SPC2. High Strength Steel Welding

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Introduction

The current research was undertaken to study the effects of fluoride additions to yttrium-containing consumables on the development of diffusible hydrogen, weld metal oxides, microstructure, and mechanical properties in low alloy steel welds. The use of high-strength low alloy (HSLA) steels has been limited to due the lack suitable filler metals. Hydrogen assisted cracking is a major concern in HSLA steel weld metal. Optimal weld metal oxide size and spatial distribution will allow a microstructure consisting primarily of acicular ferrite to develop, which in turn improves the mechanical properties of the weld metal.

Technical Approach & Results

To study the effects of fluoride on weld metal microstructures produced with yttrium-containing consumables, flux-cored weld consumables were manufactured with varying amounts of fluoride and used to produce multiple pass low alloy steel weld deposits. The weld deposits contained approximately 2.8 weight percent nickel, 1.5 weight percent manganese, 0.4 weight percent molybdenum, 300 ppm titanium and 300 ppm yttrium. The characterization of oxides was performed by light optical microscopy and scanning transmission electron microscopy. Microstructural characterization was performed by LOM on the top bead deposit. Mechanical properties of these deposits were determined through tensile testing and Charpy V-notch impact testing.

Welds containing a [%Y]/[%O] ratio between 0.20 and 0.45 resulted in a microstructure that is predominately acicular ferrite, which is expected to result in optimal mechanical properties. The microstructures comprise of 65 to 75 percent acicular ferrite, with the remaining being ferrite with aligned second phases. The oxides present are spherical and randomly distributed throughout the weld metal. Due to this ratio of yttrium to oxygen, titanium can combine with oxygen to form Ti_2O_3, which is known to act as nucleation sites for acicular ferrite. The use of the optimal consumable resulted in improved weld metal mechanical properties.

Conclusions

The optimal mixture of yttrium and fluoride additions results in a FCAW consumable which produces weld metal with improved mechanical properties and lower diffusible hydrogen content. The brittle transition temperature has decreased. Diffusible hydrogen content is less than 2.0 mL H_2/ 100g weld metal. The efforts of this research will be beneficial to naval shipyards and fabrication of low alloy steel structures.