Review on Energy Analysis of Vapor Compression Refrigeration System Using R134a and LPG mixture with Varied Concentration of SiO_2 Nano Lubricant with Varied Capillary Tube Length

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Abstract : This review paper presented on the energy analysis of the vapor compression refrigeration system using a mixture of R134a and LPG refrigerants with various concentrations of SiO_2 nano lubricant with various capillary tube length in R134a compressor of a domestic refrigerator. In this paper the R134a (HFC) coolant high global warming capacity (GWP), immiscibility with issues of conventional mineral oil and flammability issue in Liquefied petroleum gas (LPG) (HC), and these problems can overcome by mixture of R134a and LPG coolant gives excellent results. It guess that the Nano particle refrigerant SiO2 is used in the mixture of R134a and LPG refrigerant can gives better properties and better results in domestic refrigerator .With the use of Nano refrigerant, the refrigerator parameters like compressor power can be reduced and compressor life can be increased. Coefficient of performance (COP) can be increased, second law efficiency and minimum IR-reversibility.LPG and SiO_2 nano lubricant mixture work safely and efficiently in domestic refrigerator with and without modification of capillary tube length.

***IndexTerms* - LPG, SiO_2 nanoparticles , Power consumption ,COP ,Total irreversibility, Domestic refrigerator.**

I. INTRODUCTION

The vapor compression cycle is the most extensive system for a cold generation. It is largely used in domestic, commercial, and industrial refrigeration (including air conditioning systems).These systems typically present high energy consumption , and this use may increase in case of system failure .Thus reduction of energy consumption is a major concern in vapor compression refrigeration system. For the reduction of energy consumption in these systems, it is necessary to have efficient systems. Inside developing nation, most of the vapor compression refrigeration system (VCRS), keep running on halogenated refrigerants because of their excellent thermodynamic as well as thermo physical properties in addition to the lowprice .However ,the international protocols (Montreal and Kyoto) restrict the use of the halogenated refrigerants in the vapor compression based refrigeration systems .As per Montreal Protocol 1987, the use of chlorofluorocarbons was completely stopped in most of the nations. However, hydro chlorofluorocarbons refrigerants can be used until 2040 in developing nations, and in developed nations, should be phased out by 2030.Thus to meet the global demand in refrigeration and air-conditioning sector, it is necessary to look for long-term alternatives to satisfy the objectives of international protocols [1].

As per the Kyoto Protocol to the United Nations Framework Convention on Climate Change, the particular emission of hydro fluorocarbon (HFC) refrigerants required to lessen possibly. Many developing countries still uses R134a (HFC) in refrigeration devices due to lowcost and excellent thermodynamic as well as thermophysical properties. Moreover protecting against the specific loss of R134a by refrigeration devices seriously is not very easily attainable and leakage of HFC refrigerants make a substantial contribution to the Global Warming .Consequently, to obtain environmentally safe practices, R134a is going to be prohibited quickly. Also, there are a few additional difficulties connected with R134a for example, high global warming potential (GWP) of 1430 and its immiscible nature along with conventional mineral oils .For this reason, Polyolester oil (POE) usually preferred for R134a systems[2]. The high hygroscopic character of Polyolester oil requires strict maintenance practices to prevent the moisture absorption, therefore; the need for long-term alternative refrigerants which meet the objectives of international protocols is obvious [2].

Many researchers have reported that liquefied petroleum gas (LPG) refrigerants are found to be energy efficient and environment-friendly alternative option in vapor compression refrigeration systems. In the relatedwork, reported that liquefied petroleum gas (composed of R290, R600, and R600a, in the ratio of 30:55:15, by mass) showed the better performance compared to that of R12. Furthermore,[3] also reported that LPG showed the better performance compared to that of R134a in domestic refrigerators . Although hydrocarbons(HC) including LPG have flammability issues, they still used in the refrigeration system with charge limit of 150 g because of being not expensive, zero ozone depletion potential, available in bulk and low global warming potential. Recently, workability of hydrocarbons including liquefied petroleum gas in existing refrigeration system, with or without modification and their high energy efficiency has the primary justification for their application in the VCRS. Moreover, a decrease inflammability of LPG (HC) may be accomplished just by blending along with R134a (HFC). HC and HFC refrigerant mixtures with small environmental impacts are considered as potential alternatives to phase out the existing halogenated refrigerants [4].

