THE STUDY OF THE HELICAL DRILL BY 3D MODELING

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Abstract: The most important problems that arises when designing the helical drills is to establish the profile of the helical channel, respectively, to determine the profile of the mill of the second order for it's processing, This can be solved graphically of analytically. In the paper, the cross-sectional profile of the helical channel is determined by calculation for drill with the following characteristics: diameter 20 mm; 2,8 mm core diameter; top angle 118^o the angle of the channel propeller of 30^o tooth width of 11,5 mm diameter of 18,5 mm back tooth: facet of 1,75 mm. Also, based on the calculated date, the 3D modelling of the drill body with helical channels and the geometry of the active part obtained after sharpening was performed. Making evident methods and schemes of sharpening and other sharpening of helical drills can be done using 3D modelling Software.

Keywords: Helical drill, helical channel profile, 3D modelling

1. INTRODUCTION

In order to be able to determine by calculation the profile of the channel it is necessary to know: drill diameter *d*; the angle of the top $\varepsilon = 2\kappa$; the inclination angle of the channel ω; diameter of the core of the deep d_0; tooth width *b*; the width of the face *f*; diameter of the back of the of the tooth de; the shape d_1, the cutting edge of the drill.

The angle at the top 2κ has the values set (STAS R 1320- 74) depending on the material processed and has values between 118 and 140^o. The inclination angle ω of the helical channel has values given in table 1.

The diameter of the core of the drill d_0, the width of the face *f*, the width of the tooth *b*, and the diameter of the back of the tooth d_1 are determined according to the diameter of the drill *d*, according to table2.

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Table 1 **The angle values of the helical channel, in degrees**

The type of drill	**Diameter of the drill, mm**				
	Up to 1	**1 … 3,2**	**3,2 … 5**	**5 … 10**	**> 10**
N	18±3	20±3	22±3	25±3	30±5
D	-	10±2	12±3	13±3	
M	-	35±3	35±5	40±5	

Table 2. **Relations the determining the elements of the right dried d_0, *f*, *b* and d_1**

Diameter of the drill, *d*, mm	**0,5 … 10**	**11 … 60**	**61 … 80**
Diameter of the core, d_0, mm	(0,28 … 0,165)d	(0,16 … 0,15)d	(0,15 … 1,375)d
Width of the face, *f*, mm	(0,32 … 0,1)d	(0,1 … 0,06)d	(0,059 … 0,045)d
Width of the tooth, *b*, mm	(0,6 … 0,57)d	(0,58 … 0,57)d	(0,57 … 0,56)d
Diameter of the back of the tooth, d_1, mm	d - (0,08 …0,8)	d – (0,8 … 2,5)	d – 2,5

Observation: The first values in parentheses correspond to the small values of the drill diameter.

To increase the strength of the drill the core is made conical, its diameter increasing towards the tail of the drill by 1,5 mm to a length of 100 mm, to the drill in carbon steel and 1,75 mm to the drill in rapid steel.

To reduce the friction with the wall of the hole, the outer diameter of the dried is made with an undercut, whose values are 100 mm, in length:

- for drills with diameter up to 6 mm it is 0,03…0,08 mm;
- for drills with diameter 6..18 mm it is 0,04…0,10 mm;
- for drills with diameter over 18 mm it is 0,05…0,12 mm.

By construction and sharpening must be ensured an angle of constructive place went α, of variable value, $\alpha = 8 \dots 14^o$ on the outside and on $\alpha = 20 \dots 25^o$ on the inside The angle of inclination of the transverse edge ψ has the following values:

- $\psi = 47 \dots 50^o$ for drills with diameter smaller then 12 mm;
- $\psi = 52 \dots 55^o$ for drills with diameter bigger then 12 mm.

The main out of the drill tooth can be rectilinear, convex and concave Generally, the helical drills are made with rectilinear cut.

2. CALCULATION OF THE HELICAL CHANNEL PROFILE OF THE DRILL

The determination by means of analytical methods of the helical channel profile can be made only with the help of the computer, by determining the coordinates of the active profile points of the channel. In general, the cutting edge of the helical drill to rectilinear, which allows to determine the channel profile in a cross section.

