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Research Article

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Establishment of tooth-cutting model on internal gearing machine tool

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ABSTRACT

Based on sports of machine tool and principle of forming involute, mathematic equation and tooth face equation of involute outline internal gear is got. Then the milling theory of machine tool is analyzed based on this equation which can provide theory for involute outline internal gearing machine tool. At the end the milling machine for milling straight outline internal helical gearing is designed.

Keyword: Involute helical gear, Power head milling, Milling machine, Helical Milling model

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INTRODUCTION

The involute gear is widely used in mining, automobiles, tractors, tanks and other industries and its manufacturing process and quality directly affect the quality of various types of mechanical assemblies.

Based on the analysis the milling machine movement and theory and application of modern principles of geometry the movement of the machining and gear teeth formation model are established. Then the equation for machining tooth surface of internal gear is derived and the mathematical model line involute gear milling machining is also reached.

PRINCIPAL OF INVOLUTE INTERNAL GEAR TOOTH PROFILE

To achieve numerical control it should be established the mathematical model firstly. The machine with Z-X-C coordinates and linkage milling spindle, it can be milled different surfaces using different mathematical models and it also can give different coordinate trajectory. Therefore, the NC forming milling technology should have some versatility without limit to a fixed shape . According to this topic involute gear milling machine CNC needs, the imaginary circle around the base as shown in Figure 1 can be drawed and if expansing the circle from point B the trajectory of point B is traversed involute.

The length of each point of the involute to the base circle is equal to the length of the arc length of the cutting point. For example the BC length is equal to the length of the tangent of the AC arc .Let the tangent length is L, the base circle radius R, the angle of the base circle is rotated θ, then $L = R\theta$. Visible , involute shape is determined by the base circle radius and the tangent length uniform changes with the base circle corner. So the initial point of each corner of the base circle of the involute to a corresponding point .

From the principle of forming involute the involute tooth gear can be realized by rotating the base circle and changing the base circle tangent length which can be realized by two different ways. One is similar to the principle of hobbing exhibition which one milling cutter is rotated along an imaginary piece with the base circle , the other to move to the hob cutter imaginary tangent straight line along the base circle . This approach developed into gear due to the processing power of a fixed cutter head heavier, larger inertial force , following poor performance , and higher CNC servo system requirements, so it is very difficult to achieve. The second way is proposed in this paper method which using the CNC rotary table simulation involute base circle of uniform rotation and a mobile speed cutter head mounted power involute V to simulate the tangent point to the change in length of the base circle , which with rotary table ω is the angular velocity relationship : V = Rω (R is the radius of the base circle). If the power head and rotary table to achieve linkage with numerical control device it can continuously milled involute shape. This method requires less precision cutter shape , the smaller the amount of milling , stable milling, high accuracy, so that the volume is extremely beneficial.

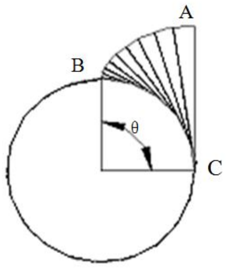

Fig 1. Principle of forming involute tooth gear

THE ESTABLISHMENT OF PROCESSING INVOLUTE INTERNAL GEAR TOOTH PROFILE EQUATION

Establish a coordinate system with the origin point based on to the center involute base and Y-axis based on the line starting the center and to connect the involute starting shown in figure 2. In order to expand the involute angle θ to solve the variable rectangular involute coordinates, let the involute point with spread angle θ, the Cartesian coordinates of point A is calculated as follows:

$$X_A = r_b \sin\theta - r_b\theta\cos\theta$$

$$Y_A = r_b \cos\theta + r_b\theta\sin\theta$$

The base circle radius： $r_b = mz\cos\alpha / 2$

Point A polar radius (polar vector)： $r_A = r_b / \cos\alpha_A$

Point A expansion angle： $\theta = tg\alpha_A$

m - the modulus; z-number of teeth; α-pitch circle pressure angle; αA-A point pressure angle.

