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Parametric Design of Cycloid Gear Based on SolidWorks

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Abstract. In order to improve the efficiency and quality of design of complex parts, cycloid gear, in the pin-cycloidal transmission, this paper used SolidWorks to built accurately cycloid gear 3d model, and the VBA to program procedure for the secondary development, realized the parametric design of cycloid gear. Designer just enter the design parameters of cycloid gear , then gain the accurately generated cycloid gear 3d model rapidly , greatly improving the speed of cycloid gear design.

Introduction

Because of a wide range of applications in features of pin-cycloid gear planetary transmission, such as the range, high bearing capacity, compact structure, high reliability , especially in the 1990s, industrial automation robots usually choose cycloid transmission as a kind of ideal form of turning device. For example, Japan's sumitomo heavy machinery industry corporation developed robots successfully using R-V series, FA series and FT series transmission products, which all adopt the pin-cycloid transmission structure form. Because of applying the newest design concept, beautiful exterior, reasonable internal structure ,increasing transfer power , especially high reliability, this corporation's products have been used in a wide range of the industrial robot field, occupied the international market.

For the whole pin-cycloid gear planetary transmission, designing and manufacturing of cycloid gear is the most complex and the most time-consuming work, thus we obtains the idea to proceed the parametric design for cycloid gear. In the production process, different series of cycloid gear have common characteristics in shape structure, just have some difference in the relative size or local characteristics, if we can derive the different model from a template one, we will greatly improve the design efficiency. Parametric design is using the corresponding variable instead of the parameters changing with the different specifications in generalization, serialization, and standardization finalize products, by modifying the variables to realize the parameterization of the design of mechanical parts in similar structure .The key of parametric solid modeling is the extraction, expression, solution of geometric constraint relations and the construction of parametric geometry model . SolidWorks is the first set 3d mechanical design CAD software of the world based on Windows system. The software provides the technology that no fully constrained parametric entity feature modeling and surface modeling combine with each other, by formidable parts design function [1]. This paper using VB language developed a parametric design system of cycloid gear based on SolidWorks.

Tooth profile of cycloid

According to the meshing and processing principle of pin-cycloid gear planetary transmission , the actually used cycloid gear must go through the tooth shape, to make that the decrease number of tooth cannot reach half of the number in theory. The shape means are the combination methods of the following three basic form, as travel distance modification, isometric modification and rotary angle modification.

(1) Travel distance modification(modified value is Δr_p) :as processing cycloid gear, eccentricity, pin tooth radius and transmission ratio are same as processing standards tooth shape. the different is to move the grinding wheels in the direction of the cycloid gear center r_p to reduce a modified value Δr_p ,

relative to of the pin tooth's center circle radius in theory ,decrease is positive and increase is negative, make pin tooth's center circle radius reduce from r_p to $r_p + \Delta r_p$. For this gear is less than standard tooth shape, when meshing with standard pin gear ,it can produce meshing clearance naturally.

(2) Isometric modification (modified value is Δr_{rp}) :as processing cycloid gear, the adjustment of the machine tool's movement and parameter selection is same as processing standard tooth shape ,the different is to increase the pin tooth radius from standard r_{rp} to $r_{rp} + \Delta r_{rp}$. So the teeth grinded are less than standard tooth gear, when meshing with standard pin gear ,it can produce meshing clearance naturally. Pin tooth radius increased a modified value Δr_{rp} ,decrease is positive and increase is negative.

(3) Rotary angle modification (modified value is $\Delta\delta$) : other parameters are constant, relative to the pin gear meshing position in theory, the blank of cycloid gear turn a modified angle around the center to each different directions , minifying the cycloid gear processed out, meanwhile the tooth profile of cycloid gear and that of pin tooth are conjugate tooth profile, but we can't produce diametral clearance at root and roof of tooth , so it can't be used alone, can be only combined with travel distance modification (or isometric modification) to use[2].

The established cycloid gear's tooth shape equations summarized three modification shows as following, cycloid tooth profile is shown in Fig.1.

