MULTI-FLUTE HELICAL DRILL WITH ELIPTICAL CUTTING EDGES

BY

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Abstract. In this paper is presented an analytical model of a sharpening process for helical drill with curved cutting edges, characterized by that the main cutting edge is an ellipse. This form of cutting edge assure a reduced unitary energetically load that in case of circular cutting edges [1], [2]. The analytical model of the cutting edge and the form of the back face is analyzed from the conditions to accomplish the minimal requirements of the drill sharpening process: an increasing value of the back angle from periphery to the tool's top; the relieving of the main back face and the tool's position regarding the sharpening surface

Key words: multi-flute helical drill, cylindrical sharpening, analytical modeling

2000 Mathematics Subject Classification: 53B25, 53C15

1. Introduction

The helical drills have a specifically geometry due of the difficult conditions of the chip forming and elimination.

A large number of solutions were applied for the improvement of these tool's qualities.

Also, new analytical models [7], [8], [3], for the complex geometry of helical drills study, were developed.

A deep analyze of the chip formation process allow the model elaboration for the cutting edge form which leads to an evenness energetically load of points on the cutting edge [2], [3], [4].

The realization of new types of drills with curved cutting edges impose the tool's synthesis for it's generation, as so as, new specifically sharpening process [3], [1], [6].

The analyses development in order to improve the main cutting edge leads to a spatial cutting edge model [1], [6].

These new geometries impose new sharpening process for the main cutting edge, assuring an increasing value of the back angle, from periphery to the tool's axis, simultaneous with the continuous decreasing of the main tool cutting edge angle, from the tool's top to periphery.

Also, new method must assure a good relieving of the main back face, from a single positioning of drill on the sharpening device. It is proposed a new form, after a cutting method with a simple kinematics (a minimum number of movements) which allows a rigorous reproduction of the sharpening process.

2. Principal kinematics, back face

In figure 1, is presented the model of the sharpening surface — revolving cylindrical surface — as so as it's position regarding the sharpened drill. The main cutting edge results from the intersection between the drill's helical flutes with the sharpening surfaces. If the sharpening cylinder axis isn't perpendicularly to the drill's axis, the cutting edge will be an ellipse arc.

They are defined:

β is the angle between the sharpening surface's generatrix and the normal to the cutting edge plane;

χ_t and χ_{per} the extremes values of the tool cutting edge angle, along the main cutting edge;

e — the sharpened drill's axis position regarding the sharpening cylinder axis.

The cylindrical surface generation presumes a drill swing movement around the cylinder axis, the movement 1.

Also, is need a drill's feed movement along it's own axis, the movement 2, in order to made the feed movement; the revolving movement of the grinding wheel, which materialize the cylindrical surface's generatrix, movement 3,

$$(1) \qquad S\left|\begin{array}{l} X = a\cos\varphi; \\ Y = t\cos\beta; \\ Z = b\sin\varphi + t\sin\beta; \end{array}\right.$$

$$a = R;\; b = R/\cos\beta\,,$$

with φ and t variables parameters.

