NITRATING BY MPD THRUSTER - IS THE ECOLOGICAL CLEAN ALTERNATIVE TO CHEMICAL–THERMAL METHODS OF STRENGTHENING

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Introduction

The application of electrojet propulsion systems for fulfillment of technological problems is stipulated by a number of positive specific properties, which are inherent by systems of such type. The thrusters help to decide almost all problems of materials surface processing which are perspective alternative chemical-thermal methods. Electrojet thrusters have number of advantages in comparison with these methods, for example, it is a minimum time of system output to working operational mode and ecological cleanness of technological process.

It is known essence of process nitrating is the saturation of metal surface layer by nitrogen. Thus the most significant increase of detail service properties (hardness, wear resistance etc) is observed at doping of iron by Al, Cr, V etc. However increased contents of doping elements essentially reduces speed of diffusion of nitrogen in a material. It results in useful increase of nitrating time , and impossibility of nitrating in number of cases (for stainless steels).

On the other hand, the methods of covers deposition by carbides (Ti_nC_m, Cr_nC_m) and nitrides (Ti_nN_m, Cr_nN_m) possessing high hardness (up to 3600 HV) and wear resistance are known. But deposition technology of such covers is difficult and has a number of essential disadvantages, basic of which the increased probability sparation of very hard cover from a rather soft substrate and small width of cover.

Solution of problem

The problem, which have been decided by the authors, consists in nitrating of a hard chromium marked by galvanic method. That it is impossible to make by conventional methods. Such hardening reaches a very high adhesion of cover to a material of a substrate. The surface hardness can reach limiting values for nitrating covers. The availability of a diffusion transient layer provides a maximum of useful service properties.

During ionic nitrating processes the atoms of iron beaten out from a surface of a detail interact with ions of nitrogen with derivation of iron nitride. Last is adsorbed by a surface of a detail and dissociates with allocation of nitrogen atoms. The atoms of nitrogen diffuse by taking root in a surface layer of a material, both on boundaries of grains, and through them. Depending on duration of processing there is an appropriate concentration profile describing distribution of nitrogen on depth.

Nitrating was carried out with use of modified rocket engines of a type SPT, MPD, and ion thrusters, which have shown good outcomes. The further greater attention was given to nitrating with use of the magneto plasma dynamic (MPD) thruster.

The MPD- (see fig. 1) includes the anode made from a heat resisting material, the hollow cathode and neutral insert divided by ceramic insulators. The magnetic system is located on the anode, which allows controlling the form of a jet. It is necessary to mark, that in the given device the separate submission of working gases is stipulated. Ar or Xe moves through hollow the cathode for increase of service life, and the nitrogen moves immediately in a zone of discharge.

The tests of MPD have shown, that it steadily works on a mixture of gases, and the parameters of the accelerator can be changed in limits:

- Discharge current 10 ... 40 A;
- Discharge voltage 20 ... 60 V;
- Induction of solenoid magnetic field 0,005 ... 0,05 Tl;
- Consumption of working gas is possible to regulate in limits 0,5 ... 2 mg/s.

In fig. 2 the exterior of the working engine is shown at the consumption Xe m = 0,3 mg/s and N_2 at n = 2,5 mg/s. We can see disjoining MPD-thruster in fig.3. In a fig. 4 are shown comparative Volt-Current characteristics of the engine working on Xe and mixture of gases

Through an anode channel of the engine the nitrogen with the consumption $\dot{m}$ = 0,75±0,05 mg/s and , through the cathode the inert gas a xenon with the consumption 0,3±0,05 mg/s falls to the vacuum chamber. Parameters of discharge were supported at a level voltage Ud = 250±20 V, Id = 2,8±0,2 A (fig.4). The voltage on a detail varied in range from 500 V up

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to 3 кV and currents from 40 up to 300 mA. The chamber pressure in nitrating process was supported at a level 2 ... 6 × 10^{-4} Pa.

Results and discussing.

Ionic nitrating of a detail was carried out at various temperatures of a substrate from 300 up to 600 ^{0}C.

