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

Jai Parkash

Assistant Professor, School of Mechanical Engineering

Lovely Professional University, Phagwara-144411

Email: jai.19578@lpu.co.in

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 evaporators are usually working with pressure upto 0.3 MPa with temperature limits of 190K-269K. The database related to different properties of refrigerant for the calculations and analysis taken from National Institute of Standards & Technology (NIST). Pak and Cho[10] equation is considered for the calculation of specific heat at different volume of nano particles in percentage. The specific heat falls with the involvement of nano-particles and rises with the gain in temperature. The addition of the nano-particle has also shown the enhancement in other properties also.

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.

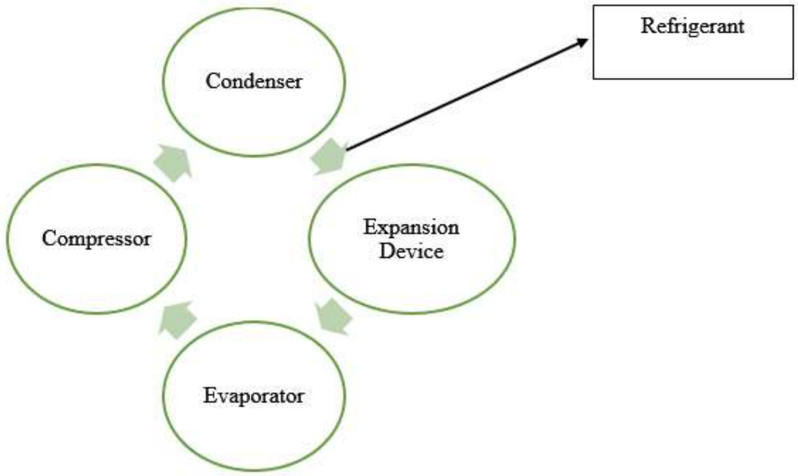

Fig. 1

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 after the addition of 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. *Nasiri et al. [2]* analysed that there is increase in Nusselt number of nanofluid is increased after the addition of nano-particles. *Kole et al. [3]* noticed that the addition of 2% volume 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 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. *Kole et.al [6]* 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. *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 power required in heat exchanger. *Manay et al. [8]* resulted that the heat transfer is rises with gain in Reynolds number. It also affected by the increase in 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 with 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 different properties are taken from the reference fluid thermodynamic and transport properties database and for the analysis. The values are taken at different pressure and temperature. To analyse the variation in specific heat Pak and Cho [10] equation 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. The refrigerants usually works with the temperature range of 190K-269K. The Pak and Cho[10] correlation which depends on the density and specific heat both i.e. base fluid as well as of nano-particle. Volumetric concentration of nano-particle is also a major factor. 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 analysis has been done to verify 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 change with the involvement of nano-particles and rises with the gain in temperature. This variation is observed in all the refrigerants.