In addition to this, HC/HFC blends have good miscibility with conventional mineral oil . The global warming potential (GWP) associated with HC/HFC blends is also less than one-third of HFC if it used alone. The literature in this paper refers that R134a (HFC) refrigerant has high GWP, immiscibility with conventional mineral oils issues and LPG (HC) has flammability issue, and these problems can be overcome by mixing the R134a and LPG with an appropriate mass fraction. Therefore, the mixture composed of R134a and LPG considered as an alternative to R134a. LPG used in this is a mixture of three hydrocarbons (30% propane, 55% n-butane, 15% iso-butane). Shows the variation of vapor pressure on saturation temperature for R134a, LPG, and R134a/LPG refrigerants. It observed from the that the vapor pressure chrematistics of R134a/LPG (28:72) closely matched with the R134a over a wide range of saturation temperatures[5]. The properties of R134a/LPG in comparison with R134a are tabulated in. The literature review brings out the fact that many researcher have studied with LPG as an alternative to R12 and R134a in a vapor compression refrigeration system. However, the possibility of replacing of R134a in the vapor compression refrigeration system with R134a/ LPG by energy analysis needs investigation .The nano refrigerant is used to improve system performance and its decreased energy consumption of the system (viz .enhance the heat transfer rate in cooling coil). If the nano- refrigerant does not cool at the desired level in the condenser , then the cooling coil does not cool the water to the saturated level .As seen in hot and dry weather , performance of air- cooled condenser decrease ,which is increased the energy consumption of the chillers . The heat rejection in the condenser is not offered in sufficient quantity; The nano- refrigerant choked the chiller , In that case the system does not work properly [6] .

Therefore some researchers are trying to reduced the consumption of electricity by using nano refrigerant . Application of nano particle in refrigeration system using hydrocarbons have been found to improve their efficiency consideribily . Numerous experimental investigation have been performed recently [7]. nanoparticle and mineral oil mixture as replacement for POE (polyol-ester) oil in a vapor compression domestic refrigerator, charged with different refrigerants (R436A, R436B and R134a), and observed under varied ambient temperature conditions .Nano lubricant, which was prepared by dispersing nanoparticles in lubricant, performed better than base fluid when using in refrigeration compressor. Several works have applied nanolubricant in vapour-compression refrigeration systems and found that it is an effective way to reduce refrigerator ir-reversibility, enhance energy efficiency ratio of domestic refrigerator and residential air conditioners, as well as increase the coefficient of performance of the refrigeration system. In a domestic refrigerator, lubricant plays roles of lubricating internal parts, cooling the compressor during working, cleaning the system, and circulating with refrigerant as working fluid. Therefore, there were two main causations for the improving performance of refrigeration system using nanolubricant. On one hand, adding of nanoparticles should change tribological properties of the lubricant, which could improve the energy efficiency of refrigerating compressor[8].

Damola S Adelekan[3] found that TiO_2 nanoparticles increased the density and viscosity of base lubricant (synthetic polyolester) and mineral oil, while discovered the same tendency by dispersing Si nanoparticles into mineral oil [9]. Jatinder Gill[1] investigated the friction and antiwear characteristics of TiO_2, SiO_2 ,Al_2O_3 added nanolubricant mix with mineral oil in scroll compressors .The result indicated that the fullerene nanoparticles improved the lubrication property of base lubricant by coating the friction surfaces. And higher volume concentration of these nanoparticles resulted in the lower friction coefficient and less wear. Further more, the viscosity of lubricant played a major role in the wear behavior of sliding contacting surfaces experiencing extreme[10]. The most commonly used refrigerant in small hermetically sealed units is R134a, but it has high Global Warming Potential (GWP). In this scenario, research has to be carried out to develop an eco-friendly refrigerant mixture with low ODP and low GWP values with performance that is as good as R134a. In present work, attempted to find a binary mixture of refrigerant R436A (R290/R600a)(54%/46%) which could be an alternative to R134a. Efforts have been made to specify a particular composition of binary mixtures and to study their performance compared to R134a.By using experimental values to generate the enthalpies values at a different processes[11].

