

Determination of Rational Processing Modes Based on Electromagnetic Properties of Tool Materials

Maria Ostapenko

Tyumen industrial University

Andrey Tveryakov

Tyumen industrial University

Anton Shtin

Tyumen industrial University

Yury Klochkov (✉ y.kloch@gmail.com)

Peter the Great St. Petersburg Polytechnic University <https://orcid.org/0000-0002-7913-8285>

Research Article

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Abstract

Currently, enterprises appoint cutting conditions according to reference data or on the recommendations of manufacturers. Often this information does not provide rational processing conditions. The situation is getting worse if we talk about modern automated metalworking equipment. The tool's premature failure involves high economic losses due to damage to the processed detail surface and according to receiving a manufacturing defect. Prevention of premature exit of metalworking tools will allow investigating changes of their operability under the effect of temperatures arising during cutting. Research subject: interchangeable cutter elements (plates) The goal of research: determine rational machining conditions based on electromagnetic properties of instrumental materials.

The article analysed existing methods for determining the temperatures of the ultimate operational capability of cutting elements from tool hard alloys (THA). We analysed the existing test facilities. As a result, a new facility was developed to determine the temperature of the ultimate operational capability of cutting THA elements, eliminating existing devices' identified shortcomings. A description of the developed method of determining the temperature of ultimate operational capability by changing the electrical conductivity of cutting elements from instrumental two-carbide titanium-tungsten-cobalt hard alloys WC-TiC-Co is given.

As a result of the work, electrical conductivity was studied depending on alloys' test temperature of group WC-TiC-Co. We determined the temperature conditions of ultimate operational capability of alloys 15%TiC+79%WC+6%CO, 5%TiC+75%WC+10%CO and obtained the corresponding temperature range of ultimate operational capability based on the obtained data. The obtained results can be used to determine rational cutting conditions when processing with these tool materials.

1. Introduction

The development of information technologies made it possible to automate a large number of processes related to metalworking. The advent of numerical control machines in the second half of the last century developed the work capacity, accuracy, and repeatability processes. Such equipment in some cases allows continuous processing of the entire product from a single facility. The modern facility is distinguished by high reliability, especially from eminent manufacturers of machine tools [1,2]. Note that the work tool is, as a rule, the weakest component in the system: machine tool, accessory, work tool, billet [3]. Modern metal cutting tools have also undergone some development. Built-up toolings with replaceable cutter today occupy the leading share of metal cutting tools. They have several advantages over neat or solid tools. From the point of view of efficiency, it is possible to reuse the tool body, use several faces for cutting, use different grades of interchangeable cutter elements in the same body, and select them for a specific technological operation [4]. This confirms the relevance of scientific research to determine the operability of replaceable cutting inserts from THA [5]. During operation, high temperatures caused by the work performed undercutting forces affect the tool [6]. Studying the dependence of physical and mechanical properties of THA on temperature will make it possible to determine the

operability of interchangeable cutter elements for prefabricated tools in the entire temperature range characteristic of the process of cutting materials [8] [9].

Therefore, increasing the efficiency of machining by determining the temperature of the ultimate operational capability of THA is an urgent problem [8] [9], [10], [11].

Several methods determine the conditions of ultimate operational capability of THA based on their physical and mechanical characteristics depending on temperature. [12], [13], [14]. Among the known methods for determining the ultimate operational capability of THA, in our opinion, the most suitable technique for practical use is based on determining the dependence of the electrical conductivity of a solid alloy on temperature [14], [15]. Unlike other parameters, electrical characteristics are easier to define due to the availability of measurement tools to determine these values' conditions. Electrical values due to the physical principle of electric power transmission are good indicators of material properties change.

The source [14] presents the study of samples' electrical conductivity from THA group WC-Co (single carbide tungsten-cobalt alloy). It remains unclear how much the proposed approach applies to other tool materials, with a higher red hardness.

The research subject is interchangeable cutter elements (plates).

The goal of the research is to determine rational machining conditions based on electromagnetic properties of instrumental materials.

Studies were carried out on two-carbide titanium-tungsten-cobalt hard alloys (WC-TiC-Co). For the experiment, we chose widely used THA (5%TiC+75%WC+10%CO, 15%TiC+79%WC+6%CO).

The objectives of the study were:

1. Develop a unit to determine the ultimate operational capability temperature.
2. Carry out experimental studies to determine temperature conditions of ultimate operational capability of THA of group WC-TiC-CO
3. Set graphical dependencies of THA electrical conductivity values on the test temperature.
4. Determine conditions of ultimate operational capability of THA of the group WC-TiC-CO provide rational machining conditions.

