International Journal of Scientific Research & Engineering Trends
Volume 8, Issue 3, May-Jun-2022, ISSN (Online): 2395-566X

A Review of Nano Refrigerant R134a+Al2O3 based Vapour Compression Refrigeration System

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Abstract- This research paper is deals about the today's world refrigeration systems which play a significant role to meet the human desires and never-ending analysis is being dole out by several researchers so as to boost the performance of those systems. Here, an endeavour has been created to boost the performance of the system. Our, gift study on experimental investigations into the performance of nano refrigerant (R134a + Al2O3) based mostly cooling. it absolutely was ascertained that there's additional temperature drop across the condenser for the nano refrigerant (12.37% — 10.88%) compared to refrigerant R134a. Similarly, a gain of five.52% and 9.24% was obtained for evaporator temperature. Associate in nursing improvement in COP was additionally ascertained throughout the investigations (1.17% — 9.14%). This was achieved underneath 25–26 oC evaporator temperature load. The results indicate that constant of performance will increase with the usage of nano Al2O3. So mistreatment Al2O3 nano refrigerant in cooling is found to be possible.

Keywords- Aluminium Oxide Nano particles, Silicon Oxide Nanoparticles, Nano refrigerant, Thermal Conductivity, a cop, Energy Consumption.

I. INTRODUCTION

In cooling and heating applications, thermo– physical properties of matter play a great role. It has been observed that the performance of any system mainly depends on the thermal conductivity, viscosity, specific heat and density of gases and liquids which are used in system. Conventional fluids have poor heat transfer capacity and low thermal conductivity which limits its performance. Due to this, there is always a need to develop effective & efficient fluids capable to deal with high heat transfer rate. Small solid additives usually in micrometer are good option to enhance the thermal properties of fluids, but it has been found that these small solid additives pose number of problems like particle sedimentation, particle clogging, large pressure drop in the system, corrosion of components, etc. (Maxwell et al., 1873).

Investigations shows that use of nanoparticles in typical fluids may be a sensible choice because it additionally reduces the amount of different issues as a result of, at nano-meter the fabric behaves like colloidal suspension. Fashionable technology offers us many routes to prepare nanometer sized particles. It's doable to interrupt down the bounds of typical solid particle suspensions by conceiving the concept of nanoparticle-fluid suspensions.

Area unit termed nano-fluids, obtained by admixture nano-meter sized particles in an exceedingly a base fluid like, water, oil etc. Nanoparticles like bronze oxides (Al_2O_3, CuO, SiO_2), chemical compound ceramics (AlN, SiN), semiconductors (TiO_2, SiC), inorganic compound ceramic (SiC, TiC), metals (Cu, Ag), single, double or multi walled carbon nanotubes area unit used.

Even at terribly low concentrations the nano fluids show an honest improvement within the thermal physical phenomenon and performance (Choi et al., 2001; industrialist et al., 2001). With increase in concentration and temperature they show massive improvement (Wang et al., 1999). Choi S.U.S et al. (1995) urged the thought of nanofluids by suspending bronze or nonmetallic particles. Recently some studies are according on nanoparticles in refrigeration systems as a result of its capability to enhance heat transfer characteristics, thus potency improvement.

Kumar R.R et al. (2013) investigated the result of aluminum oxide primarily based nano-lubricant on the COP of the system and phase transition capability of the system. The experimental came upon was built as per Indian standards. Refrigerants like R12, R22, R600, R600a and R134a were used as a refrigerant.

The performance of the system depends upon the thermos physical properties of the refrigerant. The addition of nanoparticles to the refrigerant leads to improvement within thermo- physical properties thereby up the performance of the cooling system. The experimental studies indicate that the cooling system with nano refrigerant works unremarkably. There was increase within the COP of the system by 19.6 %. Oil with corundum nanoparticles oil mixture was investigated and it absolutely was found that there's an increase in freezing capacity and reduction in power consumption by 11.5 % as compared to polyester. Aluminum oxide-based nano-lubricant in refrigeration system was found working satisfactorily.

