

文章编号:1004-2539(2008)03-0025-04

基于UG/OPEN API的蜗杆传动参数化系统开发

(合肥工业大学 机械与汽车工程学院, 安徽 合肥 230009) 周 卿 赵 韩 吴振华 张建国

摘要 介绍了利用UG/OPEN API开发蜗轮蜗杆参数化系统的方法。以VC为编程语言,实现了蜗轮齿面接触强度、齿根弯曲强度设计计算和校核,并建立以蜗轮蜗杆材料、特征参数为中心的数据库系统。本文以开发阿基米德蜗杆参数化系统为例,探讨了UG/OPEN API三维参数化建模的关键技术。

关键词 蜗轮蜗杆 强度设计 数据库系统 UG/OPEN API

引言

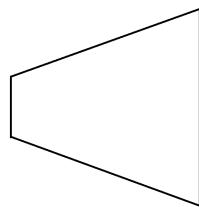
目前用于三维建模的软件很多,如SolidEdge,UG,Pro/E,Solidwork等。其中Unigraphics(简称UG)是美国UGS公司推出的一款先进的集CAD/CAE/CAM于一体的三维工程软件,其实现了设计优化技术与基于产品和过程的知识工程的组合,使用户能够数字化地创建和获取三维产品。

蜗杆传动是在空间交错的两轴间传递运动和动力的一种传动机构。由于蜗轮蜗杆传动具有传动比大、传动平稳、结构紧凑等优点,所以在工程应用中十分的广泛。UG作为通用三维CAD/CAM系统在功能上能完全满足机械产品设计要求,但是在系统操作的人性化和易用性方面并非完全尽人意。为此本文以UG软件为平台,研究了使用UG/OPEN API来创建参数直接驱动蜗轮蜗杆三维实体建模的程序。所开发的设计系统功能齐全,可以方便的查阅图表,尤其是系统的计算功能和参数化绘图模块,使用户在设计蜗轮蜗杆传动时既直观又快捷,大大提高了设计效率。由于阿基米德蜗杆传动较为常见,故本文将以此为例进行介绍。

1 建立数学模型

1.1 蜗杆数学模型的建立

截面线的建立:阿基米德蜗杆螺旋面的形成与螺纹的形成原理相同,由一梯形截面绕螺旋线扫描得到。在UG/NX的Modeling状态下,蜗杆的齿槽截面,如图1所示。



螺旋线的数学方程^[1]建立

$$\begin{aligned} x &= (q \times m/2) \times \cos(360 \times n \times t) \\ y &= (q \times m/2) \times \sin(360 \times n \times t) \\ z &= n \times \pi \times m \times z_1 \times t \end{aligned}$$

式中, m 为模数, q 为蜗杆直径系数, n 为蜗杆螺纹圈

数, z_1 为蜗杆头数。

1.2 蜗轮数学模型的建立

对于蜗轮而言,端面齿廓曲线为渐开线。在UG/NX的Modeling状态下,为了生成渐开线,需要建立渐开线的参数方程。设参数方程的参数为 $t(0 \leq t \leq 1)$, 则90°范围内的渐开线方程^[2]为

$$\begin{aligned} d_b &= m \times z_2 \times \cos \\ &= 90 \times t \\ s &= \times d_b \times \frac{1}{4} t \\ x_t &= \frac{1}{2} \times d_b \times \cos + s \times \sin \\ y_t &= \frac{1}{2} \times d_b \times \sin - s \times \cos \\ z_t &= 0 \end{aligned}$$

式中, d_b 为基圆直径, m 为模数, z_2 为蜗轮齿数, t 为蜗杆的压力角。

蜗轮分度圆螺旋线参数方程的建立

$$\begin{aligned} &= 90 \times t \\ x &= a - 0.5 \times b \times \cos \\ y &= -0.5 \times b \times t \times \tan \\ z &= 0.5 \times b \times t \end{aligned}$$

式中, b 为齿宽, a 为分度圆螺旋角, a 为蜗轮蜗杆之间的中心距。

2 系统开发的关键技术

对于绘制蜗杆螺旋线、蜗轮齿廓曲线、蜗轮分度圆螺旋线,本文所采用的是样条曲线拟合法^[3],即首先根据相关公式计算出曲线上若干个点在工作坐标系下的三维坐标,然后绘制通过以上点的样条曲线,利用样条曲线来代替该曲线。在拟合过程中,拟合点越多,样条曲线就越逼近真实曲线。

