Numerical Analysis of Conjugate Heat Transfer in Foams

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Abstract

Introduction: Heat and mass transfer within a porous foam with a laminar fluid flow was analyzed. A 2 x 2 x 2 mm cubic unit cell with a 1 x 2 x 2 mm fictitious input region was considered. The input region made negligible the lead effects. The afore said conjugated structure is sketched in Figure1, where both the green solid phase and the blue fluid phase are shown. Use of COMSOL Multiphysics: The three-dimensional structure was developed and the corresponding mesh was imported into COMSOL Multiphysics, that allows the simultaneous analysis of mass and convective, conductive and radiative transfer. The conjugate conductive, convective and radiative problem was solved thanks to the peculiarity of COMSOL Multiphysics. The cell was based on a well-known model proposed by Weaire and Phelan [1], who developed a cell structure that minimizes the surface tensions. The analysis was carried out with reference to a 92.5 % foam porosity, a 0 Pa outlet relative pressure and various inlet velocities. Results: Temperature, velocity and pressure fields in a cell, made up of a ceramic material (SiC) and air were predicted. Results are presented in Figure 2, Figure 3 and Figure 4, respectively. Results allow the evaluation of process parameters that can be used to model the foam as a continuous medium. The continuous approach decreases computational times and costs. Conclusion: The analysis proposed in the paper is suitable for the evaluation of equivalent parameters and coefficients that allow to replace the three-dimensional solid-fluid porous structure by a far simpler continuous representation of the foam. The afore mentioned approach could be applied to the study of different applications, ranging from the high-temperature solar power to thermal insulation.

Reference

1. R. Phelan, D. Weaire, E. A. J. F Petres, The conductivity of a foam, Journal of Physics: Condensed Matter 8 (1996).

Figures used in the abstract

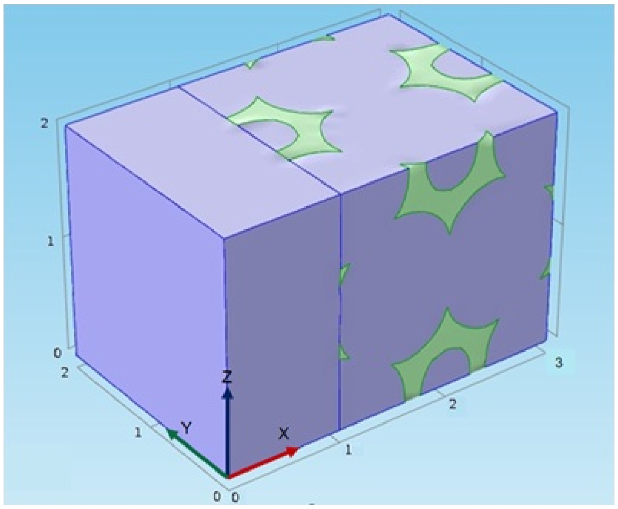

Figure 1: Sketch of the discrete structure.

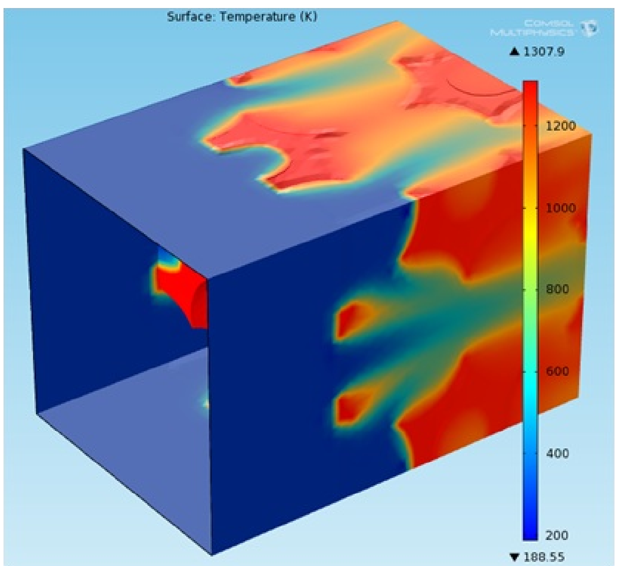

Figure 2: Temperature field in the cell.

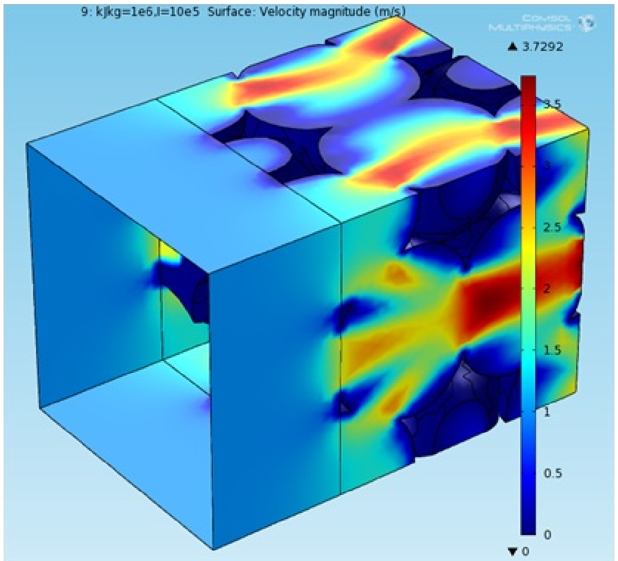

Figure 3: Velocity field in the cell.

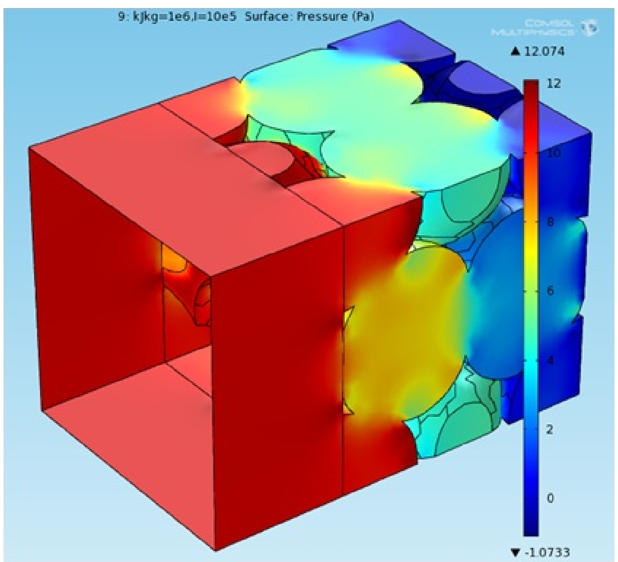

Figure 4: Pressure field in the cell.