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Experimental Study of Tool Life Depending on Cutting Speed for 100CrMn6 Materials & Statistical Processing using Linear Regression Analysis

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To increase the service life of the cutting tool, various types of coatings are used in modern times, which have a beneficial effect on extending the service life of the tools. Which contributes to reducing the economic costs of production. The present article examines the effect of cutting speed on the durability of a cutting tool. In the experimental measurements, three types of replaceable cutting inserts were used, without coating, with TiC and TiN coating. The measurements were carried out during technological operations of longitudinal turning on bearing steel 100CrMn6 without the use of coolant. The durability of the cutting discs was evaluated by the method of short-term tests, in which the main evaluation criterion was the amount of wear on the back surface of the cutting tool VB_{Bcrit} = 0.25 mm. For the statistical processing of the measured results, a detailed mathematical calculation was performed using the method of least squares to determine the parameters of the linear regression function.

Keywords: Durability, Wear, Cutting Speed, Turning, Coating

1 Introduction

An important feature of any cutting tool is its service life. The durability of the cutting tool determines the service life of this cutting tool and determines its suitability for the selected technological operation. In order to increase the service life of the cutting tool, it is necessary to eliminate these factors as much as possible. Determining the durability of a cutting tool is very important, because it provides comprehensive information on how to determine the appropriate technological conditions for the selected cutting tool. In mechanical engineering, the T-v_c dependence is used to determine the durability of cutting tools [1]. The paper authors Vasilko et al. dealt with tool-wear, tool-life regarding the cutting speed for machining by conventional and coated tools. The paper authors provide complete experimental T-v_c dependencies obtained in turning regarding various parameters as depth of cut, feed for different machined and cutting tool materials [2]. Further the authors of the article Vasilko et al. suggest a modification of the original Taylor equation to better suit the current conditions of productive machining. The goal of this modification is to improve the accuracy of tool life prediction and to optimize cutting conditions for increased productivity. The essence of the Taylor equation remains relevant in this context as it provides a framework for understanding the relationship between cutting parameters and tool life [3]. Tool wear is closely related to intelligent operation and maintenance of automated production, workpiece surface quality, dimensional accuracy, and tool life. Therefore, it is necessary to improve production efficiency and quality by predicting tool wear values [4]. The purpose of the research of the authors Korkmaz, Mehmet Erdi et al. [4] was to investigate the in-depth analysis of cutting tools under different parameters. The results showed that there was a 44.40% increase in tool wear when the cutting speed was increased by 100% while keeping the feed rate at the same level. On the other hand, there was an increase in tool wear of 22.78% when the cutting speed was kept at the same level. The author W. Bouzid Saï [5] focused on the turning of AISI 4340 steel at different cutting speeds using a commercially available insert. The wear of the back surface of the cutting tool was measured in relation to the cutting time. The author confirmed through his research that tool wear increases rapidly when the coating layer has been removed from the tool surface. The author's research also included the implementation of a wear model in relation to time and cutting speed. He also developed an empirical model for determining tool life in conjunction with cutting speed. In his research, the author stated that based on the obtained results, it is possible to set the optimal cutting speed to achieve the maximum service life of the tool. Author Martina Gassner et al. [6] dealt with the investigation of wear mechanisms after longitudinal turning of sintered carbide inserts with different coatings. With three different steels. The cutting speed varied between 150 and 250 m.min^{-1}. The main findings of the author in terms of the influence of cutting speed were as follows, that as the cutting speed increased, the life of the tool decreased. High cutting speed reduces wear on the back surface of the cutting tool. By Sudhansu Ranjan Das et al. [7] investigated AISI 4340 steel using a multi-layer CVD ($TiN/TiCN/Al_2O_3/TiN$) coated carbide tool. Their research focused on surface roughness, back surface wear and chip morphology during dry hard turning. The results of the authors' research showed that the surface roughness and wear of the back surface are statistically significantly affected by the feed and cutting speed, as well as that an increase in the cutting speed led to a better surface quality, but also to an increase in the wear of the back surface. The aim of the research of the authors Masoud Farahnakian et al. [8] was to investigate the wear of tungsten carbide tool back in ultrasonic turning of hardened alloy steel compared to conventional turning. Experiments were carried out by the authors for different cutting speeds below the critical speed during turning operations. Application of the tool with the modified specifications resulted in initial tool back surface wear, but ultimately the authors noted that a significant improvement in tool wear was observed. The authors of the article Majerík et al. [9] also focused in their research on tool wear and service life of cutting materials through finishing turning. The authors conducted a detailed search of the results of various studies, the aim of which was to assess the dependence of cutting parameters on the service life of the cutting material, as well as to compare the wear of the back surface of the tool at certain cutting parameters of the process. Their goal was to determine suitable cutting parameters for the process of finishing turning of hardened material with a hard cutting material based on polycrystalline cubic boron nitride. The study by the author Ali Riz Motorcu [10] deals with the investigation of the service life of various cutting tools when turning from various materials, such as cubic boron nitride (CBN/TiC) and others. The goal was to identify effective wear mechanisms and compare the service life of these tools under different cutting conditions. The results showed that the life of cutting tools decreases with increasing cutting speed for all tested materials. CBN/TiC tools showed longer tool life when machining hardened AISI 52100 steels. Smooth backface wear of the CBN/TiC tool was identified as the main wear mechanism, while other tools showed different forms of wear, including backface wear and tool tip deformation. The subject of the article by Guangming Zheng et al. [11] was also an analysis of the influence of cutting parameters on tool life, wear mechanisms during high-speed dry machining of 300M steel with a coated carbide tool. The research focused on the effect of cutting speed on tool durability and wear on the back surface of the cutting tool. Cutting speed has been found to have the greatest effect on tool life. The main mechanisms of coated tool wear include abrasion, adhesion, oxidation and diffusion. The results of the authors' research can be beneficial in the optimization of cutting parameters, prediction of tool life. The aim of the research of the authors S. Thamizhmnaii et al. [12] was to demonstrate tool wear by hard turning of martensitic stainless steel. In conclusion, the authors stated the following that the wear of the back surface occurred at a low cutting speed with a high feed rate and with a greater depth of cut. The effect of wear on the back surface of the tool was caused by the abrasive action between the tip of the tool and the cutting tool, hard carbides in the workpiece material.

