8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

IMAGE BASED SIMULATION OF THE DENSIFICATION OF OPEN CELLED FOAMS

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Key Words: *Image based meshing, Foams, Dynamic stress-strain, Compression Velocities, Linear elastic material properties, Elasto-plastic material properties.*

ABSTRACT

Image-based meshing is opening up exciting new possibilities for the application of computational continuum mechanics methods (e.g. CFD and FEA) to material characterisation based on micro-structural scan data. An innovative mesh generation technique has been developed which converts 3D scanner data (such as from micro-CT) directly into meshes for use in FE and CFD simulations. The approach has several key advantages including: i) Multi-part meshing; ii) Image-based accuracy; iii) The ability to assign material properties within a given structure based on signal strength. These provide a powerful new range of tools for exploring micro to macro-scale properties.

An example case study exploring the large strain behaviour of open celled foam under loading is presented. Open celled foams are used in industrial applications, (e.g. seating, helmets, space vehicles) as well as commonly found in natural structures (e.g. bone, plant stalks, corals). Analytical models and experimental tests have been carried out by a number of material scientists to gain an understanding of the influence the complex relationship between the parent material properties and the architecture of the foam has on the resultant effective physical properties. Computational modelling offers the prospect of providing a deeper understanding than experimental tests of the mechanisms at work during deformation and more realistic model results than can be achieved via analytical approaches. However the difficulty of meshing the complex topologies of foam micro-architectures has proved, until recently, a barrier to effectively using the most popular of physics based simulation techniques for mechanical characterisation: the finite element method. In the present study, for the first time, a new image-based meshing approach is used, $^+$ScanFE [1] to obtain geometrically and topologically accurate finite element meshes of open celled foams based on 3D imaging data.

The aims of the paper is to demonstrate the potential of the proposed approach across a range of applications for understanding the nexus between micro-scale architecture and

macro-scale properties, and illustrate the ability to simulate topologically complex problems with a high degree of accuracy but in a fraction of the time taken by other approximate methods. The finite element models were used in an explicit code, LS-DYNA [2], to characterise the quasi-static through to dynamic stress-strain behaviour of the materials for various compression velocities and for both linear elastic and elasto-plastic material properties from small strains right through to strains well into the compaction regime. Both end-plate contacts and general foam to foam contact of the cell walls with sliding were modelled.

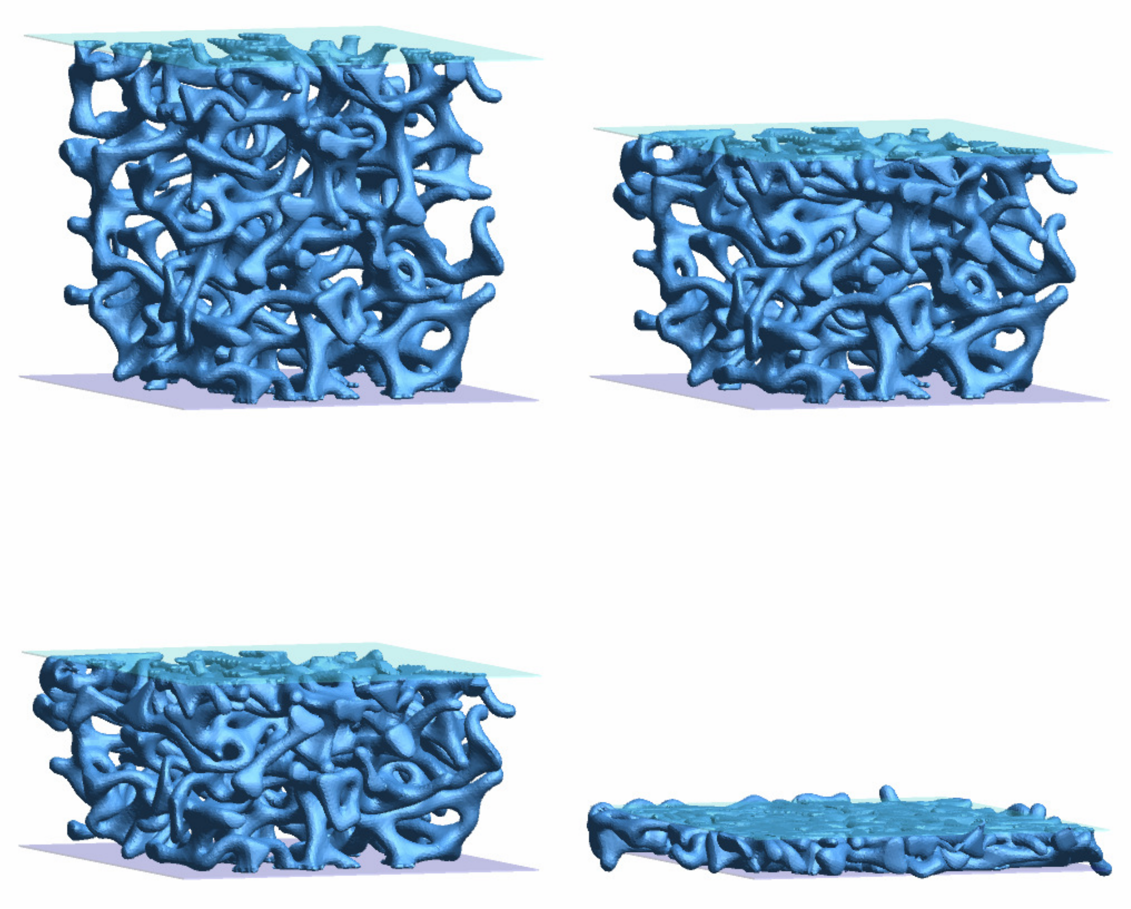

Figure 1: Large strain analysis of foam in LS-DYNA.

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