Numerical study of compact heat exchanger performance using nanofluid

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Abstract

The effect of using MWCNT nanofluids as the heat transfer medium in microchannel heat exchanger (MCHE) will be investigated. The heat transfer performance of CNT nanofluids in micro channels will be assessed for a wide range of operating conditions comprising the overall parameters known to directly influence the thermophysical and transport properties of the heat transfer fluid, namely its base fluid, nanoparticle geometry and concentration. The overall problem will be solved through the one-phase, 3D, steady, laminar and turbulent developing flows and conjugate heat transfer phenomena governing equations for different micro heat exchanger geometries using finite volume methods in Fluent-ANSYS software. The thermophysical properties of MWCNT nanofluids have been measured experimentally and conveniently modelled. This study intends, therefore, to investigate through a numerical approach, the heat transfer phenomena in microchannels typically subjected to high pressures and where high rates of heat transfer in relatively small spaces and volumes are required. The study will provide a means to establish the relative influence of the CNT nanofluids properties on the overall heat transfer and fluid flow effectiveness of such systems rendering it a tool to assist the tailoring of the heat transfer fluid to specific heat exchanger applications, namely: micro-electromechanical systems, solar energy, aerospace applications.

Background

Compact heat exchangers are characterized by high heat transfer performance resulting in a small volume per heat load, lower fluid requirement and lower operational cost. However, there are some known limitations: the limited channel cross section results in a higher pressure drop and the heat transfer intensification is limited by the physical properties of the working fluid. This work plan focuses on the study of CNTs nanofluids as a heat transfer working fluid in heat exchanger applications. The enhanced thermo-physical properties of MWCNTs nanofluids (namely, thermal conductivity, viscosity, specific heat and density) obtained using mixtures of Distilled Water (DW) and Ethylene Glycol (EG) as base fluids and different nanoparticle geometries at different concentrations have been studied and modelled by this research team in the last years. Multiphysics Computational Fluid Dynamics (MCFD) is today a powerful research tool to study realistic heat exchanger geometries and assembly configurations. The analysis of the individual and conjugated importance of parameters such as fluid temperature, Nusselt number, thermal resistance, friction factor, entrance length and pressure drop will establish the importance of nanofluids properties on the overall heat transfer phenomena as well as on the micro channels fluid flow dynamics, required to support the design of high performance heat exchangers.

Problem

- Compact heat exchangers’ performance is limited by working fluid properties.
- Studies related to enhancing heat transfer coefficient in compact heat exchangers using nanofluids as working fluid are limited in number and complexity.
- Very rare studies on MWCNTs nanofluids as real working fluids

Solution/proposal

- Obtain a numerical model of CNT nanofluids thermal behaviour flowing in micro channels for a variety of flow regimes (i.e. laminar or turbulent, steady state or transient) and channel geometries.
- Evaluate the performance of different compact heat exchangers geometries and configurations working with MWCNT nanofluids as thermal working fluids, using CFD tools.

References