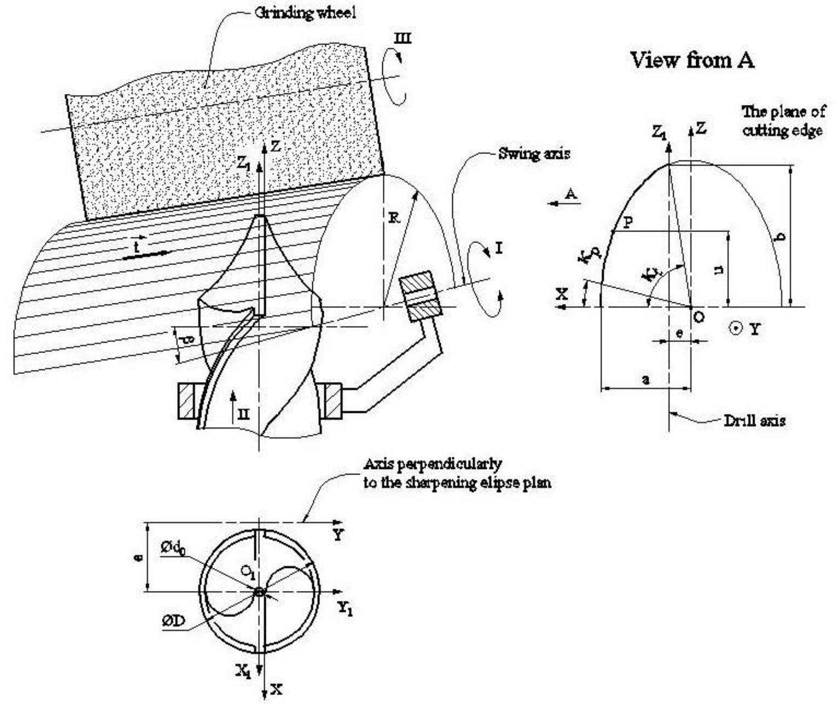

Fig.1 – Sharpening cylindrical surface

3. Back face relieving

As first requirement of a sharpening process is impose to analyze the relieving on the back face, see figure 2.

So the relieving condition for points on the relieving curve is

$$\rho_1 \leq r_x \tag{2}$$

where ρ_1 is the distance from the current point of the relieving line to the Z_1 drill's axis and r_x is the value of ρ in the point on the cutting edge.

The crossing section of the back face is

$$Z_1 = u \quad \text{(u – variable).} \tag{3}$$

Is defined the polar radius

$$\rho_1 = \sqrt{(a\cos\varphi - e)^2 + \left[\frac{u - b\sin\varphi}{tg\beta} + \frac{d_o}{2}\right]^2} \, . \tag{4}$$

So, the r_x radius, see the definition (2), is give by

$$r_x = \sqrt{(a\cos\varphi - e)^2 + \frac{d_o^2}{4}} \tag{4}$$

$$b\sin k_{per} \leq u \leq b\sin k_{\mathrm{var}\,f} \, . \tag{5}$$

Now, is possible the numerical check of the back face $A_\alpha(S)$, for all points corresponding to the cutting edge, regarding the characteristically values of the back face model: *R, e,* k_{per}, k_{varf}, β.

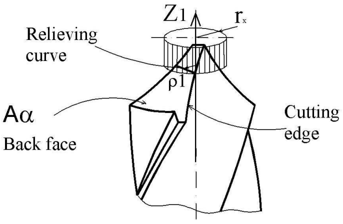

Fig. 2 – Back face relieving

4. Back angle value

They are defined: — the tool reference plane in point M_X on the cutting edge as the axial plane which contain this point and is perpendicularly to the cutting movement direction;

— the tool orthogonal plane, parallel with drill axis and perpendicularly in the measuring point on the tool reference plane, see figure 3.

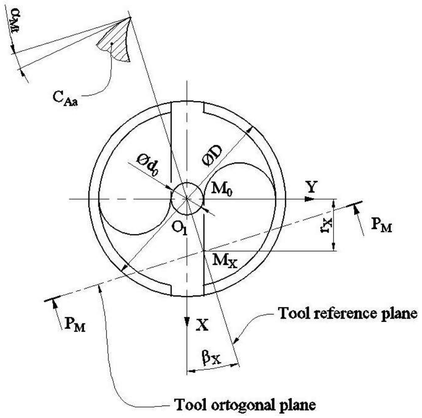

Fig. 3 – Tool orthogonal plane

Is defined the orthogonal plane P_M in the drill reference system:

(6)
$$[X_1 - X_{1Mx}]\cos\beta_x + [Y_1 - Y_{1Mx}]\sin\beta_x = 0;$$

(7)
$$tg\beta_x = {}^{d_o}\!/_{2r_x}.$$

The intersection curve between the orthogonal plane and the back face is defined as:

(8)
$$C_{A_\alpha}\begin{cases} X_1 = a\cos\varphi - e; \\ Y_1 = \dfrac{r_x + e - a\cos\varphi}{\cos\beta \cdot tg\beta_x} + \dfrac{d_o}{2}; \\ Z_1 = b\sin\varphi + (r_x + e - a\cos\varphi)\dfrac{tg\beta}{tg\beta_x}, \end{cases}$$

with φ and r_x variables parameters.

