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Research on Machining and Positioning of the Space Double Deflector Plane and the Oblique Hole of Deflector Groove

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Abstract:

In order to solve the problems of clamping and positioning of space double deflector plane and oblique hole of deflector groove during machining. This paper studies the bracket parts when milling, the locating angle and the orientation angle and the key to the angle were calculated by the method of V-spherical figure, H-spherical figure and W-spherical figure respectively. At the same time, the calculation method of spatial angle of sliding core parts in milling is also studied. Using the V-spherical graph method, H-spherical graph method and W-spherical graph method to calculate the locating angle and the orientation angle. The results show that the three methods are accurate and feasible.

Keywords: *The space double deflection plane, Deflection groove oblique hole processing, The locating angle, The orientation angle, The key to the angle.*

I. INTRODUCTION

With the rapid development of current science and technology, the accuracy, rapidity and simplicity of engineering calculation are increasingly required. As a spatial angle calculation method, spherical map has been widely used in mold design and manufacturing and machine tool fixture design [1]. Three-dimensional geometry, three-dimensional analytic geometry, projection geometry and other methods are usually used to calculate spatial angle [2], but these methods are more complicated, and slightly less accurate. We have also explored the use of spherical diagram method to calculate spatial angle in the process calculation of mechanical processing for many times, and it has been proved that this aspect is simple and fast with high accuracy [3], which is a spatial angle calculation method worthy of promotion.

In this paper, a graphic method that is a spherical graphic method is introduced to calculate the spatial angle. It mainly uses V, H, W three kinds of spherical map method to solve the positioning angle and orientation angle of a bracket part and a sliding core part, which shows that the spherical map method is correct and feasible to solve the spatial angle, to ensure that such parts can be installed and positioned smoothly in the milling process, to ensure the machining accuracy of parts.

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II. METHODS AND APPLICATION

As is shown in Fig 1 for the parts of a diagram, the figure shows that on the bracket parts milling space bottom, M and N side of the chute, positioning method, as is shown in the Fig 3 locating surface on the W side view with an angle on the surface of the H, 2 point positioning surface in H plane view with the angle of V for 5 °, chute base M on V side view with the angle 60 ° W, The side N of the chute is parallel to plane V. The spherical method is used to calculate the positioning angle, orientation angle and key angle of the assembly fixture.

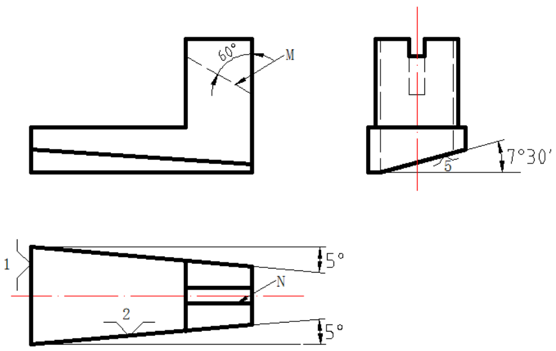

Fig 1: Schematic diagram of some support parts

Fig 2 is the V spherical diagram. In the spherical right triangle ABC, it is known that $C = 90°$, $a = 90° - 60° = 30°$, $B = 90° - 7°30' = 82°30'$; So let's figure out the orientation angle θ and the bond angle γ , which is respectively the A in the V sphere diagram and the b in the V sphere diagram.

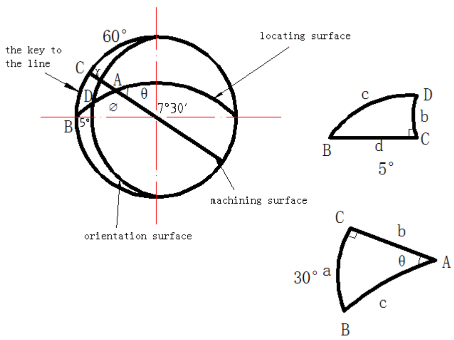

Fig 2: V-spherical diagram

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\cos A = \sin B \cdot \cos a \tag{1}$$

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Substitute the known data into formula (1), and it can be obtained:

$$\cos A = \sin 82°30' \cdot \cos 30° = 0.85862\,; \tag{2}$$

$$A = \theta = 30°50'16''\,; \tag{3}$$

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\cos a = tgb \cdot ctgB\,; \tag{4}$$

