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Experimental Investigation on Nano Refrigeration

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ABSTRACT

Evaporating heat transfer is very important in the refrigeration and air conditioning systems. But refrigerant were used in refrigeration process and they were having a global warming coefficient at high level, Though the global warming up potential of HFC134a is relatively high, it is affirmed that it is a long term alternative refrigerants in lots of countries. By addition of Nano particles to the refrigerant results in improvements in the thermo physical properties and heat transfer characteristics of the refrigerant, thereby improving the performance of the refrigeration system. In this experiments comparing the effect of using, CuO-R134a & mineral oil in the vapour compression system on the evaporating heat transfer coefficient. Polyester Oil was tested along with suitability and environmental friendly refrigerant R134a. Results show that CuO nanoparticles concentration of 0.8wt% is optimal and gives highest heat transfer enhancement and improve the coefficient of performance (COP). An experimental apparatus was build according to the national standards of India. Nano CuO concentrations ranged from 0.05 to 0.8% volume proportion and particle size from 10 to 70 nm. The results indicate that evaporator heat transfer coefficient increases with the usage of Nano CuO. But economically cost for Nano refrigerant.

Keywords:— *Nan refrigerant, Nanoparticles, Cop, R134a, Mineral oil, Heat transfer enhancement.*

I. INTRODUCTION

The key to fundamental advances in technology is the structuring of new materials which are novel and vital in order to meet the challenges by substituting traditional materials. With enormous investigation and technological research over the globe: “nano”, has drastically changed and challenged every aspect of the way we think in science and technology. Nanostructured materials encompass a wide class of materials like composites, nanocrystalline materials, thin films, multilayers and so on. Their uniqueness is in exhibiting a novel behaviour in properties such as optical, thermal, magnetic and electrical due to some new physics phenomenon, or due to theories like atomic interfaces, quantum confinement, magnetic domains and many more.

Globally, 1, 1, 1, 2-Tetrafluoroethane (HFC134a) is the mainly used alternative refrigerant in refrigeration in spite of the relatively high greenhouse warming potential (GWP) of HFC134a, HFC134a has been conventional as a long-standing alternative refrigerant in many countries. In modern times, Nano refrigerants have been noted as valuable alternatives to conventional working fluids such as HFC134a, used in refrigeration systems. According to Saidur, et al., (2011), scientists use nanoparticles in refrigeration systems because of its extraordinary improvement in thermo-physical, and heat transfer capability to improve the efficiency and reliability of refrigeration and air conditioning systems. One scientist, Elcock (2007) found that TiO2 nanoparticles can be second-hand as additives to improve the solubility of the mineral oil with the hydrofluorocarbon (HFC) refrigerant. Author also report that refrigeration systems using a mixture of HFC134a and mineral oil with TiO2 nanoparticles appear to give better performance by returning more lubricant oil to the compressor with similar performance to systems using HFC134a and POE oil. According to H.K, et al., (2012) traditional mineral oil is avoid as a lubricant due to the strong chemical polarity of HFC134a in refrigeration equipment. Mineral oil as a lubricant also has the problems of flow choking and severe friction in the compressor. So nanoparticles can be used to improve the working fluid properties and energy effectiveness of the refrigerating system associated with reduction in CO2 emission. The new technology is being introduced at hand time that is, nanotechnology by the help of technology. In nano technology, a particle is defined as a small object that behaves as a whole unit with respect to its transport properties. Nanoparticles are between 1 and 100 nanometers ($1x10^{-9}$ and 1×10^{-7} m) in size. Tubes and fibers with only two dimensions below 100 nm are also nanoparticles. Novel properties that make different particles from bulk material typically increase at a critical length scale of 100 nm. They are made from ceramic objects, metals & metal oxides. nano refrigerants are form Nano refrigerant is nothing but the combination of nano particle to the refrigerant for the sake of better refrigeration process. As compared to alternative refrigerant the nano refrigerant has better heat transfer. We have seen some research hasbeen done by taking the nano refrigerant and they have found better heat transfer and energy consumption. The nano particles like CuO. Now can be form some other nano refrigerant by combining the different nano particles of same size. If it is reasonable than we can say that we can make better efforts to refrigeration processes. Refrigeration process will be converted into more efficient and more effective.

