CHAPTER VI

Conclusions

In this chapter all conclusions are comprehensively outlined in the sequence of presentation of information in various preceding chapters. The following conclusions are arrived at from the present work in Chapters 2 through 5

6.1. Conclusions from Chapter 2

Preparation of nanofluids with MWCNTs is carried out in chapter 2. The following conclusion are made from the studies done

1. 2 – Step purification process of Calcination and refluxing results in the removal of impurities in the form of oxides of metal particles and amorphous carbon in the form of soot.
2. The EDX spectrum & HRSEM images of the purified CNTs clearly indicated that the metal particles are removed and disentanglement of CNTs.
3. It is found from the images of TEM that the minimum ball milling time for preparation of stable suspension is 20 hrs at a speed of 400 RPM.
4. Functionalization of carbon nanotubes is an effective way to enhance the physical properties and improve the solubility. 5 M acid solutions could form hydroxyl, carboxyl & carbonyl groups on CNTs and are well determined in FTIR spectroscope.
5. The zeta potential of carboxylated water dispersed with CNTs is found to be better compared to normal water dispersed with CNTs.

6.2. Conclusions from Chapter 3

In this chapter, corrosion tests of nanofluids are carried out to verify the coolants that are definitely deleterious to automotive environment due to corrosion. The following conclusions are arrived at from the studies.

1. From the results of the glassware corrosion test method as per ASTM D 1384, it is observed that water COOLANT2 which is a mixture of 2 % Sebacic acid,
sodium nitrite, sodium hydroxide and tolyltriazole gave best protection against corrosion to all the metals.

2. Further from the results, it is also found that the dispersion of MWCNTs does not affect the anti-corrosive properties of carboxylated water and hence are suitable in automotive environment.

3. From the results of the test of corrosion of cast aluminum alloys as per ASTM D 4340 the heat transfer corrosion rate of all the combinations of nanofluids was found to be very less and not significant.

4. From the results of the test to determine foaming tendencies of engine coolants in glassware as per ASTM D1881, the foam volume is reducing with the increase in the concentration of the MWCNTs dispersed the nanofluids. Further the foam break time is almost same irrespective of the change in the concentration of the MWCNTs.

5. From the results of the cavitation corrosion test as per ASTM G 32, it can be observed that the weight loss due to cavitation is reduced due to the addition of nano particles. This can be attributed to low foam formation in nanofluids and hence reduced cavitation.

6.3. Conclusions from Chapter 4

In this chapter, thermo physical Properties of the nanofluids are measured. The following are conclusions from the study.

1. There is a good improvement in the thermal conductivity of fluids with dispersion of CNTs. The improvement in thermal conductivity from base fluid at 50 °C with 0.025 % CNTs is 8.12 %, with 0.05 % CNTs is 14.58 % and with 0.1 % is 17.85 %. The data for different mass fractions is correlated using 2nd order polynomial.

2. Regression is applied to the experimental data points assuming that the variation in the thermal conductivity of the nanofluids is depend upon the temperature and the concentration of the MWCNTs. The correlation is validated with an average deviation of 0.36% and a standard deviation of 0.41%
3. The effect of CNTs on specific heat is found to be marginal as the CNTs are dispersed in very low concentrations and the measurement is done at room temperature.

4. A slight improvement in the boiling point and freezing point of coolants dispersed with nano materials is observed.

5. It has been observed that there was no significant variation in the density of nanofluids.

6. Further, the variation of shear stress with shear strain is plotted at 55 °C and 90 °C and it was observed that the shear strain and shear stress are varying linearly with intercept towards the origin which is the characteristic of Newtonian fluids.

7. The absolute viscosity is measured in the range of 50 °C to 95 °C. It is found that there is no much difference in the viscosity with addition of CNTs up to 0.025 %. However when the mass fraction of CNTs exceed beyond 0.05 %, there is a moderate increase in the viscosity. The data for different mass fractions is correlated using 2nd order polynomial equations.

8. The increase in viscosity is considerably and it is around 13.5%, 16% and 24 % respectively for 0.025, 0.05 and 0.1 % mass fractions. However, at higher temperatures, the increase in viscosity is marginal at 1 %, 4.5% and 7.5% respectively. The increase in viscosity is less since lesser mass fraction of CNTs is used in preparation of nanofluids.

9. Regression is applied to the experimental data points assuming that the variation in the viscosity of the nanofluids is depend upon the temperature and the concentration of the MWCNTs and the correlation is validated with an average deviation of 1.08% and a standard deviation of 1.28%

6.4. Conclusions from Chapter 5

In this chapter an experimental set up for study of heat transfer enhancement is designed, fabricated and tested for various key factors of the heat transfer enhancement of the radiator.

The conclusions from the study are:
1. Carboxylated water dispersed with 0.025 %, 0.05 % and 0.1% of CNTs could improve the heat transfer characteristics of nanofluids.

2. Improvement in heat transfer is dependent upon the air velocity and flow Reynolds number of the liquid. At lower velocities of air the improvement in overall heat transfer coefficient with CNTs is found to be better compared to higher air velocities. The improvement in heat transfer coefficient and overall heat transfer coefficient with nanofluids is found to be more in near laminar region.

3. An average reduction of 17.5%, 29.1% and 34.6% is observed in the surface area of radiator can be achieved under similar flow rate conditions as that of base fluid when the base fluid is dispersed with 0.025%, 0.05% and 0.1% mass concentration of MWCNTs respectively

4. An average reduction of 13.88%, 15.16% and 22.66% in the mass flow rate of hot fluid is observed for 0.025%, 0.05% and 0.1% concentrations of nano particles when dispersed in the base fluid. Hence the pumping power can be saved under similar surface area conditions as that of base fluid.

5. Regression is applied to the experimental data points assuming that the variation in the Stanton number (St) of the nanofluids is depend upon Reynolds number (Re), Prandtl number (Pr) and Prandtl number at wall temperature (Prw).

6. The correlations are developed considering Pr and Pr/Prw to study the wall effect on the heat transfer of nanofluids for various concentrations of the MWCNTs.

7. Significant influence of the wall effect is observed due to the dispersion of MWCNTs in the base fluid. Also considerable influence in the wall effect with the increase in the concentration of the MWCNTs is also observed.

8. As it is observed that the wall effect is profound and increasing with the increase in the variation of the concentration of the CNTs, a correlation is developed with Regression analysis for all fluids with an average deviation of 9.61% and a standard deviation of 11.37%