DETERMINATION OF WEAR AND STEADFASTNESS OF THE CUTTERS WHEN TURNING ON THE LATHE MODEL 1K62

PURPOSE OF THE LABORATORY WORK

Studying the nature of wear of cutters, determining the allowable amount of wear using the criterion of optimal wear, obtaining the dependence of steadfastness on cutting speed.

1K62 LATHE MACHINE SPECIFICATIONS

- the largest diameter of the product installed above the bed – 400 mm;
- the largest diameter of the processed bar – 45 mm;
- the distance between centers – 1000 mm;
- the number of spindle speeds – 23 (from 12.5 to 2000 rpm);
- the number of working feeds – 42 (from 0.07 to 4.16 mm/rev).

SUMMARY OF WEAR AND STEADFASTNESS

Types of Wear

The contact surfaces of the tool wear out during operation. Regardless of the type and purpose, all tools wear only on the back surface (first type of wear) or on the back and front surfaces at the same time (second type of wear). Both types of wear occur when working with cutting modes used in production. When working with tools made of high-speed steels with cutting speeds exceeding the permissible heat resistance, a third type of wear is possible, in which only one front surface wears out.

When wearing according to the first appearance (Fig. 1a), a wear area with a width of h3 is formed on the rear surface of the tool. The shape of the wear site in cross section by the main cutting plane approximately copies the shape of the cutting surface. Along the main cutting edge, the width of the wear pad is generally not the same. As a rule, the maximum width of the wear site is observed at the transitional back surface or at the place where the main cutting edge passes into the auxiliary one (Fig. 2, a). In some cases, at the point of the main blade corresponding to the surface being machined, local wear is observed in the form of a narrow tongue (Fig. 2, b).

When worn in the second form, wear of the front surface is added to the wear of the rear surface. Depreciation of the front surface looks different. Under the action of descending chips, a wear hole is formed behind it with a width l and a depth δ (Fig. 1, b). The edges of the hole are located approximately parallel to the main cutting edge of the tool, and the length of the hole b is equal to the working length of the main cutting edge. Depending on the cutting speed with which the tool operates, the distance between the edge of the hole and the main cutting edge changes. When working with small and medium cutting speeds (tools made of high-speed steels when cutting structural steels), the distance (jumper) f remains between the main cutting edge and the edge of the hole, decreasing as the hole develops. This is due to a build-up that protects part of the front surface adjacent to the main cutting edge from the abrasive action of the chips. When working with high cutting speeds (carbide tools), when there is no growth, the edge of the hole merges with the worn back surface (Fig. 1, c), and only a part of the hole remains on the finally worn tool.