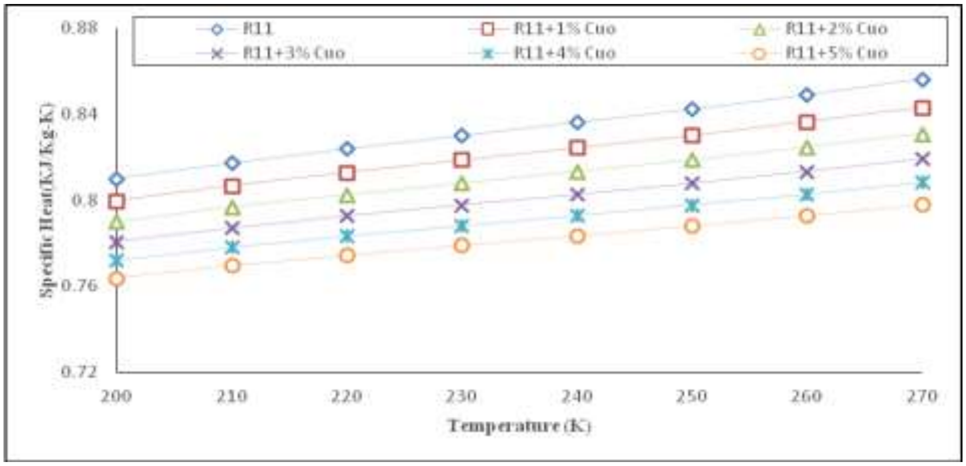

Fig. 2 Specific heat of R11 with different vol. concentration and temperature

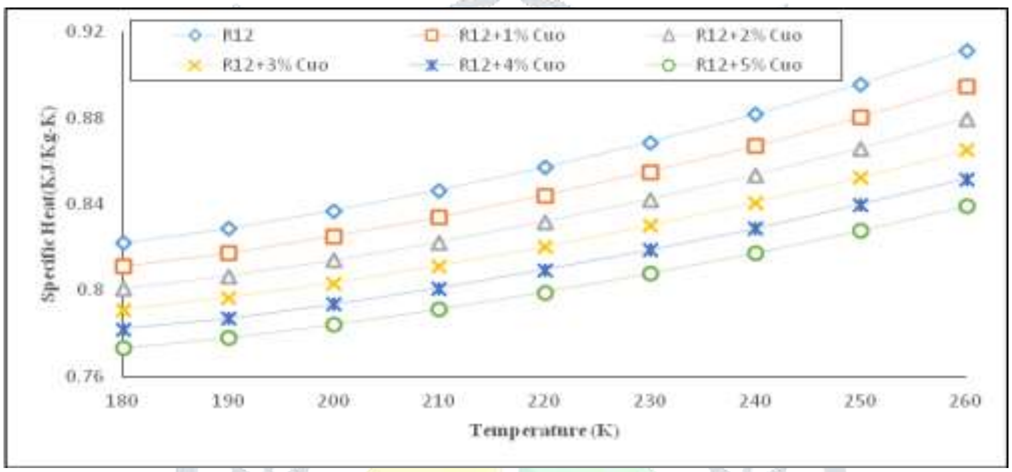

Fig. 3 Specific heat of R12 with different vol. concentration and temperature

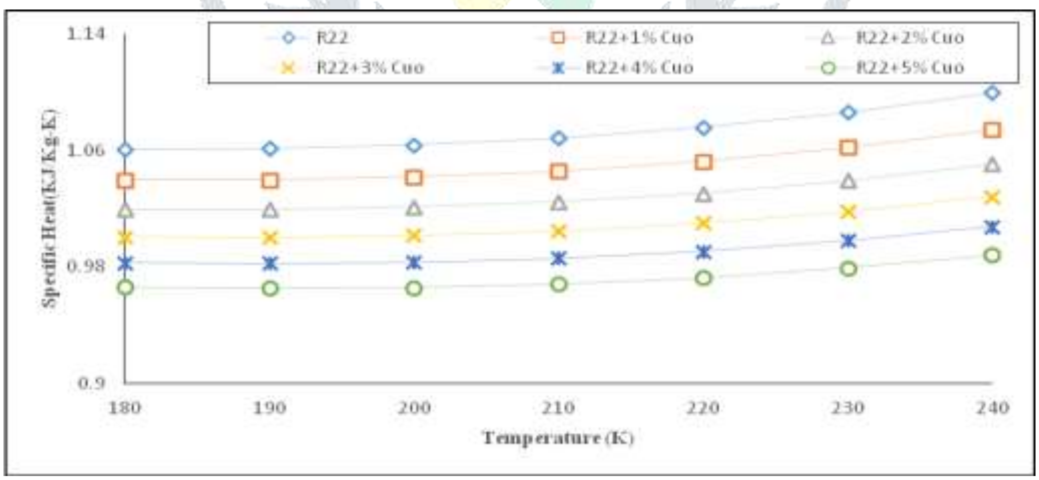

Fig. 4 Specific heat of R22 with different vol. concentration and temperature

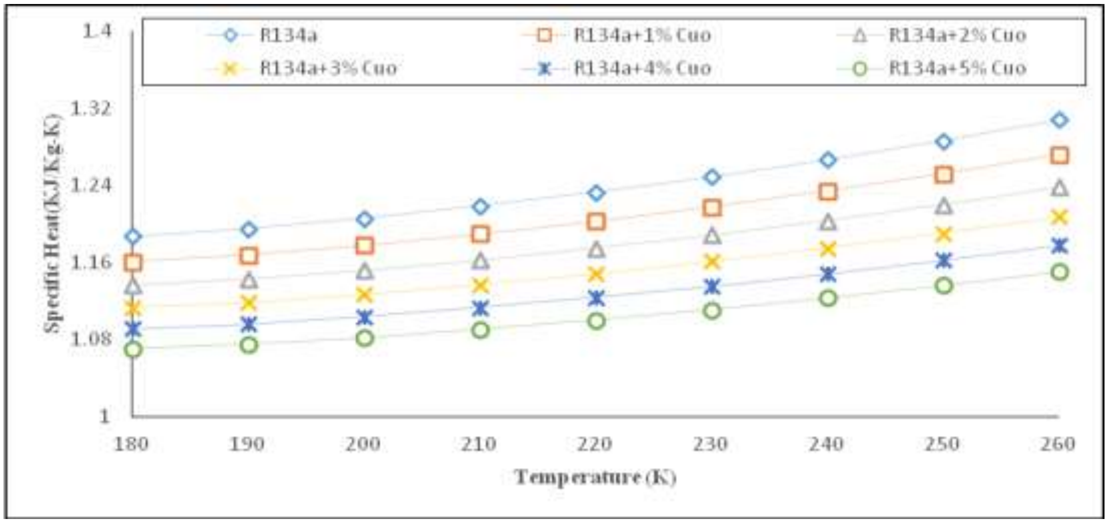

Fig. 5 Specific heat of R134a with different vol. concentration and temperature

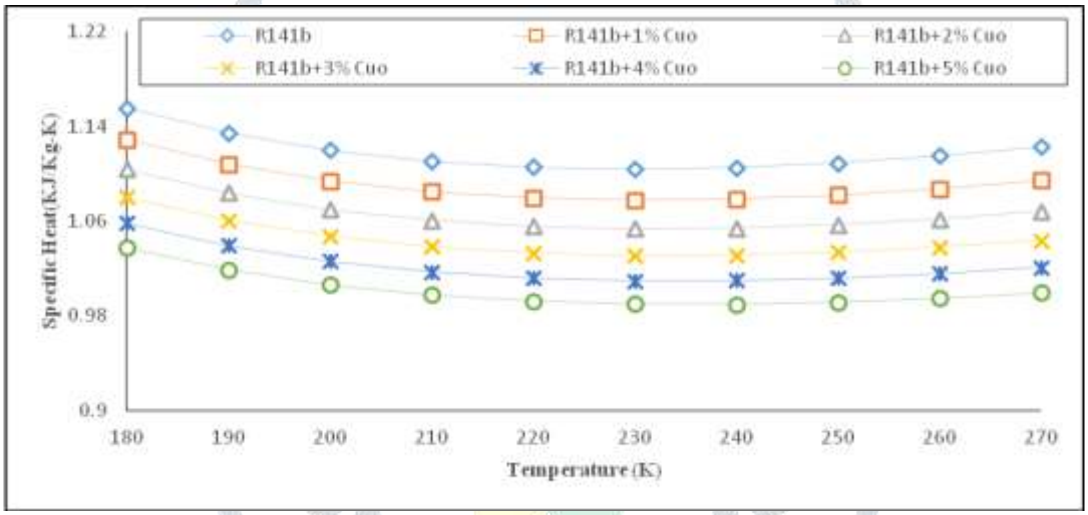

Fig. 6 Specific heat of R141b with different vol. concentration and temperature

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 future the conventional refrigerants will be replaced by the nano refrigerants due to its ability to enhance the properties of refrigerants.

References

[1] Nasiri, M., S. Gh Etemad, and R. Bagheri. "Experimental heat transfer of nanofluid through an annular duct." International Communications in Heat and Mass Transfer 38.7 (2011): 958-963.

[2] Javadi, F. S., et al. "The effects of nanofluid on thermophysical properties and heat transfer characteristics of a plate heat exchanger." International Communications in Heat and Mass Transfer 44 (2013): 58-63.

[3] Huminic, Gabriela, and Angel Huminic. "Application of nanofluids in heat exchangers: a review." Renewable and Sustainable Energy Reviews 16.8 (2012): 5625-5638.

[4] Meriläinen, Arttu, et al. "Influence of particle size and shape on turbulent heat transfer characteristics and pressure losses in water-based nanofluids."International Journal of Heat and Mass Transfer 61 (2013): 439-448.

