ASPECTS OF NITRATED LAYER STRUCTURE FOR SOME TYPES OF AUSTENITE STAINLESS STEEL

Ovidiu DIMA, Sanda LEVCOVICI,
Constantin GHEORGHIES
"Dunarea de Jos" University Galati
e-mail: dima.ovidiu@ugal.ro

ABSTRACT

The analysis of nitrated layer diffractograms and the structure marked out the presence of complex nitrides combinations layer for all types of steel except for code 6 steel type 2CuMoNiCr200 which because of the very high index of austenite stability, 29.9, presented a layer made of nitrogen solid connate solution in austenite. In the case of stainless austenite steel types nitrogen diffusion and, consequently nitrated layer formation depends on the concentration of alloying elements in steel, on austenite stability indices. Code 2 and code 3 steel types that have the smallest stability indices have the thickest layer and are followed by code 3 and code 4 steel types. On the fifth place is code 1 steel type which has a thinner layer, approx. 21 jam and on the last place there is code 6 steel type that, as it was shown, does not form a nitrides layer.

KEYWORDS: austenite, stainless steel, nitrated, structure

1. Introduction

In order to point out the nitration behavior of stainless steel, a number of six characteristic steel types CrNi, CrNiMo with low and higher carbon content, titanium stabilized or not, was chosen. The steel types have been subjected to fluidized bed thermo chemical nitration treatment for 1, 2, 3 hours, at a temperature of 550 ^oC so as to marl-out the process dynamics. The treatment has been applied in order to increase surface hardness and implicitly materials resistance to abrasion.

2. Materials studied

The materials that have been studied were plates made from stainless austenite steel Cr-Ni and Cr-Ni-Mo with low carbon content %C<0.03, with higher carbon content %C=max. 0.12 but also steel types with higher carbon content and stabilized with Ti or Nb. The chemical composition of these steel types is presented in table 1.

Table 1

Steel code	Related mark	%C	%S	%P	% Mn	% Si	%Cu	%Cr	%Ni	% Mo	% Ti	% V
1	12NiCrl80	0.12	0.028	0.055	1.24	1.64	0.06	23.2	9.8	0.11	0.01	0.02
2	10TiNiCrl80	0.06	0.008	0.036	1.55	0.65	0.08	17.1	9.3	0.05	0.60	
3	2NiCrl85	0.03	0.005	0.028	1.27	0.42	0.19	18.9	8.95	0.15	0.01	0.02
4	2MoNiCrl75	0.02	0.005	0.039	2.06	0.78	0.27	20.0	8.8	2.7	0.03	0.03
5	10TiMoNiCrl75	0.045	0.012	0.031	0.96	0.54	0.16	18.1	11.6	2.04	0.32	
6	2CuMoNiCr200	0.02	0.008	0.027	1.12	0.41	0.70	20.1	18.1	6.1		0.2

In order to point out process dynamics samples of 60x20x3 have been made from plates and then subjected to fluidizing bed thermo-chemical nitration treatment for 1, 2, 3 hours, at a temperature of 550°C. The treatment has been made in order to increase surface hardness and implicitly the resistance of materials to abrasion.

Metallographic samples which have been subjected to grinding, polishing and electrochemical attack so as to show the structure by optical microscopy were cut off from nitrated samples by means of the abrasive wheel and with abundant cooling.

2. Results

Structure analysis points out a nitrides surface which has a distinct aspect and is separated from the base austenite structure by a buffer zone, more or less thick, made of a mechanical mixture of austenite and complex nitrides. Electrolytic attack in nitric acid - 50% is more emphasized on the layer and on the buffer line and more reduced upon the matrix. The layer presents a poly-phase structure. Nitrogen diffusion determines the separation between complex nitrides and iron and all other steel alloying elements. This justifies the increase in hardness. After one hour of treatment the layer is thin and even discontinuous if we speak about steel type code 3. For steel types code 1 and 6 a metallographic distinct metallographic aspect layer is not pointed out. The discontinuous aspect is explained by the fact that on the samples surface are shown areas with different degrees of absorption and diffusion.

The more active areas alternate with less active ones. The fact that for steel types code 1 and 6 there is no nitrides layer after the first hour of treatment is explained by the high stability of austenite.

For these steel types nitrogen diffuses in austenite structure, nitrogen concentration increases and this is completely diluted.