Substitute the known data into formula (4), and it can be obtained:

$$\mathrm{tgb} = \frac{\sin a}{ctgB} = \frac{\sin 30°}{ctg 82°30'} = 3.79788\,; \tag{5}$$

$$\mathrm{b} = \gamma = 75°14'54''\,; \tag{6}$$

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\cos \mathrm{B} = tg\mathrm{a} \cdot ctg\mathrm{C}\,; \tag{7}$$

Substitute the known data into formula (7), and it can be obtained:

$$\mathrm{ctgC} = \frac{\cos B}{tga} = \frac{\cos 82°30'}{tg 30°} = 0.22608\,; \tag{8}$$

$$\mathrm{C} = 77°15'38''\,; \tag{9}$$

And in the spherical right triangle DBC, it is known that $B = 7°30'$, $d = 5°$, let's figure out the c.

According to the spherical right triangle calculation formula, it can be obtained:

$$\cos \mathrm{B} = tg\mathrm{d} \cdot ctg\mathrm{c}\,; \tag{10}$$

Substitute the known data into formula (10), and it can be obtained:

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$$\mathrm{ctgc} = \frac{\cos B}{tg\mathrm{d}} = \frac{\cos 7°30'}{tg5°} = 11.33227 \; ; \tag{11}$$

$$\mathrm{c} = 5°2'35'' \; ; \tag{12}$$

$$\phi = \mathrm{b} - \mathrm{c} = 77°15'38'' - 5°2'35'' = 72°12'3'' \; ; \tag{13}$$

The positioning angle is 30°50′16″, the orientation angle is 72°12′3″and the bond orientation angle is 75°14′54″ that can be obtained by using V spherical diagram method.

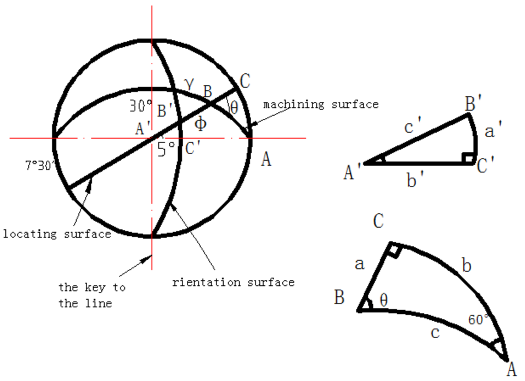

Fig 3: W-spherical diagram

In spherical right triangle BAC, it is given that $C = 90°$, $\mathrm{b} = 7°30'$, $A = 60°$, the positioning angles θ are the B and the C and the A.

$$\cos B = \sin A \cdot \cos \mathrm{b} \; ; \tag{14}$$

Substitute the known data into formula (14), and it can be obtained:

$$\cos B = \sin 60° \cdot \cos 7°30' = 0.85862 \; ; \tag{15}$$

$$B = \theta = 30°50'16'' \; ; \tag{16}$$

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\cos A = \mathrm{tg}b \cdot ctgc \; ; \tag{17}$$

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Substitute the known data into formula (17), and it can be obtained:

$$\mathrm{ctg}c = \frac{\cos A}{tgb} = \frac{\cos 60°}{tg7°30'} = 3.79788 ; \tag{18}$$

$$\mathrm{c} = 24°45'5'' ; \tag{19}$$

It can be obtained from the mathematical relationship:

$$\gamma = 90° - \mathrm{c} = 75°14'54'' ; \tag{20}$$

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\sin b = \mathrm{tg}a \cdot ctgA ; \tag{21}$$

Substitute the known data into formula (21), it can be obtained:

$$\mathrm{tga} = \frac{\sin b}{ctgA} = \frac{\sin 7°30'}{ctg60°} = 0.226085 ; \tag{22}$$

$$\mathrm{a} = 12°44'22'' ; \tag{23}$$

In spherical right triangle $A'B'C'$, it is given that $A' = 7°30'$, $\mathrm{b}' = 5°, C' = 90°$, let's figure out the c'.

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\cos A' = \mathrm{tg}b' \cdot ctgc' ; \tag{24}$$

Substitute the known data into formula (24), it can be obtained:

$$\mathrm{ctgc}' = \frac{\cos A'}{tgb'} = \frac{\cos 7°30'}{ctg5°} = 11.33227 ; \tag{25}$$

$$\mathrm{c}' = 5°2'35'' ; \tag{26}$$

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$$\phi = 90° - c' - a' = 72°12'3'' ; \tag{27}$$

The positioning angle is30°50′16″, the orientation angle is 72°12′3″ and the bond orientation angle is 75°14′54″that can be obtained by using W spherical diagram method.