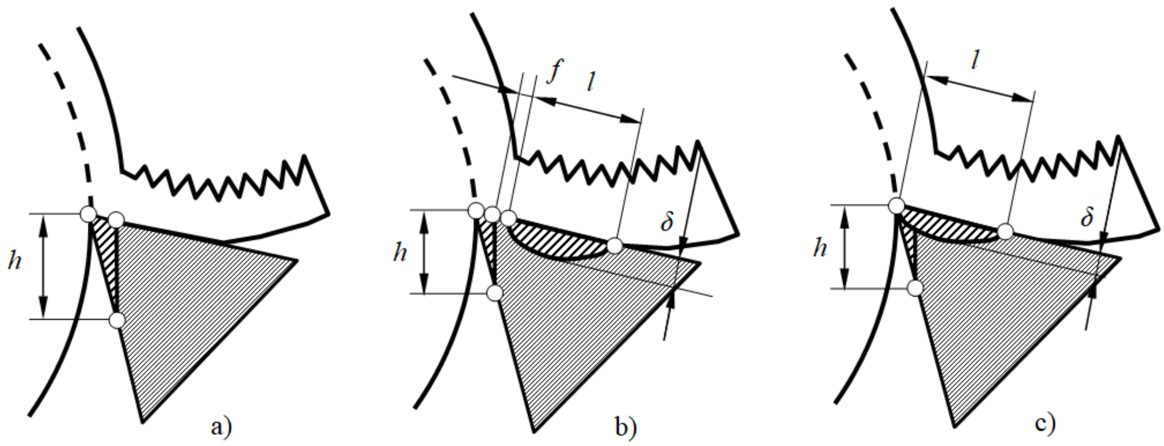

Fig. 1. Types of Tool Wear

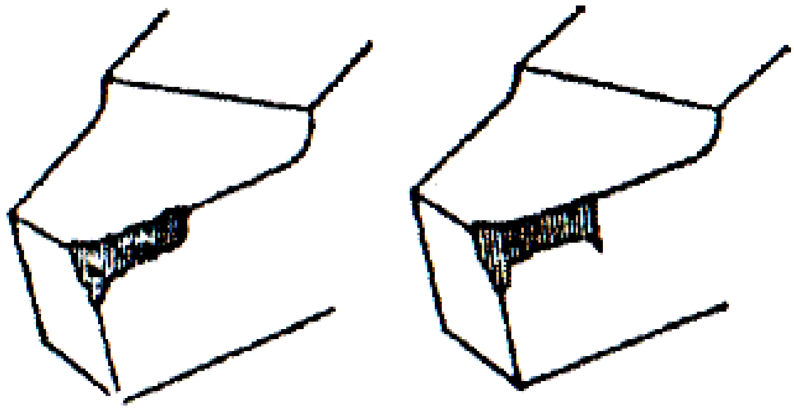

Fig. 2. Tool Wear Along the Blades

The type of wear is determined mainly by the type of material of the workpiece, the thickness of the layer to be cut (feed) and the cutting speed. When processing plastic materials (steels), tool wear on the first and second types of wear is equally common. When processing brittle materials (cast irons), tools wear much more often in the first type of wear than in the second.

The thickness of the cut layer and the cutting speed have the same effect on the type of wear. At small thicknesses of the shear layer (less than 0.1 mm) and low cutting speeds, the back surface undergoes predominant wear. As the thickness of the cut layer and the cutting speed increase, in addition to the back, the front surface also begins to wear out, the more a and V, the more the front surface wears out and the back one less. The tool angle and the coolant used have a lesser effect on the type of wear. With an increase in the rake angle and the use of coolant with high thermal conductivity, the thickness of the cut layer and the cutting speed, at which the first type of wear changes to the second, shift to the region of their large values.

Quantitative Parameters of Wear

A measure, deterioration (blunting) of a tool can be linear and mass wear. Taking linear wear as an indicator, deterioration of the back surface is judged by the maximum width h of the wear pad, and of the front surface by the maximum depth δ of the wear hole. When finishing dimensional processing, tool wear is conveniently estimated by linear dimensional wear h_P (Fig. 3.), which characterizes the displacement of the tool tip in the direction perpendicular to the machined surface as a result of wear of its rear surfaces. The amount of dimensional wear determines the increase or decrease in the size of the workpiece as the tool wears out.

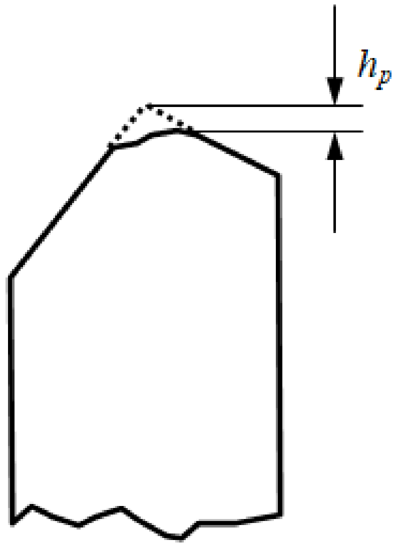

Fig. 3. Dimensional Tool Wear

Maximum linear wear can be a fairly reliable characteristic when developing industrial standards for permissible wear and consumption rates of tools for regrinding. To study the physical nature of tool wear, a more objective characteristic is mass wear – the mass of the worn part of the tool M in mg, which is proportional to the work of the friction forces spent on turning the tool material into wear products.

