Review of Thermodynamically Evolution of Refrigeration system using Nanoparticles(as a Nanorefrigerant)

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Abstract - ***The energy requires to the refrigeration system is much high in Industrial and Domestic area, so the energy efficient refrigeration system must be introduce without affecting it's performance. The mixture of nanoparticles with the conventional refrigerant increases the thermodynamic properties of the systems which results the less energy consumption for the system. This review paper is mainly focused on the working of nanorefrigerant in the refrigeration system. It indicate effect of the parameters like thermo physical properties and heat transfer characteristics of refrigerant and how it reducing cooling period and improved the COP of the system, while the nanoparticle was mixed with conventional refrigerant. The basic aim of this paper is to study the nanoparticles used in the refrigeration system and to get a fruitful future research.***

Key Words: **Nanorefrigerant, Nanoparticle, COP, Heat transfer coefficient, Refrigeration, Nano Fluid**

1. INTRODUCTION

A nanofluid is a fluid containing nanometer-sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in nanofluids are typically made of metals, oxides, carbides, or carbon nanotubes.
Nanofluids are a new class of fluids engineered by dispersing nanometer-sized materials (nanoparticles, nanofibers, nanotubes, nanowires, nanorods, nanosheet, or droplets) in base fluids. In other words, nanofluids are nanoscale colloidal suspensions containing condensed nanomaterials. They are two-phase systems with one phase (solid phase) in another (liquid phase). Nanofluids have been found to possess enhanced thermophysical properties such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water. It has demonstrated great potential applications in many fields. Elena Serrano et al. [10] provided good examples of nanometer to millimeter as shown in Fig. 1.

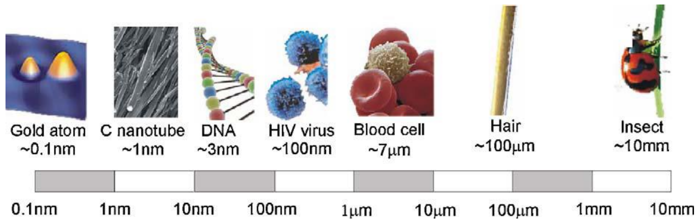

Fig - 1: Length scale of nanometer to millimeter

For a two-phase system, there are some important issues we have to face. One of the most important issues is the stability of nanofluids, and it remains a big challenge to achieve desired stability of nanofluids. In this paper, we will review the new progress in the methods for preparing stable nanofluids and summarize the stability mechanisms.
In recent years, nanofluids have attracted more and more attention. The main driving force for nanofluids research lies in a wide range of applications. Although some review articles involving the progress of nanofluid investigation were published in the past several years, most of the reviews are concerned of the experimental and theoretical studies of the thermophysical properties or the convective heat transfer of nanofluids. The purpose of this paper will focuses on the new preparation methods and stability mechanisms, especially the new application trends for nanofluids in addition to the heat transfer properties of nanofluids.

Nanofluids are prepared by suspending nano sized particles (1-100nm) in conventional fluids and have higher thermal conductivity than the base fluids.

Nanofluids have the following characteristics compared to the normal solid liquid suspensions.

- Higher heat transfer between the particles and fluids due to the high surface area of the particles
- Better dispersion stability with predominant Brownian motion
- Reduces particle clogging
- Reduced pumping power as compared to base fluid to obtain equivalent heat transfer.

Based on the applications, nanoparticles are currently made out of a very wide variety of materials, the most common of the new generation of nanoparticles being ceramics, which are best split into metal oxide ceramics, such as titanium, zinc, aluminium and iron oxides, to name a prominent few and silicate nanoparticles, generally in the form of nanoscale flakes of clay. By addition of nanoparticles to the refrigerant results in improvements in the thermophysical properties and heat transfer characteristics of the refrigerant, thereby improving the performance of the refrigeration system. In a vapour compression refrigeration system the nanoparticles can be added to the lubricant.

2. BASIC WORKING OF A REFRIGERATION PROCESS

The vapour compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. Fig. 2 depicts a typical, VCRS (Vapor Compression Refrigeration System). These systems have four main components: Compressor, Condenser, Thermal expansion valve and Evaporator.