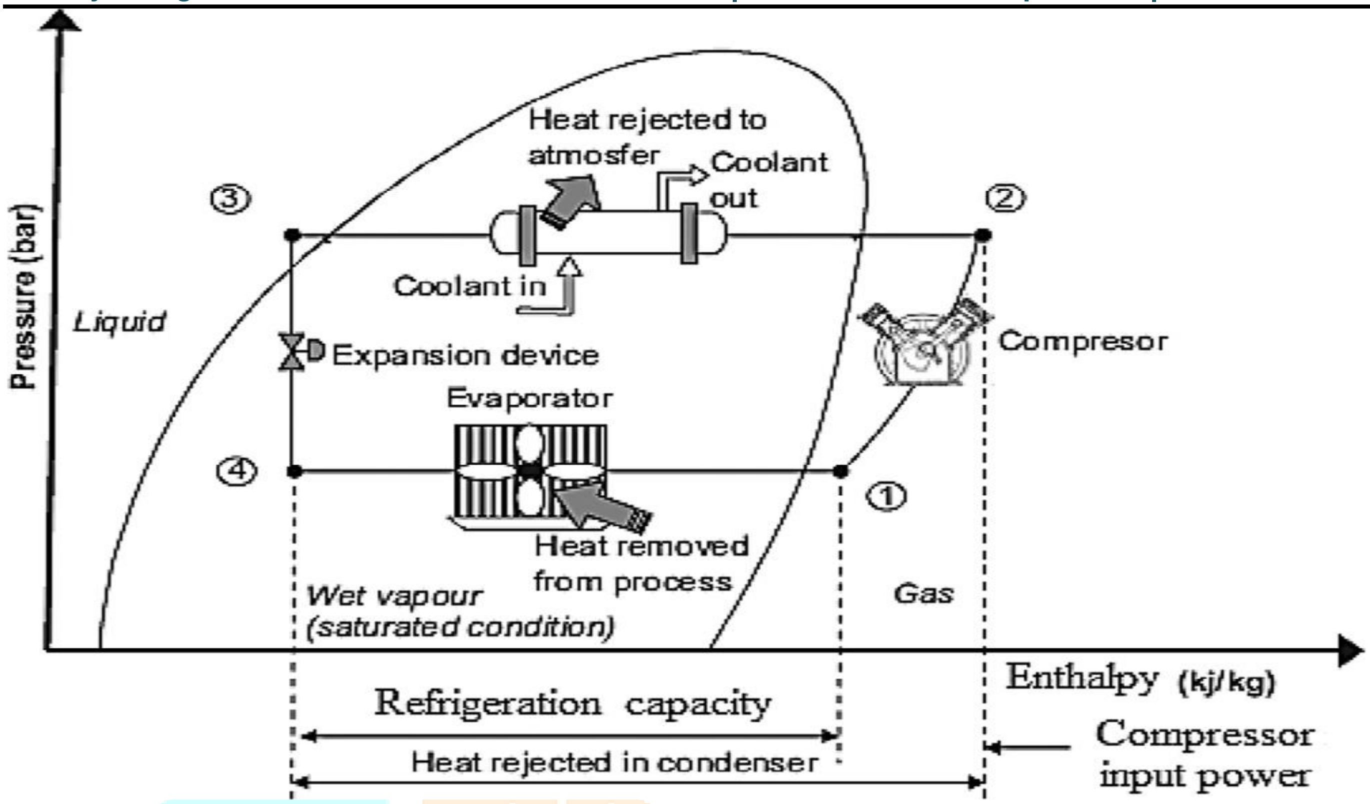

Fig. 1 – Pressure-Enthalpy (P-h) diagram of the vapor compression refrigeration system. [1]