The cutting tool is exposed to extreme conditions during machining, i.e. high surface pressure and high temperatures. A cutting tool can work efficiently and economically only as long as its wear does not exceed a certain limit. If this limit is exceeded, the tool cannot continue to work and the required characteristics of the manufactured parts cannot be guaranteed. The wear of the cutting wedge occurs very quickly and is visible after only a few minutes of work. The external signs of wear depend on the material of the cutting wedge and the geometry of the cutting wedge, on the material of the workpiece and the cutting conditions used. The term tool life T is defined as the cutting time after the specified wear criterion under the specified cutting conditions [13]. The durability of the cutting edge thus represents the period of its work, during which the cutting edge wears to the specified value VB (wear on the back surface of the cutting wedge) or KT (wear of the front surface of the cutting wedge). In addition to the cutting parameters, which have the greatest influence on the durability of the tool, the durability also depends on the machined material, the cutting material and the method of machining. If we analyze the effect of cutting conditions on the durability of tool T, we can write an empirical relationship:

$$T = \frac{C_T}{v_c^m \cdot a_p^{X_T} \cdot f^{Y_T}} \tag{1}$$

Where:

C_T…Durability constant,

m, x_T, y_T…Exponents of technological parameters determined by experiment, while $m > y_T > x_T$.

This relationship is called the fundamental law of cutting or the law of constant durability. From the relationship for tool durability, it follows that cutting speed (v_c), less feed (f) and least cutting depth (a_p) have the greatest impact on durability. The Taylor equation of durability (Eq. 1) is determined experimentally by long-term and short-term tests. With long-term methods, durability is determined based on the time course of wear, according to Fig. 1. Long-term methods give more accurate results, but their disadvantage is the time and material requirement [14].

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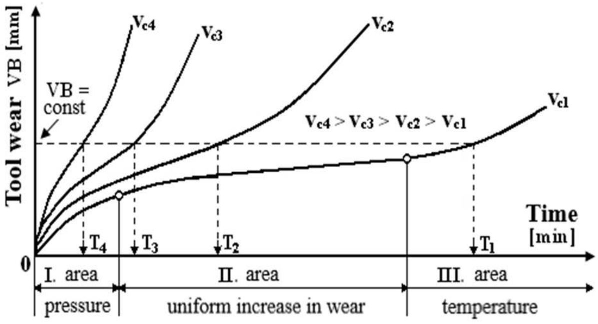

Fig. 1 *Dependence of wear on time at different cutting speeds*

For the predetermined value of the selected criterion (VB), the durability values (T_1, T_2, T_3, T_4) corresponding to the selected cutting speeds (v_{c1}, v_{c2}, v_{c3}, v_{c4}) are subtracted from the time curves. The coordinate points ($v_{c1} – T_1$, $v_{c2} – T_2$, $v_{c3} – T_3$, $v_{c4} – T_4$) are plotted in a diagram with logarithmic coordinates and form a straight line that corresponds to the selected value of VB wear (Fig. 2). The value of the constant (C_T) is read on the axis (T) for the cutting speed (v_c), the value of the constant (C_v) on the axis (v_c) for the durability T = 1 min. The exponent (m) expresses the direction of the created straight line ($m = tg\ \alpha$). In the case of short-term methods, we first determine the intensity of wear (critical wear) and calculate the durability from it.

