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Diffusion saturation from fusible liquid metal media solutions by titanium of TK and WC-Co alloys as way to increase of tool durability

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Abstract. The technology of applying titanium diffusion coatings on cutting tools of medium of fusible liquid-metal solutions has been describe. The results of research of process of heat treatment of carbide inserts of type WC-8%Co and TC after diffusion tianation from medium of fusible liquid-metal solutions has been describe. The results of influence of heat treatment of the cutting tool with diffusion titanium coating to its durability has been describe. It founded that the wear resistance of the tool and the microhardness of the coating influenced by the temperature of heat treatment and its duration, and the composition of the coated material. It is established that thermal treatment of carbide tools, the diffusion of titanium has a coating, allows to increase its durability in 1,5-2 times compared to the coated tool, but without heat treatment, relative to the tool without coating, durability is increased 7 times.

1. Introduction

The most used materials for the manufacture of cutting tool are hard alloys of TK and WC-8%Co. The advantages of these materials are high hardness, wear resistance and heat resistance. However, the performance properties of these alloys don’t meet modern requirements for the cutting tool. Currently, the most used method to improve the wear resistance of the cutting carbide tool is the application of various coatings on its surface.

There are three main technologies used for the application of coatings on carbide tool: CVD (Chemical Vapor Deposition); PVD (Physical Vapor Deposition); chemical heat treatment [1-3].

It is also common to process various methods of already coated products to give them the final properties and structure. For this purpose, various methods can be used: mechanical hardening treatment, treatment with concentrated energy flows, ultrasonic treatment, heat treatment, combined treatment, etc. [4-6].

The most wear resistance coatings, applied by diffusion saturation from fusible liquid metal media solutions, are TiC-base coatings. Diffusion saturation of carbide-tipped tools consist of two stages: short-term high-temperature carburization and actual diffusion saturation. However, in the coating, formed by used such technological process, the carbon distribution uneven. This leads to the formation of zones with high carbon content in the surface layer. This provides to increase of brittleness of the coting. The coated tools are subjected to aging process to avoid this phenomenon. This treatment provides of redistribution of carbon on the coting, which provides additional allocation of the secondary dispersed phase at the form of titanium carbide TiC. These processes lead to increase of the hardness of the coating with reducing its brittleness.

The aim of this work is study the influence of diffusion saturation from fusible liquid metal medium solutions of carbide tipped tool by titanium with subsequent aging to its performance specifications.

2. Research methodology

Diffusion titanium coatings deposited on the original plate without coating. Carbide hex plate WNUM-080404, pentagonal plates PNUM - 110408 alloys WC-8%Co, T15K6 used for diffusion saturation. The coating applied by diffusion metallization with the use of our technology [7] by immersing the carbide plates in the ampoule with the melt fusible and exposure under isothermal conditions in the environment of inert gases. As fusible melt delivering the item to the surface of the coated products were used, the melt eutectic lead-bismuth-lithium, in which in a predetermined amount was injected to the titanium.

The process of diffusion metallization from the medium of fusible liquid metal media solutions based on the phenomenon of isothermal selective transfer of coting elements dissolved in a fusible melt to the surface of the product with subsequent diffusion interaction of coating elements with the main material of the product [8].

The essence of technology lies in the fact that the production immersed in the molten low-melting metal element in which in a certain proportion of dissolved elements coatings. Products maintained in the melt at given temperatures from 10 minutes to 5 hours. During this time, the coating elements diffuse into the surface layer of the product, doped them, forming a diffusion coating [8].

Before diffusion saturation plates subjected short-term high-temperature carburization. The aim of carburization is saturation of surface layer by carbon. Hereinafter the titanium carbides in coating will forming by carbon got during carburization. The carburization conducted using vacuum carburization in propane butane mixture technology in vacuum furnace BMI BMICRO.

After diffusion saturation covered plate subjected aging at 5000C. The aging subjected for redistribution of carbon in surface layer and for additional allocation of the secondary dispersed phase in the form of titanium carbide TiC.

