Post weld heat treatment effects on SMSS deposit mechanical properties

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Abstract
Supermartensitic stainless steels have been developed as an alternative technology, mainly for oil and gas industries. In these steels, the post-weld heat treatments are usually double tempering treatments, to ensure the complete tempering of martensite and high austenite content. The aim of this work was to study the effect of post-weld heat treatments (solubilizing with simple and double tempering) on the mechanical properties of a supermartensitic stainless steel deposit obtained with a FCAW wire welded under gas shielding.

Materials and methods
One all-weld metal test coupon was prepared according to standard ANSI/AWS A5.22-95 using a GMAW SMSS metal cored wire, under Ar/20%CO_2 gas shielding. Post weld heat treatments were a) series 1: solubilizing (1000°Cx60 min)+single tempering (at 580, 600, 620, 640, 660 and 680°Cx15min.) and b) series 2: solubilizing (1000°Cx60 min)+first tempering (at 580, 600, 620, 640, 660 and 680°Cx15min.)+second tempering (600°Cx15min.). All-weld metal chemical composition analysis, metallurgical characterization by both optical and electronic microscopy and XR diffraction, HV1 hardness and tensile property measurements and Charpy-V tests were carried out.

Results and discussion

All weld metal chemical composition (%wt/wt except C in ppm)

C	Mn	Si	S	P	Cr	Ni	Mo	Cu	V	O	N
150	1.70	0.44	0.015	0.015	11.9	6.11	2.69	0.46	0.09	490	110

In all cases the microstructure was constituted by a matrix of martensite with different retained austenite contents.
Varying the first tempering treatment between 600 and 680 °C, there was a maximum of austenite content at 620-640 °C, with second tempering and without it. The austenite content was higher in the samples submitted to double tempering.

Austenite content. (ST: single tempering; DT: double tempering).

Sample	**1000**	**580 ST**	**600 ST**	**620 ST**	**640ST**	**660 ST**	**680 ST**
Austenite content [%]	0	7	9	14	9	6	3
Sample	**1000**	**580 DT**	**600 DT**	**620 DT**	**640 DT**	**660 DT**	**680 DT**
Austenite content [%]	0	10	22	25	42	33	30

Through a diffusional mechanism, the austenite produced during the tempering is enriched in elements such as N, C and Ni, stabilizing it. If tempering is performed at temperatures slightly above A_{C1}, the enriched austenite will be stable at room temperature; if it is done at temperatures well above or well below A_{C1}, the austenite will loose chemical enrichment and, as a consequence, stability and will be transformed to fresh martensite during cooling. Highest contents of austenite will be obtained with tempering temperatures above A_{C1} in 40-50 °C.

For series 1, with the increase of temperature treatments, hardness, tensile and yield strength decreased up to a minimum value for 620°C of tempering temperature; above this temperature these properties increased. On the contrary, elongation and toughness increased up the mentioned 620 °C tempering temperature and decreased from this value. The same behavior could be found for series 2, being toughness values only slightly higher than those obtained under single tempering. In spite of the fact that between series 1 and 2 there were an important difference in the % of retained austenite, toughness only presented a slight increment.

Conclusion

Yield and tensile strengths and hardness decreased with the increase of retained austenite content and toughness and elongation showed the opposite effect.

The performance of the double tempering treatment generated a noticeable increase of the retained austenite content, regarding the samples submitted to only a tempering treatment: this fact was not reflected in a significant improvement of toughness.

As a general conclusion, it seems not to be justifiable to perform the second tempering treatment as the improvement of toughness here measured is very little, probably inside the method error, in the conditions here studied.