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A Comparative Analysis of Variation in Specific Heat of CuO based Nano-Refrigerants

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Abstract

The ability of nano-refrigerants to enhance the thermo-hydraulic properties of refrigerants, achieved the curiosity of researchers to contribute their useful efforts in this era. The involvement of ultrafine sized particle (1-100 nm) of metal oxide in a conventional refrigerant as a colloidal solution is recognized as a nano-refrigerant. The CuO nano-particle is considered for the comparison of specific heat. This nano-particle is applied in different refrigerants R11, R12, R22, R134a and R141b at volumetric concentration 1%-5%. The evaporator conditions are selected with temperature range of 190K-269K at a constant pressure of 0.3 MPa. The database for the properties of refrigerant at different temperature and pressure has been collected from National Institute of Standards & Technology (NIST). Pak and Cho[10] correlation is used for the calculation of specific heat. The specific heat indicated a negative variation with the addition of nano-particles and rises with the gain in temperature. The addition of the nano-particle has also shown the enhancement in thermal conductivity, density and viscosity of the refrigerant.

1. Introduction

The refrigeration system is the curious demand of the society for the various domestic and industrial purposes. It is the process to obtain the desired temperature for the human comfort as well as to store the perishable material for long time. Usually vapour compression refrigeration system and vapour absorption refrigeration system is widely used for the refrigeration. In the refrigeration system the most important content is a refrigerant as shown in fig1. It runs through all the parts of the refrigeration system and absorbs the heat from the required place which needs to be cooled through the evaporator. These conventional refrigerants are converted into nano-refrigerants with the involvement of nano-particle. The nano-refrigerant is a colloidal solution which is prepared by the process of magnetic stirring or ultra-sonication.

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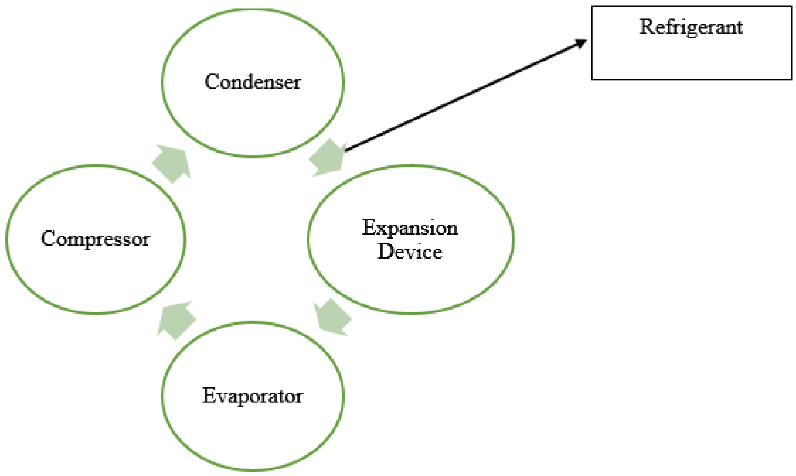

Fig. 1

The addition of these particles is a key to enhance the properties of refrigerant which in turn improves the overall efficiency of the refrigeration system by affecting the thermal conductivity, density, viscosity and specific heat.

2. Literature Review.

In the previous part a brief idea of refrigeration system and nano-refrigerants has been discussed. The history of nano-refrigerants is recorded with lot of useful results which is given by the different researchers after performing the various experiments and analysis. The effort of different researchers is very helpful for the next step of research. These results are a path for the further research in this field. A review has been made to highlight these results.

Gabriela et. al. [1] found that the performance of heat exchanger is improved with the nano-particles. The increased concentration of nono-particles increases the thermal conductivity. The viscosity and density is found to be increased and heat capacity is decreased. *Kole et.al [2]* studied the rise in viscosity variation when alumina particles are added to car engine coolant. It rises with increased volumetric concentration of nano-particles and falls with rise in temperature. *Kole et al. [3]* noticed that the addition of 2% volumetric concentration of Cu particles in gear oil increases the thermal conductivity by 24%. The behaviour of fluid also changed from Newtonian to Non-Newtonian. The variation in thermal conductivity is non-linear. *Bi et al. [4]* examined

