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Some properties of stainless steels with chromized diffusion layers

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Materials used for constructions in food processing industry should meet mechanical specifications and sanitary requirements [4,5]. The most often used types of steel 304 and 316L have similar mechanical characteristics, but the corrosion resistance of 316L stainless steel is considerably better [6,7]. On the other side the price of that steel is twice higher than price of steel type 304. Mean directions of chemical modifications of surface layers were characterised in this paper. There was also presented effects of chromizing of steel type 304 in order to increasing erosion – corrosion resistance. Structures and types of precipitations in the surface layer and its influence on durability there were also analysed.

1. INTRODUCTION

The main aim of chromizing of machine elements for food processing is enlarge mechanical properties and corrosion – erosion resistance. Diffusion of atoms of different size from the matrix gives increasing of the strength. On the other side the corrosion resistance depends on the kind of diffusing element [1].

Perspective directions in chemical modification of stainless steels surface layer are nitriding, chromizing and titanizing. The nitriding process is well recognized [2]. Chromizing is a process, which is used primarily to increase the heat-resistance. The chromizing process, presented at this work, is a novelty in this filed. The Polish State Hygiene Institution doesn’t admit in food processing the use of elements with chromium galvanic layers. The process worked out by Authors creates a diffusion layer of chromium, which during next thermal treatment is joined in solid solution or creates some kinds of precipitations; it’s advantageous for reliability, durability and – what’s most important – for consumer’s safe. The chromizing process allows also using cheaper materials, such as 304L stainless steel.

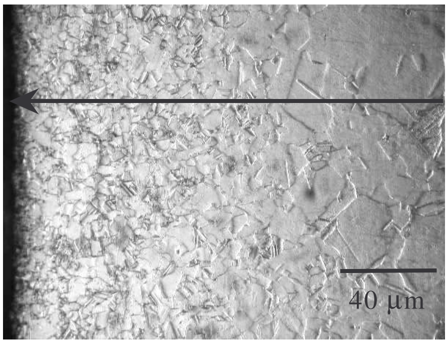
2. EFFECTS OF CHROMIZING

Producing diffusion layers of chromium on stainless steels leads to structural changes, such as dissolving chromium in solid solutions and creating some kinds of precipitations (intermetallic phases such as FeCr or $CrNi_2$ and carbides $M_{23}C_6$) [3]. The chromium equivalent increases, which in consequence causes forming of two-phase structure. The two-phases structure and the presence of carbides and precipitations can considerably increase the hardness and decrease the corrosion resistance. To avoid that, Authors worked out a heat-treatment of chromized stainless steels. In researches there were used chromized specimens of steel type X2CrNiMo17-12-2 with following heat-treatment.

The research of chemical composition and its distribution was conducted on scanning electron microscopy Hitachi S-3500N with EDS Thermo NORAN VANTAGE. The cross section of specimen with marked path of chemical composition analysis and concentration gradient was presented on Fig. 1.

The chromium diffusion caused reduction of grain size (Fig. 1), probably as effect of dissolving chromium in austenite during heat treatment. Dividing of grains was a result of different chromium distribution in micro areas, which size was similar to grain boundaries. To confirm this theory there's need to conduct a substructural research.

In the subsurface area there was increased the chromium content; the evaluated level was 24 % while in the core it was 17%. The thickness of chromized layer was estimated on 1300 μm. Results didn't point on significance correlation between the content of Cr, Ni and C in chromium diffusion layer. Mappings of elements distribution were presented on Fig. 2. There were observed a uniform distribution of mean elements in subsurface area, especially chromium, nickel and carbon. Precipitations of manganese sulphide were also detected, there were observed agglomerations of manganese and sulphur in the same places (Fig. 2, Mn, S). This precipitations are remains of metallurgical process.



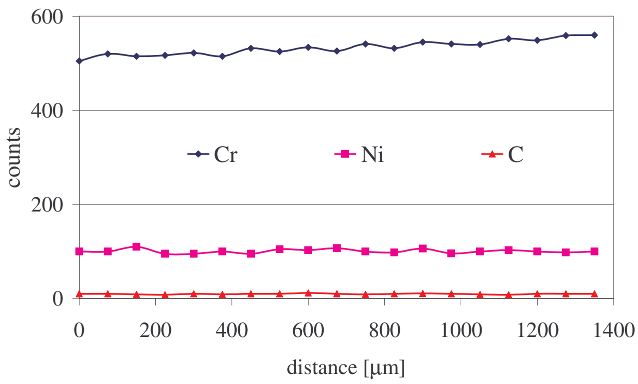


Figure 1. Microstructure of chromized X2CrNiMo17-12-2 steel, cross section with marked path of chemical composition analysis and concentration gradient (SEM, EDS).

The hardness was measured by Vicker's method on load 49,05N, whereas the microhardness was measured on Neophot2 microscope with the Hannemann's microhardness lens on load 0,981 N. The hardness of annealed stainless steel was 160HV5 and the chromized steel 215HV5. Microhardness distribution is presented on Fig. 3.

The distribution of microhardness was used to obtain a "functional" thickness of the layer: 0,3 mm. That layer had the hardness about 150HV0,1 higher than the core. It is a good prognosis for durability and reliability in food processing industry.

