Improvement of operational characteristics of the assembly tool equipped

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Abstract. The article describes the studies of the performance of tool hard alloys using two different methods based on mechanical and physical properties. The studies were carried out in laboratory conditions without the use of metalworking machines, which is an undoubted advantage over persistent tests, where a lot of trial processing is necessary to assign rational operating conditions. A comparative analysis of the obtained experimental studies of the electromagnetic properties of replaceable cutting inserts made of tool hard alloys with the known results of studies on impact strength is given. The comparison results showed that the change in the state of the hard alloy diagnosed by impact strength correlates well with the results of studies of electromagnetic properties depending on the temperature in the range specific to the cutting process of materials. The data obtained with high accuracy make it possible according to the test results to assign rational processing modes corresponding to the temperatures at which the maximum operational characteristics of the tool are observed. As a result of the study, a scientifically based method for choosing rational performance processing was obtained, which is based on the physical and mechanical properties of tool materials, reacting to the structural changes during operation under the influence of high temperatures, and allowing to assign performance conditions providing the conditions to get maximum tool operability.

1. Introduction
Hard alloy plates are obtained by powder metallurgy methods. This method provides high manufacturing precision and reflects high values of the properties and characteristics of the end product. Products manufactured by powder metallurgy methods come out either ready-made or requiring minimum mechanical processing. Sintered hard alloys are sometimes called ceramic metal, and their production technology is similar to the technology of ceramics production. The tool modularity with carbide plates is carried out either by means of soldering or mechanical fastening. The most common representatives of this group are BK alloys (for example, BK6, BK8), TK and TTK. These are hard alloys based on tungsten carbide.

This method of plates production allows to give them high values of physical and mechanical characteristics in – what is more – a wide temperature range.

These characteristics are subject to changes due to temperatures. Knowing the effect of such changes on the operational characteristics of the cutting tool will allow to predict any premature failure of the tool, as well as to increase the durability and productivity of processing.
Such scientists as Vereschaka, A.S. [1], Grigoryev, S.N. [2], Kushner, V.S. [3], Loladze, T.N. [4], Makarov, A.D. [5], Poletika, M.F. [6], Silin, S.S. [7], Uteshev, M.Kh. [8], Shalamov, V.G. [9], Neugebauer, R., Hochmuth, C. [10], Zhang, H. [11], etc., have dedicated their studies to improve the performance of a cutting tool.

The aim of this study is to increase the operational characteristics of an assembled tool by determining the conditions for the maximum working capacity of replaceable cutting inserts made of tool hard alloys when machining difficult-to-process materials.

To achieve this goal, it is necessary to solve the following problems.

- to conduct the analysis of literature in order to identify the knowledge of the issue;
- to conduct the comparative analysis of the obtained experimental dependences of the change in the electromagnetic properties of hard alloys with the dependences of the impact strength of hard alloys on the temperature.

The subject of this study is a replaceable tool hard alloy cutting insert.

2. Research Methodology.

The analysis of literature showed that the determining factor affecting the operational characteristics of the cutting tool, in all the interrelation of phenomena when cutting materials, was the temperature and force factor in combination with the physical and mechanical characteristics of the tool materials and processed materials [12], [13].

The ability of hard alloys to maintain sufficient hardness and resist deformation at high temperature in combination with satisfactory strength is an important advantage over other tool materials.

Scientists have been studying the mechanical properties of hard alloys and their influence on temperature characteristics for a long time. For example, a study of the impact strength of hard alloys showed a change in this characteristic under the action of temperatures specific to the process of cutting materials. Impact strength is the ability of a material to absorb mechanical energy in the process of deformation and fracture under the influence of an impact load. Scientists conducted tests of samples from the BK group hard alloys and plotted the dependence of impact strength KCV on temperature [14]. The graphs of the dependences showed a change in the values of impact strength, which indicated a change in the state of the tool hard alloy. Up to the point of transition of the alloy from brittle to brittle-ductile state, a horizontal straight line is observed, characterizing the absence of changes in this section. Next, the transition from brittle to brittle-ductile state takes place, characterized by an increase in KCV values. The third section is a horizontal line, until the point of catastrophic destruction of cobalt is reached at 1100°C, characterizing the ductile state of the material [15]. Since this technique has a number of drawbacks associated with the need to produce special samples, the difficulty to ensure the temperature of the sample during testing, it was decided to develop a technique that would allow the study of standard cutting inserts.

The authors analyzed the physical properties of hard alloys, and found a structure-sensitive parameter. To compare and confirm the hypothesis that the physical properties of hard alloys reflect the state of the material during the cutting process very well, studies were conducted on changing the electromagnetic properties of hard alloys with the same group of materials.

The studies were carried out at the laboratory sites of the Machines and Tools Department of TIU on a specially designed installation Figure 1 [16]. In order to conduct the experiment, 3 regular representatives of the BK group were selected (BK6, BK8, BK10). The developed installation consists of a self-oscillating circuit 1 and an instrument panel 3. The self-oscillating circuit contains a field coil of an eddy current transducer assembled according to an autotransformer circuit 2, covered with a thermally insulating coating, and a housing with a printed circuit board 11 in it, consisting of a power supply 4, a transistor 5, two series-connected capacitors 6 and resistance 7. On the instrument panel 3, readings are taken from the thermometer 8 and voltmeter 9 [17].
Figure 1. Diagram of Installation for Determining the Temperature of Maximum Performance of Replaceable Cutting Inserts Made from Tool Hard Alloys

Based on the results of the research, a graph of the dependence of the EMF of the self-oscillatory circuit coil is constructed. The graph has a similar character of changes as the studies shown above. At the very beginning, we see an increase in EMF values, which corresponds to the transition of the alloy from a brittle to a brittle-ductile state, then peak values of the characteristic correspond to a transition from a brittle to a brittle-ductile state, and the third section, a drop in the EMF values, until the point of the catastrophic destruction of cobalt at 1100°C is reached, corresponds to the ductile state.

3. The results and their Discussion
The technique for determining the maximum performance temperature is based on the dependences of the measured characteristics changes on the temperature.

The data obtained by two methods were plotted on a single temperature scale.

Figure 2. Comparative Analysis of the Obtained Dependences for the BK8 Tool Hard Alloy

This graph clearly showed high correlation of the results obtained with the known method. The temperature range of the maximum self-oscillating coil EMF values corresponds to the zone of the increase of impact strength values and corresponds to the ductile state of the BK8 alloy.
4. Conclusions
The research data showed that the authors developed the method for determining the temperature of the maximum working capacity of replaceable cutting inserts by changing the magnetic field of eddy currents induced in tool hard alloys, which was highly correlative with the known method for determining the temperature of the maximum working capacity of replaceable cutting discs based on the dependence of impact strength on temperature, and the present method adequately reflected the state of the hard alloy during processing under the influence of high temperatures.

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