2.1 蜗杆螺旋线的生成

根据蜗杆螺旋线公式,采用样条曲线拟合法:从 $t=0$ 开始,参数 $t(0 \leq t \leq 1)$ 每增加 0.005 就取一个点,

每计算出三个点就用三点画弧函数生成一条弧线段,这样将会获得一系列的弧线段并将所获得的所有弧线拟合成一条样条曲线,如图 2 所示。

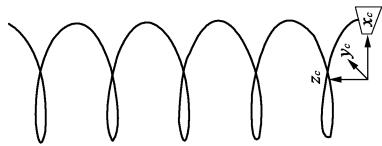


图 2 蜗杆螺旋线

2.2 蜗轮齿廓曲线的生成

对于制作蜗轮的轮齿来说,展角必须从 0 开始,到 60 已经足够使用。在这一范围内,本文所编制的程序等角设定了 20 个点以上,即可充分满足拟合精度要求。但需要注意的是,由于在拟合渐开线前,工作坐标系已经发生了旋转,所以必须将这些在绝对坐标系下的点转换到新的工作坐标系下。具体实现方法如下

(1) 根据渐开线方程,在基圆和齿顶圆之间,从基圆开始半径每增加 0.25mm 就计算一个点的三维坐标,一直到半径大于等于齿顶圆半径为止。在本文中为了使齿廓曲线封闭,在齿顶圆以外,额外地计算了一个点。

(2) 从基圆上的点开始,每计算出三个点就用一条弧线连起来,这样将会获得一系列的弧线段并将所获得的所有弧线拟合成一条样条曲线。

(3) 为了获得另一侧的齿廓曲线,从分度圆和渐开线的交点发出一条通过原点的直线。由于在分度圆上一个齿的包角为 $180^\circ z_2$,将直线绕垂直于齿廓曲线所在的面的一个轴旋转复制 $90^\circ z_2$,然后以此直线作为镜像直线,来建立另一侧的渐开线。

(4) 为了实现实体减的操作,必须将两条渐开线封闭。在靠近齿顶端,用一条直线将两条渐开线的端点连接起来,而靠近齿根圆端,由于基圆内的部分不影响齿轮的啮合,故可用一条过两条渐开线另一端点并且和齿根圆相切的圆弧连接起来,从而形成封闭曲线,如图 3 所示。

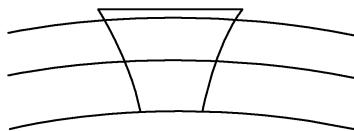


图 3 新工作坐标系下的齿廓曲线

2.3 蜗轮分度圆螺旋线的生成

根据蜗轮分度圆螺旋线公式,采用样条曲线拟合法:从 $t=0$ 开始,参数 $t(0 \leq t \leq 1)$ 每增加 0.005mm 就

取一个点,每计算出三个点就用三点画弧函数生成一条弧线段,这样将会获得一系列的弧线段并将所获得的所有弧线拟合成一条样条曲线。为了获得另一半的螺旋线,对蜗轮分度圆螺旋线公式进行修改:取 $y_t = -y_t$, $z_t = -z_t$ 然后根据修改后的蜗轮分度圆螺旋线公式采用样条曲线拟合法。这样就获得了完整的蜗轮分度圆螺旋线,如图 4 所示。

2.4 强度校核

在使用本文所设计系统时,用户首先进行蜗杆传动类型的初步选择,系统根据用户的初步选型调用不同的强度校核^[4]子模块,在强度校核前首先根据蜗轮蜗杆的工作要求、工作环境选择蜗轮蜗杆的材料和精度等级,而后系统按蜗轮齿面接触疲劳强度和齿根弯曲疲劳强度两项准则进行计算和校核,最终定出模数 m 、直径系数 q 、分度圆导程角等基本参数,具体流程图如下图 5 所示。