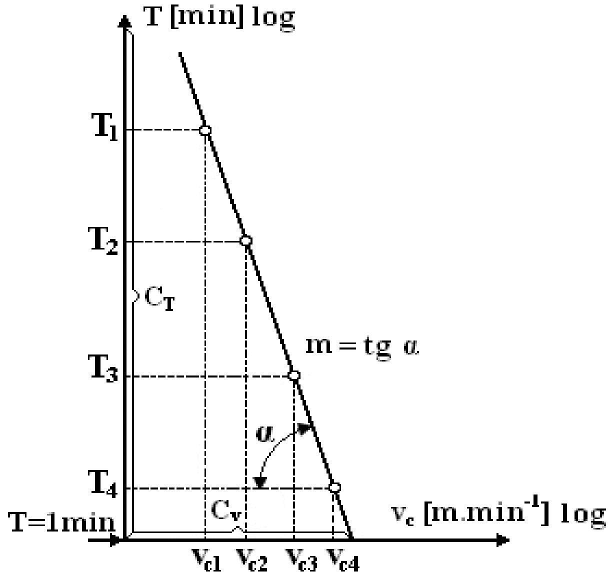

Fig. 2 *Logarithmic diagram* $T – v_c$

2 Experimental material and experiment

Heat-treated bearing steel 100CrMn6 was used for the determined experimental measurements during longitudinal external turning. The chemical composition of the selected machined material is shown in Tab. 1. The microstructure of bearing steel after heat treatment is shown in Fig. 3.

Tab. 1 *Analysis of the chemical composition (wt. %) of bearing steel 100CrMn6*

Steel	Chemical composition (wt. %)								
100CrMn6	C	Cr	Mn	Si	Ni	Cu	P	S	Al
	0.93-1.05	1.40-1.65	1.00-1.20	0.45-0.75	max 0.30	max 0.30	max 0.025	max 0.015	max 0.05

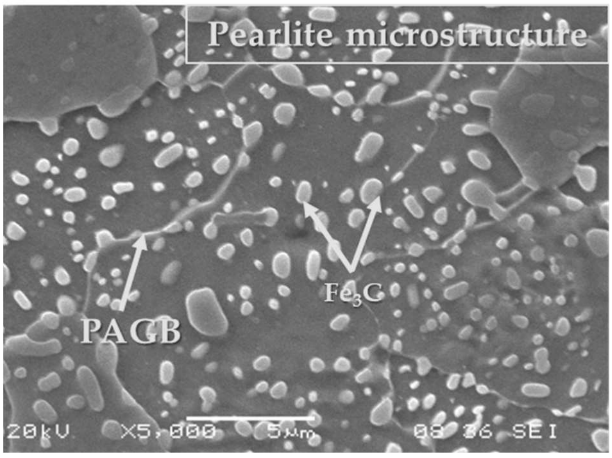

Fig. 3 *Microstructure of bearing steel 100CrMo6*

The optimal resulting structure of steels after soft annealing is fine globular pearlite with evenly sized and evenly distributed carbides. The reference sample was annealed conventionally for 11 hours at 790 °C and cooled in the furnace. Photomicrographs show well-spheroidized cementite particles in a ferritic matrix. Image analysis confirmed a high degree of spheroidizationUsed cutting materials with basic characteristic data for individual replaceable cutting plates made of cubic boron nitride KNB type 4NC–CNGA 120408 with BNC 200 and BNC 300 coating and 2NU–CNGA 120408 without BNX 20 coating are shown in Tab. 2. The cutting parameters recommended by the manufacturer for the selected replaceable cutting discs are listed in Tab. 3.

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Tab. 2 *Interchangeable cutting plates used in experimental measurements*

Type of replaceable cutting disc	Designation	Coating type	Percentage volume of KBN grains in VRP	KNB grain size	Binder
	BNX 20	without	65 – 70	1 µm	TiN
	BNC 200	TiC	65 – 70	1 µm	TiN
	BNC 300	TiN	60 – 65	1 µm	TiN

Tab. 3 *Cutting parameters recommended by the manufacturer for replaceable cutting inserts*

Cutting parameters	**The type of coating of the replaceable cutting plate**		
	without	**TiC**	**TiN**
Cutting depth a_p [mm]	0.1 – 0.5	0.1 – 0.5	0.1 – 0.5
Tool feed f [mm]	0.15 (0.03 – 0.3)	0.08 (0.03 – 0.13)	0.1 (0.03 – 0.2)
Cutting speed v_c [m.min^{-1}]	130 (70 – 170)	170 (120 – 230)	190 (120 – 300)

