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The substitution of the curve with circle in the NC interpolation in the machining of guide pulley

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Abstract

The guide pulley, also called pilot wheel, is an important part in textile machine. It is a kind of spatial cam with complicated profile. This paper solved the problem of how to use the circle interpolate function of numerical controlled machine tool to machine the circle portion in the developed graph of the cam contour.

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Key words: curve, circle, guide pulley

1. introduction

The presentation of the problem: In practical practice of engineering, the design and manufacture of the cylindrical cam, the spatial cam is often considered as a planer cam. This approximation is relatively reasonable. The planer development of the cam contour consists of a series straight lines and circles. But in practical manufacture, the machine tool still works in the manner that: the cutter moves along the longitudinal axis, while the cam rotate about it axis, or , in the other words, 2-coordinates NC control. Let y be the coordinate along the circumferential direction, let r be the radius of the cam, we have:

$$y = r\varphi \quad (1)$$

So that, we have: $\varphi = y / r$

If equation (1) is expressed in the degree:

$$\varphi' = y/r \cdot 180/\pi \quad (2)$$

But, when the cam rotate an angle of one degree about its axis and the work platform of the machine tool moves a displacement of one millimeter, the corresponding pluses is different, (it depends on the construction of the machine) so that, in the equation (2), a coefficient k is needed

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$\varphi = 180/r\pi.ky$
 Let: $e = 180/r\pi k$
 e is the coefficient of condensation when the coordinate system xy is transformed into the coordinate system xφ. The tangent of the line would be changed, while a circle will be condensed to be a elliptical circle.
 As shown in Fig.1, is the development of the guide pulley of a imported precise machine.

1.1. The guide pulley

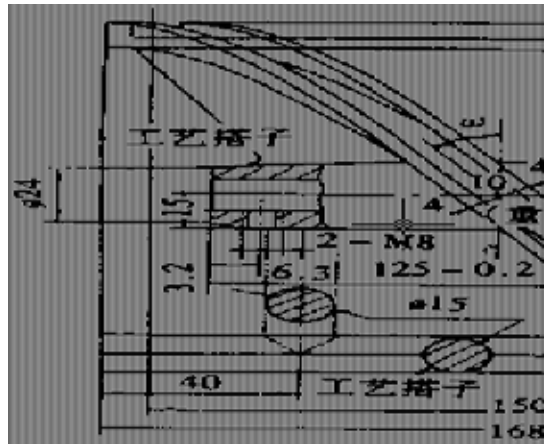
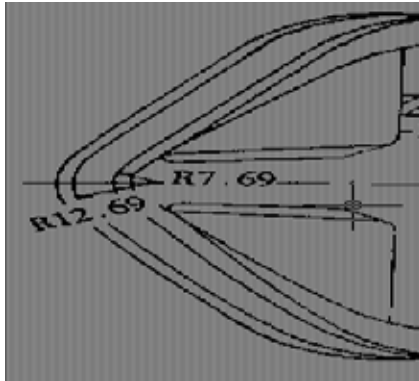


Fig.1 a guide pulley

$R = 12.69\text{mm}$ $r = 75\text{mm}$ $L = 75\text{mm}$
 $\alpha = 33.338^\circ$ $\beta = 90^\circ - \alpha = 56.662^\circ$
 when: $k = 5/9$
 $e = 180/r\pi.k = (180 \cdot 5/9) / 70 \cdot \pi = 0.4244131$
 The tangent of the original curve: $\text{tg}\alpha = dx/dy$
 After condensation: $\text{tg}\alpha' = dx/d\varphi = dx/edy = \text{tg}\alpha/e$
 $\therefore \alpha' = \text{arctg}(\text{tg}\alpha/e) = 57.171^\circ$
 $\therefore \beta' = 90^\circ - \alpha' = 32.829^\circ$

The figure after condensation is shown in Fig.2

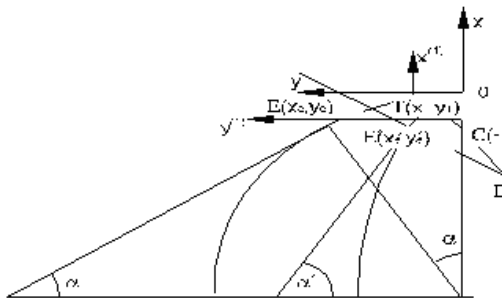


Fig.2 the circle on the pulley

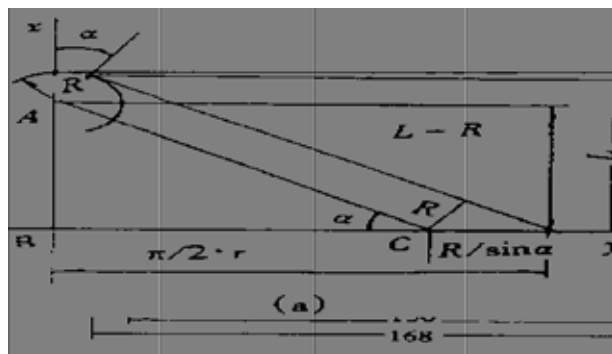


Fig.4 the substitution of the curve with circle

1.2. The approximation of the elliptical circle with circles

First, let's find the curvature of the elliptical circle at the tip of the it.

