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BEHAVIOR OF SOME STAINLESS NITRIDED AUSTENITE STEEL TYPES TO CORROSION AND ABRASION

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ABSTRACT

By nitriding, stainless austenite steel types can become surface hardened. Hardness can be greater at more than 1000 HV_{005} when the composition layer made of complex nitrides is obtained and more reduced till 500 HV_{005} when a diffusion layer made of highly alloyed austenite including nitrogen is obtained. The tests in salt fog for resistance to corrosion show a decrease of this resistance to corrosion from Perfectly resistant materials (appreciation mark 1.1) to Very resistant materials (appreciation mark 2.1 or 2.2), for the nitrided steel types which form complex nitrides layers and which can keep the resistance to corrosion in the group of perfectly resistant materials or an insignificant decrease for the steel type that forms a diffusion layer. The tests for resistance to abrasion show a decrease of two or three times for mass losses this meaning a significant increase in resistance. This is as important as surface treatment and thickness of nitrided layer are bigger. The steel, the surface treatment, so the type of diffusion surface layer with austenite structure or the combinations with nitrides complex separations will be chosen depending on aggressive factors weight for corrosion and abrasion of the environment in which the product is working.

KEYWORTS :stainless steel, austenite, nitriding process, corrosion, abrasion.

1. Introduction

Stainless austenite steel types are very resistant to corrosion but less resistant to abrasion due to depressed hardness, below 200 daN/mm^2. An increase in surface hardness and implicitly in resistance to abrasion is possible through nitriding process. For this purpose some samples from plates of 60x20x3, from 6 characteristic stainless steel types with low carbon content, with higher carbon content stabilized or not by titanium, have been subjected to fluidized bed nitriding process. The identification marks and chemical composition of these steel types are presented in table 1.

Table 1

Steel code	Related mark	C	S	P	Mn	Si	Cu	Cr	Ni	Mo	Ti	V
		[%]										
1	X10CrNil8.8	0.12	0.028	0.055	1.24	1.64	0.06	23.2	9.8	0.11	0.01	0.02
2	X6CrNiTil8.10	0.06	0.008	0.036	1.55	0.65	0.08	17.1	9.3	0.05	0.60	
3	X2CrNil8.9	0.03	0.005	0.028	1.27	0.42	0.19	18.9	8.95	0.15	0.01	0.02
4	X2CrNiMol7.11.2	0.02	0.005	0.039	2.06	0.78	0.27	20.0	8.8	2.7	0.03	0.03
5	X6CrNiMoTil7.12.2	0.045	0.012	0.031	0.96	0.54	0.16	18.1	11.6	2.04	0.32	
6	X1CrNiMoCu20.18.7	0.02	0.008	0.027	1.12	0.41	0.70	20.1	18.1	6.1		0.2

2. Experiments and results

In order to estimate the resistance to corrosion, the accelerated corrosion test in salt fog STAS 9229 per 1995 was made. Estimation of behavior to corrosion was made by comparing the samples from initial materials and nitrided samples.

The test was carried out for 300 hours weighing the samples every 100 hours in order to point out the process dynamics.

The values of mass losses resulted after weighing as well as corrosion average speed are shown in table 2.

Table 2

Steel code	Mass loss after 100h	Mass loss after 200h	Mass loss after 300h	Corrosion average speed
	[g]			[g/m^{2}h]
Materials in initial form(quenching for adding in to solution)				
1	0.00053	0.00093	0.00133	0.0016
2	0.00070	0.00133	0.00183	0.0024
3	0.00063	0.00126	0.00186	0.0026
4	0.00043	0.00083	0.00123	0.0015
5	0.00046	0.00080	0.00120	0.0016
6	0.00021	0.00044	0.00072	0.0009
Fluidized bed nitrided materials				
1	0.00263	0.00467	0.00570	0.0075
2	0.00384	0.00648	0.00778	0.0105
3	0.00416	0.00796	0.00989	0.0128
4	0.00343	0.00601	0.00858	0.0114
5	0.00483	0.00904	0.01186	0.0152
6	0.00033	0.00064	0.00086	0.0012