In order to determine by calculation the profile of the helical channel, shown in, figure 1, it is necessary to know: *d* - diameter of the drill, in mm; d_m - diameter of the core of the drill, in mm; ω - the angle of inclination of the helical channel of the drill, in degrees; κ - semi-angle at the top of the drill, in degrees, i_{max} - the number of intervals in which the length of the attack come of the drill is divided $l_z = i_{max}\,\Delta z$.

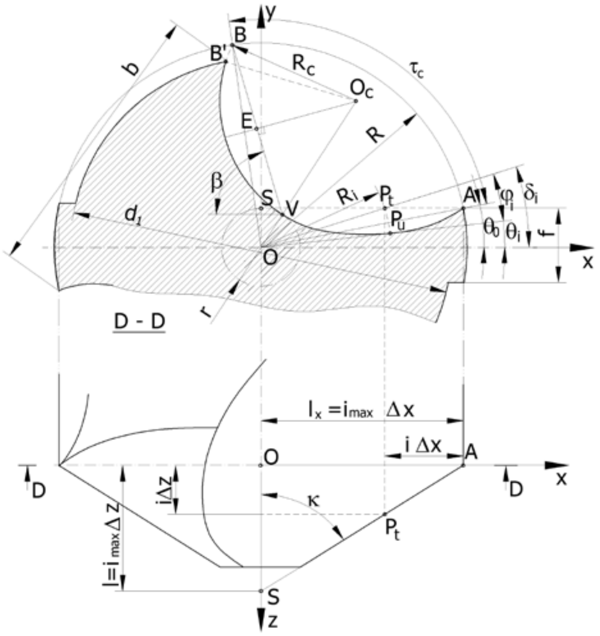

Fig. 1. Channel profile elements

The calculation consists in determining the coordinates x_i and y_i of the points of useful profile AV, cutting edge rectilinear and of the non-useful profile VB, which is a circle arc.

For the useful part it is considered that a current point on the cutting edge P_t corresponds to the point P_u on the useful part, which is obtained by a helical movement, composed of a rotation with the angle φ_i being on the radius R_i and an axial displacement with $i\,\Delta z$.. If at a complete rotation 2π, corresponds to a displacement on the axis Oz equal to the pitch of the helical channel p_E, then at a rotation with the angle φ_i will correspond to an axial displacement, $i\,\Delta z$, which is determined by the relation:

$$i\,\Delta z = \frac{i\,\Delta x}{tg\kappa} = \frac{i\,l_x}{i_{max}\,tg\kappa}\,; \quad l_x = \sqrt{R^2 - r^2}\,, \tag{1}$$

where i is a certain position of the point P_t on the cutting edge of the drill tooth, with values between 0 and i_{max}; l_x - projection on the Ox axis of the distance OA=R, in mmm ; R - drill radius, $R= d/2$ in mm; r - drill core radius, $r=d_0/2$ in mm.

Radius R_i, of the current point on the useful side of the drill channel is determined by the relation,

$$R_i = \sqrt{r^2 + l_x^2 \left(\frac{i_{max} - i}{i_{max}} \right)^2}\,, \text{ mm.} \tag{2}$$

The pitch of the helical channel helix, p_E, is calculated with the relation,

$$p_E = \frac{\pi\, d}{tg\omega}\ \text{, mm.} \tag{3}$$

The central angle, φ_i, between the current point of the cutting edge P_t and the point P_u on the useful part of the drill channel is calculated with the relation,

$$\varphi_i = \frac{i}{i_{max}} \frac{2\pi\, l_x}{p_E\, tg\kappa}\text{, rad.} \tag{4}$$

The central angle, δ_i, ad of the current point P_t to the axis Ox is determined by the relation,

$$\delta_i = arcsin\left(\frac{r}{R_i}\right)\text{, rad.} \tag{5}$$

The central angle θ_i between the point P_u on the useful side of the drill channel and the Ox axis is calculated with the relation,

$$\theta_i = \delta_i - \varphi_i\text{ , rad.} \tag{6}$$

The coordinates of the point P_u on the useful side of the drill channel is determined by relations,

$$x_i = R_i\, cos\,\theta_i\text{ , mm;} \tag{7}$$

$$y_i = R_i\, sin\,\theta_i\text{ , mm.} \tag{8}$$

The coordinates for I = 0 correspond to point A, and those for is i = i_{max} correspond to point V, of the intersection of the useful and neutral parts of the helical channel, on the surface drill core.