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that the TiO_2 particles with R600a can work safely in domestic refrigeration system. The addition 0.5 g/ litre of TiO_2 reduces the energy consumption by 9.6%. The solubility of lubricating oil and refrigerant is also found to be increased with involvement of nano-particles. *Marilainon et al. [5]* investigated that spherical nano-particles are less efficient as compare to cylindrical nano-particles for heat transfer. The amount of pumping power is also encountered with the increase in coefficient of heat transfer. *Nasiri et al. [6]* analysed that Nusselt number of nanofluid is increased after the addition of nano-particles. *Stephen et al. [7]* observed that less thermal conductivity is the challenge in the development of energy. The metal oxides are added to encounter the problem. It also reduced the amount of pumping power in heat exchanger. *Manay et al. [8]* resulted that the heat transfer is rises with gain in Reynolds number and volume concentration of particle. *Xuan et al. [9]* studied that nano-particles are increasing the heat capacity by enlarging the surface area. *Chook Pak et al. [10]* investigated the behaviour of dispersed fluid in terms of heat transfer and turbulent friction. The addition of Al_2O_3 and TiO_2 particles at a 10% volume concentration increases the viscosity by 3 times larger than water.

These results were marked after performing different experiments and analysis.

3. *Research Methodology.*

The thermo-hydraulic properties searched from the reference fluid thermodynamic and transport properties database and have been analyzed for different pressure and temperature. To analyse the variation in specific heat Pak and Cho [10] correlation is used. The difference of specific heat is observed by adding the CuO particles in R11, R12, R22, R134a and R141b at evaporator conditions which works between the pressure range of 0.2-0.4 MPa. Table 1 shows the temperature range for different refrigerants in the evaporator.

Table 1 Applicable temperature range for different refrigerants

Refrigerants	Temperature Range
R-11	198 K- 277 K
R-12	173 K-260 K
R-22	173 K-247 K
R-134 a	173 K- 263 K
R-141 b	173 K- 277K

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The Pak and Cho[10] correlation which depends on the density of base fluid and nano-particle, specific heat of the base fluid and nano-particle, Volumetric concentration of nano-particle.The equation is given below:-

$$C_{pNF} = \frac{(1-\varphi)(\rho C_p)_{BF} + \varphi(\rho C_p)_{NP}}{(1-\varphi)\rho_{BF} + \varphi\rho_{NP}} \quad (1)$$

C_{pNF} = Specific heat of Nanofluid

φ = Volumetric concentration of nano-particles in percentage

ρ = density

C_p =Specific heat

BF = Base Fluid

NP = Nano-Particle

4. *Results and discussion*

The analytical study has been done to observe the variation in specific heat of various nano-refrigerants. The analysis is done by adding the CuO nano-particles at different volumetric concentration. The specific heat indicated a negative variation with the addition of nano-particles and rises with the gain in temperature. This variation is observed in all the refrigerants.

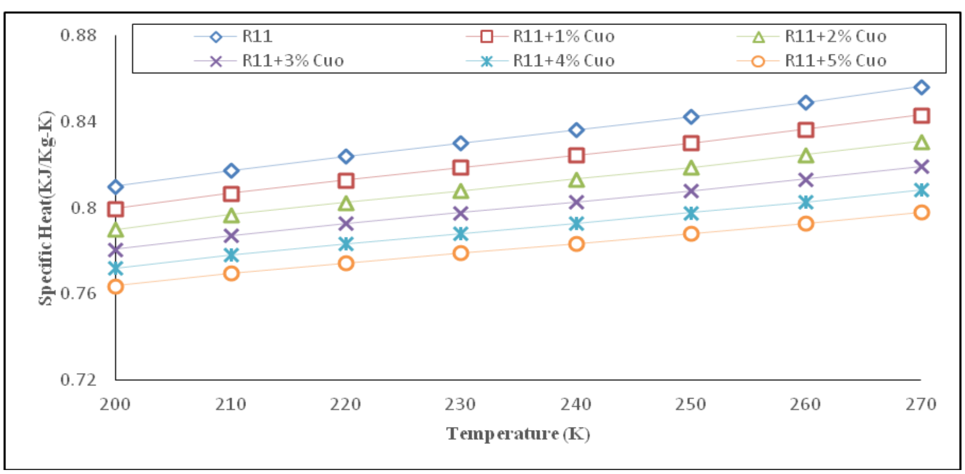

Fig. 2 Effect on specific heat in R11 with different vol. concentration w.r.t. temperature

