Modification in Specific Heat of Heavy Earth Moving Machinery Coolants with CuO, Al_2O_3, TiO_2 and SiO_2 Nanoparticles

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Abstract

Nano particles in conventional coolant of HEMM (Heavy Earth Moving Machinery) are used for enhancement in thermophysical properties. In present study the change in specific heat HEMM coolants with the dispersion of nanoparticles is evaluated. Specific heat determines by using well-known correlations. The effect of CuO, Al_2O_3, TiO_2 , and SiO_2 nano- particles with water and ethylene glycol has been investigated.

Nomenclature

T Temperature, K

C Specific heat capacity (C_p)

ϕ Volume fraction of suspension particles

ρ Density

Subscripts

bf and nf for base and nanofluids respectively

s and m for solid and medium respectively

Introduction

The limiting heat transfer properties of water, ethylene glycol (EG) and lubricating oil are key hurdle in durability of Heavy Earth Moving Machinery (HEMM). Dispersion of nanoparticles to improve thermal conductivity are widely employ, but it produces decrement in specific heat capacity. The use of solid nanoparticles as an additive are termed as nanofluids [1-2]. This suspension of solid particles also create problem of channel clogging and pressure drop [3-4].

In the present paper, the effect of CuO, Al_2O_3, TiO_2 and SiO_2 nano-sized particles on the HEMM coolants specific heat are investigated.

2. Mathematical models of Nanofluids used

Existing literature reveals the dominance of model 1 (Pak and Cho [5]) and model 2 (Xuan and Roetzel [6]) for determination of specific heat. Equation 1 and 2 shows the model 1 (Pak and Cho [5]) and model 2 (Xuan and Roetzel [6]) respectively.

$$C_{pe} = \phi C_{pp} + (1-\phi) C_{pm} \quad (1)$$

$$C_{pe} = \frac{(1-\phi)(\rho C_p)_m + \phi(\rho C_p)_p}{(1-\phi)\rho_m + \phi\rho_p} \quad (2)$$

3. Results and discussions

Using the above mentioned theoretical models, the results were plotted for nanofluids. The variation in behavior of different nanofluids was studied with variation in volume fraction of the added particles.

Figure 1 shows the variation C_p of TiO_2 –water nanofluid with respect to the nano particle volume fraction. Graph is plotted using values obtained by equations and experimental values. It can be depicted from Figure 1 that specific heat values obtained by models and experimental values are almost linear with negative slope. Magnitude of slope of Model II and experimental value are almost equal and is greater than the magnitude of slope of model I. General trend is that C_p of nano-fluids decreases with the increase in the vf of the nano fluids using both the models.

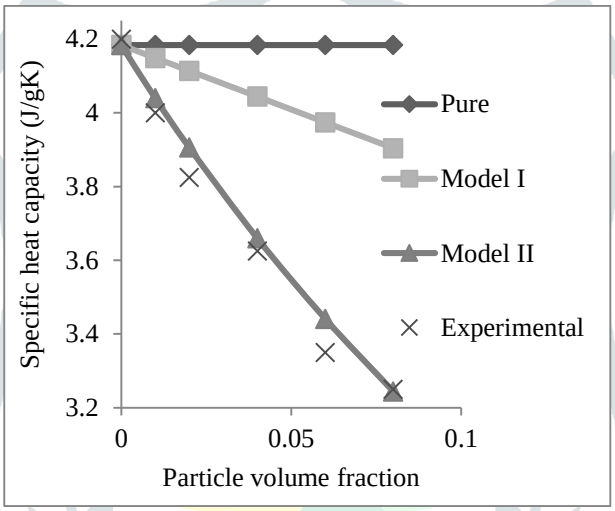

Figure 1: C_p variation for TiO_2-water nanofluid

Figure 2 shows the variation of C_p of TiO_2 –EG nanofluid wrt the nano particle vf. Graph is plotted using values obtained by models and experiment. Graph plotted by models and experimental values are almost linear with negative slope. Magnitude of slope of Model II and experimental value are almost equal and is greater than the magnitude of slope of graph I. General trend is that C_p of nf decreases with the increase in vf of nano fluids using both the models.

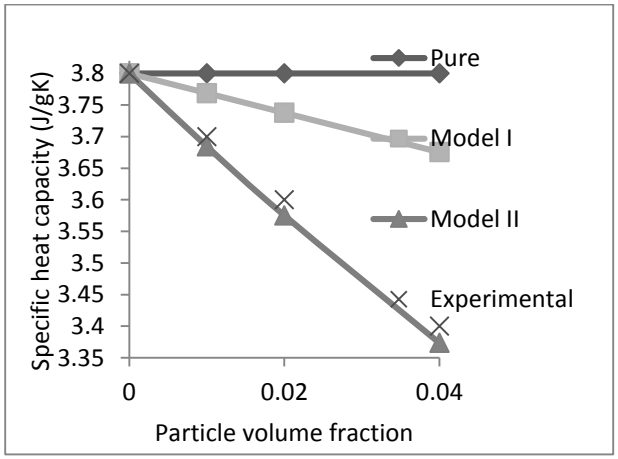

Figure 2: C_p variation for TiO_2-EG nanofluid

Figure 3 shows the variation of C_p of Al2O3 –EG nanofluid with respect to the nano particle volume fraction. Graph is plotted using values obtained by models and experiments. Graph plotted by models and experimental values are almost linear with negative slope. Magnitude of slope of Model II and experimental value are almost equal and is greater than the magnitude of slope of graph I. General trend is that C_p of nfs decreases with the increase in the vf of the nano fluids using both the models.

