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Experimental characterization of magnetic field effects on heat transfer coefficient and pressure drop for a ferrofluid flow in a circular tube

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Highlights

- Magnetic field effects on the thermal entrance region heat transfer are studied.
- Verification is performed by applying TEM, DLS, Zeta potential and VSM.
- The Nusselt number is enhanced using a ferrofluid instead of pure water by 10%.
- Constant and alternative magnetic fields with four different Patterns are studied.
- The effect of magnetic field frequency of 10, 100 and 1000 Hz is investigated.

Abstract

In this paper, an experimental study is performed to characterize the effect of constant and alternative magnetic fields on pressure drop and heat transfer coefficient for a ferrofluid in laminar flow in a circular straight tube. The ferrofluid considered in this study is prepared using Fe_3O_4 nanoparticles. The verification of the size of nanoparticles is accomplished using TEM images and DLS distribution. A two-step preparation method is used to produce a ferrofluid with 0.5 and 1 wt%. The ferrofluid is stabilized using a surfactant and ultrasonic waves. The Zeta potential is employed to evaluate the stability of the ferrofluid, and the VSM to check its magnetization property. An uncertainty analysis is also performed where a maximum uncertainty of 1.8% is obtained. Experimental results are first compared with those of Shah and London equation for pure water as the working fluid. The Nusselt (Nu) number is enhanced using a ferrofluid instead of pure water for various Reynolds (Re) numbers. Next, two constant and alternative magnetic fields of 770 and 1300 G with four different Patterns are applied. The Nu number is improved by using a constant magnetic field. It is found that the Nu number is enhanced by 11.85 and 14.8% by using an alternative magnetic field with a frequency of 10 and 100 Hz, respectively. Further increase in the frequency (above 100 Hz up to 1000) does not lead to a positive outcome.

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Keywords

Ferrofluid; Heat transfer; Flow; Constant magnetic field; Alternative magnetic field

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