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Flow Characteristics and Heat Transfer Performance of Magnesium Oxide-Water Nanofluid in the Entrance Region in Circular Cross Section Microchannel

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Extended ABSTRACT
The present paper reports the flows characteristic and the heat transfer performance of Magnesium Oxide-water nanofluid entering a microchannel with circular cross section area. The flow is studied by CFD method using finite volume method. The simulation results were validated with data from literature. A recently introduced viscosity correlation is used to predict the nanofluid effective viscosity. A range of Re number is investigated in the present paper. Various temperature ranges were used as constant temperature boundary condition. The increase of the nanoparticle volume fraction was found to increase the heat transfer rate. Nanofluid showed better enhancement in heat transfer compared to the conventional water fluid. The increase in Re number promoted the heat transfer rate.
The change of velocity, temperature and viscosity in the entrance region was extensively investigated. The effect of the temperature and Re number on the effective viscosity in the channel was also reported. The friction factor is investigated and studied against the available conventional correlations. The present prediction of friction factor highlighted the needs for further experimental investigation to predict the friction factor in microchannels accurately.
Keywords:
Heat Transfer, CFD, Nanofluid and microchannel

Problem Description
The geometry studied in this research is indicated in Fig. 1. This shows a microchannel with length L, with ø 106 μm and a constant external temperature. The nanofluid is passing in the microchannel. The thermophysical properties of the nanoparticle are shown in Table 1.

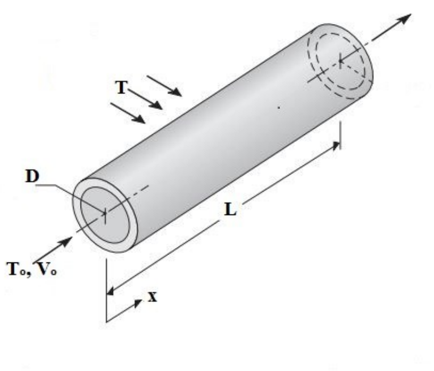

Figure 1 Microchannel geometry

Table 1 Nanoparticle thermal properties

Nanoparticle	ρ	K	C_p
MgO	3580	50	950

The governing equations were solved in the present study are continuity, momentum equation and energy equation and can be written as

Continuity equation

$$\nabla(\rho\vec{v}) = 0 \qquad (1)$$

Momentum equation

$$\nabla(\rho\vec{v})\vec{v} = -\nabla p + \nabla(\tau) + \rho g + F \qquad (2)$$

Energy equation

$$\nabla(\vec{v}(\rho E + P)) = \nabla\left(K_{eff}\nabla T - \sum h_j J_j + (\tau\vec{v})\right) \qquad (3)$$

The density of Nanofluid is expressed as:

$$\rho_{nf} = (1-\phi)\rho_f + \emptyset\rho_s \qquad (4)$$

Results

Some of the results samples are presented in Fig 1, Fig. 2 and Fig. 3

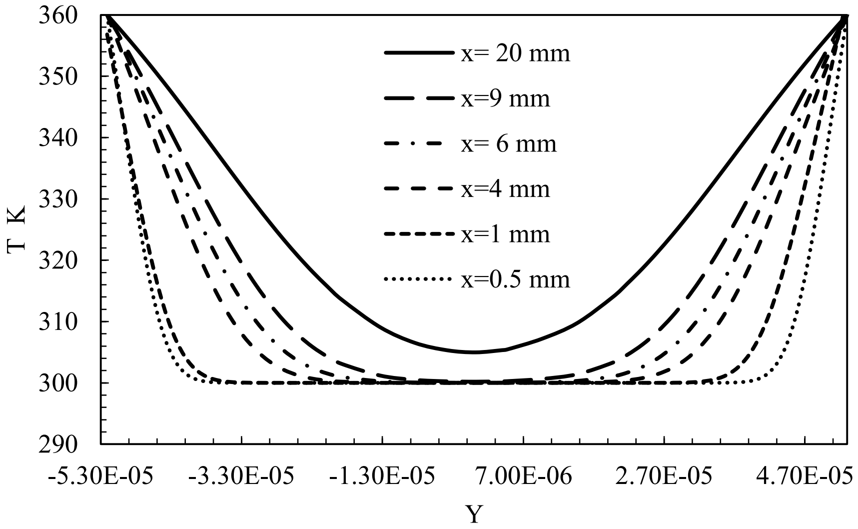

Figure 2 The Temperature change in the entrance region

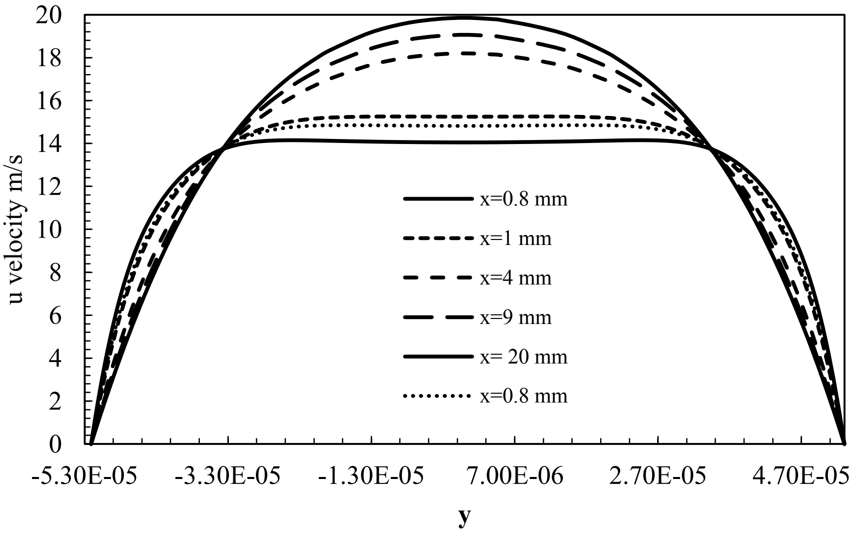

Figure 3 Velocity change in the entrance region

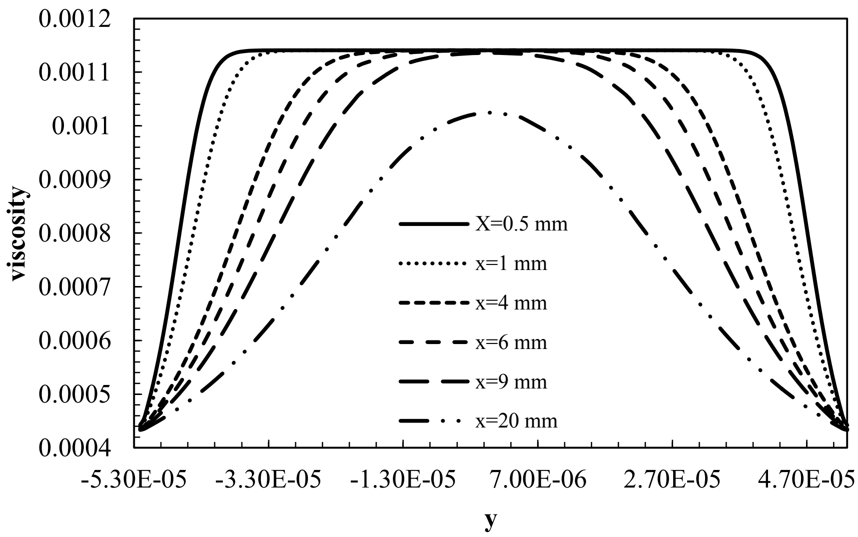

Figure 4 Viscosity change in the entrance region