3 Application of the method of least squares for the calculation of durability

In technical practice, the method of least squares is the most frequently used method for estimating the parameters of a linear regression model. In many cases, the relationship between the independent variable (x) and the dependent variable (y) is linear or expressed by another curve. However, it is difficult to decide how to translate such a straight line (or curve) with the data in such a way that it expresses the relationship between the two variables as accurately as possible. One of the possible criteria for translating the straight line is to achieve the smallest possible deviation of the straight line from the measured data. Since the data can deviate from a straight line in a positive or negative direction, the deviations are squared (thereby losing the negativity and positivity of the deviations). The calculation method that leads to the determination of the interpolated straight line (curve) is called the method of least squares. Therefore, when experimentally measuring the effect of cutting speed on tool durability, it is necessary to apply the mentioned method and statistically process the measured results using linear regression analysis. We will look for the function in the form:

$$y = a + bx \tag{2}$$

$$\sum_{i=1}^{n}(y_i - y_i)^2 = 0 \tag{3}$$

The approximation criterion is the condition that the sum of deviations according to Eq. 4 was the minimum:

$$\sum_{i=1}^{n}(y_i - y_i)^2 \tag{4}$$

$$\sum_{i=1}^{n}(y_i - a - bx_i)^2 = \mathrm{F(a,b)} \tag{5}$$

The partial derivatives of the function according to the individual variables are equal to zero, so we can write:

$$\frac{\partial F(a,b)}{\partial a} = 0 \tag{6}$$

$$\frac{\partial F(a,b)}{\partial b} = 0 \tag{7}$$

After derivation, we get a system of equations and two unknowns:

$$2 \cdot \sum_{i=1}^{n} (y_i - a - bx_i) \cdot (-1) = 0 \quad (8)$$

$$2 \cdot \sum_{i=1}^{n} (y_i - a - bx_i) \cdot (-x_i) = 0 \quad (9)$$

The equations of ds are further adjusted to the form:

$$\sum_{i=1}^{n} (a + bx_i - y_i) = 0 \quad (10)$$

$$\sum_{i=1}^{n} \left(ax_i + b{x_i}^2 - x_i y_i\right) = 0 \quad (11)$$

By editing we get:

$$\sum_{i=1}^{n} y_i = na + b \sum_{i}^{n} x_i \quad / \frac{1}{n} \quad (12)$$

$$\sum_{i=1}^{n} x_i y_i = a \sum_{i}^{n} x_i + b \sum_{i}^{n} {x_i}^2 \quad / \frac{1}{n} \quad (13)$$

For a simpler notation, we have introduced the substitution of $\bar{y}$ and $\bar{x}$ and the following applies:

$$\frac{\sum_i^n y_i}{n} = \bar{y} \quad a \quad \frac{\sum_i^n x_i}{n} = \bar{x} \quad (14)$$

According to Eq. 14, the relations of Eq. 12 and Eq. 13 we simplify:

$$\bar{y} = a + b\bar{x} \quad (15)$$

$$\overline{x \cdot y} = a\bar{x} + b\overline{x^2} \quad (16)$$

From Eq. 16 we express a:

$$a = \frac{\overline{x \cdot y} - b\overline{x^2}}{\bar{x}} \quad (17)$$

After substituting into the relation Eq. 15 we get:

$$\bar{y} = \frac{\overline{x \cdot y} - b\overline{x^2}}{\bar{x}} + b\bar{x} \quad (18)$$

$$\bar{x} \cdot \bar{y} = \overline{x \cdot y} - b\overline{x^2} + b\bar{x}^2 \quad (19)$$

$$\bar{x} \cdot \bar{y} = \overline{x \cdot y} + b\bar{x}^2 - b\overline{x^2} \quad (20)$$

$$\bar{x} \cdot \bar{y} - \overline{x \cdot y} = b\left(\bar{x}^2 - \overline{x^2}\right) \quad (21)$$

After modification, we get the resulting relations for the calculation of the parameters, which we will use in the calculation of the Taylor relation:

$$b = \frac{\bar{x} \cdot \bar{y} - \overline{x \cdot y}}{\bar{x}^2 - \overline{x^2}} \quad (22)$$

$$a = \bar{y} - b\bar{x} \quad (23)$$

4 Methodology for calculating durability and wear

Three cutting inserts of type BNX 20 (without coating), BNC 200 with coating (TiC) and BNC 300 with coating (TiN) were used for experimental determination of durability and wear. The durability of the cutting plates was evaluated by the method of short-term tests, in which the amount of wear on the back VB_{Bcrit} = 0.25 mm was chosen as the criterion value. Wear values were measured for individual replaceable cutting plates at different cutting speeds, at constant feed and constant depth of cut. By measuring the wear at the specified cutting speeds, the time during which critical wear of the replaceable cutting disc occurred was determined. From the measured wear values, characteristic wear curves were constructed as a function of time for individual replaceable cutting discs, which are shown in Fig. 4, 5 and 6.