Mahbubul I.M et al. (2012) studied the volumetric and temperature effects over viscosity of R123-TiO2 nano refrigerant for 5ºC to 20ºC temperatures and up to 2 % volume concentration of nanoparticles. The effect of pressure drop with the increase in viscosity has also been investigated. Based on the analysis it was found that viscosity of nano refrigerant increases accordingly with the increase of nanoparticles volume concentrations and decreases with the rise in temperature.

Furthermore, pressure drop increases significantly with the intensification of volume concentrations. Therefore, low volume concentrations of nano refrigerant are suggested for better performance of a refrigeration system. Bi et al. (2007) have experimented on a domestic refrigerator with R134a as refrigerant and a mixture of mineral oil and TiO2 was used as the lubricant. It was found that the refrigeration system with the above combination works normally and efficiently and the energy consumption reduces by 21.2% as compared with R134a/POE oil system.

Jwo C.S et al. (2009) had mixed mineral lubricant with Al2O3 nanoparticles to improve the lubrication and heat-transfer performance. This study showed that R134a + 0.1 wt % Al2O3 nanoparticles were optimal for best performance. Under these conditions, the power consumption was reduced by about 2.4%, and the coefficient of performance was increased by 4.4%.

Kang Y.T et al. (2012) measured the thermal conductivity of the Al2O3 nanofluids using the transient hot-wires method (THWM). The experimental uncertainties in repeatability were obtained as 1.95% for DI water and 1.34% for pure methanol, respectively. The results show that the dispersed nanoparticles can always enhance the thermal conductivity of the base fluid and the highest enhancement observed was 6.3% in the concentration of 0.1% (vol.) of Al2O3 nanoparticles, 40% (vol.) of CH3OH and 10% (wt.) of NaCl at 293.15 K.

In addition, the zeta potential, visualization and Tyndall effect were also investigated to discuss the stability of nanofluids. Subramani N et al. (2011) studies indicated that the refrigeration system with nano refrigerant works normally. It was found that the freezing capacity is higher and the power consumption reduces by 25% when POE oil is replaced by a mixture of mineral oil and alumina nanoparticles. Calculations showed that the enhancement factor in the evaporator is 1.53 when nano refrigerant were used instead of pure refrigerant.

Kumar S.D et al. (2012) did experimental work on nano refrigerant. Nanoparticle Al2O3-PAGoil in R134a vapor compression refrigeration system. An experimental setup was designed and fabricated. The system performance was investigated victimization energy consumption take a look at and freeze capability takes a look at.

The results indicated that Al2O3 nanorefrigerant works commonly and safely within the cooling. The performance of cooling was higher than pure lubricating substance with R134a operating fluid, a 10.32% less energy was consumed once zero.2% volume of the concentration employed in the system. The results indicated that heat transfer constant will increase with the usage of nanoparticles Al2O3. Thus, victimization Al2O3 nano refrigerant in cooling is found to be possible and works commonly.

Gupta H.K et al. (2012) in step with them advancements in technology have originated the new rising heat transfer fluids known as nano fluids. Nano fluids ar ready by dispersing and stably suspending millimicron sized solid particles in standard heat transfer fluids.

Past researches have shown that a awfully bit of suspending nanoparticles have the potential to reinforce the thermo physical and transport properties of the bottom fluid to improved properties, an improved heat transfer performance is obtained in several energy overwhelming and warmth transfer devices as compared to ancient fluids that open the door for a brand-new field of research project and innovative applications.

Wang K.J et al. (2006) applied AN experiment and studied boiling heat transfer characteristics of refrigerant R22 with Al2O3 nanoparticles. The study showed improvement in heat transfer properties and reduced bubble size close to heat transfer space. Peng H et al. (2011) investigated through an experiment influence of refrigerant-based nano fluids composition and heating condition on the migration of nanoparticles throughout pool boiling.

