Study on tool compensation of NC carton samplemaker

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Abstract

In paper processing V groove process, the actual knifepoint position is not programmed to coordinate the point of machine as a result of the use of a special tool, which results in a large error in the processing, so tool compensation calculation must be carried out. Firstly, it is assumed that the knife tip can be processed in accordance with the line given, in order to deduce transform programming coordinates. The path of the azimuth angle and the position relationship between the cutting path coordinates are also processed in calculation of cutter compensation, in which the amount of cutter compensation calculation is reduced, simple calculation expressions were deduced, and the writing of the program is simplified.

Keywords

Carton samplemaker ,V groove;azimuth angle,cutter compensation.

1. Introduction

Carton samplemaker is a kind of machine which can help designers to design the structure of the paper, die-cutting, indentation, and forming operations [1].It can not only save a lot of knife die, die cutting machine and human cost for the enterprise, but also improve the production efficiency and product quality greatly. Cartons usually needs to undertake indentation or V groove cut in the process of production, in order to fold better. The pressure roller is common tool used in indentation, and because the outer circumference of the roller and the actual machine tool path in a straight line, you just need simple compensation of the tool based on the depth of the indentation, in order to prevent the over-cutting phenomenon. However, another tool called “V cutter” will be needed to use for V groove cutting of paper, as shown in figure 1.V . The cutter installed on the tool carrier makes a non-90 degree angle with the machining of plane, therefore there is offset between point and the actual machining path, which makes the control object transform to point or blade edge. The NC carton samplemaker reminded in this article is the master-slave controller composed of ARM board + MCX314 motion controller .

2. Structure model of NC carton samplemaker

Most NC carton samplemaker control system to control four step/servo motor and a vibrating motor, generally realizing “three-axis linkage”& “four axis independent” control: X, Y direction of horizontal movement, Z direction vertical movement, and C direction rotation movement [2].The NC carton samplemaker in the article include six axes, which can realize the three axes linkage, so the 2 axis interpolation and 3 axis interpolation can be implemented in the processing.This machine is composed of two machine clips, which can be installed both on the machine tool. And this machine can be installed according to the requirements of different different types of cutting tools. Although proof machine has two cutter holders, they share the same horizontal motion axis, and respectively have a horizontal movement axis and a rotation axis, as shown in Fig.2, only showing an installed V cutter machine clip of the machine tool structure model. It can be seen from the graph that the tool nose is not in the center of the cutter holder, programming coordinate point of machine tool, which has larger bias in a horizontal direction ,considering the point in the direction of the vertical level compensation is relatively simple, therefore only give a level tool compensation calculation and analysis.

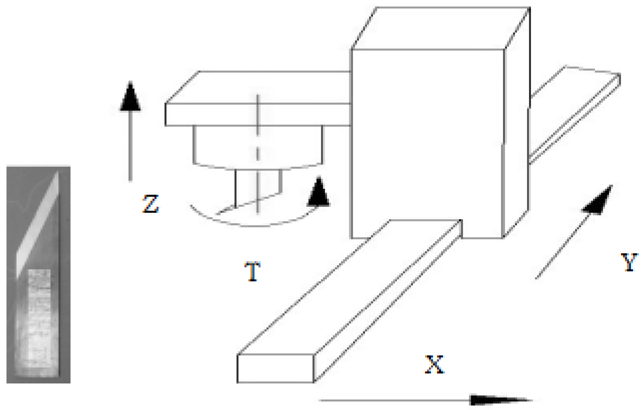

Fig. 1 Cutter and the structural model of proofer

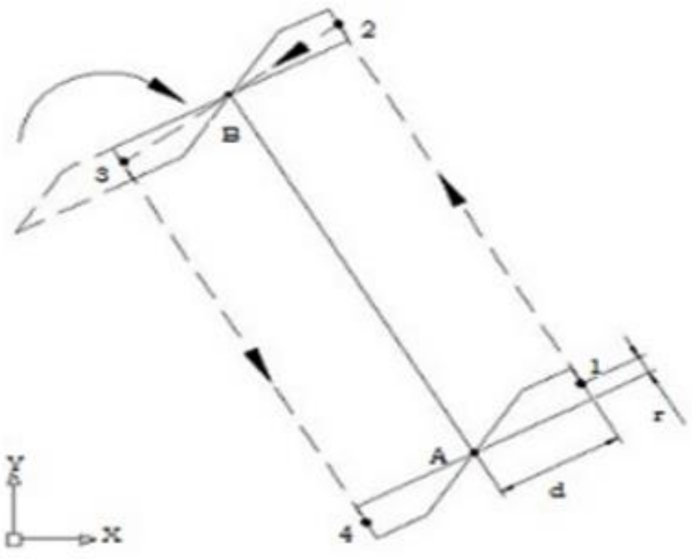

Fig. 2. Trajectory of V cutter

3. Analysis of V Cutter Trajectory

In the process of production, V cutter carried out the V groove cut at paper folding where needs for V groove cutting, and cutting path is usually a straight line.

The tool nose of the V cutter blade can work out a V groove, through the three axis interpolation movement of the machine tool inserting processing centers with an oblique angle, and cut twice on the machining path.

Therefore, in order to make the tip trajectory can be consistent with the actual machining path, the original programming coordinates must be transformed. Firstly, it is assumed that the processing arbitrary path be a straight line segment, and take two endpoints in a straight line as processing centers.

In order to facilitate the analysis, V is the vertical projection of the blade to processing plane. Finally, it is supposed that the tip trajectory has been converted to the actual machining path, as shown in Figure 2.

