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DESIGN AND FABRICATION OF REFRIGERATOR USING LPG AS REFRIGERANT

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Abstract - *Nowadays, electricity is not available in several remote areas to run the refrigerator. To solve this problem, LPG which is generally used for the cooking purpose can also be used for the refrigeration purpose. The domestic refrigerator which uses Chlorofluorocarbon (CFC) and hydro chlorofluorocarbon (HCFC) refrigerants has comparatively high ozone depletion potential than LPG refrigerant. LPG is a hydro carbon which has several characteristics such as non-toxic, Good compatibility and zero ozone depletion potential. The changes in climate and increase in global warming demands accessible and affordable cooling system in the form of refrigerator. It works on the principle that during the conversion of LPG into gaseous form expansion occurs and there will be a pressure drop and result in increase in volume of LPG. This causes a drop in temperature of LPG and a cooling effect is produced.*

Key Words: Refrigeration, LPG, Ozone Depletion Potential, Temperature drop, cooling effect.

1.INTRODUCTION:

Before the refrigerator was introduced, Icehouses were used as refrigerator. Generally, icehouses were placed near the fresh water lakes or packed with snow were very common. They were used as natural refrigerator. The artificial refrigerator was first introduced in the year 1755 by Scottish professor WILLIAM CULLEN where he used a pump to create a vacuum in a container carrying diethyl ether which when boiled absorbs heat from the surrounding air but it had no practical application during that time.

The first practical vapor compression system of refrigeration was developed by Scottish Australian JAMES HARRISON during the year of 1856 by using ether, alcohol or ammonia as refrigerant. The first gas absorption system of refrigeration was developed by FERDINAND CARRE of France during the year 1859 which uses gaseous ammonia dissolved in water often referred as “Aqua Ammonia” as refrigerant.

Before the refrigerator was introduced for domestic purpose they were used for commercial purposes. They used ammonia or Sulphur dioxide refrigerants which leaked occasionally made them unfit for domestic use. Moreover, Sulphur dioxide is corrosive to ice and may cause loss of vision and painful skin burns. The domestic refrigerator was invented by FRED W.WOLF of Fort Wayne ,Indiana during the year 1913 which consists of a unit mounted on top of ice box however practical refrigerators were introduced in 1915 which used nontoxic ,Nonflammable refrigerant freon:12 but it damaged the ozone layer which caused the government to ban its use in 1994 and came up with a replacement using R-134a (Tetrafluoro ethane) refrigerant since 1990 .Almost all the refrigerators using nowadays require electricity since it uses compressors and condensers.

This paper briefly discusses on eliminating usage of electricity to run the refrigerator by replacing the refrigerants that were used widely by LPG which only requires capillary tube to expand and absorb heat from the surroundings. When a liquid vaporizes rapidly, it expands at a faster rate which increases its property of absorbing heat from the nearby source. This principle is used in the LPG refrigeration system to cause the refrigerating effect.

2. TYPES OF REFRIGERATORS:

2.1 COMPRESSOR REFRIGERATORS:

In this kind of refrigerators, the vapors are compressed in order to absorb heat from the substance and result in refrigeration.

2.2 ABSORBTION REFRIGERATORS:

In this type of refrigerators, when the refrigerant evaporates, it takes away heat from the objects placed inside the refrigerator, which produces the cooling effect.

2.3 SOLAR REFRIGERATORS:

The solar refrigerator works on the principle that the sunlight is used to release the gaseous ammonia from the solvent and the gas released absorbs the heat from the substance and the cooling effect is produced.

2.4 PELTIER REFRIGERATORS:

This type of refrigerator uses the Peltier effect to remove the heat from the substance and thus the refrigerating effect is produced.

2.5 MAGNETIC REFRIGERATORS:

This kind of refrigerator works on the principle of the magneto caloric effect. The cooling effect is caused by placing a metal alloy in a magnetic field.

3 CONSTRUCTION:

3.1 LPG CYLINDER:

LPG is a mixture of propane (C3H8), butane (C4H10) and pentane (C6H6) which are blend together in a cylinder. LPG is a colorless gas and non toxic in nature. It is highly flammable. It can be prepared by the refining of petroleum or wet natural gas and is almost derived from the fossil fuels like crude oil.

3.1 LPG CYLINDER

3.2 HIGH PRESSURE TUBES:

High pressure tubes are used to carry the LPG at a very high pressure. High pressure tubes are generally designed by the fundamental mechanism called Townsend discharge which ensures that there is no gas leakage in the pipe.

3.2 HIGH PRESSURE TUBE

3.3 HIGH PRESSURE REGULATOR:

High pressure regulator is used to transmit the gas coming out from the cylinder to the high-pressure tubes. Pressure regulator is generally a valve which can be used for controlling the pressure of the substance passing through it to get the desired value of pressure. High pressure regulator is used for regulating the pressure from 1 psi up to 60 psi.