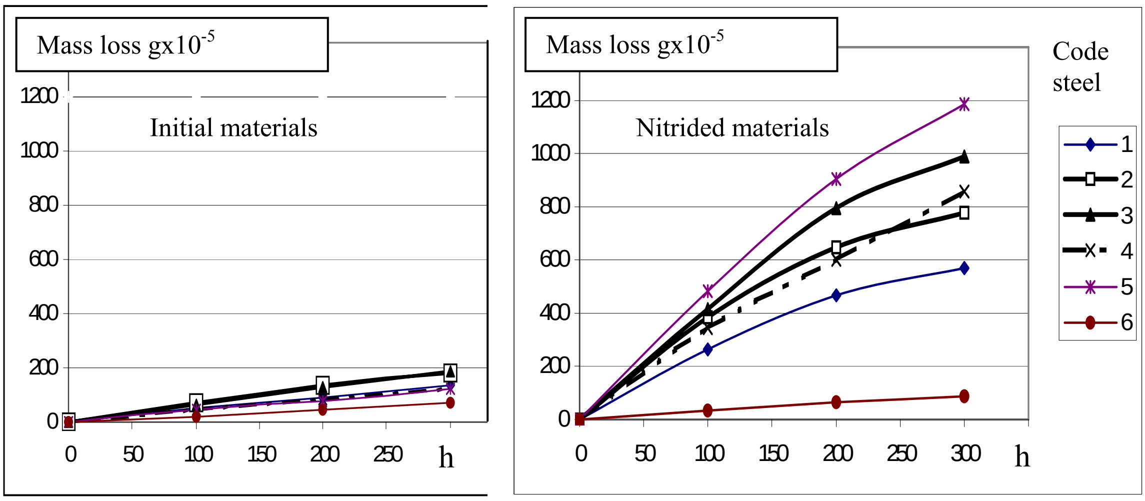

***Fig.1.** Time variation of mass losses for initial and nitrided materials*

The diagrams in fig. 1 present the time variation of mass losses for all the 6 steel types which have been analyzed both for initial materials and for nitrided ones.

The analysis of these diagrams points out that the corrosion phenomenon is more acute for nitrided materials compared to initial materials. This can be explained by the fact that the single-phase austenite structure of initial materials is more stable than any other multi-phase structure. As a result of nitridind process, the hard layer which is formed presents important separations of iron nitrides and chrome from austenite.

The two types of phase have different corrosion potentials and form micro-piles that accelerate the general corrosion process.

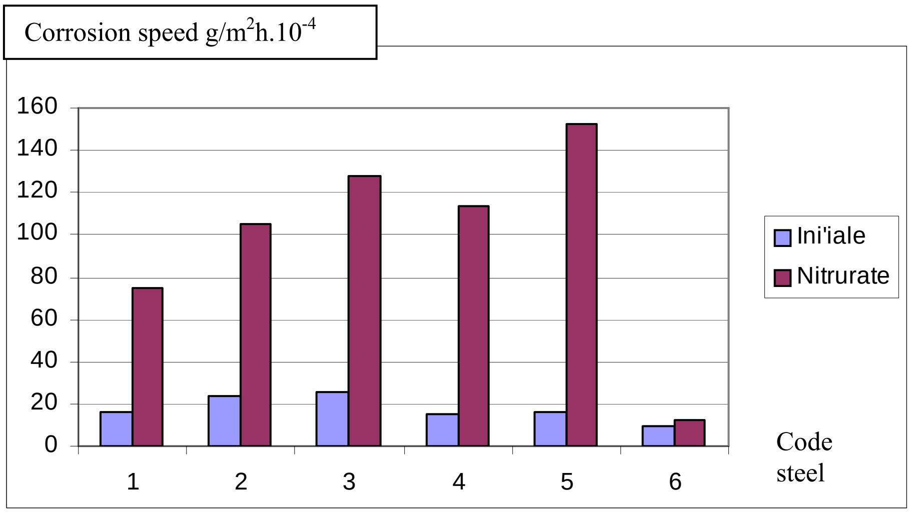

Fig.2. *Average corrosion speeds for initial and nitrided materials.*

Figure 2 presents the corrosion average speed for the 6 materials in initial and nitrided status that were calculated during the testing cycle of 300 hours.

In order to group the steel types which have been analyzed into classes adequate to general corrosion resistance, table 3 presents the provisions in STAS 6855 per 1978 regarding this subject.

