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MODELLING LARGE COMPRESSION OF ADVANCED PORE MORPHOLOGY FOAMS WITH DISCRETE ELEMENT METHOD

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Since the first introduction of metal foams in 1926 [1], some of their most important applications were energy absorption and structural stability improvement. Because of good strength to weight ratio, high energy absorption and sound dampening abilities, they have a lot of potential for use in automotive, aerospace, naval and lightweight engineering [2]. The two most important challenges that hinder a more frequent use in common engineering practice are high fabrication costs and inadequate control over the complex forming procedures.

With that in mind, IFAM Fraunhofer Institute in Bremen, Germany, developed a new type of granular composite metal foam, called advanced pore morphology (APM) [3, 4]. These APM composites are assembled from a large number of pre-fabricated spherical granules with cellular internal structure, Fig. 1a, b. In contrast to conventional metal foams, they allow more cost-efficient implementation in serial production of engineering components, and improved control of the final foam morphology. The granular structure of APM also leads to another important advantage: mechanical properties can be varied easily and controllably along the composite's geometry, by assembling granules with different mechanical properties. This potential invoked the need to study the influence of different element distributions on the mechanical behaviour of the bulk composite.

The authors present an efficient methodology for analysis of granular influence on the mechanical behaviour of bulk APM composites. The methodology is based on the discrete element method (DEM), where every APM granule is spatially discretised with a single node. The method was initially used for fast generation of computer model geometries of APM composites, which can be easily converted to FEM computer models for analysis of their compressive behaviour. Later, the method was extended with simple models of inter-granular contact and material hardening, which opened the possibility for simulating large compression of APM composites, Fig 1c, d.

Past computer models of APM foams were all based on the finite element method (FEM) [5, 6]. DEM allows description of the same APM geometry with much smaller number of nodes than FEM models, Fig. 2c. This makes the DEM more appropriate for simulations of structures with very large number of APM granules and provides for an efficient tool for simulation of APM composites under large compression.

The conducted computational study was supplemented with corresponding experimental testing, where bulk engineering stress dependency on bulk engineering strain was measured with good correlation between computational and experimental results.

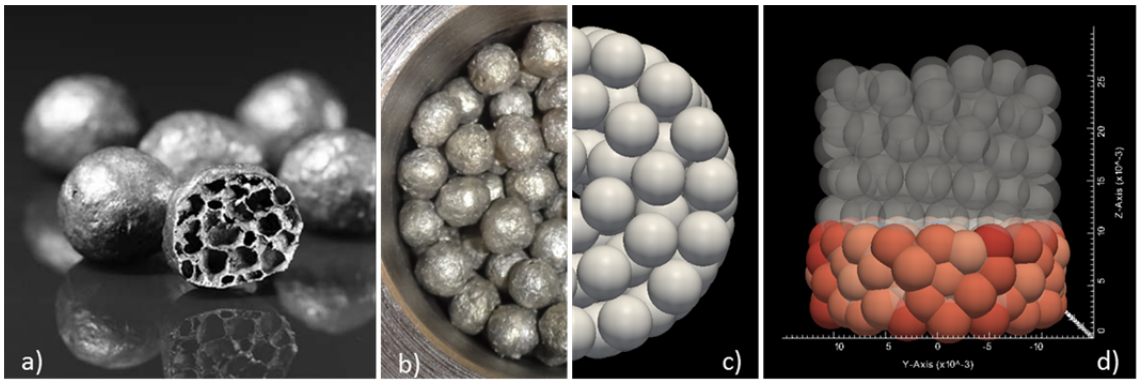

Figure 1: APM a) granules, b) composite, c) computer model and d) its deformation.

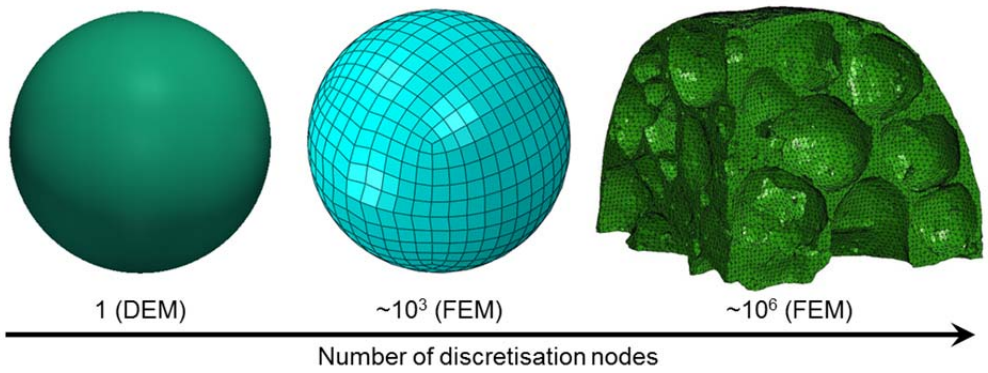

Figure 2: Number of nodes for different discretisation of single APM granule.

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