Fig 4 shows the H-sphere diagram method. In the spherical right triangle ABC, it is known that $C = 90°$, $B = 90° - 7°30' = 82°30''$, $a = 90° - 60° = 30°$, How to solve the A, b, c.

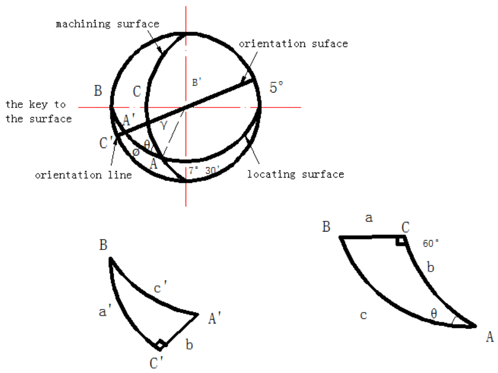

Fig 4: H-spherical diagram

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\cos A = \sin B \cdot \cos a ; \tag{28}$$

Substitute the known data into formula (28), it can be obtained:

$$\cos A = \sin 82°30' \cdot \cos 30° = 0.85862 ; \tag{29}$$

$$A = \theta = 30°50'16'' ; \tag{30}$$

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\sin a = tgb \cdot ctgB ; \tag{31}$$

Substitute the known data into formula (31), it can be obtained:

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$$\text{tgb} = \frac{\sin a}{ctgB} = \frac{\sin 30°}{ctg82°30'} = 3.79788; \quad (32)$$

$$\text{b} = \gamma = 75°14'54''; \quad (33)$$

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\cos\text{B} = tg\text{a} \cdot ctg\text{c}; \quad (34)$$

Substitute the known data into formula (34), it can be obtained:

$$\text{ctgc} = \frac{\cos B}{tga} = \frac{\cos 82°30'}{tg30°} = 0.22608; \quad (35)$$

$$\text{c} = 77°15'38''; \quad (36)$$

In the spherical right triangle $A'BC'$, it is known that $B = 7°30'$, $\text{a}' = 5°$, $C' = 90°$, How to solve the c'.

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\cos B = tga' \cdot ctgc'; \quad (37)$$

Substitute the known data into formula (37), it can be obtained:

$$\text{ctgc}' = \frac{\cos B}{tga'} = \frac{\cos 7°30'}{tg5°} = 11.33227; \quad (38)$$

$$\text{c}' = 5°2'35''; \quad (39)$$

$$\phi = AB - A'B = 72°13'3''; \quad (40)$$

The positioning angle is 30°50′16″, the orientation angle is 72°12′3″ and the bond orientation angle is 75°14′54″that can be obtained by using H spherical diagram method. Fig 5 shows the installation diagram of the workpiece. The workpiece is clambed and positioned according to the positioning angle, the orientation angle and key-direction angle are solved by the above method.

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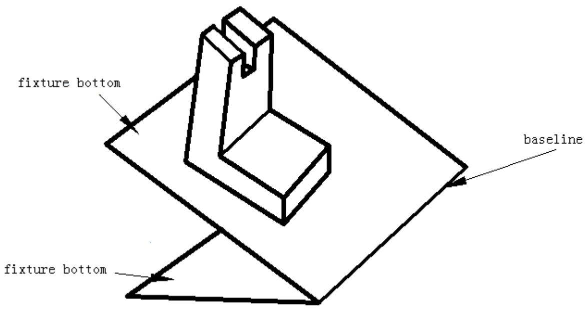

Fig 5: Workpiece installation diagram

Fig 6 and Fig 7 is show the schematic diagram of sliding core and the annotation diagram of each feature point of the parts respectively. The double angle inclined plane when milling the part who has the angle of 4°35′ and 25°, according to the projection angle marked on the part drawing which is respectively 4°35′ and 25°, the spherical triangle method is used to convert the positioning angle and orientation angle.

