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Method of Blocking Lines at Shape-Generating Of Helical Surfaces by Disk Blade.

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ABSTRACT

Products with helical surfaces are widely used in automobile manufacturing, machine tool industry and tool-making. Many cutting tools have helical surface (HS), which forms the cutting edges and serves to dispose the chip scrap and lubricating oil. Designing and manufacturing of cutting tools of the second order to process such surfaces are the most complex issues in tool production. Due to the increasing demand for quality of cutting tools to process helical surfaces, determining the installation parameters of disk blades for processing of helical surfaces is one of the main issues in tool production. This can be explained by the fact that there is no one-to-one correspondence between the tool profile and the helical surface profile. It was recognized that to prevent errors, the following installation parameters (IP) must be selected properly: a w – center-to-center spacing of the work piece and the disk tool (DT); ε – crossing angle between the positive direction of the work piece axis and the negative direction of the DT (axial angle); Ψ – rotation angle of transverse profile of the work piece relative to interaxial perpendicular line. We propose blocking lines method, enabling to determine accurately optimal installation parameters of the disk blades without transition curves and undercuts in the contingence area of helical surface profile with the second order tool. The article presents the analysis of blocking lines shape depending on the type of predetermined helical surface profile, as well as the results of studies, showing the effect of the inclination angle of the helical surface on the shape of blocking lines and restrictions on the choice of installation parameters. It was found that a change in the inclination angle of the helical surface leads to change of installation parameters of the tools. With increasing angle ω, parameter ψ increases, while ε decreases. Best installation parameters can only be achieved at the angles ω ranging from 10° to 60°. Approximate congruence of τ angles at the nodal points of helical surface profile can be reached just within these limits.

Keywords: helical surface parameters, installation parameters, blocking lines, milling cutters.

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INTRODUCTION

Due to the increasing demand for quality of cutting tools, the definition of the installation parameters of the disk blades for processing helical chip grooves is one of the main issues in the machine-tool production. Resolving this issue requires a knowledge and mastery of the profiling methods [1] to ensure the creation of high-performance designs of cutting tools.

The literature [2] provides a large number of tool profiles recommended for the machining of helical surfaces of various cutting tools and machine parts, without any indication of any installation parameters, which provide an opportunity to obtain the correct shape of a helical surface.

In practice [3] various methods of tool profiling are widely used that allows one to not only build a particular profile, but also to analyze the effect of each initial parameter on the profile and the structural dimensions of the tool. Such methods include graphical approaches [4] alone or in combination with some analytic calculations of certain factors of predominantly auxiliary character [5]. All these methods are rather bulky and of low precision.

Processing of helical surfaces by tools whose generating surface is a revolution surface, takes a significant place in the mass production of parts with the helical surfaces [6]. Such tools include disk, finger and comb thread mills, grinding wheels, flying cutters, and rollers [7]. Radii of generating surfaces of the instruments may be of any value, and, in particular, an infinitely large. Profiling of these tools provides a number of problems to be solved, which are related to their design and manufacture, and in particular, finding of installation parameters [8].

Processing of helical chip grooves of cutting tools provides a special challenge. Unlike the machine parts, helical chip grooves have complex asymmetrical and usually undercut profile, contoured by multi-conjugate or crossing segments of different lines, such as circular arcs, straight lines, elongated involute, the Archimedean spiral, and so on. At that, the undercutting and formation of transitional curves of inappropriate size, which may appear as a result of an error when treating helical surface, is not tolerated [9].

To prevent errors, it is necessary to choose the installation parameters of the tool with respect to the axis and the profile of the treated helical surface. Determination or search for IP, in particular, the crossing angle between axes of the tool and the helical surface and their center-to-center spacing, as well as optimization of IP relative to helical surface axis is a formidable task [10], especially in those cases, where helical surface has an undercut profile just on one side (milling cutters, broaches et al. at a positive values of rake angle ranging within the limits of $y = 15 \ldots 25^0$), or on both sides (drills, three-fluted countersink drills, tap screws, and others.). Similar problems arise when designing disk blades for machining of gear and helical parts (gear wheels, screw shafts, worm screws, etc.) [11].

Therefore, the definition or search for installation parameters, as well as their optimization with respect to the coordinate axes of the helical surface remains relevant scientific and technical challenge.