The nanoparticles embrace copper (average diameters of twenty, fifty and eighty nm), Al and Al2O3 (average diameters of twenty nm), and CuO (average diameter of forty nm). The refrigerants embrace R113, R141b and n-pentane. The mass fraction of grease RB68EP is from zero to ten skyscrapers, the warmth flux is from (10 to 1000) kW/m2 and therefore the initial liquid level height were from 1.3 to 3.4 cm.

The experimental results showed that a migration magnitude relation of nanoparticles throughout the pool boiling of refrigerant based nano fluids will increase with the decrease of nanoparticles density, nanoparticles size, coefficient of refrigerant, mass fraction of grease or heat flux; whereas will increase with the rise of liquid-phase density of refrigerant or initial liquid level height.

Hafez E.A et al. (2011) used CuO-R134a within the vapor compression system and evaporating heat transfer constant was through an experiment investigated.

Measurements were taken for warmth flux ranged from ten to forty kW/m2, victimization CuO nanoparticles with totally different concentrations (0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.55, 0.6, 0.8 and 1%) and nanoparticles size was from fifteen to seventy nm. there's increase in heat transfer constant up to 0.55% within the investigated concentration vary so decreases for all values of warmth flux. With nanoparticles examine to twenty-five nm heat transfer constant will increase than decrease with the rise in size of nanoparticles.

II. LITERATURE REVIEW

Air conditioners and refrigerator-freezers are major energy users in a household environment and hence efficiency improvement of these appliances can be considered as an important step to reduce their energy consumption along with the environmental pollution prevention. As per the Montreal Protocol, CFC12 is being fazed out following a stipulated time frame. The developed countries have already phased out these substances and the developing countries are to totally phase out the CFCs by 2030 as per the Montreal Protocol. Most of the developing countries are drastically reducing their CFC production and consumption. This demand for a suitable substitute for CFC12 for possible retrofitting of existing systems as well as for new systems.

S. Joseph Sekhar et al. (2004) presented two potential substitutes, namely, HFC134a and HC blends are available as drop in substitutes for CFC12. HC (hydrocarbon) refrigerants do have inherent problems in respect flammability. HFC134a is neither flammable nor toxic. But HFCs (hydro fluorocarbons) are not 15 compatible with mineral oil and the oil change is a major issue while retrofitting. They carried out an experimental analysis in a 165 liters CFC12 household refrigerator retrofitted with eco-friendly refrigerant mixture HFC134a/HC290/HC600a without changing the mineral oil. Its performance, as well as energy consumption, is compared with the conventional one. As the system has been running successfully for more than 12 months consumption by 4 to 11% and improve the actual COP by 3 to 8% from that of CFC12.

The new mixture also showed 3 to 12% improvement in theoretical COP. The overall performance has proved that the new mixture could be an eco-friendly substitute to phase out CFC12.

Satnam Singh et al. represented a review on behavior of Nano- refrigerant in vapour compression cycle with different concentration of Nano-particles. The experimental studies revealed that the performance of such systems gets improved by using Nano refrigerants. It is observed that using a Nano-refrigerant with higher concentration is not always true.

T. Coumaressin et al. studied performance of a refrigeration system using nano fluid and concluded CuO nanoparticle with R134a refrigerant can be used as an excellent refrigerant to improve the heat transfer characteristics of a refrigerant. Heat transfer coefficients were evaluated using FLUENT for heat flux ranged from 10 to 40 kW/m2, using nano CuO concentrations ranged from 0.05 to 1% and particle size from 10 to 70 nm. The results indicate that evaporator heat transfer coefficient increases with the usage of nano CuO.

Kuljeet Singh et al. carried out an investigation into the performance of a Nano refrigerant (R134a+Al2O3) based refrigeration system. It has been found out that the improvement in coefficient of performance (COP) is maximum (7.2 to 8.5%) with 0.5% Al2O3 (% wt.) nanoparticles. When the mass fraction of nanoparticles increased to 1% in refrigerant COP is found to be lower than even from pure R134a.