2.0 NANO LUBRICANTS

The nanoparticles are particles between 1 and 100 nanometers (nm) in size, with the surrounding interfacesial layer. The interfacial layer is an integral part of nanoscale material, which basically affects all its properties. The interfacesal layer usually consists of ions, inorganic and organic molecules. Nanoparticles can be added to the lubricant (compressor oil) and the lubricant nanoparticles mixture is known as nanolubricant. Similarly nanoparticles can be added to the refrigerant and the refrigerant nanoparticles mixture is known as nanorefrigerant. Nanolubricant-refrigerant can be prepared by mixing pure refrigerant with nanolubricant. Nanolubricant, nanorefrigerant & nanolubricant-refrigerant are type of nanofluids. In refrigeration systems, nanolubricant improves tribological characteristics improving compressor performance; nanorefrigerant improves thermo-physical properties, improving refrigerating effect.The tribological properties of surface modified SiO_2 nanoparticles suspension in water-based lubricant have been studied. SiO_2 (5-15 nm) nanoparticles were dispersed through surface modification with mineral oil. Transmission electron microscope (TEM) and infrared (IR) spectroscopy show that SiO_2 nanoparticles disperse well and stably in the water-based lubricant. The diameter of the nanoparticles is about 30-40 nm. Tribological properties of the water-based lubricant were evaluated using four-ball wear test machine and pin-on-disk tester under different loads and different concentrations of SiO_2 nanoparticles. Wear surface morphology, element chemistry configuration of steel balls and steel rings were studied by means of X-ray photoelectron spectroscopy (XPS) and scanning electron microscopy (SEM).

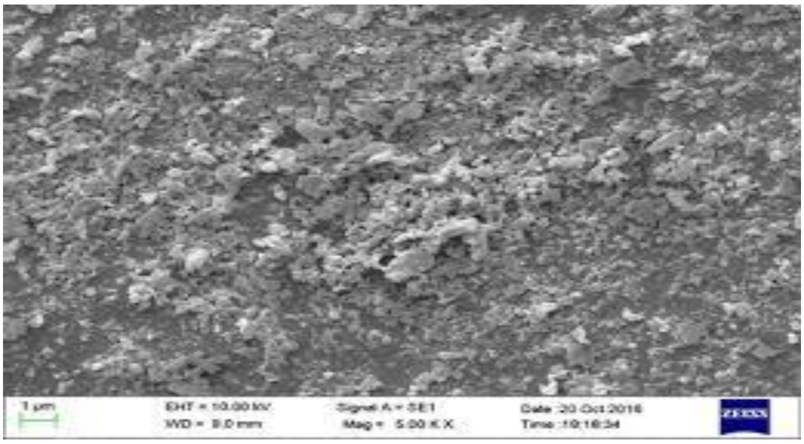

Fig. 2- SiO2 (5–15 nm), Nano particles [5]

3.0 DIFFERENT PART USED IN VAPOR COMPRESSION REFRIGERATION SYSTEM

3.1 Compressors

A compressor is the most important and often the costliest component (typically 30 to 40 percent of total cost) of any vapor compression refrigeration system (VCRS). The function of a compressor in a VCRS is to continuously draw the refrigerant vapor from the evaporator, so that a low pressure and low temperature can be maintained in the evaporator at which the refrigerant can boil extracting heat from the refrigerated space. The compressor then has to raise the pressure of the refrigerant to a level at which it can condense by rejecting heat to the cooling medium in the condenser.

3.2 Condensers

Condenser is a device or unit used to condense a substance form its gaseous to its liquid state by cooling it. In so doing the latent heat is given up by the substance and transferred to the surrounding environment. Condenser can be made according to numerous design, and come in many sizes ranging from rather small to very large . A refrigerator uses a condenser to get rid of heat extracted from the interior of the unit to the outside air.

