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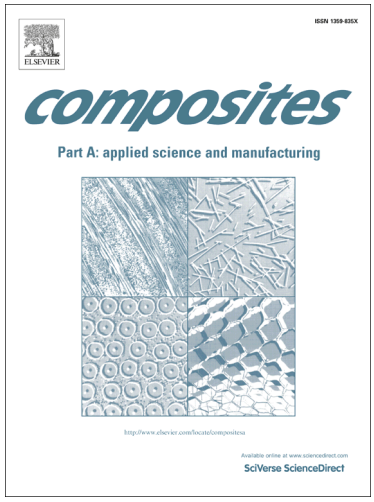

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The development and scalability of a high strength, damage tolerant, hybrid joining scheme for composite-metal structures

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A. Hybrid; B. Strength; B. Damage Tolerance; E. Joints/Joining

Abstract

Advanced hybrid joints, which incorporate a specially designed array of macro-scale pins that provide mechanical interlocking reinforcement, have been developed in order to address the challenges associated with joining fibre reinforced composites to metals. In the present work, important joint characteristics including strength, mechanical fatigue, damage tolerance and durability have been studied and discussed. The results indicate that with advanced hybrid joints it is possible to achieve the benefits of the respective bonded and bolted systems but with virtually zero net weight gain, or conceivably a weight reduction as the increased performance of the hybrid scheme could facilitate smaller joints. The authors also present initial results from a comprehensive manufacturing and scalability trial, and demonstrate that low-cost, large-scale manufacture of hybrid joints is now feasible.

1 Introduction

Combining dissimilar materials such as fibre reinforced polymer (FRP) composites and metals in structural applications can facilitate lower mass structures and enhance design freedom. However, forming robust joints between these materials can be challenging, particularly for safety critical structures and for systems subjected to challenging conditions, such as blast loading. The mechanical fastening of composites introduces two key problems. Firstly, preparing such joints usually involves machining or drilling which can introduce damage in the composite material, and secondly, stress is concentrated at the discrete loading points associated with the fixing locations. Both factors contribute to premature failure of the composite by tensile fracture, shear out, cleavage, bearing or pull-through failure modes as described by Camanho and Matthews [1]. Elongation of holes during fatigue can also constitute problems. Adhesive bonding is a common alternative and is now applied widely in industry for joining composites. However, adhesive bonding is very sensitive to surface preparation, and may require expensive pre-treatments and quality control procedures. Adhesives also degrade over time, especially in hot/wet environments, and further, high strength adhesives tend to fail in a sudden brittle/catastrophic manner. Inspection of adhesive joints during service can also be difficult.