METHODOLOGY

Currently, the definition of the tools installation parameters relative to the workpiece are solved using both direct and inverse problem for the disk blade profiling, when forming helical surfaces [12]. In the tool designing process, as a rule, the calculated profile of the tool, for technological or other reasons, cannot be accepted as a final profile [13]. There raises a need to define the deviation of the profile shape of the helical surface, caused by the mismatch of theoretical and actual tool profile. First of all, there arises a need to define certain optimal position of the tool relative to the workpiece, i.e. installation parameters, providing the opportunity to close tolerance machining the entire helical surface or it’s the most important part.

A. Search for installation parameters of the tools for machining of helical surfaces having a smooth profile

As a basis we considered a helical surface profile with the following basic design dimensions (Fig.1a): the outside diameter D = 50 mm; the rake angle of the cutter in the face section γ = 15°; the groove bottom radius ρ_1 = 5.2 mm; the number of teeth Z = 8; the groove depth h = 8 mm; the chamfer size f = 1 mm; the relief angle at the point C in the face section α = 15 °; the helix parameter P = 25, and the inclination angle of helical surface ω = 45°. In this case, the tool diameter and center-to-center spacing were d_{ao} = 55 mm, a_w = 48.5 mm, respectively.

Figure 1b represents a graphs of blocking lines for this option with the angle ω = 45°.

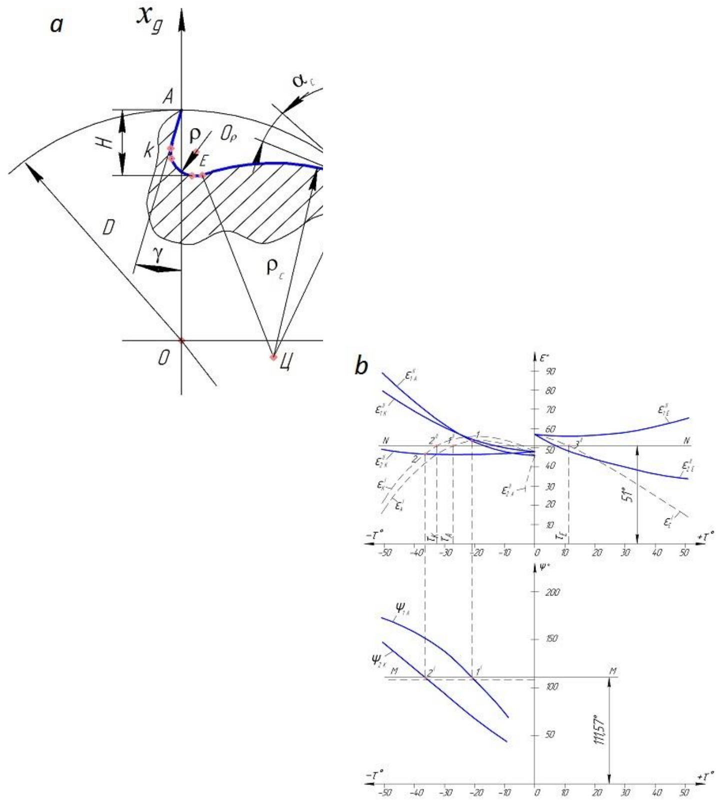

Fig.1. The helical surface profile (a); blocking lines to determine installation parameters of the DT at the angle ω = 45° (b)

The sequence to determine installation parameters of the DT is as follows.

1. First, select the nodal points on the profile: point A, located on the largest radius of the workpiece, point K, where the profile has the highest undercut, point E on the concave part, which corresponds to the smallest angle of the DT profile when processing the right part of the profile. If in the noted points shape-generating conditions are satisfied, then in remaining points they will also be met. Since *K* and *E* are junction points, they simultaneously belong to both segments. We agree that both points *K* and *E* are located on the *KE* segment.
2. Calculate the parameters *r*, δ, ξ, *x*, *y*, and ρ in the selected nodal points by the known formulas [14]. The values of these parameters are given in Table 1.
3. Assuming that the helical groove will be milled, take d_{ao}= 55 mm and α_w = 48.5 mm. If necessary, these values can be adjusted.

Table 1. Parameters of the helical groove profile at the nodal points of the profile.