The mass of the worn part of the tool M is equal to the product of the volume W of the worn part and the density ρ of the tool material, i.e. $M = W\rho$. The volume of the worn portion of the rear surface can be calculated by measuring visible signs of wear.

Wear Curves

Wear curves express the dependence of blade surface wear on tool life τ. Under production conditions, the measure of wear for most tools is the width of the worn area h_{max} on the main rear surface of the blade.

A typical linear wear curve $h=f(\tau)$ is shown in Fig. 4.

In the general case, three sections can be distinguished on the wear curve *h*. 1 – work-in period. At this time, the surface layer of the tool is subjected to intensive wear, which received structural changes or microcracks during sharpening. In addition, accelerated wear is the result of abrasion of the protruding sections of the original microroughness of the surface of the blade after sharpening. 2 – the period of normal wear, when the roughness of the working surfaces of the tool becomes small, and the layer with the changed structure after sharpening is removed. In this case, the wear rate is approximately proportional to the tool operating time. 3 – period of rapid (catastrophic) wear. This is due to an increase in the work of the friction forces on the worn contact surfaces of the blade, an increase in the cutting temperature and related structural changes in the thin contact surfaces of the tool blade. Further work with the tool is unacceptable and its regrinding is necessary. The dependence of the worn mass of the rear surface of the blade on the operating time $M=f(\tau)$ shows that there is a monotonous increase in the worn mass *M* throughout the entire processing time with this type of tool.

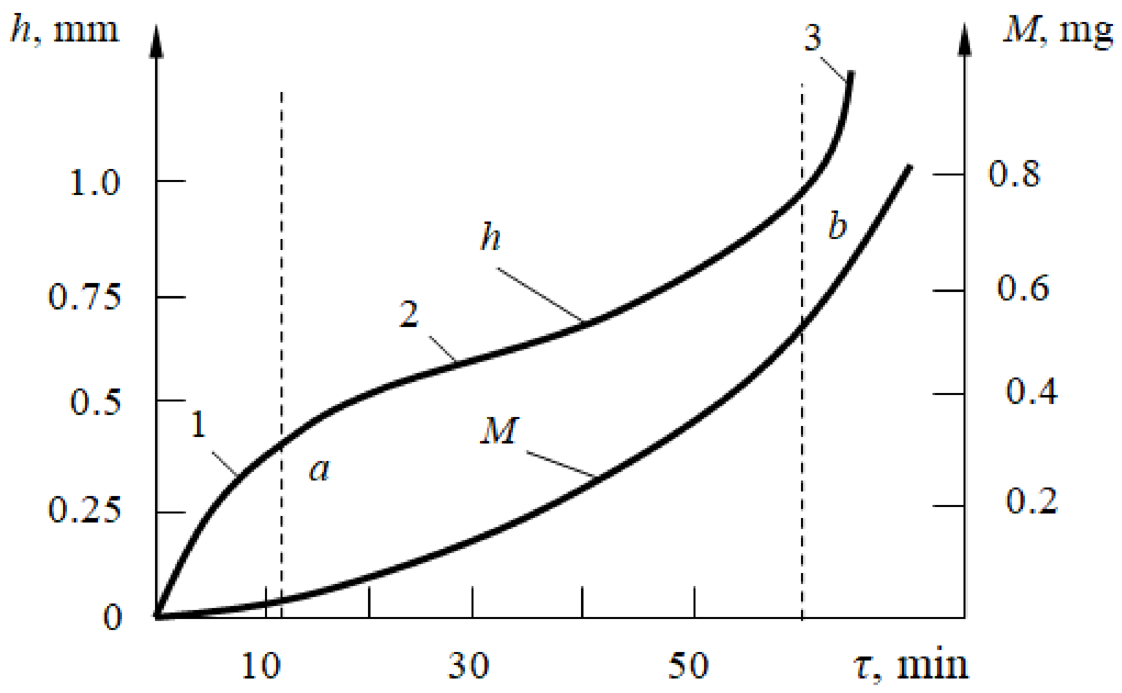

Fig. 4. Linear *h* and Mass *M* Surface Wear Curves

The wear rate and the current value of linear wear *h* in quantitative terms depend both on the processing time *τ*, and on the parameters of the cutting mode and the geometry of the cutting part of the tool, the mechanical properties of the processed material. For each combination of specific values of the listed factors, a separate wear curve can be constructed. In fig. 5 provides a family of wear curves for various cutting speeds, where $V_1<V_2<V_3$. From the graphs it follows that wear increases faster with increasing cutting speed.

