Abstract

This paper presents a numerical investigation for natural convection of air in a three dimensional inclined annulus enclosure. This study wills examine the effect of radius ratio of an annulus made from graphite/epoxy laminated composite material on heat transfer taking two types of optimization of effective thermal conductivity in consideration: minimization and maximization of thermal conductivity. The annulus enclosure is filled with porous media between two concentric cylinders with 12 fins attached to the inner cylinder. Two cases are taken for the inclination angle of the annulus: horizontal and vertical annulus. The system is under steady state condition and constant walls temperature boundary condition. The parameters affected on the system are modified Rayleigh number \((10 \leq Ra^* \leq 500)\), the annulus inclination angle \(\delta\) (0° and 90°) and the radius ratio \(R_r = (R_I/RO)=0.2, 0.3, 0.4\) and 0.5.

For all parameters, results showed that Nusselt number decrease with the decrease of the radius ratio \(R_r\) (which means larger gap) for the outer cold cylinder. the average Nu number increases with an increase in modified Rayleigh number and decrease with the increase of \(\delta\) for
high values of Ra*, but hardly affected by δ for low values of Ra*. The deviation between the average Nu for the maximization and minimization of the thermal conductivity is equal to 5.1% for horizontal annulus δ=0° and 10% for vertical annulus δ=90°. Local Nu increases with the length of the cylinder and the effect of the fins attached to the inner cylinder is more significant for the horizontal cylinder because of its hindering effect. A correlation for the average Nusselt number in terms of Ra* and δ, has been developed for the outer cold cylinder.

References


Index Terms
Keywords

Natural convection, laminar flow, porous media, graphite/epoxy, composite material.