Table 1: In recent usage, nanomaterials are categorize under three module

Type Of Nanomaterial	Dimensionality	Morphology	Characteristics	Comments
Discrete nanomaterials (dn)	0D or 1D	particle or fiber	Large surface functionalization	Potential Health Hazard
Nanoscale device (node) materials	Usually 2D, occa-sionally 1D	Thin films, occasionally wires	Functionalization, electrical/ thermal characteristics	Semiconductor fabrication
Bulk (nc or ns) materials	3D	Minimum mm3	Mechanical and structural application	May be built from dn and nd materials

II. Literature Survey

Table 2: Fundamental research

2008	Bi, S., et al	TiO_2	50	R134a & (MO+TiO_2)	Reduced power consumption (>20 %) & improved cold capability with (MO + NP) compared with (R134a + POE) in household refrigerator. MO is most important part for power reduction with additional 5-10 % power saving achieve by use of NP. Oil return enhanced with NP. Studied two NP have effect on performance.
		Al_2O_3	0.01, 0.06, 0.1 NPMFL	R134a & (MO+ Al_2O_3)	
2009	Jwo, C. et Al	Al_2O_3	—	Hydrocarbon + MO + Al_2O_3	Replace R134a refrigerant by means of hydrocarbon refrigerant in addition to adding together Al_2O_3 nanoparticles to the lubricant successfully reduced power utilization.
			0.05,0.1, & 0.2 NPMFL		
2013	Kumar, R., et al	Al_2O_3	< 50	R600a + (MO + Al_2O_3)	Fluid: MO+NP / MO / POE — COP: 3.51 / 3.4 / 3.2
			0.06 NPMFL		
2014	Kumar, D., Elansezhian, R.	ZnO	50	ZnO + R152a	Presentation of refrigeration system enhanced with reduction in power consumption
			0.1, 0.3,05 NPVF		
2015	Vandaarkuzhali S., Elansezhian, R.	CuO, ZnO, Al_2O_3	50	R22+ (de-ionized Water + NP)	Air conditioning system with CuO nanorefrigerant is establish to be more power efficient than ZnO & Al_2O_3 nanorefrigerants.
			0.1 NP MF		

Table 3: Applied research in refrigeration systems

Year	Researcher	NP	Size, nm / NPC	Nanofluids	Key Results & Remarks
2008	Bartelt, K., et al	SiO_2	*30*	R134a + POE (RL68) + CuO	At 4 % NPVFL, flow boiling research show 0.5 % NLMF have no effect on flow HTC. 1 % NLMF increase HTC 42 to 84 %. 2% NLMF increase HTC 50 to 101 %. Presence of NP have insignificant effect on system pressure drop.
2009	Jiang, W., et al	*Cu*	*25*	R113+ NP	Thermal Conductivity ~ NPVF. Thermal Conductivity of nanorefrigerants with various kinds of NPs is close to one another if NPVF is same.
		Al	*18*		
		Ni	*20*		
		CuO	*40*		
		Al_2O_3	*20*		
2010	Henderson	SiO2	—	R134a + SiO_2	NP decrease flow roasting HTC. opposite result compare to supplementary studies. Distribution method influences results.
			.05,.08,.5 NPVF		
2011 2012	Mahbubul, I., et al	TiO_2	—	R123 + TiO_2	Imaginary learning shows viscosity increase with increase in particle volume fraction.
			Up to 2 NPVF		
2013	Mahbubul, I., et al	*Al_2O_3*	*30*	R134a + Al_2O_3	Thermal Conductivity ~ NPVF Thermal Conductivity ~ High temperature Thermal Conductivity ~ (1/ Particle size) NPVF ~ pressure drop ~ pumping power ~ viscosity
			1 to 5 NPVF		

III. Nanoparticle Production Techniques

Nanoparticles can be produced from mechanical erosion, pyrolysis, gas condensation, chemical precipitation. Methods like dc plasma jet, dc arc plasma, radio frequency induction plasmas, chemical synthesis, gamma rays and laser ablation are used. Inert-gas condensation is frequently used to make nanoparticles from metals with low melting points. Depending upon application (properties) & cost, specific manufacturing technologies are chosen.

IV. Limitation of Using Nano Refrigerant

The use of nano refrigerant seems attractive but its application is hindered by many factors like poor long term stability, high pressure drop, high pumping power, low specific heat, particle settling, fouling and high production cost.

