Prediction of effective properties for simulation and optimisation of metal foams

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ABSTRACT

Metallic foams are widely used as core and/or as filler materials for sandwich panels and thin-walled structures, respectively. In these assemblies thin metal sheets and thin-walled structures ensure the required mechanical strength, while the foam core or filler contribute to the geometrical stabilization and lead to improved crashworthiness. Therefore, a detailed understanding of the mechanical properties and behaviour, and a characterization of the effective properties are necessary for their application in large scale. Nonetheless, there is a great difficulty in predicting the properties of these inhomogeneous materials due to their irregularities and micro-defects. The aim of this work is to study analytical models and numerical methods for describing the mechanical behaviour of these foams in an elastic regime. To do this, numerical methods and analytical models provided by previous research were used. Accordingly, Kelvin and Weaire-Phelan structures were selected to model the closed-cell and open-cell representative unit-cell geometries. The open and closed-cell geometries were modelled using different numerical simulation approaches, including far field approaches with single freedom constraints and the use of periodic boundary conditions for the Asymptotic Expansion Homogenization (AEH) method. The analytical, numerical and experimental results were compared, in particular for the relative Young’s modulus as a function of the relative density [1].

The detail and depth of information that the AEH provides on the orthotropic nature of these materials opens a path to other studies, namely for material optimisation. The asymptotic expansion homogenisation also integrates a localisation procedure, able to obtain detailed information on the behaviour of the material within the unit-cell, giving way to local sensitivities that can be used to control optimisation procedures. This leads to a material topology optimisation approach, perfectly suited for the design of this type of material [2, 3]. Within this scope, this work also explores the analysis of effective material properties of cellular materials designed with topology optimisation procedures.

REFERENCES