Nodal points	r, mm	δ, rad	ξ, rad	ρ, mm	x_q, mm	y_q, mm
A	25.0	0	0.262	10^5	25.0	0
K	23.593	–0.017	0.278	5.2	23.546	– 0.390
E	21.841	0.437	0.045	5.2	19.790	9.241

4. Having set the value of the profile angle at the current point τ within the range, e.g., from 0 to ± 40 ° (with a step of 10°), we calculate the parameter for the nodal points *A, K,* and *E* according to the equation [15]:

$$\varepsilon''_{1,2} = \mathrm{arctg}\left(G \pm \sqrt{G^2 - E}\right), \quad (1)$$

where $G = P(Sx_0 - u\rho\sin\tau\cos\tau)/Q$; $S = r\cos\mu - \rho\sin\tau$; $x_0 = r\cos\mu - a_w$; $Q = x_0\left(S^2 - C\right) - \rho\sin\tau\left(u^2 + P^2\sin^2\tau\right)$; $C = \rho(\rho - V)\sin^2\tau$; $\mu = \tau - \xi$; $u = r\cos\xi$; $V = r\sin\xi$;

$E = P^2(S - a_w)/Q$;

where ρ is the curvature radius of the profile at the selected point of face section. The radius is taken with the plus sign at the right side (index "1"), and with a minus sign at the left side of the profile (index "2"); for rectilinear segments it is given by a large positive number, for example, 10^3 ... 10^5. Further construct graphs of blocking lines (Fig. 1b). Hereinafter numerals I and II mean that ε is calculated from the first and second shape-generating conditions [16].

5. Calculate the parameter $\psi''_{1,2}$ for the same values of τ, as in the step 4, and the corresponding values of $\varepsilon''_{1,2}$ by the following equation [17]:

$$\psi^{II} = \frac{n_2\cos\tau - n_1}{\sin\tau} - \tau + n_3, \quad (2)$$

where $n_1 = u\left(a_w + P\mathrm{ctg}\varepsilon\right)/P^2$; $n_2 = u^2 + a_w P\mathrm{ctg}\varepsilon/P^2$; $n_3 = \delta + \xi + uV/P^2$,

and plot the graphs $\psi''_{1,2} = f(\tau)$ of blocking lines for points *A*, *K*, *E* (see Fig. 1,b).

6. Find ψ и ε using plotted graphs. To do this, draw a straight line *MM* parallel to the τ axis, so that the point 1' of intersection of this straight line and the line ψ''_{1A} corresponds to the conditions $|\tau_A|$ > 15…20° and $|\tau_K| > |\tau_A|$.

Next, project point 1' to a point 1 on the line $\varepsilon''_{1,A}$. Project point 2' at the intersection of a straight line *MM* and the line ψ''_{2K} to point 2 on the line $\varepsilon''_{2,K}$. Draw a straight line *NN* parallel to the τ axis, so that it passes between the points 1 and 2. These lines correspond to the values of ε = 51°, ψ = 111.57° for the left side of the profile.

$$\varepsilon^1 = \text{arctg}\frac{P(a_w \cos\tau - u)}{u(a_w - u\cos\tau) + P^2(\psi - n_3 + \tau)\sin\tau}. \quad (3)$$

7. Check the fulfillment of the first condition for the points *E* and *K*.

To do this, calculate ε'_E by the equation, taking $\psi = 111.57°$, $\varepsilon = 61°$:

$$\varepsilon^1 = \text{arctg}\frac{P(a_w \cos\tau - u)}{u(a_w - u\cos\tau) + P^2(\psi - n_3 + \tau)\sin\tau}. \quad (3)$$

Using the calculation results construct the graph ε'_E, shown in Fig. 1b by dashed lines.

It is clear from the plot that the second condition for the point *E* is satisfied, since the line ε'_E intersects the line *NN* between the lines ε''_{1E} and ε''_{2E} (point 3^1), i.e., inequality $\varepsilon''_{2E} \le \varepsilon'_E \le \varepsilon''_{1E}$ is satisfied. In this case, for the selected node points τ_K = –34° and τ_E = 12°.

For the found values of installation parameters we calculate the DT profile, the profile angle α_0 and the curvature radius ρ_C [18]. The calculation results for the nodal points, as well as for the points *A* and *C* (for the complete idea of the DT profile) are shown in Table 2.

