Abstract

Forced convective heat transfer in a vertical channel symmetrically heated with a constant heat flux, and packed with saturated porous media, has been investigated theoretically and experimentally in the present work. The porous media was made with spherical glass particle of four different diameter (3, 5.6, 12 and 15.4 mm), in a range of porosities ($0.38<\varepsilon<0.533$). The water flow in the packed channel was assumed to be hydrodynamically fully developed, and the effect of inertia in the momentum equation is negligible.

The results were obtained for a Reynolds number range of ($14< Re<1506$) and particle Reynolds number range of ($3< Re_d<11.5$). The heat flux applied was for the range of (1.5-6) kW/m^2.

In the experimental setup, the packed bed assembly consists of aluminum channel of square cross sectional area with a (46 mm) hydraulic diameter and (1150 mm), the packed bed subjected to a constant heat flux boundary condition. The channel test section was vertically oriented with water flowing upward. The results show an increase in local Nusselt number when Reynolds number and heat flux increase, the heat transfer rate increase as the particle diameter increase at the range of (3 – 5.6 mm) and decrease with increasing the particle diameter at the range (5.6 – 15.4 mm). The friction factor decrease with increases the particle diameter and particle Reynolds number. Different correlations that related Nusselt numbers, pressure drop, friction factor, and drag coefficient with Reynolds number for different particle size where developed from experimental results.

The numerical solution including the solution of continuity, momentum, and energy equations were solved using a finite volume method, the velocity and temperature distribution are introduced into entropy equation to solve it. Differentially heated isothermal walls are selected as thermal boundary conditions. (the left vertical wall kept at T_{hot}, while the left vertical wall kept at T_{cold}).The other two walls are kept insulated.

The effect of Darcy, Reynolds, Eckert numbers on Entropy generation were studied in the numerical solution. The entropy generation was found to be inversely proportional to both Reynolds and Darcy number, while it was directly proportional with the Eckert number.

The ratio of an irreversibility due to Heat transfer to the total irreversibility was presented using Bejan number, it was shown that as Darcy and Reynolds numbers were increasing, the Bejan number decreases ,i.e., the irreversibility due fluid friction is dominated, while as the Eckert increases ,the irreversibility due to heat transfer increases. The effect of Reynolds and Darcy number on heat transfer and friction factor was also presented.

A comparison between this study and previous studies from literature are presented for validation of the Numerical procedure used. The agreement was fairly good.