EFFECT OF SUCTION/INJECTION ON FREE CONVECTION ALONG A VERTICAL PLATE IN A NANOFUID SATURATED NON-DARCY POROUS MEDIUM WITH INTERNAL HEAT GENERATION


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The effect of internal heat generation on free convection along a vertical plate embedded in a nanofluid saturated non-Darcy porous medium in the presence of suction/injection is analyzed. The non-linear governing equations and their associated boundary conditions are initially cast into dimensionless forms by non-dimensional variables. The resulting equations are solved numerically by an accurate, implicit, iterative finite-difference methodology and the obtained results are compared favorably with previously published work. A parametric study is performed to illustrate influence of the temperature exponent, non-Darcy, suction/injection, Brownian motion and thermophoresis parameters on the profiles of the velocity components, temperature and nanoparticle volume fraction. The numerical data for the heat and nanoparticle mass transfer rates have been tabulated for various parametric conditions.

Key words: Free convection; non-Darcy porous medium; nanofluid; suction/injection; internal heat generation.
1. INTRODUCTION

The study of convective flow, heat and mass transfer in porous media has been an active field of research as it plays a crucial role in diverse applications, such as thermal insulation, extraction of crude oil and chemical catalytic reactors, etc. Considerable work has been reported on flow, heat and mass transfer in Darcian porous media. Cheng and Minkowycz [1] presented similarity solutions for free convective heat transfer from a vertical plate in a fluid-saturated porous medium. The problem of combined convection from vertical plates in porous media is analyzed by Minkowycz et al. [2]. However, Darcy’s law is valid only for slow flows through porous media with low permeability. At higher flow rates, there is a departure from the linear law and inertial effects become important. The simultaneous effects of fluid inertia force and boundary viscous resistance on the flow and heat transfer in a porous medium are discussed by Vafai and Tien [3] for forced convection and by Ranganathan and Viskanta [4] for mixed convection. From their reports, it is found that both boundary and inertia effects exhibit a significant influence on the velocity distribution and heat transfer and thus, these effects cannot be ignored. The Darcy-Forchheimer model describes the effect of inertia as well as viscous forces in porous media. A detailed review of convective heat transfer in Darcian and Non-Darcian porous medium can be found in the book by Nield and Bejan [5]. Several authors, Narayana and Murthy [6], Kairi and Murthy [7] and Chamkha et al. [8] to mention but few, have studied the convective heat and mass transfer over different surface geometries in a fluid saturated non-Darcy porous media.

A large number of physical phenomena involve free convection driven by internal heat generation. The most important applications are in the field of nuclear energy and also to fire and combustion modelling, the development of metal waste form from spent nuclear fuel and for storage of spent nuclear fuel. Studies in natural convection driven by internal heat generation have been done by Roberts [9], Jahn and Reinke [10], Hardee and Nilson [11], Stewart and Dona [12], etc. A couple of papers have been devoted to the subject of similarity solutions for free or mixed convection with internal heat generation in porous media for several geometric configurations, see Postelnicu et al. [13] and Chamkha [14]. For an exhaustive discussion of the free or mixed convection heat transfer in the boundary layers about different surface geometries in porous media in the presence of internal heat generation or absorption, the reader is referred to the works of Singh et al. [15] (also see the references cited therein).

The effect of blowing or suction on convective heat transfer over a vertical permeable sur-