TASHKENT STATE UNIVERSITY OF ECONOMICS

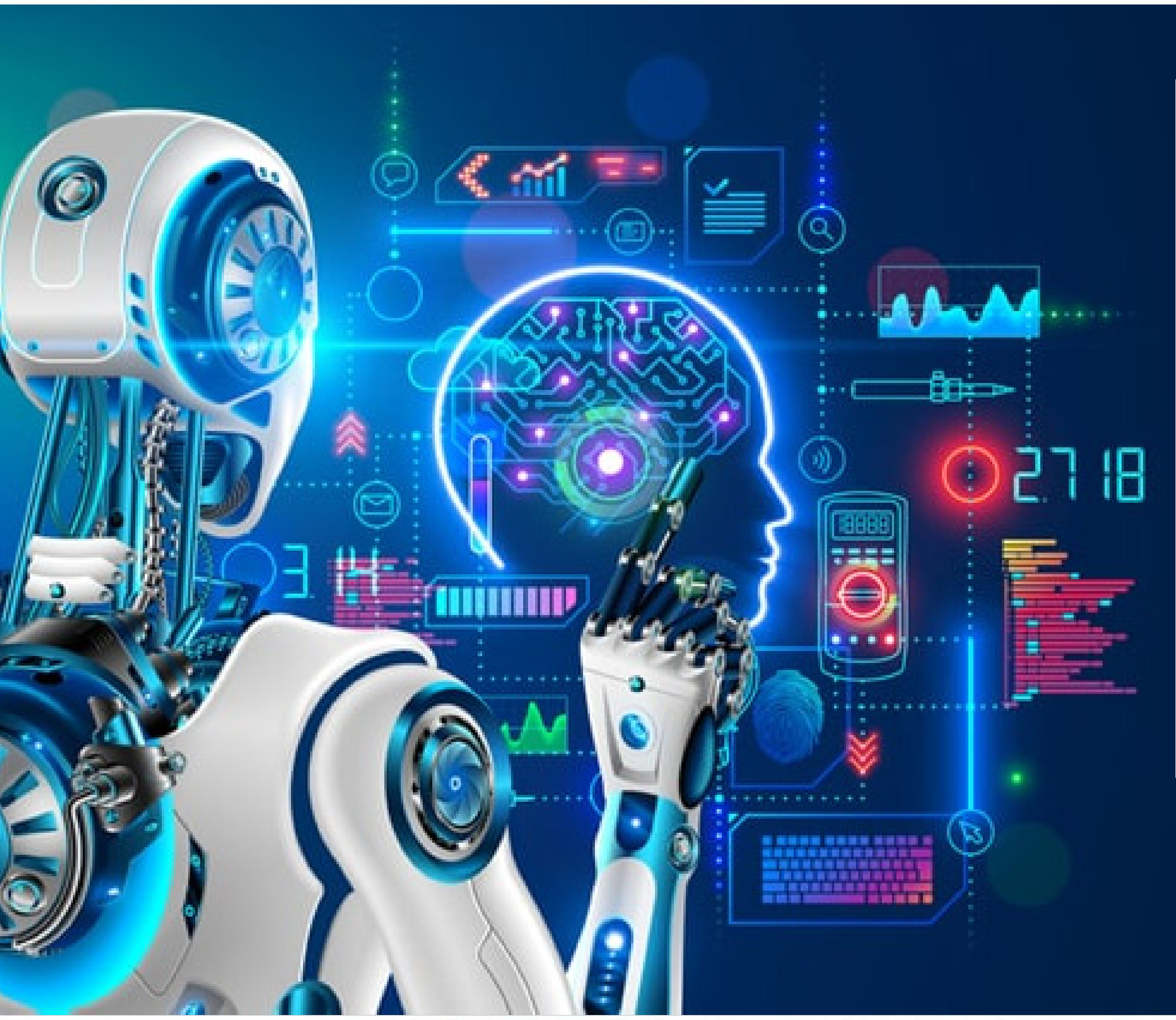
International journal of topics

INNOVATION SCIENCE AND TECHNOLOGY

Scopus || Electronic journal specializing in Scopus

ISSUE 12

Acceptance of papers **December, 2025**



Acceptance of papers

Published monthly

Topics

economics, technology, social sciences

ISSN 3060-5229

OpenAIRE Google Scholar Academic Resource Index ResearchBib BASE doi Digital Object Identifier OPEN ACCESS

