Mechanical Engineering Doctoral Defense

A Study of Latent Heat of Vaporization in Aqueous Nanofluids

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abstract

Nanoparticle suspensions, popularly termed "nanofluids," have been extensively investigated for their thermal and radiative properties. Such work has generated great controversy, although it is arguably accepted today that the presence of nanoparticles rarely leads to useful enhancements in either thermal conductivity or convective heat transfer. On the other hand, there are still examples of unanticipated enhancements to some properties, such as the reported specific heat of molten salt-based nanofluids and the critical heat flux. Another largely overlooked example is the apparent effect of nanoparticles on the effective latent heat of vaporization (h_{fg}) of aqueous nanofluids. A study have focused on molecular dynamics (MD) modeling supplemented with limited experimental data to suggest that h_{fg} increases with increasing nanoparticle concentration.

Here, this research extends those exploratory experiments in an effort to determine if h_{fg} of aqueous nanofluids can be manipulated, i.e., increased or decreased, by the addition of graphite or silver nanoparticles. Our results to date indicate that h_{fg} can be substantially impacted, by up to ± 30% depending on the type of nanoparticle. Moreover, this dissertation reports further experiments with changing surface area based on volume fraction (0.005% to 2%) and various nanoparticle sizes to investigate the mechanisms for h_{fg} modification in aqueous graphite and silver nanofluids. This research also investigates thermophysical properties, i.e., density and surface tension in aqueous nanofluids to support the experimental results of h_{fg} based on the Clausius - Clapeyron equation. This theoretical investigation agrees well with the experimental results. Furthermore, this research investigates the h_{fg} change of aqueous nanofluids with nanoscale studies in terms of melting of silver nanoparticles and hydrophobic interactions of graphite nanofluid. As a result, the entropy change due to those reasons could be a main cause of the changes of h_{fg} in silver and graphite nanofluids.

Finally, applying the latent heat results of graphite and silver nanofluids to an actual solar thermal system to identify enhanced performance with Rankine cycle is suggested to show that the tunable latent heat of vaporization in nanofluilds could be beneficial for real-world solar thermal applications with improved efficiency.

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