

USE OF ACOUSTIC EMISSION (AE) TO UNDERSTAND A WELDABILITY TEST

Sameer Bachani, Jack Devletian, Portland State University

INTRODUCTION.

Weld cracking is an ongoing problem in practical welding and needs to be avoided. Predicting and hence avoiding solidification cracking is an area that falls to weldability testing. Many weldability tests are in use now, each with its advantages and disadvantages, one of them being the Sigmajig test¹. Yet another weldability test aiming at better weld control and simplicity is introduced here.

Solidification cracking is hot centerline cracking observed in weld metals when the weld passes over the test material. The primary influencing factors for material resistance to solidification cracking are the alloy composition, tensile stress, welding process and heat input.

The intent of this work is to develop and understand a weldability test for solidification cracking and to produce similar results to the Sigmajig test but more friendly to work with, give reproducible cracks, be sensitive to cracking, be economical and use real scale welds. The question this paper is going to focus on and answer is how we can use AE to better understand the weldability test.

SET-UP.

The diagrammatic and actual representation of the set-up is as shown in Figure 1 below: -

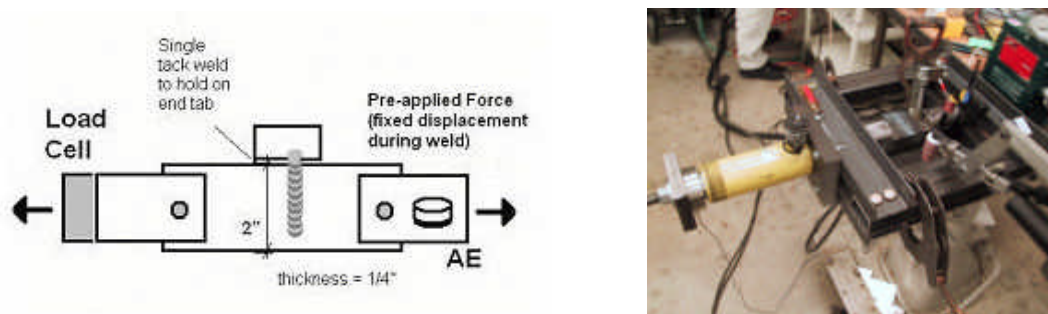


Figure 1:- Diagrammatic and actual representation of the set – up.

The specimen sizes used in this test are coupons of length 6 inches, width 2 inches and thickness of 0.25 inches. The pins that load the specimen are of diameter 0.5 inches. The travel speed of the TIG weld was controlled using a milling machine and was kept constant at 6 inches per minute. The distance between the specimen and the tip of the electrode is 0.0625 inches.

A pin loaded test specimen with tabs is inserted horizontally into the test machine. The specimen is tensioned and this is read by the load cell connected to the strain gauge. At a desired tension level, the

¹ Sigmajig test is a hot-cracking test used commonly for sheet metal. The test uses a pre-applied load during welding and determines a threshold stress above which a centerline crack initiates.

displacement is fixed and the changes in load are registered thereafter. An autogenous bead-on-plate weld is then made across the coupon and onto the tab at constant weld speed.

The weldability test here employs a simple fixed transverse load before welding hence the weld is subjected to a constant displacement. The distance between the test material and the weld tip is kept constant. A series of welds with increasing applied load produce a cracking transition load. In this manner, it is similar to the Sigmajig test. It differs in that the test specimens are loaded through pins, making the test specimens easier to manufacture and load. Tabs are added to the coupon so that the crater does not influence the cracking. To qualify this test, tests with various materials and under different heat input levels and different tensile loads are tested. Additionally, monitoring in-situ parameters from a load cell and AE sensor during a series of welds are used to see how the weld evolves.

The resonance sensor used for the AE is a 375 kHz with a frequency range of 95 – 850 kHz. A donut load cell connected to a strain gauge is used to record the applied load to the specimen. The load cell has a loading capacity of 10000 lb.

RESULTS.

As with the sigmajig, an activation load level for centerline solidification (or hot cracking) is found, which is a function of heat input. Unlike the sigmajig test, these centerline cracks are often initiated before the mid section of the weld is reached. Results are still unfolding.