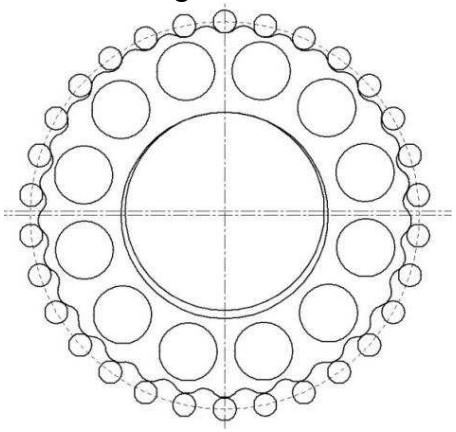

Fig.1 Tooth profile of cycloid

$$x_c = (r_p + \Delta r_p - (r_{rp} + \Delta r_{rp})\varphi^{-1}(K_1^{'}, \varphi)] \cdot \cos[(1 - i^H)\varphi - \delta] - \frac{a}{r_p + \Delta r_p}[r_p + \Delta r_p - z_p(r_{rp} + \Delta r_{rp})\varphi^{-1}(K_1^{'}, \varphi)] \cdot \cos(i^H\varphi + \delta)$$

$$y_c = (r_p + \Delta r_p - (r_{rp} + \Delta r_{rp})\varphi^{-1}(K_1^{'}, \varphi)] \cdot \sin[(1 - i^H)\varphi - \delta] + \frac{a}{r_p + \Delta r_p}[r_p + \Delta r_p - z_p(r_{rp} + \Delta r_{rp})\varphi^{-1}(K_1^{'}, \varphi)] \cdot \sin(i^H\varphi + \delta)$$

In the formula:

K_1' --short width coefficient of the tooth shape by travel distance modification $K_1' = az_p/(r_p + \Delta r_p)$

i^H -- and relatively transmission ratio between cycloid gear and pin wheel $i^H = z_p / z_c$

φ -- rotary angle of the rotary arm relative to the center radius vector of one pin tooth (°)

$$\varphi^{-1}(K_1^{'}, \varphi) = (1 + K_1^{'2} - 2K_1^{'}\cos\varphi)^{-\frac{1}{2}}$$

Development method and key technology

Development of SolidWorks is to use the medium high-level language ,such as Visual Basic, VBA, Visual C++ , call the API nuclear function of SolidWorks to realize the corresponding function, this design used VBA to program the parametric design for cycloid gear . VBA (Visual Basic for

Application) actually is the development language integrated in the internal SolidWorks, it can be seen as a simplified version of VB. The program developed by VBA is called "macro", but the macro developed by VBA can't be run independently without the application program, namely that the macro of SolidWorks must be run under the environment of SolidWorks , the method of opening SolidWorks in VBA: use the menu[tools /macros operation/new...]or [tools /macros operation/edit].

In SolidWorks software, its internal powerful macro function can proceed entity modeling, this paper will use this function to process cycloid gear parametric design, the main process is as follows:

(1)When using SolidWorks to create cycloid gear 3d model, transcribe the whole process of the gear modeling for "macro" documents, find out the key function in the "macro" file related to generating the model , and determine the key constant. Find out the effects on the entity modeling causing by key constant changes ,use variables instead of the key constant ,then get the parametric model of cycloid gear in SolidWorks .

(2) Use VB language to work out application interface, when proceeding the gear design, designers input the initial parameters through the application program interface , compile the program and generates executable programs for SolidWorks calling.

(3) Complete application executable program, use the "macro" operation command of SolidWorks to embed program to SolidWorks, realize their links[3].

Realization to parametric Design of Cycloid Gear

This paper use FA45-29 to design the basic parameters of cycloid gear, the pin tooth's center circle radius r_p is 85 mm, transmission ratio i is 29, the pin tooth radius r_{rp} is 5.0 mm, eccentricity a is 0.75 mm, travel distance modification Δr_p is 0.3627 mm, and isometric modification Δr_{rp} is 0.2627 mm.

The basic ideas of cycloid gear secondary development are as following:

1) In fully understanding of cycloid gear's function and design intention, and on the basis of correct design relationship, record macro file of establishing cycloid gear 3d model in SolidWorks.