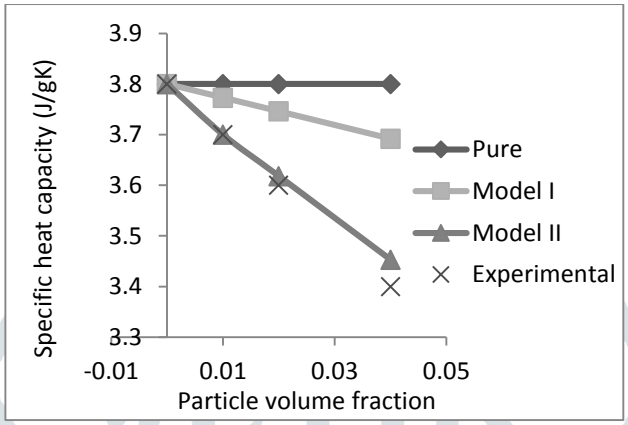

Figure 3: Specific heat variation for Aluminum oxide -EG nanofluid

Figure 4 shows the variation of C_p of Al2O3 – water nanofluid wrt the nano particle volume fraction. Graph obtained by models and experimental values are almost linear with negative slope. The curve of experimental values lies below the values obtained with Model II. Magnitude of slope of Model II is greater than the magnitude of slope of curve obtained by Model I. General trend is that C_p of nano-fluids decreases with the increase in the vf of the nano fluids using both the models

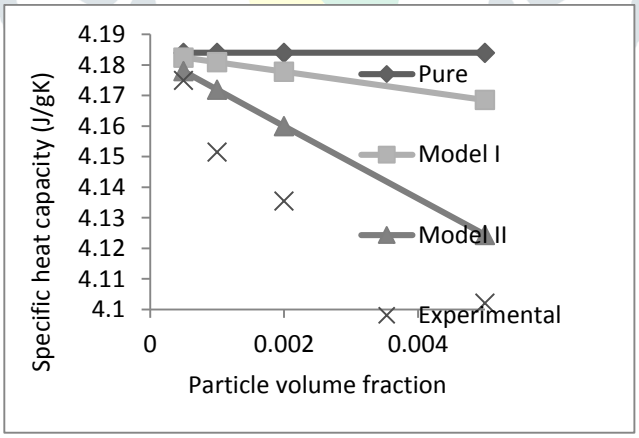

Figure 4: Specific heat variation for Aluminum oxide-EG nanofluids

Figure 5 shows the variation of C_p of silicon oxide- water nanofluid with respect to the nano particle volume fraction. Graph obtained by models and experimental values are almost linear with negative slope. Curve obtained by plotting experimental values lies between the curve obtained by Model I and Model II. Magnitude of slope curve obtained by Model II is greater than the magnitude of slope of curve obtained by Model I. General trend is that C_p of nfs decreases with the increase in the vf of the nano fluids using both the models.

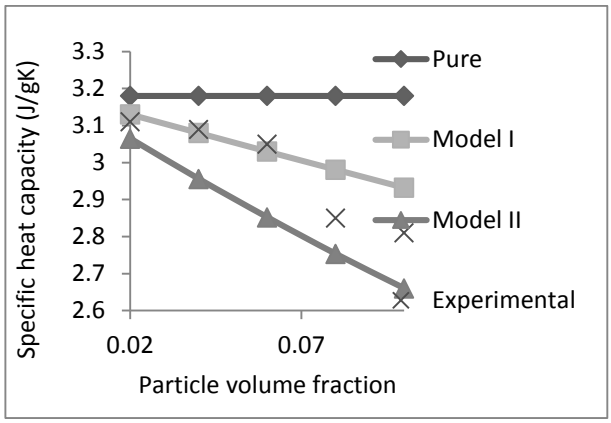

Figure 5: Specific heat variation for Silicon oxide-EG nanofluids

Figure 6 shows the variation of C_p of Copper oxide- water nanofluid with respect to the nano particle volume fraction. Graph obtained by model I, model II are linear with negative slope whereas the curve obtained by plotting experimental values is non- linear. Curve obtained by plotting experimental values lies below the curve obtained by Model I and Model II. Magnitude of slope curve obtained by Model II is greater than the magnitude of slope of curve obtained by Model I. General trend is that C_p of nfs decreases with the increase in the vf of the nano fluids using both the models

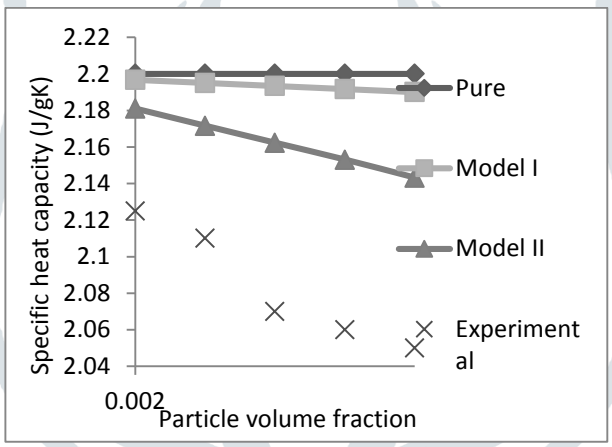

Figure 6: Specific heat variation for Copper Oxide -EG nanofluid

4. Conclusion

The present paper various mathematical models were used to study the variation of C_p of nanofluids with CuO, Al_2O_3 TiO_2 and SiO_2 in base fluids water and ethylene glycol. The general trend of the C_p was found to be decreasing with increase in volume fraction of nano particles.

References:

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