3.3 Expansion Device

Expansion device is also known as throttling device is an important device that divides the high pressure side and the low pressure side of a refrigerating system. It is connected between the receiver and the evaporator containing liquid refrigerant at high pressure and liquid refrigerant at low pressure). The expansion device performs the following function. It reduces the high pressure liquid refrigerant to low pressure liquid refrigerant before being fed to the evaporator. It maintains the desired pressure difference between the high and low pressure side of the system, so that the liquid refrigerant vaporizes at the designed pressure in the evaporator. It controls the flow of refrigerant according to the load evaporator.

3.3.1Capillary tubes

Capillary tube is one of the commonly used throttling devices in the refrigeration and the air conditioning systems .The capillary tube is a tube whose diameter is less than 1 cm. This tube is used to reduce pressure and temperature. We want to use the length of the capillary tube in this experiment by changing it. So that the result of our project is good.

3.4 Evaporators

An evaporator is a device in a process used to turn the liquid form of a chemical substance such as water into its gaseous form/vapor .the liquid is evaporated ,or vaporized , into a gas form of the targeted substance in that process. An evaporator /evaporative – process can be used for separating liquid chemicals as well as to salvage solvent.

4.0 REFRIGERANT

A refrigerant is a material whose boiling and condensation moves heat from one heat exchanger to another .Any substance which can be used to abstract heat from other substance, and thereby lower their temperature, can be used as a refrigerant. The refrigerant is a heat carrying medium, which undergoes the thermodynamic cycle of refrigeration (i.e. compression, condensation, expansion, evaporator).The ideal working fluid or often called refrigerant would have favorable thermodynamic properties, be noncorrosive to mechanical components, and be safe, including freedom from toxicity and flammability. It would not cause ozone depletion or climate change**.**

4.1 R134a

Refrigerant R134a is a hydrofluorocarbon (HFC) that has zero potential to cause the depletion of the ozone layer and very little greenhouse effect. R134a is the nonflammable and non-explosive, has toxicity within limits and good chemical stability. It has somewhat high affinity for the moisture. The overall physical and thermodynamic properties of refrigerant R134a closely resemble with that of refrigerant R12. Due to all the above factors, R134a is considered to be an excellent replacement for R12 refrigerant. It is safe for normal handling as it is non-toxic, non-flammable and non-corrosive.

4.2 Liquefied Petroleum Gas (LPG)

Liquefied petroleum gas (LPG) refrigerants are found to be energy efficient and environment-friendly alternative option in vapor compression refrigeration systems. In the relatedwork, reported that liquefied petroleum gas (composed of R290, R600, and R600a, in the ratio of 30:55:15, by mass) showed the better performance compared to that of R12. Furthermore,[3] also reported that LPG showed the better performance compared to that of R134a in domestic refrigerators . Although hydrocarbons(HC) including LPG have flammability issues, but use in refrigeration system with charge limit of 150 g because of being not expensive, zero ozone depletion potential, available in bulk and low global warming potential. Recently, workability of hydrocarbons including liquefied petroleum gas in existing refrigeration system. Table 1 shows different properties of R-134a and Liquefied petroleum gas.

Table 1 Properties of R-134a and LPG

No	Properties	R-134a	LPG
1	Ozone Depletion Level	0	≈ 0
2	Global Warming Potential (GWP)	1200	0
3	Boiling Point	-26.1°C	-42°C
4	Critical Temperature	122°C	104°C

5.0 CONCLUSION

The selection of high quality refrigeration lubricants is driven by compressor, application parameter, and most importantly, the type of cooling liquid. We provide a wide range of synthetic and mineral oil-based refrigeration oils, which are manufacturer-approved manufacturers, and suitable for a wide range of refrigeration applications.

1. The mixture of R134a and LPG gives better properties in comparison to R134a ,and gives better result better working condition with the use of SiO_2 nano lubricant.
2. It is use as a lubricant hence compressor can work efficiently without wear and tear.
3. SiO_2 nano lubricant has excellent properties and better result in the mixture of R134a and LPG refrigerant.

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