DEVELOPMENT OF NOVEL GASES AND PROCEDURES FOR HIGH SPEED WELDING USING MELT-IN PLASMA PROCESS

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1. OBJECTIVES AND MOTIVATION

The objective of this work was to propose and evaluate novel gases and procedures for melt-in PLASMA welding that make a significant increase of the operation speed in low-carbon-steel-sheet unions possible. The main goal of this work was to present to the market an option of high-speed welding without the need of electrode-wire. The possibility of not using wire in a productive welding process may have logistic advantages, since this approach eliminates a supplier and one more item in relation to purchase/transportation/stock operations. This production option is claimed to have great acceptance for up to 3-mm sheet joining with edge, lap or butt joints, if high productivity is required (automated welding). Examples of applications would be refrigeration compressors, axles and girders for self-driven vehicles, car parts, white line components, etc. This process is regarded as a high cost process and can become viable for high speed operations only.

2. DIFFICULTIES IN PLASMA WELDING USING THE MELT-IN TECHNIQUE

This process has been employed with the use of Argon as plasma and shielding gases. A great limitation in the use of this process for carbon steel welding is the maximum value of travel speed that can be used, since above a certain value, the weld bead presents irregularities, as shown in Figure 1.

Figure 1. Appearance of a nonconformity weld bead, due to operational difficulties, over an edge joint using pure Ar melt-in Plasma process (the dragon's back shape is caused probably by over limit speed)

3. OVERCOMING THE DIFFICULTIES OF MELT-IN PLASMA WELDING

Several methods were evaluated so as to overcome the problem related to the irregularities of the welding bead, yet working at higher speed than the conventional weldments. The goal would be to reach travel speeds that would make this process technically and economically viable, i.e., to reach the maximum travel speed with sound weld finishing, as shown in Figure 2.

Figure 2. Appearance of weld beads in which the operational difficulties were overcome (conform weld over edge joint)

The above condition was reached with the following setting of parameters and procedures:

- Welding current: 140 A;
- Plasma gas flow: 0,7 l/min;
- Shielding gas flow: 10,6 l/min;
- Stand-off distance: 3,5 mm;
- Electrode type: AWS EWTh-2;
- Electrode diameter: 5 mm;
- Included angle of electrode: 33°;
- Electrode set-back: 0,8 mm;
- Leading angle: 105º (pushing); and
- Sand blasting of the joints.

4. DEVELOPMENT OF NOVEL GASES

As a means of improving the performance of the process, a group of gas blends was experimented. Because of the ownership of this technology (work done on a private contract basis), in this work the blends were not explicit, but presented in code. All the blends were Argon based and with variable content of gaseous additives, called A, B and C. The novel gas blends that provided the greatest increase in welding travel speed were Argon plus additive A (binary blend), and Argon plus additives A and C (ternary blend). Besides increasing the welding travel speed in a remarkable way, the usage of these gas blends improved the weld bead finishing, yet keeping the mechanical soundness of the joints. Figure 3 shows the maximum welding travel speed as a result of use of the additive A content, while Figure 4 shows the evolution of this parameter as a result of the use of additives A and C contents. Figure 5 illustrates the weld bead finish obtainable by using these blends.

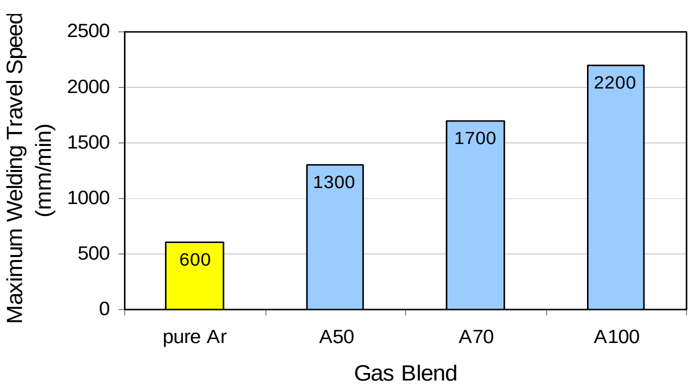


Figure 3. Evolution of the Maximum Welding Travel Speed as a result of the use of the additive A content