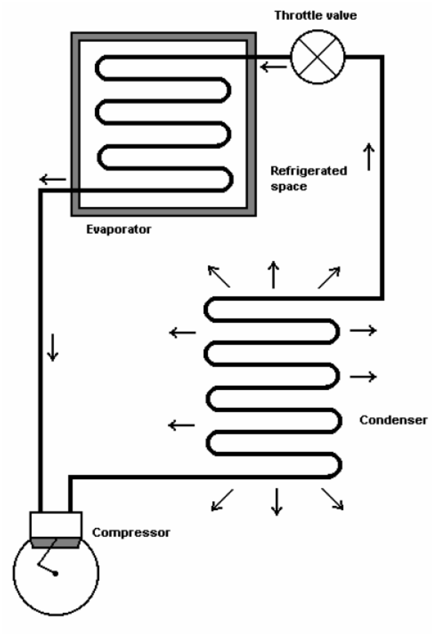

Fig – 2 Working of VCRS

Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapor and is compressed to a higher pressure, resulting in a higher temperature as well. The hot vapour is routed through a condenser where it is cooled and condensed into a liquid by flowing through a coil or tubes with cool air flowing across the coil or tubes.

The condensed liquid refrigerant, in the thermodynamic state known as a saturated liquid, is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of the liquid refrigerant. The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapour mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature.

3. LITERATURE REVIEW

Shengshan Bi [1], Performance of a domestic refrigerator using TiO_2-R600a nano refrigerant as working fluid,Energy Conversion and Management 52 (2011) 733–737, 2010:

By performing a experimental analysis on refrigerator author observed that the mixture of nanoparticles of TiO_2 with a refrigerant R600a work normally in domestic refrigerator. The 0.1 & 0.5 g/L concentration of TiO_2 - R600a mixture can save 5.94% and 9.60% energy consumption respectively. As indicates that the cooling period is reduces as shown in the Chart - 1 Fresh food storage compartment temperatures with respect to time.

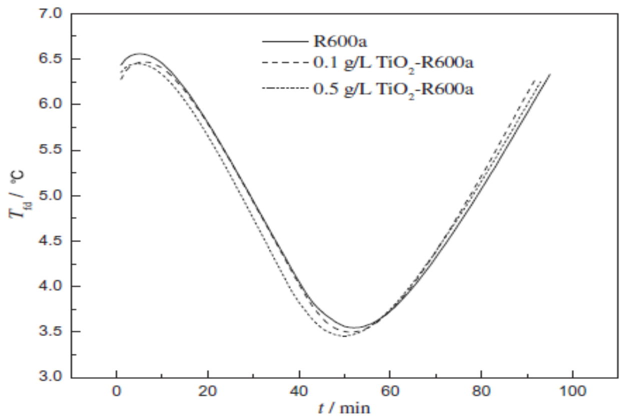

Chart – 1: Fresh food storage compartment temperatures

Hao Peng [2], Effect of nanoparticle size on nucleate pool boiling heat transfer of refrigerant/oil mixture with nanoparticles, International Journal of Heat and Mass Transfer 54 (2011) 1839–1850, 2010:

In this paper the author used Cu nanoparticles for mixing with R134a/oil mixture and observed that the Heat transfer co-efficient is increased with the reduction in the size of nanoparticles. The maximum heat transfer co-efficient is increase by a 23.8% with decreasing a nanoparticles size from 80nm to 20nm. The Impact Factor which is define as the ratio of the nucleate pool boiling heat transfer coefficient of refrigerant/oil mixture with nanoparticles to that of refrigerant/oil mixture, increases with the decrease of nanoparticles/oil suspension concentration increases with the increase of nanoparticles concentration in the nanoparticles/oil suspension.

V. Kumaresan [3], Convective heat transfer characteristics of secondary refrigerant based CNT nanofluids in a tubular heat exchanger, international journal of refrigeration 35 (2012) 2287-2296, 2012:

The author experimentally investigated that the Reynold number reduces with the addition of MWCNT(Multi Wall Nano Tube) in pure secondary refrigerant which enhanced the convective heat transfer and found that the thermal conductivity is increased by a 19.73% at 40˚C with the addition of 0.45 vol% MWCNT in base fluid. The optimal fraction of nanoparticles addition in base fluid is must be found for achieve the maximum heat transfer performance without increasing a pumping power. 0.15vol% of MWCNT is highly favourable for enhancing the heat transfer performance with a negligible increase in pumping power.

