Appl. Phys. A (2014) 117:1821–1833
DOI 10.1007/s00339-014-8760-1

Applied Physics A
Materials Science & Processing

Cooling performance of a nanofluid flow in a heat sink microchannel with axial conduction effect

M. Izadi · M. M. Shahmardan · M. Norouzi ·
A. M. Rashidi · A. Behzadmehr

Received: 14 June 2014 / Accepted: 27 August 2014 / Published online: 30 September 2014

Abstract In this work, the forced convection of a nanofluid flow in a microscale duct has been investigated numerically. The governing equations have been solved utilizing the finite volume method. Two different conjugated domains for both flow field and substrate have been considered in order to solve the hydrodynamic and thermal fields. The results of the present study are compared to those of analytical and experimental ones, and a good agreement has been observed. The effects of Reynolds number, thermal conductivity and thickness of substrate on the thermal and hydrodynamic indexes have been studied. In general, considering the wall affected the thermal parameter while it had no impact on the hydrodynamics behavior. The results show that the effect of nanoparticle volume fraction on the increasing of normalized local heat transfer coefficient is more efficient in thick walls. For higher Reynolds number, the effect of nanoparticle inclusion on axial distribution of heat flux at solid–fluid interface declines. Also, less end losses and further uniformity of axial heat flux lead to an increase in the local normalized heat transfer coefficient.

M. Izadi (✉) · M. M. Shahmardan · M. Norouzi
Mechanical Engineering Department, University of Shahrood, P.O. Box 3619995161-316, Shahrood, Iran
e-mail: m.izadi.mec@gmail.com

A. M. Rashidi
Nanotechnology Research Center, Research Institute of Petroleum Industry (R.I.P.I), Tehran, Iran

A. Behzadmehr
Mechanical Engineering Department, University of Sistan and Baluchestan, P.O. Box 98164-161, Zahedan, Iran

List of symbols

C_p	Specific heat (J/kg K)
d	Diameter
d_{bf}	Molecular diameter of base fluid (nm)
d_h	Hydraulic diameter (nm)
d_p	Nanoparticle diameter (nm)
h	Heat transfer coefficient (W/m^2 K)
h_c	Channel height (μm)
h_c	Channel height
k	Thermal conductivity (W/m K)
K_b	Boltzmann's constant
L	Channel length
M	The molecular weight of the base fluid
N	Avogadro number
p	Pressure (pa)
Pr	Prandtl number
q	Heat flux (W/m^2)
t	Wall thickness (μm)
T	Temperature (K)
TR	Thermal resistance, $q/(T_{m,sf} - T_b)$ (k/W)
u	Velocity (m/s)
x	Coordinate (m)

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0	Reference condition (inlet)
1, 2	Horizontal and vertical direction
a	Area average
ave	Average length
b	Base flux
b	Bulk
bf	Base fluid
d	Down
eff	Effective
fr	Freezing point