The metallographic analysis can point out only nitrides, the combinations layer resulted after nitration treatment but not the diffusion and dilution layer. After two hours of treatment the combinations layer is leveled and becomes more continuous and more uniform for the major part of the steel types except steel type code 1 for which the combinations layer is thin and discontinuous and code 6 which has no combinations layer.

After three hours of treatment the combinations layer is pointed out for all steel types, with great and uniform thickness exception is the steel type code 6 which presents small combinations areas of micro-metrical dimensions. Granulation of austenite grains within the combinations layer area as a result of nitrides chains that have been formed is expected to lead to some reduction of the resistance to corrosion.

In Figures 1 a, b, c, d, e, f we present the aspects of surface layer microstructures for all 6 steel types that have been analyzed in 3 nitration conditions of 1, 2 respectively 3 hours. The microstructures have been made at an increase of x400.

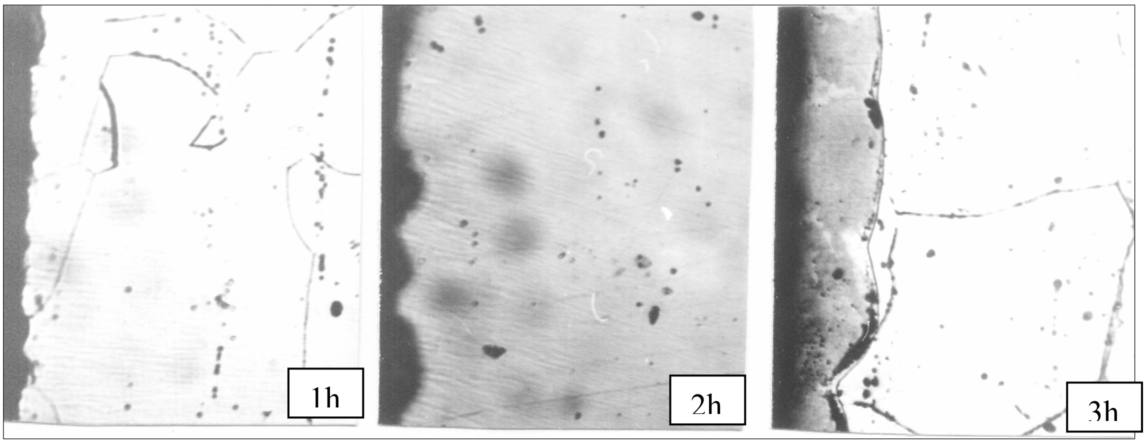

Fig.1a *Microstructures of nitrated samples code 1 steel type -12NiCr180*

The aspect of diffractograms for steel type code 6 is very likely to that of the initial samples of stainless austenite steel types. Its analysis points out some bits that correspond to diffraction angles which are determined by the presence of gamma phase Fe_γ inside nitrated layer's structure. For nitrated stainless austenite steel types gamma phase is solid connate nitrogen in the austenite structure highly alloyed with chrome, nickel, and molybdenum.

As it was told above, steel type code 6 has a content of more than 50% alloying elements, a high index of austenite stability S-29.8 and, when nitrated, nitrogen is diluted in austenite without causing nitrides separations. But austenite enrichment with nitrogen determines a smaller increase in hardness. Hardness maximum value is 508 HV_{005}

