Thermal Property Investigation in Nanolubricants via Nano-Scaled Particle Addition

Dr. Nitin Sherje
Head of Mechanical Department, S.K.N.C.O.E. Pune India
npsherje@sinhgad.edu

Article History

Article Submission
19 November 2020
Revised Submission
17 January 2021
Article Accepted
1 March 2021
Article Published
31st March 2021

Abstract

In nanolubricants, the increase in scholarly attention has been attributed to the affirmation that they exhibit enhanced thermo-physical features and that they can also be used in various thermal applications. Some of these applications where they could be incorporated include solar energy harvesting, industrial applications, and heat exchanger effectiveness enhancement. Recently, various approaches have been employed to enhance the coefficient of heat transfer, especially between the fluid contact surfaces and the working fluids. When it comes to conventional fluids of heat transfer, examples being ethylene glycol/water, thermal oils, and water, some studies document that they exhibit limitations. For instance, these fluids exhibit low thermal properties when compared to the solids with which they interact. To respond to this dilemma, there have been efforts in this study to have the fluids' thermal properties improved via nano-scaled particle addition, causing marked evolutions in the evaluations of the behavior of fluids of heat transfer. Indeed, findings suggest that in base fluids, when the solid particles are suspended, there tends to be an enhancement in the fluid's energy transmission; hence, notable improvements in material thermal conductivity properties, besides the betterment of material heat transfer characteristics.
Keywords: *Nanolubricants, Heat Transfer Characteristics*

I. Introduction

Nanolubricants entail nano-scaled particles' engineered colloidal suspensions in the given base fluids [1]. Generally, the nano-scaled particles come in the form of carbon-based elements, metallic oxides, and metals [2]. Indeed, with nanoparticle introduction, more and more studies have investigated the subject of colloidal dispersion in selected fluids. Here, it has been avowed that upon dispersion in fluids, nanoparticles exhibit some notable degree of stability. Also, they have been documented to be able to steer improvements in the fluids' thermal properties [3]. The adequacy of nanolubricants that makes them ideal for use as heat transfer fluids has also been linked to their promising features such as reduced pump power (outperforming pure liquids and ensuring that the intensified heat transfer is realized), particle/fluid nanolayer existence, and the particles' state of Brownian motion [4].

II. Methodology

Of importance to note is that even with the aforementioned benefits with which nanolubricants tend to be associated, they have been observed to experience certain application-based limitations. For instance, in the fluid, issues of aggregation and sedimentation continue to be raised even at a time when the nanolubricants' stability has been improved via the addition of surfactants and the use of magnetic stirring, pH modulation, and ultra-sonication [5]. In addition, given devices, fluid circulation rate increase tends to minimize potential sedimentation, but the process could cause heat transfer erosion in flow streams or devices [1].

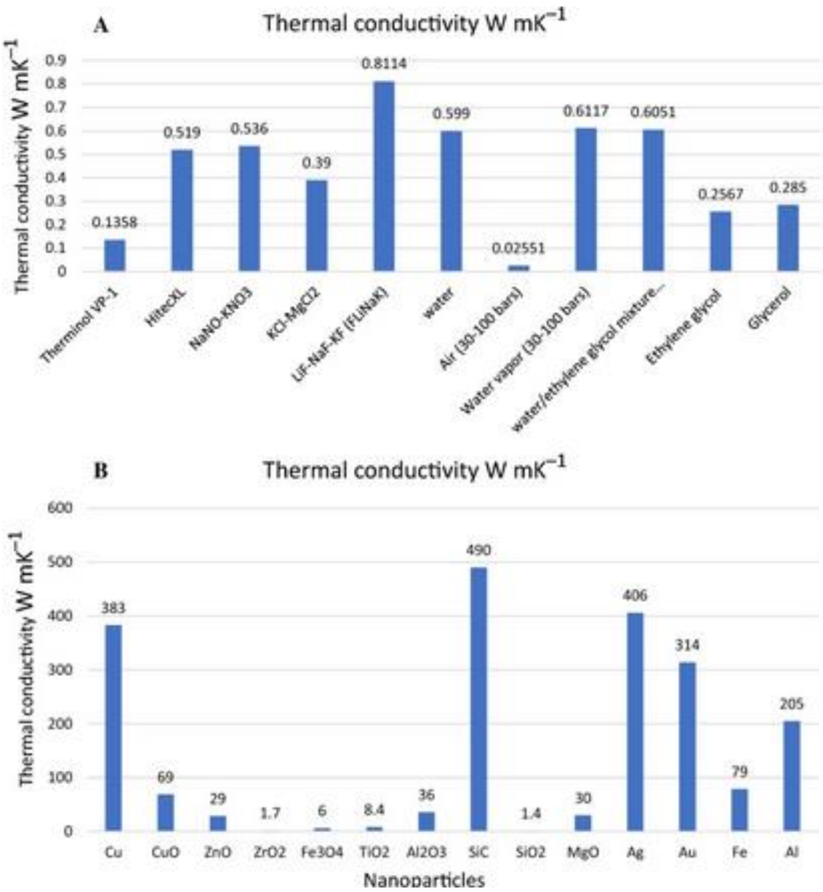

Figure 1: (A) Thermal Conductivity Materials, (B) Thermal Conductivity Nanoparticles

Nanoparticles are also observed to be reactive in nature and prove toxic, besides being expensive to prepare. Additional findings tend to suggest that for larger-sized particles, their clogging of flow channels accounts for device pressure losses as viscosity increases marginally [3]. The mixed observations above point to the need for a holistic analysis of how the properties of nanolubricants tend to shape the heat transfer characteristics of materials or devices. In this paper, the main aim is to conduct and offer a critical analysis of selected nanolubricant properties and their influence on the heat transfer characteristics of materials or heat transfer devices in which they (the nanolubricants) are used. Importantly, some of the specific heat transfer devices in which nanolubricants are used include electronic cooling, thermal storage systems, radiators, refrigeration systems, heat exchangers, and solar collectors [4].