3.3 HIGH PRESSURE REGULATOR

3.4 CAPILLARY TUBE:

The main function of the capillary tube is to reduce the pressure of the gas passing through it. It also increases the latent heat of vaporization. Capillary tube is either straight or coiled depending on its application. However the mass flow rate through the coiled tube is lower than that of the straight tube but the coiled tube can absorb more heat than the straight tube.

3.4 CAPILLARY TUBE

3.5 EVAPORATOR:

Evaporator is a device which is used to carry out the process of converting liquid phase into vapour phase. It also absorbs heat from the object placed inside the evaporator by the effect of gas passing through the tubes of the evaporator. An evaporator is a refrigeration system which boils the refrigerant at low pressure which results in drop of temperature which further removes the heat from the object placed inside the refrigerator.

3.5 EVAPORATOR

3.6 PRESSURE GAUGE:

Pressure gauge is a device which is used to monitor the pressure of the gas passing through the tubes. Pipe vibration and water condensation are the main reasons for the failure of pressure gauge. During winter season there is a chance for the pressure gauge to freeze and get damaged. The lifetime of the filled pressure gauge is higher than that of other pressure gauges as the pressure gauge is completely filled with viscous oil and has very few moving parts.

3.6 PRESSURE GAUGE

4. LITERATURE SURVEY

"Use of artificial neural network approach for depicting mass flow rate of R134a /LPG refrigerant through straight and helical coiled adiabatic capillary tubes "By **Jatinder Gill, Jagdev Singh** which deals with the experimental mass flow rate of R134a/LPG through straight and coil adiabatic capillary tubes were presented and also the mass flow rate through coil adiabatic capillary tubes are found lower than straight adiabatic capillary tubes.

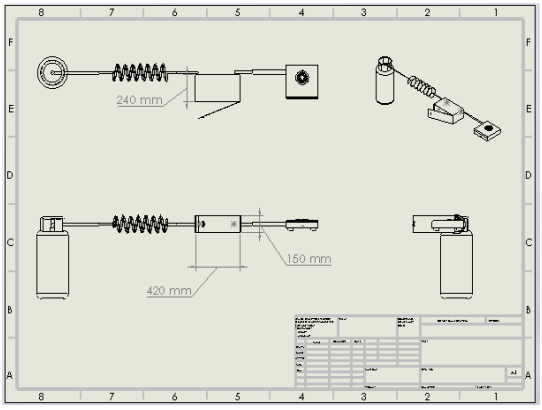
"Energy and exergy analysis of LPG (liquefied petroleum gas) as a drop-in replacement for R134a in domestic refrigerators ". By **Mohamed El-Morsi** in which the results show that R600 has the highest COP & exergy efficiency, and the lowest irreversibility and also shows that LPG has the lowest COP & exergy efficiency, and the highest irreversibility. Compared to R134a, LPG has a lower COP and exergy efficiency by an average of 10% and 5%, respectively.

5. WORKING

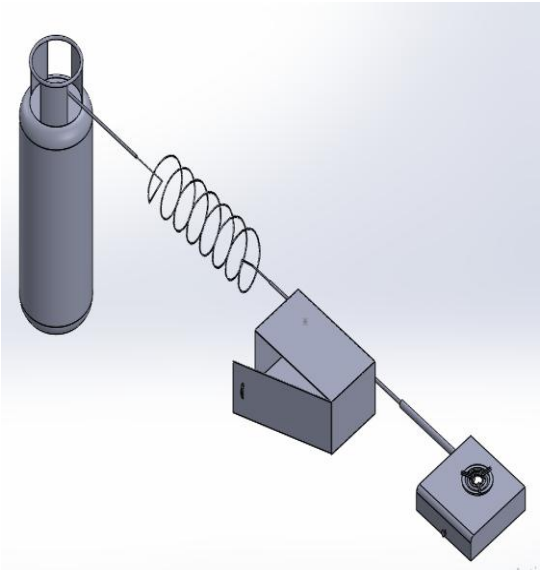
PRINCIPLE:

The basic principle is to remove heat from the objects with the help of LPG. The gas is being stored in the cylinder in the liquid form at high pressure. The stored liquid vaporizes when it is exposed to atmosphere because of its boiling temperature. The gas is made to come out of the cylinder by adjusting the regulator connected to the cylinder knob. The gas coming out from the cylinder will be of high pressure. The high-pressure gas coming out from the cylinder is adjusted by means of the regulator and then passed to the capillary tube by means of the high-pressure tube. In the capillary tube the pressure drop of the LPG occurs and the latent heat of vaporization increases. The gas leaving the capillary tube will be of low pressure and this gas is now allowed to pass through the evaporator. In the evaporator when the gas pass through the tubes of the evaporator, it absorbs the heat from the objects placed in the chamber of the evaporator. The gas coming out from the evaporator will be of higher temperature and low pressure and this gas is then given to the stove connection where it can be used for cooking purpose.