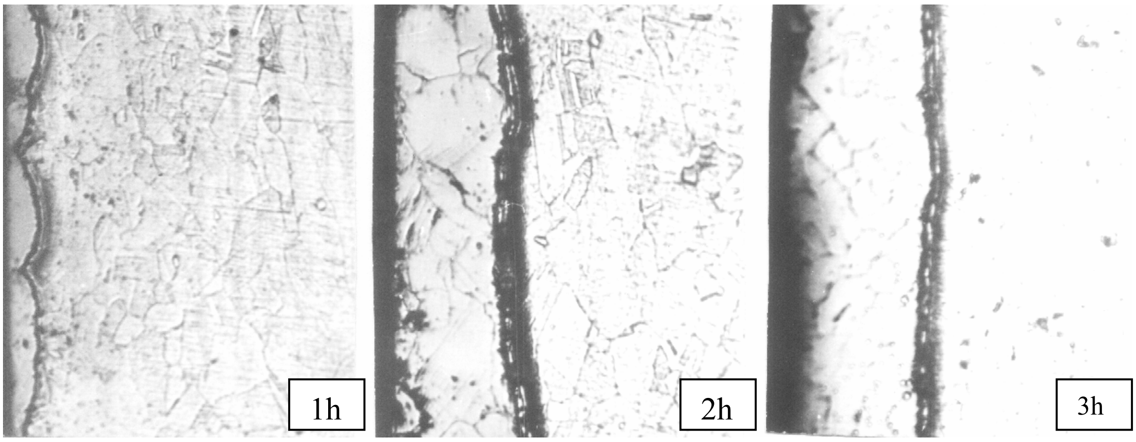

Fig.1b. *Microstructures of nitrated samples code 2 steel type –10TiNiCr180.*

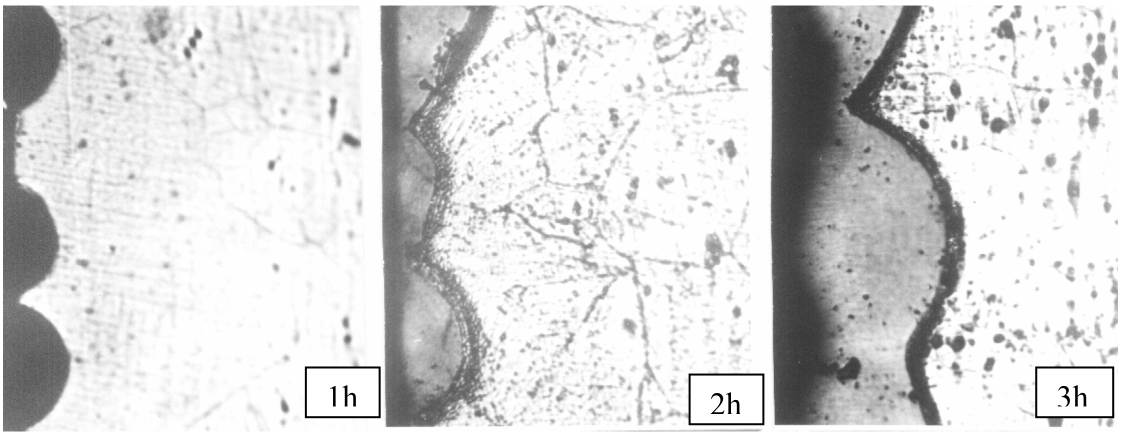

Fig.1c. *Microstructures of nitrated samples code 3 steel type -2NiCr185.*

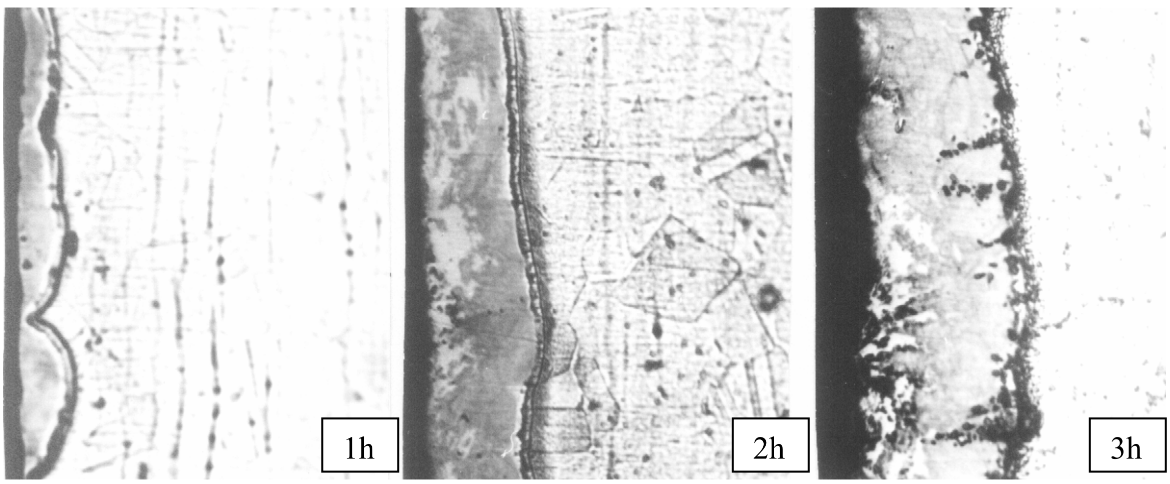

Fig.1d. *Microstructures of nitrated samples code 4 steel type –2MoNiCr175.*