Table 2. Calculation results

Nodal points	τ°, degree	r_0, mm	z_0, mm	α_0, degree	ρ_C, mm
A	27.33	53.97	-51.19	26.02	58.96
K	41.51	59.06	-48.05	35.46	60.93
E	15.43	59.23	-43.22	18.17	-54.07
C	25.73	41.39	-36.85	25.53	-68.17

The MT profile is shown in Fig. 2. The calculations show that the profile angles at the least favorable points *A* and *E* (in the context of side back relief angles and fixity of the DT) differ from each other.

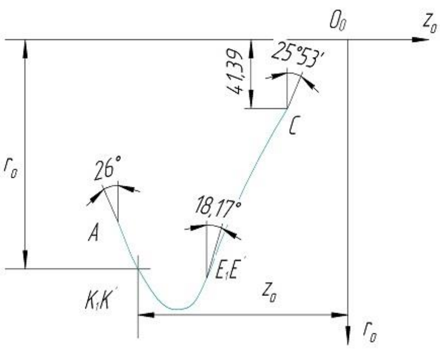

Fig.2. Profile of the disk blade for machining of grooves with a smooth profile.

To align them it is necessary to change slightly the values of ψ and ε, repeating the operations described in the step 7 and performing calculations according to the step 8. Comparison of radii r_0 and ρ_c also shows that the condition $\rho_c \ge r_0$ holds for all selected points.

A negative value of ρ_c means that the curvature of the line corresponding to cross-section of helical groove at the contact points *E* and *C* is opposite to curvatures of the MT that also indicates the performance of the second shape-generating condition.

B. Search for installation parameters of tools for machining helical surfaces having angular profile

Consider the search technique for installation parameters of disk blade as exemplified by processing a helical surface with a break point *K* and undercut at the segment *AK* for helical carbide blades. The profile is outlined by three segments (Fig.1): rectilinear segments *AK* and *KE* with a break point *K*, and curvilinear segment *EC*, outlined by a circular arc with the radius ρ. Nodal points include: *A* and *C* with largest radius, the point *K*, which corresponds to the jog, and the point *E*, which has the smallest profile angle of the 2nd order tool. Since the cutting blade is attached to the side *AK,* generation of transition curve in the vicinity of the point *K* is not allowed.

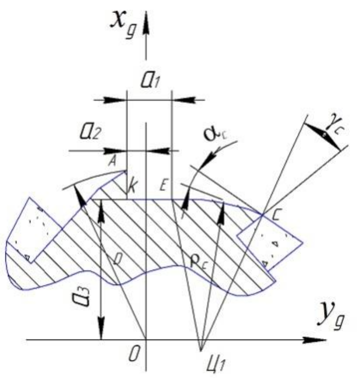

Fig.3. Helical surface with an angular profile

The profile has the following dimensions: the outer diameter D = 47 mm; the sizes of the angular profile: α_1 = 5.2 mm; α_2 = 2.5 mm; α_3 = 17 mm; the radius of the machined tooth back ρ = 18.89 mm; the number of teeth Z = 6; the helix parameter P = 33.57 mm, which corresponds to the inclination angle of the helical surface ω = 37 °; and back relief angle at the point *C* equal to 15°.

The sequence of determining the installation parameters of the disk blade is as follows.

1. Select the nodal points on the profile: *A, K, E* and *C.* Since *K, E* are junction points, they both belong simultaneously to two segments. In the calculations we agree that the points *K* and *E* are located on the *KE* segment.

2. Calculate the parameters *r*, δ, ξ, *x*, *y*, and ρ in selected nodal points by the known formulas. The values of these parameters are given in Table 3.

Table 3. Parameters of the helical groove profile at the nodal points of the profile

Profile points	r, mm	δ, rad	ξ, rad	ρ, mm	x_q, mm	y_q, mm
A	23.50	– 0107	– 0107	10^5	23.367	– 2.50
K	17.183	– 0.146	0.146	10^5	17.00	– 2.50
E	17.213	0.158	1.117	17.01	17.00	2.70
C	23.50	0.941	1.307	17.01	13.848	18.986

3. Assuming that the groove will be milled, we take the outer diameter of the 2nd order milling cutter d = 55 mm, and center-to-center spacing of the work piece and the tool; a_W = 39.2 mm. If necessary, this value can be adjusted.

4. Perform calculations and plot blocking lines (Fig. 4).

5. Calculate the value of $\varepsilon_{\min}$ for point *A*: $\varepsilon_{\min} = \operatorname{arctg}\dfrac{P}{r_k} = 1{,}064 = 61°$.

