Enhancement of Efficiency of Refrigeration System with Nano-Refrigerants: A Review

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Abstract

In the field of refrigeration system, the nano-refrigerants are being widely used in enhancing the characteristics of refrigerants. The ultrafine sized nano-particles ranging from (1-100 nm) are added to commercially available refrigerants. These are added at a varying volumetric concentration levels to develop various refrigerants. This paper highlights the research work undertaken by various researchers achieved by the researchers after performing experiments. These experiments can yield different results on important aspects like thermal conductivity, specific heat etc. and there by analysis had been performed. It has been also found that with the addition of different metal oxides (CuO, Al_2O_3 , TiO_2) along with mineral water, lubricating oil etc. were found to be effective in increasing the thermal conductivity and efficiency of the refrigeration system. Further the pumping work was found to be varying significantly at various levels as per experimental studies on refrigeration system.

Key words:- **Nano-particles, Heat transfer, Quality of vapour, Pressure drop.**

1. Introduction

A Refrigeration system has its wide application in domestic as well as in industries. It is used to get the desired temperature for our comfort and various other purposes in industries. In a refrigeration system, the refrigerant which is a fluid is the main content because its function is to absorb the heat through the evaporator. So without the use of this fluid it is not possible to run a refrigeration system. In this system it is a challenge to improve the heat carrying capacity of fluid. To encounter this problem, a technique is highlighted which is recognized as a concept of nano-fluid or nano-refrigerants. The nano-refrigerants has marked its better efficiency in the field of refrigeration system due to its improved thermal conductivity as compare to conventional fluids.

1.1 ***Nano-particles.*** Nanotechnology is a science which is used to change the characteristic of material. The ultrafine particles (1-100 nm) of metal oxides and carbides are considered as nano-particles. These metal oxides can be CuO, Al_2O_3 etc. For the purpose of heat transfer coarse and fine particles are avoided because it creates the problem of pressure drop, erosion and sedimentation.

1.2 ***Nano-Refrigerants.*** The blending of ultrafine particle of metal oxides with a fluid forms a colloidal solution and becomes a nano-refrigerant. Two methods are adopted to fulfill this purpose i.e. magnetic stirring and ultra-sonication.

2. Literature Review.

In the field of nano-refrigerants many useful results are highlighted by the different researches. The objective of the current research is to determine the various parameters affecting the refrigeration system. This paper presents an insight into effect of addition of various metal oxides on important aspects like thermal efficiency and conductivity of the system.They have contributed there experience in the form of these results future and for the further improvements and no doubts will also reduce the useless efforts in future.

Gabriela et. al. [1] has noted that performance of heat exchangers with the use of nano-refrigerant is improved. The increase or decrease in volume of nano-particles is affecting the thermal conductivity of fluid. This also increased the density and viscosity of the fluid. To calculate the performance different methods are used. *Yang [2]* observed that, the addition of Cu and CuO has increased the performance of the system as compare to Al_2O_3, in term of convective heat transfer. These particles are used with R141b based refrigerants. *Murshed et al. [3]* studied that the temperature, particle size and shape i.e. cylindrical or spherical, also affects the performance. The performance of fluid having Al is better than the fluid having Ti in terms of thermal conductivity. *Hao, Peng, et al. [4]* found that due to the increase in amount of vapour in smooth tube, the coefficient of heat transfer increased. The maximum increase in the same is 29.7% with mass flux of 100 $kg/m^{-2}s^{-1}$. *Mahbubul et al. [5]* observed that the increase in concentration of nano-particles affects the quality of vapour. With the addition of Al_2O_3, the pressure drop increased upto large extent. *Kole et.al [6]* resulted that with the use of Al particles in the coolant of heat engine, the viscosity of fluids is increased with increase in concentration and decrease with rise in temperature. Non-Newtonian fluids are formed from Newtonian fluids with the addition on nano-particles. *Saidur et al. [7]* verified that R134a is used with TiO_2 and lubricating oil, the performance of the refrigeration system is improved by reducing the energy consumption by 26.1%. It is obtained by adding the quantity of TiO_2 by 0.1% by mass fraction. *Zhang et al. [8]* noticed that the properties of refrigerants are also affected by the type of nano-refrigerants mass fraction applied during the operation. The efficiency of the system is improved due to the decrease in the value of frictional coefficient. *Sunder et al. [9]* resulted that the addition of nanoparticles by 2% , the thermal conductivity of 20:80 (ethylene glycol/water mixture) rises by 46%. With the same concentration of nanoparticles and by varying the temperature form 20°-60° Celsius, the thermal conductivity is measured with the increased value of 21.69%. *Kole et al. [10]* marked that the increment of Cu particles with 2% when used with gear oil, it raised the thermal conductivity by 24%. This rise in thermal conductivity is non linear and also transfers the behaviour of fluid to Non-Newtonian from Newtonian. *Marilainon et al. [11]* found that the capacity of fluid to transfer the heat is improved by changing the shape of the particle from spherical to cylindrical. The more

concentration also increases the viscosity which affects the pumping effort. There is measurable increase in pressure loss due to increase in Reynold's number. *Mahbubul et al. [12]* resulted that the gain in concentration of particles and temperature causes the improvement in thermal conductivity. The large sized particles, makes the deficiency in thermal conductivity. The more concentration causes the high viscosity which rises the pumping power. *Bi et al. [13]* explained that for domestic refrigeration system, the particles of Ti and Al are very useful in context of safety and efficiency. The solution of TiO_2 (1%) and mineral oil with R143a saved the consumption of energy upto 26%. *Peng et al. [14]* have investigated, in the situation of pool boiling of nano-refrigerannt, the increase in concentration of nano-particles causes the increased migration ratio. This ratio is more for Al particles with R113 as compare Cu nano-particles. *Cheng and Liu 2013 [15]* verified that gain in concentration of carbon nano-tubes with R113 based nano-refrigerants, improves the performance in terms of thermal conductivity. Convective heat transfer of R113 with Cu and R134a with CNT, with addition of 1% volumetric concentration rises with the rise of heat flux. *Bi et al. [16]* resulted that Refrigeration system can with more efficiency with the addition of nano-particles. A system using R600a can save energy upto 9.6% with the implement of 0.5 g/ litre of TiO_2. It also enhanced the thermal conductivity and solubility of fluid with refrigerant. *Manay et al. [17]* found that with the rise in Reynolds number and particle concentration, the amount of heat transfer is increased. The variation in friction factor is also measured. *Koo et al. [18]* examined that the suspended particles in base fluid with Brownian motion raised the thermal conductivity of fluid. *Duangthongsuk et al. [19]* resulted that when the nano particles of size 21 nm are added in water with the concentration of 0.2%, the heat transfer is increased by 6% to 11% as compare to only base fluid. For the calculation of heat transfer Pak and Cho equations are used and results are found same to the results of Xuan and li equation. *Nasiri et al. [20]* marked that in case of nano-fluids the Nusselt number is higher as compare to Nusselt number of only base fluid and increased with increase in concentration of nano-particles. *Xuan et al. [21]* verified that the thermal conductivity of nano-fluids increased, because nano-particles are increases the surface area. It was given by the results calculated from Hamilton and crosser model and Wasp model and equation. *Javadi and Siadur [22]* studied that TiO_2 and Al_2O_3 are very safe and effective to use with domestic refrigerants. The addition TiO_2 nano-particles with 0.1% in R134a and mineral oil cause the energy reduction in energy consumption 25%. *Sun and Yang 2013 [23]* given that the increase in mass fraction of nano-particles, the amount of heat transfer also increased. It also happens due the improved quality of vapour. *Stephen et al. [23]* examined that the addition of nano-particles redused the pumping power in heat exchanger. *Chook Pak et al. [24]* studied the experimental results of dispersed fluid in terms of turbulent friction and heat transfer. The addition of 10% of Al_2O_3 and TiO_2 particles makes the viscosity of dispersed fluid upto 3 times larger than water. The Nusselt number expression is considered for this fluid. *Nassan et al. [25]* found that coefficient of convective heat transfer is to be increased. With the application of CuO and water the convective heat transfer is increased.

3. Conclusions

This paper highlights the research work undertaken by various researchers achieved by the researchers after performing experiments. These experiments can yield different results on important aspects like thermal conductivity, specific heat etc. and there by analysis had been performed. A lot of useful and measurable results are given by the different researcher from their experiments. The application conventional refrigerants with nano-particles results the more efficient refrigeration system. It improves the efficiency by improving the thermo-hydraulic characteristics of fluid. In some cases the pumping work is also increased due to the addition of nano-particles. This research can pave a way for design and development of nano-refrigerants. Further one can ascertain the effect of addition of various metal oxides in improving the efficiency and thermal conductivity of the system.

4. Future Scope.

Nano fluids find a vast potential in the field of the refrigeration system. A significant amount of work can be done in the field of production of nano-fluids. The un-stability of nano-particles in the refrigerants is also a challenge. The effectiveness of the system can be also improved by reducing the cost.

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