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RESEARCH OF SURFACE HARDENING INFLUENCE ON THE MICROSTRUCTURE, MICROHARDNESS AND WEAR RESISTENCE 18CrNi3MoA-Sh STEEL

WPŁYW UTWARDZANIA POWIERZCHNI STALI 18CrNi3MoA-Sh NA JEJ MIKROSTRUKTURĘ, MIKROTWARDOŚĆ I ODPORNOŚĆ NA ZUŻYWANIE

Key words:

electrolyte-plasma hardening, microhardness, wear-resistance

Słowa kluczowe:

obróbka elektrolityczno-plazmowa, mikrotwardość, odporność na zużywanie

Summary

The research shows the results of electrolyte-plasma treatment influence on structure-phase state, mechanical properties and wear-resistance of drilling tool steel samples. The comparative analysis of the microstructure, microhardness, and wear-resistance of the samples in initial state and after electrolyte-plasma

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treatment is represented. It was found that 18CrNi3MoA-Sh steel has a fine-grained martensite-bainite microstructure after the treatment. It was determined that 18CrNi3MoA-Sh steel possesses high wear-resistance after electrolyte-plasma treatment and that this technology is characterised by low power consumption and cost. The average initial state microhardness is 2800 MPa. The average microhardness on the bearing lane surface after electrolyte-plasma processing is 7500 MPa. Microhardness increases bay a factor of 2 to 2.5, indicating technology efficiency.

INTRODUCTION

As is known **[L. 1]**, increased requirements on quality of the surfaces of automotive parts have stimulated the creation of new methods of purposeful change of phase structure and the structure of their layers. In particular, much interest has been focused on the influence of concentrated streams of energy on the surface of automotive parts. In our opinion, the most perspective, energy-saving, and ecologically pure technology among them is electrolyte-plasma processing **[L. 2]**. Thus, there is a change of structure and properties of a material in thin layers due to the physical influence of ions of high-temperature plasma and electrical energy.

The basic advantages of method electrolyte-plasma processing are the possibility of difficult profile hardening, internal surfaces and cavities; the absence of the necessity of the special preparation of surfaces before hardening; ecological safety (it is not required special treatment facilities). The analysis of the existing technologies of low-carbon alloyed steel product treatment has allowed developers to assume that electrolyte-plasma hardening can be the most comprehensible technology for thermal hardening **[L. 3]**.

MATERIAL AND EXPERIMENT TECHNIQUE

For research, we have chosen 18CrNi3MoA-Sh steel (0.16-0.18% C; 3.3% Ni; 0.9% Cr; 0.51% Mo; 0.44% Mn; 0.34% Si; 0.05% Al; 0.008% S; 0.012% P; 0.015% N; 0.01% O; 0.01% H) GOST 4543-71. The 18CrNi3MoA-Sh steel is usually applied to surface manufacturing of drill chisels and rolling cutters. The steel cementation processes is used on surfaces where high durability demands are made on viscosity and wear resistance, and also for surfaces which are exposed to high vibrating and dynamic loading. The steel can be applied at temperatures from -70 to +450^{0}C **[L. 7]**.

Samples of steel 30×30×10 mm^3 in the size were cut from a drill bit in initial condition with a diamond disk 1 mm thick. It was immersed into a cooling liquid. The cutting speed was n = 350 revolutions per minute, with a loading m = 250 gr (at these conditions the sample does not test significant deformations and thermal influence). For metallographic microanalysis, after polishing with application of chrome dioxide paste, sections were etched by 5 % of nitric acid spirit solution.

Experimental research and mechanical tests were carried out at the regional engineering profile laboratory «IPГETAC» at D.Serikbaev EKSTU of and in scientific laboratory of sub-department «Technical physics». Metallographic analysis was made using an optical microscope «МИМ 7» with a digital camera «Fujifilm». The qualitative and quantitative structure phase analyses of steel samples were made using an X-ray diffractometer «X′Pert PRO» of "PANanalytical" firm with application of Cu-K_α radiations. The elemental structure of samples processed in the electrolyte to plasma were investigated using a scanning electronic microscope JSM-6390LV - JEOL firm (Japan). Microhardness measurements were made using a PMT-3 with diamond a pyramidion with a 1 N loading on the indentor. The wear resistance of the samples were estimated using weight loss in a time unit as a result of sliding friction abrasion of an abrasive disk without lubricant. Weight measurements of samples were made using electronic scales VL-120 with 0.1 mg precision.

