Parametrization Design of Multi-thread ZI Worm Based on Pro/Program

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Abstract

Under the circumstance of Pro/E, by utilizing the combining relation of the tool program, this paper introduced the method and procedure to realize three-dimensional parameterized modeling with ZI type involute worm. Through inputting relevant parameters, such as characterization factor, modulus, number of threads, pressure angle and other known conditions, this method could generate new solid model of worm accurately and quickly, providing reference for other gear-type parts to make three-dimensional parametric modeling.

Key words: PRO/PROGRAM, MULTI-THREAD ZI WORM, COMPUTER AIDED DESIGN, PARAMETRIZATION DESIGN

1. Introduction

Worm drive is a kind of drive that transmits movement and momentum between the two axles spatially crossed. It possesses the advantages in bevel wheel and screw drive. Due to this kind of drive is featured by compact structure, large drive ratio, stable drive, reliable self-locking under certain conditions and so forth, it is widely used in machine tool, instrument and meter, automobile, metallurgy, mine and hoisting equipment. According to the different tooth profile curve, the common cylindrical worm could be divided into three types: Archimedes worm (ZA worm), involute worm (ZI worm) and straight sided normal worm (AN worm). Among which, the involute worm (ZI worm) has been widely used in engineering. The transverse tooth profile of ZI worm is involute [1] [2], however, it is difficult for average CAD software to model the accurate tooth profile on account of its complicated shape. While Pro/E has solved this, its parametrization design and solid model system based on characteristics offer great convenience for modeling designing this kind of parts.

2. Program in Pro/E

The Program provided by Pro/E records every procedure and condition that generates model, which includes establishing process to all characteristics, parameter, dimension, relation and other model information. That is to say, when every characteristic is established, Pro/E would generate the Program of that characteristic, the user could edit and modify to that Program according to the design idea [3], and deassign to each parametric variable could be done. After the parts regenerates, automatic modeling to the product could be realized, and the parts that satisfy parameter requirements could be got. In this way tedious and complicated rehandling could be reduced, and the design efficiency could be enhanced [4-6]. With regard to conduct ZI-type involute worm design by means of Pro/E software, main parameters and

relation that are shown in table 1 shall be used.

Table 1. Main Parameters and Relation to Worm

Name	Type	Value	Remarks
q	Real	10	Diametral coefficient
z1	Real	4	Number of threads of worm
m	Real	2	modulus
z2	Real	20	Number of teeth on worm wheel
l	Real	40	Length of worm
x2	Real	0	Modification coefficient of the worm wheel
alpha	Real	20	Pressure angle
gamma	Real	atan(z1/q)	Lead angle of worm
ha1	Real	m	Tooth addendum of worm
hf1	Real	1.2*m	Tooth dedendum of worm
hf2	Real	m*(1.2-x2)	Tooth dedendum of worm wheel
s	Real	pi*z1*m	pi*m is axial pitch
tx	Real	ceil(l/s)	Ceil is the smallest positive integral that is no less than its value
la	Real	tx*m*z1*pi	
beta	Real	gamma	Helical angle
alpha_t	Real	atan(tan(alpha/cos(beta)))	

3. Parametrization design process to the involute worm

(1)Before realizing parametrization design to ZI-type worm by applying Pro/Program, basic parameters to the worm shall be set, see table 1.

(2)Establish datum.

Establish datum plane DTM1, setover downward on TOP plane, edit the relation d0=(m*z2-m*q)/2. Establish worm axis A_1, lines on the FRONT plane and TOP plane are crossed.

Establish axis A_2, lines on RIGHT plane and DTM1 are crossed.

Establish rectangular coordinate system CS0, the TOP plane that is vertical to x is upward, the FRONT plane that is vertical to y is outward, and the RIGHT plane that is vertical to z is towards the right.