2) Use VBA to compile the application procedure, find the design variables generated automatic in the process of cycloid gear modeling , and according to variable parameter given in the mechanical design manuals or other materials to modify; after popping up macro toolbar click "recording/pause macro", to start recording.

3) Establish application procedure and SolidWorks connection, realize the parameterized modeling[4].

Realization process is as following:

In order to improve the efficiency of programming, click on the "tools"→"options"→" system option "→" normal ". Check the "record to edit macro" of system options. Click on the "new" icon, create a new parts files. Click the menu "view"→"toolbar"→" macro ",declaring and instantiating SolidWorks API top object and a document object [5], choose datum, use the equation curve method drawing cycloid, this is the most important step of the whole modeling process, choose "sketch rendering"→" convert entity references "→" tensile convex platform/matrix ", after the completion of stretching ,slotting the cycloid gear entity, complete cycloid gear modeling, click "stop macro", save the file. At this moment click "view SolidWorks" on the interface of VBA back to SolidWorks interface, click on the "new" icon, make the macro playing environment as same as its recording environment, click "run", but it's easy to make a mistake, the reason is that the code generated from macro recording usually emerge problems, it is necessary to compile the code to normal operation.
edit the macro after modeling, debugging to accomplish the parametric design of cycloid gear in SolidWorks .

The key code for generating cycloid :

```
Part.InsertCurveFileBegin
For n = 0 To 1 Step 0.001
ff1 = n * (2 * pi + 2 * pi / zz1) * zz1
```

```
bb1 = -rrz / zz2 * Sin(ff1 / zz2) + aa * Sin(ff1)
aa1 = rrz / zz2 * Cos(ff1 / zz2) - aa * Cos(ff1)
cc = Sqr(aa1 * aa1 + bb1 * bb1)
x = (rrz * Sin(ff1 / zz2) - aa * Sin(ff1) + rrg * bb1 / cc) / 1000
y = (rrz * Cos(ff1 / zz2) - aa * Cos(ff1) - rrg * aa1 / cc) / 1000
z = 0
   Part.InsertCurveFilePoint x, y, z
   Next n
   Part.InsertCurveFileEnd
```

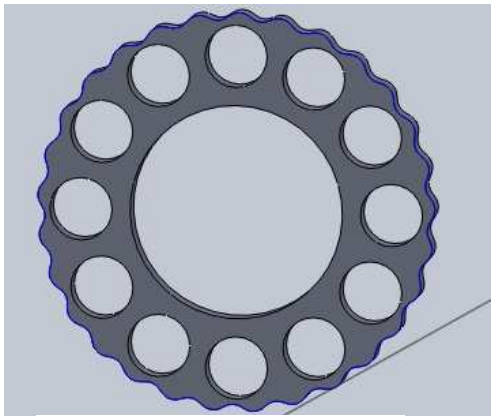

Fig.2 Generated cycloid gear

Conclusions

This paper introduces that in the integrated development environment of VB, by calling SolidWorksAPI function for secondary development, we realized the cycloid gear parametric design. Designer just enter the design parameters of cycloid gear , then gain the accurately generated cycloid gear 3d model rapidly , greatly improving the speed of cycloid gear design . Referencing this method can also proceed secondary development for other complex parts, to establish a specialized SolidWorks function system to suit users' requirements.

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References

[1] LIDong ,LU Xiaoyang, GAO Fang: Achieving Parametric Design of OX-HORN CORE BAR Based on Solidworks[J]. Modern Machinery. 2009,2. In Chinese.

[2] Guan TianMin ,SunYingShi, LeiLei: Two teeth differenced cycloid planetary gear stress analysis. The Journal of Mechanical Engineering. 2002, (3) : 59-63. In Chinese.

[3] Ye Xiuzi,Chen Chaoxiang: SolidWorks Programming: Secondary Development and API (2007 Edition). China Machine Press, 2009,1. In Chinese.

[4] LI Congde,WANG Desheng:Study on Secondary Development of Involute Gear in SolidWorks Based on VB. Mechanical & Electrical Engineering Technology. 2008,11. In Chinese.

[5] ZE Sufang: Parameterized Solid Modeling for Involute Gear Based on the Secondary Development of SolidWorks. ModernMachinery. 2008,06. In Chinese.

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