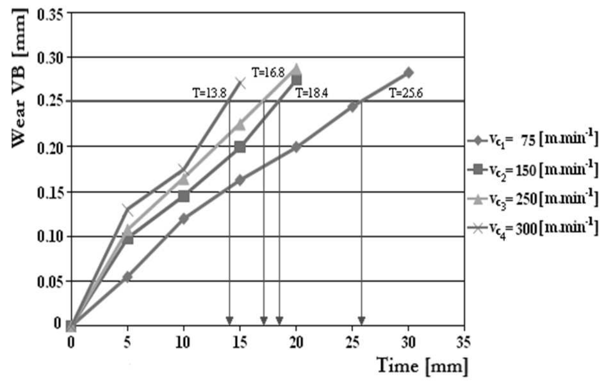


Fig. 4 *Graphical dependence of wear on time during turning for a cutting insert without coating (BNX 20)*

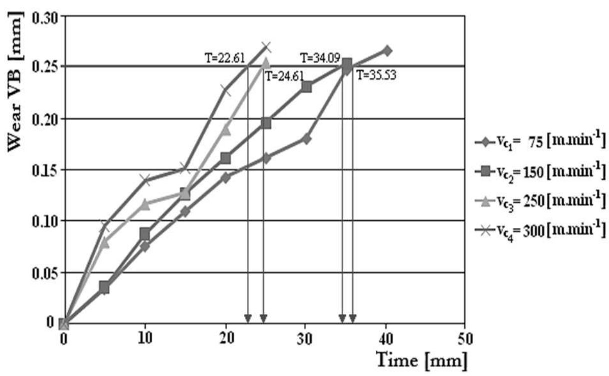


Fig. 5 *Graphical dependence of wear on time during turning for a TiC coated cutting insert (BNC 200)*

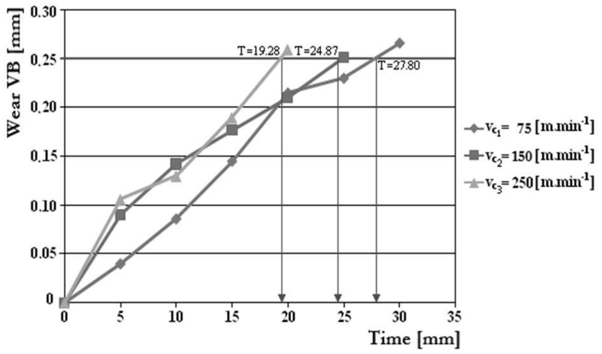


***Fig. 6** Graphical dependence of wear on time during turning for a TiN-coated cutting insert (BNC 300)*

It is proven that the cutting speed has the greatest influence on the durability of the tool among the cutting parameters. According to Taylor's relationship, the dependence between the durability of the cutting edge and the cutting speed is mathematically described by this simplified empirical relationship and applies:

$$T = \frac{C_T}{v_c^m} \tag{24}$$

Where:
C_T…Constant [-],
v_c…Cutting speed [m.min^{-1}],
m…Exponent; degree of dependence of cutting speed on durability [-].

By logarithmizing the relation Eq. 24 we get the equation and calculate the C_T constant and the exponent m using the method of least squares. For the calculation, we will use Tab. 7, in which the calculated logarithmic values of cutting tool life T and cutting speed v_c for an uncoated insert are given.

$$\log T = logC_T - m \cdot logv_c \tag{25}$$

Where:
m = tg α…The angle of inclination of the straight line in logarithmic coordinates.

***Tab. 7** Calculated logarithmic values of durability T and cutting speed v_c*

Number of measurements	v_{ci} (m.min^{-1})	T_i (min)	log v_{ci}	log T_i	log v_{ci} . log T_i	log v_{ci}^2
	x_i	y_i	log x_i	log y_i	log x_i . log y_i	log x_i^2
1	75	25.6	1.8750	1.4082	2.6405	3.5158
2	150	18.4	2.1760	1.2648	2.7523	4.7353
3	250	16.8	2.3979	1.2253	2.9382	5.7501
4	300	13.8	2.4771	1.1398	2.8236	6.1361
$\frac{\sum}{4}$	-	-	2.2315	1.2595	2.7886	5.0343

To calculate the C_T constant and the exponent m according to Taylor's empirical relation, we will use the relations obtained using the method of least squares. The complex calculation of these parameters (a, b) is described in part 2 – the application of the method of least squares for the calculation of durability.