6. Set the value τ_A = 20°; find the intersection point *1* between the line ψ''_{1A} and the straight line *MM,* drawn parallel to the τ axis. Project point *1* to point *1′* on the line ε''_{1A}. Draw a straight line *NN* through the point *1′* parallel to the τ axis and determine the value of ε''_{1A} = 62° (we accept that $\varepsilon''_{1A} \ge \varepsilon_{\min}$). Find ψ_k by the formula [19]:

$$\psi_k = \frac{a_w}{P^2}\sqrt{r_k^2 - P^2\operatorname{ctg}^2\varepsilon_k} + \arccos\frac{P\operatorname{ctg}\varepsilon_k}{r_k} - \delta_k \quad (4)$$

$\psi_k = 35^{o}$.

7. Check the condition $\psi_k \ge \psi''_A$. In this example ψ_k =35° and ψ''_A = 57°; hence, the noted condition is not satisfied. Therefore, τ_A should be increased by taking it, for example, equal to 25°, and repeating the calculation, as indicated in step 7. Then ψ''_A = 66°; and ψ_k = 78.8°. Now the condition $\psi''_k \ge \psi''_A$ is satisfied. At that, ε_A will be equal to 68° (see straight line $N'N'$).

8. Check the validity of the first and second shape-generating conditions at points A, K and E. To do this calculate ε' by equation (1) taking $\psi = \psi_k$ = 78.8°. Plot the curves ε' (τ) by dashed lines both for point E' and for the points A and K to determine the roots of τ (see Fig. 4).

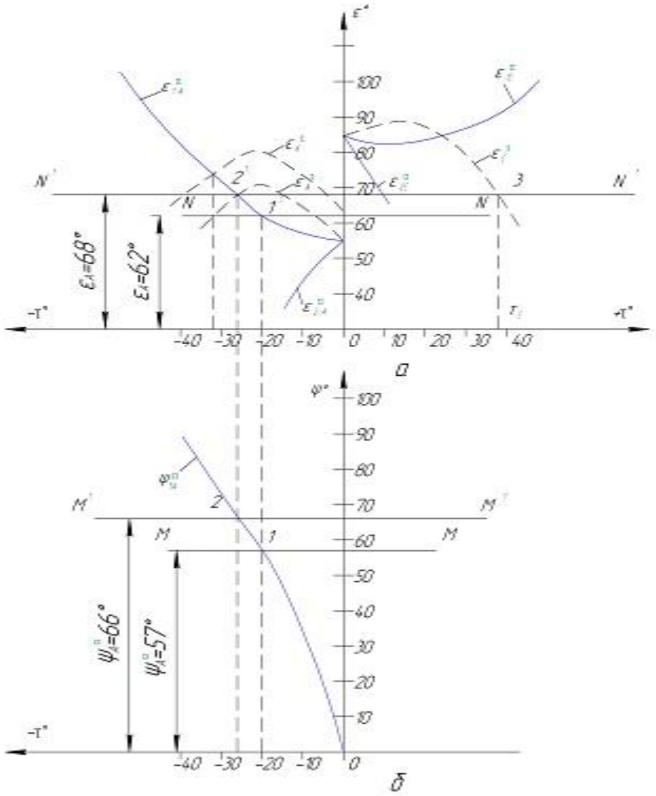

Fig.4. Blocking lines to search for the installation parameters of the MT at d_{ao}= 55 mm.

The graphs show that the condition $\tau_k > \tau_A$ and inequality $\varepsilon''_{2E} \le \varepsilon'_E \le \varepsilon''_{1E}$ are satisfied. Therefore, the installation parameters ψ = 78.8°, ε = 68° при τ_A = – 25°are chosen correctly.

Using the values of found installation parameters, we calculate the MT profile, the profile angle α_0 and curvature radius ρ_c . The calculation results for the nodal points, as well as for the points *A* and *C* (for the comprehensive idea of the MT profile) are shown in Table 4.