Visit the website
t.me/scopus_IST2100

EDITOR-IN-CHIEF:
Mirzaliyev Sanjar Makhamatjon ugli

DEPUTY EDITOR-IN-CHIEF:
Makhmudov Nosir Makhmudovich
DSc., Prof., Academican

DEPUTY EDITOR-IN-CHIEF:
Ochilov Bobur Bakhtiyor ugli – Senior lecturer at TSUI

THE SCIENTIFIC-POPULAR ELECTRONIC JOURNAL **"INNOVATION SCIENCE AND TECHNOLOGY"** HAS BEEN REGISTERED UNDER THE NUMBER **C-5669633** BY THE AGENCY FOR INFORMATION AND MASS COMMUNICATIONS (AOKA) OF THE REPUBLIC OF UZBEKISTAN, EFFECTIVE FROM OCTOBER 9, 2024.

CONTACTS

Phone: **+998 50 737 87 88**

Website: https://ist-journal.uz

Email: innovationist2025@gmail.com

The scientific electronic journal "Innovation Science and Technology" has been included in the list of scientific publications recommended for the publication of main scientific results of dissertations for the award of PhD and DSc degrees in economics and technical sciences, in accordance with the Resolution No. 370 of the Presidium of the Higher Attestation Commission of the Republic of Uzbekistan, dated May 8, 2025.

Electronic publication, Issue 12. 263 pages.
Approved for publication on December, 2025.

Editorial board:

Sharipov Kongiratbay Avezimbetovich,
Doctor of Technical Sciences (DSc), Professor

Abdurakhmanova Gulnora Kalandarovna,
Doctor of Economic Sciences (DSc), Professor

Cham Tat Huei,
Doctor of Philosophy (PhD), Professor (Malaysia)

Muhammad Imran Sadiq
Doctor of Philosophy in Economics (PhD), Professor, Malaysia

Ahmed Aziz Ismail
Doctor of Technical Sciences (DSc), Professor (Egypt)

Lee Chin
Doctor of Philosophy in Economics (PhD), (Malaysia)

Asongu Simplice
Doctor of Philosophy in Economics (PhD), Cameroon

Rui Dang
Doctor of Chemistry (DSc), Professor, China

Zahoor Ahmed
Doctor of Philosophy in Economics (PhD), Turkey

Shujaat Abbas
Doctor of Philosophy in Economics (PhD), Russia

Tina A Coffelt
Doctor of Philosophy in Educational Sciences (PhD), USA

Abdikarimova Dinara Rustamxanovna
Doctor of Economic Sciences (DSc), Professor

CONTENTS

CONTENTS

THEORETICAL STUDY OF TEMPERATURE AND THERMAL PHENOMENA IN MECHANICAL CUTTING OF WHITE CAST IRON

Allanazarov Akmal Abdulxaqovich
Associate Professor, Termez State University of Engineering and Agrotechnologies
ORCID: 0000-0003-3332-6843
Email: allanazarov1213@gmail.com

Abstract: The article is devoted to the theoretical study of temperature and heat phenomena during the mechanical cutting of white cast irons, the primary plastic deformation occurring in the shear plane, the amount of heat released in the conditional shear plane were analyzed. It is known that white cast irons have high hardness, strength and creep resistance, which greatly complicates the process of their mechanical processing. We theoretically studied the change in the temperature generated by friction on the front surface of the cutting tool during the mechanical processing of white cast irons depending on the type of white cast iron and the cutting speed.

Key words: mechanical energy, white cast iron, hard alloy, chip, wear, cutting speed, density, plastic deformation, physicochemical, tool blade, cutting tool, friction.

Annotatsiya: Maqola oq cho'yanlarni mexanik kesib yo'nish jarayonida harorat va issiqlik hodisalarini nazariy tadqiq etishga bag'ishlangan bo'lib, siljish tekisligida sodir bo'ladigan birlamchi plastik deformatsiya hamda shartli siljish tekisligida ajralib chiqadigan issiqlik miqdori tahlil qilindi. Ma'lumki, oq cho'yanlar yuqori qattiqlik, mustahkamlik va yeyilishga bardoshlik xususiyatlariga ega bo'lib, bu holat ularni mexanik ishlov berish jarayonini o'ta murakkablashtiradi. Tadqiqotda oq cho'yanlarni mexanik ishlov berish jarayonida kesuvchi asbobning oldingi yuzasida ishqalanish natijasida hosil bo'ladigan haroratning oq cho'yan turlariga va kesish tezligiga bog'liq holda o'zgarishi nazariy jihatdan o'rganildi.

