APPLICATION OF HF DISCHARGE FOR NITRIDING OF VARIOUS SURFACES

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The experimental results on nitriding of flat and inner surfaces of cylindrical specimens made from Ti and stainless steel (SS) are presented. The HF discharge was applied for nitriding with and without the application of an external magnetic field. The changes of specimens' properties dependent on process conditions were investigated.
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INTRODUCTION

The properties of surface layer are known to affect the durability and service lifetime of various tools and mechanisms. Nitriding used to enhance the wear, friction, corrosion properties of production tools and components made of various alloys is widely applied throughout industry and modern plasma surface treatments provides many opportunities for end users to improve performance and reduce life cycle costs. The application of gas-discharge plasma for surface modification during nitriding of Ti and its alloys is an actual problem since it allows to increase the nitriding rate by 3-5 times as compared to traditional technology of simple gas nitriding. Commonly used methods based on a glow discharge require high pressures and high temperatures for hardness, wear and corrosion resistance increase. At the temperatures exceeding α→β polymorphic transformation (885…900°C), nitriding of technical titan BT1-0 without having Cr or V in its structure leads to minor changes in microstructure providing softening of samples bases that is unacceptable in many cases [1]. Moreover, some methods of nitriding utilize ammonia as a working gas which is not convenient from ecological point of view and risks of explosion hazards. In other cases, the presence of hydrogen leads to an embrittlement of tools under testing dynamic load. When nitriding simple surfaces without local exceptions, the discharge with constant biasing is also effective [2]. Basically all methods of nitriding based on pure gases give 2 time increase in microhardness [3]. The use of HF discharge for nitriding of tools made from Ti and SS allows to lower process temperature and to apply pure gases [1,4].

EXPERIMENTAL

The experiments were carried out in a vacuum chamber (Fig. 1), which is pumped out to 10^{-5} Torr. The nitriding was conducted at a 10^{-2} Torr working gas pressure. An external coil wrapped around produced an external magnetic field (Fig. 2). The samples were placed on substrates of various configurations. Before processing, the samples were cleaned using HF discharge (1 kV) for 5…10 minutes in Ar media. Nitriding was carried out by nitrogen ions in HF plasma (1.5 kV) at a pressure of $P_N=10^{-2}$ Torr. The process time was 60 min.

RESULTS

Three different experimental techniques were proposed to conduct nitriding. The first experiment provided nitriding without an external magnetic field on the flat holder.

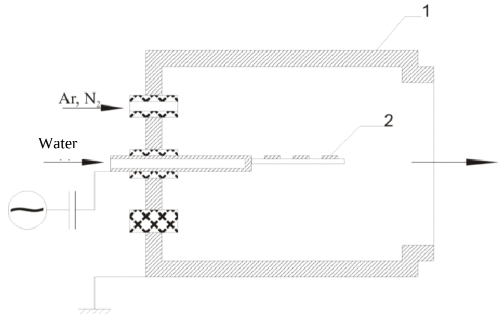

Fig. 1. Scheme of experimental device:
1 – vacuum chamber, 2 – samples from Ti and SS

It was revealed that the microhardness increased on samples made from Ti, whereas on SS it remained unchanged. The discharge was generated throughout the entire volume of the chamber. The change of microhardness is shown in the Table.

The change in microhardness of processed samples

Exp-t №	Sample	Hμ initial, Kgs/mm^2	Hμ nitrogen, Kgs/mm^2
1st	SS	150	150
	Ti	200	230
2nd	SS	150	265
	Ti	200	280
3rd	SS	150	280
	Ti	200	300

The second experiment was carried out by applying magnetic field on the flat holders.

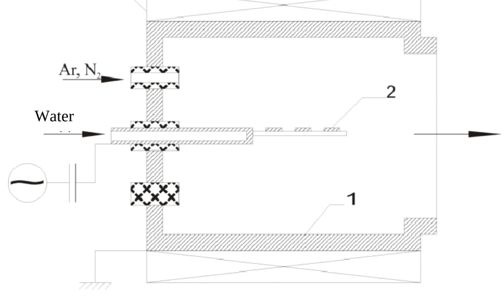

Fig. 2. Scheme of experimental device:
1 – vacuum chamber, 2 – samples from Ti and SS,
3 – magnetic field coil

The increase in microhardness was noticed on the samples made from Ti and SS. The discharge was generated throughout the entire volume of the chamber.