EXPERIMENTAL RESULTS AND DISCUSSION

Cementation was carried out in cathodic mode with two-level electrolytic heating in electrolytes of the following structure: 15% sodium carbonate water solution Na_2CO_3 and 15% sodium carbonate water solution Na_2CO_3 + 10% of glycerine $C_3H_8O_3$. Voltage at heating to cementation temperature (860°C) has made at 320 Volts, and the voltage exposure interval at cementation temperature has made at 180 Volts. Heating temperature at cementation is 850-860°C. After heating to the set temperature, the samples were kept at constant temperature for 1.5, 2, 2.5 or 3,5 minutes. The subsequent hardening was made in stream of cooled electrolyte.

In **Figure 1**, the microstructure of 18CrNi3MoA-Sh steel before and after cathode warming under influence of electrolyte plasmas is shown. After cathode warming with a short duration of sustained temperature and the subsequent hardening, the steel surface has a fine-grain structure due to martensite (A→M) transformation does not proceed and there is the disintegration of products in the steel **[L. 7]**. An increase in sustained temperatures up to 3.5 minutes leads to an increase of grain sizes.

This electrolyte-plasma processing allows a strengthened layer with thickness 1000 … 1700 microns to be created. **Figure 2** indicates the relationship between microhardness and processing time. The microhardness of initial condition is 2700 MPa. After processing for the sustained 1.5 minutes, the microhardness increases to 5000 MPa. With increase in processing duration, the microhardness decreases. It is connected with the fact that at grain sizes increase with sustained temperature processing.

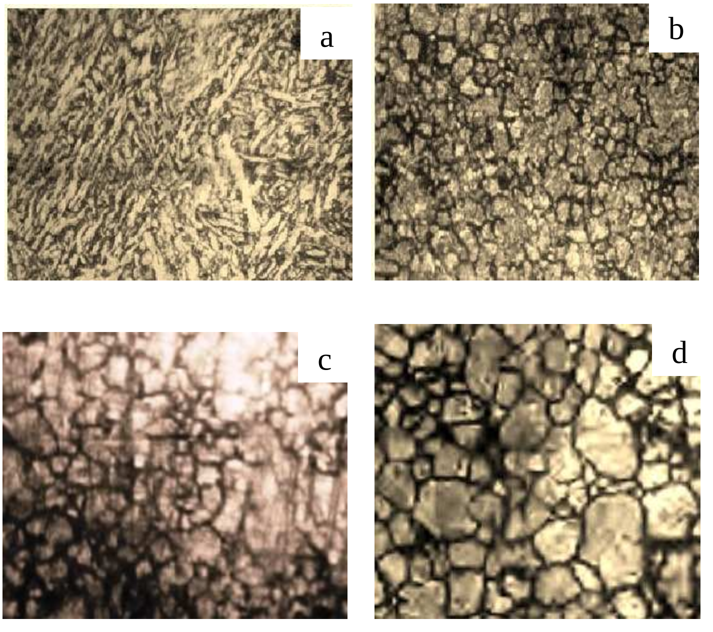

Fig. 1. Microstructure 18CrNi3MoA-Sh steel, X100: a - to cathodic warming, after cathodic warming at 860°C, during b – 1.5 minutes, c – 2.5 minutes, d – 3.5 minutes

Rys. 1. Mikrostruktura stali 18CrNi3MoA-Sh, powiększenie X100: a – przed ogrzaniem, po ogrzaniu w 860°C, w czasie b – 1,5 minuty, c – 2,5 minuty, d – 3,5 minuty

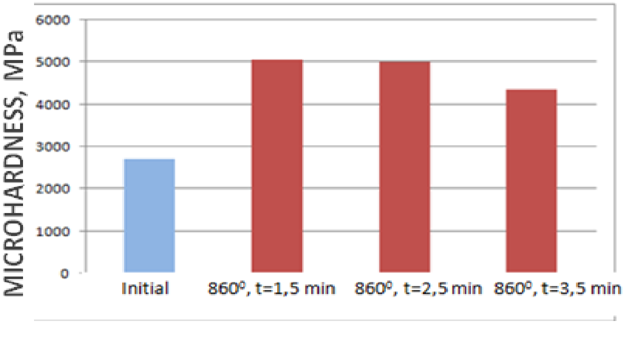

Fig. 2. Microhardness of 18CrNi3MoA-Sh steel 15% water solution sodium carbonate Na_2CO_3 without glycerin

Rys. 2. Mikrotwardość stali 18CrNi3MoA-Sh po obróbce w wodnym roztworze 15% węglanu sodowego Na_2CO_3 bez gliceryny

The were resistance of samples was estimated by loss of mass per unit of time, as a result the attrition of the sample after abrasion without lubricant. Tests using a rubber disk with quartz sand (**Figure 3**) were performed for certain time periods with a speed of 60 rpm. After 600 disk revolutions, the loss of mass is determined for the sample.

