Determination of conditions ensuring maximum operability of replaceable hard-alloy cutting plates during blade processing

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Abstract. This study is devoted to the definition of conditions ensuring maximum operability of replaceable hard alloy cutting plates during blade processing of hard-to-process materials, with assessment of the possibility to use the tool of Russian production without loss of processing efficiency, as well as the possibility to implement adjustments of regime conditions in non-stop mode, using cloud services in enterprises with network structure, thus supporting the implementation of smart production and the fourth industrial revolution.

1. Introduction
Today the industry is experiencing the fourth industrial revolution – ‘INDUSTRIE 4.0’. Smart manufacturing is a continuous interaction between the digital and the real world. Digital processes with a network structure in INDUSTRIE 4.0 will make it possible to produce products with rational use of resources and economic effect.

Storing of various technological reference information on cloud media will speed up the process of digitalization. Systems will be able to quickly learn and develop. Today we are creating a completely new world of manufacturing.

![Figure 1. Development of industrial revolutions.](image)

The new world will enable you to adjust cutting modes from data on cloud storage.

Leading tool companies such as Sandvik Coromant, Mitsubishi, Walter, Iscar and others give the recommended operating characteristics in their brochures, but as is known from factory practice, these cutting modes are set too low to ensure maximum tool life.

Many domestic and foreign scientists, such as: A.S. Vereshchaka [1], S.N. Grigoriev [2], V.S. Kushner [3], T.N. Loladze [4], A.D. Makarov [5], M.F. Poletika [6], S.S. Silin [7], M.Kh. Uteshev...
[8], V.G. Shalamov [9], R. Neugebauer [10], H. Zhang [11] and etc. worked on improving the efficiency of cutting tools.

The goal of this study is to determine the conditions that ensure maximum performance of replaceable hard-alloy cutting plates during blade processing.

To achieve this goal, it is necessary to solve the following tasks:
1. To conduct an analysis of literature.
2. To study the known methods for determining the conditions that ensure the maximum performance of replaceable hard-alloy cutting plates during blade processing.
3. To investigate the possibility of applying the conditions that ensure maximum performance of replaceable hard-alloy cutting plates with cloud services.

The subject of this research is a cutting plate made of a tool hard alloy.

2. Description of research.

The literary analysis showed that the determining factor in the entire relationship of phenomena during cutting of materials is the temperature-force factor in combination with the physical and mechanical characteristics of the tool and processed materials [12], [13].

The mechanical properties of tool materials change during cutting under the influence of various factors; this phenomenon is very complex and has not been fully studied. These changes should be turned in our favor, for this it is necessary to have an idea of the physical component of this process [14], [15].

The patent analysis showed that the eddy-current method of non-destructive testing, which is based on the interaction of the external magnetic field of the excited eddy currents in the object with the magnetic field of the coil, will be most suitable for this study.

![Figure 2. Eddy current method of non-destructive testing.](image)

Tool hard alloys are composites, which means that the properties of their components can be considered separately. The connecting element is cobalt, which has magnetic properties, as well as two phase transitions at 427 °C and at 1100 °C - (Curie point, the point at which the material symmetrically changes its properties).

Professor Loladze T.N. carried out some investigations and it was found that hard alloys during blade processing have a point of loss of shape stability of the cutting wedge at 1100 °C. This study proves correctness of the chosen physical phenomenon for the development of a device for determining conditions that ensure the maximum performance of replaceable hard-alloy cutting plates during blade processing.

To solve the second problem, a special laboratory setup was developed.
3. Results and their discussion.

The experiment was carried out in laboratory conditions on standard replaceable cutting plates of a tetrahedral shape in accordance with GOST 19051 from instrumental hard alloys of the VK group (WC-Co), Figure 4.

![Figure 4. Replaceable cutting plate (GOST 19052-80).](image)

The plates are heated up to 1000 °C, simulating the conditions to which the plates are exposed during metal cutting. The magnetic field is measured and a graph of dependences on temperature is plotted, Figure 5.

![Figure 5. The resulting dependence.](image)

From the dependence shown in Figure 5, it can be seen that there is a characteristic temperature interval corresponding to 5% of the error, and corresponding to the conditions providing the maximum performance of replaceable hard-alloy cutting plates during blade processing. The obtained temperature interval correlates with the results obtained by Professor A.D. Makarov during resistance tests [5].
The obtained data in the form of a temperature interval can be used in production with a network structure implemented in the enterprise.

