Natural Convection Heat Transfer Enhancement of Power Law Fluid in a Cylindrical Gap Using Internal Flat Tube

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Abstract

A numerical study conducted on the steady state laminar natural convection in the annular space created by inserting internal flat tube concentrically into an external cylinder filled with power-law fluid. The internal flat tube receives hot temperature T_h from heat source while the external cylinder is cooled at temperature T_c. The governing equations for the power-law fluid are solved numerically with the ANSYS-CFX package based on the finite volume technique.

The effects of the relevant parameters such as Rayleigh number ($10^3 \le Ra \le 10^5$), Prandtl number ($10 \le Pr \le 10^3$), power law index ($0.6 \le n \le 1.4$) and internal flat tube inclination angle ($0° \le \varphi \le 90°$) on the thermal performance of the channel are presented and discussed, three cases are studied for various values of Rayleigh and Prandtl numbers and power law index in the ranges considered earlier corresponding to inclination angles $\varphi=0°$, $\varphi=45°$ and $\varphi=90°$ respectively. The results are interpreted in form of isotherms, velocity vectors, curves of velocity and dimensionless temperature, besides the average Nusselt number is determined.

The obtained results indicated to an increase in thermal fields disturbances for increasing Ra especially for pseudoplastic fluids and this refers to the large cooling effect in the annular space; Additionally, the magnitude of the velocity component is found to be greater for pseudoplastic fluids and smaller for dilatant fluids when compared to Newtonian fluids ; Also, increasing the inclination angle leads to an improvement in the heat transfer rate for the same set of the other parameters ; Finally, the influences of the precedent parameters on the heat transfer rate are represented and explained in detail.