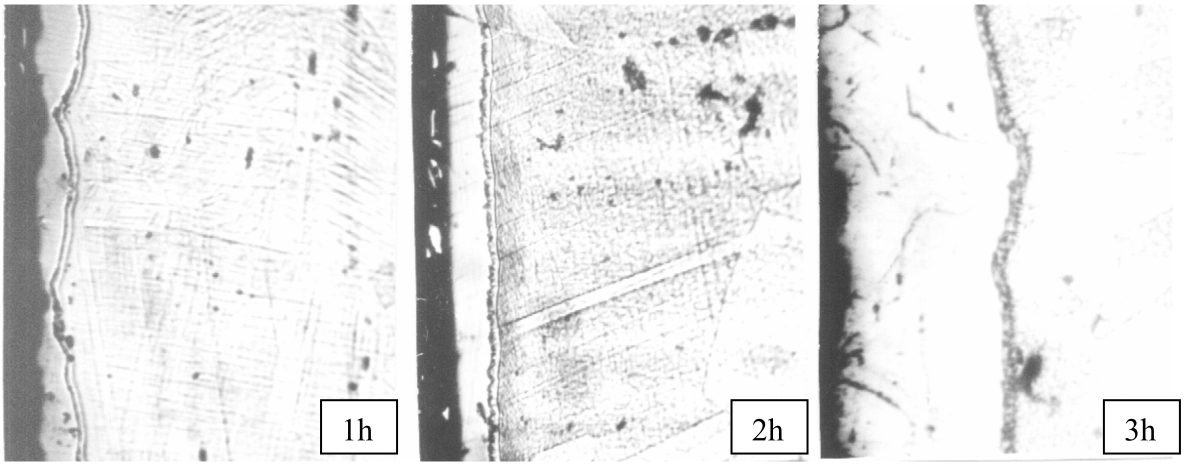

Fig.1e. *Microstructures of nitrated samples code 5 steel type –10TiMoNiCr175.*

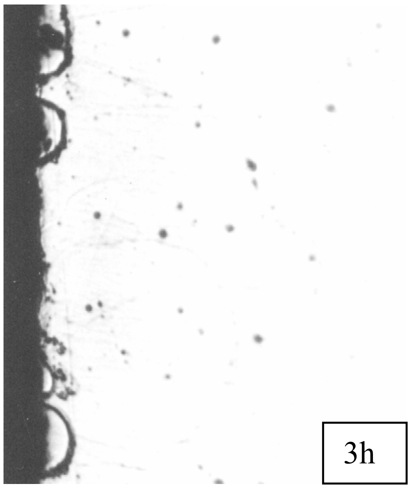

Fig.1f. *Microstructures of nitrated samples code 6 steel type –2CuMoNiCr200.*

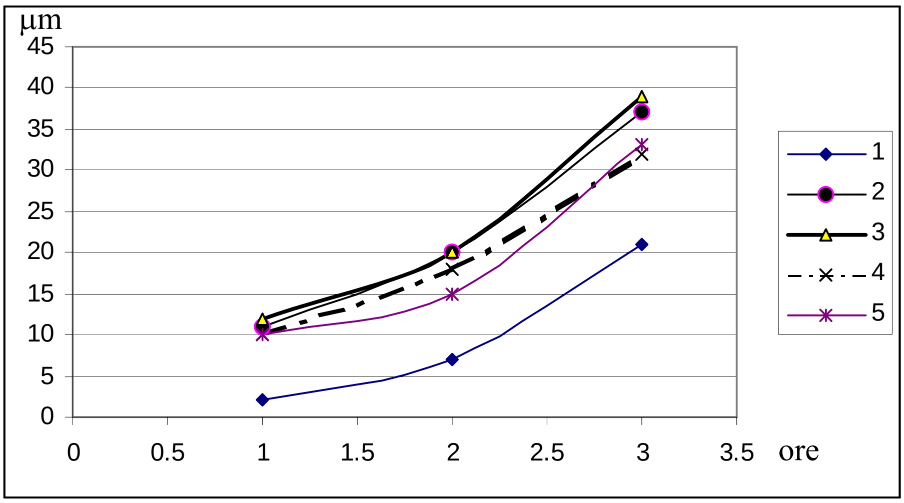

Fig.2. *Variation in thickness of nitrated layer and the duration of nitration process.*