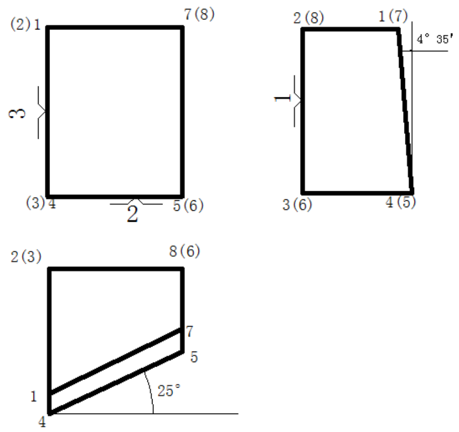

Fig 6: Schematic diagram of sliding core

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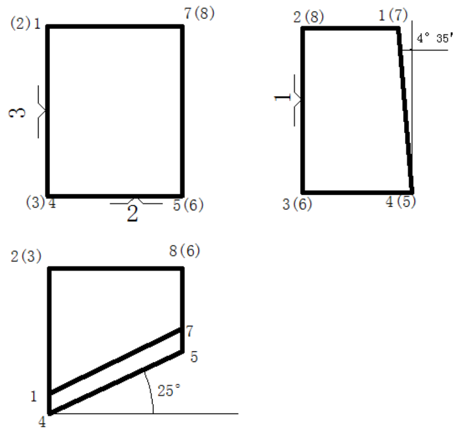

Fig 7: Annotation diagram of each feature point of the part

As shown in Fig 8, the main view is selected as V spherical diagram. In the right angle spherical triangle ABC, it is known that $C=90°$, $A=\theta$, $b=90°-4°35'=85°25''$, $a=90°-25°=65°$, the V spherical graph method is used to solve the positioning angle and the orientation angle.

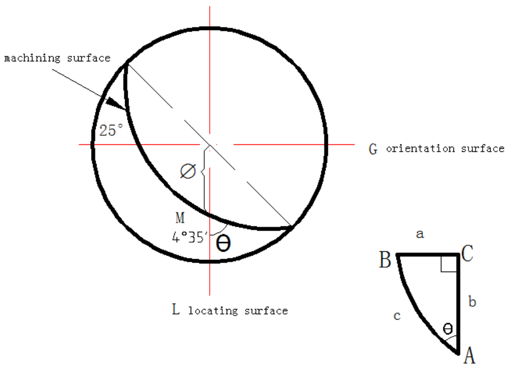

Fig 8: V-spherical diagram

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\sin b = tga \cdot ctgA; \tag{41}$$

Substitute the known data into formula (41), it can be obtained:

$$\text{ctg}A = \frac{\sin b}{tga} = \frac{\sin 85°25'}{tg65°} = 0.46482; \tag{42}$$

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$$\theta = A = 65°4'12'' ; \tag{43}$$

$$\phi = \mathrm{b} = 90° - 4°35' = 85°25' ; \tag{44}$$

The positioning angle and the orientation angle obtained by V spherical graph method are respectively 65°4′12″ and 85°25′.

As is shown in Fig 9, the side view is selected as W spherical diagram. It is Known that in right-angle spherical triangle EFG, $G = 90°$, $E = \theta$, $\mathrm{f} = 90° - 4°35' = 85°25'$, $\mathrm{e} = 90° - 25° = 65°$, The W spherical diagram method is used to solve the positioning angle and the orientation angle.

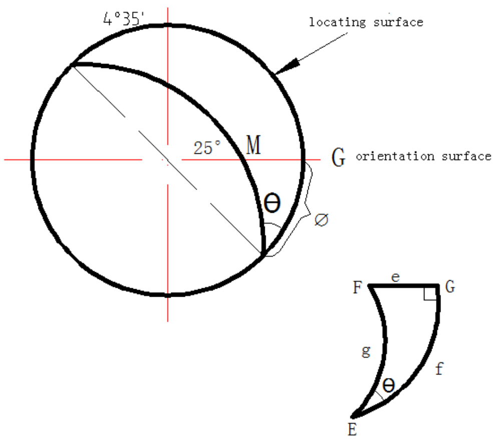

Fig 9: W-spherical diagram

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\sin f = tge \cdot ctgE ; \tag{45}$$

Substitute the known data into formula (45), it can be obtained:

$$E = \mathrm{arcctg}\frac{\sin 85°25'}{tg65°} = 65°4'12'' ; \tag{46}$$

$$\theta = E = 65°4'12'' ; \tag{47}$$

$$\phi = \mathrm{f} = 90° - 4°35' = 85°25' ; \tag{48}$$

The positioning angle and the orientation angle obtained by W spherical graph method are respectively 65°4′12″ and 85°25′.

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As is shown in Fig 10, the side view is selected as H spherical diagram. It is Known that in right-angle spherical triangle IJK, $K=90°$, $J=\theta$, $\mathrm{i}=\phi=90°-4°35'=85°25'$, $\mathrm{j}=90°-25°=65°$, The H spherical diagram method is used to solve the positioning angle θ and the orientation angle ϕ .