The coordinates of the points of the ventral part of the channel, VB, are found on a circle are passing through points V and B, whose center is at the intersection of the line OV with the perpendicular taken through the middle of the line VB.

The opening angle of the channel, τ_c, is calculated with the relation,

$$\tau_c = \pi - 2\,K\,arctg\left(\frac{b}{d_1}\right)\text{, rad,} \tag{9}$$

where: b is the width of the tooth, in mm; d_1 - the diameter of the back of the tooth, in mm; K - a coefficient of correction of the tooth width, $K = 1,1\ldots1,2$

Coordinates of point s are determined with the relations:

$$x_B = R\,cos(\theta_0 + \tau_c),\ \text{mm;} \tag{10}$$

$$y_B = R\,sin(\theta_0 + \tau_c),\ \text{mm.} \tag{11}$$

The length of the line sequent VB, is calculated with relation,

$$l_{VB} = \sqrt{(x_B - x_V)^2 + (y_B - y_V)^2}\ ,\ \text{mm.} \tag{12}$$

The angle β of the live segment VB, is determined by the relation,

$$\beta = arctg\left(\frac{y_B - y_V}{|x_B - y_V|}\right),\ \text{rad.} \tag{13}$$

The radius of the circle are is determined from the isosceles triangle VBO_c in which EO_c it is height, with the relation

$$R_c = \frac{l_{VB}}{2\,cos(\pi - \beta - \theta_{i_{max}})}\ ,\ \text{mm.} \tag{14}$$

The coordinates of the center of the circle are, O_c, is determined with relations,

$$x_{O_c} = (R_c + r)cos\,\theta_{i_{max}}\ ,\ \text{mm;} \tag{15}$$

$$y_{O_c} = (R_c + r)sin\,\theta_{i_{max}}\ ,\ \text{mm.} \tag{16}$$

3. 3D MODELLING OF THE HELICAL CHANNELS OF THE DRILL

The cross-sectional profile of the helical channel for a drill is determined by calculation, with the following characteristics; diameter, 20 mm; core diameter, 2.8 mm; the angle of the top 118^o; the angle of the helix of the channel, 30^o ; the width of the tooth, 12,5 mm; diameter of the back of the tooth, 18,5 mm; facet, 1,75 mm.

Based on the relations from 1 to 16, the excel spreadsheet from, figure 2.a, was prepared, on the left side are the data for the useful part of the channel and in the right for the neutral part. Based on them, the spreadsheet from figure 2.b was generated, which allows, in Solid Edge, to draw the generating curve of the channel produce, presented in figure 3.a, using the calculation tables, through the command *Curve by Table*.

Between the x and y coordinates of the two spreadsheets or inserted to wake a drill with the helical channel on the right.

With the help of the profile of the helical channel and of the other constructive data(faced width, back tooth diameter), the profile of the cross-section of the drill, presented in figure 3.b, was made.

In figure 2. c is presented the spreadsheet of the helical channel's steering curve, with the help of the relations,

$$\begin{array}{l} x_i = R \sin \varphi_i \; ; \\ y_i = R \cos \varphi_i \; ; \\ z_i = R \varphi_i \, tg(\pi/2 - \omega). \end{array} \text{, mm,} \qquad (17)$$

where: φ_i is the rotation angle around the axis of the drill, in rad.

With the help of the cross-section profile and the two helical steering curves, figure 3.c generates the useful part of the helical drill, shown in figure 4.a, with the help of the solid Edge software and the *Swept Protrusion* command figure 4.b shows the drawing of the active part of the drill, with its constructive dimensions, The geometry of the head of the drill will be specified after sharpening it.

