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HEAT TREATMENT EFFECT FOR STAINLESS STEEL CORROSION RESISTANCE

László TÓTH[1], Ferenc HARASZTI[2], Tünde KOVÁCS[1]

[1]Óbuda University, Bánki Donát Faculty of Mechanical and Safety Engineering, Material Science Department, 1081, Hungary, Budapest, Népszínház, 8
[2] Óbuda University, Bánki Donát Faculty of Mechanical and Safety Engineering, Doctoral School of Safety and Security Science, Népszínház u.8. Budapest H1081, Hungary

Abstract

Corrosion is a real risk of the steel constructions because this phenomenon cause mass loss. Some kind of the corrosion is well monitorable but others are difficult to detect. Known that the heat treatment caused microstructure changement can cause decreasing the corrosion resistance in case of unstabilized stainless steels. The reason of this problem, that the heat can cause chromium-carbide (Cr23C6) precipitation simultaneously with the reduction of the chromium content in the local grain boundaries. The chromium content ensures the corrosion resistance level. We wanted to find a relationship between the corrosion resistance and the heat treatment affected microstructural changement [1-3].

Keywords*: corrosion, precipitation, corrosion resistance, stainless steel*

Introduction

Corrosion cause real damage and risk in case of the steel constructions. The uniform corrosion is well monitorable, but it known other kind of the corrosion are (intercrystalline corrosion, knife line corrosion, pitting corrosion, stress corrosion (Fig. 1.)) more dangerous because increase without visible signs. The stainless steels are very useful and popular in the industrial and the building engi-neering. The stainless steels wide range well known (austenitic, ferritic, martensitic, duplex) which have many different chemical composition (almost high contain of chromium and nickel) and dif-ferent properties. The austenitic stainless steels have high ductility and high corrosion resistance properties what ensured by the chemical composition.

The steel sheets made by cold rolling while on the surface creating from the chemical composi-tion a thin corrosion resistant passive layer. The heat can cause the creation of some precipitation in the microstructure, which decrease the corrosion resistance level [4, 5].

Fig. 1. Local corrosion form on the surface of stainless steel

Corresponding author: kovacs.tunde@bgk.uni-obuda.hu

The experimented steel

The used austenitic steel (1.4307) chemical composition showed below (Tab. 1.). This kind of steel is without high carbon affinity elements (eg. Ti, Ta, Nb) contain, even that the carbon contain is low, that means the formation aptitude of the chromium carbide ($Cr_{23}C_6$) is low.

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

C	Mn	S	P	Si	Ni	Cr	N
0,026	1,71	0,004	0,004	0,23	8,15	18,3	0,09

The corrosion resistance depends on the chemical composition of the steel, in case of the tested stainless steel this level is very high. The pitting resistance equivalent number (PREN) calculated by the next most common equation (1), with the elements in weight percentage (%).

$$PREN=Cr+3,3\ Mo+16\ N \qquad (1)$$
$$PREN=19,74$$

Surface preparation

The tested samples surfaces were cleaned and grinded by grinding paper (Al_2O_3). The grinding process established different surface roughness in case of the tested samples surfaces. The average surface roughness of the samples was different, showed in the Table 2.

Table 2. The used grinding papers parameters and the surface roughness of the grinded sheets

Number of the sample	1	2	5	6
Surface roughness Ra (μm)	2,353	1,412	0,677	0,54

Heat treating of samples

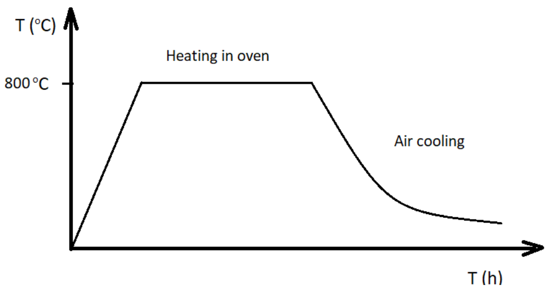

Fig. 2. Heat treatment of samples

Heating during one hour in 800 ºC temperature and cooling by air, the heat treatment t-T diagram shows by Fig. 2. In case of the used steel, the heat treatment can establish precipitations of $Cr_{23}C_6$. This form of carbide precipitation in the grain boundary affect, of the local chromium contain de-creasing between the crystals. Even that the corrosion resistance depend on the chromium contain this process cause a corrosion resistance decreasing.

Experiments

The surface roughness and the heat affected changement of the microstructure and the corrosion resistance. This process modelled by laboratory experiments [9 - 11]. We made corrosion resistance test on heat-treated samples and we tested without heat-affected samples too. The tested samples were trait in FeIIICl solution (ASTM G48), during 96 hours and on 30 ºC temperature. Under this loads the sheets are showed weight loss, what we could measure by analytical scales [12]. The measured weight loss volumes (g) showed in the Table 3.

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

Experimented samples tested by microscopy, the results showed on the Fig. 3-6. On the surface we detected pitting corrosion phenomenon by visual testing, we used stereo microscopy, (100x magni-fication Fig. 1-4.) the figures shows 10x10mm area of the experimented samples.