Establish rectangular coordinate system CS1, the DTM1 plane that is vertical to x is upward, the RIGHT plane that is vertical to y is towards right, and the FRONT plane that is vertical to z is inward. Refer to CS1 to establish rectangular coordinate system CS2, the rotation angle relative to z axis (see anti-clockwise from the front view), add relation:
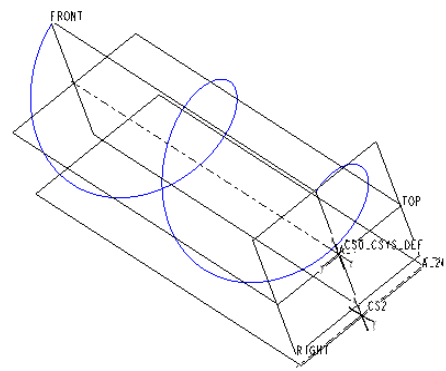
d3=360/(4*z2)+180*tan(alpha_t)/pi-alpha_t.

(3)Establish the helical datum curve to the worm through inserting datum curve—equation. select the cylindrical coordinate system CS0, and input the equation:
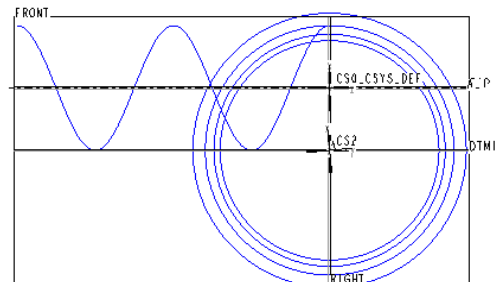
r=m*q/2
theta=-t*tx*360
z=-t*la

Figure 1. Establish Helical Line

Figure 2. Establish Reference Circle, Base Circle, Addendum Circle and Root Circle

(4)Establish sketch curve to reference circle, base circle, addendum circle and root circle. Select sketch plane as the FRONT plane by referring to A_2 axis. Take A2 axis as the circle center and draw four concentric circles, establish the relation as below as well. Figure 2 shows curve after completion.

d9=m*z2
d10=d9+2*m
d8=d9*cos(alpha_t)
d7=d9-2.4*m

(5)Establish the base circle involute to the worm through inserting datum curve to the equation. Select Cartesian coordinate system CS2, and the equation is:

r=m*z2*cos(alpha_t)/2
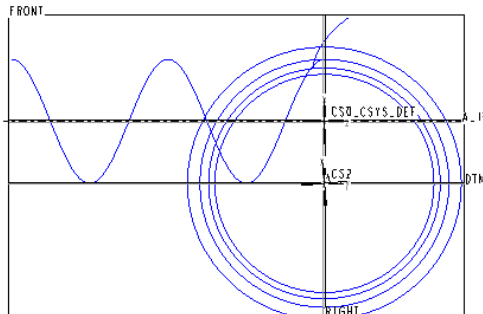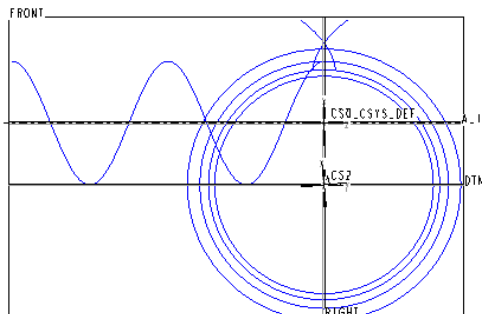theta=t*60
x=r*cos(theta)+r*sin(theta)*theta*pi/180
y=r*sin(theta)-r*cos(theta)*theta*pi/180
z=0

(6)Let the upper involute along with the mirror image on RIGHT flane, and then obtain the involute on the other side. Completion figure is shown in figure 4.
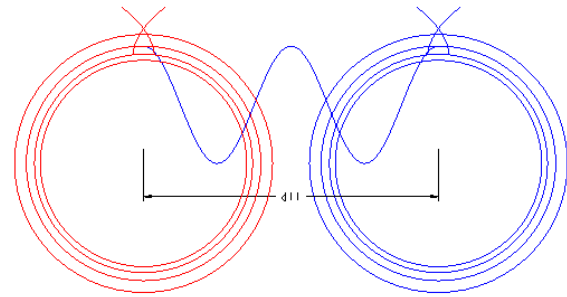

Figure 3. Involute Profile Curve to Worm

Figure 4. Involute Profile Curve to Mirror Image

(7)Establish involute profile curve to the other side of the worm. Duplicate the moving distance d11 to the involute and the four concentric circles that completed mentioned-above along the worm axis A_1, add relation d11=1a. Figure 5 shows completion status.