[5] Kole, Madhusree, and T. K. Dey. "Enhanced thermophysical properties of copper nanoparticles dispersed in gear oil." Applied Thermal Engineering56.1 (2013): 45-53.

[6] Pak, Bock Chook, and Young I. Cho. "Hydrodynamic and heat transfer study of dispersed fluids with submicron metallic oxide particles." Experimental Heat Transfer an International Journal 11.2 (1998): 151-170.

[7] Bhimani, V. L., P. P. Ratho, and A. S. Sorathiya. "Experimental study of heat transfer enhancement using water based nanofluids as a new coolant for car radiators." International Journal of Emerging Technology and Advanced Engineering 3.6 (2013): 295-302.

[8] Bi, Sheng-shan, Lin Shi, and Li-li Zhang. "Application of nanoparticles in domestic refrigerators." *Applied Thermal Engineering* 28.14 (2008): 1834-1843.

[9] Saidur, R., et al. "A review on the performance of nanoparticles suspended with refrigerants and lubricating oils in refrigeration systems." *Renewable and Sustainable Energy Reviews* 15.1 (2011): 310-323.

[10]https://www.google.com/search?q=refrigeration+system+layout&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjMgebZpPHnAhXPyjgGHYsLC24Q_AUoAXoECA0QAw&biw=1366&bih=657#imgrc=qtJkyBTeoaF6ZM.

[11] Jai Parkash, Sanjeev Saini, Ankush Kohli, Balkar Singh, “Comparative analysis of thermohydraulic properties of Nano-refrigerants”, International journal of engineering & technology, *7 (4.12) (2018) 34-3*