Kalit so'zlar: mexanik energiya, oq cho'yan, qattiq qotishma, qirindi, yeyilish, kesish tezligi, zichlik, plastik deformatsiya, fizik-kimyoviy, asbob tig'i, kesuvchi asbob, ishqalanish.

Аннотация: Статья посвящена теоретическому исследованию температурных и тепловых явлений при механической обработке резанием белых чугунов. Проведен анализ первичной пластической деформации, протекающей в плоскости сдвига, количества выделяющегося тепла в условной плоскости сдвига. Известно, что белые чугуны обладают высокой твердостью, прочностью и сопротивлением ползучести, что значительно затрудняет процесс их механической обработки. Теоретически исследовано изменение температуры, возникающей при трении на передней поверхности режущего инструмента при механической обработке белых чугунов, в зависимости от марки белого чугуна и скорости резания.

Ключевые слова: механическая энергия, белый чугун, твердый сплав, стружка, износ, скорость резания, плотность, пластическая деформация, физико-химические свойства, лезвие инструмента, режущий инструмент, трение.

INTRODUCTION

During mechanical cutting of metals, the cutting tool is subjected to active loads, elevated temperatures, and chemical interactions with the material being machined. This article is devoted to a theoretical study of temperature and thermal phenomena occurring during the mechanical cutting (machining) of white cast irons, based on a theoretical analysis of the mechanical cutting process of materials.

In mechanical cutting of metals, the generated heat is determined by the sum of the heat produced by primary plastic deformation occurring in the shear plane AB (Figure 1) and the frictional heat generated on the contact surfaces of the cutting tool's rake face (and the flank face in the case of constrained cutting processes) [1].

REVIEW OF LITERATURE ON THE SUBJECT

Theoretical and experimental studies of temperature and thermal phenomena in metal cutting have long occupied a central place in machining science, as thermal effects largely determine tool wear, surface quality, and process stability. Classical works in the field of materials cutting emphasize that heat generation during cutting is primarily associated with plastic deformation in the shear zone and friction at the tool–chip and tool–workpiece interfaces. In this context, Vereshchak and Kushner provide a comprehensive theoretical foundation for understanding cutting mechanics, heat generation sources, and their influence on tool performance. Their work systematically analyzes the interaction between cutting parameters, material properties, and thermal loads acting on the cutting tool, forming a methodological basis for subsequent studies on temperature fields in cutting processes.

Further development of cutting theory is closely related to the study of chip formation mechanisms and their dynamic behavior. Kozočkin's research on self-excited oscillatory mechanisms of chip formation highlights the complex nature of deformation and friction processes occurring during cutting. Although his work focuses primarily on chip instability, it also implicitly demonstrates the role of thermal effects, since temperature variations significantly affect material plasticity, friction conditions, and the stability of chip formation. These findings are especially relevant for hard-to-machine materials, such as white cast iron, where high cutting temperatures intensify tool wear and affect chip morphology.

A significant contribution to the theoretical analysis of thermal phenomena in cutting processes is made through computer modeling and optimization approaches. Pestretsov's учебное пособие on computer modeling of cutting processes presents modern methods for simulating heat generation, heat transfer, and temperature distribution in the cutting zone. The application of numerical modeling allows for a more detailed analysis of local temperature maxima in the shear plane and contact zones, which is difficult to achieve experimentally. Such approaches are particularly valuable for white cast iron, whose high hardness and resistance to plastic deformation lead to concentrated thermal loads in limited contact areas.

The concept of automated design of cutting processes, developed by Pestretsov, Altunin, Sokolov, and Odnolko, further advances the theoretical framework by integrating mechanical and thermal models into computer-aided process planning systems. Their work emphasizes the need to account for material thermophysical properties, cutting conditions, and tool geometry when predicting temperature levels and heat fluxes. This integrated approach is directly applicable to the theoretical study of temperature and thermal phenomena in the mechanical cutting of white cast iron, as it enables systematic evaluation of how cutting speed, material strength, and thermal conductivity influence frictional heating and overall temperature in the cutting zone.