The third experiment provided nitriding of an internal surface of cylindrical products in a magnetic field.

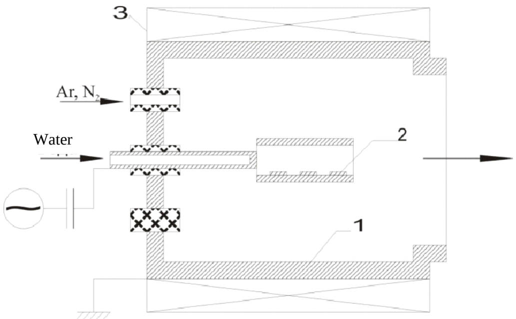

Fig. 3. Scheme of experimental device: 1 –vacuum chamber, 2-samples from Ti and SS in a cylindrical product, 3 –magnetic field coil

In this case, an intensive burning of the discharge was observed in a cylindrical tube that is caused by presence of a longitudinal magnetic field which increases length of run of the charged particles [5].

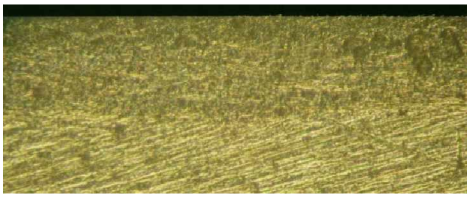

Fig. 4. Cross-section tubes from Ti

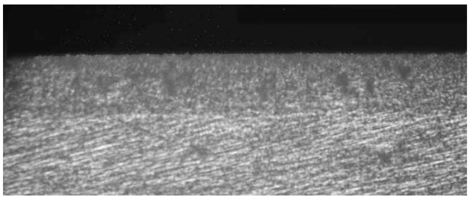

Fig. 5. Cross-section cut of tubes from SS

An increase in microhardness was noticed in comparison with the previous experiments.

Figs. 4 and 5 present cross-sections cuts of titanic and SS tubes after nitriding on the third scheme.

The microhardness of the processed samples increased by 2 times as compared to the initial state. Fig.4 revealed a fine-grained structure of 4…5 µm thick, which corresponded to Ti_XN structure. In Fig. 5, the similar structure of the nitrated layer on SS, with the same thickness of 4…5 µm was observed.

CONCLUSIONS

The possibility of nitriding of internal surfaces of cylindrical-shaped products made from Ti BT1-0 and SS in HF discharge was shown. The method of nitriding in HF discharge turns to be advantageous due to its ecological safety in comparison with other methods.

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ИСПОЛЬЗОВАНИЕ ВЧ-РАЗРЯДА ДЛЯ АЗОТИРОВАНИЯ ВНУТРЕННИХ ПОВЕРХНОСТЕЙ ЦИЛИНДРИЧЕСКИХ ИЗДЕЛИЙ ИЗ ТИТАНА И НЕРЖАВЕЮЩЕЙ СТАЛИ

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Представлены результаты азотирования плоских и внутренних поверхностей цилиндрических изделий из титана и нержавеющей стали. Азотирование производилось с использованием ВЧ-разряда, в присутствии и без внешнего магнитного поля. Исследовано изменение характеристик изделий в зависимости от условий процесса.

ВИКОРИСТАННЯ ВЧ-РОЗРЯДУ ДЛЯ АЗОТУВАННЯ ВНУТРІШНІХ ПОВЕРХОНЬ ВИРОБІВ З ТИТАНУ ТА НЕРЖАВІЮЧОЇ СТАЛІ

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Надано результати азотування пласких та внутрішніх поверхонь циліндричних виробів з титану та нержавіючої сталі. Азотування проводилось з використанням високочастотного розряду, в присутності та без зовнішнього магнітного поля. Досліджено зміну характеристик виробів в залежності від умов процесу.