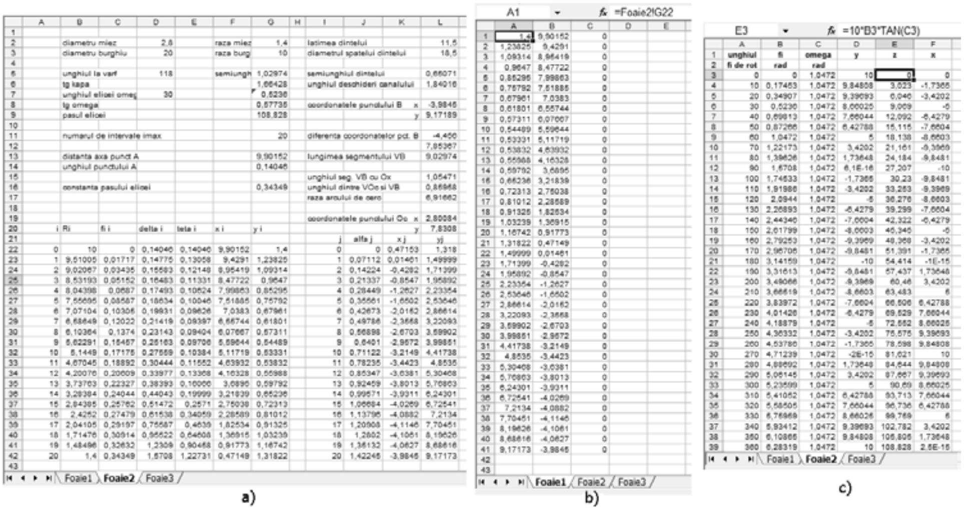

Fig. 2. Calculation of the helical channel profile in Excel

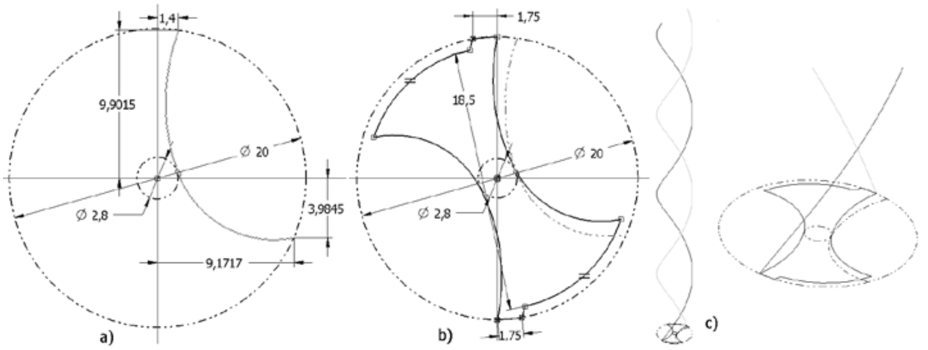

Fig. 3. The stages of carrying out the cross- section and of the steering curves of the drill

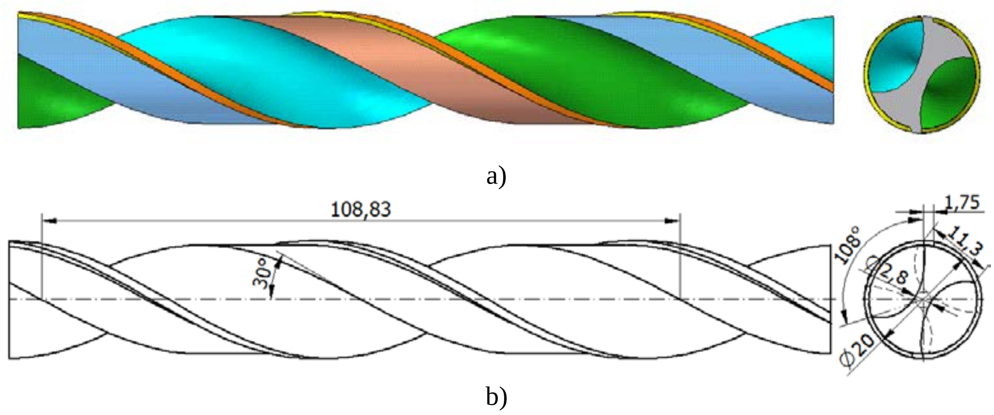

Fig. 4. The 3D model and the drawing of the active part of the helical drill

4. SHARPENING OF THE HELICAL DRILLS.

Sharpening has a decisive importance on the precision of the hole obtained, the forces and moments that appear at the drills, the durability and productivity of the helical drills.