Table 3

Class	Corrosion speed		Appreciation mark	
	[mm/year]	[g/m^{2}h]		
1	<0.001	<0.0009	1.1	Perfectly resistant
2	0.001-0.005	0.0009-0.0045	1.2	Perfectly resistant
3	0.005-0.01	0.0045-0.009	2.1	Very resistant
4	0.01-0.05	0.009-0.045	2.2	Very resistant
5	0.05-0.1	0.045-0.09	3.1	Resistant
6	0.1-0.5	0.09-0.45	3.2	Resistant
7	0.5-1.0	0.45-0.9	4.1	Decreased resistance
8	1.0-5.0	0.9-4.5	4.2	Decreased resistance
9	5.0-10	4.5-9	5	Low resistance
10	>10	>9	6	Non-resistant

Table 4

Steel code	Corrosion speed after l00 h	Corrosion speed after 200 h	Corrosion speed after 300 h
	[g/m^{2}h]		
Fluidized bed nitrided materials			
1	0.0104	0.0081	0.0040
2	0.0158	0.0107	0.0051
3	0.0167	0.0141	0.0078
4	0.0136	0.0102	0.0098
5	0.0187	0.0159	0.0109
6	0.0014	0.0012	0.0009

Comparing the data we obtained with the STAS ones, it is estimated that all samples from initial status steel types are included in the class of perfectly resistant materials respectively steel type code 6 in the 1st class (appreciation mark 1.1) and the other steel types code 1, 2, 3, 4, 5 in the 2nd class (appreciation mark 1.2).

The tests on nitrided samples indicate a decrease of the resistance to corrosion more clear for steel types code 1, 2, 3, 4, 5 which are enclosed in the class of very resistant materials respectively steel type code 1 in class 3 (appreciation mark 2.1) and the others in class 4 (appreciation mark 2.2) Steel type code 6 contains more than 50% alloying elements Cr, Ni, and Mo for which the nitrided layer was enriched with nitrogen without changing its austenite structure. Although it presents a slight reduction of resistance to corrosion it remains in the class of perfectly resistant materials but in class 2, having an appreciation mark of 1.2.

Also, from the analysis of data achieved after corrosion test resulted that corrosion speed for nitrided samples decreases in time. The data is given in table 4.Decreasing of corrosion speed is explained by depth variation of the layer, of nitrogen quantity separated from the base austenite mass. As a result of corrosion, the surface layer becomes thinner and deeper layers with less nitride separations are being exposed to corrosion effect till the layer is completely corroded. This way you can reach the base austenite material more or less sensitized by the heating process during nitriding.

Figure. 3 presents the speed variation to corrosion, in time.

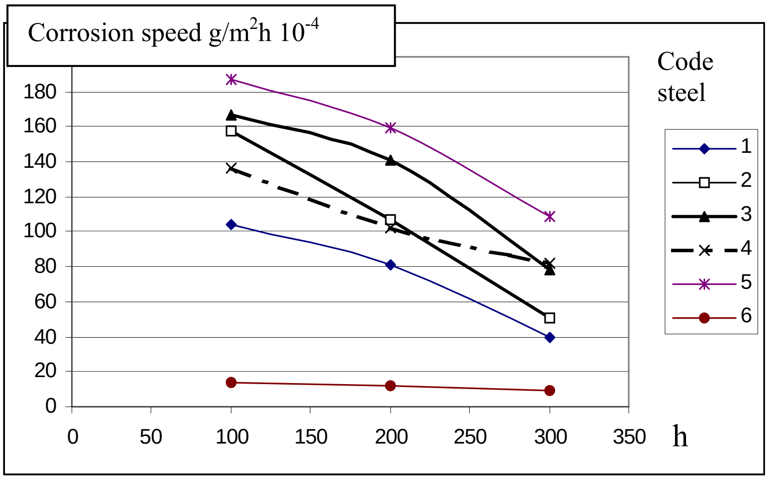

Fig.3. *Variation of corrosion speed in time.*

In order to point out the resistance to wear, samples from initial and from nitrided materials with the section of 50 mm^2 have been subjected to abrasive test STAS 9639 per 1981 using the abrasion coupling represented by the sample and a rotary disk with abrasive paper with a granulation point of 800.

The effective parameters of the test were: disk rotation 25 rot/min.; sample radial advance 0.5 mm/rot.; sample pressure 1 daN/cm^2 ; average sliding speed 10m/min.; distance length 25 m.

The results of abrasive test are shown in table 5.