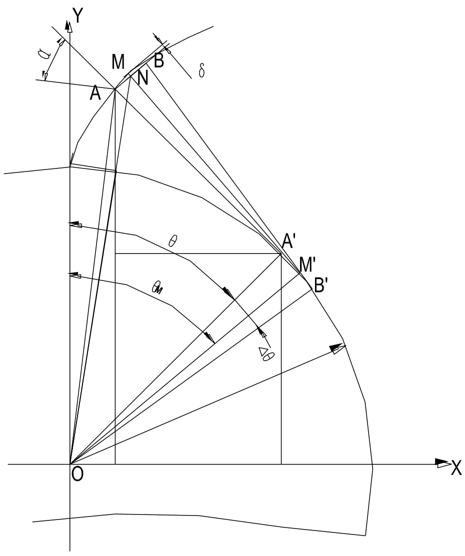

Fig2. milling equation of involute interpolation

According to CNC machine tool design principles that arc CNC machine is running are fitted by a straight line from the countless.so the involute tooth profile machining process appears inevitable bias. Now with involute AB segment as an example, instead of a straight line AB arc, the maximum error δ at the midpoint of AB N , create NM over N points and extend M'N cross involute at point M andM point on the base circle of the spread angle is:

$$\theta_M = arctg(x_n / y_n) + \arccos(r_b / ON)$$

Length of M'M and length of the ON:

$$\mathrm{M'M} = r_b \times \theta_M$$

$$ON = \sqrt{x_n^{\ 2} + y_n^{\ 2}}$$

The coordinates of N points:

$$x_n = (x_A + x_B)/2$$

$$y_n = (y_A + y_B)/2$$

Length of M'N:

$$M'N = \sqrt{ON^2 + r_b^{\ 2}}$$

The error:

δ =MN= M'M−M'N.

Finally, calculate the maximum error δ and compare δ with the machine precision. If it is not completed the CNC rotation angle increment continue until far exceeds the precision, and finally get the appropriate processing increments.

THE THEORETICAL BASIS OF THE MILLING PROCESS

In order to enable the power head milling force balance and preventing the occurrence of chattering it is usually used to increase the size of the power head design and the balanced cutting forces. So the cutting model thus established is also essential. Since this is a common NC device type, therefore creating two movement coordinates is important which is shown in figure 3 where the $\sigma_1 = \{\mathrm{O}_1(t); i_1, j_1, k_1\}$ [3] is coordinates movement for the cutter coordinate systemand $\sigma_2 = \{\mathrm{O}_2; i_2(t), j_2(t), k_2(t)\}$ is workpiece coordinate system coordinates.

Set the time at t = 0:

$$i_2(0) = i_1,\ j_2(0) = j_1, k_2(t) = k_1$$

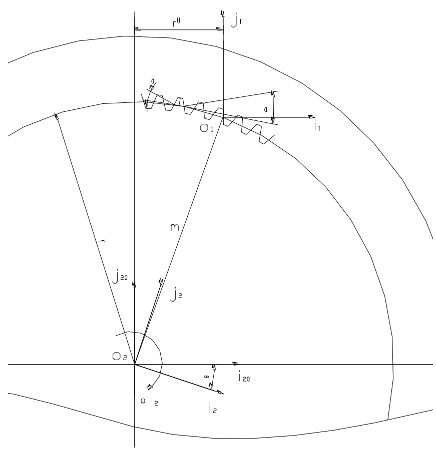

Fig.3 Milling model of processing

When t = 0, that is, the workpiece is rotated clockwise around the axis angle θ can be obtained after the equations

$$\begin{cases} i_1 = \cos\theta i_2(t) + \sin\theta j_2(t) \\ j_1 = -\sin\theta i_2(t) + \cos\theta j_2(t) \\ k_1 = k_2(t) \end{cases}$$

Let the radius of the pitch circle of the workpiece is r, the rotational speed of the workpiece is $\frac{d\theta}{dt} = 1$. When the workpiece turned θ angle cutters should translate rθ rotational direction (to the right), so it can be got:

$$m = r\theta i_1 + rj_1$$

Within this model involute gear milling gear suitable for a variety of parameters for milling on the milling machine.

