Optimized hybrid welded metal-thermoplastic composite joints using laser microtexturing as a surface treatment

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Abstract

Transport industry is usually dominated by the light-weight challenge driven by both environmental concerns (increase the fuel efficiency and reduce the carbon dioxide emissions) and cost reduction. Utilization of a mixture of materials and multi-material design of components provides an opportunity to develop products which could achieve this challenge. For this reason, the demand for hybrid joints or the union of different materials is continuously growing. In addition, for certain applications and features, individually existing materials do not allow meeting the requirements. Critical aspects to be considered can be forming and joining these different materials, surface condition and multi-material modelling. Local reinforcement based on fibre reinforced polymer composites is one of the most important candidates for the optimization of the classical solution based in metal in transport industry. The key aspects in this field of research are the improvement in the weight/performance ratio, enhancing the mechanical properties and energy absorption and also preventing the component failure. On the other hand, surface conditions have to be optimized in order to achieve a good mechanical and chemical bond between the materials involved at the joint.

In this work, laser textured aluminium parts were joined to fibre reinforced thermoplastic composite coupons by ultrasonic welding. Different laser textures on aluminium surface were obtained using laser ablation and laser keyhole techniques. Figure 1 shows a laser texturing made on an aluminium surface by laser keyhole technique. Thermoplastic composite was pre-treated by atmospheric plasma to improve adhesion properties, as well as aluminium samples were cleaned, degreased and chemically treated to improve its interaction with thermoplastic composite matrix. In order to study this interaction between both materials, preliminary tests were carried out by using the ultrasonic welding process with texturized aluminium and thermoplastic polymer samples. Metal surface conditions were validated at this stage of the study. Confocal microscopy and contact angle measurements were carried out to study surface conditions after laser microtexturing treatment. Surface optimization and adhesion properties were studied using tensile lap-shear strength tests and pull-off tests, in order to check the resistance of the joint to shear and direct tensile stress. After the mechanical tests, fracture surface was analyzed. The most suitable microtexturing technique between laser ablation and laser keyhole was selected according to welding process results and mechanical tests. Then, the best laser microtexture pattern and joint configuration were selected to perform structural hybrid metal-composite joints.

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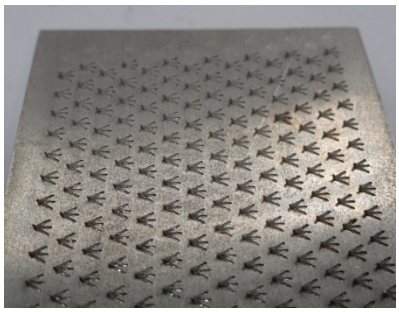

Figure 1. VELCRO laser texturing on aluminium surface.

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