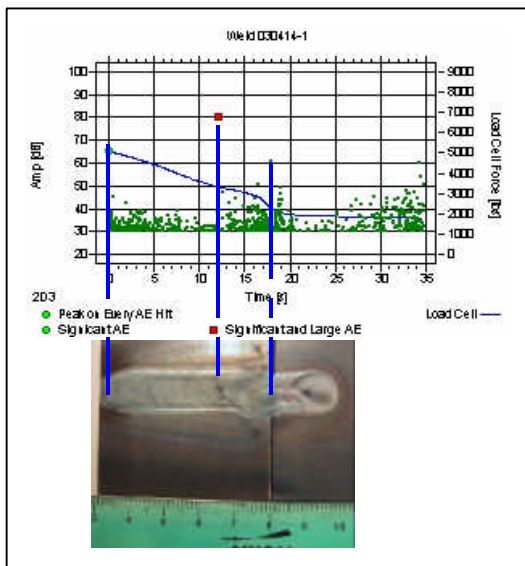


Figure 2

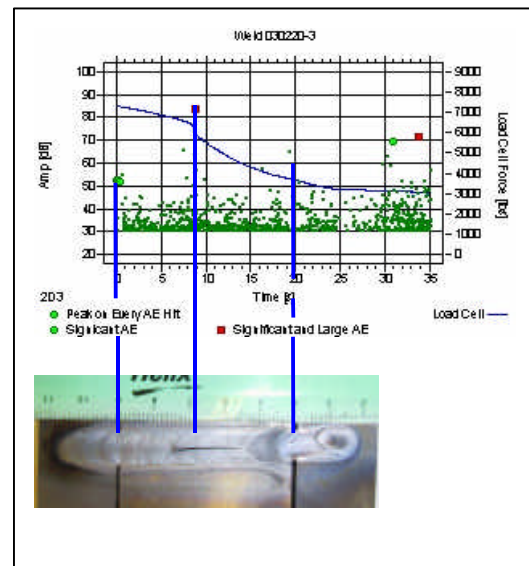


Figure 3

Figure 2:- AE graph showing small crack growth and subsurface crack growth in 1018 steel.

Figure 3:- AE graph showing large interdendritic solidification cracks in 1018 steel

With the help of AE analysis, from Figure 2, we can locate where the cracks initiate and determine whether there are any subsurface cracks present in the test specimen. These subsurface cracks occur with high heat inputs and low stress. A significant large AE of 80 dB (highlighted with larger red point) is observed at the time 12 seconds and a distance of 1.2 inches from the weld beginning. There is also a drop in load cell force as seen on the AE graph at this point, about 12.5% (from 4000 lb to 3500 lb). The total load drop in this analysis is 64% and this correlates well with the load cell.

The AE analysis for this test gives us the following results:

1. Synchronization of the welding process is possible using AE.
2. The crack only appears on the surface after the large AE

Figure 3 shows us that there is a lot of AE activity going on around the point of crack initiation and propagation. In this case, since the crack is propagating, it will have different depths at different points and thus the reason behind having varying AE activity in amp (dB). It is believed that the point of maximum depth of crack is at 84 dB, further investigations are being performed to confirm this. The load drop in this case is 57% and this also correlates well with the load cell.

We can see from the graphs that AE is helpful in telling us the point at which the weld is going to pass over the edges between tabs and the coupon. The 20 seconds time corresponds with the 2 inches length of the coupon. We know the speed of the milling machine (6 inches per minute), so we can know how fast forward the weld pool moves (0.1 inch per second). This is how we can correlate the AE and load cell measurements with the photograph.

Background noises due to the weld process are always monitored by the AE. Both the background noises and the AE signals created by the weld crack are attenuated due to the sensor being on the grip of the test machine instead of onto the test specimen. Two features of the AE, amplitude and energy, were used to separate the background noise from the AE signals created by the weld crack. As in the case of Figure 3, only one hit had both higher amplitudes (highlighted by the red square boxes in graph) and higher energy (called significant AE and highlighted with larger points in the graph). Over many welds, both cracked and uncracked, AE that has both high amplitude and energy is observed consistently in the cracked welds and not at all in the uncracked welds.

CONCLUSION.

The following points were noted, that make us better understand this weldability test, using AE: -

1. Higher heat inputs hide solidification cracks below the surface and AE shows the point where they exist.
2. AE helps correlate the load cell measurements with the surface cracks (photographs).
3. Load drops, AE and positions of cracks observed on weld surface are found to correspond.