

Surface Roughness Effect in the Case of Welded Stainless Steel Corrosion Resistance

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Abstract

It is known that fusion welding can cause a decrease in the corrosion resistance of the heat affected zone of unstabilized stainless steels. The reason for this problem is that the welding heat (in the heat affected zone (HAZ)) can cause chromium-carbide (Cr₂₃C₆) precipitation with the simultaneous reduction of chromium content at the local grain boundaries. The chromium content dictates the corrosion resistance level. The relationship between surface roughness and corrosion behaviour is well known. We sought to find the difference between the corrosion resistance and surface roughness relationship in the case of cold rolled stainless steel and in the case of heat treated (welding heat effect simulated) stainless steel [1-3].

Keywords: *corrosion, precipitation, corrosion resistance, surface roughness, heat affected zone (HAZ).*

1. Introduction

Stainless steels are very useful and popular in the industrial and civil engineering fields. There is a wide variety of stainless steels each having different properties and chemical composition. The austenitic stainless steels, due to their chemical composition, have high ductility and high corrosion resistance. Heat can cause some precipitation in the micro-structure, and this decreases the corrosion resistance level [4, 5].

The effects of surface roughness on the behaviour of steel in the presence of corrosion is well understood: Corrosion is more aggressive in the case of the high surface roughness steels than in case of those with low roughness [6, 7]. Due to chemical composition, the cold rolling of steel sheets creates a thin corrosion-resistant passive layer. For aesthetic purposes, the building industry often requires grinding of the steel surface. This gives a nice finish to the sheet's surface. However, it also decreases the corrosion resistance as the protective layer is removed and the surface roughness changes.

Theoretically, the resistance layer renews rapidly on the surface of stainless steels, but this

process is inhibited by the grinding process, causing the corrosion resistance to decrease [8].

2. The experimented steel

2.1. Austenitic stainless steel (1.4307)

The chemical composition of the used austenitic steel is shown in **Table 1**. High carbon affinity elements (eg. Ti, Ta, Nb) are not found in this chemical composition and the carbon content is low.

The level of corrosion resistance of this steel is very high. The pitting resistance equivalent numbers (PREN) are calculated by the following most common equation, with the element weight as a percentage.

$$PREN = Cr + 3.3 Mo + 16 N \quad (1)$$

$$PREN = 19.74 \quad (2)$$

2.2. Surface preparation

The tested sample surfaces were cleaned and ground according to grain size and the same chemical composition (Al₂O₃) of the grinding

Table 1. The used steel chemical composition in weight percentage (the rest is iron) (%)

C	Mn	S	P
0.026	1.71	0.004	0.004
Si	Ni	Cr	N
0.23	8.15	18.3	0.09

papers. The used paper parameters are shown in the **Table 2**. The grinding process created different surface roughness in the case of the tested samples. The surface roughness (Ra) of the samples was different, results shown in **Table 2**.

2.3. Heat treating

In the case of stainless steels, the fusion welding process is a very common joining technology. Fusion welding technology produces a high heat effect during the joining process, which can change the microstructure in the heat affected zone (HAZ). We heated all samples for one hour at 800 °C and cooling was by air. .

Table 2. The used grinding paper parameters and the surface roughness of the ground sheets

	1	2	5	6
Grinding Paper	P120	P180	P320	P400
Surface roughness Ra (µm)	2.353	1.412	0.677	0.54

3. Corrosion tests

The surface roughness and heat caused changes in both microstructure and corrosion resistance. This process was modelled by laboratory experiments [9–11]. The tested samples were treated in FeIII Cl solution (ASTM A 262), for 96 hours at 30 °C. Under this load, the sheets showed a weight loss that is measurable with analytical scales [12]. The measured weight loss volumes (g) are shown in the **Table 3**.

Tested samples were examined by microscopy and the results are shown in **Figure 1-4**. On the surface we detected pitting corrosion phenomena through visual testing, we used stereo microscopy, (100x magnification **Figure 1-4**) the figures show a 10x10mm area of the test samples.

We detected that in the case of the tested samples the unsuitable surface roughness caused reduced corrosion resistance. In the case of the heat treated samples, the heat treatment decreased

corrosion resistance. (**Figures 1–4**) show the heat treated different surface roughness samples after corrosion tests. The corrosion was recognizable by visual testing and measurable by weight loss control.