2. Section Title

The installation for determining the ultimate operational capability temperature of cutting tools used in early studies [16] has several drawbacks. They are related to the instability of the process of a heating hard metal tip, insufficient accuracy of determining values by visual control, unreliable clamping of a sample from THA through two electrically conductive leads. Therefore, it was decided to develop a new installation for determining the temperature of the ultimate operational capability of cutting elements

from THA by measuring electrical conductivity. Tests were carried out on a group of WC-TiC-Co alloys having a higher red hardness than the WC-Co group. Therefore, to achieve a stable temperature rise, we used pawl arrangement for a gas burner. Also, to simplify practical use, the process of constructing explicit dependencies and determining the temperature interval of the ultimate operational capability of THA using a personal computer was automated.

There are three representatives of the group WC-TiC-Co to determine the temperature of THA's ultimate operational capability: 5%TiC+75%WC+10%CO, 15%TiC+79%WC+6%CO. During the experiment, cutter elements of the standard tetrahedral form SNMA according to GOST 19051 [17] were used. Tests were carried out on the developed installation (Fig.1), which consists of mounting rack, table, power supply system (which includes measuring instruments: voltmeter, ammeter and thermometer) and personal computer (PC). The mounting rack is a platform with a leading screw, along which the nut moves, lifting and lowering the tab with a clip on the hinge to fix and adjust the position of the gas burner. Table comprises a body and a dielectric loading. Table comprises a body and a dielectric loading, a sample of THA fixed by clamping jaws in the cavity of which there is a ceramic dielectric with a groove with a rectangular copper current-carrying plate installed in it, a pressure butterfly screw with rounded petals. Power supply system and measuring instruments are brought together into installation console with the possibility of visual monitoring of test indication, and transmission of information from measuring instruments during operation of installation via communication bus is transmitted to PC for instrumentation recording and determination of the temperature of ultimate operational capability.

The experiment began by placing a comparison specimen of THA on the dielectric loading located in the body of the developed plant table. The comparison specimen from THA is fixed with clamping jaws in the cavity of which there is a ceramic dielectric with a groove with a rectangular copper current-carrying plate installed in it, a pressure butterfly screw with rounded petals. The console remote controller is then energised by turning on the button, and the power supply indicator light is turned on. Fine adjustment of burner position is performed by height using nut on leading screw and by tilt angle using clip on the hinge, and the heating rate is controlled using the gas delivery adjustment screw. During comparison specimen heating from THA, fixation of test indication using command console, information from measuring instruments during operation of the unit is transmitted via communication buses to PC to record measurement results determination of ultimate operational capability temperature.

The ultimate operational capability temperature is determined using the software. Software plots dependency diagram of electrical conductivity on temperature $G = f(\theta)$ (Fig.2) of cutting elements from THA based on test results. The range for metal cutting treatment is taken from 400 to 1000 ° C [20].

The software determines value G^* equal to the sum of minimum value of electrical conductivity G_{\min} (10^{-2} S) and five per cent value of change of this characteristic (since five per cent error is considered acceptable for engineering calculations) [21]. Next, in the graph, the program puts the value G^* (10^{-2} S) and through this point draws a straight parallel to the abscissa axis before intersecting with the graph lines. The sharp point projected on the abscissa axis is accepted as the limits of the temperature interval

of the ultimate operational capability of the THA. [22]. The program displays information on the experiment results in the form of a message to the user.

3. Results And Discussion

The results of studies of alloys of group WC-TiC-Co obtained the following temperature intervals of ultimate operational capability: 5%TiC+75%WC+10%CO - (740-780 °C), 15%TiC+79%WC+6%CO - (590-670 °C), (Fig.2-3).

The obtained temperature range of the conditions of ultimate operational capability of the THA correlates well with the results of studies using different methods given in the works [8], [16], [17].

Table 1 Analysis

Material	Known techniques	Methods of authors
5%TiC+75%WC+10%Co	720÷790°C	730÷780°C
15%TiC+79%WC+6%Co	850÷940°C	860÷970°C

4. Conclusion

Thus, during the study, a new installation was developed to determine the temperature of the ultimate operational capability of cutting elements from THA. It takes into account the shortcomings identified from previous studies. Investigational study of cutting elements was carried out at the developed plant to determine ultimate operational capability temperatures. Graphical dependencies of electrical conductivity values on temperature were built, and temperature conditions of ultimate operational capability of the THA of group WC-TiC-Co were determined. The procedure workability has been proved not only for alloys of the WC-Co group but also for alloys of the WC-TiC-Co group in laboratory conditions. Rational machining conditions are determined by fixing process variables corresponding ultimate operational capability temperature of cutting element material.