III. Results and Discussion

For nanolubricants, when the subject of their properties is considered, it has been avowed that the nature of their thermo-physical behavior poses a direct impact on the materials' application, especially in relation to the process of heat transfer. To determine how effective nanolubricants can be, especially concerning they use as fluids of heat transfer, it can be seen that vital properties ought to be considered and they include features such as the specific heat capacity, density, thermal conductivity, and viscosity.

From the experimental perspective, some standards and techniques have been followed when it comes to the measurement of nanolubricants' different thermo-physical properties. In particular, three main approaches have been utilized and aid in determining nanolubricants' thermal conductivity. They include the use of the thermal comparator, the steady-state technique, and the transient technique. When compared to the steady-state technique, the transient technique has been observed to be more reliable and accurate because of its ability to ensure that there is complete reduction of the impact posed by natural radiation and convection. To measure nanolubricants' viscosity, it is also worth noting that the main instrument types that have been used entail rotational viscometers. Indeed, the role of the viscometers does not only lie in the determination or measurement of the fluid's viscosity. Rather, they also aid in determining the fluids' rheological behavior.

When it comes to the differential scanning calorimetry (DSC), it has been used to determine the nanolubricants' specific heat capacity because of its ease of use, the ability to offer adequate accuracy, and the capacity to ensure that short measurement times are achieved. On the one hand, numerous studies have focused on the measurement of the thermo-physical properties of nanolubricants via the techniques mentioned above.

On the other hand, an increasing number of researchers have directed their attention on the development of theoretical models that could be deemed more accurate relative to the nanolubricants' thermo-physical behavior's prediction. It is also worth noting that prior to nanolubricant invention, several scholarly efforts strived to theorize the relationship between particle dispersion and the thermo-physical properties of fluids of heat transfer that have been employed conventionally. For example, given liquids, particle dispersions have had their thermal conductivity theorized in, with additional investigations in theorizing liquids' particle dispersions' state of dynamic viscosity. Indeed, both research efforts reflect the initial postulations concerning fluid suspensions' thermo-physical behavior. In the recent past, more studies have proposed some of the frameworks of predicting the fluid suspensions' thermo-physical behaviors, deviating from classical models that were established prior to the nanolubricant classification.

IV. Conclusion

To a limited range, it can be seen that most of the classical models were limited in their accuracy, failing to offer adequate levels of predictions of specific heat capacity, viscosity, and thermal conductivity values. This failure, as documented, accrues from the observation that. Given the nanoscale, factors that had not been considered previously have ended up affecting the fluid dispersion's thermo-physical properties, yet the majorities of the classical models had their concentration directed at the property of the base fluid and the volume consideration as the most critical variables used to establish thermo-physical properties. Of importance to note is that most of the scholarly results indicate that various variables influence the thermo-physical properties of nanolubricants. Some of these variables include the mixture ratio (for the case of hybrid nanolubricants), nano-layers, and the pH of the fluid, as well as the packing fraction, particle agglomeration, the property of the base fluid, the volume concentration, and the particle size. Indeed, given that the classical models have failed to account for such variable conditions, their use has ended up being limited to a narrow value range.

References

[1] Bellos E, Tzivanidis C. A review of concentrating solar thermal collectors with and without nanofluids. *J Therm Anal Calorim.* 2019; 135: 763-786

ISSN: 2250-0839

[2] Manikandan GK, Iniyan S, Goic R. Enhancing the optical and thermal efficiency of a parabolic trough collector—a review. Appl Energy. 2019; 235: 1524-1540

[3] Dr. Avinash Pawar. (2020). Development and Verification of Material Plasma Exposure Concepts. International Journal of New Practices in Management and Engineering, 9(03), 11 - 14. https://doi.org/10.17762/ijnpme.v9i03.90

[4] Singh SK, Kumar A. An effect of twisted tape with nanofluid on the performance of double pipe heat exchanger: a comprehensive review. Int J Mech Prod Eng Res Dev. 2019; 9(1): 531-540

[5] Dr. Nitin Sherje. (2020). Biodegradable Material Alternatives for Industrial Products and Goods Packaging System. International Journal of New Practices in Management and Engineering, 9(03), 15 - 18. https://doi.org/10.17762/ijnpme.v9i03.91

[6] Xian HW, Sidik NAC, Najafi G. Recent state of nanofluid in automobile cooling systems. J Therm Anal Calorim. 2019; 135: 981-1008

[7] Yang L, Huang J, Ji W, Mao M. Investigations of a new combined application of nanofluids in heat recovery and air purification. Powder Technol. 2019

ISSN: 2250-0839