4. Conclusions

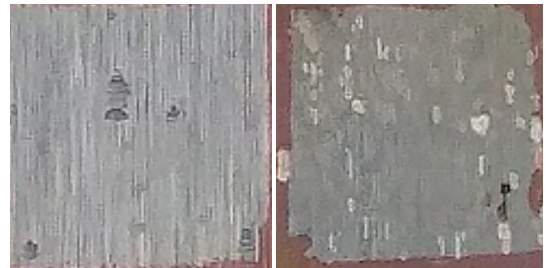
We have concluded on basis of our experimental results that the corrosion resistance of the ground surface samples was lower than that of the cold rolled samples.

We also concluded that the corrosion weight loss in case of the heat treated samples was higher than in case of the others.

- I. We found a relationship between surface roughness and weight loss in the tested samples.
- II. Heat treating caused the decreasing of corrosion resistance.

Table 3. Weight loss of the tested samples

Number	Without heat treating	Heat treated
1	0.4217 g	0.9608 g
2	0.4005 g	1.2904 g
5	0.4468 g	1.0636 g
6	0.561 g	1.7667 g

**Figure 1.** N. 1. samples: a) without heat treating, b) heat treated**Figure 2.** N. 2. samples: a) without heat treating, b) heat treated

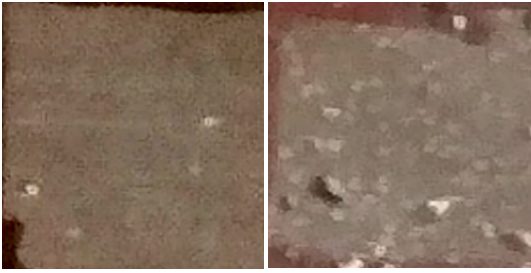


Figure 3. N. 5. samples: a) without heat treating, b) heat treated

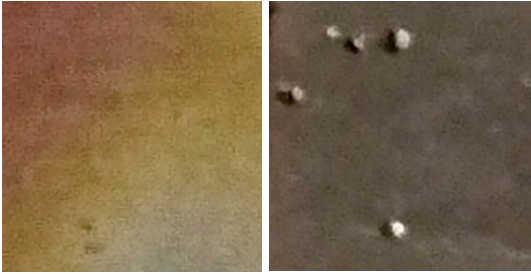


Figure 4. N. 6. samples: a) without heat treating, b) heat treated

III. We detected that in the case of the stainless steel samples, surface grinding negatively affects corrosion resistance. Between surface roughness and corrosion resistance, we found a measurable correlation in the case of the tested samples.

IV. We carried out our test immediately after surface grinding and consequently, the protective surface layer was not able to re-cover in this short time. We assume that after surface grinding the protective layer can renew but requires a longer time.

These results are very important and therefore further research is needed in order to better understand the surface properties of stainless steels.

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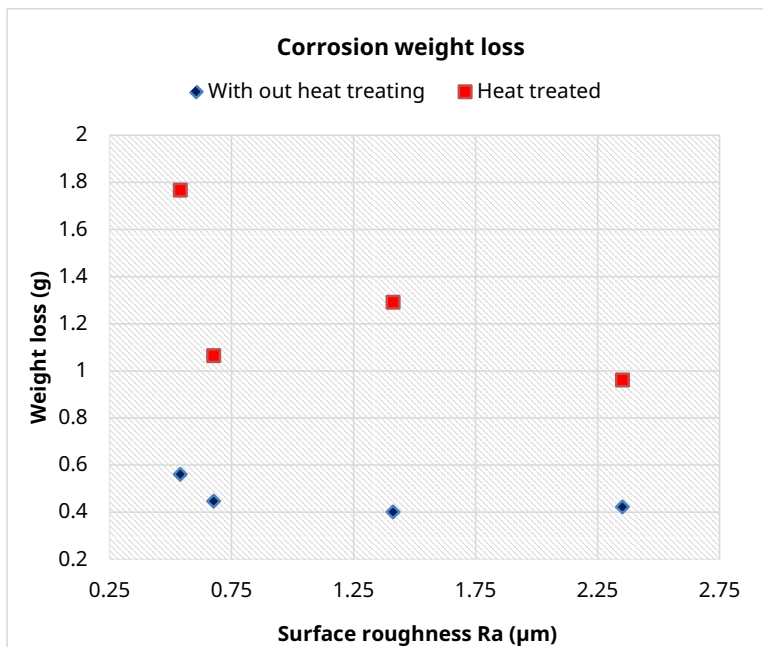


Figure 5. Corrosion effected weight loss in the case of heat treated and non-heat treated samples

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In September 2023, the prefixes were corrected in all articles on the websites of the journal issues:

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