Overall, the reviewed literature demonstrates that the theoretical study of thermal phenomena in cutting processes requires a combined analysis of mechanical energy dissipation, frictional interactions, and heat transfer mechanisms. Existing studies provide a solid scientific basis for analyzing temperature fields in metal cutting; however, the specific case of white cast iron, characterized by high hardness and low machinability, necessitates further focused theoretical investigations. This justifies the present study, which aims to deepen the understanding of temperature formation and thermal behavior during the mechanical cutting of white cast iron.

RESEARCH METHODOLOGY

According to A.D. Makarov and V.S. Mukhina, the amount of heat released in the conditional shear plane during the cutting process can be determined using the following formula [2]:

$$Q_{AB} = \frac{a_1 b_1 c_\rho \theta_A}{\operatorname{erf}\sqrt{\frac{\mathrm{Pe} B}{4}}}, \quad (1)$$

Here, θ_A – denotes the maximum temperature of the primary plastic deformation in the conditional shear plane (at point A of the cutting tool edge), °C.

The mechanical energy of plastic deformation in the conditional shear plane of the material being machined and in the adjacent regions is expressed by the following formula:

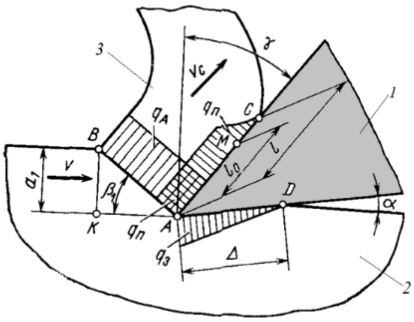
$$L_{AB} = R_c \cos\beta_1 v = \frac{\tau_p a_1 b_1 v}{B}, \quad (2)$$

Thus, using the equality of mechanical and thermal energies $L_{AB} = Q$, the maximum temperature at point A on the conditional shear plane can be expressed as follows:

$$\theta_A = \frac{\tau_p a_1 b_1 v}{c_\rho B} \operatorname{erf}\sqrt{\frac{\mathrm{Pe}B}{4}}, \quad (3)$$

According to equation (3), the maximum temperature in the conditional shear plane depends on the mechanical and thermal properties of the material being machined (λ, s, ρ, a), as well as on the degree of its deformation and the cutting conditions.

Mechanical cutting processes are characterized by the presence of three main rapidly moving planar heat sources, with width $AB = \frac{a_1}{\sin\beta_1}$, AC = l and lengths $AC = l$ and $AD = \Delta$, associated with the chip and the workpiece. The heat sources AS and AD are stationary relative to the cutting tool (Figure 1).



1 – cutting tool edge; 2 – workpiece being machined; 3 – chip being formed

Figure 1. Scheme of the distribution of heat release intensity on the contact surfaces of the cutting tool edge and in the shear plane [3]

The maximum heat release intensity q_A, q_n, and q_3 in the conditional shear plane AB and in the adjacent contact regions $AC = l$ and $AD = \Delta$ can be determined from the balance equation of mechanical and thermal energies.

According to equation (2), the amount of heat released over 1 second is expressed in J/s as follows:

$$Q_{AB} = q_A \frac{a_1 b_1}{\sin\beta_1}, \quad (4)$$

Since $L_{AB} = Q_{AB}$, we obtain:

$$q_A \frac{a_1 b_1}{\sin\beta_1} = \frac{\tau_p a_1 b_1 v \cos\beta_1}{\sin\beta_1}$$

After simplification, the final expression is:

$$q_A = \tau_p v \cos\beta_1. \quad (5)$$

Thus, the heat release intensity in the conditional shear plane AB increases with an increase in the strength τ_p of the material being machined and the cutting speed v, as well as with a decrease in the inclination angle of the conditional shear plane.

Analysis and results

The mechanical energy of friction in the contact region of the cutting tool edge is given by:

$$L_{AC} = \overline{\tau}_{AC} b_1 l v_c = 0{,}6875 \tau_p b_1 l \frac{v}{k_a}. \quad (6)$$

Here, τ denotes the average shear stress in the AC region, N/m².

Then, the amount of heat released over 1 second is:

$$Q_{AC} = \overline{q}_{AC} b_1 l_{\Gamma} = 0,6875 q\ b l \quad (7)$$

Here, q represents the average heat release intensity in the AC region.