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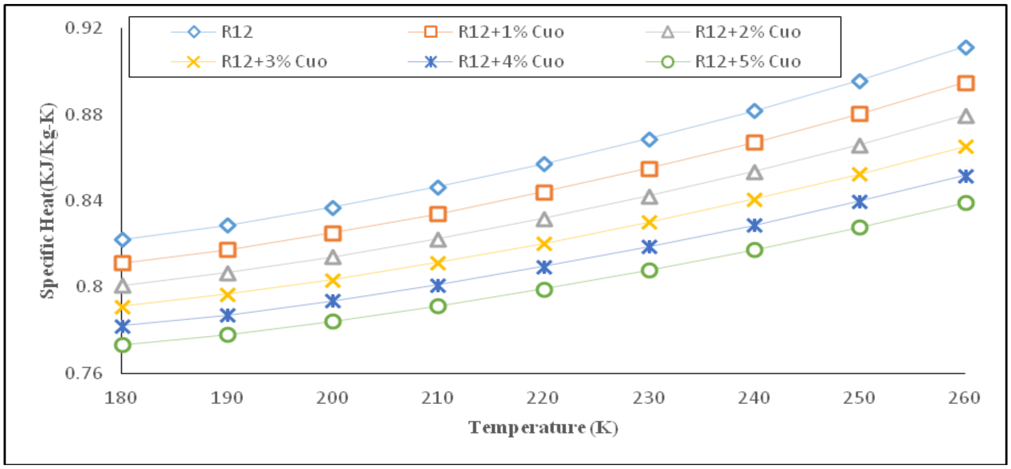

Fig. 3 Effect on specific heat in R12 with different vol. concentration w.r.t. temperature

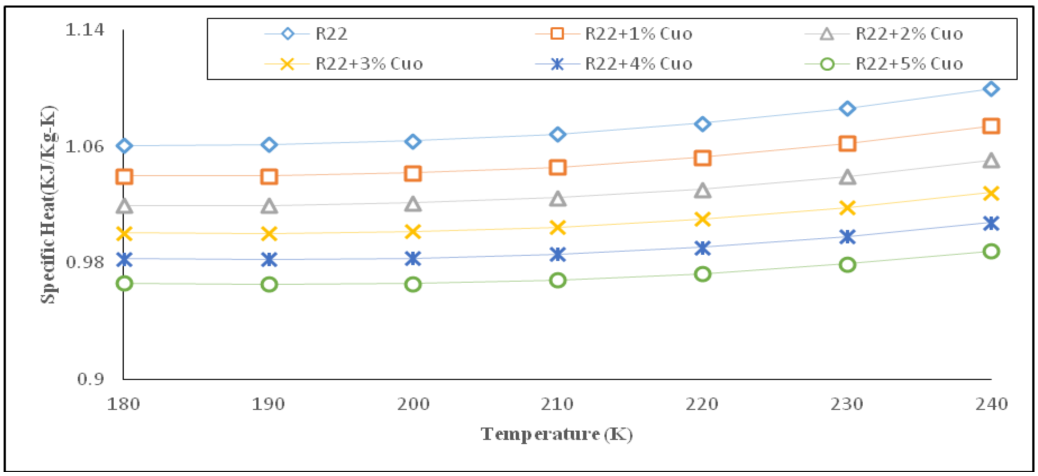

Fig. 4 Effect on specific heat in R22 with different vol. concentration w.r.t. temperature

