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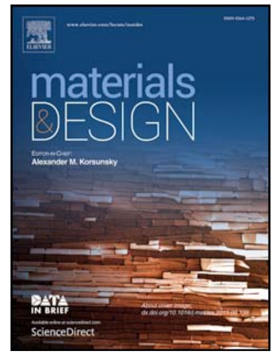

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Fabrication of lattice truss structures by novel super-plastic forming and diffusion bonding process in a titanium alloy

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Abstract: A novel superplastic forming/diffusion bonding method has been developed to produce lattice truss structure from Ti6Al4V titanium alloy. A three-layer lattice sandwich structure was fabricated. The compression and shear processes of as-made structures were simulated by finite element method and measured by tests. The results showed that the relationship between shear stress and strain for the present structure was different from that of structures made through traditional brazing or welding process. Several stress fluctuations occurred in the compressive stress-strain curve and there was no conventional yield platform in shear stress-strain curve. The compressive finite element simulation pattern was consistent with test result, while there was relatively large deviation between the shear simulation and test results. The face sheet-core interface had adequate bond strength and no node failure was observed in both tests. The node robustness was mainly attributed to the homogeneity of the fine microstructure at node positions.

Keywords: lattice truss structures; super-plastic forming; diffusion bonding; titanium alloy

1. Introduction

Owing to relatively high compressive and flexural stiffness, large strength-to-weight ratios, lightweight metallic lattice truss structures are the most promising structure for advanced lightweight materials. These metallic truss structures have been widely used in engineering and aerospace field for structure supporting and multifunctional applications [1-2], such as channel of heat exchange [3-4], energy absorbing component during dynamic loading [5-7] and acoustic damping [8].

According to topology morphology, the metallic lattice truss structures include hexagonal, pyramid, X and Kagome types etc. [9-10] and correspondingly can be fabricated by different methods: investment casting, stamping-braze welding, wire/hollow tube lay-up, perforated metal sheet forming, additive manufacturing and so on. [11-14].

Except for investment casting, almost all of above methods need an assembly step for creating a cellular structure and a bonding step for later attaching the cellular structure to face sheets. For example, pyramidal lattice truss structures made of ductile aluminum alloys and stainless steel can be produced by the following steps: (1) forming a periodic diamond perforation pattern through perforating a metal sheet, (2) followed by a node row folding process, (3) and then, the folded core and solid face sheets can be brazed or laser welded together to form a sandwich structure [15-16]. These methods require a good forming capacity of master alloys and are fit to those ductile alloys such as ductile aluminum alloys. Previous studies showed that the problem of sheet fracture or node failure is commonly encountered during deformation processes with low ductility alloys [17-18].

Accordingly, for titanium alloys with higher specific yield strength and service temperature [19], the limited ambient temperature formability makes it hard to fabricate lattice truss structures from them by traditional folding methods and often cause other disadvantages. Taking