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Nanofluid heat transfer anomaly: Theoretical explanation of observations in the development region of microchannels

J.T.C. LIU, School of Engineering, Brown University — Continuing from http://meetings.aps.org/link/BAPS.2010.DFD.CP.7 is the work on analytical solutions to the first order perturbation problem for momentum, heat and volume concentration following the continuum conservation equations for nanofluids (Buongiorno 2006; Pfautsch 2008; Tzou 2008), simplified by the Rayleigh-Stokes approximation and perturbation in small free stream volume fraction. The disparate momentum, heat and volume fraction transport layer thicknesses$\delta_u > \delta_T >> \delta_\phi$, are estimated for metallic nanofluids, further structures the transport problems. From experiments of, e.g., Wen & Ding 2004, Jung, et al. 2009, it is concluded that the observed large "anomalous" surface heat transfer rates for small increases in the volume fraction, especially at the leading edge of laminar microchannel nanofluid flows, is partially attributable to the nanofluid modification of the temperature profile by the inertial effects of modified density and heat capacity and of conduction effects of the modified thermal conductivity. The solutions obtained display these contributions explicitly. Thus the use of nanofluid transport properties in the correlation of laminar heat transfer must necessarily be accompanied by the detailed considerations of the temperature profile modification in nanofluid flow via the conservation equations.

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