3. CONCLUSIONS

- ✓ Thickness of chromized layer had a value of 1,3 mm, whereas the "functional" thickness was about 0,3 mm.

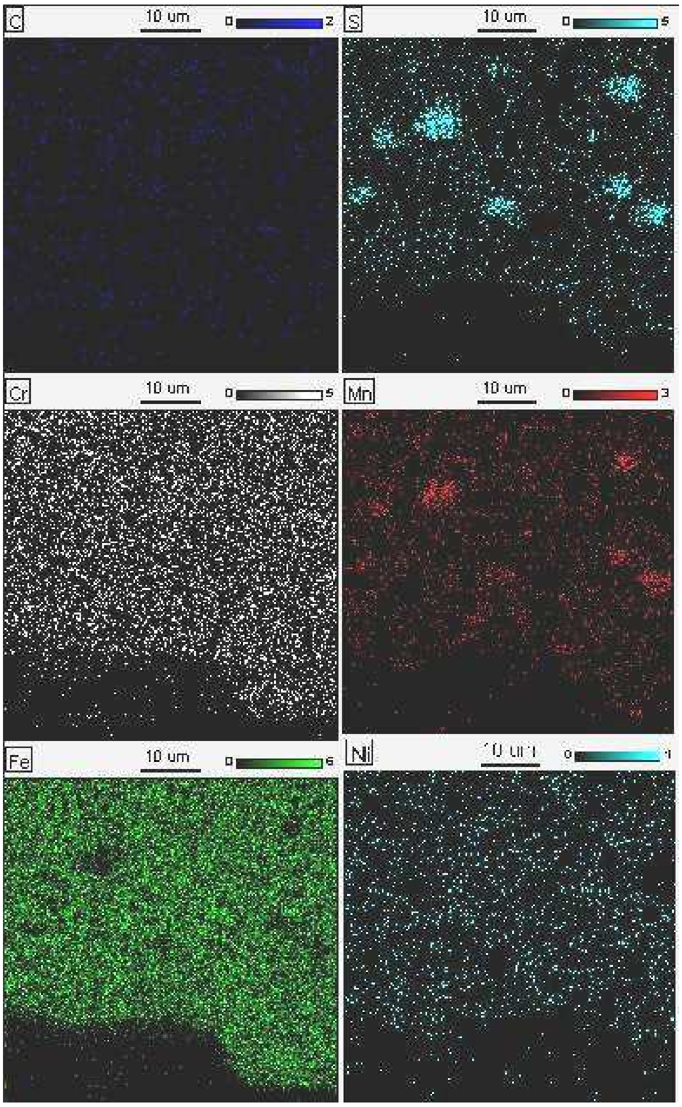


Figure 2: Distributions of mean elements in chromized 316L stainless steel.

- ✓ The chromium content was softly decreased from surface to the core.
- ✓ The heat treatment enabled to dissolve chromium in solid solution and there was received the one-phase structure (austenitic). It is advantageous for the corrosion resistance.
- ✓ The chromized specimens had a higher hardness in comparison to untreated ones: adequately chromized: 215HV5, untreated: 160HV5
- ✓ It's necessary to determine a corrosion resistance of obtained layers.
- ✓ The process worked out by Authors creates a diffusion layer of chromium, which during next heat-treatment is joined in solid solution; it's advantageous for reliability, durability and – what's most important – for consumer's safe.

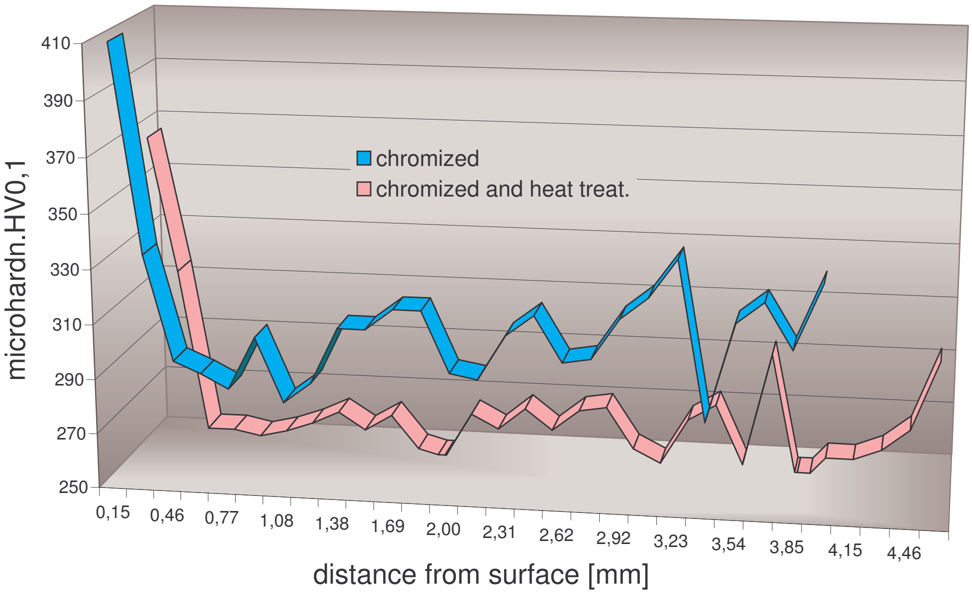


Fig. 3. Microhardness distribution of chromized steel

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