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A review has revealed that very little information is available in open literature on thermal behaviour of nanofluids and particularly Graphene based nanofluids are scarcely available. Graphene based nanofluids are chosen with the aim of exploring the possible heat transfer enhancement. Experiments have been conducted with prepared Graphene nanofluids in order to determine their behaviour in convective heat transfer mode and to collect scarce data that may assist in explaining the phenomena.

Cylindrical & spherical shaped nanoparticles of Graphene with five particle diameters are chosen. The thermal conductivity, viscosity and nature of fluid are determined. The convective heat transfer has been studied experimentally in constant heat flux as well as constant wall temperature condition.

The information available from the literature and the results of the present work are discussed. From the results and discussion the following conclusions are drawn:

- To ascertain the convective heat transfer characteristics it is necessary to evaluate thermal conductivity since significant discrepancy in experimental data is seen with different researchers with different nanoparticles considered. Hence thermal conductivity of nanofluid is determined experimentally with varying particle size, volume fraction and temperature,

- Adopting Hamilton and Crosser model for Al₂O₃ particles the present results of Graphene nanofluid show similar behaviour i.e., the thermal conductivity increases with particle size for all volume fractions. It is found that Graphene
nanofluid shows slightly higher values of thermal conductivity than \( \text{Al}_2\text{O}_3 \) for all particle sizes and for all volume fractions higher by about 3 to 4%.

- Where as with Xue and Xu model for Cu particles the behaviour of Graphene nanofluid is similar. Also that the values of thermal conductivity of Graphene nanofluids are found to be higher values of about 6-8% for all particle sizes and volume fractions.

- To ascertain temperature dependence of thermal conductivity the results were analyzed with Koo & Kelinskiester model and Jang & Choi models. It is found that with both the models the trends are same but with the first model at higher temperatures there are slight lower values of \( K \) for all volume fractions, whereas with second model there is slight enhancement at lower temperatures for all volume fractions. It may be noted that both models were developed with \( \text{Al}_2\text{O}_3 \).

- From the literature it is observed that the classical correlations for convection based on pure fluids under predict the heat transfer of nanofluids. It is also observed that application of thermal dispersion model to the governing energy equation explains the experimental data very well. As such single phase analysis of convective heat transfer of nanofluids sufficiently predicts the heat transfer as long as temperature dependence of thermal conductivity is taken into account.

- The experimental data collected and application of thermal dispersion showed that the local Nusselt number is greater with nanofluids. The Graphene also has shown greater values of local Nusselt number. This may be due to flattening in the radial temperature profile of constant wall temperature conditions.
- The results of the fully developed flow under constant wall temperature conditions Nusselt numbers and the heat transfer coefficients with different particle volume fractions bring out the fact that the thermal conductivity enhancement has more pronounced effect on heat transfer enhancement.

- When it comes to the constant wall temperature boundary condition, the dominant parameter that affects the heat transfer is found to be the wall temperature. As the wall temperature increases, the heat transfer and the associated enhancement increases.

- It is observed that if empirical constant “C” in dispersed thermal conductivity expression is sufficiently small, the effect of thermal conductivity dominates particle size dependence which results in increasing heat transfer with decreasing particle size. On the other hand, if “C” is large, heat transfer increases with increasing particle size.

- When it comes to the constant wall heat flux in general with Graphene nanofluid under fully developed flow the heat transfer enhancement is greater than conventional nanofluids (Al₂O₃ & Cu) at local Nusselt and average Nusselt numbers.

- Investigations carried out by using the Graphene nanofluid reveals that the effects of cooling and heating for constant wall heat flux boundary condition heat transfer is higher for heating. From the results it is clear that about 14% higher heat transfer enhancement is obtained by using Graphene nanofluids compared to Al₂O₃ and Cu based nanofluids.

- From the present work it is concluded that Graphene nanofluids can provide better heat transfer in critical applications where heat removal rates are high with smaller heat transfer area.
SCOPE FOR FUTURE WORK

The work can be extended by considering more factors which influence the thermal conductivity like Brownian motion, Interfacial liquid layer, Ballistic nature of heat transport in nanoparticles, Nanoparticle clustering in nanofluids. Further research can be focussed on quantitative heat transfer behaviour of different shapes of Graphene nanoparticles as well as their %vol. New combinations of base fluids can be explored.