From equations (6) and (7), we obtain the following expression:

$$q_{\text{ï}} = \tau_p \frac{v}{k_a} = \frac{\tau_p v B}{\cos\gamma + B\sin\gamma} \quad (8)$$

From the given equation, it can be seen that the heat release intensity on the rake face of the cutting tool increases with an increase in cutting speed and with a decrease in the thickness (cross-sectional engagement) of the chip.

The mechanical energy of friction in the contact region on the flank face of the cutting tool is:

$$L_{AD} = \overline{\tau}_{AD} b \Delta v \cos\alpha = 0,5 \tau_p b \Delta v \cos\alpha \quad (9)$$

Here, $\overline{\tau}_{AD}$ – denotes the average shear stress in the AD region, N/m²;

Δ - is the size of the contact region between the flank face of the cutting tool edge and the machined surface (Figure 1), m;

b – is the width of the flank face of the cutting tool edge, calculated according to equation (9), m.

Then, the amount of heat released over 1 second is:

$$Q_{AD} = \overline{q}_{AD} b \Delta = 0,5 q_3 b \Delta \quad (10)$$

Here, $\overline{q}_{AD}$ – denotes the average heat release intensity in the AD region.

According to equations (9) and (10), we obtain:

$$q_{\text{ç}} = \tau_p v \cos\alpha \quad (11)$$

From expression (11), it can be seen that an increase in the strength τ_p of the material being machined and the cutting speed v, as well as a decrease in the clearance angle α, leads to an increase in the heat release intensity on the flank face of the cutting tool edge. Taking into account that the sum of the average heat fluxes is equal to q_n and q_3, and considering equations (8) and (11), we obtain:

$$\overline{q}_{\text{ï}} = 0,6875 \frac{\tau_p v B}{\cos\gamma + B\sin\gamma}; \quad (12)$$

$$\overline{q}_{\text{ç}} = 0,5 \tau_p v \cos\alpha \quad (13)$$

The heat generated by friction on the rake face of the cutting tool edge is distributed between the chip, the workpiece being machined, and the cutting tool itself. The scheme developed for calculating thermal phenomena during the cutting process is shown in Figure 1.

According to S.S. Silin, the mechanical energy on the rake face of the cutting tool edge and the corresponding frictional heat are expressed by the following equation:

$$L_{\text{ï}} = Q_{\text{ï}} = F_{\text{ï}} v_{\text{ñ}} = F_{\text{ï}} v \frac{B}{\cos\gamma + B\sin\gamma} \quad (14)$$

If we take into account the formula developed for $F_{\text{ï}} = \tau_p a_1 b_1 \left(\frac{\cos\gamma + \sin\gamma}{B} - \cos\gamma + \sin\gamma \right)$ we obtain:

$$Q_{\text{ï}} = \tau_{\delta} a_1 b_1 v \frac{\cos\gamma + \sin\gamma - B(\cos\gamma - B\sin\gamma)}{\cos\gamma + B\sin\gamma} \quad (15)$$

This heat $Q_п$ is distributed between the chip and the cutting tool:

$$Q_{\text{ï}} = Q_{\text{ñ.ï}} + Q_{\text{ð.ï}}, \quad (16)$$

where $Q_{c.p}$ and $Q_{r.p}$ are the portions of frictional heat transferred from the contact surface to the chip and to the cutting tool, respectively, J/s.

According to S.S. Silin, the amounts of heat transferred to the chip and to the cutting tool are expressed as follows:

$$Q_{\text{č.}} = n\tau_{\text{þ}} a_1 b_1 v \frac{\cos\gamma + \sin\gamma - B(\cos\gamma - \sin\gamma)}{\cos\gamma + B\sin\gamma}; \quad (17)$$

$$Q_{\text{č.}} = (1-n)\tau_{\text{þ}} a_1 b_1 v \frac{\cos\gamma + \sin\gamma - B(\cos\gamma - \sin\gamma)}{\cos\gamma + B\sin\gamma}. \quad (18)$$

Then, the following expressions for the heat fluxes are valid:

$$\bar{q}_{\text{ñ.ï}} = \frac{Q_{\text{ñ.ï}}}{b_1 l} = \frac{0,6875 n\tau_p vB}{\cos\gamma + B\sin\gamma}; \quad (19)$$

$$\bar{q}_{\text{ñ.ï}} = \frac{Q_{\text{ñ.ï}}}{b_1 l} = \frac{0,68759(1-n)\tau_p vB}{\cos\gamma + B\sin\gamma}. \quad (20)$$

Equations (17)–(20) take into account only the frictional heat in the contact region $b_1 l$ and do not consider the heat generated in the conditional shear plane AB.