In the figure, AB stands for blade machining path, 1, 2, 3, 4 for the actual programming coordinates, there is deviation between V cutter tip and actual programming coordinates in X and Y direction : d for deviation value and live long, r for the half width, and the back of a knife blade goes perpendicular with machining path and blade width.

4. Calculation of cutter compensation

V cutter tool compensation is to be known to calculate the actual programming by machining path of coordinate point, pointing to the actual programming coordinate point position and the position of the cutting tool and machining path coordinate point. As processing path coordinates points have been given, there only needs to point to the reference points to calculate the actual programming in the X and Y direction of the offset value.

Through the analysis of the machining path of tool in all directions, it is concluded that the calculation of cutter offset value is associated with the machining path on the coordinate system of azimuth. Because the tip and the actual programming point of relative position is certain, the offset value calculation expression of unity can be deduced. Firstly, calculate the azimuth angle, and then the offset value of X and Y direction.

4.1 machining path azimuth calculation

It is assumed that any a machining path ab, in which a is taken as the starting point, b as the finish line, the coordinates are respectively (Xa, Ya), (Xb, Yb), and azimuth is β_{ab}.The following five types of expression is obtained by analysis:

$$\text{a. } \Delta X_{ab} > 0, \Delta Y_{ab} \geq 0, \beta_{ab} = \arctan\frac{\Delta Y_{ab}}{\Delta X_{ab}}$$

$$\text{b. } \Delta X_{ab} = 0, \Delta Y_{ab} > 0, \beta_{ab} = 90$$

$$\text{c. } \Delta X_{ab} < 0, \beta_{ab} = 180 + \arctan\frac{\Delta Y_{ab}}{\Delta X_{ab}}$$

$$\text{d. } \Delta X_{ab} = 0, \Delta Y_{ab} < 0, \beta_{ab} = 270$$

$$\text{e. } \Delta X_{ab} > 0, \Delta Y_{ab} < 0, \beta_{ab} = \arctan\frac{\Delta Y_{ab}}{\Delta X_{ab}} + 360$$

4.2 The calculation of offset value

The V cutter's motion path in Figure 3 is taken as example, and then the offset value of 1, 2, 3, 4 is calculated. From the analysis of tool motion trajectory and the position of the tool in the starting point and end point relationship can we make a conclusion that point 1 and point 2 share the same axis offset value in the X and Y, point 1 and point 4 are symmetrical about A point, and point 2 and point 3 are symmetrical about B point. So you can just calculate the offset value of one points, and other point offset value can be based on the analysis of the not timely just now.

Here takes Point 1 in Figure 3 as example: It is supposed that its offset value in X and Y direction be ΔX_1， ΔY_1 respectively, β_{AB} be the machining path AB azimuth direction. Point A coordinates (XA, YA), Point 1 (X1, Y1). The expression is as followed:

$$\text{a. } \Delta X_1 = d \times \sin\beta_{AB} + r \times \cos\beta_{AB}$$

$$\text{b. } \Delta Y_1 = -d \times \cos\beta_{AB} + r \times \sin\beta_{AB}$$

Lastly, the coordinate calculation expression of Point 1 is given, calculation expression of the other point are similar, so there is no need give the other calculations.

$$X_1 = X_A + \Delta X_1$$

$$Y_1 = Y_A + \Delta Y_1$$

4.3 The implementation of cutting tool compensation program

Here are parts of the code of cutting tool compensation function developed by NC carton samplemaker in the KEIL environment:

/ * line azimuth calculation. Respectively taking (X0, Y0) and (X1, Y1) as the starting point coordinates and end coordinates, ultimately the return value is the straight line of packaging function of azimuth * /

```
Double AzimuthAngle(double X0,double Y0,double X1,double Y1)
{
double k,a;
int dx,dy;
dx=(int)(100*(X1-X0));
dy=(int)(100*(Y1-Y0));
k=(Y1-Y0)/(X1-X0);
a=atan(k);
if(dx==0)
{
if(dy>0)
{
a=1.570796;
}else
{
a=-1.570796;
}
}
else if(dy==0)
{
if(dx>0)
{
a=0;
}
else
{
a=-0.000001;
}
}
else
{
a=atan(k)
}
a = a/Pi*180;
if( dx<0 )
a = a + 180;
while ( a<0 )
{
a = a + 360;
}
return a;
}
```

```
/ * V :cutter tool compensation after calculating the coordinates of the point;
NOR_POS []array : to store the original coordinate point;
 RE_VDATA [] : the coordinates of the point after cutting tool compensation;
d : the length of the back of a knife blade;
r : the width of the knife.
Int VdaoPoint(double NOR_POS[],double RE_VDATA[])
{
angle_next=AzimuthAngle(NOR_POS[0],NOR_POS[1],NOR_POS[2],NOR_POS[3]);
RE_VDATA[0]=NOR_POS[0]+d*sin(angle_next/180*Pi)+0.5*r*cos(angle_next/180*Pi);
RE_VDATA[1]=NOR_POS[1]+(-d*cos(angle_next/180*Pi))+0.5*r*sin(angle_next/180*Pi);
 ⋮
}
```

5. Conclusion

In accordance with the analysis of the V cutter trajectory, it can be showed that the actual machine tool programming coordinate point is not on V cutter blade, therefore compensation of CN carton samplemaker V cutter must be carried out. The relationships between azimuth angle and tool offset value and the geometric relationships between the coordinate points are used in the cutting tool compensation calculation, in which the cutter compensation calculation is reduced, the simple calculation expression is deduced, and the writing program is simplified. Other types of machine tool can be realized through the similar calculation of cutter compensation.

References

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[2] L.S. Liu: Design and Embedded axis motion controller (Guangdong University of Technology, China 2007),p.37-39.(In Chinese)