Performance Evaluation of Vapour Compression Cycle Operating On LPG as A Refrigerant

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ABSTRACT
Most of refrigerants used in vapor Compression system were Chlorofluorocarbon (CFCs) and Hydro Chlorofluorocarbon(HCFCs) which contains chlorine and if any leakage in the system, these gases will group and reach stratosphere. The chlorine atoms in the gases will act as a catalyst to destroy ozone layer and cause ozone depletion which causes health hazards, global warming, melting of polar ice caps and drought. Hence, it is necessary to minimize the Global warming and Ozone depletion. The refrigerant R22 widely used in the air conditioners is a major Contributor of Chlorofluorocarbons (CFCs) which cause irreparable loss to the ozone layer and has to be replaced. There are two types of global warming contributions through refrigeration and air conditioning systems. The first one is the Direct Global Warming Potential (DGWP) due to the emission of refrigerants and their interaction with heat radiation. The second one is the Indirect Global Warming Potential (IDGWP) due to the emission of Carbon Dioxide (CO_2) by consuming the energy that is generated through the combustion of fossil fuels. Experimental work has been performed on three capillary tubes of different diameter to determine the performance of domestic water cooler when a extemporaneous is liquefied petroleum gas (LPG) which is locally available and comprises 24.4% propane, 56.4% butane and 17.2% iso butane which is very from company to company. The LPG is cheaper and possesses an environmental friendly nature with no ozone depletion potential (ODP). It is used in world for cooking purposes.

Keywords
Global warming, Vapour compression cycle, Refrigerant, coefficient of performance.

1. INTRODUCTION
The term 'refrigeration' in a broad sense is used for the process of removing heat(i.e. cooling) from a substance. It also includes the process of reducing and maintaining the temperature of a body below the general temperature of its surroundings. In other words, the refrigeration means a continued extraction of heat from a body, whose temperature is already below the temperature of its surroundings. For example, if some space (say in cold storage) is to be kept at -2 ºC, we must continuously extract heat which flows into it due to leakage through the walls and also the heat, which is brought into it with the articles stored after the temperature is

one reduced to -2 ºC. Thus in a water cooler, heat is virtually being pumped from a lower temperature to a higher temperature. According to second law of thermodynamics, this process can only be performed with the aid of some external work. It is thus obvious, that supply of power (say electrical motor) is regularly required to drive a water cooler. Theoretically, the water cooler is a reversed heat engine, or a heat pump which pumps heat from cold body and delivers to a hot body. The substance which works in a heat pump to extract heat from a cold body and to deliver it to a hot body is called refrigerant. When people hear the word refrigeration they immediately think of the water cooler in their kitchen. However there are actually quite a few different kinds of refrigeration out three and they each have their own. Methods of functioning. One particular type of refrigeration is industrial refrigeration. This type of refrigeration is typically used for cold storage, food processing, and chemical processing. The equipment is very large and made of industrial stainless steel. Industrial refrigeration, which frequently uses ammonia refrigeration to maintain temperature, is necessary for computer, foodstuffs, blood, vaccines, and quite a few other goods that must maintain a constant and steady temperature at all times. Temperatures that are too high or too low may spoil certain goods or ruin them. As a result industrial refrigeration is especially important maintaining temperature is as well. Since temperature is so important into industrial refrigeration companies offering this service must pay attention at all times to the temperature of the industrial water coolers.

2. HISTORY OF REFRIGERATION
The refrigeration system is known to the man, since the middle nineteenth century. The scientist, of the time, developed a few stray machines to achieve some pleasure. But it paved the way by inviting the attention of scientist for proper studies and research. They were able to build a reasonably reliable machine by the end of nineteenth century for the refrigeration jobs. But with the advent of efficient rotary compressors and gas turbines, the science of refrigeration reached its present height. Hebrews, Greeks, and Romans placed large amounts of snow into storage pits dug into the ground and insulated with wood and straw. The ancient Egyptians filled earthen jars with boiled water and put them their roofs, thus exposing the jars to the night's cool air. In India, evaporating cooling was employed. When a liquid vaporizes rapidly, it expands quickly. The rising molecules of vapour abruptly increase their kinetic energy and this increase is drawn from the immediate surroundings of the vapour. Instead of cooling water at night, people rotate long-necked bottles in water in which saltpeter had been dissolved. This solution could be used to produce very low temperature and to make ice. The refrigerated railroad car was patented by J.B. Sutherland of Detroit, Michigan in

1867. Brewing was the first activity in the northern states to use mechanical refrigeration extensively, beginning with an absorption machine used by S .Liebmann's Sons Brewing Company in Brooklyn, New York in 1870.commercial refrigeration was primarily directed at breweries in the 1870 and 1891,nearly every brewery was equipped with refrigerating machines .Natural ice supply became an industry unto itself. Refrigeration technology provided the solution: ice, mechanically manufactured, giving birth to mechanical refrigeration.

