IMPACT RESISTANCE OF CRUSHABLE FOAM SKELETON

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1. Introduction

The analyses of the modern cellular materials due to complexity of their internal structure require efficient computer methods and codes. The new method that has been developed mostly in the last 10 years is peridynamics [1, 2]. The developments resulted in highly parallelized code [3] that we use in our analysis.
The subject of the study are alumina foams produced by gelcasting method. The results of microtomography of alumina foams are used to create the numerical model reconstructing the structure of foam skeleton. The numerical simulations of failure strength under compression for alumina foams are performed. The calculations with use of the numerical model are time consuming. Therefore, the simplified method of the assessment of failure strength is proposed. The 3D model of the foam structure is created. The detailed description of the model generation is presented in Nowak *et al.* [5].
The numerical models of real Al_2O_3 foam with porosity 96 %, and discussion of theirs mechanical properties have been presented. The method of the assessment of failure strength of real alumina foam produced by the gelcasting is proposed.
We attempt to present the mechanism of damaging of a crushable foam under impact.

2. Material model of solid alumina

We analyse a skeleton of a 3D ceramic foam that impacts a stiff wall with velocities 50 m/s and 100 m/s, Figure 1 and Figure 2, respectively. The velocities are directed down along the Figures.
One of the most important aspects in numerical simulation of the material is to formulate constitutive material model. The elastic part of deformation for solid alumina describes isotropic Hooke's law.
In terms of small deformations and when the stress level is much smaller than the elastic limit, the Hooke's model is a good way to describe the behaviour of solid alumina.
Concerning the assumption that the damage is isotropic, the maximum reduced stress can be expressed as follows, [4]

(1) $$\sigma^{D}_{\max} = \sigma_{\max}(1-D)$$

where the reduced stress is related to the non-dimensional damage variable $D=A/A_o$ where A is the damaged area, and A_o is the initial area. The variable D varies between 0 and 1.

3. Numerical results

We assume Young's modules 370 GPa and Poisson's ratio 0.22 and density 3.92g/cm3, see Nowak et al. [6]. The foam is discretized with 585897 points. The critical strain is 0.0005. We note gradual damage in the samples in both Figures 1 and 2. An interesting observation is done in Figures 1 (c) and 2(a). We find that the maximum values of damage variable that are close to 1, form islands in the entire structure, far from the attacking edge. It can be interpreted that stress wave phenomena play a role during this kind of process.

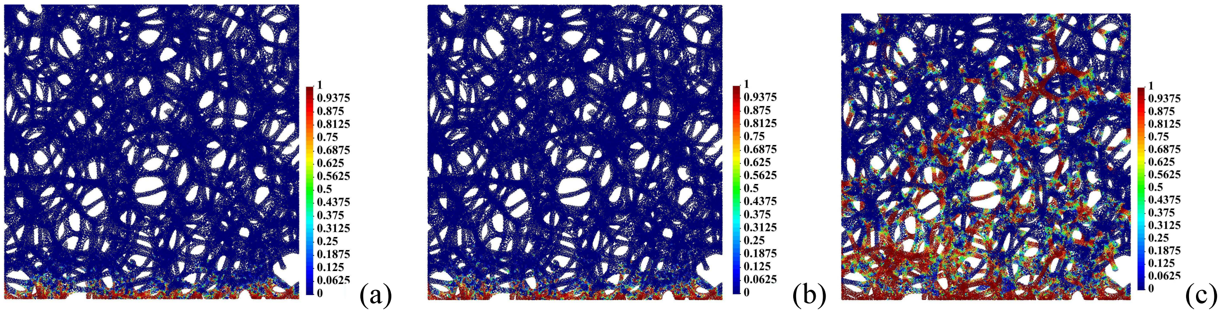

Figure 1. Damage advancement, impact velocity 50 m/s: (a) time instant 11.51E-08 s; (b) time instant 21.74E-08 s; (c) time instant 26.85E-08 s

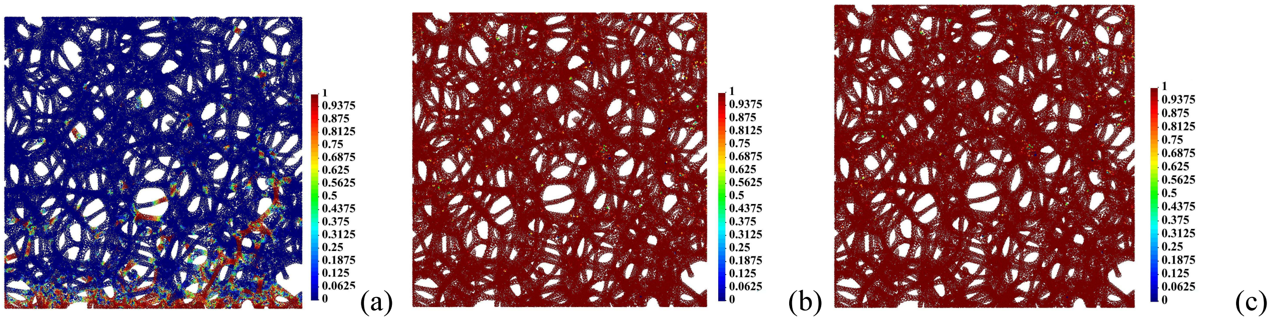

Figure 2. Damage advancement, impact velocity 100 m/s: (a) time instant 11.51E-08 s; (b) time instant 21.74E-08 s; (c) time instant 26.85E-08 s

5. Final Remarks

A numerical model for the open-cell ceramic foam structures is presented.
The increase of localized stresses and the brittle nature of ceramics cause the failure of some struts of ceramic foam. For this reason the understanding of stress state in ceramic foam is necessary.
Several numerical simulations have been performed to analyze the influence of applied velocity on the compressive strength of the considered alumina foam. The peridynamic modelling is applied to investigate its dynamic damage process under axial compression. The results show that, it is the alumina ceramic phase that makes the dominant contribution to the model's damage due to its intrinsic brittleness.

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