Further, increased mass fraction of Al2O3 (1%), lowers down the pressure and temperature after expansion of the Nano refrigerant in the expansion valve. In addition to this the specific heat of refrigerant gets decreased. So these both factor will results in decrease in the refrigeration effect, hence COP. Improvement is found to be maximum by using Nano-refrigerant R134a+0.5% Al2O3 keeping refrigerant flow rate as 6.5 LPH.

N. Subramani et al. done experimental studies on a vapour compression system using nano-refrigerants. It was found that, the R134a refrigerant and mineral oil mixture with nanoparticles worked normally (ii) Freezing capacity of the refrigeration system is higher with SUNISO 3GS + alumina nanoparticles oil mixture compared the system with POE oil (iii) The power consumption of the compressor reduces by 25% when the nano-lubricant is used instead of conventional POE oil (iv) The coefficient of performance of the refrigeration system also increases by 33% when the conventional POE oil is replaced with nano-refrigerant (v) the energy enhancement factor in the evaporator is 1.53.

D. Sendil Kumar et al. Nano Al2O3-PAG oil was used as nano refrigerant in R134a vapour compression refrigeration system and it was found that addition of nano Al2O3 in to the refrigerant shows improvement in the COP of the refrigeration system. Usage for Nano refrigerant reduces the length of capillary tube and cost effective. The system performance was investigated using energy consumption test and freeze capacity test.

The refrigeration system performance was better than pure lubricant with R134a working fluid with 10.32% less energy used with 0.2%V of the concentration used.

Omer A. Alawi et al. presented a comprehensive review of fundamentals, preparation and applications of nano refrigerants. Physical properties of nanorefrigerants such as density and viscosity, surface tension and specific heat have a significant effect on nucleate pool boiling, convective flow boiling and condensation. He concluded that adding nanoparticles to the refrigerant enhanced the heat transfer and that the heat transfer coefficient increased with increased nanoparticle mass fraction. From the literatures, it has been found that the thermal conductivities of Nano refrigerants are higher than pure refrigerants. The power consumption was reduced by about 2.4%, and the coefficient of performance was increased by 4.4%. The refrigerator's performance was found 26.1% better with 0.1% mass fraction of TiO_2 nanoparticles compared to a refrigerator's performance with the HFC134a and POE oil system.

R. S. Mishra et al. studied thermo physical properties by addition of different nanoparticle mixed with ecofriendly refrigerant are analyzed and their effects on the coefficient of performance (C.O.P.). The experimental results are indicating the thermal conductivity, dynamic viscosity and density of Nano-refrigerant (different nanoparticle i.e. Cu, Al_2O_3, CuO and TiO_2 with eco-friendly refrigerant R134a,R407c and R404A) increased about 15 to 94 %, 20% and 12 to 34 respectively compared to base refrigerant on the other hand specific heat of Nano refrigerant is slightly lower that the base refrigerant. Moreover, Al_2O_3/R134a Nano refrigerant shows highest C.O.P. of 35%. R404A and R407 with different nanoparticle show enhancement in C.O.P. about 3 to 14 % and 3 to 12 % respectively.

The cooling capacity of the domestic refrigerator is increased by 10 - 20% by using nano – refrigerant. The results indicated that CuO - R600a can work normally and efficiently in refrigerator. Combined with refrigerator using pure R600a as working fluids. 0.1 & 0.5g/L concentrations of CuO - R600a can save 11.83% and 17.88% energy consumption respectively and the freezing velocity of CuO - R600a was more quickly than the pure R600a system several investigations have been carried out to tackle the problem of Global Warming and Ozone layer depletion with the usage of alternative refrigerants in the refrigeration system. Hence it is felt that a detailed investigation on the possibility of exploring new alternative refrigerant and addition of nano additives to the refrigerant. Accordingly, the specific objectives of the present research work are as follows:

III. EXPERIMENTAL METHODOLOGY

The temperature of the refrigerant at inlet/outlet of each component of the refrigerator is measured with thermometers. Temperature measurement is necessary across each component of the system in order to investigate the performance. Similarly, pressure measurements are also taken across different components of the refrigeration system. The Pressure gauges are fitted at the inlet and outlet of the compressor and expansion valve. The pressure gauges are fitted with the T-joint and then brazed with the tube to measure the pressure at desired position.