(8)Establish the body cylinder to the worm. Select RIGHT plane as the sketch plane, stretch it from both sides by utilizing stretching feature. Take A_1 axis as the reference circle center and draw a circle, add the relation: diameter d20＝m*q-2.4*m; depth d19＝2*la, d22=la. Figure 6 shows completion status.


**Figure 5.** Establish Involute Profile Curve to the Other Side
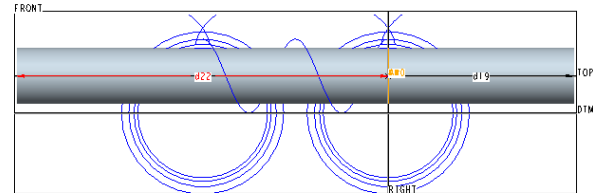
Figure 6. Establish the Body Cylinder to the Worm

(9)Establish scan mix order and generate worm. The origin path line is helical. Sketch the two sections, the start and end of the helical line are the locating points to two sections. The single-thread screw after generated is shown in figure 7.

(10)Array the above single-thread worm to multi-thread worm, as shown in figure 8, which is the 4-thread worm. After finished arraying, add the relation p43=z1.
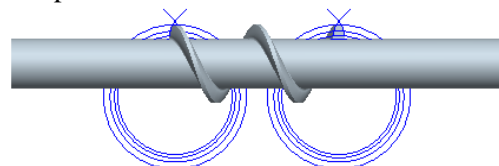

**Figure 7.** Single-thread Screw Generated
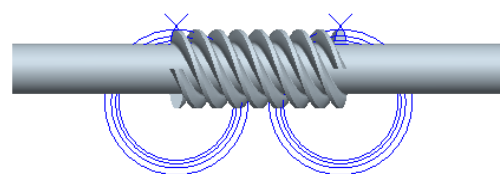
Figure 8. Worm with 4-thread after Arrayed (11)Cut the surplus screw flights on both ends through rotational shearing

Establish datum point PNT0 at the point of intersection between the involute and sketch curve behind the mirror image (as shown in figure 9). Make a plane DTM2 parallel to RIGHT through PNT0. Take the FRONT plane as the sketch plane, and refer to A_1 axis and DTM2 plane. Establish the rotational shearing characteristics, the sketch section is shown in figure 10.
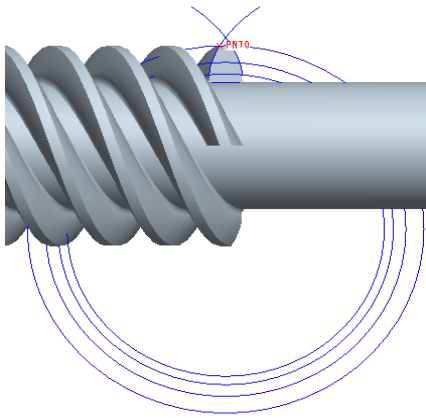
Figure 9. Establish Datum Point PNT0
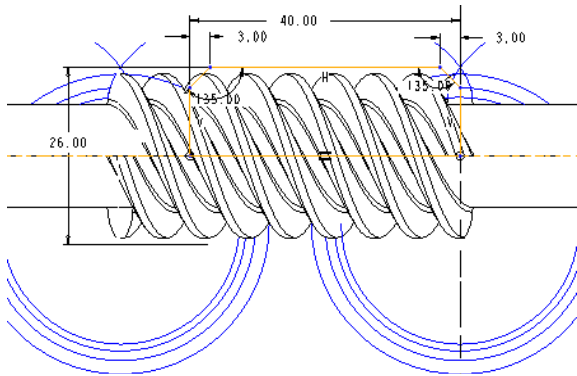
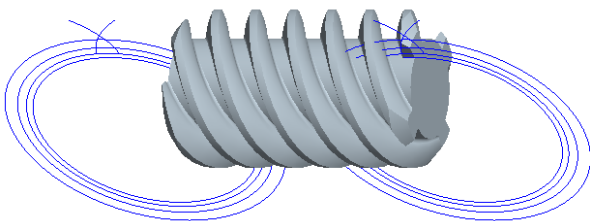**Figure10.** Sketch Section with Rotational Characteristic