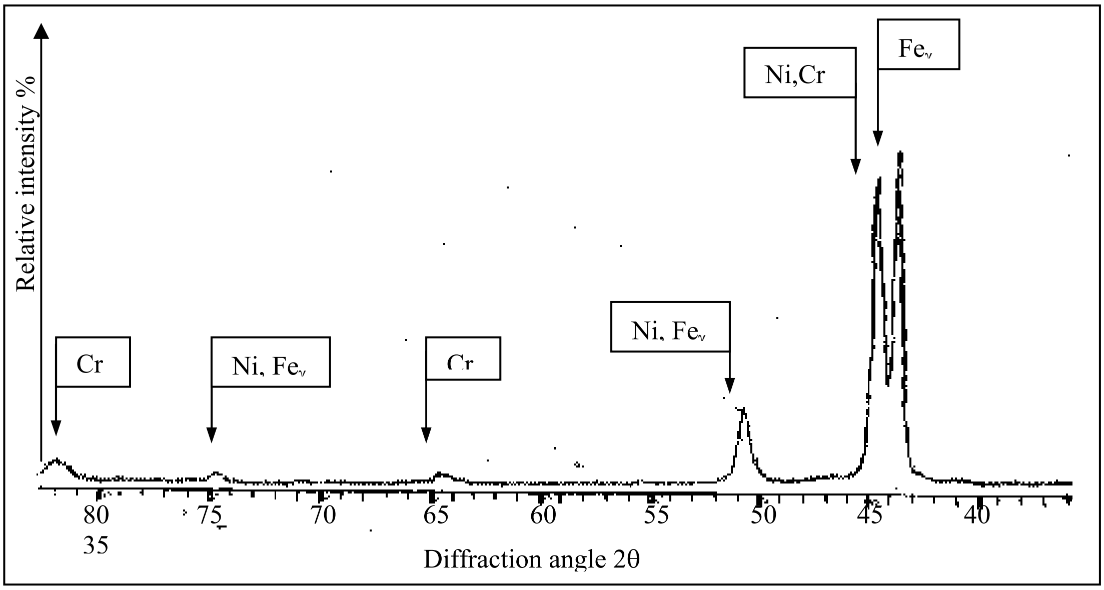

Fig.3. *Diffractograms for sample 6 stel type –2CuMoNiCr200.*

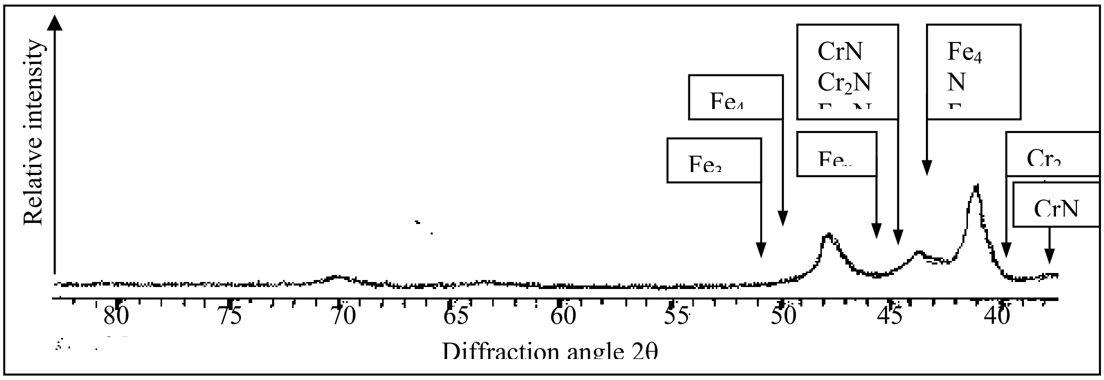

Fig.4 *Diffractograms for sample 2 stel type –10TiNiCr180*

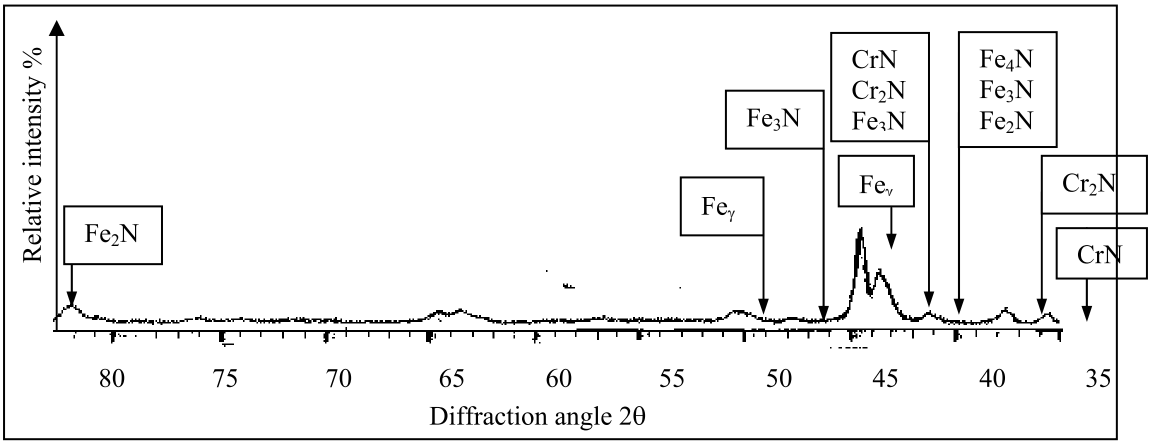

Fig.5 *Diffractograms for sample 4 stel type –2MoNiCr175*

Diffractograms analysis for steel type code 2 10TiNiCrl80 indicate the presence of bits that correspond to iron nitrides Fe_2N, Fe_3N, Fe_4N, presence of chrome nitrides CrN, Cr_2N and less for gamma phase Fe_γ. The presence of nitrides and solid solutions in austenite determines a strong increase of hardness for values that can be more than 1000 HV_{005}

Diffractograms aspect is almost the same for the first 5 steel types but with the remark that bits intensity corresponding to gamma phase has a bigger or smaller value, depending on its stability degree.

Fig. 5 presents the diffractograms for steel type code 4 2MoNiCrl75, the austenite stability index being bigger if compared to steel type code 2.

It is also noticed that relative intensity of gamma phase bits is greater.

3. Conclusions

Nitrogen diffusion and, in consequence, nitrated layer forming for stainless austenite steel depends on the concentration of steel alloying elements, of austenite stability indices.

Steel types code 2 and code 3 have the smallest stability indices and the thicker layer, being followed by steel types code 3 and code 4.

On the 5th place there is steel type code 1 having a very thin layer, approx. 21um and on the last place is steel type code 6 that as we showed above does not form nitrides layers.