Table 4. Calculation results

Nodal points	τ°, degree	r_0, mm	z_0, mm	α_0, degree	ρ_c, mm
A	– 31.58	36.899	– 24.228	31.08	43.09
2	– 37.61	37.937	– 23.543	35.15	88.61
3	– 42.86	39.469	– 22.379	39.18	542.35
K	– 47.87	41.211	– 20.845	43.49	– 176.38
E	21.08	37.968	– 17.642	21.70	– 31.59
4	24.78	35.380	– 16.539	24.79	– 52.18
5	29.83	33.095	– 15.378	29.36	– 79.77
6	36.19	30.933	– 4.014	35.33	– 105.10
C	53.04	26.745	– 10.068	51.75	– 126.46

The DT profile is shown in Fig. 5. The calculations show that the profile angles at the least favorable points *A* and *E* (in the context of side back relief angles and fixity of DT) differ from each other.

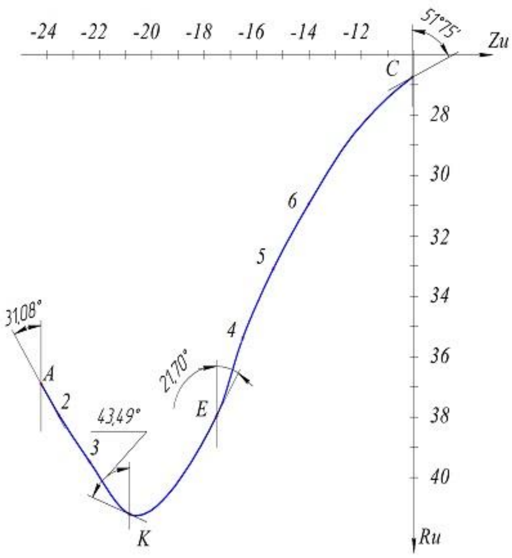

Fig.5. Profile of the disk blade for machining grooves with an angular profile.

RESULTS

When conducting studies of the influence of inclination angle ω of helical surface on the shape of blocking lines and restrictions on the choice of installation parameters, the following values of the ω angle were taken 5°; 10°; 20°; 30°; 40°; 50°; and 60°.

Figure 6 shows graphs of blocking lines at generating of helical surface shape with basic design parameters (see Fig. 1) for ω angles equal to 10° and 60°, respectively.

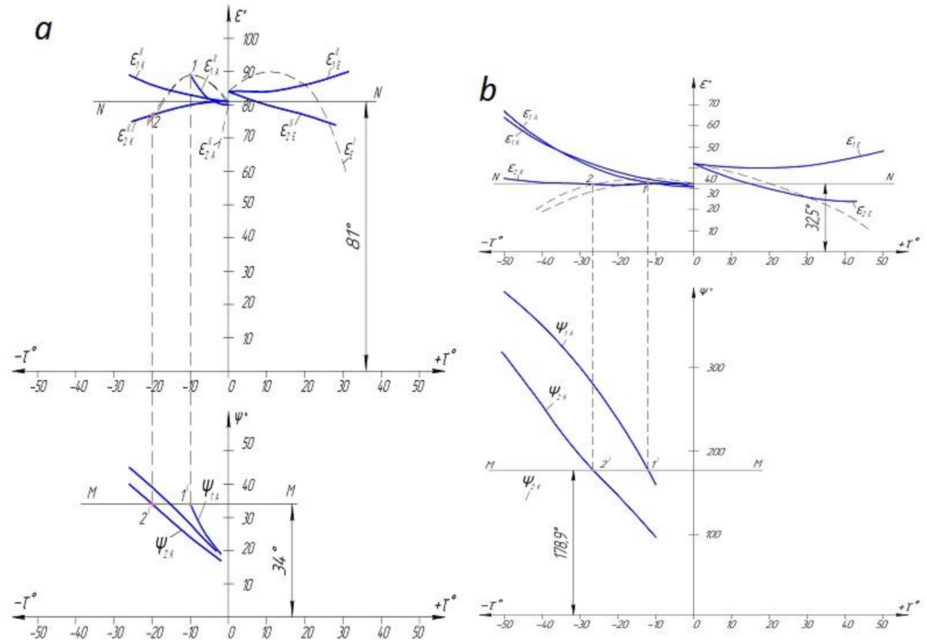

Fig.6. Blocking lines to search for installation parameters at ω = 10° (a) and ω = 60° (b)

After analyzing blocking lines we obtain the values of installation parameters respectively equal to ε = 81°, ψ = 34° (Fig 6, *a*); ε = 32.5°, ψ = 178.9° (Fig. 6b).

