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A PATH FOR HORIZING YOUR INNOVATIVE WORK

ENHANCEMENT OF PRODUCTIVITY BY A-TIG WELDING

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Abstract: - The depth of penetration in TIG welding can be significantly increased by the use of an 'activated' flux. Furthermore, it is widely acknowledged that joint completion rates can be increased by the use of argon-helium or argon-hydrogen shielding gas mixtures. The results of an investigation into the benefits of combining the flux with an appropriate shielding gas are outlined

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INTRODUCTION

The penetration capability of the arc in TIG welding can be significantly increased by the application of a flux coating containing active ingredients, onto the joint surface prior to welding. In particular, recent attention has focused on the A-TIG welding process, developed by the E O Paton Electric Welding Institute. It has been claimed that the ATIG process can achieve, in a single pass, a full penetration weld in C-Mn steel up to 12mm thickness, without the use of a bevel preparation and the addition of filler wire1. Furthermore, the weldment mechanical properties and soundness are claimed to be unaffected. A-TIG fluxes are available for the welding of a wide range of materials including carbon steel, low alloy steel and stainless steel.

The A-TIG process has been exploited to improve production efficiencies in a wide range of industries in the former Soviet Union, including power generation, chemical and aerospace. There is a significant level of interest in exploiting the potential benefits of the flux outside the Commonwealth of Independent States. TWI is currently carrying out a Group Sponsored Project to develop a knowledge base to facilitate the utilization of this technology with argon shielding gas.

Welding details

Welding trials were carried out to assess the weld penetration of the TIG welding process using the A-TIG flux, with a range of argon-helium and argon-hydrogen shielding gas mixtures. The programme of work involved a series of autogenous TIG welds in stainless steel on bare (uncoated) plate and plate coated with a grade of A-TIG flux developed specifically for stainless steel by PWI, with each shielding gas composition.

The welds were carried out in the flat position using the mechanized TIG welding process. The joint preparation was a close fit, square edge butt. One weld was manufactured for each combination of flux and shielding gas composition. The first half of the weld was made on the bare plate, to provide a reference point for the comparison of flux performance. The second half of the weld was coated with an estimated 0.1-0.25gm of flux. The thin layer of flux was deposited by painting on a suspension of the flux in acetone. The acetone evaporated leaving the flux coating on the surface. The welding parameters were modified to ensure that the arc energy(2.5kJ/mm) was similar for all of the welds without flux. The arc length and welding current (200A) were held constant, with the travel speed adjusted to compensate for changes in the arc voltage due to the shielding gas composition.

Effect of the flux on weld bead penetration

There was a clear change in the weld bead profile between the bare and flux coated sections of the welds, fig 1. For welds produced at a fixed arc energy using shielding gas mixtures containing argon and/or helium, a significant increase in the depth of weld penetration was observed, fig 2, along with a reduction in the weld bead width at the top face. Typically, the welds on the bare plate were of a shallow ‘U’ profile. The profile of the welds on the coated plate appeared to tend towards a ‘peanut shell’ shape. The mechanism for the change in weld profile and depth of weld penetration is not well understood. Proposed explanations include the effect of the flux constituents on the material flows within the weld pool and/or the constriction of the arc and concentration of the heat source.

Effect of the shielding gas

The travel speed which may be achieved when welding the flux-coated plate at a given arc length and arc energy, increases with the proportion of helium in the shielding gas, fig 3. This is due to the increase in arc voltage, which for a given arc length requires an increase in the travel speed to maintain a fixed arc energy. Compared to argon shielding gas, pure helium allows a 33% increase in travel speed for a given arc energy which, although helium is more expensive, will potentially result in a net reduction in the cost of fabricating a joint. If the efficiency in generating weld metal with each of the shielding gas mixtures was similar, it would be expected that, given the fixed arc energy and with a similar depth to width ratio, the depth of penetration would be the same irrespective of the composition of the shielding gas. Whilst the limited number of data points are not statistically conclusive, it appears that there may be a tendency for a slight increase in penetration with an increase in the helium content of the shielding gas, although this appears to be of second order in effect, behind the flux. The welds produced with a combination of flux and a shielding gas containing a proportion of hydrogen exhibited significant levels of porosity, fig 1. It therefore appears that the use of a combination of flux and a hydrogen bearing shielding gas should be avoided.