D. Sendil Kumar [4], Experimental Study on Al_2O_3-R134a Nano Refrigerant in Refrigeration System, International Journal of Modern Engineering Research (IJMER), Vol. 2, Issue. 5, Sep.-Oct. 2012 pp-3927-3929, ISSN: 2249-6645, 2012:

The author experimentally found that the power consumption will reduce 10.32% by the mixing Al_2O_3 nanoparticles of 0.2%vol concentration with R134a refrigerant. The COP of the system is increases with the capillary tube length increasing from 8m to 10.5 and then decreases with the Al_2O_3 nanoparticles of 0.2%vol concentration mixed with R134a refrigerant.

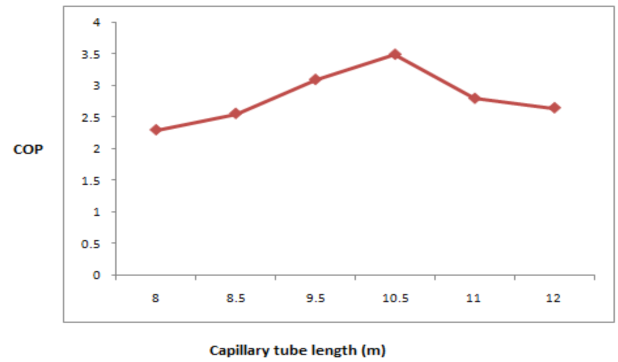

Chart – 2: COP increases with the increasing the capillary tube length

Bin Sun [5], Flow boiling heat transfer characteristics of nano-refrigerants in a horizontal tube, international journal of refrigeration 38 (2014) 206-2I4, 2013:

The author mixed four different nanoparticles(Cu, Cuo, Al, Al_2O_3) to the refrigerant, and found that it will enhanced the heat transfer and that the heat transfer coefficient increased with increased nanoparticles mass fraction. With increased mass velocities, the heat transfer coefficient of nano-refrigerant increased but the nanoparticles impact factor decreased so the enhancement in heat transfer performance decreased.

R. Reji Kumar [6], Heat transfer enhancement in domestic refrigerator using R600a/mineral oil/nano-Al_2O_3 as working fluid, International Journal of Computational Engineering Research||Vol, 03||Issue, 4||, 2013:

The R600a refrigerant and mineral oil mixture with Al_2O_3 nanoparticles worked normally which is investigated by author experimentally. Freezing capacity of the refrigeration system is higher with mineral oil + alumina nanoparticles oil mixture compared the system with only POE oil. The power consumption of the compressor reduces by 11.5% when the nanolubricant with a mass fraction of nanoparticles 0.06% is used instead of conventional POE oil.

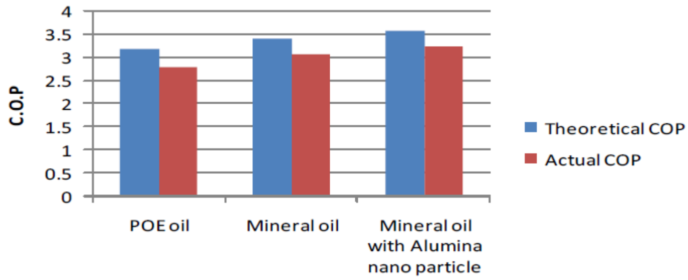

Chart – 3: COP at different conditions

D. SENDIL KUMAR [7], ZnO nanorefrigerant in R152a refrigeration system for energy conservation and green environment, Front. Mech. Eng. 2014, 9(1): 75–80, 2014:

The author experimentally observed that the system work normally and safely with replacement of R152a with R132a without any modification. And found that the maximum COP of the system 3.56 and power reduction of 21% while 0.5%v of ZnO nano particles and R152a mixture is used compared to conventional R134a refrigerant and lowest pressure ratio also obtained.