3. LPG AS A REFRIGERANT

In India, more than 80% of the domestic water cooler utilizes HFC 134a as refrigerant, due to its excellent thermodynamic and thermo- physical properties. But,HFC 134a has a high global warming potential (GWP) of 1300. There is a need of assess various refrigerant option considering the existing water coolers in the field and for the future market. CFC's are principally destroyed by ultraviolet radiations in the stratosphere; the chlorine released in the high stratosphere catalyzes the decomposition of ozone to oxygen; and ultraviolet radiations penetrates to lower altitudes. Credible calculations of the magnitude of the effect (Hoffman 1987) and his team predicted 3% global ozone emissions of 700 thousand tonnes/year after a hundred years. The ozone impact of car air conditioners also cannot be ignored. Hydro fluorocarbons (HFC's) can be thought of as a replacement, but unfortunately the radiation properties of HFC's like R-134a make them powerful global warming agents. HFC 134a and the HC blends have been reported to be substitutes for CFC 12, but they have their own drawbacks in energy efficiency, flammability and serviceability aspects of the systems. HFC 134a is not miscible with mineral oil, and hence, poly ester oil is recommended, which is highly hygroscopic in nature. This hygroscopic demands stringent service practices, which otherwise results in moisture entry into the system. Thus, hydrocarbon refrigerants; particularly LPG serves as the best contender to replace CFC's from domestic water cooler as well as car air conditioners. LPG consists mainly of propane (R-290) and butane (R-600), and LPG is available as a side product in local refineries. In Cuba for already several decades LPG is used as a drop-in refrigerant. LPG mixtures have composition of a commercial LPG mixture suitable as 'drop-in' replacement for R-12 was calculated crudely as64% propane and 36% butane by mass. Liquefied petroleum gas (LPG) of 60% propane and 40% commercial butane has been tested as a drop-in suitable for R 134ain a single evaporator domestic water cooler with a total volume of 10 ft3. Engineers had known since the 1920's that LPG refrigerants performed well and in the 1980s water coolers manufacturers again tested them (Kuijpers et al. 1988). Fear of a flammability campaign from the chemical industry deterred any manufacture .In march 1989, the Institute of Hygiene in Dortmund Germany needed a new cold storage room. The young idealistic director, Dr Harry Rosin, could not consider using a CFC refrigerant and so tried propane and iso-butane. Greenpeace Australia imported a Foron water cooler in February 1993 and in December 1993 Email Ltd, Australia's largest appliance manufacturer, displayed prototype LPG water coolers. In 1994, German manufacturer announced one by one their intention of switch to LPG refrigerants. OZ Technology Inc, a start up company in Idaho, introduced OZ-12 a mixture of commercial propane and butane in1992. they sold over 50,000 170 g cans the first summer. The Mobile Air-Conditioning Society made flammability hazard claims including 'a bomb in the passenger compartment' (Keebler 1993, MACS 1993). The US EPA refused to approve OZ-12 on flammability grounds. OZ then introduced another LPG refrigerant HC-12a, which has already sold over 100,000 cans. The USEPA may not approve this either but OZ's petition (OZ 1994) is convincing, comprehensive and technically sound especially on safety.

4. EXPERIMENTAL SET UP

The experimental setup consists of an evaporator, a hermetically sealed reciprocating compressor, air cooled condenser, filter, receiver tank, rota meter to measure the flow rate, ball valve with manual control, helical coil capillary tube with internal capillary diameters 0.36 mm. 0.55 mm, 0.64 mm, 0.78 mm and 0.90 mm made of copper, digital energy meter of 0.5% accuracy and Watt meter with an accuracy of 1%. The experimental setup was placed in an environmental chamber of dimension 3000 mm x 3000 mm x 2500 mm to maintain a constant environment temperature. In order to reduce the experimental uncertainties.

4.1 Technical Specifications of Experimental Set Up

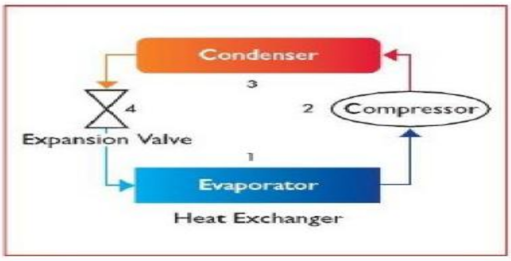


Figure 1: Refrigeration System

Capacity = 0.4960 TR

Refrigerant= LPG and R134a

Compressors= hermetically type

Condenser= Air Cooled

Evaporator= Copper Coiled dipped into water

Expansion Device= Capillary Tube, 3 nos.