A power meter is connected with compressor and heater to measure the power and energy consumption. Firstly, performance of the system is investigated with pure refrigerant R134a. Then nanoparticles are injected in the refrigerator through charging line for the refrigerant. Then performance is investigated with the Al_2O_3 nanoparticles. Volumetric concentration of nanoparticles, mass flow rate of refrigerant are the key parameters which varied during experimentation.

IV. EXPERIMENTAL SETUP

This section provides a detailed description on the facilities developed for conducting the experimental work on a domestic refrigerator. The technique is used for charging nano particles and the evacuation of the system is also discussed here. A detailed report on this facility development is as follows.

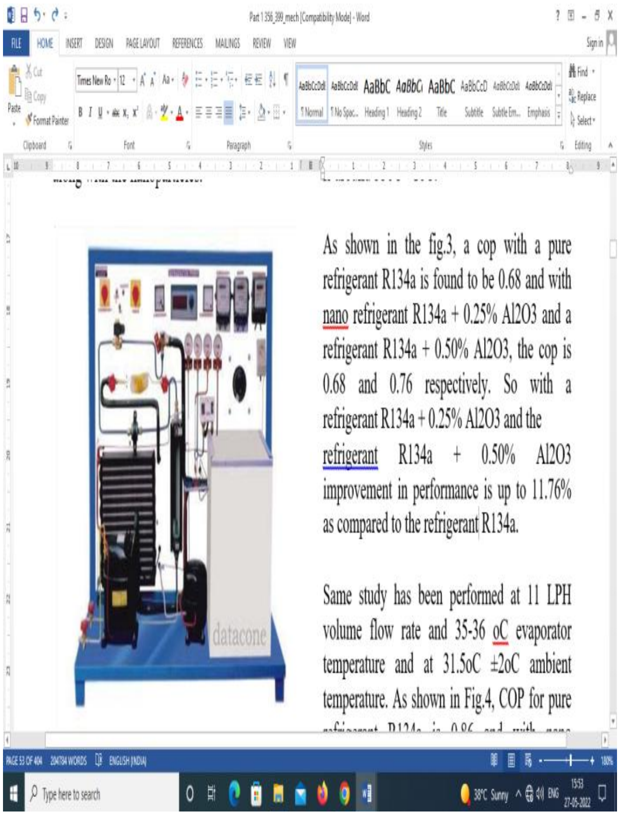

Fig 1. Shows the actual setup for vapor compression domestic refrigerator in which R134a refrigerant is used as working fluid along with the nanoparticles.

V. CONCLUSIONS

The present research work entitled―An Experimental investigation into the Performance of Nano refrigerant (R134a+ Al2O3) Based Refrigeration System‖ was aimed at, to use nanoparticles in conjunction with R134a refrigerant. It has been decided to use nanoparticles Al2O3 of size 60-70 nm each. Two concentrations of nanoparticles were taken to compare performance with pure refrigerant R134a.

The system was charged with nano refrigerant R134a + Al2O3with 0.25 gm mass and 0.50 gm mass of nanoparticles Temperature drop in condenser,temperature gain in evaporator, COP for the system and temperature-time chart was studied for both nanoparticles at both concentrations.

It was found that addition of aluminum oxide nano-particles to the refrigerant results in improvement in the thermo physical properties and heat transfer characteristics of the cooling. It was discovered that there's additional temperature drop across the condenser for the nano refrigerant (12.37% — 10.88%) compared to refrigerant R134a. Similarly, a gain of five.52% and 9.24% was obtained for evaporator temperature. Associate in nursing improvement in COP was conjointly discovered throughout the investigations (1.17% — 9.14%).

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