Is defined the back angle between the tangent to the $C_{A\alpha}$ curve and the plane $Z_1=const$,

$$\sin\alpha = \frac{b\cos\varphi + a\sin\varphi\cdot ctg\beta_x\cdot tg\beta}{\sqrt{a^2\cdot\sin^2\varphi + \dfrac{a^2\cdot\sin^2\varphi}{\cos^2\beta\cdot tg^2\beta_x} + \left[b\cos\varphi + a\sin\varphi\cdot\dfrac{tg\beta}{tg\beta_x}\right]^2}}. \qquad (9)$$

5. Numerical models

In figure 4, are presented models of the variation laws for the back angle along the main cutting edge, for drills with dimensions: $D = 16$ mm, $d_o = 5$ mm and the constructive parameters values: β, e, D_o, d_o, R, k_{pher}, k_{top}.

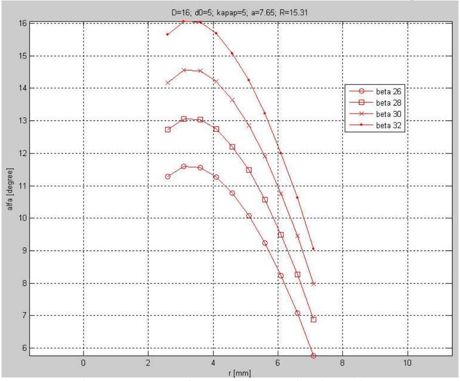

Fig. 4 – Back angle variation law

Also, for a sharpened drill was measured the relieving curves and results are presented in figure 5.

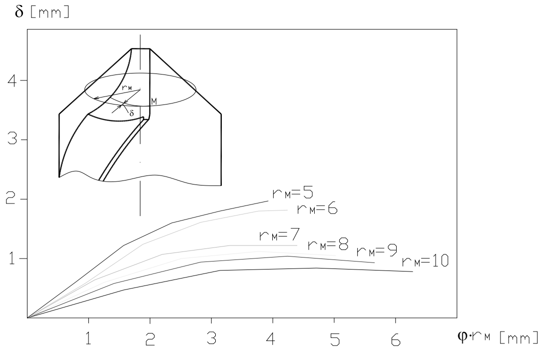

Fig. 5 – Relieving curves

6. Conclusions

The sharpening method for drills with cured cutting edges, presented in this paper, represent a new method for the sharpening of tools wit in-plane cutting edge.

Also, were study the back face relieving, proofing, by numerical models, that the back teeth relieving is made totally, by a single positioning of cutting edge regarding the sharpening surface.

The sharpening method has a simple kinematics, with a reduced movement number, regarding other known methods.

Acknowledgements. The authors gratefully acknowledge the financial support of the Romanian Ministry of Education and Research through grant PN_II_ID_791/2008.

Submitted:
Accepted:

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BURGHIE ELICODALE MULTITĂIŞ CU MUCHII DE AŞCHIERE ELIPTICE
(Rezumat)

Lucrarea prezintă un model analitic al unui procedeu de ascuţire a burghielor elicoidale cu tăişuri curbe, caracterizate prin aceea că muchia de aşchiere principală este de formă eliptică. O astfel de formă a muchiei de aşchiere principală asigură o încărcare energetică unitară mai redusă decât în cazul muchiilor de aşchiere circulare [1], [2]. Modelul analitic al muchiei de aşchiere şi a formei suprafeţei de aşezare este analizat din condiţiile îndeplinirii cerinţelor minime ale unui procedeu de ascuţire a burghielor: asigurarea unei legi crescătoare a mărimii unghiului de aşezare de la periferie spre vârful sculei; realizarea detalonării suprafeţei principale de aşezare, la o singura poziţionare a sculei în raport cu suprafaţa de ascuţire.