NUMERICAL SIMULATION AND VALIDATION OF THE PROGRESSIVE COLLAPSE OF MICRO LATTICE STRUCTURES IN THE CONTEXT OF FOREIGN OBJECT IMPACT OF AEROSPACE SANDWICH PANELS

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Abstract

The work described in the paper was conducted during the FP6 STREP, CELPACT (2006-2009). In this work, the innovative manufacturing process of selective laser melting was used to realise tailored cellular core materials in stainless steel. These cellular materials took the form of micro lattice structures, with a micro strut diameter of 0.2mm. The application of interest was low velocity dropped object impact of sandwich panels, and an integrated experimental and numerical campaign was conducted to fully characterise the behaviour of the micro lattice structure, both on its own and in the context of the sandwich panel. LS DYNA was used to simulate the dynamic non linear behaviour of blocks of micro lattice structure, as well as the perforation behaviour of panels, with and without skins. The simulations gave good comparison with experiment, and provided a model that can be used to investigate different parent materials, micro strut architectures and panel configurations.

Keywords Micro lattice; Validation; Simulation; Twin Skinned; Foreign object impact

1. Introduction

Twin skinned, sandwich, structures are of interest for application for aerospace structures found in fuselage and wing components. Such structures have advantages over monolithic shells, such as improved specific bending stiffness and strength, and multi function potential, e.g. acoustic and thermal properties (Heimbs et al, 2009).

A feature of twin skinned construction is the cellular core. Conventionally in aerospace applications, the most widely used architecture is that of honeycomb, in either aluminium or aramid. However, such materials have the disadvantage of closed cells, when used with skins, which give rise to moisture and gas retention.

One of the major weaknesses of twin skinned construction is their foreign object performance. This can be a result of dropped tools, hail, runway debris, and bird strike. Impact can give rise to sub critical damage, or partial and full penetration. This paper addresses the latter impact scenario (Mines, 2008).

The focus for this paper is the study and use of a new, innovative, core material manufactured using selective laser melting [SLM] (Yadroitsev, 2009). In this process, metallic powder is selectively melted to form spatial micro lattice structures. Previous papers on micro lattice structures have discussed the manufacturing process for stainless steel micro lattices (Tsopanos et al, 2010), some testing of micro lattice blocks and beams (Shen et al, 2010) and some theoretical parametric studies (Ushijima et al, 2010).

A feature of the SLM manufacturing process is the ability to realise lattice structures with 50 micron features, which means that the lattice structures can be tailored with the application in mind. This shifts emphasis to detailed study and optimisation of cellular materials, which includes structural engineering at the small scale. Ushijima et al (2010) developed parametric compressive models for the body centred cubic micro lattice geometry in the form of blocks, and showed the complexity of parametric modelling. These ideas need to be developed further to include multiple collapse mechanisms, so as to fully exploit the manufacturing process.