The Fig. 3-6 show well the tested samples. The unsuitable surface roughness caused reduced corrosion resistance. In case of the heat-treated samples, the heat-treating effected the corrosion resistance decreasing. The showed figures demonstrated the heat-treating effect and the surface rough-ness effect for the corrosion resistance.

a) without heat treating b) heat treated

Fig. 3. No. 1. samples

a) without heat treating b) heat treated

Fig. 4. No. 2. Samples

a) without heat treating b) heat treated

Fig. 5. No. 5. Samples

a) without heat treating *b) heat treated*

Fig. 6. No. 6. samples

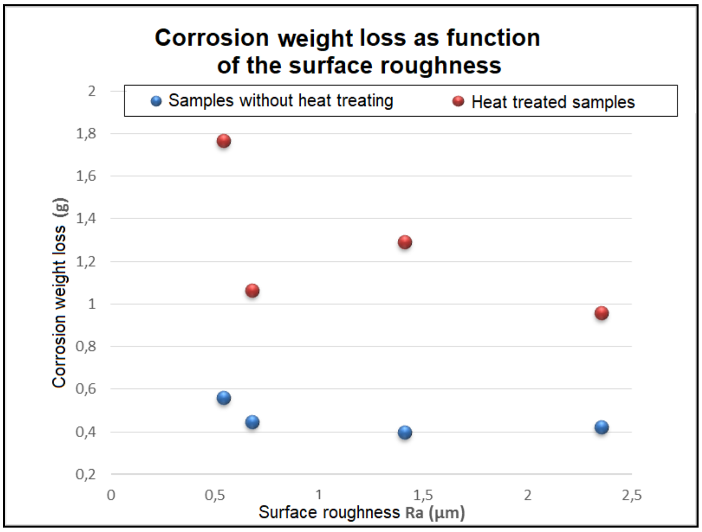

Fig. 7. Corrosion effected weight loss [12]

Conclusions

We concluded on base of our experimental results, which the grinded surfaced samples corro-sion weight loss was higher than in case of the cold rolled mean the corrosion resistance decreased as function of the heat affect and the surface roughness. Heat-treating affect decreasing of the corrosion resistance. The used heating treating process cause corrosion resistance changement. We can assume that the used heat temperature and the time of the heating is not fallowing in case of the tested steel grade.

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References

[1] F. Haraszti, T. Kovács: *Plastic deformation effect of the corrosion resistance in case of austenitic stainless steel*, **IOP Conference Series: Materials Science and Engineering 175**: Paper 012048. 4 2017.

[2] C.S. Tedmon et all.: *Intergranular corrosion of Austenitic stainless steel*, **Journal of the Electrochemical Society Vol.118 Issue 2.** 1971 pp. 192-202.

[3] Gy. Bagyinszki, E. Bitay: *Welding II. Instruments and tests. Vol.2.* **Műszaki Tudományos Füzetek 10**., EME, Cluj Napoca, 2010. ISSN 2068 – 3081, ISBN 978-606-8178-06-6, ISBN 978-606-8178-05-9, 286 pp. http://eda.eme.ro/handle/10598/15438.

[4] F. Haraszti: *The bases of corrosion's investigation* EME press, **Műszaki Tudományos Füzetek 21,** Cluj Napoca 2016 pp. 185-188.

[5] F. Haraszti: *Corrosion investigation of steel smaples* EME press, **Műszaki Tudományos Füzetek 21,** Cluj Napoca 2016 pp. 189-192.

[6] T. Kovács, L. Kuzsella: *High Energy Rate Forming Induced Phase Transition in Austenitic Steel*, **Journal of Physics Conference-Series 790**: Paper 012039. 5 2017

[7] Á. Szigeti, T. Kovács-C.: *Manufacturing Design for High Temperature Working Spring in Corrosive Midium*, **Műszaki Tudományos Füzetek 21**: 2016 pp. 377-380.

[8] M. Dománkova, E Kocsisová, I. Slatkovský, P. Pinke; *The Microstructure Evolution and Its Effect on Corrosion Properties of 18Cr-12Ni-2,5Mo Steel Annealed at 500-900°C*, **Acta Polytechnica Hungarica,** 11(3) 2014. pp. 125-137.

[9] Z. Nyikes, Z. Rajnai: *Big Data, As part of the Critical Infrastructure*, SYSY 2015. **IEEE 13th International Symposium on Intelligent System and Informatics: Proceedings**, pp. 217-222.

[10] Reti T, Kovacs T: *A phenomenological method for the prediction of damage accumulation processes under varying external conditions* In: Materials Science Forum, 414-415, 2003, pp. 317-322.

[11] L. Tóth, F.Haraszti, T.Kovács: *Surface roughness effect in case of welded stainless steel corrosion resistance*, **Acta Materialia Transylvanica** 1 2018 (under pressing).

[12] ASTM Standard Practice in A 262 for Detecting Susceptibility to Intergranular Corrosion in Austenitic Stainless Steels, **ASTM Standard.**

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