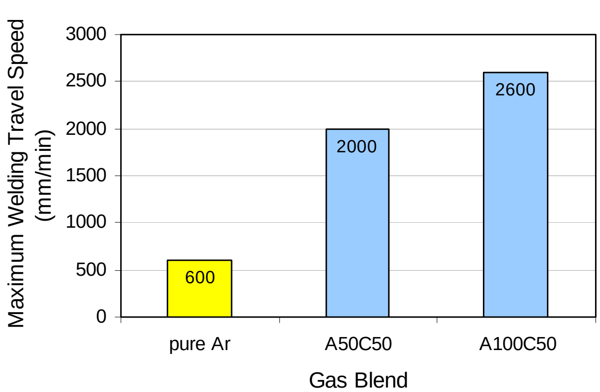
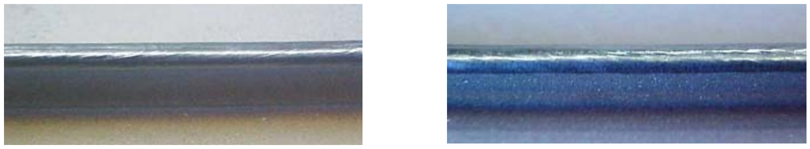


Figure 4. Evolution of the Maximum Welding Travel Speed as a result of the use of the additives A and C contents



A50 gas blend A100C50 gas blend

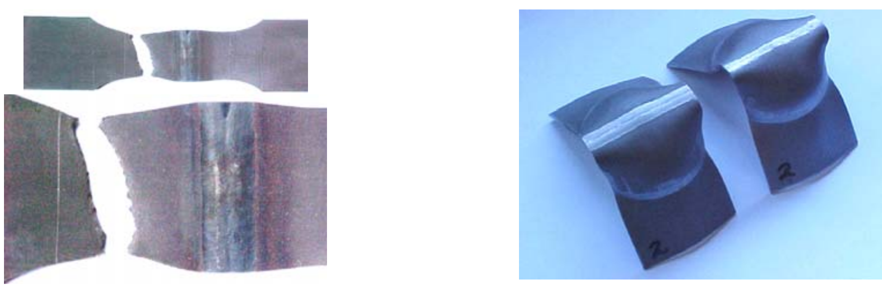
Figure 5. Weld bead finish obtainable with Argon plus additive A and Argon plus additives A and C

5. MECHANICAL PROPERTIES OF THE WELDED JOINTS

The main concern in relation to the use of the gases developed for the welding of plain carbon steel was the weakness of the joints. The evaluation of a possible weakness of the joints was made through microstructure and micro-hardness analyses, which results are as follows:

- Microstructure at FZ: predominantly polygonal ferrite, with presence of aligned second phase ferrite and non-aligned second phase ferrite (hardness around HV 180);
- Microstructure at HAZ: polygonal ferrite with presence of fine perlites in the grain contours, with grain (coarse HAZ) (hardness around HV 140);
- Microstructure at BM: polygonal ferrite with presence of fine perlites in the contours of the grains, typical of normalized low carbon steels (hardness around HV 125).

Tensile tests and formability test were made as well. Figure 6 shows the test specimens after these tests.



a) b)

Figure 6. a) Fractured specimens after tensile test; and b) Specimens submitted to formability test

Considering the level of hardness achieved, the position of the fracture due to tensile tests (out of the joint), and the joint resistance presented in face of the formability effort applied, it is possible to assert that the additive A does not weaken the welded joint.

6. CONCLUSIONS

This work shows that it is possible to develop novel plasma gas blends that are able to increase the welding speed in over 400% in comparison to pure Argon usually used in Plasma melt-in processes. The mechanical and appearance qualities of the beads are not compromised, as long as the procedures for joint cleaning and torch positioning are observed. Thus, it is demonstrated that, at higher speeds and without the need of wire feeding, the use of the Plasma Melt-in process for sheet welding of plain carbon steels is of great viability.

Keywords: PAW, Melt-in Technique, Gas Blends, High Speed Welding.