Moreover, the best result will be achieved if we can, in the treatment process, in real-time, collect the temperature values in the cutting zone. Based on these data, using a computerised numerical control system, correction of machining conditions is carried out to ensure a constant temperature in the cutting zone. With this, we will significantly increase the reliability of the entire machine tool-tool-part system. With this, we will significantly increase the reliability of the entire machine tool-accessory- work tool-billet.

Declarations

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The authors have consent to participate.

Consent to Publish:

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Authors Contributions:

Study conception and design: **Maria Ostapenko**

Acquisition of data: **Anton Shtin, Yury Klochkov**

Analysis and interpretation of data: **Andrey Tveryakov**

Drafting of manuscript: **Yury Klochkov**

Competing Interests. There is no any conflict of interest to declare.

Availability of data and materials: The data that support the findings of this study are available from the corresponding author

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Figures

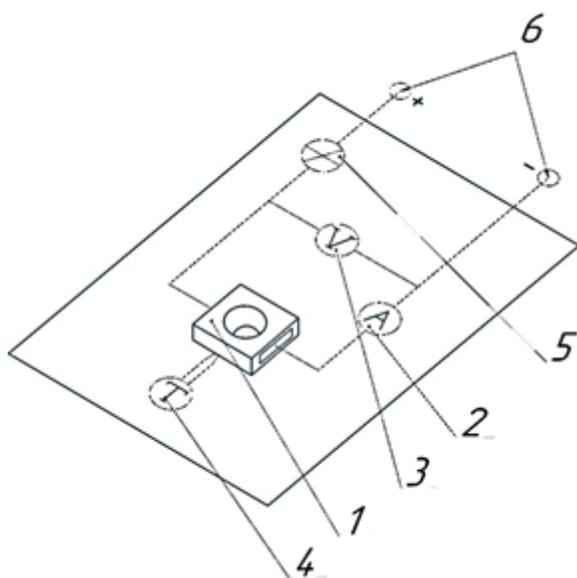


Figure 1

Installation diagram: 1 - Replaceable cutting insert; 2 - Ammeter; 3 - Voltmeter; 4 - Thermometer; 5 - Performance indicator; 6 - Power outputs.

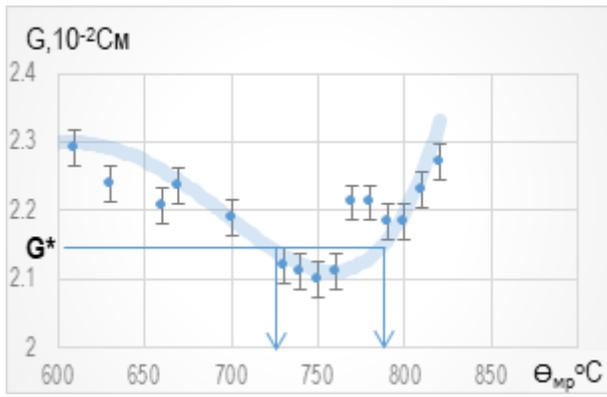


Figure 2

Dependence of electrical conductivity on alloy temperature 5%TiC+75%WC+10%Co

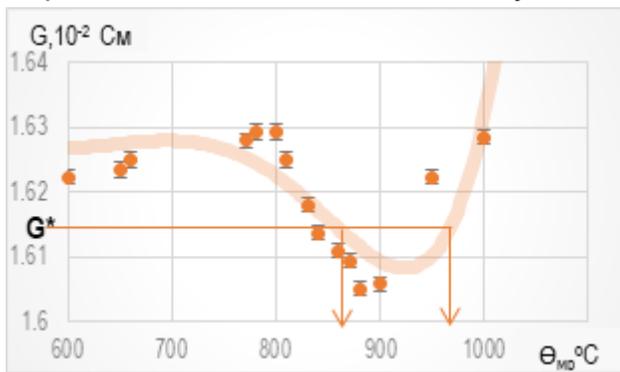


Figure 3

Dependence of electrical conductivity on alloy temperature 15%TiC+79%WC+6%Co