The sharpening method must ensure the following qualities of the cutting part of the drill :

- relief angle increased from about 6^o anterior at $20\text{-}30^o$ at the intersection of principal cutting edge with the transverse;
- ensure self-centering drill and a larger take angle;
- a convenient form principal cutting edge;
- perfect symmetry of geometric parameters on the two teeth;
- superior quality seating surfaces;
- a wear resistance.

Also, the sharpening method must be technological, the generation of the seating surfaces to be made by composing a minimum number of simple movements, the grinding scheme to ensure maximum cutting regimes, the abrasive disk to have a simple force and does not require many corrections.

Re-sharpening have practiced before reaching the limit on the wear facets sitting h_α = 0,8 – 1, otherwise a rapid wear of the main tops and facets appears.

The classical procedures for sharpening the helical drills are shown in Figure 5, thus:

- circular cylindrical procedure, the figure 5.a;
- conical procedures, the figures 5.b and 5.c;
- double plan procedure, the figure 5.d;
- cylindrical- elliptic procedures, the figures 5.e, 5f and 5.g.

The kinematics of the melting processes is achieved by composing the moments; *I* - main, abrasive disk rotation; *II* - advanced circular around the axis of the device, for the realization of the cylindrical or conical surfaces, or of the axis of the drill in the cylindrical-elliptical procedures; *III* - advance of penetration in the direction of the axis of the drill; *IV* - for uniformizing the wear of the abrasive disc, alternative or eccentric rectilinear motion in cylindrical-elliptical procedures; *V* - the land relief of back edges of the tooth and the procedures cylindrical-elliptical.

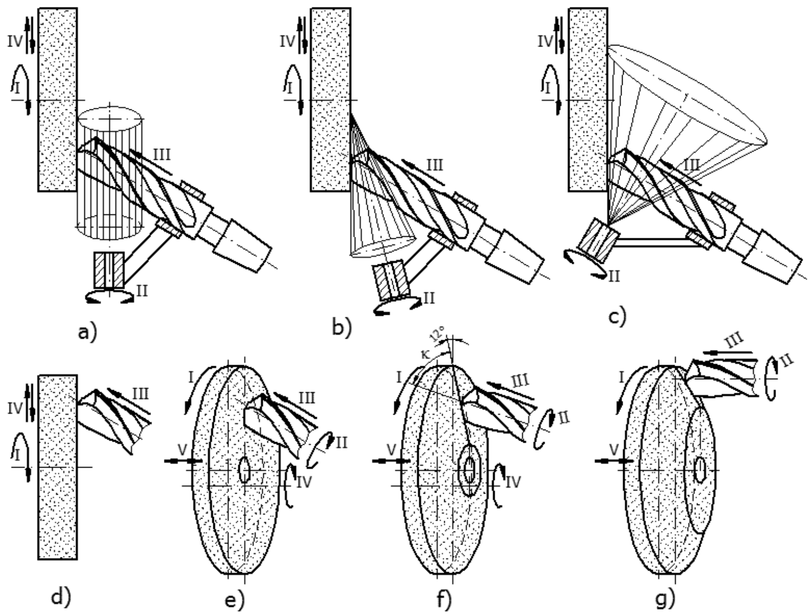

Fig. 5. Sharpening procedures

At the circular cylindrical procedure Blau, figure 5.a, settlement face results from the circular cylindrical shape, the axis of oscillation, of the movement *II* being parallel to the flat active our face of the abrasive disc. The contend procedure Bancroft-Washbourne-Stock, figure 5.b, in which the face of the drill is conical, the axis of the drill making a sharp angle with the axis of the word after which the sharpness is made. The conical procedure Weiscker, figure 5.c, is distinguished from the first by the fact that the axis of the drill makes an angle of 90^o with the axis of the cone after which the sharpness is made.

The double plane procedure, figure 5.d, is characterized by the fact that the settlement face is composed of two intersected plane surfaces, the central area resulting by the self-centered pyramidal shape.