![Diagram](image)

**Figure 6.** The diagram for implementing adjustments through cloud services at an enterprise with a network structure.

4. Conclusions

Literary analysis, as well as our research show that with all the complexity of the processes occurring during blade processing, temperature is the main indicator of the state of the tool. Thus, this study shows that determination of the temperature of the maximum performance of replaceable hard-alloy cutting elements based on changes in the electromagnetic properties of tool hard alloys from temperature responds well to changes in properties. At the same time, the obtained temperature intervals correlate well with the results of known techniques, and the proposed solution not only simplifies determination of cutting conditions for new alloys and processed materials, but also makes it possible to implement corrections of operating conditions in non-stop operation, using cloud services in networked enterprises, thereby supporting implementation of smart manufacturing and the fourth industrial revolution.

References

[1] Vereshchaka A.S. Efficiency of cutting tools with wear-resistant coatings. / Vereshchaka A.S. - M.: Mashinostroenie Publ., 1993. - 336 p.: ill. - (Library of toolmaker). - ISBN 5-217-01482-2.
[2] Grigoriev S.N. Methods for increasing resistance of the cutting tool: a textbook for students of technical colleges [Electronic resource]: textbook. - Electr. data. - Moscow: Mashinostroenie Publ., 2009. - 368 p.
[3] Vasin S.A. Cutting materials: Thermomechanical approach to the system of interconnections during cutting: textbook for technical universities. / S.A. Vasin, A.S. Vereshchaka, V.S. Kushner - M.: Publishing house of N.E. Bauman MSTU, 2001. - 448 p.
[4] Loladze T.N. Strength and wear resistance of the cutting tool. / T.N. Loladze - M.: Mashinostroenie Publ., 1982. - 320 p.
[5] Makarov A.D. Optimization of cutting processes. / A.D. Makarov, 2nd ed. - M.: Mashinostroenie Publ., 1976. – 278 p.
[6] Poletika M.F. Contact loads and temperatures on a worn tool. / M.F. Poletika, V.N. Kozlov // Progressive technological processes in mechanical engineering: Collection of scientific papers. - Tomsk: TPU, 1997. - pp. 18-21.
[7] Silin S.S. Similarity method for metal cutting / S.S. Silin - M.: Mashinostroenie Publ., 1979. - 152 p.
[8] Zorev N.N. Untersuchung der Kintakt-spannunger auf den Arbeits-flachen des Werkzeugs miteiner Schneidenabrundung / Zorev N.N., Uteshev M.H. – Berichte der Internationalen For
schungesgemeinschaft für mechanische produktionstechnik Vol. 20-1 Schweiz, 1971.

[9] Shalamov V.G. Savel’ev D.A., Smetanin S.D. Producing powder by rotary grinding. Allerton Press, Inc. (New York) Volume 33, Issue 3, 2013, Pages 133-135 DOI: 10.3103/S1068798X13030167

[10] Neugebauer R., Hochmuth C. Schmidt G., Dix M. Energy efficient process planning based on numerical simulations. Advanced Materials Research 2011, Volume 223, Pages 212-221, 17th CIRP Conference on Modelling of Machining Operations; Sintra; Portugal; 12 May 2011 до 13 May 2011. DOI: 10.4028/www.scientific.net/AMR.223.212.

[11] Zhang H., Fang Z.Z., Lu Q. Characterization of a bilayer WC-Co hardmetal using Hertzian indentation technique. International Journal of Refractory Metals and Hard Materials Volume 27, Issue 2, March 2009, Pages 317-322. DOI: 10.1016/j.ijrmhm.2008.07.014.

[12] Artamonov E.V., Strength and performance of replaceable hard alloy plates for prefabricated cutting tools, Tyumen, Vector Buk Publ., 2003, 190. ISBN: 5-88465-416-2.

[13] Vasilega D.S., Shtin A.S., Method for the determination of hard alloys' maximum performance temperature in the context of the metal-cutting tools' usage quality estimation technique.// Key Engineering Materials 737. M. pp. 59-63, 2017.

[14] Artamonov E.V., Vasilega D.S., Tveryakov A.M., Determination of temperature of the maximum workability of hard alloy cutting plates based on electrical conductivity. // Factory laboratory. Diagnostics of materials. Vol. 80. No. 9, pp. 36-39.

[15] Tveryakov A.M., Shtin A.S., Setup for determining the maximum temperature for increased performance longevity of replaceable cutting discs.// AIP Conference Proceedings, 1785,040088, 2016. DOI: 10.1063/1.4967145.

[16] RF patent No. 172959 IPC B23B1/00. Installation for determining the temperature of maximum performance of hard-alloy cutting plates / E.V. Artamonov, A.M. Tveryakov, A.S. Shtin - Application No. 2016130884 dated July 26, 2016. Publ. 08/02/2017 Bulletin No. 22.