

Parametric Modeling for Globoidal Cam Based and NC Machining

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Abstract

The design and machining of globoidal cam is difficult, because the shape of working surface is complex, and the curved surface of its space is undevelopable. Based on the above reasons, we proposed the parametric Modeling method for globoidal cam based. Through the secondary development, we realized the parameterized modeling of globoidal cam. Base on using of globular indexing cam NC milling machine existing in the lab, research the programming technology, analyses the defects of conventional programming method, raise improvement measures, control the programming error, modify the feeding speed, develop the special purpose programming software, creat globular indexing cam NC machining program automatically, improve the machining precision and efficiency of globular indexing cam.

Keywords: Globoidal indexing cam, Parametric modeling, NC Machining, Researech.

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1. Introduction

With the development of machinery manufacturing and the improvement of automation degree, the demand of globular indexing cam which as the core transmission device in high-speed and high precision intermittent indexing movement automatic machines is increasing, globular indexing cam as the core parts in indexing institutions, the working surface is not invited, and the shape is complication, which make it hard to design and manufacture. The quality of the working surface of cam affect the agency workability directly. So, improve the processing level of cam is one key of the research of globular indexing cam [1-5].

2. The Parametric Modeling for Globoidal Cam Based

Embed button and menu below the Part *Design.Insert* the dialog used to input parameters of globoidal cam with the style of CATIA. Generate the response for interface function. Finally modeling.

2.1. The embedding of button and menu

The embedded part of button is actually a function button and menu items, also is the Addin of CAA. Through the call named Implementation of CAA can realize its insert. This calling mechanism is nterface/Implementation. It realized the function of object Implementation from the CATIA Implementation quoted by Interface, which is a user-defined interface [6-10].

We defined a user interface PartAddin in this paper. Firstly, establish a program module PartAddin as the user scalable object Interface. Then define the describe category of plugin, Insert Component in PartAddin, and set its name, such as "NewAddin", select CAIPrtWksAddin in TIE Mode. The next, create command header, the simplest approach is to use macros, such as MacDeclare.Header(PartCmdHeader). Using the function createcommands() to instantiate a new order, such as adding the codes into function body as follow:

New PartCmdHeader("CreateCam", "CmdModule", "CamCmd".(void+)NULL) Using the function CreateToolbars() to creat toolbars and menus, adding the codes into functions as follow:

```
NewAccess(CATCmdContainer, pPartBenchTlb, PartBenchTlb);  
NewAecess(CATCmdContainer, pCAACChartWindowMnu, IndexCam);
```

The workbench and the workplace of CATIA can be seen as a collection of entrance. Using the macro NewAccess can create such an entrance. These two macros SetAccessChild and SetAccessNext can connect to the entrance sequentially. Add the icon of button, it means to store bitmaps in Cnext/resources/graphic/icons/normal. Then add codes into PartCmdHeader.CATNIs as follows:

```
PartCmdHeader.CreateCam.Icon.Normal="cam".
```

2.2. Establish the dialog used to input parameters of globoidal cam

Insert CATIA Resources-dialog' into the dialog, save the files after adding control. The wizard can add codes in function Build automatically as follows:

```
Frame001=new CATDlgFrame(this,"Frame001",CATDlgGridLayout).
```

To set up radio buttons and combo boxes and so on, it needs to add the following codes manually:

```
RadioButton024->SetState(CATDlgCheck,0).
```

```
CATUnicodeStringILineContentsI("Fixed sine").
```

```
FirstLineI=_Comb0019->SetLine(iLineContentsI,iLineNumberI,CATDlgDataAdd).
```

The established dialog .

2.3. The generation of model

The derivation of work surface equation for globoidal cam is complex. There is no detailed derivation in this paper, it can be seen in [1]. The final work surface equation of globoidal cam is .

$$\begin{cases} x_1 = x_2 \cos \phi \cos \theta - p y_2 \sin \phi \cos \theta - z_2 \sin \theta - C \cos \theta \\ y_1 = -x_2 \cos \phi \sin \theta + p y_2 \sin \phi \sin \theta - z_2 \cos \theta + C \sin \theta \\ z_1 = p x_2 \sin \phi + y_2 \cos \phi \end{cases} \quad (1)$$

The general conjugate contact equation for spin around cam is :

$$\operatorname{tg} \psi = \frac{pr}{C - r \cos \phi} \left(\frac{\omega_2}{\omega_1} \right) \quad (2)$$

In the formula: r, ψ -The surface parameters for the workface equation of cylindrical roller.

ρ - roller radius.

P -The option symbol of CAM indexing period contour line, levo $P = +1$, dextro $P = -1$

ω_1 -The angular speed of cam.

ω_2 - The angular speed of clutch plate.

$\frac{\omega_2}{\omega_1}$

ω_1 -The instantaneous angle ratio of mechanism.

C -The center distance between cam and rotor.

ϕ -The included angle between the roller axis O_2X_2 and O_0X_0 of clutch plate.

x_2, y_2, z_2 -The 3D coordinate of conjugate contact point on the workface of cylinder roller.

θ -The intersection angle of cam, $0 \leq \theta \leq \theta_f$, At the beginning of indexing period $\theta = 0$, θ_f is the intersection angle of cam indexing period.

φ_0 -The starting angle of roller,The values φ_0 of every roller in different direction are,
 $\varphi_{01} = \frac{\pi}{z}$, $\varphi_{02} = -\frac{\pi}{z}$, $\varphi_{03} = -\frac{3\pi}{z}$

ϕ_i -The angular displacement of roller.

Scheduling through the contour surface equation of globoidal cam can calculate the 3D coordinate of conjugate contact point on the workface of cam quickly and precisely [2], the specific calculation steps are:

- (1) Make the beginning of cam indexing period is $\theta = 0$,seperate the cam indexing period corner into several divisions using the calculation step length as 1°
- (2) Calculate the angular displacement of clutch plate ϕ which corresponded to every cam angle and the angular velocity ratio ω_2 / ω_1 ,through the move rules of selected indexing plate.
- (3) After selectting the center distance C,bring the getted ϕ and ω_2 / ω_1 into meshing equation,it can get the every corresponding corner value,and the restrict equation between r and ψ .
- (4) Setting a series of values of r using the step length as 1mm,form the restrict equation getted form step 3 can get the corresponding parameters meeting the conjugate condition.
- (5) Bring the every value of cam corner r and the every corresponding value of ψ into contour surface equation of cam,it can get the corresponding 3D coordinates for work contour surface of cam.

After getting the 3D coordinates of contacted points.Firstly using three functions named CreatePoint,CreateSplinePoints and CreateLof form the tool set named CATIGSMFactory to creat point,line and plane respectively. Then using the function named CreateCloseSurface form the mechanism design tool set named CATIPrt.Factory to creat solid,generating the final model of Globoidal cam.

3. NC Machining of Globular Indexing Cam

The processing of surface cam is the key to the globular indexing cam, it have strictly demand of processing precision.Processing precision affect the dynamic performance of the entire organization directly.The model number of CNC milling machine in the lab is XK6401, the milling machine have shaft A and shaft B to creat linkage to rotate, it can use generating cutting to mill surface cam [11-14].

The machine consists of lathe bed, workbench spindle box, CNC control box, electric cabinet, cooling box and hydraulic pump .The NC system can contral the four directions of workbench ,as transverse X axis, longitudinal Z axis, rotate B axis of the workbench and workpiece axis A axis. The machine has a manual adjustment axis, it mainly used to adjust the center distance of the surface cam and the indexing plate .the manual adjustment axis installs a ball grid measuring devices, and use digital display to adjust the center distance conveniently.

3.1. Programming principle

The G code (G100) in this paper uses the variables H, J, Q, C, V, F, applied respectively for passing parameters to subroutines: rotation angle of cam graduator, number of thread, roller number, starting angle of B axis, sense of rotation, spindle speed. Each parameter of the address as Table 1.

3.2. Programming examples

T The parameters given in the cam:number of indexing is 8, number of thread is 1, spin left ,the center distance is 180mm, rotation angle of cam graduator is 120° ,using the rules of modify the sinmovement. According to this group of parameters, use user macro function write NC processing code of cam, main program and subroutines are as follows:

Main program:

```

O0001
G90 G01 Z0 F100;
B0 A0;
S200 M03;
G01 Z#500 F100;
#105=0;
WHILE[#105 LT #505] DO1;
G100 H120.0 J1.0 Q8.0 C42.0 V1.0 F100;
#105 = 105+1;
B0;
A0;
END1;
G90 G01 Z0 F100;
M30;
%
Subroutines:
O9010
#102=#5042+#502;
#103=0;
#13=#11*#22;
#33=360/#17;
#6=1;
#101=-1.0*[#3+0.8];
/G90 G01 B#101 F#9;
WHILE[#6 LE 3] DO1;
#32=[#6-2.5]* #33;
/G90 G01 A#32 F#9;
#4=1;
.....
END1;
M99;
%
```

Visibly, using macro call subroutine can make the program simple, flexible, modify, convenient and readable. However, the program using etc step length processing, step length is 1°, and setting spindle speed 100 in the code, which are the defects of this program.