Water Tank Capacity= 50 litre

Water Heater= 1 nos. 5 kw

Electrical Supply= 440 AC

5. OBSERVATION RECOREDED

a) Capillary Tube Diameter

D1= 1.524 mm, D2=1.397 mm, D3=1.27mm

b) Temperature Sensors

T1.=At outlet of Compressor

T2.=At outlet of Condenser

T 3.=At outlet of Capillary tube

T4.=At outlet of Evaporator

T5.=Water tank temperature

T6.= Ambient temperature

c) Pressure Gauge

P1=Pressure Gauge at Inlet of Compressor

P2= Pressure Gauge at outlet of Compressor

P3= Pressure Gauge at outlet of Condenser

P4= Pressure Gauge at outlet of Evaporator

5.1 Observation Table

Insert Table No-1 & 2

5.2 Calculations

At 40 C & for capillary tube No-1

Cooling Capacity:

$$\text{Refrigerating Effect} = \frac{Mw * Cpw * (\text{Initial temp.-Final temp.})}{40 * 60}$$

Where, Mw= mass of water (litre)

Cpw=specific heat of water (4.187 kJ/kgk)

$$R.E = \frac{50 * 4.187 * (41-31)}{40 * 60}$$

R.E=0.87229 KW

$$\text{Work Supplied} = \frac{3600 * \text{No. of impulse} * \text{efficiency of motor}}{EMC * \text{time for 10 blinks}}$$

$$= \frac{3600 * 10 * 0.8}{3200 * 25.32}$$

W.S =0.371 KW

$$COP = \frac{\text{Refrigerating Effect}}{\text{Work Supplied}}$$

$$= \frac{0.87229}{0.371}$$

COP = 2.35

6. RESULT AND DISCUSSION

Table 3.

Temp in ◦ c	Capillary Tube No	COP	
		LPG	R134a
25	1	1.48	1.35
	2	1.3	1.14
	3	1.16	0.97
30	1	1.39	1.22
	2	1.22	1.01
	3	1.03	0.88
35	1	1.96	1.34
	2	1.51	1.23
	3	1.37	1.11
40	1	2.35	1.61
	2	2.19	1.47
	3	2.06	1.36
45	1	2.25	1.54
	2	2.15	1.42
	3	2.19	1.3
50	1	2.15	1.47
	2	2.02	1.35
	3	1.62	1.25

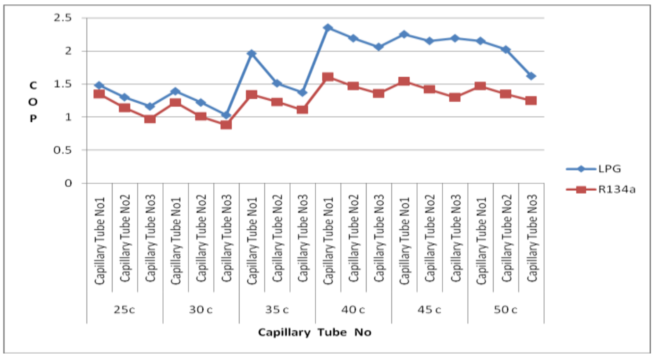


Table 4.LPG as a Refrigerant

Temp in ◦ c	Capillary Tube No 1	Capillary Tube No 2	Capillary Tube No 3
25	1.48	1.3	1.16
30	1.39	1.21	1.03
35	1.96	1.51	1.37
45	2.25	2.15	1.96
50	2.15	2.02	1.62

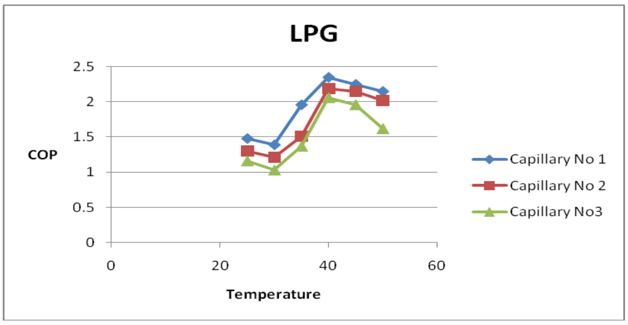
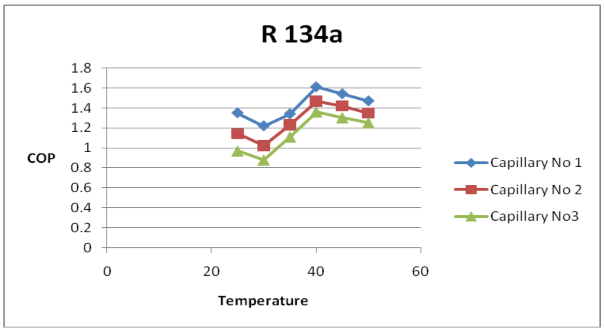


Table 5. R134a as a Refrigerant

Temp in ◦ c	Capillary Tube No 1	Capillary Tube No 2	Capillary Tube No 3
25	1.35	1.14	0.97
30	1.22	1.02	0.88
35	1.34	1.23	1.11
40	1.61	1.47	1.36
45	1.54	1.42	1.30
50	1.47	1.35	1.25



1. The COP of LPG as a refrigerant is greater as compare to R134 as a refrigerant
2. The COP of both the refrigerant is higher for capillary tube no 1 which has greater diameter as compare to remaining two i.e. due to lower frictional losses.
3. The difference between COP of LPG Refrigerant and R134a refrigerant is goes on increasing as the temperature increases.

7. CONCLUSION

Due to ozone depletion & global warming impact, most of CFe Refrigerant are phased out. LPG is one of the good replacements for CFe. Using LPG as a refrigerant it gives more COP as compared to R-134(a) which is considered as one of the eco-friendly refrigerant. Use of LPG for commercial application will be possible if property table for LPG & solution for its higher flammability is developed.

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