1354 kWh

So for 1 kg of LPG = 3.1354/14.5 = 0.2162 kWh
and mass flow rate of LPG = $9.45x10^{-4}$ kg/sec.

We run the set up for 1 hr = 0.2162×1000/

(9.45/10000) ×3600 = 63.55kJ/kg

COP = $(h_3-h_2)/W$ = (267.66)/63.55 = 4.2

IX. 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 1.41bar with capillary tube. The refrigerating effect changes in properties of LPG before and after the evaporator, with the 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.

X. FUTURE SCOPE

- The future scope of this project is to focus on restaurant and community hall for preserving vegetables, dairy products where it serves both the purpose of preservations well as cooking of food.

- This kind of system can be implemented on the Food trucks as well where it can store in various quantities .

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