According to relation (22), we calculate the parameter b, which in our case is the exponent m:

$$m = b = \frac{\bar{x} \cdot \bar{y} - \overline{x \cdot y}}{\bar{x}^2 - \overline{x^2}} = \frac{(2.23155 \cdot 1.25956) - 2.78868}{(2.23155)^2 - 5.03436} = -0.40515 \tag{26}$$

$$m = tg\alpha = -0.40515; \text{from that } arctg\alpha = -0.40515; \alpha = -22°05' \tag{27}$$

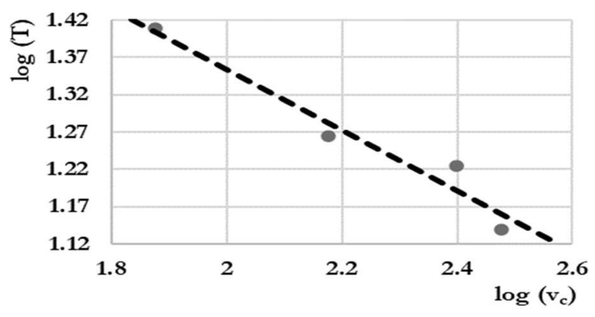


***Fig. 7** Graphical dependence of T = f (v_c) for a cutting insert without a coating*

Graphical dependence of durability in a double logarithmic system for a replaceable cutting disc without coating after statistical processing is shown in Fig. 7 with the calculated linear function, which has the form logT = 2.163 – 0.4049x, where x is log v_c and the angle formed by the straight line with the x axis is α = 22°05'.

According to relation (23), we calculate the parameter a, which in our case is the C_T constant, and after substitution we get:

$$C_T = a = \bar{y} - b \cdot \bar{x} = 1.25956 - (-0.40515) \cdot 2.23155 = 2.16367 \tag{28}$$

$$C_T = 10^{2.16367} = 145.770 \tag{29}$$

The equation according to Taylor for the durability of a cutting insert without a $T_{without}$ coating during wear will have the form a_p = 0.3 mm, f = 0.055 mm for the given cutting conditions:

$$T_{without} = \frac{145.770}{v_c^{0.40515}} \quad (min) \qquad (30)$$

In this way, the values of the C_T parameters and the exponent m were calculated, so that we have the expressed dependence of the life of the cutting tool T on the cutting speed v_c. Fig. 8 shows the measured values from Tab. 7 and the dependence T=f(v_c), which was worked out by calculation. Basically, it approximates the measured points by an assumed function using the method of least squares.

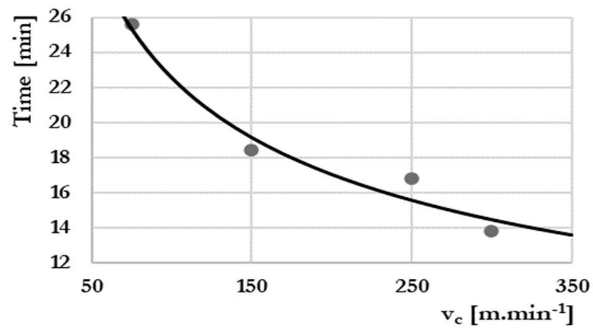


Fig. 8 *Graphical dependence of the life of the cutting tool T on the cutting speed v_c (T=f(v_c)) without a coating*

In the same way, we will determine the durability for a TiC and TiN coated cutting insert under the same cutting conditions. The Taylor equation for the durability of a T_{TiC}-coated cutting insert during wear will have the form for the given cutting conditions a_p = 0.3 mm, f = 0.055 mm:

$$T_{TiC} = \frac{168.538}{v_c^{0.3427}} \quad [min] \qquad (31)$$

Graphical dependence of durability in a double logarithmic system for a T_{TiC}-coated replaceable cutting insert after statistical processing is shown in Fig. 9 and 10 with the calculated linear function, which has the form log T = 2.2267 – 0.3427x, where x is log v_c and the angle formed by the straight line with the x axis is α = 18º91'.

