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STEADY-STATE NANOFLUID CONVECTIVE FLOW IN FRACTURED POROUS MEDIA

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Abstract: Suspended nanoparticles in conventional fluids, called nanofluids, have been the subject of intensive study worldwide. The use of nanofluids as an advanced kind of fluids to improve heat transfer efficiency and performance is a comparatively recent development. This article presents steady-state transport of nanofluid in a fractured porous media by two-dimensional modelling. In the porous region, the Brinkman–Forchheimer extended Darcy model was used to describe the fluid flow pattern. The model used for the nanofluids incorporates the effects of Brownian motion and thermophoresis. The velocity and temperature profiles and expressions for the Nusselt number values were obtained for fully developed nanofluid flow. In addition, a parametric study was conducted to investigate the influences of various parameters on the nanofluid flow pattern and heat-transfer performance.

Keywords: Nanofluid, Fractured porous media, Heat transfer, Modelling, Numerical solution

1. INTRODUCTION

Research on flow of fluids through fractures in rocks in oil exploration has a history that spans nearly four decades. A better understanding of reservoir performance in such cases may be obtained by including the details of the fluid flow in fractures in a coupled fracture-matrix reservoir flow model [1].

Suspensions of solid nanometer-sized particles in various fluids (called nanofluids) have been considered for applications as advanced heat transfer fluids for almost two decades. However, due to the wide variety and the complexity of the nanofluid systems, no agreement has been achieved on the magnitude of potential benefits of using nanofluids for heat transfer applications. Large volume of studies devoted to characterization of individual thermo-physical properties of nanofluids, such as thermal conductivity, viscosity, and agglomeration of nanoparticles, has been summarized in a number of review articles [2-10].

Choi is the first who used the term nanofluids to refer to the fluids with suspended nanoparticles. Some preliminary experimental results showed that increase in thermal conductivity of approximately 60% can be obtained for the nanofluid consisting of water and 5 vol% CuO nanoparticles [11, 12]. By suspending nanoparticles in heating or cooling fluids, the heat transfer performance of the fluid can be significantly improved. The main reasons may be listed as follows [13]:

1. The suspended nanoparticles increase the surface area and the heat capacity of the fluid.

2. The suspended nanoparticles increase the effective thermal conductivity of the fluid.

3. The interaction and collision among particles, fluid and the flow passage surface are intensified.

4. The mixing fluctuation and turbulence of the fluid are intensified.

5. The dispersion of nanoparticles flattens the transverse temperature gradient of the fluid.

A comprehensive survey of convective transport in nanofluids has been conducted by Buongiorno [14], who states that a satisfactory explanation for the increase in the thermal conductivity and viscosity has to be found.