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TWO-SCALE OPTIMAL DESIGN OF AERATION FILTERS USING HOMOGENIZATION METHOD FOR SOLID-FLUID MIXTURES AND X-FE DISCRETIZATIONS

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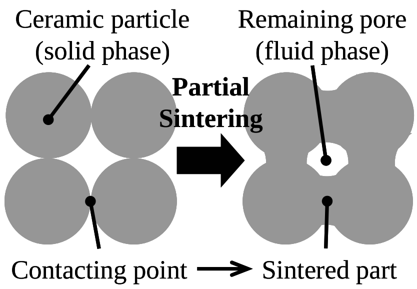
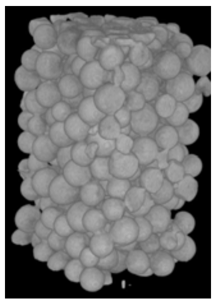
ABSTRACT

An aim of the study is to develop an efficient numerical simulation technique that can handle the two-scale optimal design of aeration filters fabricated by partial sintering of powder ceramics [1]. An illustration of the partial sintering and a CT photomicrograph of the ceramic filter are shown in Fig.1, respectively. Mechanical behaviours of the ceramics filters are characterized by the micro-macro coupled and solid-fluid coupled phenomena of an incompressible flow in elastic porous media [2, 3]. The solid-fluid mixture homogenization method [4-6] becomes powerful tool for the computer-aided design, because it enables us to predict mechanical characters such as rigidity and permeability of the porous filters from the micro scale geometry of the sintered ceramic particles.



(a) Illustration of partially-sintered ceramic particles



(b) CT photomicrograph.

Fig.1 Porous ceramics filter fabricated by partial sintering of ceramics particles.

In this study, an efficient discretization technique based on enriched interpolations of respective characteristic functions at the level set interface, using the extended finite element method [7-10], is proposed to handle the complex micro structure without interface-fitted meshes. The proposed method [11,12] can handle the non-slip velocity conditions at the interface without constraint equations such as Lagrange multipliers. Its homogenization and localization performances are presented in a typical two-dimensional bench mark problem with a hole, and its three-dimensional application to the body-centered cubic (BCC) and face-centered cubic (FCC) unit cell model is shown at the same time. The accuracy and stability of the proposed method are comparable to the standard interface-fitted FEM, and are superior to the Voxel type FEM which is often used in such complex micro geometry cases. Some optimization examples using the two-scale X-FEM, which aim to product uniform permeation velocities, will be shown.

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