Analyzing the shape of the blocking lines and restrictions on the choice of installation parameters, we can see that for small ω angles the range of valid values of ε'' is within the narrower limits. This circumstance creates difficulties in selecting optimal installation parameters. Thus, at the ω = 10° (see Fig. 6a) for points *A* and *K* the upper border of the graphs $\varepsilon''_{1,A}$, $\varepsilon''_{1,K}$, $\varepsilon''_{1,E}$ corresponds to the angles τ: 10°; 26°; 28°. At an angle ω = 5° similar values of τ are 4°; 16°; and 16°. This leads to the difficulty of the choice of ε and ψ parameters and significant reduction of angles | τ_A | and | τ_K |. Besides, the character of lines ε''_2 changes for the points *K* and *E*, because the values of ε''_2 at these points reduce more rapidly with increasing of angle τ than those at ω = 45°. Conversely, the values of ε''_1 in the point *A* at the small τ angles increase more rapidly than those at the large angles.

At larger angles ω the opposite is true. Thus, at the angle ω = 60° (see Fig. 6b) the value ε''_1 in the point *A* increases slower with increasing angles τ than at ω = 45°, and varies within a broader range of angles τ than at ω = 10°. Values of ε''_2 at the point *K* are also reduced by changing τ from 0 to 20°, and further continue growing. Area between the lines $\varepsilon''_{1,E}$ and $\varepsilon''_{2,E}$ narrows notably. This leads to the fact that the parameter ε at ω = 60° is within a narrower range.

Figure 7 shows the dependence of the installation parameters ε and ψ on the inclination angle ω of the helical surface.

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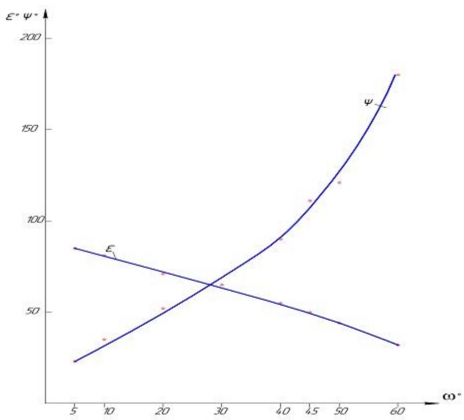

Fig.7. Dependence of the installation parameters ε и ψ on the inclination angle ω.

It follows from a consideration of the graph that with increasing ω from 5° to 60° parameter ψ increases, while parameter ε decreases. This is due to the fact that with increasing ω helix parameter *P* decreases, as these two parameters are connected by the formula $P = r / \mathrm{tg}\,\omega$, and therefore, according to relations (1) and (2), the values $\varepsilon''_{1,2}$ decrease with decreasing τ at the nodal points that leads to reduction of ε parameter and consequently to increase of parameter ψ.

However, a slight decrease in the parameter ε leads to a sharp increase in the parameter ψ; this especially takes place at large values of the ω angle.

The best installation parameters can only be achieved at ω angles varying within the range 10°<ω< 60°. Within these limits the approximate equality of the angles τ at the points *A, K,* and *E* is achieved. However, it should be noted that at large angles ω installation parameters lie within a very narrow range.

DISCUSSION

The proposed method of blocking lines to find the installation parameters of disk blades when generating helical surfaces shape is a versatile technique, suitable for any helical surface profile. It allows combining calculations of different profiles of workpieces to find optimal installation parameters of the disk blades to machine them. It allows expanding the technological capabilities of disk blades profiling when generating the helical surface shape.

To accomplish this goal it is necessary to carry out the following:

1. Identify the parameters of a helical surface, which have the greatest effect on the search for the optimal installation parameters. Specified (nominal) groove profile is determined either by equations, or by coordinates of the points and direction of the tangent. For consistency of solving the surface profiling problem, setting a profile of helical surface in a face section using polar coordinates *r* , δ, ξ and the profile curvature radius ρ is taken as a common rule. Sometimes, for example, for auger drills and screw broaches, the profile is defined in the axial section by coordinates *r* and z_a, profile angle ξ_a, and radius of curvature ρ_a. In this case the given data can be scaled for face section by the known formulas [14].

In case the profile segment in the axial section was rectilinear, the corresponding segment in face section will be outlined by Archimedian spiral.

Search for installation parameters ε and ψ of blocking lines is based on the use of two known shape-generating conditions.

