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Weld pool microstructure in plasma pulsed welded supermartensitic stainless steel

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Abstract – The objective of this work was to investigate the effect of pulsed welding on the weld pool microstructure of a supermartensitic stainless steel. Pulsed plasma surface melting was applied on high alloy supermartensitic stainless steel grade to produce a bead on plate weld. Optical metallography, micro-hardness and X-ray diffractometry test was carried out to evaluate phase distributions as well grain refinement along longitudinal weld pool. The experimental results show that, under the same heat input condition, high undercooling, promoted by large spaced pulse, resulted in delta-ferrite banding and non-uniform grain size (Fig.1) and micro-hardness distribution along the pulsed surface melting (Fig2). No retained austenite could be detected in any weld bead resulted from thermal cycles.

Supermartensitic stainless steel (SMSS) has been developed since 1990's to use in the oil and gas industry to substitute more expensive duplex stainless steel [1].

They present attractive properties when compared to former martensitic grades with higher carbon content as they have improved weldability and higher toughness. These steels are subdivided into three grades all characterized by a low carbon content (0.015%), lower than that present in the former martensitic grades. The three grades include families which can be represented as lean, medium and high alloy grades, depending on the increase in the corrosion resistant alloying elements (Cr + Mo) balanced by austenite forming elements (Ni + N) in order to secure the required microstructure [2]. The microstructure of SMSS is formed by martensite and finely dispersed retained austenite resulted from tempered.

Stainless steel components can be joined using a variety of welding methods, including plasma arc welding (PAW) [3]. PAW is conventionally carried out using one of two different current modes, namely a continuous current (CC) mode or a pulsed current (PC) mode.

As little information is available in the literature about the structure and properties of welded SMSS, it is the purpose of this work to study the morphology, phases and hardness distribution obtained by plasma pulsed welding technique. Pulsed plasma surface melting was applied on high alloy supermartensitic stainless steel grade to produce a bead on plate weld. Optical metallography, micro-hardness and X-ray diffractometry test was carried out to evaluate phase distributions as well grain refinement along longitudinal weld pool. The experimental results show that, under the same heat input condition, high undercooling, promoted by large spaced pulse, resulted in delta-ferrite banding and non-uniform grain size and micro-hardness distribution along the pulsed surface melting. No retained austenite could be detected in any weld bead resulted from thermal cycles.

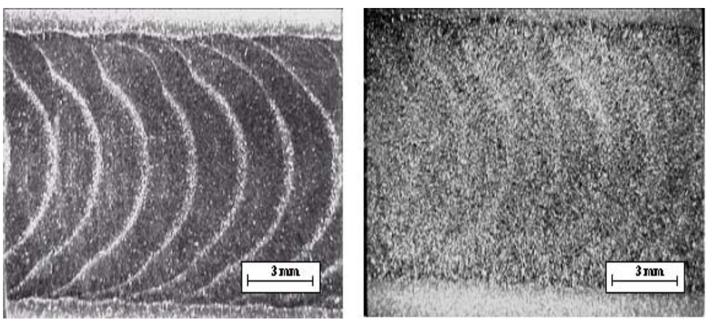

Figure 1: Superior macrograph of weld bead electrolitycally etched revealing delta ferrite lines (left). Macrostructure revealed by Villela's reagent showing grain size distribution (right)

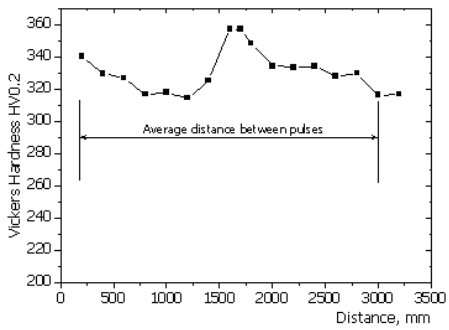

Figure 2: Vickers micro-hardness distribution along centerline weld bead.

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