Contribution ID: **154** Type: **Oral Presentation**

Experimental measurement of the heat transfer coefficients for gas flow through granular porous media

Monday, 30 May 2022 14:25 (15 minutes)

Heat transfer phenomena through granular porous media are widespread in industrial fields e.g. energy storage technology and thermal process engineering. Numerous research focused on a uniform temperature distribution within the solid phase with small Biot numbers (Bi), see [1] for a review. The volumetric heat transfer coefficient (Hv) is used to represent the internal heat exchange between the fluid and solid phases. Here we obtained Hv and the solid effective thermal conductivity for large Biot numbers ($Bi \gg 0.1$) by using an inverse analysis [2] of experimental results with well-designed simulations. The experiment was conducted using a transient technique in a 1 m long, 194 mm diameter iron tube filled with uniformly sized glass spheres (d = 16 mm). The temperatures inside the iron tube are measured at seven central axis locations (x =5, 15, 25, 35, 45, 65, 85cm) and three radial locations. The wall surface temperature is also measured at four axial locations (x =5, 35, 65, 90cm). The inlet boundary condition for the pressure is calculated based on the velocity measured at the outlet assuming a constant mass flow rate in the porous sample. The inlet mass flow rate is variable in order to obtain a range of Reynolds (Re) in the experiment. The flow inside the granular porous medium is considered compressible, the coupling between gas density and temperature is implemented in the mass conservation equation. The velocity field is modeled by the Darcy-Forchheimer equation based on the Reynolds number ($Re \gg 10$). Heat transfer is described using a local thermal non-equilibrium (LTNE) model in which there is conduction in both phases and convection in fluid phase.The governing equations are solved in the Porous material Analysis Toolbox based on OpenFoam (PATO) [3]. Hv is calculated and optimized based on the Wakao correlations [4] between the Nusselts (Nu), Prandlt (Pr) and Re numbers in which a new coefficient f has been added , Nu= 2 + f·Pr(1/3) Re(0.6). The effective solid conductivity is treated as an anisotropic tensor due to the flow. The results show that Hv is a function of space and time within granular porous media. The distribution of Hv is consistent with the gas temperature distribution e.g., where the gas temperature is high, Hv is also high. The factor f in the Nu correlations will increase withthe increase in the Re. The inverse analysis can be used to obtain Hv and effective solid conductivity in uniform sized spheres and random shape granular porous media.

Acceptance of the Terms & Conditions

Click here to agree

MDPI Energies Student Poster Award

No, do not submit my presenation for the student posters award.

Country

France

References

[1] Balakrishnan, Arcot R and Pei, David CT, Heat transfer in gas-solid packed bed systems. 1. A critical review, Industrial & Engineering Chemistry Process Design and Development, 18 (1) (1979) 30–40.
[2] S. Liu , J.Lachaud, A. Ahmadi, H.Scandelli and C.Levet, Measuring the anisotropic heat transfer coefficients in carbon fiber felt, InterPore 2021 online Conference.
[3] J. Lachaud and N.N. Mansour. Porous-material analysis toolbox based on openfoam and applications, Journal of Thermophysics and Heat Transfer, 28 (2014) 191–202.
[4] Wakao. N and Kaguei. S and Funazkri. T, Effect of fluid dispersion coefficients on particle-to-fluid heat transfer coefficients in packed beds : correlation of Nusselt numbers, Chemical engineering scienc, 34 (3) (1979) 325–336.

Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

Online

Primary author: Mr LIU, Shaolin

Co-authors: Prof. AHMADI, Azita (ENSAM - I2M); Dr LEVET, Cyril (Institut de Mécanique et d'Ingénierie de Bordeaux (I2M)); Dr LACHAUD, Jean (University of Bordeaux)

Presenter: Mr LIU, Shaolin

Session Classification: MS17

Track Classification: (MS17) Thermal Processes, Thermal Coupling and Thermal Properties of Porous Media: modeling and experiments at different scales