

CHARACTERIZATION OF LONGITUDINAL RESIDUAL STRESSES IN FRICTION STIR WELDS USING THE CUT-COMPLIANCE TECHNIQUE.

Friction stir welding (FSW) was originally promoted by the inventors as being a very low to no residual stress welding technique. While under some conditions, joints made by FSW exhibit low residual stresses, this is not always the case. For example, it has been observed that fatigue crack growth behavior in friction stir welds is strongly influenced by residual stress. Friction stir welds, like other welds, are microstructurally heterogeneous, meaning that unstressed lattice spacing is not a constant across the weld. This situation complicates the use of diffraction techniques for stress determination. Mechanical methods of stress determination are not influenced by lattice parameter variation and may therefore be quite robust. In this presentation, we will present results of cut compliance residual stress determination in friction stir welds made in (1) aluminum alloy (thick plate and thin plate), (2) titanium alloy and (3) steel. Cut compliance residual stress results will be correlated with fatigue crack growth behavior and compared to residual stress determined by (1) the ACR (adjusted compliance ratio) method, (2) neutron diffraction, and (3) the contour method. Other examples will illustrate the use of cut compliance to determine the through thickness variation of the longitudinal residual stress in a thick aluminum plate FSW and verification of residual stress relief by mechanical stretching. In general, we have observed that cut compliance is a simple and accurate technique for determination of the average (averaged through thickness) longitudinal residual stress in a wide range of friction stir welds.