The helical procedures, *Oliver* figure 5.e, Suhov - figure 5.f and Spiropoint-Cincinnati - figure 5.g, which is characterized by the fact that the helical settlement surface is generated by the time contact between the drill and the abrasive disc by composing the rotational movement *II* of the drill with an axial feed motion *V* of the disc, relieving.

From the point of view of the forces and moments of wetting at the drills, the helical and double plane sharpening, printing high values for the transverse rake angle, provides axial forces with 20…30% smaller than the other procedures, the moment being very little affected. The decrease of the axial force at the same leads to a slight increase of the durability.

If we refer to the precision of the drill, in order to avoid the next enlargement operation, the optimal sharpening is the double-plans helical or cylindrical-elliptical with self-centered pyramidal.

Take the model 3D of the helical drill (fig. 4) and apply a conical sharpening with the distance between the acts of the drill and the tip of the sharpening cone of 37 mm, l=(1,8…1,9)d, in which *d* is the diameter of the drill (d=20 mm) and a difference between the projections of the drill and cone axes of 2,2 mm, K=(0,08…0,12)d. For this a flat cutting of the tip of the drift is made at the angle at the 2 κ tip using the *Cutout* command from Solid Edge, applied in the y0z plane of the drill, figure 6.a. In continuation the two planes of positioning the axis of shake the sharpening cones, figure 6. b, are drawn, in which the sketch for generating the sharpening cone is drawn, figure 6.c and then with the command *Resolved Cutout* is obtained settlement face of the drill tooth, figure 6.d.

Similar by, the cylindrical, flat and elliptical sharpening can be 3D modelled.

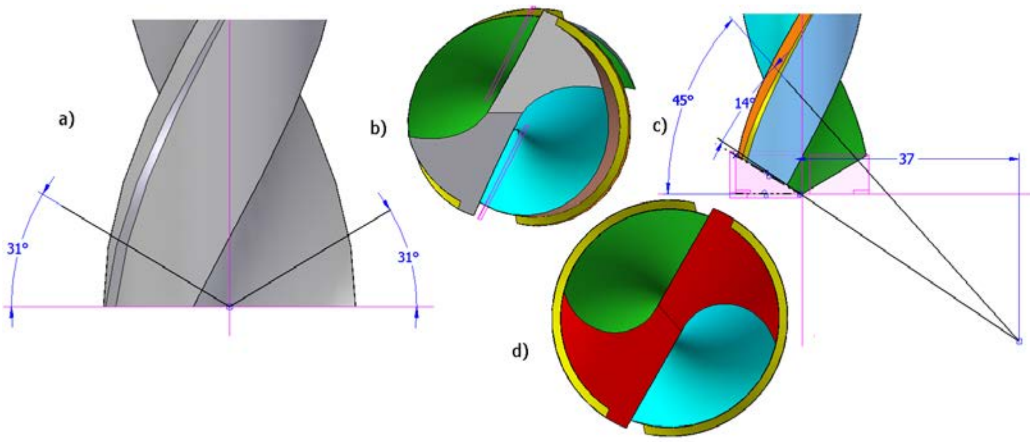

Fig. 6. The stages of 3D modelling of the settlement faces at the conical sharpening

5. CONCLUSIONS

Together with the new and modern procedures for machining materials, metal working has kept it's area of expansion and importance through the efforts of specialists in the field to permanently improve their competitiveness. It can be stated that the design and the technologies of execution and exploitation of cutting tools is an important problem for all the technological engineers in the machine building industry.

By using the 3D modeling software and the finite element analysis and calculation software it is possible to quickly study the geometry of the cutting tools and to optimize their constructive form.

The determination my by analytical methods of the profile of the helical channel can be realized only with the help of the computer, by determining the coordinates of the active profile points of the channel and its 3D modeling allows the optimization of the shape of the will of the second order for its processing.

3D modeling of the body shape of the helical drill allows two understand the construction and processing of the helical channels. Also, by modeling the drill sharpening. Also, by modeling the drill sharpening one can check the geometry of the active part of the drill and the variation of the rake and settlement angles along the main cutting edge.

3D modeling of the sharpening drill allows the establishment of the technical characteristics (dimensions, positioning angles etc.) for the design of fixtures and positioning of the drill on the sharpening machines and the movements that the device must perform in order to obtain the main settlements will tooth drill.

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