Optimal hydro-thermal characteristics of a porous annular elliptic pipe using response surface method

Natural convection of pure water within an annular condensed elliptic pipe fully filled with saturated porous metal foam is computationally evaluated. A single-phase fluid with the Darcy-Forchheimer model and LocalThermal-Equilibrium between fluid and solid is implemented for water flow through the porous zone. The outer and inner surfaces of the annular pipe are exposed to constant cold temperature and variable hot temperatures, respectively. The desirable hydraulic-thermal features for the hot surface temperature of the inner pipe (Th) and contraction ratio (CR) are considered. After achieving the optimum of Th and CR, the response surface method (RSM) is conducted to maximize heat transfer rate and minimise skin friction coefficient by utilising the multi-objective optimum design for porous metal foam properties such as porosity (ε), viscous resistance (1/K) and inertial resistance (C) simultaneously. The key results show that the local and average Nusselt number and heat transfer rate are enhanced, while the local and average skin friction coefficients have been increased with hot surface temperature increase and contraction ratio decrease. In addition, RSM shows that porosity (ε) and viscous resistance of metal foam (1/K) have a major effect on hydro-thermal efficiency enhancement, while inertial resistance (C) has a minor effect on the desired responses. Consequently, for any value of inertial resistance (C), the optimal values of porous media properties are $\varepsilon = 0.95$, $1/K = 106$. This investigation provides an original method and useful guidance for the optimum design of the annular condensed elliptic pipe.