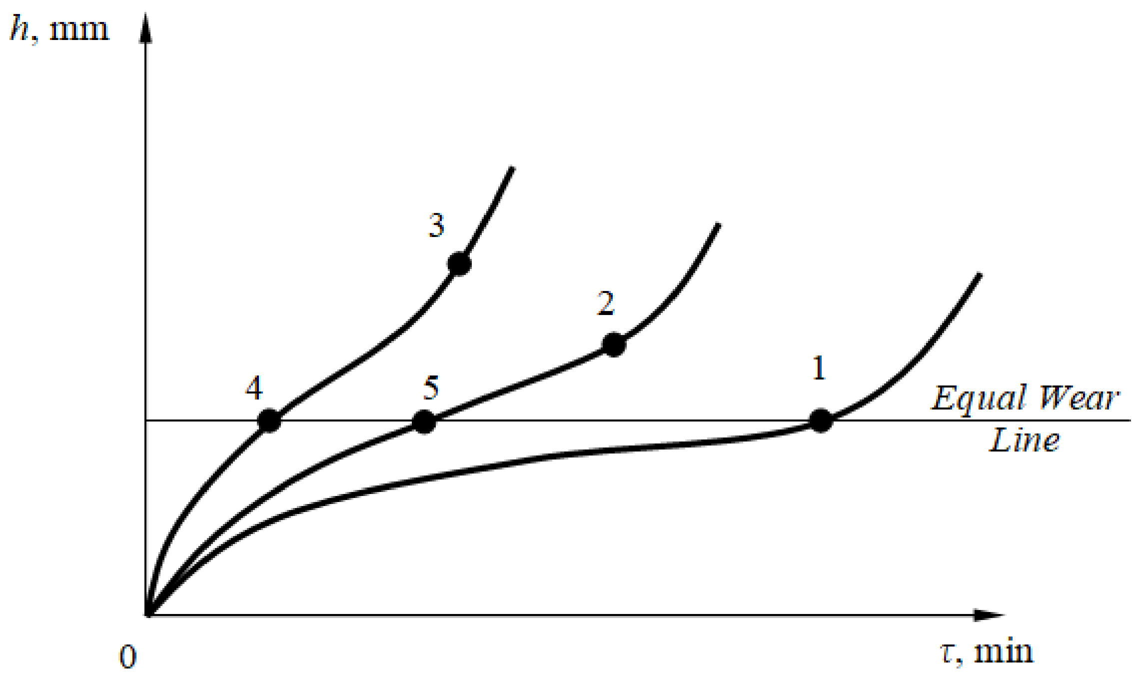

Fig. 5. Equal Wear Criteria

Considering in production conditions the work of a group of tools on a machine that can be operated at different cutting speeds, it is easiest to set the maximum allowable maximum wear on the rear surface h_{max} for all tools in the group. It is commonly called the criterion of equal wear.

In fig. 5, the criterion for equal wear is a horizontal line intersecting the wear curves at points 1, 4 and 5. The criterion for equal wear usually corresponds to the inflection point of the wear curve for the tool operating at the lowest speed from the group of tools installed on the machine. Upon reaching the established criterion of equal wear and tear, further work must be stopped and the entire group of tools re-sharpened or replaced with a new one.

The disadvantage of using the equal wear criterion is the unused reserves of the cutting properties of tools operating at speeds $V>V_1$ (sections 3-4, 2-5 on the wear curves).

