An investigation of residual stress characterization of Friction Stir Processed 7075 aluminum alloy by nanoindentation and Neutron Diffraction

M. Haghshenas[1,2,*], M. Gharghouri[3], V. Bhakhri[4], R.J. Klassen[4], A.P. Gerlich[1]

[1] Department of Mechanical and Mechatronics Engineering, University of Waterloo, Waterloo, Canada

[2] Frank Hasenfratz Centre of Excellence in Manufacturing, Linamar Corporation, Guelph, Canada

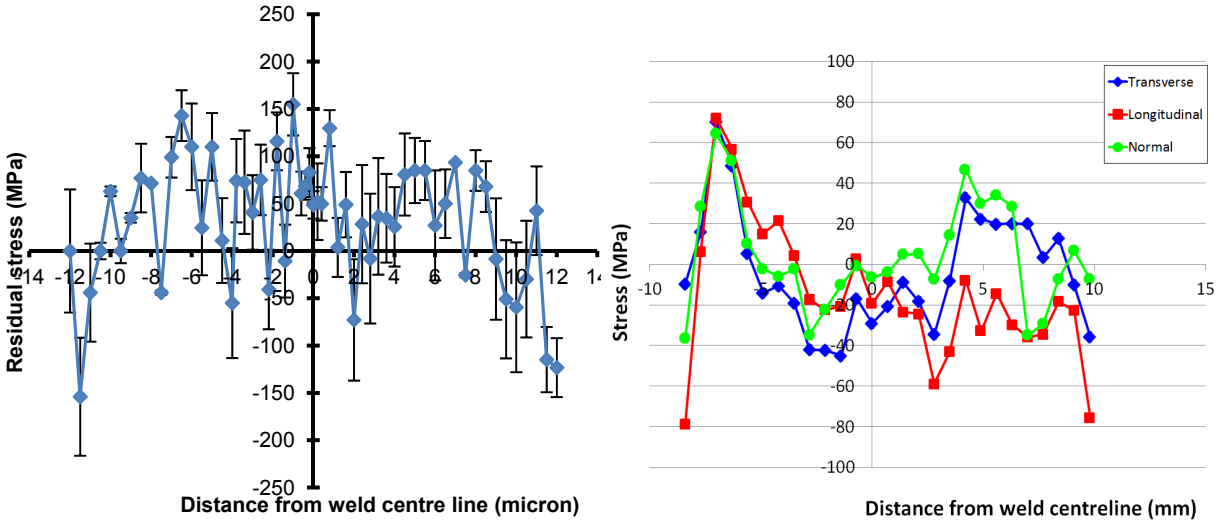
[3] Canadian Neutron Beam Centre, Chalk River Laboratories, Chalk River, Canada

[4] Department of Mechanical and Materials Engineering, Western University, London, Canada

Abstract

Precipitation hardened aluminium 7000 series alloys are widely used in aircraft structural components, and other highly stressed transportation structures. Traditional arc welding of these alloys encounters many challenges associated with softening and cracking of the base material. Friction stir welding is a technique that was developed to overcome these challenges, however few studies have reported the residual stresses in 7000 series alloys after FSW. These residual stresses may lead to issues such as distortion and potential accelerated fatigue crack growth. The objective of this study is to assess the distribution of residual stress invoked FSW processed sheets of 7075 alloy using a semi-destructive technique (depth controlled nanoindentation testing) and to confirm the results with a non-destructive method (Neutron diffraction). To this end, FSP operation with different parameters (*i.e.* tool rotation speed and tool travel speed) were performed on 8-mm sheets of an 7075 alloy to assess the effect of welding parameters on the magnitude and profile of residual stresses in three principal directions across the weld. Nanoindentation and neutron diffraction measurments shows grain-to-grain variations in the imposed residual stress within the stir zone, thermomechanically affected zone and heat affected zone as compared to the base metal. The trend in residual stress values obtained from the nanoindentation technique was in good agreement with those from Neutron diffraction, as shown in Figure 1. It was also observed that the residual stress was highly dependent on processing parameters, and that higher tool rotation speeds produced lower stresses than lower speeds.

* Corresponding Author (Meysam Haghshenas)
Emails: mhaghshe@uwaterloo.ca
mhaghshe@alumni.uwo.ca



(a) (b)

Figure 1: Comparison of residual stresses measured across the 7075 Al-alloy weld measured using (a) nanoindentation and (b) neutron diffraction.