The saturation process carried out in developed, patented and manufactured our apparatus for diffusion saturation in the medium of the fusible liquid metal solutions [9]. This apparatus provides the possibility of applying coatings in an open liquid metal bath in a cyclic made and to combine the process of diffusion metallization with heat treatment of material covered products.

The tests of tool durability with diffusion titanium coatings conducted used natural tests during cutting process. The cutting process conducted by straight turning tool with mechanical fastening of plates. The plates made of WC-8%Co and T15K6 alloys without coatings and plates had titanium diffusion coating applied of proposed technology used for tests.

The wear resistance of the covered plates investigated during cutting of bars, made U10 steel after hardening and middle abatement, HRC=43…45.

Lathe machining conducted at cutting speed 130 m/min, feed 0.8 mm/Rev, depth of cut 1 mm. During the period of tool life taken as the time during which the tool was lost cutting properties.

The hardness of the plates tested by the method of Rockwell and the method of micro-Vickers. Rockwell hardness determined on the hardness tester TK-2M according to standard methods, on a scale of "A". Metallographic studies carried out on the microsections prepared by standard methods. Studies to determine the thickness of the coatings, their structure and microhardness conducted on PMT-3.

3. Results and discussion

After diffusion saturation from the fusible liquid metal media solutions by titanium on the surface of covered plates formed diffusion titanium coating size 3-6μ. This layer formed due diffusing of carbon after carburization to titanium during diffusion saturation. Surface layer observed without etching. There is transition zone between cover and substrate material, which characterize by the presence of diffusion elements and elements of substrate material. This show that this layer forming due heterodiffusion between diffusing elements and substrate material elements [8]. The microhardness of the transition zone has changed exponentially from coating microhardness to substrate material microhardness. The microphotography of microstructure of surface layer of T15K6 alloy presented at figure 1.

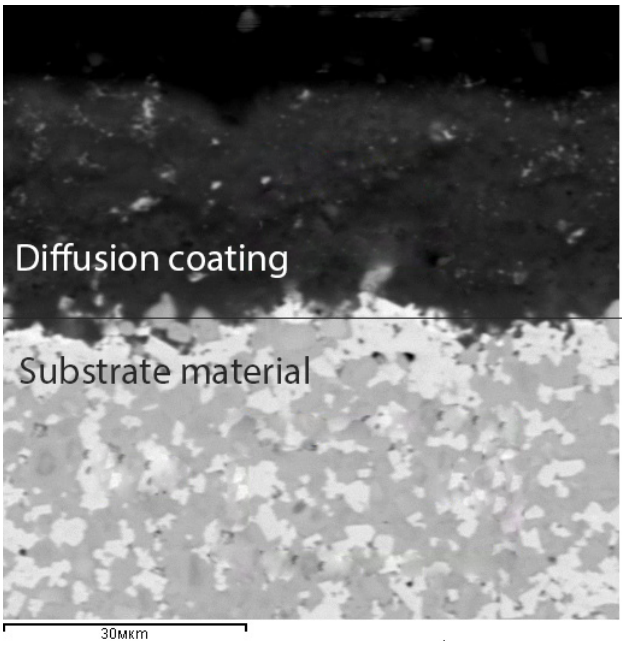

Figure1. Microstructure of surface layer of T15K6 alloy.

During the investigate has established the technology of diffusion saturation by titanium with aging of TK and WC-8%Co alloys provides increase of cutting tool life. The level of increase of cutting tool life depended of mode of diffusion saturation.

The time of diffusion saturation and temperature has ranged for depending detected of tool life to mode of diffusion saturation. The diffusion saturation conducted of temperature range from 10000C to 11000C. The time of saturation of plates ranged from 30 min to 60 min.