The maximum temperature generated by friction is expressed as follows [74]:

$$\theta_{\text{ì}} = 0,9675 \frac{n\tau_p \sqrt{\text{Pe}}}{c_p} \sqrt{\frac{\cos\gamma + \sin\gamma - B(\cos\gamma - \sin\gamma)}{\cos\gamma + B\sin\gamma}}; \quad (21)$$

To theoretically determine the overall temperature in the cutting process, the following formula is applied [4]:

$$\theta = \frac{\tau_p \operatorname{erf}\sqrt{\frac{\text{Pe}}{4}}}{c_p B(1+k)} \left[1 + 0,73\psi_M + 0,5k\left(1 + \frac{\sin^{0,25}\alpha}{\sqrt{PeE}B^{1,25}} + 1,72\psi_N\right)\right]; \quad (22)$$

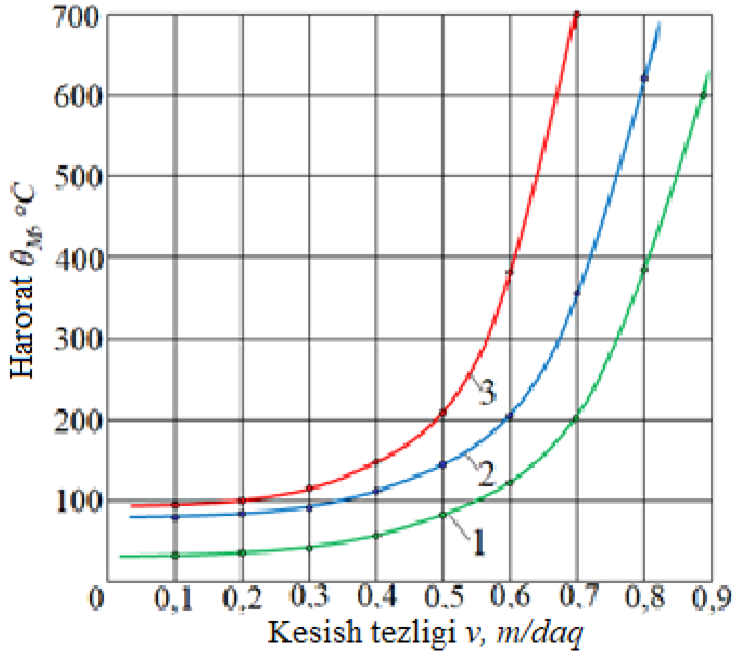
As can be seen from equation (21), the maximum temperature generated by friction on the rake face of the cutting tool edge increases with an increase in the strength τ_p of the material being machined and the cutting condition parameter Re, and decreases with an increase in the thermal conductivity λ of the material being machined and the inclination angle of the conditional shear plane.

It is known that white cast irons are characterized by high hardness, strength, and resistance to wear, which makes their mechanical machining extremely difficult. Based on equation (21), we theoretically investigated the variation of the temperature generated by friction on the rake face of the cutting tool during the mechanical machining of white cast irons as a function of the type of white cast iron (τ_p) and the cutting speed (v).

The following initial data were used in the calculations: for the cutting tool edge: VK6; geometric parameters: γ = 12°; α = 12°; φ = 45°; $φ_1$ = 15°; r = 0; thermal conductivity coefficient: $\lambda_{VK6} = 62.8\ \text{J}/(\text{m}\cdot\text{s}\cdot{}^\circ\text{C})$; for the material being machined: resistance to plastic deformation $\tau_p = 4.5 \ldots 7.5 \times 10^9\ \text{N/m}^2$; thermal conductivity coefficient: $\lambda_{\text{white cast iron}} = 80.4\ \text{J}/(\text{m}\cdot\text{s}\cdot{}^\circ\text{C})$; specific volumetric heat capacity: $c_p = 7.02 \times 10^6\ \text{J}/(\text{m}^3\cdot{}^\circ\text{C})$; thermal diffusivity coefficient: $a = 12 \times 10^{-6}\ \text{m}^2/\text{s}$; cutting conditions: feed $s = 0.2 \times 10^{-6}\ \text{m/rev}$; depth of cut $t = 2 \times 10^{-3}\ \text{m}$; uncut chip thickness $a_1 = 0.141 \times 10^{-3}\ \text{m}$; $b_1 = 2.83 \times 10^{-3}\ \text{m}$; cutting speed: v was taken in the range of $0.05 \ldots 0.9\ \text{m/min}$.

