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Ultrasonic spot welding of carbon fiber reinforced epoxy composites to aluminum: mechanical and electrochemical characterization

Francesca Lionetto[1]*, Claudio Mele[1], Paola Leo[1], Sonia D'Ostuni[1], Frank Balle[2], Alfonso Maffezzoli[1]

[1]*Department of Engineering for Innovation, University of Salento, via per Monteroni, 73100 Lecce, Italy*

[2]*Institute of Materials Science and Engineering, Hybrid Materials Engineering Group, University of Kaiserslautern, P.O. Box 3049,67653 Kaiserslautern, Germany*

**corresponding author email: francesca.lionetto@unisalento.it*

Abstract

The mechanical and electrochemical behavior of ultrasonic spot welded hybrid joints, made of AA5754 aluminum and carbon fiber reinforced epoxy with a co-cured thermoplastic surface layer, was studied. The effect of the welding parameters (energy and force) and the thickness of a thermoplastic film, applied as an upper ply in the composite lay-up, on the development of adhesion strength, was investigated. The best mechanical results were obtained when the welding parameters were able to achieve a large bonding area of mechanical interlocking between naked carbon fibers and aluminum and a better load distribution. The electrochemical results excluded the possibility of galvanic corrosion between aluminum and composite adherends thanks to the insulating action provided by the thermoplastic film.

Keywords: A. Polymer–matrix composites (PMCs); B. Mechanical properties, D. Ultrasonics; E. Joints/joining

Introduction

The increasing use of carbon fiber reinforced polymers (CFRP) in different fields and the emerging trend towards lightweight, high performance and high functionality components is leading to the use of multi-material hybrid structures. This involves the need for joining dissimilar materials, such as CFRPs and metals, which is a challenging task using conventional joining methods due to the different physical and chemical properties of the joining materials [1]. Ineffective joining procedures can drastically reduce the efficiency gained by the use of these structures [2]. The most frequently used joining methods for CFRP and metals are mechanical fastening and adhesive bonding. Conventional mechanical joining processes by means of bolts or rivets usually presents several disadvantages associated to the long joining time required by the hole-drilling and fastening operations and to the cut of the reinforced fibers [3]. This latter leads to a reduction of load carrying capability of the composite material due to stress concentrations and to delaminations and peeling through the plies of the composite [4], [5], [6], [7]. Some of these drawbacks have been overcome by recently developed fast joining processes such as clinching [8] and self-pierce riveting [9]-[10] which do not require preliminary drilling of a hole in the sheets [11]. However, although the delamination introduced by these mechanical joining processes is reduced compared to traditional mechanical fastening, this problem is