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Marangoni convection in water-alumina nanofluids: Dependence on the nanoparticle size

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Abstract A linear stability analysis for the onset of Marangoni convection in a horizontal layer of distilled water/alumina nanofluid heated from below is investigated using a model which incorporates the effects of Brownian and thermophoresic diffusions. The analysis uses realistic constitutive models for thermal conductivity and dynamic viscosity which include a dependence on average size of nanoparticles in addition to the volume fraction of nanoparticles and temperature. The lower boundary of the layer is a rigid surface at fixed temperature while the upper boundary behaves as a non-deformable free surface cooled by convection to an exterior region at a fixed temperature. Both boundaries are assumed to be impenetrable to nanoparticles so that their distribution is determined from a conservation condition. The numerical results are obtained using the method of expansion of Chebyshev polynomials. Stability boundary curves are investigated for nanoparticle sizes ranging from 15 nm to 100 nm. Nanofluids with nanoparticle of smaller average size are found to be more stable than those with larger sized nanoparticles.

Keywords : Marangoni convection, linear stability, water-alumina nanofluid, nanoparticle size, Brownian motion, thermophoresis

1 Introduction

Over the past decade, a new class of fluid called a "nanofluid" have been reported to possess substantially higher thermal conductivity than anticipated from the effective medium theories. A nanofluid refers to a base fluid that contains particles of maximum size 100 nm. The choice of base fluid and particle combination depends on the application for which the nanofluid is intended. This type of fluids appears to have the potential of increasing the heat transfer rates in many applications such as industrial cooling, lubricants, transportation industry, the delivery of drugs, in heat exchangers and in micro-channel heat sinks among other applications (Buongiorno and Hu [1]; Tsai and Chein [2]; Kleinstreuer *et al.* [3]).

The conservation equations of a non-homogeneous equilibrium model of a nanofluid have been derived by Buongiorno [4]. This model incorporates the effects of Brownian diffusion and