The best of value of tool life made of T15K6 alloy has achieved at temperature of 10000C and time of saturation 30 min (fig 2, 3). The value of tool life without coating was 30 min, after diffusion saturation and aging tool life increased to 210 min. When the time of saturation or temperature have increased the tool life decreased. This related with forming very thick coating, which contain a lot of titanium carbides TiC with high hardness and brittleness. The dependence of tool life of carbide tipped tool made of T15K6 alloy to temperature of diffusion saturation presents at figure 2. The dependence of tool life to time of saturation presented at figure 3.

Unlike of T15K6 alloy, the best of value of tool life made WC-8%Co alloy has achieved at temperature of 11000C and time of saturation 90 min (fig 2, 3). The value of tool life without coating was 24 min, after diffusion saturation and aging tool life increased to 170 min. When the time of saturation or temperature have increased the tool life decreased like in a case of T15K6 alloy. The dependence of tool life of carbide tipped tool made of T15K6 alloy to temperature of diffusion saturation presents at figure 2. The dependence of tool life to time of saturation presented at figure 3.

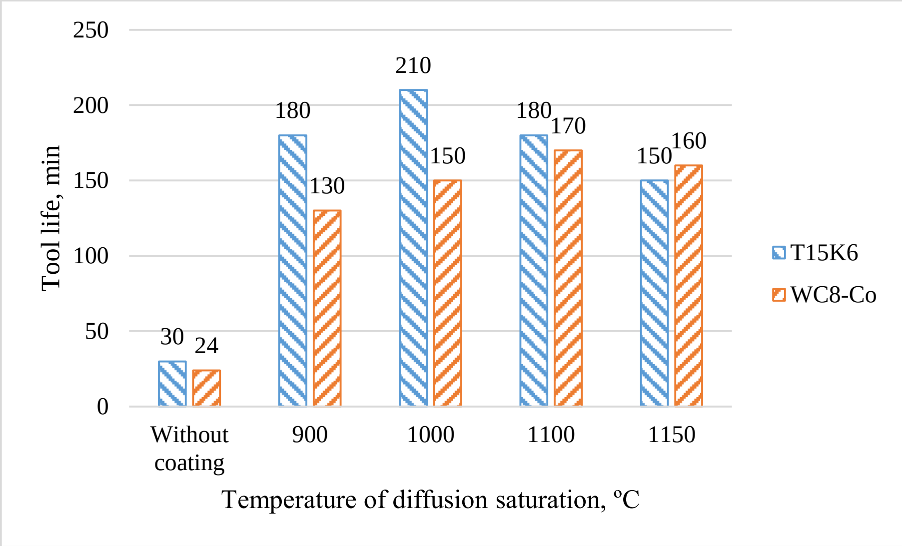

Figure 2. Depending of tool life to temperature of diffusion saturation.

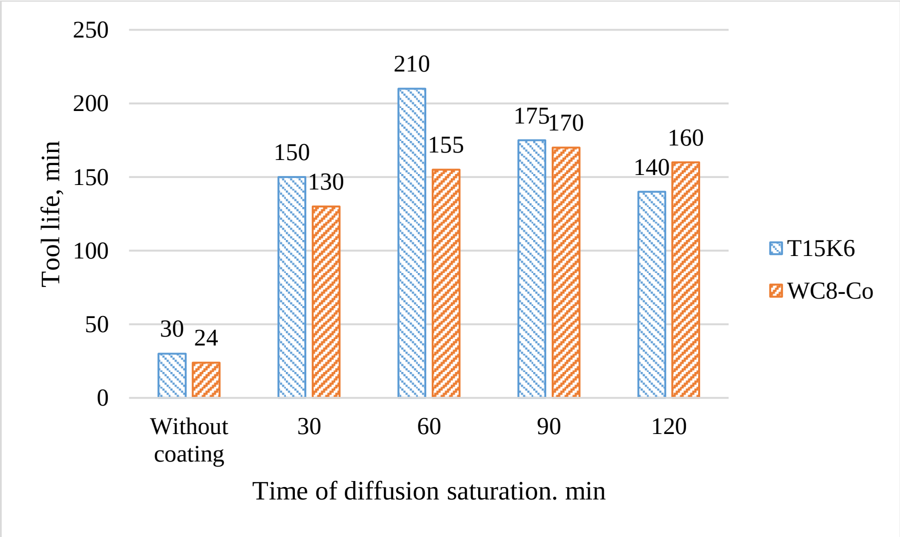

Figure 3. Depending of tool life to time of diffusion saturation.