It is necessary to mark that ionic nitrating allows essentially reducing temperature of a substrate. So for nitrating steel of a type 38XMЮA (marked by Russia standard) it can be reduced up to 400...420^{0}C, for steel 25X5M - 420 ... 450^{0}C. For nitrating chromium covers were carried out experiments at temperatures 500 and 400^{0}C (fig. 5). After chroming the surface hardness achieved 980±20 HV. In an outcome nitrating the hardness of cover was increased up to 1050±20 HV at T_N=500±10^{0}C and up to 1800±20 HV at T_N = 400±10^{0}C. Obviously, that in the first case the leave of chromium cover happened, and temperature of a deposition of ions of nitrogen was too high for obtaining maximum hardness CrN. The second version nitrating, under the judgement of the authors, optimally. Reducing nitrating temperature testifies to absence of detail basic material high-temperature leave. It is necessary to mark, that the further lowering of temperature nitrating of chromium cover results in reduction width of a transient layer increased contents of nitrogen in cover and as a corollary to increased fragility and hardness of cover. However, this difficulty can be overcome by special technological methods, that will be shown by the authors in our following activities.

Conclusions.

1. The hardness of a surface with a marked galvanic layer of a hard chromium in an outcome of experiments was increased from 1000 HV up to 1800 HV (Fig. 5.).
2. The optimum temperature modes plasma-ionic nitrating of a hard galvanic chromium about 400 ^{0}C are detected. The temperatures nitrating constructional steel by conventional methods are lower approximately on 50 - 100^{0}C.
3. The surface has increased wear resistance, hardness and strength, by virtue of absence of sharp transient layers.
4. During vacuum plasma nitrating happened full gas disadsorption of a material, that essentially increases fatigue strength at cyclical loads.
5. The absence of strong heating of a substrate does not entail changes in a structure and in mechanical properties of detail material.

This technology of strengthening can find application in production of turbojet engines, engineering, gas, oil-extracting industry.

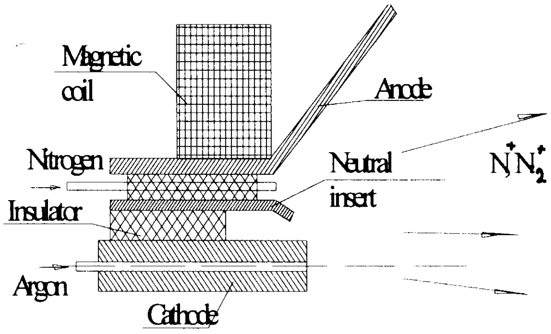

Fig. 1 The scheme of MPD-tgruster.

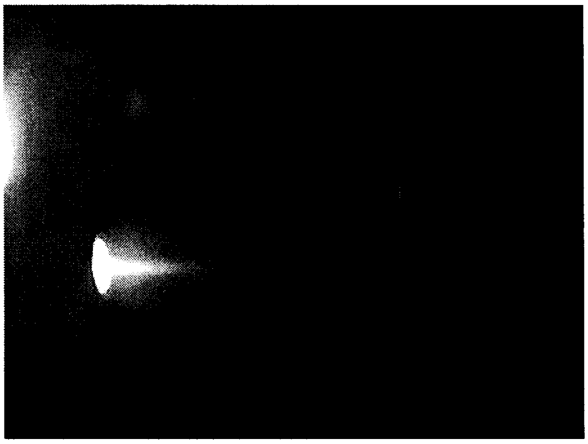

Fig. 2. The working nitrating device .