DESIGN POWERHEAD

Internal gear tooth accuracy depends mainly on the shape of the molding cutter precision, so the straight profile gear mathematical model for milling is established and the CNC gear milling machine is also designed which includes the CNC gear milling machine electrical control part and part mechanical devices. Mechanical devices powered by the milling head 1 , parallel to the axis of movement of CNC gear slide 2 , CNC Rotary 3 and 4 perpendicular to the table (with hydraulic clamps) and the mechanical axis of rotation to move the gear slide 5 components. Milling head is mounted on a slide 2 and driven by the three-speed AC induction motor and milling tooth surface is formed by its own axis of rotation perpendicular to the face driven by a hypoid gear to make high-speed rotary cutter parallel axis gear (2950r/min). The slide 2 is parallel to the axis which can mill the entire gear tooth. The milling machine table mounted with a tooth controlled by a CNC rotary and the gear has been rotated driven by plate 3 until the completion of all the tooth milling. Rotary indexing accuracy is sufficient to ensure pitch error and the tooth thickness and profile angle can be controlled by adjusting milling fixture. At the same time the milling height can be controlled by mobile slider 5. Then for different gear it is only need to replace cutters and the fixture which is very convienient.

For the entire inner helical gear milling machine, the core of the mechanical parts is the milling power head, because the head size and strength directly affects the various parameters of internal gear machining and the design is shown in Figure 4.

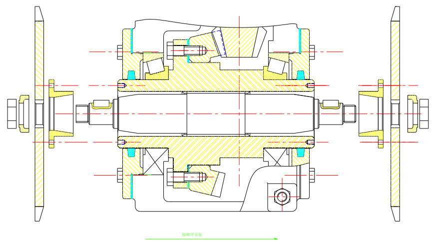

Fig.4 milling power unit

The designed milling power head is suitable for gear milling various parameters. For example let modulus is 3, teeth is 80, each tooth is 4.5 degrees, the outer ring diameter is 300mm, the pitch circle radius is 120 mm, the pressure angle α is 20 °, the helix angle is 15 degrees, thus indexing tangent angle between the direction of the normal tooth profile 20 degrees, then the workpiece is rotated clockwise 20 degrees, ie θ = α rotation angle equal to the pressure angle of the gear.

Therefore, there is a tooth profile which is in the vertical coordinate direction (X-axis perpendicular to the machine), i.e. parallel to the face milling cutter, parallel to the Y axis, then it can be calculated from the direction of rotation of the workpiece that it translate 41.042 mm in the right direction. So the corresponding coordinate and reference circle speed can be calculated which is not repeat them here. Then the workpiece alignment process can be programmed after stepping up processing until the size and acuracy .

CONCLUSION

The model and the model of the milling involute gear applied to the design and manufacture of involute internal gear teeth milling machine has been presented. By testing various technical indicators and precision the described mathematical model of the machine meets the requirements.

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REFERENCES

[1] Li Ruifang.**1998**.Side gear stiffness analysis and modification methods [M]. Chongqing: Chongqing University Press,

[2] YJ,Qu. **2011**.*Mechanical Research & Application*, 3:22-25.

[3] LX, Meng; YD, Hu. **2011**.*Chinese Journal of Construction Machinery*, , 2:127-133.

[4] Popov,**2007**.*hydraulic and pneumatic mechanical adjustment. Engineering*, 32(7):23- 24.

[5] Гусман М.Т.，Балденко Д.Ф.цдр,2011. Забой-ные винтовые двигатели для бурения скважин[J]. Недра, (2):23-26.