Friction Stir Processing of 304L Arc Welds

Name: Colin J. Sterling
Status: Graduate Student
Address: 1050 S. Orem Blvd. #44
Orem, UT 84058
Phone #: 801-362-5369
Work #: 801-422-5189
Email: sterling@byu.edu

Objective:

It has been long known that the stress concentration factor cause by a weld toe reduces the fatigue life of weldments by nearly 50%. It has become desired to increase the fatigue life of existing arc welds by some post-weld process. Friction stir processing (FSP) has been identified as a possible process for this purpose.

Background:

Friction stir welding (FSW) has been successfully used to join “un-weldable” aluminum alloys, and improve the as-welded properties over traditional arc-welded joints. A variation of FSW, FSP has been used to selectively modify microstructures to gain specific mechanical properties.

Recent tool developments have made it possible to apply both FSW and FSP to steels and other high melting point materials. While many advantages have been shown from the two processes in aluminum, it is though that this new tool material will have a larger impact in welding and processing steels.

Experimental Approach:

Arc welded 304L stainless steel weldments were FS processed at the crown and root of the weld. The welds were machined flat prior to processing in order to remove excessive oxide. The arc welds were created using 308 filler material which produces a weld with retained ferrite.

Results and discussion:

An example of an FS processed arc weld is shown below. The processed region has an improved microstructure over the arc welded region (Figure 1). It no longer exhibits a cast microstructure with ferrite stringers. Instead, the FS processed region exhibits discontinuous ferrite islands within the austenite matrix (lighter area), as shown by the OIM™ maps below (Figure 2). In the processed region the amount of ferrite is similar to that of the arc weld. The darker areas in the FS processed region exhibits a fine equiaxed austenite structure with an average grain size slightly lower that the parent material.

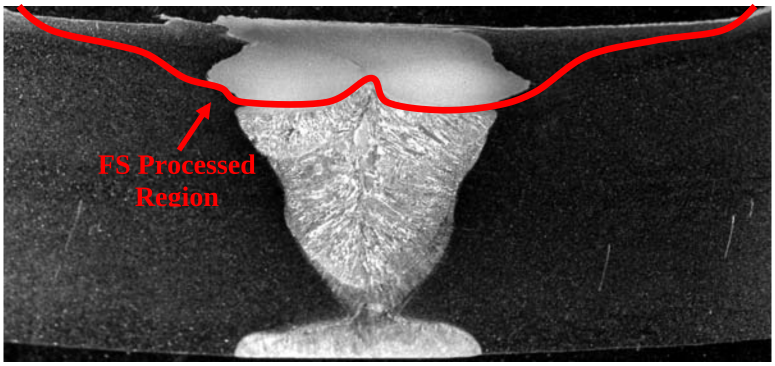


Figure 1 Macrophotograph of FS Processed Arc Weld

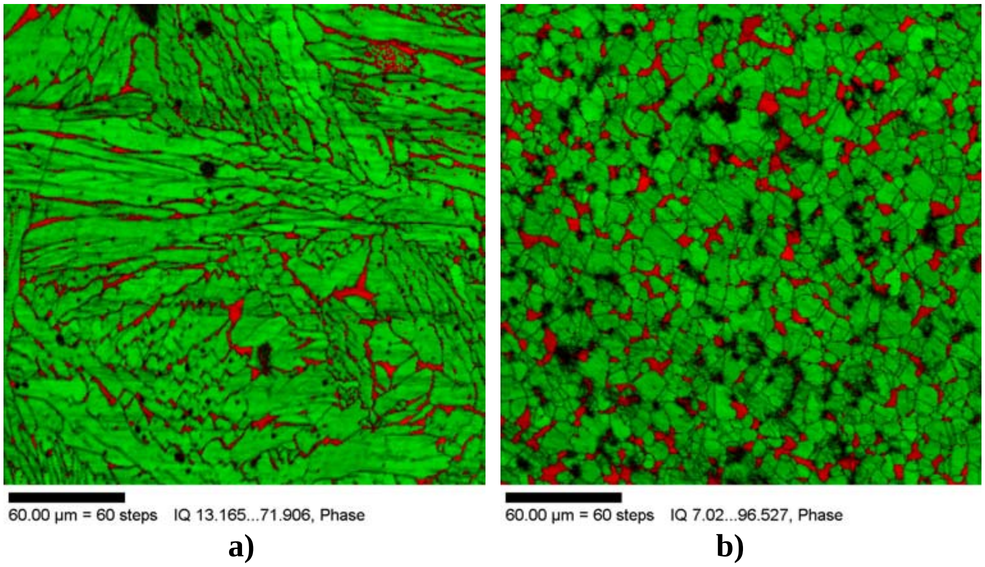


Figure 2 a) Continuous Ferrite Stringers in Arc Weld b) Refined Ferrite in FS Processed Region

Microhardness mapping indicates distinct regions within the processed region (Figure 3). While initial work indicates that the hardness is due to the presence of a second phase, this phase has not yet been identified. It seems likely though, from preliminary investigation, that it is a combination of sigma and chrome-carbides.