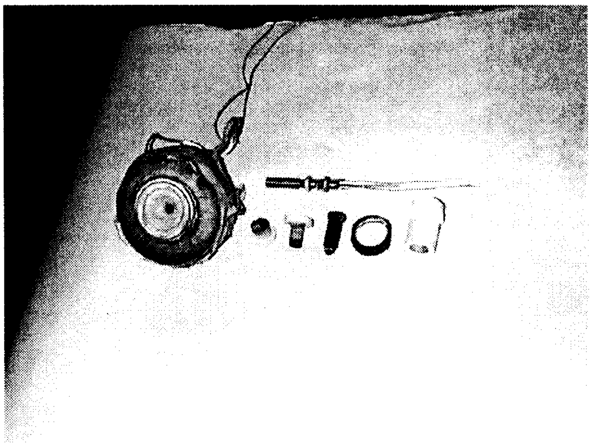

Fig.3. The disjoining MPD-thruster in

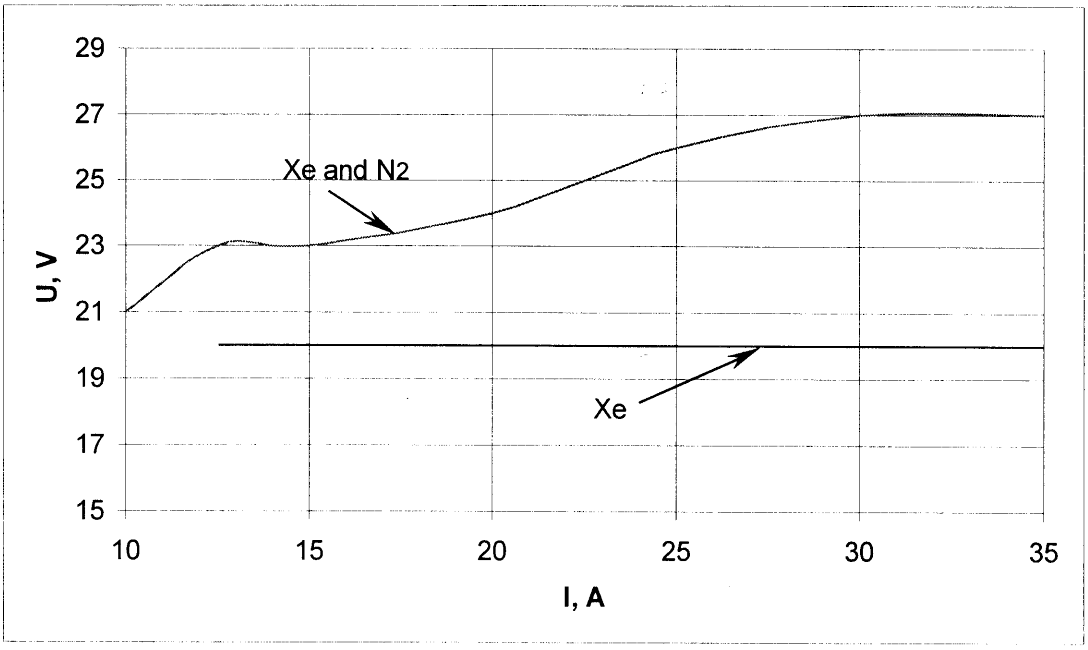

fig. 4 Currently –voltage comparative characteristics of the engine working with Xe and mixture of gases

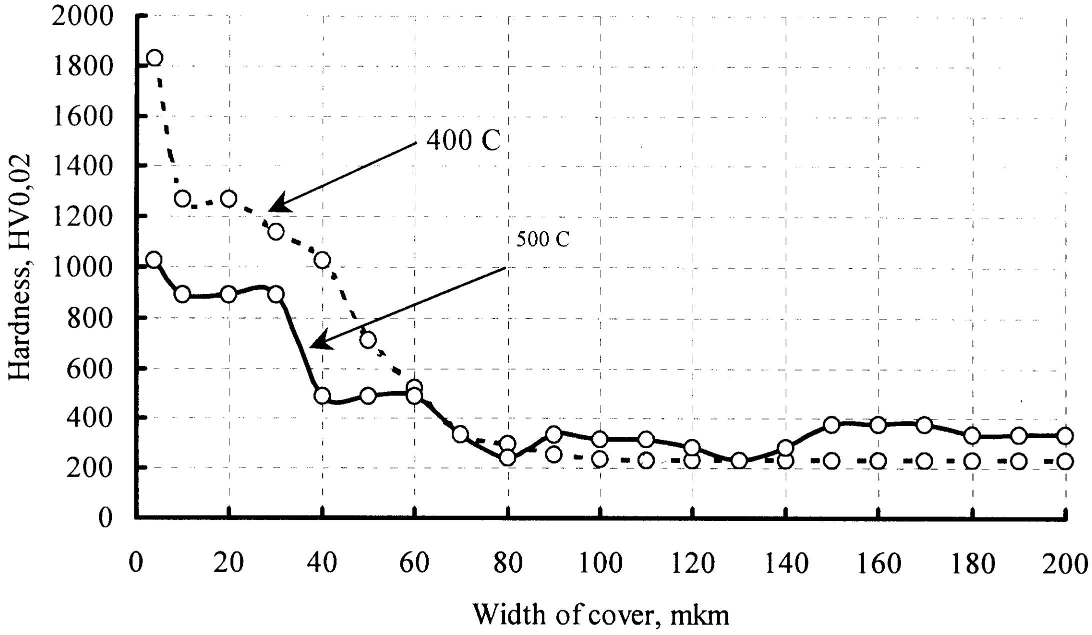

Fig. 5. Distribution of hardness on depth of a sample at various temperature