V. Basic Experimental Observation of Refrigeration Process Equipment Used

Evaporator, Hermatic compressor, Condenser, Expansion valve – Capillary Tube, Refrigerant – R134a, nanoparticle –CuO. The vapour – compression uses a circulating liquid refrigerant as the medium which absorbs and remove heat up from the breathing space to be frozen and subsequently rejects that heat elsewhere. Figure 1 depicts a typical, single – stage vapor – compression system. All such systems have four components: a compressor, a condenser, a thermal expansion valve and an evaporator. Circulate refrigerant enter the compressor in the thermodynamic state known as a saturated vapor and is compressed to a higher pressure, resultant in a higher temperature as well. The hot vapor is running scared through a condenser where it is cooled and condensed into a liquid by flowing through a coil or tubes with cool air flowing transversely through 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 decrease results in the adiabatic flash evaporation of a part of the liquid refrigerant. The cold mixture is then running scared through the coil or tubes in the evaporator. A fan circulates the hot air in the together with this space transversely the coil or tubes transportation the cold refrigerant liquid and vapor mixture. That hot air evaporates the liquid part of the cold refrigerant mixture. At the similar time, the circulating air is freezing and thus lowers the temperature of the together with this space to the preferred high temperature.

Table 4 : Experimental Readings

Descriptions	**Compressor suction pressure(kg/cm2)**	**Compressor delivery pressure(kg/cm2)**	*Temperature at junctions (ºC)*				
			T_1	T_2	T_3	T_4	TIME (min)
Before adding Cu O nano-refrigrant	0.40	4.2	28	62	30	-3	15
After adding CuO nano- refrigerant	0.35	7.3	31	57	30	-4.5	6

Figure 1: Experimental setup of the refrigeration test rig

The above table 1 illustrate the clarification made in the experimental set up with and without the CuO nano particles on the performance of the system.

VI. Results and Discussion

From table values CuO nano particle with R134a refrigerant can be used as an excellent refrigerant to improve the performance in refrigeration system. A successful model has been designed and performance of the refrigerant test has been done. Coefficient of performance result have been optimized at its maximum value for the best of CuO nano particles concentration in R134a refrigeration equipment, when 0.8% volume concentration of CuO mixed with 175grams R134a. Its cop is increased highly in less time less power consumption with high cooling load, cop, energy consumption. From, the experimental investigation it performance characteristics of the system higher with usage of CuO nano particles with 134a refrigerant.

Table 5 : COPs Calculated by using R134a Chart

Refrigerant	COPs
R134a	1.4
R134a +CuO	5

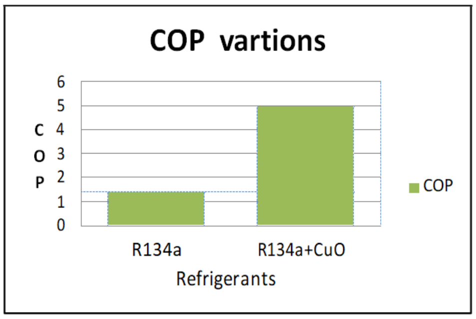

Figure 2 : COP variations

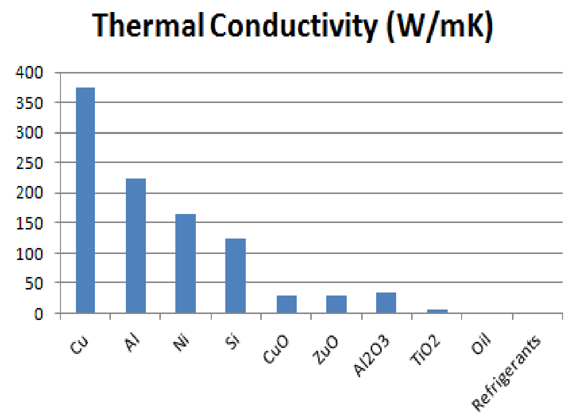

Figure 3. Thermal conductivity of Nano particles

VII. Scope for Further Work

Research were approved out with CuO, Al2O3, SiO2, TiO2, Ni, ZnO, Fe and Diamond Nano particles that are mixed in various proportions with Refrigerants R11, R113, R123, R134a, R146b and R600a. Scope is there to research with Silver oxide, Beryllium oxide and Carbon Nano tubes, Fullerene and Graphenes because of their high thermal conductivity. Silver oxide, Carbon Nantubes, Fullerene and Graphenes are very expensive and Beryllium oxide is dangerous to health if its dust is inhaled.

VIII. CONCLUSIONS

A vapour Refrigeration Compression System is experimental investigated, experimentally result show that there is considerable change the compressor with R134a and R134a with CuO, it means compressor work reduce its pumping power, work done in compressor. Here the development for new refrigeration system with low nano refrigerant is essential coefficient performance of refrigeration system which used Nano refrigeration as a working fluid, is higher than that of conventional refrigerant system. The addition of nano particles 0.8% volume concentration, has improved heat transfer properties and reduced power consumption, compressor work done. The conclusions drawn from the experiments are using nano refrigerant higher heat transfer rates are observed cop is increased, size of refrigeration system can be reduced.

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