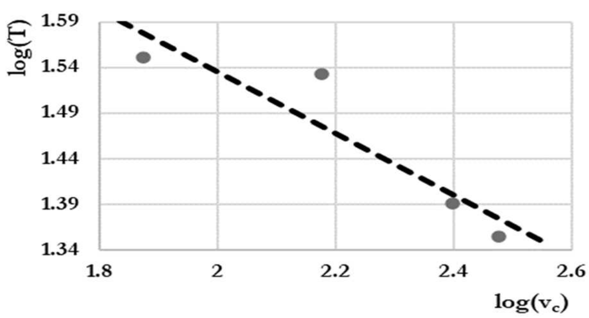


Fig. 9 *Graphical dependence of T = f (v_c) for a cutting insert with a TiC coating*

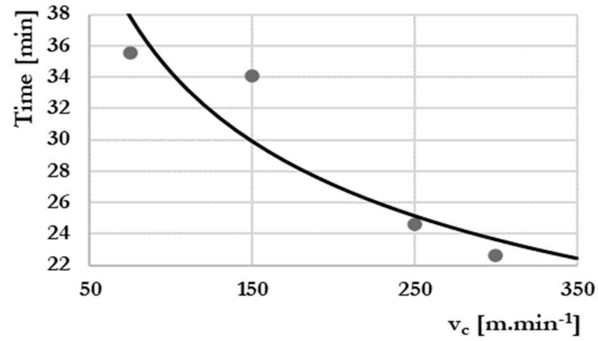


Fig. 10 *Graphical dependence of the life of the cutting tool T on the cutting speed v_c (T=f(v_c)) with a TiC coating*

The Taylor equation for the durability of a T_{TiN}-coated cutting insert during wear will have the following form for the given cutting conditions a_p = 0.3 mm, f = 0.055 mm:

$$T_{TiN} = \frac{102.494}{v_c^{0.2957}} \quad [min] \qquad (32)$$

Graphical dependence of durability in a double logarithmic system for a T_{TiN}-coated replaceable cutting insert after statistical processing is shown in Fig. 11 and 12 with a calculated linear function that has the form log T = 2.0107 – 0.2957x, where x is log v_c and the angle formed by the straight line with the x axis is α = 16°47'.

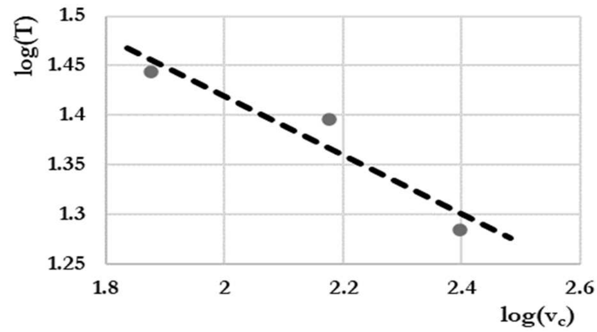


Fig. 11 *Graphical dependence of T = f (v_c) for a cutting insert with a TiN coating*

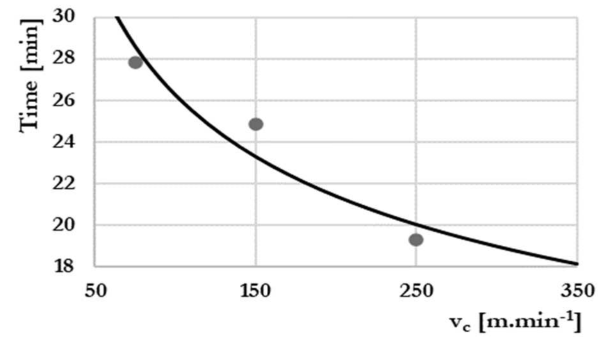


Fig. 12 *Graphical dependence of the life of the cutting tool T on the cutting speed v_c (T=f(v_c)) with a TiN coating*

In addition to the cutting speed, the correct selection of suitable cutting materials is also very important, which is also confirmed by the resulting graphical dependence (Fig. 13), from which it follows that the highest durability was achieved when using a replaceable cutting plate with a TiC coating.

When machining the material, the cutting wedge of the tool wears out due to the action of the workpiece material. Its useful life depends on the rate of wear. After a certain limit of tool wear, it is not possible to produce parts with the required dimensions and shapes since the tool does not have the required geometry. The service life of the tool significantly affects the cost of the tools and thus also the economy of machining. Tab. 8 shows the intensity and course of wear on the back surface of the cutting wedge of the tool, which was monitored on a replaceable cutting plate without coating at a constant depth of cut a_p = 0.3 mm, a constant feed f = 0.055 mm and a cutting speed v_c = 150 m.min^{-1}.

