Experimental and Theoretical Investigation of Thermal Properties of TiO_2/ Transformer Oil Nanofluids

Induranga D.K.A.[1, 2, 3 *], Galpaya G.D.C.P.[1, 3], Priyadarshana H.V.V.[1, 2, 3], and Koswattage K.R.[2, 3]

[1] *Faculty of Graduate Studies, Sabaragamuwa University of Sri Lanka, Sri Lanka*
[2] *Department of Engineering Technology, Sabaragamuwa University of Sri Lanka, Sri Lanka*
[3] *Center for Nano Device Fabrication and Characterization (CNFC), Faculty of Technology, Sabaragamuwa University of Sri Lanka, Sri Lanka*
[*] *ashaninduranga@tech.sab.ac.lk*

The study of Nanofluids is an emerging field in the 21st century. The notable thermal properties of nanofluids have attracted the attention of researchers in various scientific and engineering fields, such as mechanical, electrical, process, automobile, biomedical engineering, and biotechnology. This research study investigates the thermal properties of TiO_2-based transformer oils with different volume fractions from 0.002 to 0.012 vol.% and temperatures from 40 to 120 °C, focusing on thermal conductivity and thermal diffusivity. The volumetric heat capacity was calculated based on the values of thermal conductivity and thermal diffusivity. Apart from the study of these properties, thermal conductivity results were compared with three major theoretical models; the Maxwell model, Maxwell and Garnett 's model, and the Pak and Cho model. Five different volume fractions were considered for the study; 0 vol.%, 0.002 vol.%, 0.004 vol.%, 0.008 vol.%, 0.012 vol.%. Lower volume concentrations were selected to maintain the stability of the nanofluid samples. Also, CTAB (Cetyltrimethylammonium bromide) was used as a surfactant to enhance the stability of the nanofluid samples. All the thermal properties were measured in accordance with the ASTM D7896-19 standard using the LAMBDA multifunctional thermal conductivity meter. The maximum thermal conductivity was achieved with the 0.012 vol.% concentration at 40 °C as a 4.2% enhancement compared to the base oil. According to the comparison of the experimental data with the theoretical data, Maxwell and Garnett's model displayed a minimum error, concluding that this model is the most suitable one for predicting the thermal conductivity of TiO_2/ Transformer Oil. The highest thermal diffusivity (81.156×10^{-3} mm^2/s) was achieved by the highest volume fraction at the minimum temperature (40 °C). However, the highest volumetric heat capacity (1.52×10^6 $J/m^3.K$), which was calculated using thermal conductivity and thermal diffusivity, was achieved at 120 °C for the same sample.

Keywords: *Temperature, Thermal conductivity, Thermal diffusivity, Volume concentrations, Volumetric heat capacity*