The first condition requires that the normal lines to the helical surface at all contact points intersect the axis of the tool from the side, which is open to tangency. Otherwise, the surface will get crush grooves or undercuts. Moreover, if the shape-generating conditions are satisfied at unfavorable points, they will be fulfilled at the other points as well. Unfavorable points of the profile are considered those points having a concave or rectilinear segment with undercut at the points with the largest *r*.

To find the installation parameters, we use the equation of tangent line:

$$\frac{n_2 \cos\tau - n_1}{\sin\tau} - \tau - \psi + n_3 = 0 \quad (5),$$

solved with respect to ψ:

$$\psi = \frac{n_2 \cos\tau - n_1}{\sin\tau} - \tau + n_3 \quad , (6)$$

and with respect to ε. (equation (3)).

The second condition is fulfilled if the tangency of the groove surface with **OPS** takes place on the outer side at all the points of the tangent line. This condition will be satisfied if the curvature radius ρ_c in a section of a given groove surface crossed by a plane perpendicular to the axis of the DT, is larger at the contact point than the corresponding radius r_o of rotation circumference of the DT. Mathematically, it is expressed as $\rho_c \geq r_0$. If we solve the equation of a tangent line (5) with respect to ψ and ε, we obtain the equations (2) and (3).

2. Analyze the influence of design parameters of disk blades on the blocking lines shape and restrictions on the choice of installation parameters, as well as find helical surface profile dimensions that would provide its full machining without crush grooves, undercuts, and appearance of transition curves. Also, investigate the effect of the inclination angle of helical surfaces on the choice of installation parameters.

When studying the effect of the disk blade diameter on the shape of blocking lines and restrictions on the choice of installation parameters, the following values of d_{ao} were taken: 32.5, 40, 55, 67.5, 80 and 100 mm.

It was found that an increase in the diameter of the disk blade d_{ao} increases the rotation angle ψ of the workpiece face profile with respect to the center-to-center line, though has no significant effect on the crossing angle ε between the workpiece axes and the disk blade.

Reduction in the diameter of the disk blade d_{ao} leads to expansion of the area between the blocking lines in the nodal points on the undercut segments of the profile that contributes to a wider choice of parameter ε. These studies are not presented in the current article. To find the optimal values of the installation parameters it is necessary to carry out the research on additional parameters of helical surface.

It was revealed that the best installation parameters can be achieved only at the angles ω within the limits $10° < \omega < 60°$. The values of ω within these limits provide approximate equality of angles τ at the nodal points.

CONCLUSION

Based on the conducted studies of the installation parameters of disk blades, used for machining of helical surfaces, it was found that the proposed method of blocking lines to find the installation parameters is versatile and suitable for any profile of the helical surface, at any position of the tool axis relative to the workpiece, and makes it possible to solve all the issues of tools profiling.

The authors revealed the parameters that have the greatest effect on the search for the optimal installation parameters.

The effect of structural dimensions of different tools on choice of installation parameters and the profile of initial generating surface have been analyzed. For each specific type of helical surface, the optimal installation parameters of the disc blade were defined that would provide surface machining without undercutting and development of transition curves at the tangent point of the helical surface profile with the second order tool.

In the course of the research it was found that a change in the inclination angle of the helical surface leads to change in tools installation parameters. With increasing angle ω parameter ψ increases, while parameter ε decreases. The best installation parameters can only be achieved at the angles ω varying between 10° and 60°. The values of ω within these limits provide approximate equality of τ angles at the nodal points.

It was revealed that the reduction in diameter of the disk blade d_{ao} leads to expansion of the region between the blocking lines at the nodal points on the undercut segments of the profile that contributes to a broader choice of parameter ε. Therefore, to find the optimal installation parameters, further research is needed on additional parameters of helical surface to be carried out in future.

Computer code developed for implementation of this method is a kind of mechanism that associates the parameters of the machined workpiece with the tool's actual parameters through the installation parameters of this tool. Using this program one can solve not only a single-valued task, but also comprehensively analyze the effect of each parameter of the tool on the surface shape-generating conditions to determine the optimal values.

The results are planned to be applied in the development of manufacturing technology of screw surfaces of downhole motors. According to the data optimization of cutting parameters will improve the quality of manufacturing parts of downhole motors and increase the efficiency of their production. Now there is a production testing of the proposed methodology.

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