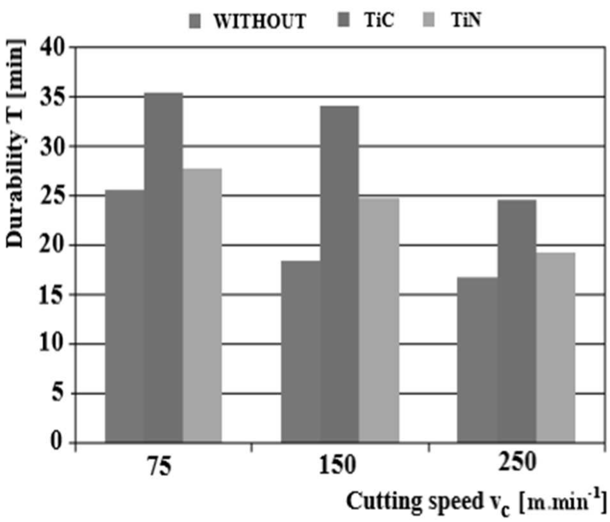
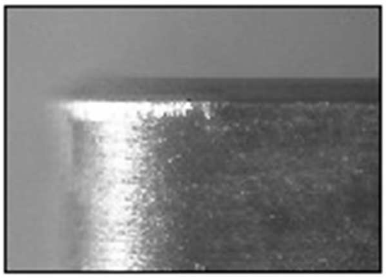
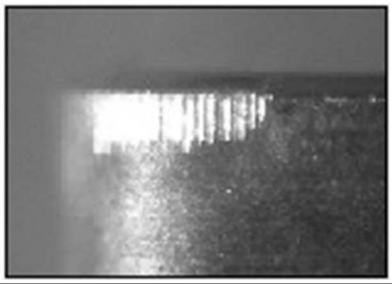
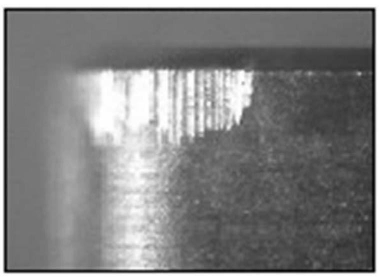
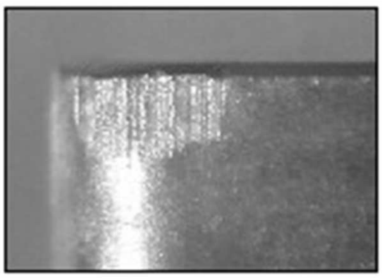


Fig. 13 *Dependence of tool durability on the cutting speed of replaceable cutting plates*

Tab. 8 *Wear course of VB_B replaceable cutting disc without coating*

Cutting time τ (min)	Size of wear on spine VB_B [mm]	Character of wear
τ = 5	VB_B = 0.098	
τ = 10	VB_B = 0.145	
τ = 15	VB_B = 0.200	
τ = 20	VB_B = 0.275	

In addition to choosing the right types of cutting materials and determining the corresponding machining parameters, the following machining criteria are also important, such as dimensional accuracy, quality of the machined surface and controlled chip removal. Looking at the cutting edge with a microscope and analysing what wear is visible on it allows you to check the suitability of durability, its reliability and even the possibility of its extension. There is an "ideal" wear pattern for every machining process. The right tool and corresponding cutting conditions, qualified professional help, professional experience, good quality of the workpiece material and good conditions for machining are important prerequisites for the emergence of an "ideal" course of wear.

5 Conclusions

In the study, the dependence of tool durability on cutting speed was monitored and evaluated. All measurements were carried out by the technological operation of longitudinal turning. The measurements in the translated study were carried out on 100CrMn6 steel intended for the production of rolling bearings. Constructed graphic dependences of wear for selected replaceable cutting inserts without coating, with TiC and TiN coating were evaluated by the method of short-term tests, in which the main criterion was the amount of wear on the back surface of the cutting tool. The mathematically described dependence between the durability of the cutting edge and the cutting speed according to Frederick Winslow Taylor's empirical relationship was calculated for individual replaceable cutting plates by the method of least squares, and the measured results were statistically processed on the basis of linear regression analysis. The following conclusions can be drawn from the presented work:

- The results showed that the use of TiC and TiN coatings significantly extends the service life of the cutting plates. From the course of wear of the basic replaceable cutting plate without coating, it can be seen that as the processing time increases, there is an almost linear increase in the amount of wear on the back surface of the cutting tool.
- The wear results clearly show that the TiC-based coated insert performed best among all three inserts tested at all cutting speeds. At the cutting speed vc1 = 75 m.min^{-1}, the highest tool life of up to 35 min was achieved.
- The results in the form of calculated C_T values for the used cutting inserts show a value of 168.583 for the TiC-based coated insert, the other values are smaller.
- From the calculated values of the direction of the straight line, parameter m, which is expressed in the form of angle α, it is not possible to state that the TiC plate achieved the greatest lifetime because the angle α = 18°91', for the TiN plate the value was α = 16°47', and for the sample without coating α = 22°05'.

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