BENCHMARKING OF A NOVEL LIGHTWEIGHT METAL-COMPOSITE-JOINT TECHNOLOGY

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1. Introduction

In the aviation industry a progressive use of fibre composite materials is observable over the last decades. Thereby key benefits like weight reduction, better fatigue behaviour or manufacturing improvements (time reduction due to shortened total process time) etc. are of principal interest. These contemporary design limitations arise during usage of these materials. One of the concerns is the local load transmission into fibre composite materials, which is a common problem for lightweight structures. To apply high loads, metallic brackets, fittings etc. are required to distribute these concentrated loads over larger areas. Therefore joints between fibre composites and metal structures are of great interest.

To compensate for the negative aspects of both conventional joining technologies (mechanical fasteners and adhesive bonding), innovative joining concepts for hybrid metal/composite structures that allow an integral design and manufacturing, are taken into consideration. Such design concepts can allow a more efficient use of the mechanical advantages of composite lightweight materials by an additional potential of saving the weight of fasteners.

2. IGEL Joining Concept

The investigations presented herein concentrate on a hybrid metal/composite joining concept named IGEL. It uses an arc welding process referred to as cold metal transfer (CMT), for the surface preparation of the metal part in order to produce arrays of metal pins of a defined geometry onto the metal surface. These pins penetrate the carbon plies and provide an additional form fit besides the bonding between the composite and the metal surface in the cured condition after the injection process is finished.

![IGEL Pin Variants](https://via.placeholder.com/150)

Fig. 1: IGEL Pin Variants

3. Experiments & Results

To evaluate the potential of such a hybrid metal/composite joint in terms of joint strength, ultimate load as well as damage tolerant behaviour etc., mechanical testing has been performed. Therefore geometries and dimensions together with manufacturing processes have been defined for two different types of test specimens. The first type of specimens has been designed for tensile testing in a double lap joint configuration, with the joint interfaces loaded in shear (see Fig. 2). The second type of specimens has been designed for bending tests in a single lap joint configuration. In a simple test setup, the metal part has been clamped and the free composite end has been loaded as a cantilever arm (see Fig. 5).

To evaluate the performance of the IGEL joining concept in contrast to the expected performance of similar bolted or riveted joints, reference data is necessary. Therefore the IGEL joining concept is compared to conventional bolted joints according to aerospace standards.
in terms of fastener spacing or edge distance valid for the use with carbon fibre composites. Test specimens of both types have been manufactured by using the same geometry and dimensions as the IGEL specimens, but joined by using an array of four titanium Hi-Lok bolts.

Mechanical testing of all types of specimens has been performed until each specimen failed, followed by a detailed analysis of the measured test results.

a) **Double Lap Shear (DLS) Specimen**

![Fig. 2: IGEL- (up) & Hi-Lok- (lower) Double Lap Shear Specimen](image)

![Fig. 3: Results Double Lap Shear Specimens](image)

b) **Bending Specimen**

![Fig. 4: Hi-Lok Bending Specimen](image)

![Fig. 5: Test Fixture Bending Specimen](image)

![Fig. 5: Results Bending Specimens](image)

The evaluation of these results shows potential of weight optimization and increase of strength properties of this alternative joining technology in comparison to traditional mechanical fastening methods.

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5. **References**
