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Selected properties of Ti(OCN) layers on stainless steel

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Minimal investment cost in increasing of the durability of constructions in food processing industry is possible by chemical modification of stainless steels surface layer. The main aim of Ti (OCN) layers production on machine elements for food processing is enlarge tribological properties and corrosion – erosion resistance. Layers of Ti (OCN) were produced in the PACVD process, in which the tetraizopropoxytitanium was a titanium donor. The process was conducted in temperature 500°C under 5 hPa pressure. In this paper there were presented the process of layer formation, also the structure of a stainless steel with the layer and its selected properties. The application area of this layer there was also presented.

1. INTRODUCTION

Stainless steels are widely used in the food processing industry [1,2], but their durability in many cases is not sufficient [1,3,4]. The main aim of Ti (OCN) layers deposition on machine elements for food processing is enlarge mechanical properties and corrosion – erosion resistance [5]. Diffusion of atoms of different size from the matrix gives interactions with dislocations, which increases the strength. Corrosion resistance depends on the kind of diffusing element [6]. Perspective directions in chemical modification of stainless steels surface layer are nitriding, chromizing and titanizing [7]. Pure titanium diffusing to surface layer makes some technological problems with finishing [5,6]. Authors decided to use their own method to obtain a diffusion layer of Ti(OCN).

2. THE PROCESS

Layers of Ti(OCN) were produced in PACVD process in which the tetraizopropoxytitanium (a liquid organometallic compound) was a titanium donor. The process was conducted in temperature 500°C under 5 hPa total pressure. The percentage of

$Ti(O_iC_3H_7)_4$ in gas mixture with H_2 and N_2 was 5% vol. The voluminal ratio of nitrogen and hydrogen was 1:2. The flow rate of nitrogen was 5dm^3/min and hydrogen 10 dm^3/min. The process was conducted in a special installation, which scheme was presented on Fig. 1. The installation was designed and made in Department of Materials Engineering of Technical University of Warsaw, Poland [8].

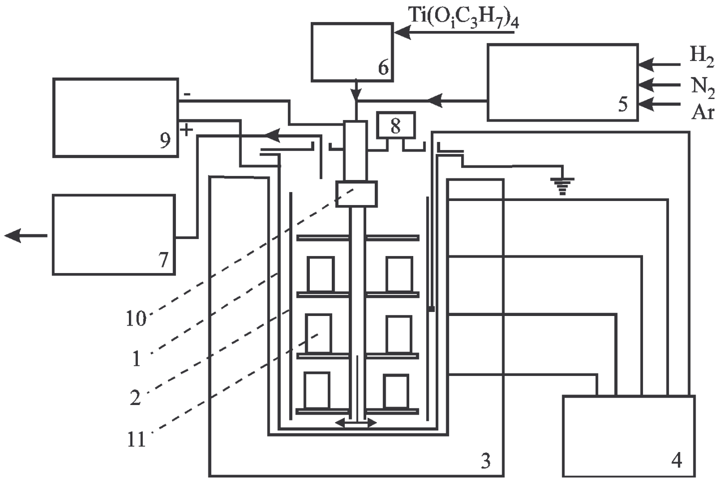

Figure 1. Scheme of installation to producing Ti(OCN) layers: 1- reactor, 2- inside shield, 3- furnace, 4- temperature stabilizer and acquisition device, 5- reactive gas source, 6- evaporator, 7- vacuum pump, 8- overpressure pump, 9- power supply, 10- electrical connection, 11 - specimen

3. THE STRUCTURE

Cross sections of specimens made from AISI 316L with Ti(OCN) layers were observed using an optical (Fig. 2) and electron microscopy (SEM) – Fig. 3. Thickness of layers was estimated on 10 μm (Fig. 2a). There were no changes observed in the structure after thermal process. The structure of 316L is austenite with primary carbides and some precipitations of intermetallic phases. There were observed particles of Ti(OCN) built in austenite grains (Fig. 2b).

The geometrical structure of produced layers was presented on Fig.3. There is visible a "globular" character of surface, which is made from Ti(OCN) agglomerates. It's very interested, that average size of agglomerates (spherulites) may changes depending on place of specimen and it seems to be connected with local chemical compound.

4. PROPERTIES OF Ti(OCN) LAYERS

The hardness of Ti(OCN) layers, measured using the Vickers method, had a value over 880 HV0,1. This value is over 4 times higher than the hardness of stainless steel without any treatment and it looks promising in the wear resistance.