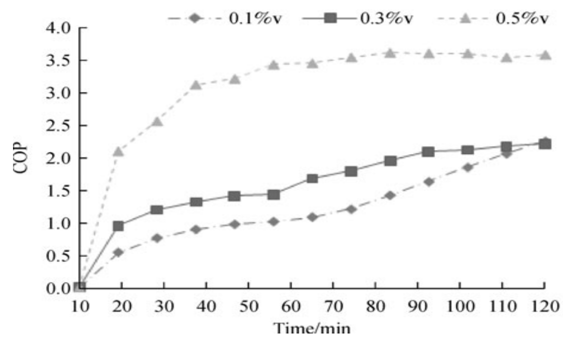

Chart – 4: COP increases with the use of nanorefrigerant

Nilesh S. Desai and P.R.Patil [8], Application of SiO_2 Nanoparticles as Lubricant Additive in VCRS: An Experimental Investigation, Asian Review of Mechanical Engineering ISSN: 2249 - 6289 Vol. 4 No. 1, 2015, pp. 1-6, 2015:

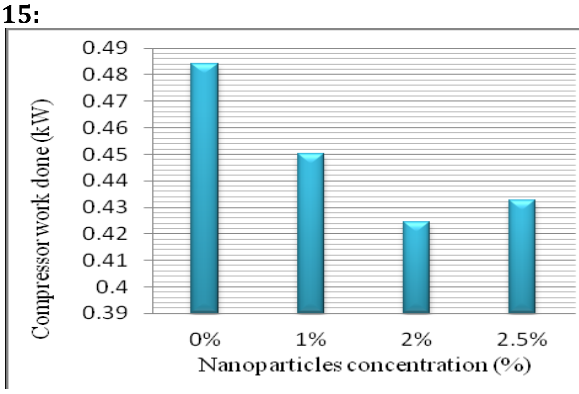

Chart – 5: Compressor work Vs Nanoparticles concentration

Experimental Investigation of author shows that by using a SiO2 nanoparticles with 1%, 2% and 2.5% by mass concentration in the POE oil, the energy saving can be achieve from 7.03% to 12.30% compared to traditional refrigerant. The production cost of nanoparticles and stability of nanofluid is major challenges in the refrigeration system.

M.E. Haque [9], Performance of a domestic refrigerator using nanoparticles-based polyolester oil lubricant, Journal of Mechanical Engineering and Sciences (JMES) ISSN (Print): 2289-4659; e-ISSN: 2231-8380; Volume 10, Issue 1, pp. 1778-1791,02016:

Author investigated the performance of a domestic refrigerator using nanoparticles-based polyolester oil lubricant and found that the nanoparticles enhance the heat transfer in the evaporator so the freezing capacity of the system increases by nanorefrigerant. The energy consumption of the compressor reduced when nanolubricants are use as compare to pure POE oil. The energy consumption of the refrigerator reduces by 27.73% when 0.1% Al2O3 nanoparticles is mixed with the POE oil and a 14.19% reduction is obtain with TiO2 nanolubricant.

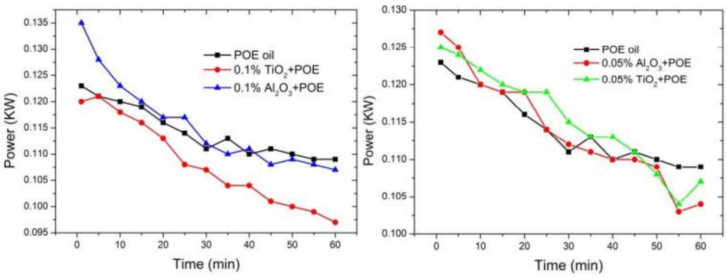

Chart – 6: Power consumption of all systems

4. CONCLUSIONS

The mixture of refrigerant and nanolubricant are work normally in the refrigeration system. The addition of nanoparticles to the refrigerant results in improvements in the thermos physical properties and heat transfer characteristics of the refrigerant. Due to improved heat transfer characteristics the cooling period was reduced. It was observed that the power consumption is reducing while nanolubricant added in the traditional refrigerant. The COP of the system was improved while nanolubricant used with the tradition refrigerant. The cooling capacity was increased for the same system while the nanolubricant was mixed with traditional refrigeration.

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