IMPURITY EFFECTS ON GAS TUNGSTEN ARC WELDS IN V-Cr-Ti ALLOYS –

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Summary

Recent research on welding vanadium alloys at ORNL has centered on gas tungsten arc welding of 6.4 mm plate of V-4Cr-4Ti. Previous research has demonstrated that the level of oxygen in the glove box atmosphere can be correlated with embrittlement of the weld, higher levels being more deleterious. Efforts to reduce the oxygen level by means of a heated titanium getter resulted in elevated levels of hydrogen in the weld with corresponding embrittlement as measured by Charpy impact testing and the tendency to crack prior to testing. A cold getter of Zr-Al was introduced to control the level of hydrogen. A residual gas analyzer installed to monitor the argon atmosphere showed that an important source of hydrogen is dissociation of water vapor by the electric welding arc. Use of the hydrogen getter and repeated pumping and backfilling with high purity argon resulted in an atmosphere with less than one wt. ppm of moisture and oxygen. Hydrogen was still a major contaminant but nonetheless reduced from that of previous welds.

The Charpy impact tests on miniature specimens 25.4 mm in length and 3.33 mm on a side were used to evaluate brittleness of the weld. In all cases, the root of the blunt notch was positioned at the center of the fusion zone. In early welds of V-4Cr-4Ti, ductile to brittle transition temperatures, DBTT, as high as 250°C were observed. In the recent welds, DBTT's as low as -28°C were attained. This is a significant improvement, but electron beam welds have demonstrated DBTT's of -90°C. This suggests that impurity control might result in further reduction of the DBTT.

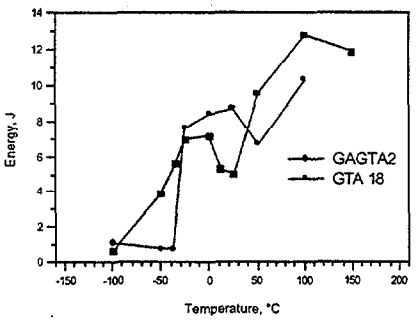

Figure 1 Charpy energy data plotted such as to show the high-temperature minima for two GTA welds in V-4Cr-4Ti.

Figure 1 shows the Charpy results of two of the most recent welds, both using filler metal of Wah Chang heat 832665 but different heats of similar base metal. Most interesting is perhaps not the low DBTT but rather the minima in the curves near 50°C. This minimum has been observed previously, often following a post-weld heat treatment to precipitate oxygen. In the case of the two recent welds shown in Fig. 1, a matrix with a low interstitial concentration was achieved, not by precipitation but by a clean welding atmosphere. This minimum is believed to result from twinning which permits plastic deformation after the initial restriction of slip as temperature is reduced. Twinning is enhanced by high strain rates, low interstitial concentrations, and large grain size, all of which are present in the high purity welds. Twinning has been observed in vanadium at low temperatures and high strain rates[1-3]. In addition, twinning has been observed in welds in the present research by TEM, and what appear to be twins have been observed following Charpy testing at temperatures below the minimum.

Further research will focus on determination of the mechanism of the high temperature minimum and, more importantly, on control of grain size as an additional mechanism of reduction of embrittlement in welds.

REFERENCES

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