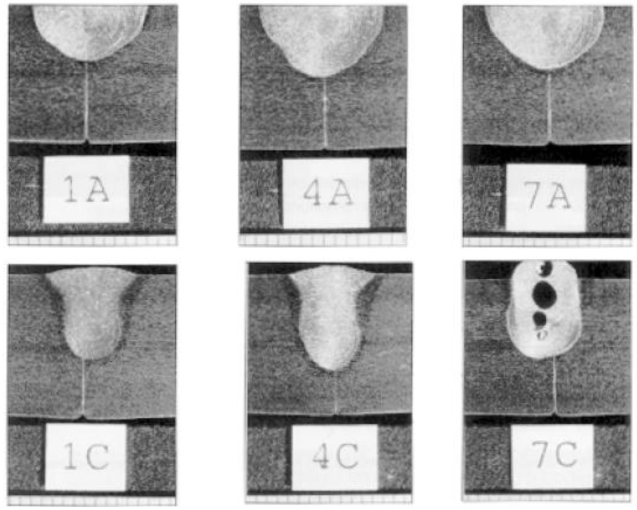

Fig 1. Weld profiles. 1A - Bare plate, Ar shielding gas; 1C - A-TIG flux, Ar shielding gas; 4A - Bare plate, Ar-70% He shielding gas; 4C- A-TIG flux, Ar-70% He shielding gas; 7A - Bare plate, Ar-3% H2 shielding gas; 7C - A-TIG flux, Ar-3% H2 shielding gas.

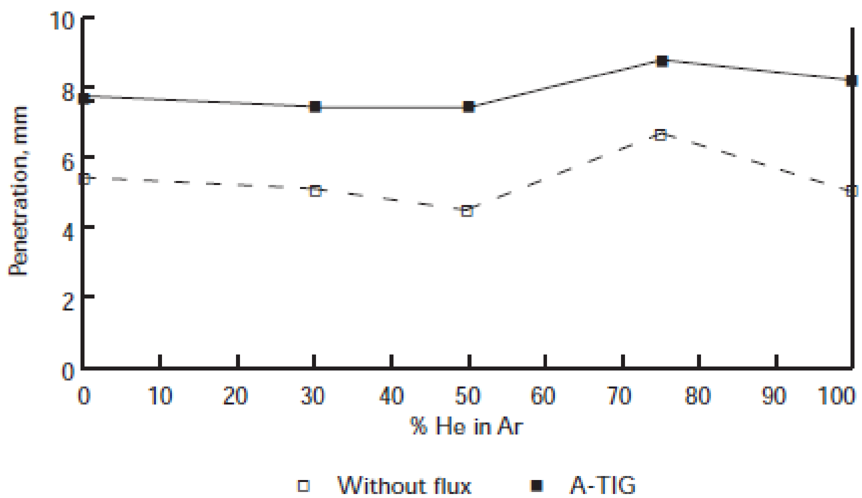

Fig 2. Effect of shielding gas mixtures and flux on depth of weld penetration. Arc energy is fixed.

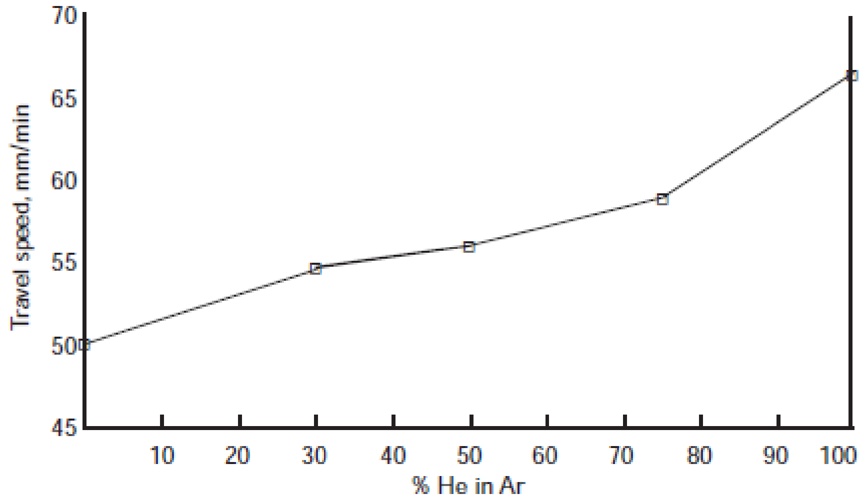

Fig 3. Influence of shielding gas composition on travel speed (arc energy 2.5kJ/mm, welding current 200A, arc length 2mm).

SUMMARY

For the autogenous TIG welding of stainless steel:

- Compared to the penetration on the bare plate, the use of A-TIG flux can lead to a change in the weld profile and a significant increase in the weld penetration.
- The use of a shielding gas mixture containing helium offers the potential of up to 33% increase in the joint completion rate compared to argon, which potentially results in a reduction in the fabrication cost of the joint.
- The use of a combination of A-TIG flux and a shielding gas mixture containing a proportion of hydrogen appears to lead to porosity. Further work is required to establish the mechanism by which the flux changes the weld bead profile and affects the depth of penetration.

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