Advanced Materials Research *Online: 2012-01-03*
ISSN: 1662-8985, Vol. 426, pp 279-282
doi:10.4028/www.scientific.net/AMR.426.279

Research on Ellipsoid Drill Point'S Molding Simulation and the Influence Factors of the Key Structure Angles

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Keywords: ellipsoid drill point, molding simulation, structure angle, Interaction design

Abstract. This paper presents the 3D molding simulation of the ellipsoid drill point based on the mathematical model, and the influence factors of the drill point's key structure angles were searched. The quantificational relations between the key structure angles of the ellipsoid point and its molding configuration parameters were presented. Variation trend of the drill point's structure parameters affected by it's molding parameters are given for design and optimize the ellipsoid drill point.

Introduction

The US scholars W. D. Tsai and S. M. Wu had concluded and established the mathematical models of drill's flank, which are the quadratic surface like cone, ellipsoid, hyperboloid, cylinder, and so on[1]. Ellipsoid drill point (Racon point) as one of the twist drills is widely used in the United States [2]. The drill point's main cutting edges are composed of an arc or a circle with a line segment, and at the arc blade's differed location the point angle will vary, the point angle near the chisel edge of the drill point is bigger, near the outer corner of the drill point is smaller. In addition, the arc blade increasing the length of the cutting edge, thus reducing the cutting load on the unit length of the lip and improved heat dissipation, and the durability of the cutting edge. The outside arc cutting edge is also beneficial to improve the machining accuracy and to reduce the surface roughness. The drill tip in the hole cut out gradually, thus increasing the hole to be machined hole wall quality and avoiding or reducing the exit hole glitches [2,3]. The author in [4] proposed quadric "Point Grinding" forming principle, theoretically by adjustment of the quadratic surface parameters and pose parameters of the grinding wheel, the ellipsoid drill point will be molded completely. But these model and configure (or molding) parameters (as shown in fig.1) can not be reflected directly to the drill's the structure geometry parameters. For example, usually the three key structure geometry angles such as: main cutting edge's point angle, chisel edge angle and the constructive clearance angle, were designated as the design standard parameters of ordinary drill point , because of the three key structure angle size direct impact on the drill point's boring performance. However, when one of the molding grinding parameters was adjusted, all these structural angles were happened of different change. Conversely, if a structure angle value was designed, one could not know exactly how to change these molding parameters to meet the design requirements. So to grasp the interaction between these parameters is very important, it determines the molding grinding operation whether can create a new drill type to meet the design requirements.

Ellipsoid twist drill molding principle is complex, although the expression of the corresponding relationship can be established by using the mathematical models, but the expressions are type of transcendental equations [5], so it is difficulty to obtain the analytical solution. To solve this problem, the author tried to use the mathematical model of the drill to form three-dimensional simulation by computer [6]. This is an interactive design approach worth exploring, especially for development of a new type of drill point and obtaining it's reasonable molding grinding parameters. The following is using this method to research quantitatively the ellipsoid drill point's molding parameters how to affect several key structure angles.

Mathematical model and molding simulation of ellipsoid drill point

Figure 1 shows the type of the ellipsoid twist drill point (the drill point's flank is part of the ellipsoid) and the orientation of drill point related to the ellipsoid in molding grinding.

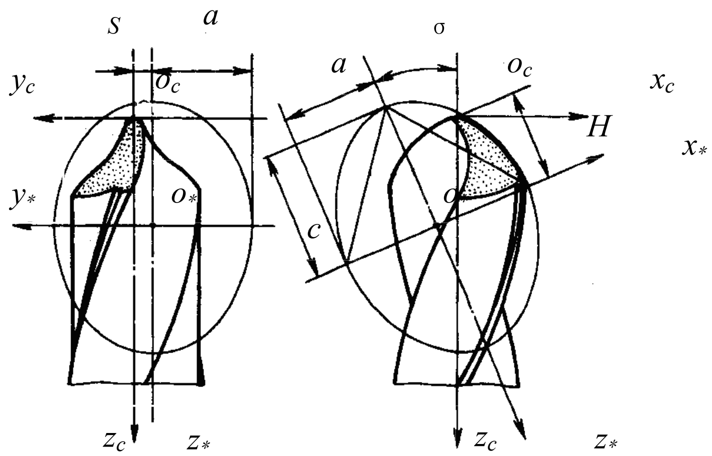


Fig.1 Configuration of the drill and the ellipsoid model

In the original coordinate system $o_* — x_* y_* z_*$, the mathematical model of the ellipsoid is:

$$\frac{x_*^2}{a^2}+\frac{y_*^2}{a^2}+\frac{z_*^2}{c^2}=1. \tag{1}$$

Where a and c are the variables which determine the shape of the ellipsoid. In Fig.1, we can see the drill flank's profile shape is not only determined by the ellipsoid parameters a and c, but also determined by the three positional parameters H, S and σ. The five parameters constitute the molding grinding parameter group of this type drill .

The rake face parameter equations in drill point's structure coordinate system $o_c — x_c y_c z_c$ can be described as [5]:

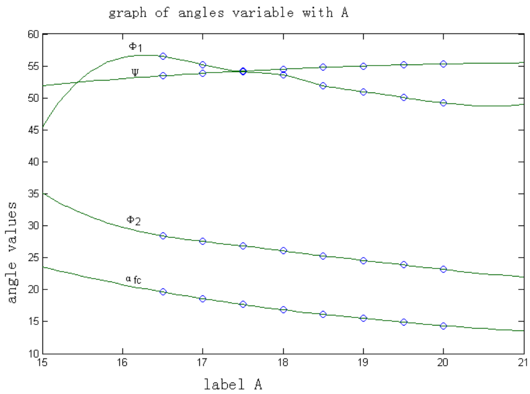
$$\left.\begin{aligned} x_c &= \sqrt{r^2-r_0^2}\cos\varepsilon + r_0\sin\varepsilon \\ y_c &= \sqrt{r^2-r_0^2}\sin\varepsilon - r_0\cos\varepsilon \\ z_c &= \frac{\sqrt{r^2-r_0^2}}{tg\varphi_0}+\frac{T}{2\pi}\varepsilon - 0.421r_0 \end{aligned}\right\} . \tag{2}$$

Where r_0 is radius of the drill's base cylinder, r is the variable radius, ε is the variable swing angle and T means lead of the helicoid of the rake face.

Based on these equations, using the software MasterCAM embedded C-Hooks program FPLOT function, the 3D molding simulation of the drill could be build. Necessary parameters also could be got in the figures simulation by the "analysis" function of the software. By comparing the experimental results of molding grinding and the simulation data, the reliability and accuracy of this method had been validated [5].

The relationship between the molding parameters and the key structure angles

Generally, twist drill's the original point angle ϕ_0, the chisel edge angle ψ, and the constructive circle clearance angle at lip's outer corner α_{fc} are the three key structure angles, which are set as design parameters in normal twist drill standard. But the ellipsoid flank forming two arc cutting edges at the drill point, they made the point angle value changing at different place of the lip. So the point angle at the lip outer corner ϕ_1 and the point angle at the chisel edge corner ϕ_2 were selected to denote the design parameters of ellipsoid drill point angle, so the ellipsoid drill point design parameters are four. For example, Φ20 twist drill (spiral angle $\beta_0 = 30^\circ$, web radius $r_0 = 1.46$) and the molding parameters : $a = 4$, $c = 5$, $\sigma = 15$, $H = 0.3$ and $S = 2.4$, were selected to explore the relationship between the four structure angles and the five molding parameters. By changing the five parameters: a , c , σ , H and S in turn, and doing the relevant molding simulation each and all. Then according to the definition of the structure angles, using the software "analysis" function, the ψ , α_{fc} , ϕ_1 and ϕ_2 value can be obtained respectively. By software Matlab, results of fitting selected spline curves are shown in fig.2 ~6.



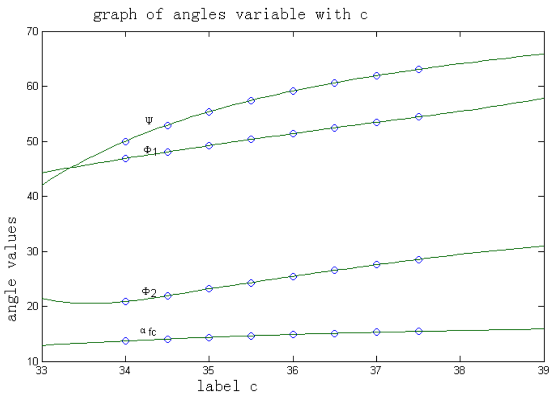
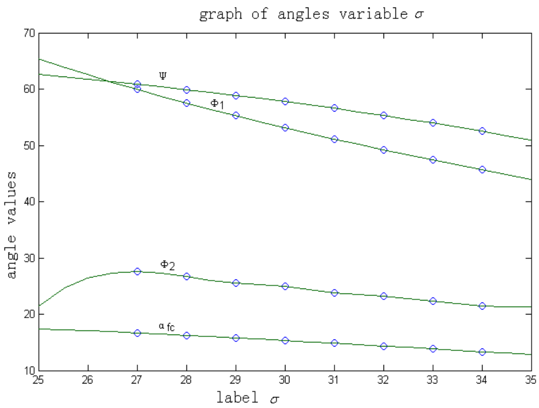


Fig.2 Influence of the parameter a Fig.3 influence of the parameter c



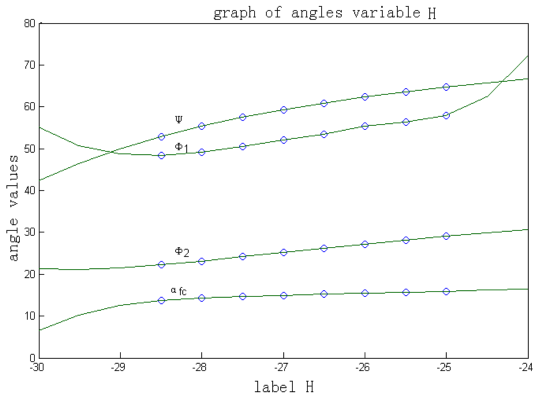


Fig.4 Influence of the parameter σ Fig.5 influence of the parameter H

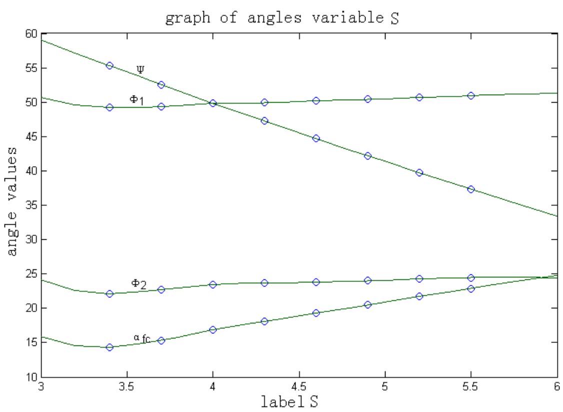


Fig. 6 Influence of the parameter S

Conclusion

The ellipsoid drill point's molding grinding depends on the five molding parameters, but in actual applications, the drill point's working performance depends on its key structure angles, so it is very important to find out how the five molding parameters influence on the four key structure angles respectively. This paper had separately changed all the modeling parameters in turn, and simulated by 3D molding, then got the change relationship of the molding parameters and these structure angles. Upwards research has settled the quantificational change relationship between the key structure angles and the molding parameters of ellipsoid drill type, which can predigest a lot of mathematical calculations during the drill type designed. It also provides convenient Interaction design means for drill type optimizing designs, especially for the point molding grinding theory on quadratic surface drill type, which had been brought forward in literature [5][7],these results provides the theoretical gist for the twist drill's actual molding grinding.

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