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Fatigue behaviour evaluation of dissimilar polymer joints: Friction stir welded, single and double-rivets

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Abstract

This article focuses on fatigue life assessment of dissimilar lap-joined polymers. The strength of the friction stir welded polypropylene-to-polyethylene specimens under cyclic loading conditions was analysed. The fatigue life of the strongest welds was compared to both the parent material and blind riveting method with single and double-riveted specimens, in order to compare the welded specimens with available commercial joining techniques. The fatigue lives of the friction stir welded and double-riveted specimens are similar, and they are of the same order of magnitude of the highest performing base material. In order to visualize the temperature variation induced by cyclic loading conditions, a thermographic camera was employed to monitor temperature distribution in the failure region during fatigue testing. For the double-riveted and the parent material specimens, thermal fatigue failure occurred due to temperature increase under cyclic loading. For these two types of specimens, thermal failure occurred when the temperature reached approximately 50°C in the failure region. Both, the friction stir welded and single-riveted specimens behaved differently from the remaining joints without any significant temperature increase during fatigue testing. The friction stir welded joints presented a brittle failure from the retreating side of the weld nugget, which suffers from defect formation when compared to the advancing side. The single-riveted method produced the weakest joint due to the stress concentration on the drilled hole, while adding a secondary rivet in the same overlapped area created strong joints due to the load transfer among the two rivets.

Keywords: Friction Stir Welding (FSW); Polymer; Welding; Fatigue; Rivet; Polymer joining; Thermography.

1. Introduction

Friction Stir Welding (FSW) is a welding method developed and patented at The Welding Institute (TWI) in 1991 for joining soft metals [1]. The transportation industry is one of the dominant industrial segments that has benefited from the technology for more than two decades [2]. This method rests on the use of the frictional heat generated between the surface of the base material and the welding tool, under an axial force. The main advantage of this welding technique originates from its solid-state concept, which does not allow the welding temperature to rise beyond the materials' melting point, creating high quality welds with low distortion. Additionally, the aptitude for full automation and the fact that it is a moderately fast method, make FSW a promising joining method for industrial applications [3].

With regards to the increase of global demand for consumption of lightweight structures, more adaptable and environmental friendly joining methods are desired in order to catch-up with rapidly growing industrial demands. Despite the fact that FSW method was invented to join lightweight alloys, the applicability of this technique is not limited to metallic materials and recently a few studies investigated the possibility of joining either different or similar polymers [4, 5] and polymers to aluminium [6]. Still, since the invention of the FSW technique, the majority of the studies have focused on joining metallic materials and only a scarce number of investigations studied FSW of similar or dissimilar polymeric materials, in particular regarding the fatigue assessment of polymer FSW.

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