Similarity Solution of Mixed Convection Boundary Layer on Horizontal Surface Embedded in Porous Medium with Internal Heat Generation and Concentration Change

Rabeya Akter, Saga University, Japan
Akio Miyara PhD, Saga University, Japan

Abstract

The aim of this work is to analytically present coupled heat and mass transfer characteristic of mixed convection boundary layer flowing on horizontal surface embedded in a porous medium with exponentially decaying internal heat generation (IHG) and internal mass generation (IMG) over specific component in the presence of thermal radiation and chemical reaction, respectively. Corresponding similarity solutions are used to reduce the governing partial nonlinear differential equations to three ordinary differential equations for the dimensionless stream function, temperature, and concentration with the following parameters: mixed convection parameter ε, exponent of x, chemical reaction parameter γ, radiation parameter R, and Lewis number Le. Media with and without IHG and IMG are compared in context with the help of graphs and tables. Computations are performed with a system of parameters using built-in codes in Maple. The influences of these parameters on velocity, temperature and concentration profiles, and Sherwood and Nusselt numbers are thoroughly compared and graphically illustrated.

The corresponding parameters are defined as

$\varepsilon = \frac{Ra_x}{Pe_x}$, where $Ra_x = \frac{g\beta k(T_w - T_\infty)x}{\upsilon\alpha}$ and $Pe_x = \frac{U_\infty x}{\alpha}$ are the local Darcy-Rayleigh number and local Peclet number respectively. $Le = \frac{\alpha}{D}$, where α and D are thermal and mass diffusivity respectively.

$\gamma = \frac{kx^2}{\alpha Pe_x}$ and $R = \frac{16\sigma^* T_\infty^3}{k^* k}$, where σ^* and k^* are the Stefan-Boltzmann constant and mean absorption coefficient respectively.

Image

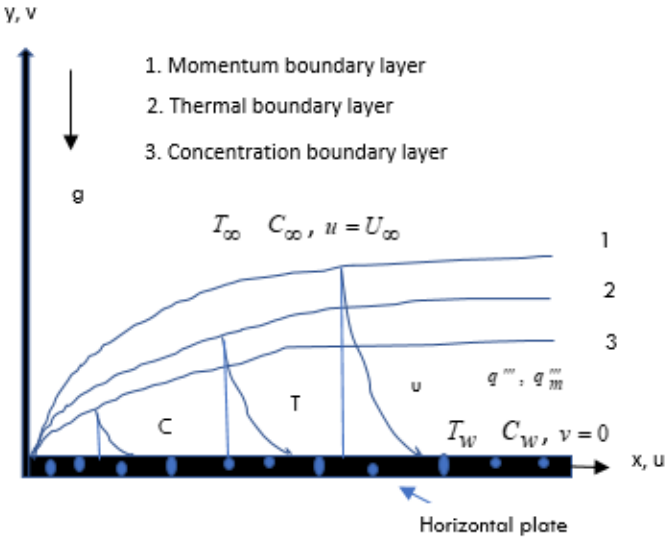


Figure 1. Schematic representation of the boundary layer flow of a horizontal plate

Recent Publications

1. Nield D.A. and Bejan A. (2013): Convection in Porous Media. – 4thEdition, New York: Springer.
2. Mealey L.R. and Merkin J.H. (2008): Free convection boundary layers on a vertical surface in a heat-generating porous medium. – IMA Journal of Applied Mathematics, vol.73, pp.231-253.
3. Magyari E., Pop I. and Postelnicu A. (2007): Effect of the source term on steady free convection boundary layer flows over a vertical plate in a porous medium. – Part I., Transport in Porous Media, vol.67, pp.49-67.
4. Bagai S. (2003): Similarity solutions of free convection boundary layers over a body of arbitrary shape in porous medium with internal heat generation. – Int. Comm. Heat Mass Transfer, vol.30, pp.997-1003.
5. Postelnicu A., Grosan T. and Pop I. (2001): The effect of variable viscosity on forced convection over a horizontal flat plate in a porous medium with internal heat generation. – Mech. Res. Comm., vol.28, pp.331-337.
6. Postelnicu A., Pop I. and Grosan D. (2000): Free convection boundary-layer flows over a vertical permeable flat plate in porous media with internal heat generation. – Int. Comm. Heat Mass Transfer, vol.27, pp.729-738.



Biography

Rabeya Akter is a student of Graduate School of Science and Engineering, Dept. of Mechanical Engineering, Saga University, Japan. Her research interests include falling liquid film, fluid flow in porous media, heat and mass transfer, nanofluids dynamics, magnetohydrodynamics, multiphase fluid-particle dynamics

Email: rabeya.ju@gmail.com

Notes/Comments: