COMPUTER MODELLING OF TWIST DRILL SHAPENED AT CONICAL SURFACE

Abstract: The present article is developed a method for computer modeling of helical drills sharpened to conical surface. The proposed method of sharpening is different from the known the manner of orientation of the drill to the axis of the virtual cone. The lateral displacement of the drill is replaced by turning the axis of certain angle. Computer modeling is done with 3D graphic designer using obtained relationships for the parameters under which the device is set in sharpening drills with different diameters established in the prism. Generated by this method drill will be used in subsequent research on the finite element method to study the effect of sharpening drills under the proposed methodology.

Keywords: 3D CAD MODELS, TWIST DRILLS, CONICAL SURFACE

1. Introduction

Drills are the most used tools for drilling holes. Their geometrical parameters are known and are shown in Figure 1. Drills are sharpening at the back surface; it is part of the cone or screw surface [5].

In this sharpening are obtained for specific dimensions: the back angle $\alpha$, point angle $\kappa_r$, chisel edge angle $\psi$ and front angle of chisel edge $\gamma_H$. Drills are sharpening on universal sharpening machines and devices for sharpening a conical surface, which have a simpler design and easier setup and operation [5]. On Fig.2 is presented the scheme for sharpening a conical surface. Sharpening is done with reciprocating rotary movement about the axis of the swing CC1.

![Fig.1 Standard Geometry of Two –Flute Twist Drill [5]](image)

As a result of sharpening, the back surface of the drill is formed by a certain section of the cone surface. In order to simplify the design, setup and operation of the device (the process of sharpening) in [4] has developed a new design of the device. In existing devices the drill laterally displaced a distance $h$, in a plane parallel to the axis of the cone. In the new design this distance is achieved as a result of the rotation axis of the drill point $L$ of the fixed angle $\theta$ (Fig. 3). Relationships are derived and the size of the angle $\theta$ and the position of $p. L$ where sharpening Drill is obtained with optimal geometrical parameters.

2. Computer modelling of drills

Over the years, to study the geometry of the drills, and the process itself, the researchers used different mathematical approaches [2,5]. For them to describe the dependencies using complex parametric equations [3], and studies are carried out experimentally, making numerous experiments to be taken into consideration various factors [2, 9, 10]. To develop accurate mathematical models of drilling and to assess them take a long time and numerous experiments. In many of these works include various restrictions due to the fact that they are based on 2D geometry of the strategies and tools is defined using the principles of projection geometry [9,11,12].

Recent years to increase the use of modern CAD systems that enable the development of new CAD tools for modeling, simulation and optimization of processes (drilling, milling, etc.). This new approach involves the development of application interface to consumer CAD systems. These strategies reveal great opportunities for modeling processes and increase the flexibility of the software environment of modern CAD systems in similar applications [6]. For their application is necessary to create 3D models of the cutting tools [6,8,13,14,15].

The proposed work is based on the concept of using modern CAD systems, allowing the development of computer-based tools for simulation and optimization of processing. The goal is to develop 3D models of drills, sharpening a conventional scheme and sharpening of drill bits with newly developed simple design of the device for sharpening. These models will be used to study and
optimize both the process of sharpening and the process of drilling in these tools. When creating 3D model of Drill is necessary to define the coordinate systems of the drill and tool sharpening. The article will be considered down the drill and the grinding disk for grinding of the proposed in [4] methodology. This methodology is base and sharpening drills on the conventional scheme are obtained as a special case of it. Fig. 3 shows the coordinate systems associated with the drill and the cone. Dependencies connecting coordinate systems are outlined in detail and explained in [1].

Fig. 3 Scheme of sharpening Drill in the proposed methodology

Sharpening parameters are:

\begin{align*}
b & \text{ - distance from point A of intersection of the axis of the drill and the axis of the cone to the top of the drill;} \\
a & = AC \text{ - the distance from the tip of the cone to point A;}
\end{align*}

\begin{align*}
k * & = AL \text{ - distance from point A to L;}
\end{align*}

\begin{align*}
h & \text{ - distance from the tip of the drill to the axis of the cone;}
\end{align*}

\begin{align*}
\delta & \text{ - the angle of the cone;}
\end{align*}

\begin{align*}
\beta & \text{ - the angle between the axis of the drill and the cone;}
\end{align*}

\begin{align*}
\theta & \text{ - angle of rotation of the drill around point L.}
\end{align*}

These distances are set and / or calculated in advance.

Modeling of drill is necessary to know the coordinates of the abrasive tip cone in the coordinate system of drill Dxyz. Generatrix of the cone is the face of the grinding disk. The coordinates C of the tip of the cone are necessary to set up the axes of the disk and perform Boolean operations, trimming the back surface and shaping of the cutting drill lip to generate the 3D model of the drill.

The coordinates of the tip C of the cone are obtained in [2] and are:

\begin{align*}
x_1 &= -a \sin \beta \\
y_1 &= (k^* + a \cos \beta) \sin \theta \\
z_1 &= (k^* + a \cos \beta) \cos \theta - (b + k^*)
\end{align*}

The described in fig.3 sharpening refers to the left flute. The coordinates of the cone for the right flute are:

\begin{align*}
x_d &= a \sin \beta \\
y_d &= -(k^* + a \cos \beta) \sin \theta \\
z_d &= (k^* + a \cos \beta) \cos \theta -(b + k^*)
\end{align*}

The parameters that generate drill are two types:

1. Geometric - Ro-radius of the drill, dc-Web thickness, \( \omega \)- helix angle, \( \kappa_r \)- point angle.

2. Manufacturing that are associated with sharpening of drills, using the method described- b, k, \( \delta \), \( \theta \) and \( \beta \).

Another important element for geometrically correct representation of the drill is the shape of cross-section of the flute.

Galloway [7] has established the first of what conditions must meet the shape of the cross-section of the flute, so that the drill has produced straight cutting edges in a conventional sharpening. This condition is described by the polar equation for contact angle \( \nu \):

\[ v = \arcsin \left( \frac{d_c}{2r} + \sqrt{\frac{d_c^2}{4} - \frac{d_c}{2R_0}} \right) \]

where \( d_c \) is Web thickness; \( R_0 \) is radius of the drill; \( \omega \) is helix angle; \( \kappa_r \) is point angle;

\( r \) is the current radius of the drill. \( r \) is varied from \( \frac{d_c}{2} \) to \( R_0 \).

This equation describes the shape of the working area of the drill flutes (Figure 4, sector 1 and 2). Non-working part of the flutes (sectors 3 and 4) be designed and based to provide rigidity of the tool and space to accommodate the chip. This part can be formed in an arc of a circle [3]. For simplicity, they can be modeled as symmetric to section 1 and 2 respectively. Add margin – length and the relief width (6) and the contour is closed with arcs of a circle (5).

Fig.4 Flute Cross-Section

To convert the flute profile from 2D to a 3D boundary surface, a z-component term can be appended to the equation to capture the helical profile. The z-component term is as follows (for drill with radius Ro):

\[ z_{kana} = \frac{\omega}{R_0} z \]

The helix height is the same as the length of the drill flute and for one revolution can be calculated of

\[ l_{kana} = \frac{2\pi R_0}{\omega} \]

3. Algorithm for obtaining the geometry of drills

Based on the above analytical formulation an algorithm is presented to generate CAD program to realize the drills in given CAD program. The general algorithm to develop 3D model of drill geometry is as follows:

1. Input and calculate the necessary parameters.
2. Draw the cross-section of the flute.
3. Draw the margins.
4. Create the solid flute body.
5. Locate and draw the cone axes at a virtual cone.
6. Use the cone to perform a Boolean-subtract cut to generate the flank surfaces at the drill.

4. Application of algorithm in Autodesk Inventor

To generate 3D model of drill used Autodesk Inventor. Autodesk Inventor allows models to be saved in different graphical formats. This product is integrated with APIs (Application Programming Interface), which contains many functions that can be called from programming languages such as Visual Basic and C++. These functions provide access to Autodesk Inventor graphical engine and can be used to create solid models.

For the generation of drills need the following two types of parameters:
Geometric: $R_o=5\text{mm}$, $d_c=1.8\text{mm}$, $\omega=30^\circ$, $\kappa_r=118^\circ$
Manufacturing that are associated with sharpening of drills: $b=17.63\text{mm}$, $h=1\text{mm}$, $k*=10.48\text{mm}$, $\delta=25^\circ$, $\beta=34^\circ$, $\theta=2.04^\circ$.

Having already established solid flute body of the drill by taking the most responsible part of the generation of 3D model of the drill - Sharpening its flank surface.

To generate the flank surface of the the drill is necessary to build the plane in which the sharpening is done. This is the plane of the abrasive cone and it intersects the plane of the drill at point $L$ and is inclined at an angle $\theta$ figure (5). Here are defined two separate planes for sharpening of left and right flute of the drill. Select one plane, which builds the tip of the cone point $C$ with the determined coordinates $x_L, y_L, z_L$ in [2], then builds the generatrix of the cone, which passes through the tip of the drill and axis of the cone angle $\delta$ (fig.6). This is finally defined by location of the abrasive cone.

The drill sharpened by the conventional method in which relocation takes place parallel to the axis of the cone is modeled at the work. The formulas required for the coordinates of the tip of the abrasive cone are given in [8].

5. Conclusion

The work is developed 3D models of two flute twist drills, sharpening a conventional scheme and sharpening of drills with newly developed simple construction of the device for sharpening a conical surface. Using this general design methodology, more complex drill models can also be abstracted to a series of grading operations and their solid models can be easily created. These 3D geometric definitions provide a data that are necessary for a number of subsequent applications such as analysis by finite element method, 3D scanning geometry of tool and others. The developed models allow simulating the process of drilling a well and imprisoned tools to examine and optimize their geometrical parameters.

6. References

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