The increase of tool life provided by formation diffusion coating contained hard titanium carbides. The macrohardness of coted material was 91 HRA for T15K6 alloy and 81,5 HRA for WC-8%Co. The diffusion saturation of hard alloys provides to increase of microhardness of surface layers. The microhardness of surface layer of T15K6 alloy after diffusion saturation at 1000^{0}C during 60 minutes with subsequent aging have amounted 30000 MPa. The microhardness of transition zone has varied of 27500 MPa to 18600 MPa at 20µ (fig. 4). The microhardness of uncoated hard alloy has amounted 18600 MPa for T15K6 alloy, 16430 MPa for WC-8%Co alloy. The microhardness of surface layer of WC-8%Co alloy after diffusion saturation at 1100^{0}C during 90 minutes with subsequent aging has amounted 25000 MPa. The microhardness of transition zone have varied of 22400 MPa to 16430 MPa at 20µ (figure 4). The increase of microhardness has explained forming a lot of titanium carbides TiC in surface layers during diffusion saturation and additional allocation of the secondary dispersed phase at the form of titanium carbide TiC during aging.

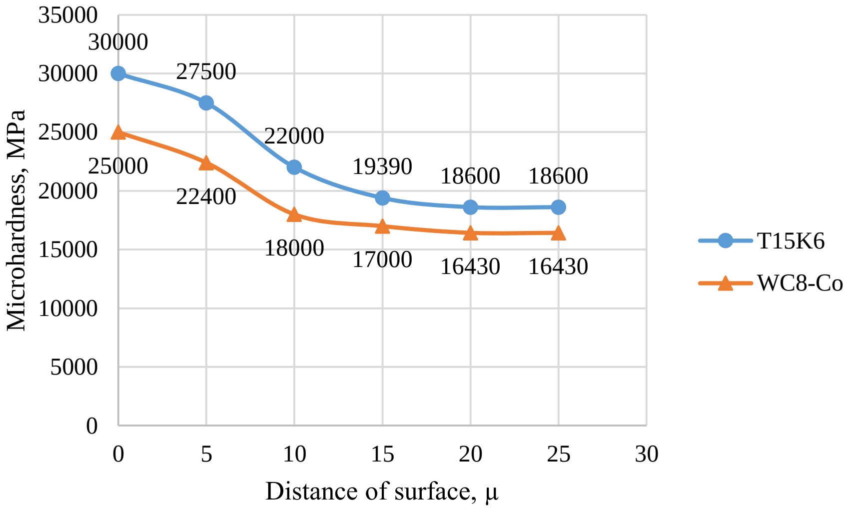

Figure 4. Microhardness of surface layers of materials with diffusion titanium coating.

During the investigation has established the diffusion saturation with subsequent aging of hard alloys provides to formation the diffusion coating at titanium carbide TiC base. This coating provides to increase of microstructure and microhardness of surface layer and as a consequence to increase of tool life. Thus the diffusion saturation from fusible liquid metal media solutions by titanium of TK and WC-8%Co alloys can use as effective way to increase of tool durability.

4. Conclusion

The greatest influence to tool life of carbide-tipped tool, with diffusion titanium coat, has the temperature of the diffusion saturation. The applying of diffusion titanium coat let to increase the tool life of carbide-tipped toll in 7 times. The optimum temperature of diffusion saturation is 10000C for T15K6 alloy, and 11000C for WC-8%Co alloys. The optimum time diffusion saturation is 60 min for T15K6 alloy, and 90 min for WC-8%Co alloys.

Acknowledgements

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