DETONATION CONTROL OF THE METAL SURFACE PLASMA MODIFICATION

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Abstract: The paper focuses on the results of the experimental study of structure, chemical composition, and mechanical and working properties of metal surfaces modified by the impact of the impulse flow formed by ionized detonation products of butane, oxygen, and nitrogen and electric discharge pulse. The electric discharge pulse duration was 0.5 ms, with the pulse frequency of up to 5 Hz. The modification of the surface layer up to 60 μm deep included recrystallization on the submicron level and alloying by the electrode components (W) as well as by the components of the detonating medium (C, N, and Si). Variation of the amount of detonating mixture allows controlling the process of commutation in the electric circuit between the electrode and the target and thus the polarity of the modified surface with respect to the central electrode of the installation. As a result, the processes of deposition and diffusion of alloying elements are brought to optimal. During the experiment, new material layers with a high content of alloying elements up to 5 μm thick and hardness up to10 500 MPa were formed on the surface of stamp steel samples without any change in the shape or dimensions of the sample. After modification, thus conducted wear resistance of stamp steel tools tested industrially increased up to 2–4 times.

Keywords: pulse-detonation combustion; plasma; electrical discharge; metal; surface; modification; hardness; wear resistance

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References

1. Alekseev, S. V., and B. G. Pal'chuk. 2011. Plazmennaya zakalka — effektivnaya tehnologiya uprochneniya poverkhnosti detaley [Plasma quenching — effective technology of products surface hardening]. *Zhurnal Promrynok* [J. PromMarket]. Available at: http://www.promrinok.ru/pages/325 (accessed January 30, 2015).

2. Korotkov, V. A., S. P. Anan'ev, and A. V. Shekurov. 2012. Issledovanie vliyaniya skorosti okhlazhdeniya na kachestvo poverkhnostnogo sloya pri plazmennoy zakalke [Investigation of the effect of cooling rate on surface layer quality during plasma quenching]. *Svarochnoe Proizvodstvo* [Welding Production] 3:23–27.
3. Vasilik, N. Ya., O. V. Kolisnichenko, and Yu. N. Tyurin. 2013. Sposob uprochneniya poverkhnosti metallicheskikh izdeliy [Method of hardening of metal product surface]. Application to Patent RF No. 2013133431 of 19.07.2013. Decision on the grant of the patent of 30.10.2014.
4. Tyurin, Yu. N., N. G. Tsygankov, and V. I. Makarov. 2003. Sposob uprochneniya instrumenta [Method of tools hardening]. Patent RF No. 2239001.
5. Vasilik, N., Yu. Tyurin, and O. Kolisnichenko. 2014. Metal surface modification by the joint impact of ionized detonation products stream and electric discharge. *14th Conference (International) on Plasma Surface Engineering Proceedings*. Garmisch-Partenkirchen, Germany.
6. Frolov, S. M., V. S. Aksenov, K. A. Avdeev, A. A. Borisov, V. S. Ivanov, A. S. Koval, S. N. Medvedev, V. A. Smetanyuk, F. S. Frolov, and I. O. Shamshin. 2013. Operation process of the pulse detonation burner. *Goren. Vzryv (Mosk.) — Combustion and Explosion* 6:98–103.

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