Normal Wear Rate and Optimum Wear Rate

Upon reaching wear of the rear surface of the blade, the values of the maximum allowable value – h_{max}, the tool is re-sharpened. At the same time, the normal wear rate is understood to mean the normalized thickness of the machined layer of the tool material – $H_{n.w.}$ (fig. 6.). Thickness is calculated on the basis of the requirement to completely remove traces of wear and tolerance for regrinding. The calculation is based on the sum of the maximum linear wear h_{max} and tolerance **Δ**=0.1–0.2 mm. Thus, the wear rate equal to the thickness of the layer to be removed during regrinding $H_{n.w.}=(h_{max} + \Delta)sin\alpha$.

One of the criteria for tool blunting is optimal wear. Optimal wear is understood to mean that amount of wear at which the tool life, taking into account all possible regrindings, will be maximum. If we denote by T, min the tool life, i.e. the time interval between two adjacent regrind, the number of regrind – K, then the total tool life (work resource) will be $\Sigma T=T(K+1)$. Each value of h allows a certain number of regrind K, which is determined as follows (Fig. 6):

$$K = 2L/3(c+a) = 2L/3[(h_3+\Delta)sin\alpha/\cos(\alpha+\gamma)] = 2L\cos(\alpha+\gamma)/3H_{n.w.} ,$$

where L is the total length of the working part of the tool blade, 2/3 is a coefficient taking into account the useful length of the working part.

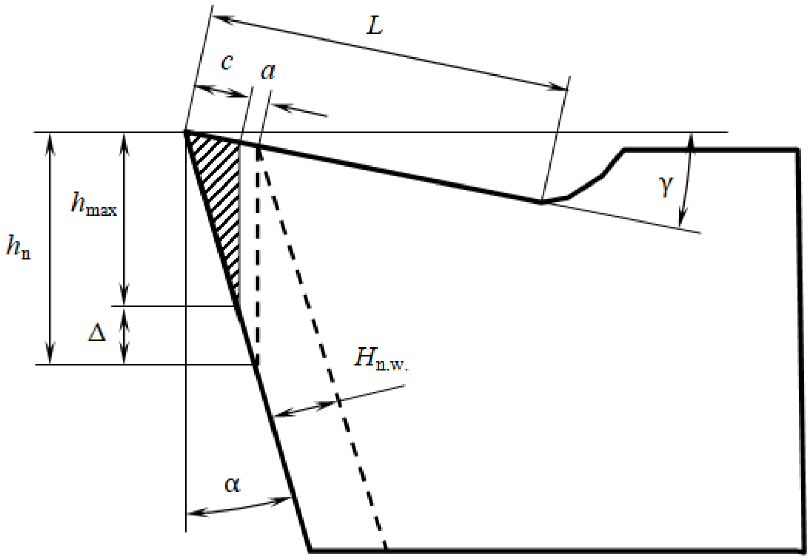

Fig. 6. The Determination of the Normal Rate of Wear

The greater the allowable wear, the longer the tool life, but the larger the layer of tool material must be removed during regrinding. Therefore, the smaller the possible number of regrinds. Therefore, the life of the tool with an increase in allowable wear first increases, and then, when the number of regrinds becomes too small, it decreases (Fig. 7).

Wear corresponding to the maximum tool life is called optimal. Its value on the wear curve lies near the transition point of the period of normal wear to catastrophic (point 1 in Fig. 5).

