Research Paper

Investigation on effective thermal conductivity and relative viscosity of cellulose nanocrystal as a nanofluidic thermal transport through a combined experimental – Statistical approach by using Response Surface Methodology

K. Ramachandran a,⇑, K. Kadirgama a,b, D. Ramasamy a,b, W.H. Azmi a,b, F. Tarlochan c

⇑ Corresponding author.
E-mail address: kaaliarasan@gmail.com (K. Ramachandran).

Abstract

Combined experimental-statistical approach for effective thermal conductivity and relative viscosity determination were investigated in this present study. Nanofluid used was dispersion of novel nanomaterial Cellulose Nanocrystal (CNC) in ethylene glycol-deionized water mixture at volume base ratio of 50:50 (BR = 0.5) and 60:40 (BR = 0.6). Influence of temperature, volume concentration and ethylene glycol volume base ratio (BR) is used to develop empirical mathematical model by using Response Surface Methodology (RSM) based on Central Composite Design (CCD) with aid of Minitab 17 statistical analysis software. The significance of the developed empirical mathematical model is validated by using Analysis of variance (ANOVA). Maximum effective thermal effectivity obtained is 1.127 and maximum relative viscosity is 4.521 which is recorded at 70 °C temperature, volume concentration of 0.9%, and BR of 0.5. Thus, effective thermal conductivity and relative viscosity has proportional relation with temperature and volume concentration which is supported by contour and surface plot from statistical software. Developed empirical model using RSM has good fit with the experimental data with maximum error of 0.77% for effective thermal conductivity and maximum error of 2.48% for relative viscosity.

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1. Introduction

Low heat transfer performance of existing thermal transport fluid is an unsolved problem in most engineering applications. Globally, Industries such as power plant, semi-conductor, automobile and manufacturing largely relying on thermal transport fluid for their daily production involving massive thermal exchange. Indeed, a small thermal property enhancement give a big impact on their production rate. According to literature study, a good thermal transport fluid should have high heat absorption rate with minimal abrasion [1]. This can be related with enhancement of thermal conductivity and dynamic viscosity property to produce efficient thermal transport fluid with better heat transfer performance [2,3].

Since the introduction of nanofluid by Masuda et al. [4] in 1993, nanofluid is well-known for drastic thermal conductivity enhancement that has potential in becoming novel replacement for conventional thermal transport fluid in near future. Meanwhile, viscosity produces frictional resistance against the shearing stress.