Table 1. Frank NC system variables address Table

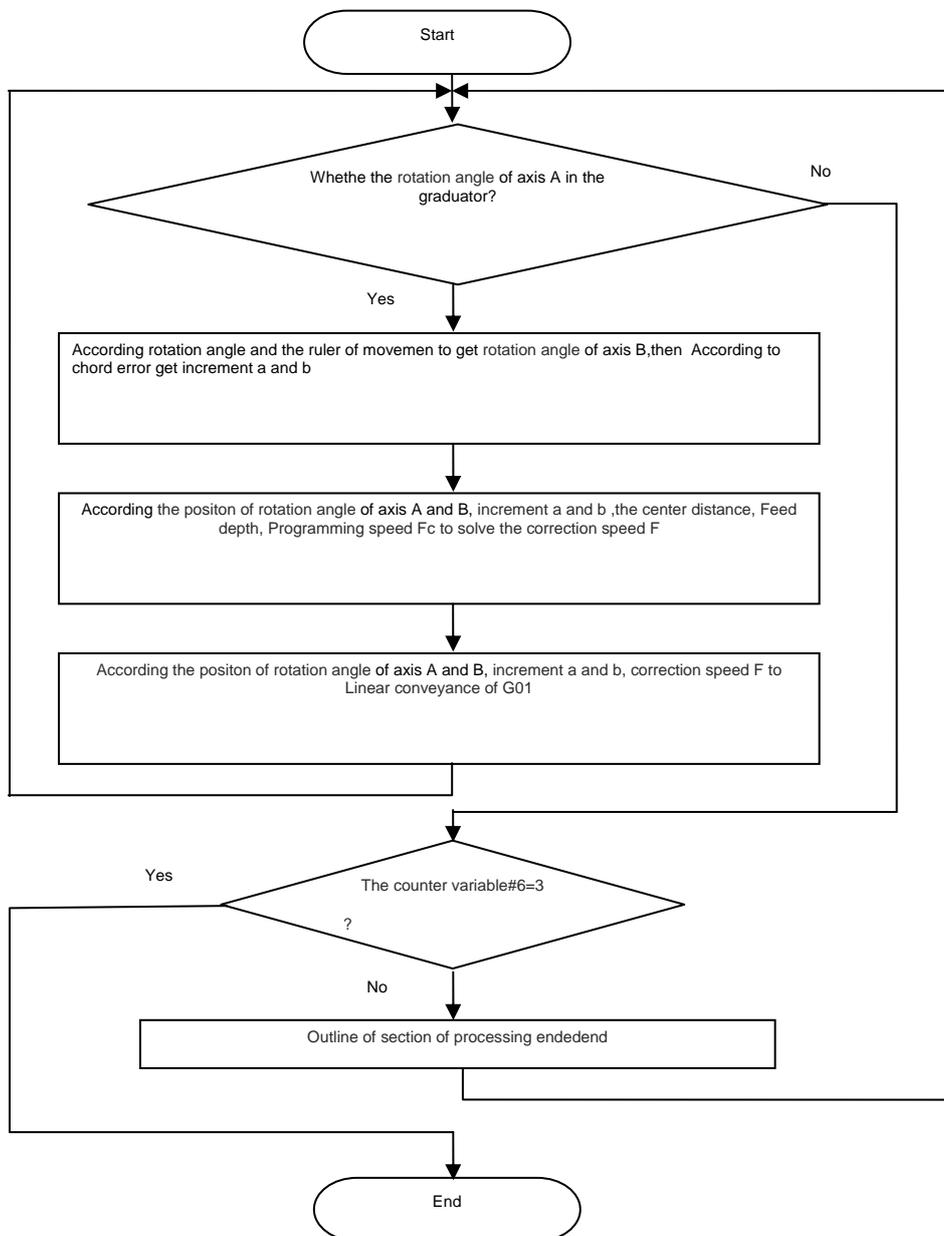
Address	Variable number	Address	Variable number	Address	Variable number
A	#1	I	#4	T	#20
B	#2	J	#5	U	#21
C	#3	K	#6	V	#22
D	#7	M	#13	W	#23
E	#8	Q	#17	X	#24
F	#9	R	#18	Y	#25
H	#11	S	#19	Z	#26

3.3. The realization of automatic programming software

For generating processing, comprehensively consider for the control of bow high error and correct the feeding speed, developed automatic programming software of machining cam, programmer only need input small amounts of data of surface cam required to the geometrical parameters and process, it can obtain processing procedure, modify the program conveniently .it can reduce the demands of machining professional knowledge for the programmer [15]. It has the advantages of high speed, high quality, convenient, etc. This software is particularly applicable for small batch, many kinds of production, it can greatly increase the production automation. Program flowcharts as shown in Figure1.

When the program is running, then, it need input the geometrical parameters of surface cam, processing parameters and file path, filename. When the user input parameters and

etermine, the program will automatically generate G code, keep them in the specified file. Finally program will be directly sent to nc machine , then process the surface cam with nc machining.



Figureure 1. The flow of automatic programming for globoidal cam

4. Conclusion

According to the complexity of design for globular indexing cam, We proposed a parametric design method of globoidal cam based , developed the parametric design programs for generating the 3D model of globoidal cam automatically,realized the 3D modeling of globular indexing cam . Based on the two coordinates linkage curve of NC machining special milling machine existing in the laboratory, considerate comprehensivly the control of bow high error and correct programming speed. Program surface cam software that can easily and quickly generate G code, produce high accuracy surface cam,and received good effecton in practical applications.

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