6. DESIGN:



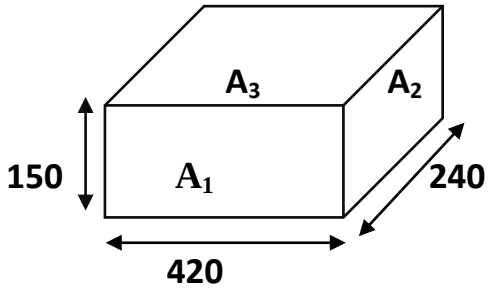
6.1 2D DRAFT



6.2 3D DRAFT

7 CALCULATIONS:

7.1 EVAPORATOR:



All units are in mm

mm – millimetre

T – Temperature

^{o}C – degree Celsius

Q – Total Heat Transfer

K – Thermal Conductivity

$A_1 = A_4$ = length * breadth

= 420*150

= 63000mm^2

$A_2 = A_5$

= 240*150

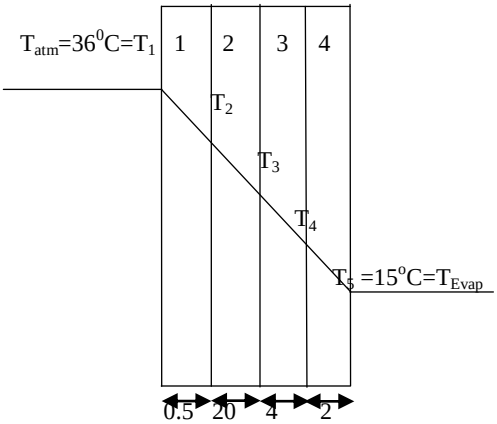
=36000 mm^2

$A_3 = A_6$

= 420*240

=100800 mm^2

NOTE: The evaporator size has been considered from the domestic refrigerator.



All units are in mm

$$Q_1 = Q_4 = \frac{T_{atm} - T_{Evap}}{(L_P/K_PA_1)+(L_{TH}/K_{TH}A_1)+(\ln[r_2/r_1]/2\pi L_{CT}K_{CT}) + (L_E/K_EA_1)}$$

K_P = 0.12 Watt/meter kelvin = Thermal conductivity of Plastic

K_{TH} = 0.02 Watt/meter kelvin = Thermal conductivity of Thermocol

K_{CT} = 386 Watt/meter kelvin = Thermal conductivity of Copper Tube

K_E = 204.2 Watt/meter kelvin = Thermal conductivity of Evaporator

Note: The thermal conductivity values are taken Heat and mass transfer data book.

$L_P = 0.5*10^{-3}$m $r_1 = 2*10^{-3}$m

$L_{TH} = 20*10^{-3}$m $r_2 = 1.5*10^{-3}$m

$L_{CT} = 4*10^{-3}$m

$L_E = 2*10^{-3}$m

$$Q1 = Q4 = \frac{36 - 15}{(0.5*10^{-3}/0.12*0.063)+(20*10^{-3}/0.02*0.063)+(\ln[2/1.5]/2\pi*3.64*386)+(2*10^{3}/204.2*0.063)}$$

$Q_1 = Q_4 = 1.32$ watts

$$Q_2 = Q_5 = \frac{36 - 15}{(0.5*10^{-3}/0.12*0.036)+(20^{*10\text{-}3}/0.02*0.036)+(\ln[2/1.5]/2\pi*3.64*386)+(2*10^{3}/204.2*0.036)}$$

$Q_2 = Q_5 = 0.38$ watts

$$Q_3 = Q_6 = \frac{36 - 15}{(0.5*10^{-3}/0.12*0.1008)+(20*10^{-3}/0.02*0.1008)+(\ln[2/1.5]/2\pi*3.64*386)+(2*10^{3}/204.2*0.1008)}$$

$Q_3 = Q_6 = 2.11$ watts

$Q_{To} = Q_1+Q_2+Q3+Q_4+Q_5+Q_6$

$Q_T = 1.32+0.38+2.11+1.32+0.38+2.11$

$Q_T = 7.62$ watts

7.2 CALCULATION OF TEMPERATURE OF REFRIGERANT:

$T_{Evap} - T_r = Q_{To}*L_T/(K_E*A_T)$

$15-T_r = 7.62*2*10^{-3}/(204.2*0.1998)$

$Q_{To} = 7.62$ W $A_T = 0.1998$ m^3

$L_T = 2*10^{-3}$m

$T_r \approx 14^oC$

7.3 CAPILLARY TUBE DESIGN:

Since the length of the capillary tube and the number of windings can be found by trial and error method, it was found that the total length of the capillary tube required for the cooling is about 40 feet and the number of windings required is 47 turns at a diameter of which provides the required minimal pressure drop and the reduction in temperature of LPG.

The temperature observed in the evaporator during the experiment is about 18^{o}C.

8. CONCLUSIONS

From this project on "Design and Fabrication of Refrigerator using LPG as refrigerant" it can be found that LPG can be used as the refrigerant in the refrigerator at a relatively lower cost than other refrigerators and it has an advantage of creating a refrigerating effect without the use of electricity. Hence it can be used in remote areas and in several places where electricity is not available frequently. This project is also eco-friendly as it does not affect the ozone layer unlike other refrigerants.

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