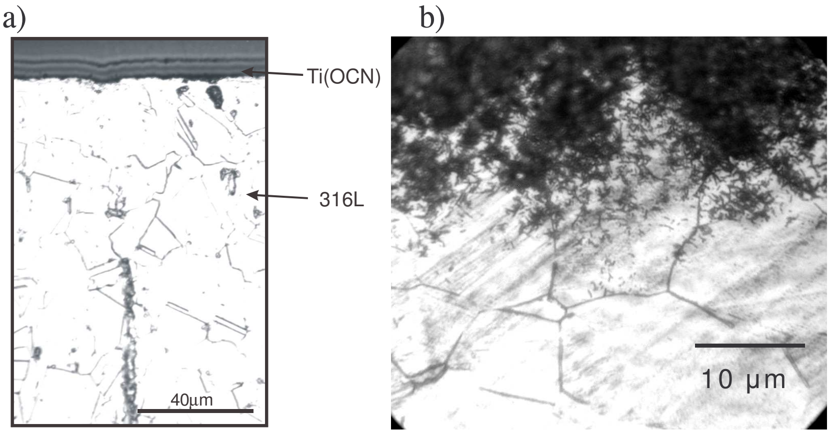

Fig. 2: Structure of 316L stainless steel with Ti(OCN) layer.

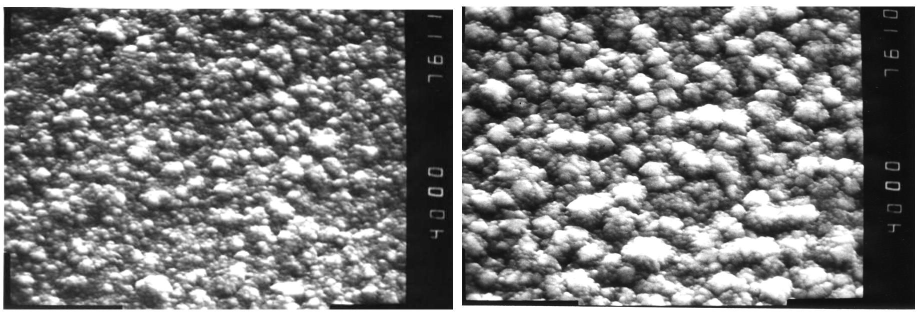

Fig. 3: The geometrical structure of Ti(OCN) surface on 316L stainless steel (picture height is equal to 12,5 μm) (SEM)

The wear resistance was measured in loose abrasive wearing conditions. The abradant was grinded quartz (<0,1 μm) used as a suspension in distilled water. The friction wear track was 500 metres at a load 327 g. Such conditions have been used as a simulation of natural conditions in food industry, especially flow treatment of products, which contains hard particles. Result of this research in comparison to untreated 316L stainless steel was presented on Fig. 4.

The Ti(OCN) layer had a good wear resistance in that testing conditions, the weight loss was about 2 times less than untreated stainless steel. The basic problem is to ensure a good adhesion of layer; it's possible, among other things, by proper surface preparation before treatment.

5. CONCLUSIONS

- ✓ The worked out method enables to product thin layers of Ti(OCN) and other compounds, the layer thickness is about 10 μm.
- ✓ Temperature of the process is sufficient to produce a diffusion layer and it doesn't make any changes in metal's structure.

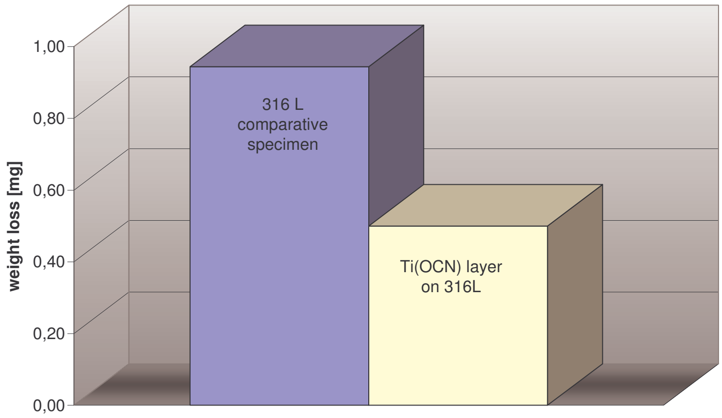

Fig. 4: The wear resistance diagram

- ✓ The layer's hardness is 880HV0,1, it's over 4 times higher than hardness of 316L stainless steel.
- ✓ The weight loss was about 2 times less than untreated stainless steel.
- ✓ Good properties of Ti(OCN) layers, especially the wear resistance, indicate the possibilities of a wide range of application.
- ✓ It's necessary to determine a corrosion resistance of obtained layers.
- ✓ Properties of obtained layers look promising in the wear resistance; they can be applied on such elements as homogenizing valves, homogeniser plungers, in cutting and grinding devices and pumps or other equipment.

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