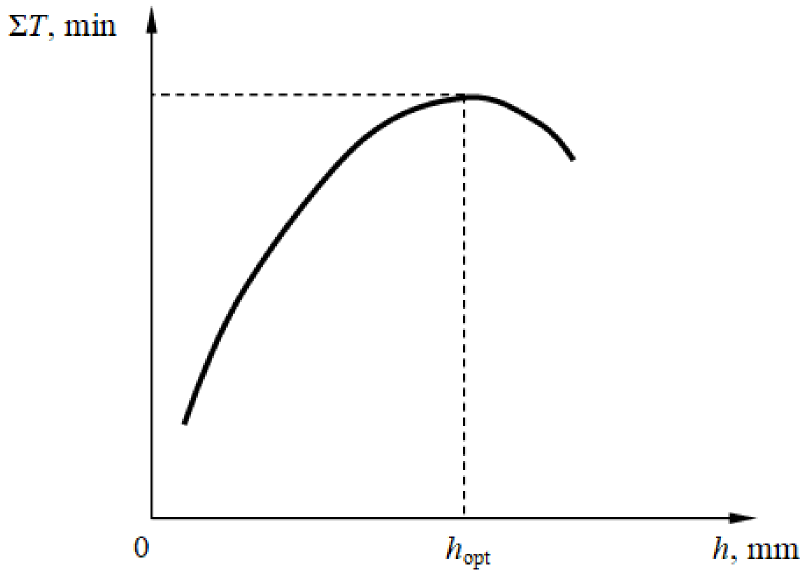

Fig. 7. Optimum Tool Wear

Tool Steadfastness Period

The tool life period (or simply life) is determined by the tool operating time until the blunting criterion is reached, i.e. to the maximum permissible wear.

The greater the wear rate, the shorter the tool life. One of the main factors determining the resistance period is the cutting speed. This is primarily due to the fact that, depending on the cutting speed, the temperature in the cutting zone changes.

The resistance period is selected within 10...60 min due to the appointment of the appropriate cutting speed, which is associated with resistance

$$T = C_T / V^{\mu} \text{ (or } V = C_V / T^{m}\text{, where } \mu = 1/m)$$

The value μ when machining with high-speed cutting tools for steels and cast irons is approximately equal to 8–10, carbide cutting tools – 5, cutting tools made of cermet – 2.

The resistance determined by the above formula is average and is used in the development of machine-building standards for cutting conditions.

INSTRUMENT MICROSCOPE

Device Purpose

Instrument microscope (simplified model of a measuring microscope) – designed to measure small objects and the distance between strokes, points and other surface irregularities. It is mainly used in technical control departments and educational institutions. The microscope has a reading ocular scale.

Main Parameters of the Microscope

Zoom…………………………………………	$19 – 33^x$
Measurement range………………………………	0.015 – 6 mm
Huygens eyepiece:	
Zoom…………………………………………	7^x
The price of division of the scale ………………	0.1 mm

Achromatic eyepiece:	
Zoom………………………………….…………………..	3.7^x
Aperture …………………………………….….….	0.11
Retractable tube scale …………………………..	130 – 190 mm
Dimensions …………………….…………….	134×67×34 mm
Weight…………………………………………..	0.29 kg

Microscope Design

The microscope consists of a retractable tube 1, inserted into the housing 2. On the tube marks are applied from 130 to 190 mm. A Huygens 3 eyepiece with a reading scale is inserted into the upper part of the tube. An achromatic lens 4 is screwed into the lower part of the housing.

The retractable tube allows you to change the distance between the lens and the eyepiece, and thereby change the magnification of the microscope. The increase in the length of the tube 130 mm – 19^x; with a tube length of 160 mm – 25.9^x, with a tube length of 190 mm – 33^x.

A clamp 5 is installed on the body, designed to mount the microscope on a universal indicator stand. The clamp can be moved along the body and fixed anywhere.