$$\begin{aligned}\rho &= b^2 / a = e^2 a^2 / a = e^2 a \\ &= 0.42441312 \times 12.69 \\ &= 2.286 \text{mm}\end{aligned}$$

The coordinates of the point at which the circle and the straight line tangent with each other:

$$\begin{aligned}x_e &= -R(1 - \cos\alpha) = -2.089 \\ y_e &= R \sin\alpha = 6.974\end{aligned}$$

After condensation, the corresponding point of point E is E', the coordinate x_e will not change, while:

$$y_{e'} = e, \quad y_e = 2.9599$$

The coordinates of the center of the curvature circle C are:

$$x_c = -2.286 \quad y_c = 0$$

Passing through point E', establish two coordinate systems, E'x(1)y(1) and E'x(2)y(2), the coordinates of the point C in the two systems are respectively:

$$\begin{aligned}x_c(1) &= x_c - x_e = -0.197 \\ y_c(1) &= y_c - y_e = -2.96\end{aligned}$$

Draw another circle which is tangential with both the curvature circle and the straight line. Let ρ_2 to be the radius of this circle. It is obvious the center of which must lay on the axis y.

$$y(2) = -\rho_2, \quad x(2) = 0$$

According to the geometrical relationship, we have:

$$(-\rho_2 + 2.594)^2 + 1.4392 = (\rho_2 - 2.286)^2,$$

solve this equation, we can get:

$$\rho_2 = 5.802 \text{mm}$$

To achieve control of machining parts with a chip, the basic problem must be solved to receive and transmit pulse through software and hardware pulse Section headings. Program Description: The entrance of the Pulse is the 8031's P3.3 pin, that is, the external signal interrupts INT1 and triggers input. Pulse is output and connected to the port P0.0. total program: a interpolation operation is required as each 1mm moving along X direction in test. For the pulses equivalent is determined by processing precision, $p = 0.04 \text{mm}$, that is, as soon as the data (0.04mm) is measured by grating, a pulse is output. As we know that 25 pulse are output by grating while X move 1mm. Choose mode 2. the Initial value of $T1 = 2^8 - 25 = 0E7H$. Step motor control program (ring distributor program). The generation of Timing pulse: in economic CNC system, the Power-on sequence in the five-phase step motor is as follows. Above table shows, the five shot control model code is output, the timing pulse is delayed to generate to control motor movement., the step motor move one step while inputting Each pulse: the motion state of the stepping motor is controlled by pulse sequence, the pulse number n control the rotation angular displacement of the step motor. $n = 360X/Hsp/i/a$, when $X = 1 \text{mm}$; Hsp = screw lead; a = stepping angle. The Step motor control program would run. Turn stop code = 1.

3. The tangent point of the two sectors of circles

From the geometrical relationship show in Fig.2, the coordinates of the tangent point $x_c(2)$ $y_c(2)$ must satisfy the following equations:

$$(x_c(2))^2 + (y_c(2) + 5.802)^2 = 5.802^2$$

$$(xc(2) - 1.439)^2 + (yc(2) + 2.594)^2 = 2.2862$$

by the above two equations, we can find:

$$xc(2) = 2.374, \quad yc(2) = -0.508$$

Transformed to the formal coordinate system again:

$$xc = x(1) + xe = -0.37$$

$$\begin{bmatrix} x_c^{(1)} \\ y_c^{(1)} \end{bmatrix} = \begin{bmatrix} \cos \beta' - \sin \beta' \\ \sin \beta' - \cos \beta' \end{bmatrix} \times \begin{bmatrix} x_c^{(2)} \\ y_c^{(2)} \end{bmatrix} = \begin{bmatrix} 1.719 \\ -1.714 \end{bmatrix}$$

$$yc = y(1) + xe' = 1.246$$

From this we can do the NC programming, the elliptical circle will be substituted by 2 smooth circles.

2. Conclusions

People who in charge of this project had asked many comrades to help him, including mathematicians, the experts of NC machining, engineers of machine tools. All of them are unable to solve this problem. It is neither a mathematical problem nor a problem with NC machining and machine tool. It is a complicated problem with many professional disciplines. Theoretical analysis and practical machining shows that, even though the development of the spatial cam is a section of circle, it can not be simply machined by the circular interpolation. Other vice there is a spit point on the tip of the cam. In fact this paper presents a new kind of circle interpolation.

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