References

[1]. Truşculescu M. Ieremia A. *Oţeluri inoxidabile şi refractare* Ed.Facla Timişoara 1983

[2]. Cheşa I. s a *Alegerea şi utilizarea oţelurilor* Ed. Tehnică Buc. 1984

[3]. Dumitrescu T. *Tratamente termochimice* Ed. Universităţii din Galaţi 1980

[4]. Dobrovici S. *Cercetări privind tehnologia carbonitrurării în strat fluidizat aplicată oţelurilor*. Teză de doctorat Galaţi 1999.

[5]. Truşculescu M. *Oţeluri inoxidabile şi refractare.* Ed. FACLA Timişoara 1983.

[6]. Berns H. *Case hardening of stainless steel using nitrogen*. Ruhr University, Bochum, Germany 2002.

[7]. Berns H. *Solution nitriding of stainless steel for process engineering,* Mat.-wisws. u. Werkstofftech. 31/2000.

[8]. Mocanu D. R. *Încercarea materialelor*. Ed.Tehnică Buc. 1982.

[9]. Vellier M. *Solution apportees aux problemes de la corosion-abrasion par certaines aciers inoxydables austenitiques et austenito-feritiques.* Conference internationale des arts chimiques Paris 1976.

[10]. Dima O. Mitoşeriu O. Levcovici S. *Studiu asupra aspectelor de coroziune evidenţiate pe table şi îmbinări sudate din instalaţiile de fabricaţie a celulozei chimice prin procedeul sulfit din cadrul combinatelor CCH Zărneşti, CCH Letea Bacău, CCH Brăila*. Tehnologii Calitate Maşini şi Utilaje 36 Ed. Tehnică Buc.1999. Lucrările simpozionului Ecologie. Acoperiri metalice. Braşov 1999.

[11]. Dima O. *Surface hardening by nitration for some stainless austenite stainless steel type*. Galati 2006