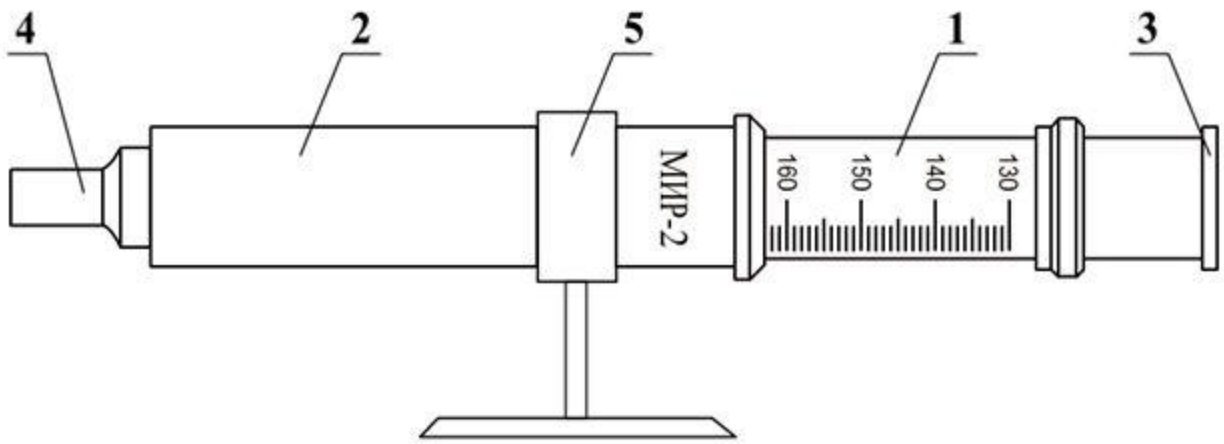

Fig. 8. Instrument Microscope

Microscope Technique

For convenience, it is recommended to install the microscope on any tripod, for example, an indicator tripod. After focusing the microscope on the test surface, two points should be found in the field of view, the distance between which must be measured with an eyepiece scale. The magnification of the microscope changes with a change in the distance between the lower and upper sections of the lens barrel and eyepiece within 130 - 190 mm; accordingly, the division price (a) of the eyepiece scale will also change (see Table 1).

Table 1. Application of the Value of the Division Value of the Eyepiece in the Plane of the Lens

Tube Length, mm	Division price (*a*) of a scale, mm
130	0.058
140	0.053
150	0.049
160	0.045
170	0.041
180	0.038
190	0.036

To determine the true distance T between two points, it is necessary to count the number of divisions P of the eyepiece scale falling within this distance, then multiply the price of the division of the scale corresponding to the given tube length by the number of divisions of the eyepiece scale: $T=a\cdot P$, mm.

PROCESSING THE EXPERIMENTAL RESULTS

Table 2. The Results of Determining the Wear of the Cutter from the Cutting Time

№	Cutting Time τ, min	Wear on the Back Surface h, mm	Normal Wear Rate $H_{n.w.}$, mm	Changing the Width of the Blade $c+a$, mm	Number of Regrinds K	Full Steadfastness ΣT, min
1	2	3	4	5	6	7

Each measured value of wear is taken in turn as the maximum allowable. For each measured value of wear *h* determine:

normal wear rate

$$H_{n.w.} = (h + \Delta) sin\ \alpha;$$

changing the width of the blade

$$c + a = H_{n.w.} / cos(\alpha + \gamma);$$

the permissible number of regrind *K* when dragging it through such periods of time for which the cutter reaches such wear

$$K = 2L/3(c+a);$$

full period of steadfastness (life resource) of the cutter

$$\Sigma T = T(K+1).$$

Then build a graph of the dependence of the full period of resistance of the cutter on the amount of wear on the rear surface $\Sigma T=f(h)$. Wear corresponding to the full life of the cutter is optimal, i.e. the most advantageous (see Fig. 7). Putting this value on the wear curve $h=f(\tau)$, we find the optimal resistance T_{opt} at a given cutting speed.

To determine the «Speed–Steadfastness» relationship, turning is carried out by four cutters with the same design, dimensions, geometry and material of the cutting part, with different cutting speeds (*V*) until the cutter is completely worn, with measurement of the operating time (τ).

Table 3. The Results of Determining the Relationship «Speed–Steadfastness»

№	Diameter of the Workpiece *d*, mm	Spindle Speed *n*, rpm	Cutting Speed *V*, m/min	Steadfastness *T*, min
1	2	3	4	5

Processing of the results of the experiment is carried out by graphical-analytical method. Build a graph of the dependence of the steadfastness *T* on the cutting speed *V* in double logarithmic coordinates. Using the equation of the straight line obtained, $\lg T = \lg C_T + \mu \lg V$ find the coefficients μ and C_T.

The coefficient μ is defined as the tangent of the angle of inclination of the graph to the axis of speed.

The coefficient C_T is equal to the ordinate at a cutting speed of V=1 or is determined by calculation (according to the formula $C_{Ti} = T_i V_i^{\mu}$) as the arithmetic mean of all experimental values.