In presence of fine-grained martensite, a strong surface structure is formed. It is does not collapse even with the heaviest forms of abrasion wear. The greatest wear is observed on initial - raw sample of steel. The ferrite-pearlite structure is easily destroyed by the abrasive. That is confirms the low wear resistance of thermally unprocessed steel. **Figure 4** presents the comparison of processed and unprocessed steel

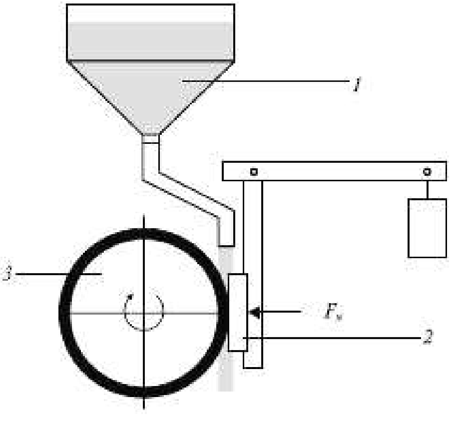

Fig. 3. Scheme of installation for tests on abrasion wear: 1 – abrasive (sand); 2 – sample; 3 – rubber wheel

Rys. 3. Schemat stanowiska do badania zużycia ściernego: 1 – ścierniwo (piasek); 2 – próbka; 3 – koło gumowe

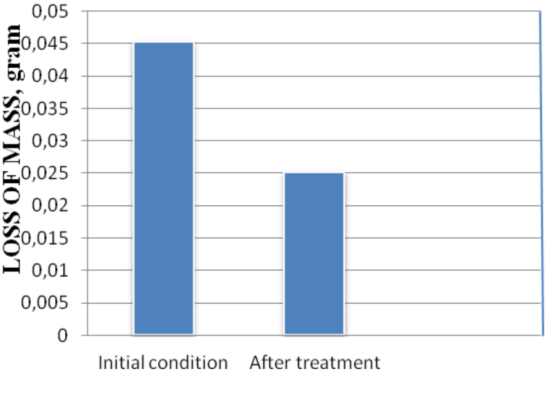

Fig. 4. Wear resistance of 18CrNi3MoA-Sh steel before processing

Rys. 4. Odporność na zużywanie stali przed obróbką elektrolityczno-plazmową

CONCLUSIONS

1. The influence of electrolyte-plasma processing modes on the structure and phase compounds of steel was investigated. It is established that, in the plasma layer of the electric gas category, the electric current ionises carbon which carbonise the surface of the sample and leads to the formation carbide phases which were formed in the water solution of soda ash Na_2CO_3 and glycerin.
2. The influence of surface hardness and the depth of the tempered layer on modes of electrolyte-plasma treatment was investigated. It is established that after, processing of 18CrNi3MoA-Sh steel, microhardness increased more than twice the initial condition. Abrasive wear resistance of the unprocessed steel exceeds the wear resistance of the processed sample by a factor of two.

Thus, on the basis of the analysis, it has been established that the most effective way of surface hardening for the bearing unit track of the boring tool is electrolyte-plasma processing. The advantages of such approach are low power inputs, the simplicity of process implementation, and the ability to use the process with complex configurations that will be subjected to high loads.

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Streszczenie

Wyniki badań przedstawiają wpływ obróbki elektrolotyczno-plazmowej na stan strukturalno-fazowy, własności mechaniczne i odporność na zużywanie próbek stali na narzędzia wiertnicze. W pracy przedstawiono analizy porównawcze mikrostruktury, mikrotwardości i odporności na zużywanie próbek w stanie wyjściowym i po obróbce. Stwierdzono, że martenzytyczno-bajnityczna mikrostruktura stali 18CrNi3MoA-Sh po obróbce jest drobnoziarnista. Zauważono, że obróbka podwyższa odporność stali na zużywanie, co jest korzystne przy jej niskim zapotrzebowaniu na moc i niskim koszcie. Wartość średnia mikrotwardości próbek w stanie wyjściowym wynosi 2800 MPa, natomiast po obróbce wartość średnia mikrotwardości wzrasta do 7500 MPa. Mikrotwardość stali po obróbce elektolityczno-plazmowej wzrosła więc 2–2,5-krotnie w odniesieniu do stanu początkowego, co świadczy o skuteczności zastosowanej obróbki.