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Mixed convection inside a fluid-porous composite cavity with centrally rotating cylinder

(2018) *Heat Transfer - Asian Research*, 47 (4), pp. 684-701. Cited 1 time.

Abstract

The mixed convection in a fluid-porous composite medium lying inside a square cavity with a centrally rotating cylinder has been investigated in the present work. The bottom half of the cavity is filled with a porous material and the top half is filled with a clear fluid. The bottom wall of the cavity is at a higher temperature, and the top wall is at a lower temperature. The vertical walls are thermally insulated. The convection inside the cavity sets through the combined mechanisms of the thermal buoyancy force and the shearing action of the centrally rotating cylinder. The relative importance of each driving mechanism over the other is featured through the Richardson number. The Darcy–Brinkman–Forchheimer equation is used for the flow modeling in the porous medium, and a single-domain approach is adopted for the numerical solution in the fluid-porous composite medium. The simulation is carried out with ANSYS Fluent software, and a parametric analysis involving the Rayleigh number (Ra), Richardson number (Ri), and the Darcy number (Da) is conducted showing their effects on the flow and heat transfer. The phenomena are quite interesting at higher Darcy number and Rayleigh number. The distributions of isotherms, streamlines, and vector plots are plotted, along with the local Nusselt numbers for different parameters, to explore the underlying physics of the phenomenon. The system is found stable at lower Darcy number, and the heat transfer is minimum around Ri = 10. From the numerical study, an empirical correlation for the average Nusselt number is developed as a function of the other dimensionless numbers. © 2018 Wiley Periodicals, Inc.

2-s2.0-85048034352
Document Type: Article
Publication Stage: Final
Source: Scopus