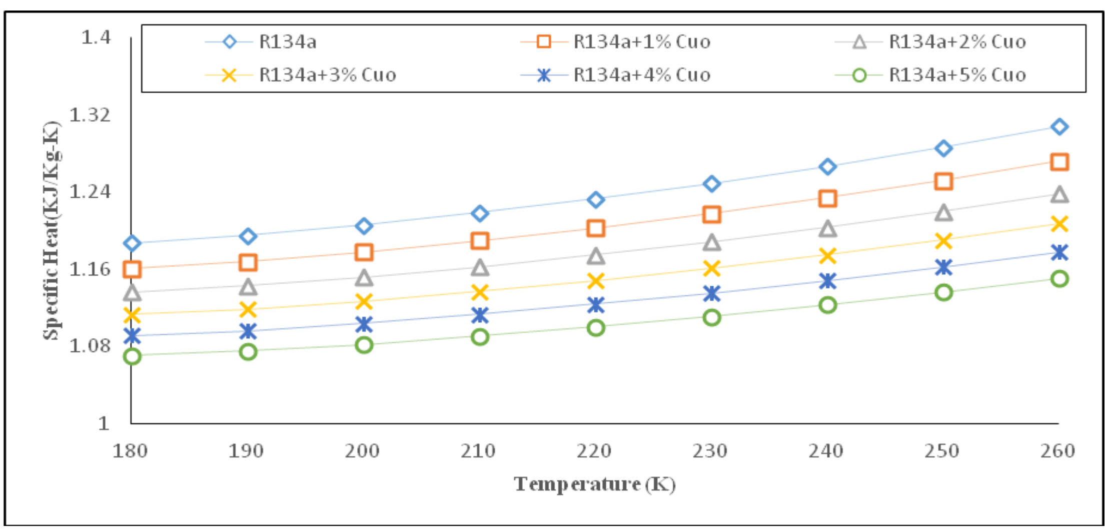

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Fig. 5 Effect on specific heat in R134a with different vol. concentration w.r.t. temperature

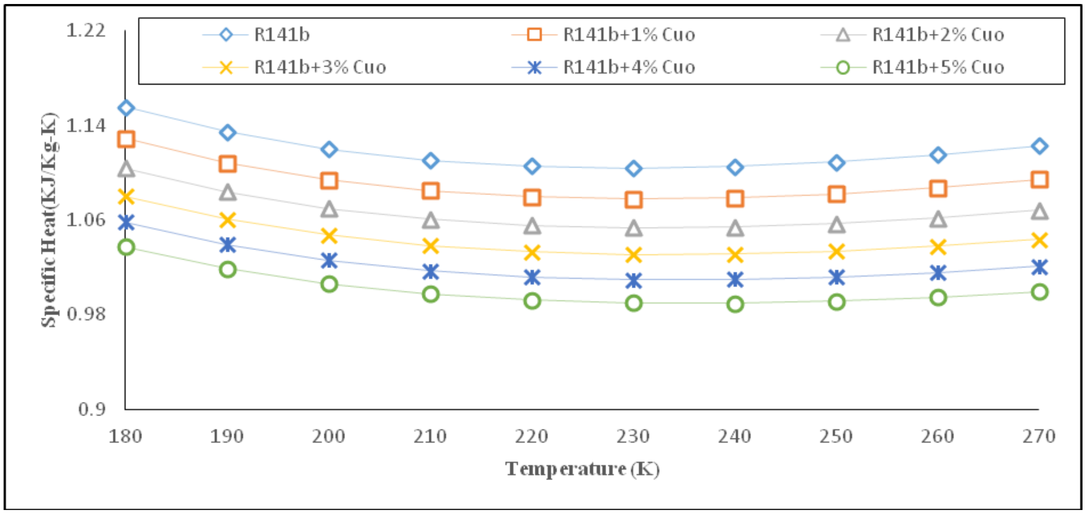

Fig. 6 Effect on specific heat in R141b with different vol. concentration w.r.t. temperature

From the different graphs, it has been observed that with the increase in volume concentration of nano-particles, the specific heat decreases. The minimum and maximum value is observed at 1% and 5% respectively.

5. Conclusion.

The heat capacity of CuO based nano-refrigerants is less. The increase concentration of nano-particles decreases the specific heat but it also rises the viscosity and density of fluid. The specific heat decreases with rise in temperature. In the coming era, the nano refrigerants will replace the traditional refrigerants because of they're enhance thermophysical properties.

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