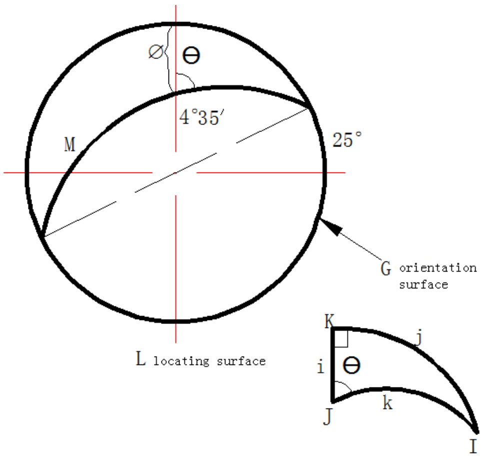

Fig 10: H-spherical diagram

Based on the spherical right triangle calculation formula, the following equation can be obtained:

$$\sin \mathrm{i}=tgj \cdot ctgJ\ ; \tag{49}$$

Substitute the known data into formula (49), it can be obtained:

$$J=\operatorname{arcctg}\frac{\sin 85°25'}{tg 65°}=65°4'12''\ ; \tag{50}$$

$$\theta=J=65°4'12''\ ; \tag{51}$$

$$\phi=\mathrm{i}=90°-4°35'=85°25'\ ; \tag{52}$$

The positioning angle and the orientation angle obtained by W spherical graph method are respectively 65°4′12″ and 85°25′.

To sum up, the positioning angle which is 65°4′12″ and the orientation angle which is 85°25′ can be calculated by using the three spherical projection maps.

As is shown in Fig 11, it is the installation and the positioning diagram of the sliding core workpiece when it is milling the double-angle inclined plane which has the angle of 25° and 4°35′. When the workpiece is processed on the CNC milling machine, it first turns a certain angle which is 65°4′12″ and

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then twists a certain direction angle which is 85°25′ on the combined fixture to ensure that the space angle is inclined to the milling process. In the vertical CNC milling machine, milling the inclined surface, should be set to Z- direction knife [4].

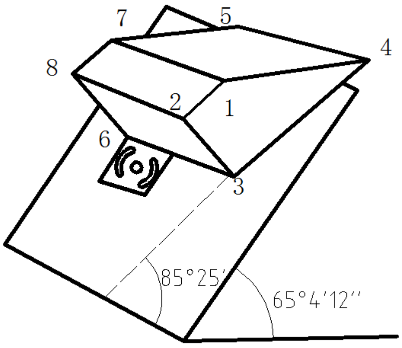

Fig 11: Positioning and installation of the workpiece on the combined fixture

Fig 11 shows the positioning and the installation of the workpiece on the combined fixture. It can be seen from the Fig 11, 1457 is the machining surface of the machine tool which is paralleled to the horizontal plane. It is Select point 7 as Z direction to calculate the tool alignment point, that is, Z coordinate is the tool alignment size. The conversion base sites were calculated with 8 and 6 points as the opposite knife points. First, the X, Y and Z coordinate dimensions are rotated twice to work out the z-coordinate dimensions of point 7 and point 8. Then, the z-coordinate relations between point 7 and point 6 are worked out by converting the quadratic coordinates between point 8 and point 6. The 6 point is a point on the combined clamp point. The Z direction of the relative machine tool table can be obtained from the structure size of the combined fixture, and then the Z direction of the tool size of the machining plane 1457 can be obtained.

III. CONCLUSION

The positioning angle and orientation angle of a support part solved by V, H and W spherical graph method are consistent, which indicates the correctness and feasibility of spherical map method to solve spatial angle, it is ensuring that such parts can be installed and positioned smoothly during milling process, and it is ensuring the machining accuracy of parts. The positioning angle and the orientation angle of a sliding core part solved by V, H and W spherical diagram method are consistent, which is ensures that the installation and positioning of such parts can be carried out smoothly during milling and it is ensures the machining accuracy of parts. [5-8]As can be seen from the above examples, the spherical graph method can preserve the original spatial position relationship between the plane and the axis of the object, with authenticity. Using spherical triangle to solve spatial angle is a very simple and practical method [9,10]. Compared with other spatial angle calculation methods, the more difficult the calculation, the more simple the method appears.

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