CONCLUSIONS AND SUGGESTIONS

Based on the results of the theoretical calculation of the temperature θ_M generated by friction in the contact region on the rake face of the cutting tool edge during mechanical turning of white cast irons as a function of the cutting speed v, the corresponding graph is presented in Figure 2 (Figure 2).



1 – hypoeutectic white cast iron; 2 – eutectic white cast iron; 3 – hypereutectic white cast iron

Figure 2. Graph showing the variation of the temperature generated by friction on the rake face of the cutting tool edge as a function of the resistance of white cast irons to plastic deformation.

From the presented graph, it can be seen that as the resistance of white cast iron to plastic deformation increases, the temperature generated by friction in the contact region on the rake face of the cutting tool edge during machining rises sharply.

List of used literature:

1. Верещак, А. С. Резание материалов / А. С. Верещака, В. С. Кушнер. – М.: Высшая школа, 2009. – 535 с.
2. Козочкин, М. П. Автоколебательный механизм формирования стружки / М. П. Козочкин // «Станочный парк». - 2011. - Выпуск № 5. - С. 48 - 52.
3. Компьютерное моделирование и оптимизация процессов резания: учеб. пособие / С.И. Пестрецов. – Тамбов: Изд-во Тамб. гос. техн. ун-та, 2009 – 104 с.
4. Пестрецов С.И. Концепция создания системы автоматизированного проек тирования процессов резания в технологии машиностроения / С.И. Пестрецов, К.А. Алтунин, М.В. Соколов, В.Г. Однолько. – М. : Издательский дом «Спектр», 2012. – 212 с.

Proofreader: Zokir ALIBEKOV

Layout and Designer: Oloviddin Sobir ugli

2025. № 12

© When materials are reproduced, the INNOVATION SCIENCE AND TECHNOLOGY journal must be cited as the source. Authors are responsible for the accuracy of the information in materials and advertisements published in the journal. Editorial opinions may not always align with those of the authors. Submitted materials will not be returned to the editorial office.

To publish articles in this journal, you may submit articles, advertisements, stories, and other creative materials through the following links. Materials and advertisements are published on a paid basis.

You may subscribe to the journal at any time using the following details. Once subscribed, please send a screenshot or photo of your payment confirmation to our Telegram page @iqtisodiyot_77. Based on this, we will send the latest issue of the journal to your address each month.

“The journal “INNOVATION SCIENCE AND TECHNOLOGY” has been registered by the Agency for Information and Mass Communications under the Administration of the President of the Republic of Uzbekistan from 09.10.2024 under the registration number №390637. License number: C-5669633. PNFL: 30407832680027

Our address: Tashkent city, Yunusobod district, 19th block, House 17.

TASHKENT STATE UNIVERSITY OF ECONOMICS

Google Scholar
OPEN ACCESS
ULRICHSWEB GLOBAL SERIALS DIRECTORY
Academic Resource Index ResearchBib
ISSN INTERNATIONAL STANDARD SERIAL NUMBER INTERNATIONAL CENTRE
CYBERLENINKA
OpenAIRE
ROAD
НАУЧНАЯ ЭЛЕКТРОННАЯ БИБЛИОТЕКА LIBRARY.RU
BASE
INDEX COPERNICUS INTERNATIONAL
Crossref
doi Digital Object Identifier
CiteFactor Academic Scientific Journals
zenodo

Acceptance of articles

Published every monthly

Directions

Social, economic, political, technological, scientific

Scopus || Scientific electronic journal specializing in Scopus

CERTIFICATE NUMBER: №390637

ORDER NUMBER ACCORDING TO THE LICENSE REGISTER: C-5669633

Journal official website
https://ist-journal.uz/index.php/IST

CONTACT:

Contact us
+998 50 737 87 88

Telegram channel
t.me/scopus_IST2100