After finishing the material cut, edit and add the following relation:

Length dimension: d50=l

Diameter dimension: d47=m*(q+3)

Chamfer dimension: d48=1.5*m; d49=1.5*m

The integrate worm tooth profile after generated finally is shown in figure 11.

Figure 11. Integrate Worm Tooth Profile

4. Parameterizaton program design to the worm solid

By utilizing the Program module embedded in Pro/E, parts with full parametric drive could be designed, so in this way, serialized design problems to similar parts could be solved efficiently. Through editing Program, automatic control characteristic to Pro/E could be set up, and models with different versions could be produced. Click "tool"—"program"—"edit and design", insert the following statements between INPUT

and END INPUT on the notes editor popped up, and then the input of worm characteristic parameter could be realized.

Q NUMBER

"Please input the characterization factor to the worm"

M NUMBER

"Please input the modules to the worm"

Z1 NUMBER

"Please input the number of thread to the worm"

Z2 NUMBER

"Please input the number of teeth to the worm wheel"

ALPHA NUMBER

"Please input the pressure angle to the worm"

L NUMBER

"Please input the length of the spiral part on the worm"

After finish editing the program of parameterization design to the worm, save it and execute regenerate order, and the Pro/E system will execute that program automatically. As long as the user inputs the required modified characteristic parameter, new worm model will be generated. In case of the worm with different thread numbers are needed, select parameter Z1 in editor and input the corresponding value will do. Figure 12 is the worm after modified Z1 with the thread number 2.
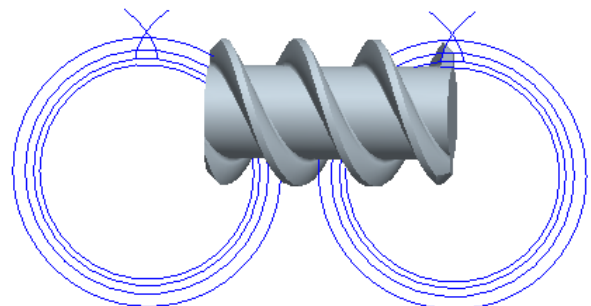
Figure 12. Worm with Thread Number 2

5. Conclusions

By using the parameterization software Pro/E as the development tool, and combining with the Pro/Program by virtue of parameter relation, this paper finished the parameterization solid modeling to multi-thread ZI worm. By adopting parameterization program design to model parts could reduce the design cycle to the serialization products and the repeated modeling work, and thus enhance the work efficiency to the design and modify largely.

References

1. Qiu Xuanhuai et al. (2002) *Mechanical*

Design (Version 4). Higher Education Press, p.p.255-266.

2. Zheng Wenwei, Wu Kejian (2000) *Mechanical Principal (Version 7).* Higher Education Press, p.p.217-222.

3. Wangpeng, Wu Jianliang, Liuqi, Tan Shili (2004) Brief Talk on the Usage of Pro/Program in Pro/ENGINEER. *Machine Tool and Hydraulic Pressure,* No. 8, p.p.152-153.

4. Liao Hanyuan, Kong Jianyi (2007) *Mechanical principle*. Mechanical Industry Press, China.

5. Tian Xudong, Guan Dianzhu (2009) *Pro/E4.0 Three-dimensional Mechanical Design.* Mechanical Industry Press, China.

6. Zhang Jichun, Li Xinghu, Xu Bin (2011) Research on Key Technologies for Parametric Design of Rolling Bearings. *Journal of Engineering Graphics*, 1(4), p.p.19-20.