Influence of Process Variables on ANSI/AWS A5.29-98 E81t1-Ni1 Flux Cored Wire All-Weld Metal Properties

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Introduction/Background

The knowledge of the relationship between welding parameters and mechanical properties of the weld deposits allows to optimize the welding procedure specification. The objective of this work is to study the influence of welding procedure parameters on tensile properties and the Charpy-V notch toughness of ANSI/AWS A5.29-98 E81T1-Ni1 flux cored wire all weld metal.

Procedure

Weldments

Eight all weld metal test specimens were prepared with the mentioned consumable (1.2 mm diameter) according to ANSI/AWS A5.29-98 with two shielding gases (CO_2 and a mixture of 80% Ar-20% CO_2), two heat inputs (2 and 3 passes per layer), and in the down-hand and vertical up positions.

Mechanical and Microstructural Characterization

All weld metal chemical composition, Vickers hardness (1000 g), tensile (Minitrac specimens) properties and Charpy-V impact Absorbed Energy vs Test Temperature curve were determined. Microstructural studies were carried out using light microscopy.

Results and Discussion

Ar-CO_2 shielding led to an increase in Mn and Si in the weld metal. No significant chemical composition changes were observed with heat input variation, although a slight increase in Mn and Si was observed when welding in the vertical up position. Tensile strength corresponding to test specimens welded under Ar-CO_2 mixture exhibited higher values than samples welded under CO_2 as expected from the chemical composition results. An increase in the heat input led to a reduction in tensile strength. The influence of heat input was more marked in samples welded under the gas mixture. A slight tensile strength increase was achieved with test specimens welded in vertical up position, when compared to those in flat position. A general agreement was found between tensile strength and hardness values.

The impact test results showed that although all the specimens satisfied the minimum AWS requirement of 27J at –51ºC, ample variations in toughness were found when welding procedure parameters were changed, Figure 1. At this temperature absorbed energy values varied between 40J and 140J approximately. The 100J and 50J transition temperatures were below –30ºC and –70ºC respectively. Although it was not possible to establish a clear variation pattern of toughness in terms of welding parameter changes, it was observed that the highest impact values corresponded to weld deposits with Mn contents of 1.3-1.4% and Si content of 0.24-0.28%. It is worth noting that the specimen welded under gas mixture, in the flat position with two passes per layer, presented the best impact properties throughout the whole temperature range studied, being the toughness values between 125J and 190J in the temperature range of –80ºC and 20ºC. The lowest toughness corresponded to the sample welded under gas mixture, in the flat position but with three passes per layer. In this case the absorbed energy varied between 40J and 95J in the same temperature range.

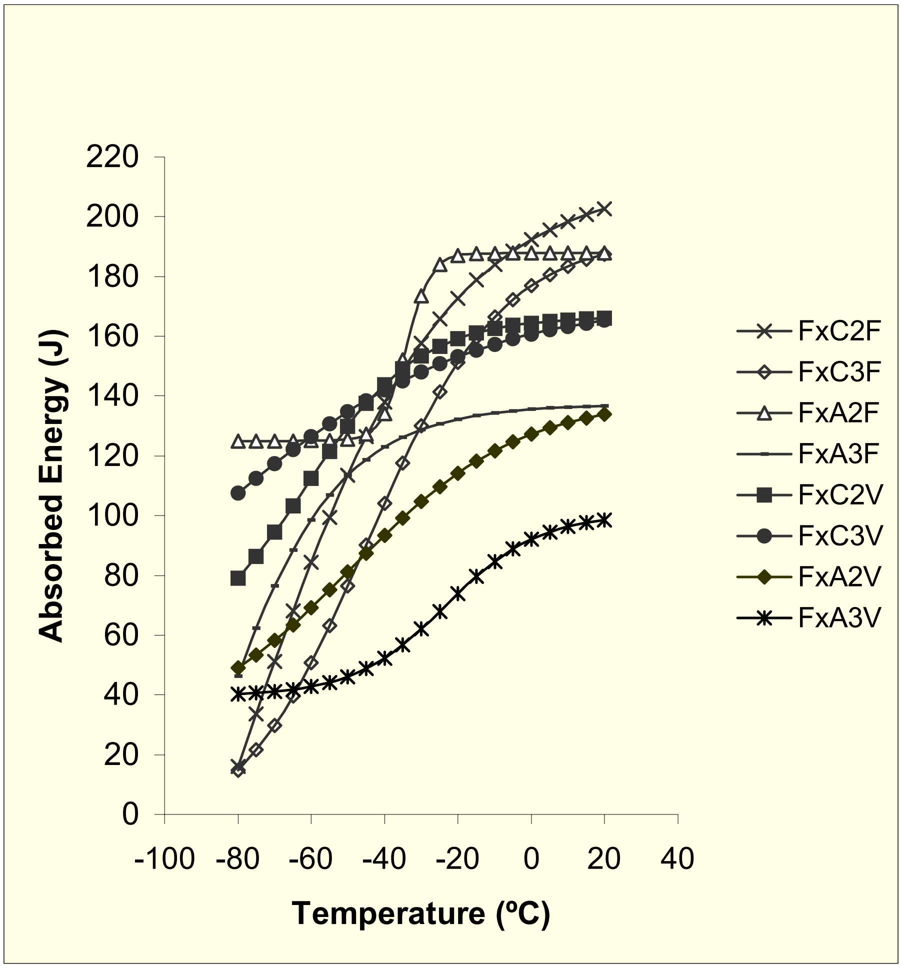

Figure 1: Charpy-V notch impact Absorbed Energy vs. Test Temperature curve. Fx: flux cored wire; C: CO_2 shielding; A: Ar-CO_2 shielding: F: flat position, V: vertical up position.

The microstructure corresponding to the location of the Charpy-V notch consisted mainly of reheated zone. Low heat input specimens showed a slight increase in the amount of columnar zone as compared to those of high heat input under both gas shielding gases. The fine grain recrystallized zone grain size was smaller under Ar-CO_2 shielding notwithstanding the fact that the prior austenite grain width was larger in this case.

The microstructural analysis conducted in the last bead showed that under Ar-CO_2 shielding the larger proportion of acicular ferrite and the least amount of grain boundary polygonal ferrite was found.

The best impact properties were obtained under the Ar-CO_2 mixture in the flat position with two passes per layer; this deposit presented the lowest amount of columnar zone, the highest fine grain recrystallized zone percentage, the lowest amount of grain boundary polygonal ferrite, a high acicular ferrite proportion, and the lowest crystallized fine grain zone grain size.

Conclusion

The all weld metal from the ANSI/AWS A5.29-98 E81T1-Ni1 flux cored wire used in this study, obtained by varying shielding gases, heat input and welding position presented tensile properties and impact toughness exceeding in all cases the minimum requirements of the relevant AWS standard. Toughness was found to be very sensitive to changes in procedure parameters, the highest impact values throughout the whole temperature range studied, corresponded to weld deposits with Mn content around 1.4% and Si content around 0.25%, with the specimen welded under gas mixture, in the flat position with two passes per layer. This result has to be taken into account when the welding procedure is specified.

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