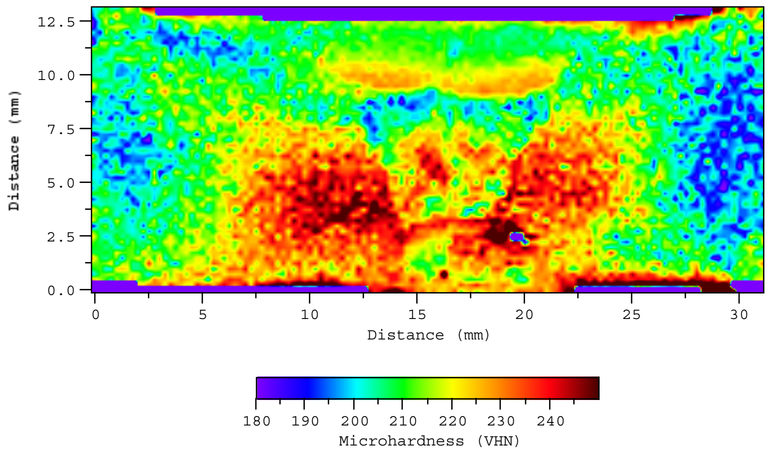
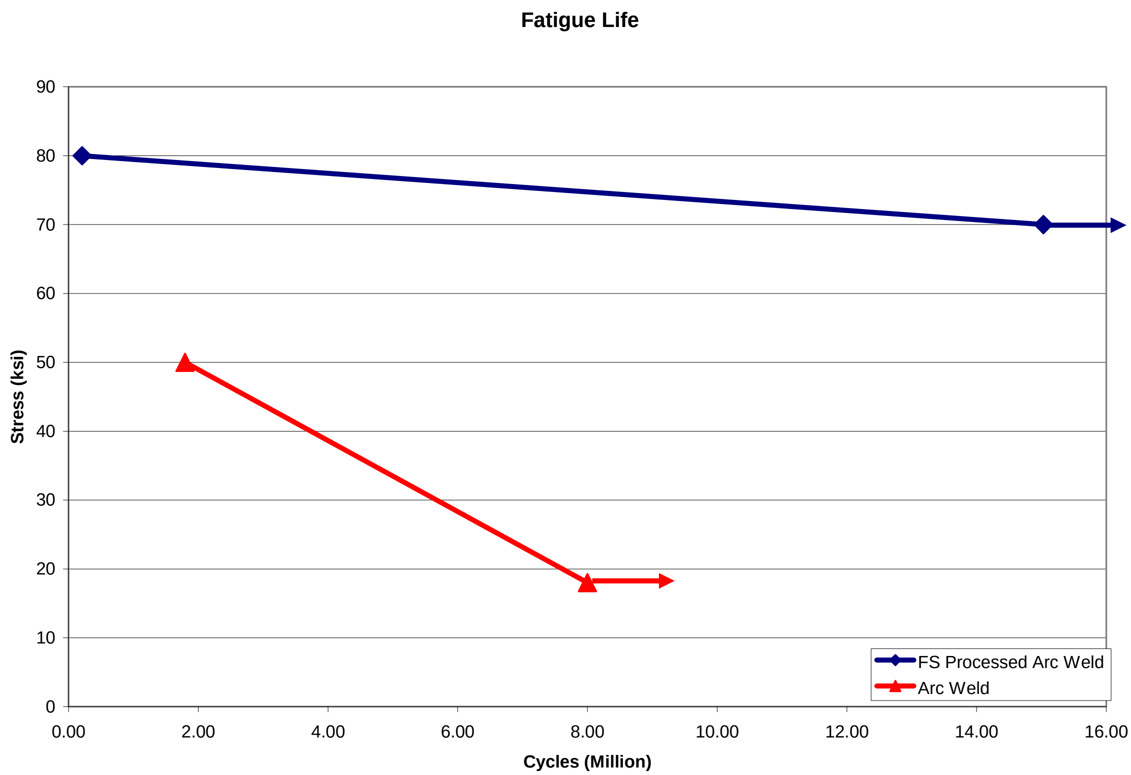


Figure 3 Microhardness Map of FS Processed Arc Weld

While interesting microstructural analysis will be performed the goal of increasing fatigue life has been achieved (Figure 4).



Future Work:

While the initial fatigue work shows an improvement over the as-welded condition, more testing will be performed to complete the SN curve.

Detailed metallography is being performed to determine the percentage and composition of the second phases.