CORROSION RESISTANCE OF S355J2 STEEL WELDED BY SAW BEFORE AND AFTER SURFACE TREATMENT BY PHOSPHATING

Kamil Borko[1], Filip Pastorek[2], Branislav Hadzima[1,2]

[1] University of Žilina, Faculty of Mechanica, Department of Materials Engineering, Univerzitná 8515/1, 010 26 Žilina. E-mail: kamil.borko@fstroj.uniza.sk

[2] University of Žilina, Research Centre, Univerzitná 8515/1, 010 26 Žilina. E-mail: branislav.hadzima@rc.uniza.sk, filip.pastorek@rc.uniza.sk

1. Introduction

Corrosion resistance is of great importance for the materials usage, particularly for steel. The corrosion resistance depends on an environment where the material is present, on the chemical composition and structure of the material. Resistance to atmospheric corrosion of steel can be increased by addition of a small addition of copper. Addition of Ni is also effective. Increase of atmospheric corrosion resistance can be also reached by sufficient amounts of Cr in a combination with Cu. In general, maximal resistance to atmospheric corrosion can be achieved by a higher content of alloying elements [1, 2].

Submerged arc welding (SAW) is an arc welding process and the arc is shielded by a layer of flux which protects the molten weld metal from atmospheric contamination. The base metal (BM), the heat affected zone (HAZ) and the weld metal (WM) are parts of the welded joint and define the properties of the welded joints and welded constructions [3, 4].

SAW is the most widespread method for welding large diameter pipes because of its elevated productivity. Its main drawback, however, is that very high residual stresses develop around the welded area [5]. This may also influence the corrosion resistance of the weld metal.

2. Experiment

S355J2 steel was used as an experimental material with a known chemical composition listed in table 1. The microstructure of the S355J2 steel (Fig. 1) is formed by ferrite-pearlite matrix with a low pearlite content (local pearlite occurrence) and with the grain size of about 10 microns. Fillet welds were made on plates of 250 mm × 500 mm × 30 mm using SAW.

elem.	C	Mn	P	S	Si	Cu	Fe
wt.%	0.2	1.600	0.025	0.025	0.550	0.550	bal.

Tab. 1 Chemical composition of S355J2 steel

Electrochemical characteristics of the material (E_{Corr}, i_{Corr}, v_{Corr}) were investigated on the ground material (P1000 emery paper) with and without further surface treatment. Electrochemical characteristics were measured in a 0.1M Na_2SO_4 solution by potentiodynamic tests using a potentiostat SP300 .


Fig. 1 Microstructure of S355J2 steel

Phosphating process was carried out in phosphating bath composed of: 1000 ml demineralized water, 15 g H_3PO_4, 15 g MnO_2 and 5 g very fine steel wires. The temperature of phosphating process was set to 92 - 95 °C.

3. Results

As can be seen from the measured potentiodynamic curves (Fig. 2) and electrochemical characteristics (Table 2) in 0.1M Na_2SO_4 evaluated by the Tafel analysis, the base material (BM) has higher thermodynamic stability than weld metal (WM), because the value of corrosion potential (E_{Corr}) is more positive about 41 mV. However, higher kinetic stability

is reached by WM than by BM, representing by lower corrosion current density (i_{Corr}) value and corresponding corrosion rate (v_{Corr}) value.
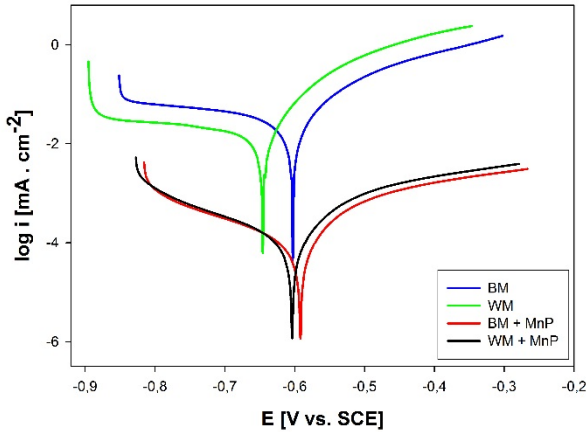
Fig. 2 Potentiodynamic curves of S355J2 steel

Created phosphate layer has porous nature and homogenous crystalic structure with negligible visual differences on both tested surfaces (BM and WM). By forming a stable mechanical barrier against corrosion mechanisms this layer increased the corrosion resistance of the tested surfaces in 0.1M Na_2SO_4 environment. Electrochemical corrosion characteristics of the phosphate layer created on BM and WM are very similar as seen in table 1.

	E_{Corr} [mV]	i_{Corr} [$\mu A.cm^{-2}$]	v_{Corr} [$\mu m.y^{-1}$]
BM	-604 ± 10	20.3 ± 1.5	472 ± 21
WM	-645 ± 13	14.1 ± 1.9	325 ± 18
BM + MnP	-592 ± 12	0.086 ± 0.003	1.95 ± 0.1
WM + MnP	-603 ± 10	0.099 ± 0.005	2.29 ± 0.2

Tab. 2 Electrochemical characteristics of S355J2 steel

The difference between corrosion properties of the surface with and without phosphate layer is mainly in i_{Corr} and v_{Corr} values as the corrosion potential (-592 mV resp. -603 mV) of the phosphate layer is similar to values of BM (-604 mV) This means, that forming a phosphate layer results in increase of corrosion resistance through a reduction of the corrosion current density from 20.3 $\mu A.cm^{-2}$ resp. 14.1 $\mu A.cm^{-2}$ to 0.086 $\mu A.cm^{-2}$ resp. 0.099 $\mu A.cm^{-2}$ and corrosion rate from 472 $\mu m.y^{-1}$ resp. 325 $\mu m.y^{-1}$ to 1.95 $\mu m.y^{-1}$ resp. 2.29 $\mu m.y^{-1}$.

4. Conclusions

The present work describes the influence of surface treatment by phosphating on corrosion properties of S355J2 steel and welded SAW joint in 0.1M Na_2SO_4 solution. It may be concluded:

✓ Tested base material (S355J2 steel) has higher thermodynamic stability than weld metal, which shows higher kinetic stability in 0.1M Na_2SO_4.
✓ Corrosion resistance of BM and WM after phosphating is very similar.
✓ Increased corrosion resistance of phosphate surfaces is reached kinetically by reducing values of i_{Corr} and v_{Corr}.

Acknowledgements

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