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VISCOUS FLOWS ACROSS CERAMIC FOAMS – A NUMERICAL AND EXPERIMANTAL STUDY

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The industrial importance of structures with open porosity such as ceramic or metallic foams has been growing over recent years. Their specific properties such as remarkably huge specific surface area, high porosity, low density, mechanical, thermal and corrosion resistance outperform other materials and predestine them to serve as compact heat exchangers, reaction catalysts, flow stabilizers or filters. This results in an increased demand for accurate hydrodynamic properties (such as pressure drop) in these materials without a priori knowledge of flow characteristics[1].

The simplest relation between the pressure drop and flow's bulk velocity has the form of the Darcy-Forchheimer equation that links the pressure gradient to viscous and inertial drag of the medium:

$$\frac{\Delta \boldsymbol{p}}{\boldsymbol{L}} = \frac{1}{\boldsymbol{K}}\mu \boldsymbol{u} + \rho \boldsymbol{C}\boldsymbol{u}^2 \tag{1}$$

With K as the so-called permeability and C being an arbitrary constant.

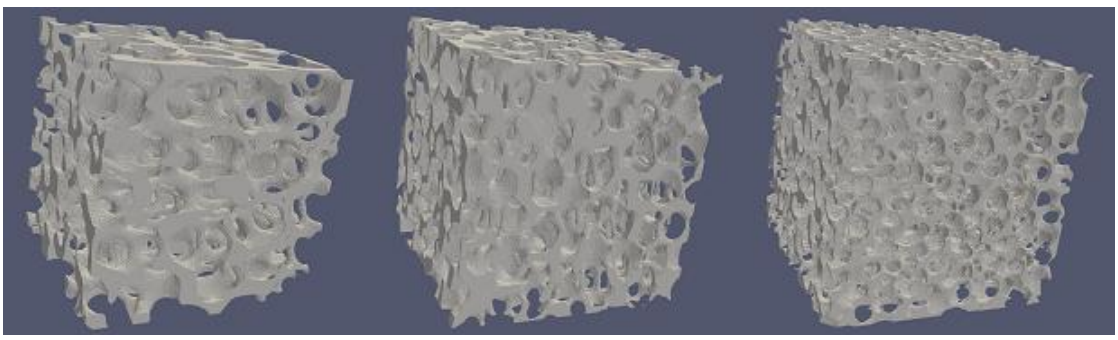

Fig. 1 –CT images of ceramic foams: 10ppi, 20ppi and 30ppi foams respectively.

In recent years simplified regular models of porous materials were proposed and accurate yet concise relations for the pressure drop in the flows across such geometries were given[2]. These correlations contain the coefficients K and C that are only pore-geometry dependent and involve the pore size, a, strut diameter, d_s, specific surface area, a_c, and porosity, ε. They, however, do not involve the effect of the pore blockage, which has little

influence on the porosity of the medium but influences the pressure drop significantly, especially in case of media with smaller pores (larger PPI, *pore per inch,* number).

This study consists of two parts. First, real ceramic foams are investigated both experimentally and numerically. A series of foams with varying PPI number (10ppi, 20ppi, 30ppi, 40ppi and 50ppi) is examined for their hydraulic resistance to obtain the coefficients to fit equation (1). Furthermore, CT-reconstructed images of these foams serve as an input geometry to numerical simulations performed with Lattice Boltzmann Method (LBM), which is particularly efficient in case of flows across very complex geometries and perfectly scales up on massively parallel architectures [3]. Advanced LB collision models such as Multiple Relaxation Time [4] are used due to their superior stability over standard BGK model. Both experimental and numerical data is compared against existing theoretical correlations.

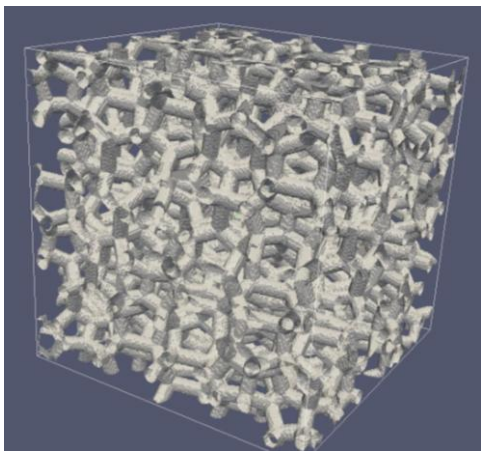

Fig. 2 – Tesselation with Weire-Phelan polyhedra.

In the second part, the effect of pore blockage in the porous materials is investigated with use of their artificial counterparts. A series of numerical and experimental studies on the idealised Weire-Phelan [5] geometries with controllable geometrical parameters as well as varying percentage of blocked pores is performed. These structures are generated numerically to fit the LBM simulations and later manufactured with use of rapid-prototyping printer to use in the experimental facility. The effect of the huge influence of the pore blockage is demonstrated and serves as the first step to derive improved coefficients to the equation (1).

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