THE EFFECT OF PORE TO THROAT SIZE RATIO ON INTERFACIAL CONVECTIVE HEAT TRANSFER COEFFICIENT

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ABSTRACT

The microscopic scale analysis is employed to develop models for macroscopic characters of transport phenomena in porous media. Numerical experiment is widely used to analyze heat and fluid flow in the microscopic scale. Several microscopic scale studies on porous medium with spherical or cubical particles, square rods or finite cylinder rods were performed and reported in literature [1-4]. The aim of these studies is to observe heat and fluid flow in microscopic scale and then use the achieved results for determination of heat and fluid flow characteristic parameters or improvement of macroscopic scale models.

In the present study, a microscopic scale analysis is performed for a porous medium with periodic structure. The porous medium consists of rectangular rods with in-line arrangement. The continuity, momentum and energy equations are solved to find the local fluctuations of velocity and temperature in the voids between particles. Volume averaging theory is employed to determine values of permeability, Forchheimer and interfacial convective heat transfer coefficients. The obtained results for square rods are compared with the reported studies in literature and good agreement is observed. The study is performed for rods with pore to throat size ratios (β) of 1.11 and 10 and wide range of Reynolds number from 10^{-2} to 10^{2}. A high porosity of porous media (ε=0.91) is assumed.

The main aim of the present study is to analyze the effect of particle shape and pore to throat size ratio on heat and fluid flow in porous media. By increasing pore to throat size ratio, the distance between particles (which are in-line arrangement) is reduced and this causes a steep drop of permeability due to the throat effect. The change of pore to throat size ratio considerably influences flow patterns in the voids between rods and consequently the interfacial heat transfer coefficient is highly influenced. After presenting a brief review on the previous works and the employed mathematical model, the changes in permeability, Forchheimer coefficient and interfacial heat transfer coefficient with pore to throat size ratio for different values of Reynolds number are discussed in details. It is shown that, permeability, Forchheimer coefficient and interfacial heat transfer of two porous media with the same porosity, Reynolds number, hydraulic pore diameter values are differ considerably when the pore to throat size ratios are different.

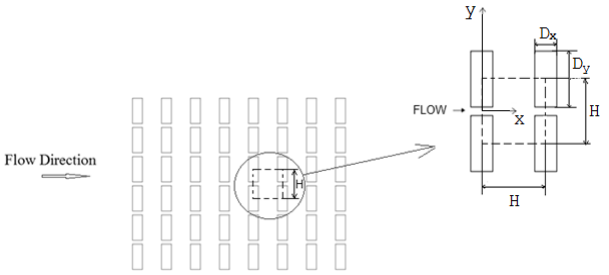
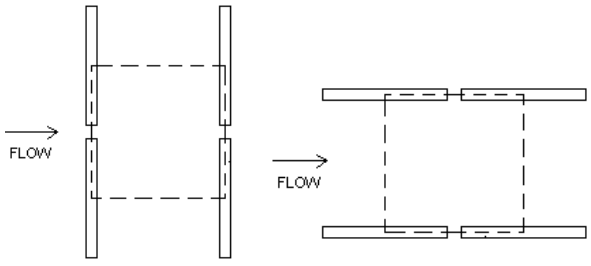


Figure 1 – Considered periodic porous structure



(a) (b)

Figure 2 – Structural units consist of rectangular rods with the same sizes: a) β=1.11, b) β=10.

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