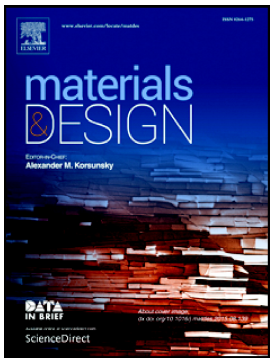

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Modelling and characterization of structural behaviour of Al open-cell foams

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Abstract
The application of foams is widespread in many industrial scopes, because of the capability of the material as energy absorber or thermal controller and the possibility of realizing them in different materials as polymers, metals and ceramics.
In this paper an original FE modelling of open cell aluminium foam by means of solid elements is performed. The equivalent model presents a structure made of Kelvin cells with ligaments characterized by variable circular sections. A detailed shaping of ligaments and nodes of the cell has been tuned starting from literature and original experimental evidences. Consequently, a calibration of the model, based on the experimental foam characterization, permitted to obtain an original solid model of the foam, whose structural behaviour is equivalent to the actual one. The use of sub-structuring techniques permits to perform FE analyses on solid elements models of specimens with actual dimensions and to combine high accuracy in stress field evaluation with compatible computational effort.

Keywords: FEA, open-cell foam, aluminium, Kelvin cell, solid model.

1. Introduction

The increasing interest on cellular materials is due to the possibility of combining the mechanical properties of the solid material with a cellular microstructure. The result is a material with a high specific strenght in respect to the weight. The application of foams is widespread in many industrial scopes, because of the capability of the material as energy absorber or thermal controller and the possibility of realizing them in different materials as polymers, metals and ceramics. These characteristics led to the implementation of several technologies for the production of synthetic foams [1].
The disadvantage associated to this technology is the difficulty in obtaining models that reliably predict the material properties, caused by the high complexity of foam geometry and its irregularity. Moreover, the foam presents a structure with a characteristic three-dimensional variability.
In the past, the approch to the problem was solved considering an equivalent material substituting the foam. Its characteristics in terms of density and stiffness can be represented as homogenuos up to a certain scale [1]. This model takes into account only the boundary conditions of the foam region considered and is not representative of the real foam structure.
A different approach to the modelling of foam structure considers a geometry made up by a succession of regular cells, commonly known as Kelvin cells. Each cell is a tetrakaidecahedron with 6 square faces and 8 hexagonal faces. This simplification of the structure allows analysing the elastic behaviour of the foam through linear elastic beam theory ([2] [3] [4]), with the limitation of losing three-dimensional local effects.
In [5], [6] and [7] Jang and Kyriakides studied the geometry of aluminium open-cell foam and defined a FE model of Kelvin cell using beam elements with variable thickness. Through the calibration of beam elements, representing the cell ligaments, they show that it is possible to determine the compressive behaviour of the foam. Moreover, in [6] and [7] it is demonstrated that the stiffness of the foam is characterized by stress localization only at the cell level, so that, a simple material constitutive model is appropriate for the simulation.

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