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Recent developments for laser beam joining of CFRP-aluminum structures

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Abstract

Modern lightweight structures including dissimilar materials allow an improvement of the weight-specific properties. However, novel joining concepts are necessary to exploit the potential and to enable efficient manufacturing. The DFG research group "Schwarz-Silber" (FOR1224) aims to develop and investigate transition structures for advanced CFRP-aluminum connections. In five interdisciplinary projects novel concepts are under development considering textile, welding, brazing and casting techniques. Within their work the research group focuses on three approaches realizing the transition: the usage of wires (titanium), foils (titanium) and fibers (glass fiber) as transition elements between CFRP and aluminum. The "wire concept" represents a parallel arrangement of miniaturized loop connections. Carbon fibers are threaded through titanium wire loops which are joined to an aluminum component by a combined laser welding-brazing process. The "foil concept" is based on titanium laminates. This concept is characterized by joining a Ti-CFRP laminate to an aluminum sheet. This hybrid laminate, in which CFRP-layers alternate with titanium foils, has been fabricated. The titanium side of the laminate is joined to the aluminum sheet. In this paper, the joint configurations based on titanium wires and foils are presented. First specimens are discussed with respect to their properties. It is shown that the novel approaches are principally suitable to produce advanced CFRP-aluminum structures by using laser beam processes.

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Keywords: lightweight; CFRP-titanium-aluminum structures; laser joining; combined welding-brazing; hybrid; dissimilar.

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1. Introduction / Motivation

Modern lightweight designs include an increasing number of multi-material structures in order to adapt properties to specific local requirements (Kocik et al., 2006). Hybrid structures are applied in aviation and automotive engineering (Schumacher et al., 2007). As a result, suitable hybrid joints of dissimilar materials have to be realized. Especially, light metals and carbon fiber reinforced plastics (CFRP) become more severe.

For joining aluminum (Al) and CFRP parts an overlapping is necessary to enable typical joints by mechanical (e.g. riveting or bolting (Bashford, 1986)), adhesive bonding (Davies et al., 1991) or combined joining techniques (e.g. combined riveting and bonding (Groß and Schäfer, 1990)). Moreover, drilling for rivets interrupts fibers and deteriorates load paths. Failures could result due to the fabrication (e.g. interface failures or edge defects). Due to the locally concentrated transmission of force the structures have to be strengthened in the joining zone. Furthermore, a direct contact of carbon and aluminum materials worsens the corrosion behavior. Thus, a novel integral method to join aluminum and CFRP structures would be preferred.

Therefore, the research group “Schwarz-Silber” (FOR1224) funded by the DFG (Deutsche Forschungsgemeinschaft) investigates new concepts to join CFRP and aluminum components by integrating a transition structure (Fig. 1). As transition materials titanium (Ti) and glass fibers are used. Two hybrid joining zones result between the transition structure and the two base materials. Combinations of welding, brazing, casting and textile technologies are applied. Five interdisciplinary projects of different research institutes cooperate within the research group at the University of Bremen. Two concepts include a thermal joining of aluminum and titanium transition structures by laser beam processes. Titanium offers excellent mechanical properties and corrosion resistance combined with low specific weight (Neugebauer et al., 2010). Due to its abundant advantages laser joining technologies are used for assembling by an increasing number of manufacturers (Bley et al., 2007). Usage of combined welding-brazing processes to join aluminum and titanium sheets is documented for overlap, butt and T-joint techniques (Kreimeyer and Vollertsen, 2005). First experiments with a titanium wire structure were reported in (Möller et al., 2010) and showed the general feasibility of the “wire concept” of the project “Schwarz-Silber”. The research group investigates a second concept consisting of a titanium foil laminate as transition structure (“foil concept”) which goes beyond the actual state of art.

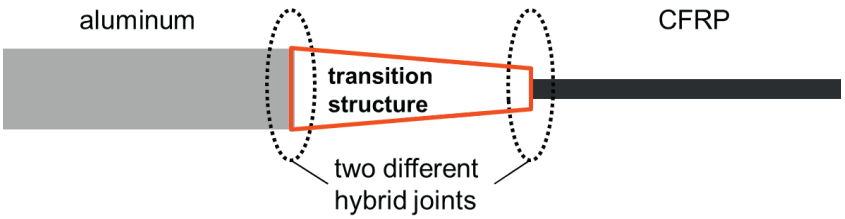

Fig. 1. Principle of joining CFRP and aluminum components by integrating a transition structure