Table 5

Steel code	S index	Initial materials		Nitrided materials		
		HV$_{005}$ Hardness	Abrasive wear	Layer depth	HV$_{005}$ Hardness	Abrasive wear
		[daN/mm^2]	[g]	[μm]	[daN/mm^2]	[g]
1	24	198	0.0066	21	1310-500	0.0027
2	19	202	0.0065	37	1180-500	0.0015
3	17.5	188	0.0065	38	1315-500	0.0015
4	21.6	180	0.0069	33	1320-500	0.0022
5	22.6	204	0.0064	32	1170-500	0.0023
6	29.8	182	0.0071	35^s	508-500	0.0036

The analysis of these results shows a decrease in mass losses through abrasion and consequently, an increase of 2 or 3 times at resistance to wear in the case of nitrided samples. The increase depends on hardness and it is bigger for steel types code 1, 2, 3, 4, 5 which, as a result of the treatment, has formed a hard nitrided layer of more than 1000 HV_{005} and smaller for steel type code 6 which is approx. 500 HV_{005} hard. Also, the increase depends on layer thickness and hardness variation in the nitrided, hard layer.

Thus, the resistance to wear of steel type code 1 is smaller than that of steel types code 2, 3, 4, 5. Also for steel type code 1 the layer is harder because the thickness is smaller and hardness decreases more abrupt.

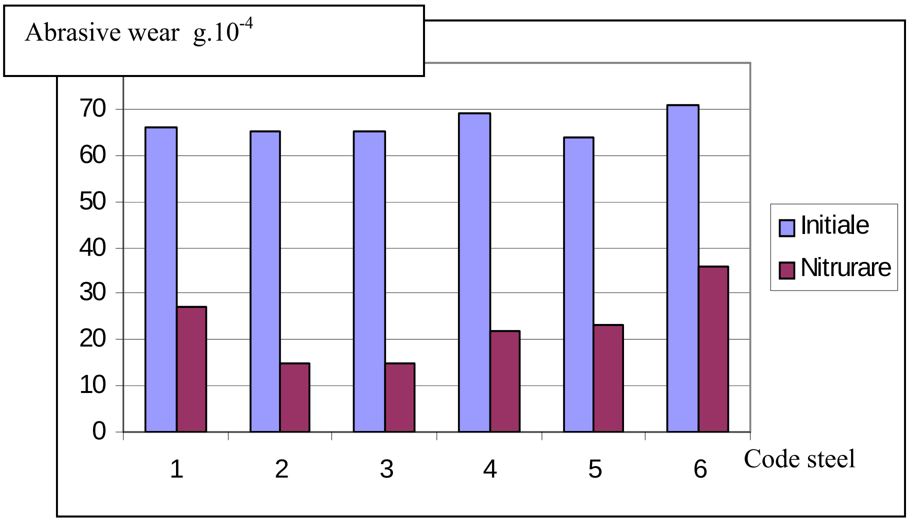

Fig. 4 presents a comparison between the abrasion wear in initial and nitrided status, pointing out the strict decrease of mass losses for nitrided samples against the initial ones.

3. Conclusions

Researches on nitrided samples indicate a decrease of resistance to corrosion, more clear for steel types code 1, 2, 3, 4, 5 which are enclosed in the class of very resistant materials respectively steel type code 1 in class 3 (appreciation mark 2.1) and the others in class 4 (appreciation mark 2.2) The steel type code 6 contains more than 50% alloying elements Cr, Ni, and Mo for which the nitrided layer was enriched with nitrogen without changing its austenite structure. Although it presents a slight decrease in resistance to corrosion, it remains in the class of perfectly resistant materials but in the 2nd class (appreciation mark 1.2). The results of tests for abrasive wear show a decrease of mass losses and, consequently, an increase of 2, 3 times in resistance to wear in the case of nitrided samples. The increase depends on hardness. It is bigger for steel types code 1, 2, 3, 4, 5 which after the treatment have a hard nitrided layer of more than l000 HV_{005} and smaller for steel type code 6 for which the hardness was approx. 500 HV_{005}- The increase depends also on the thickness of the layer and hardness variation in the nitrided layer. This way, the resistance to wear of steel type code 1 is smaller than of steel types code 2, 3, 4, 5. The layer hardness is bigger. This is explained by the fact that layer thickness is smaller and hardness decrease more abrupt. The steel type, the surface treatment and though the type of diffusion surface layer with austenite structure or the combinations with nitrides complex separations will be chosen depending on the weighing of corrosion aggressive factors, respectively on abrasion.

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