

RESIDUAL STRESSES IN FRICTION STIR WELDING: NUMERICAL SIMULATION AND EXPERIMENTAL VERIFICATION

G. Buffa^{1*}, L. Fratini¹, S. Pasta²

¹ Dipartimento di Tecnologia Meccanica, Produzione e Ingegneria Gestionale, Università di Palermo, Italy;

² Dipartimento di Meccanica, Università di Palermo, Italy

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Abstract

It is well known that Friction Stir Welding (FSW), presented and patented by TWI in 1991, is nowadays a very effective welding technology even with the so called difficult to be welded or even unweldable materials, such as aluminum alloys, since no melting is reached. In the most recent years several researches have been developed on FSW with the aim to fully highlight and optimize its process mechanics, material flow, metallurgical aspects, and both static and dynamic resistance. High residual stresses can be thus considered the last main obstacle inhibiting the full application of the FSW process by the manufacturing industries, due to the detrimental bending and distortion of the welding plate. As a matter of fact, although FSW does not show many of the metallurgical problems generally observed in fusion welding, such as liquation and solidification cracking, it still undergoes from similar levels of residual stresses, resulting from the weld thermal field. In the present paper the effects of the thermal and mechanical actions, occurring in FSW processes of AA7075-T6 aluminum alloy, on the residual stresses found in the welded joint in the three main directions are investigated. In particular both numerical simulations and experiments have been developed in order to highlight the occurring metallurgical phenomena and the induced residual stresses in the FS welded blanks. The FSW has been simulated using a continuous rigid-viscoplastic FEM model with FEA software DEFORM-3DTM, previously developed by some of the authors to simulate the FSW process with a single block approach. Then, the temperature histories of each node of the FE model, were extracted and transferred to a further FE model of the joint considering an elasto-plastic behaviour of the AA7075-T6 material. The used model was developed with Abaqus/Standard using the Coupled Temperature-Displacement analysis option. As far as the experiments are regarded, the method of cut-compliance was used to determine the depth profile of residual stresses as well as the stress intensity factor (SIF); this provides extremely accurate measurements of longitudinal and transversal residual stresses occurring in FSW joint. Furthermore, the method enables the residual stresses in front of the crack-tip to be determined, which in crack retardation play a role as important as the closure effects. The performed analysis permitted to fully highlight the residual stress distribution in the longitudinal, transverse and along thickness directions.