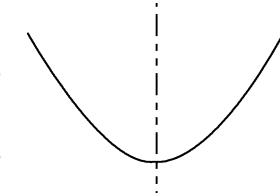


图 4 蜗轮分度圆螺旋线

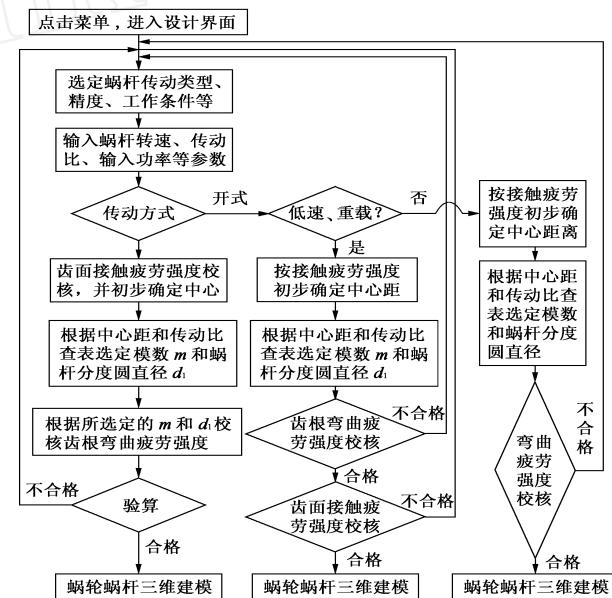


图 5 强度校核流程图

本软件系统采用了向导型设计界面,使用方便、清晰,如图 6、图 7 所示。所涉及到的主要设计计算公式(式中 a 为蜗杆传动的中心距,mm)为

蜗轮齿面接触疲劳强度设计计算

$$a = \sqrt[3]{KT_2 \left(\frac{Z_F Z}{l_H} \right)^3}$$

蜗轮齿根弯曲疲劳强度设计计算

$$\frac{1.53 KT_2}{d_1 d_2 m} Y_{Fa2} Y_f [F]$$

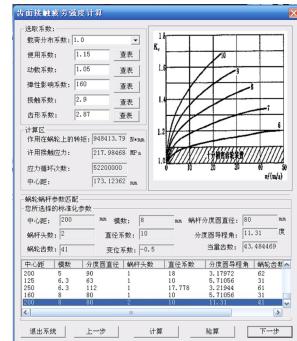


图6 齿面接触疲劳
强度计算界面

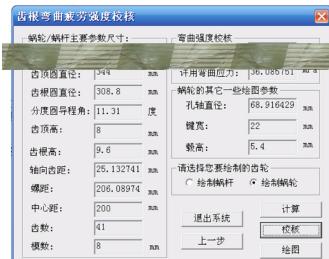


图7 齿根弯曲疲劳
强度校核界面

2.5 数据存储

无论是初步选型、强度校核还是三维建模都需要从相应的数据库中读取数据。本文所阐述的系统根据企业需求和建库的规范,采用ADO(ActiveX Data Objects)方式建立和管理数据库,ADO是Microsoft提出的应用程序接口,用以实现访问数据库中的数据。数据库采用Windows平台的通用的关系型数据库SQL Server 2000数据文件,它支持多用户操作、网络应用、分布式事务处理等功能,能够方便的完成对数据的各项操作。本文在编制程序过程中,所建立的数据库存储了蜗轮进行强度校核所需的中间参数以及三维建模所需的尺寸驱动参数。

3 三维参数化建模

3.1 系统功能模块

本文所开发的系统可分为:功能嵌入,强度校核,数据存储和三维建模4个模块。系统的功能嵌入模块实现设计系统对应的菜单项和按钮项响应;强度校核模块实现蜗轮的强度计算和校核过程;数据存储模块对蜗轮的校核参数和尺寸参数进行相应的操作管理;建模模块调出尺寸参数并建立蜗轮蜗杆的三维零件模型,如图8所示。

3.2 蜗杆三维建模

3.2.1 建模方案

对于蜗杆来说,只要将齿槽截面沿着螺旋线扫描切除,即可在圆柱体(初始毛坯)上形成完整的齿槽。具体步骤如下

(1) 根据设计要求确定蜗杆的基本参数,包括模数、

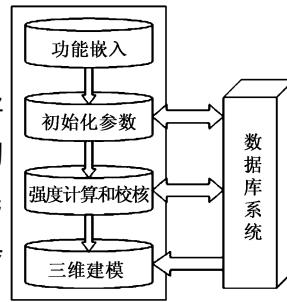


图8 系统模块工作流程图

蜗杆头数、直径系数等,并创建蜗杆的初始毛坯。

(2) 以坐标平面ZC-XC作为草图平面,绘制草图,并绘制两条螺旋线(蜗杆头数为2,对于第二条螺旋线可以先将坐标轴绕Z轴旋转,然后再用样条曲线拟合出该螺旋线),如图9所示。

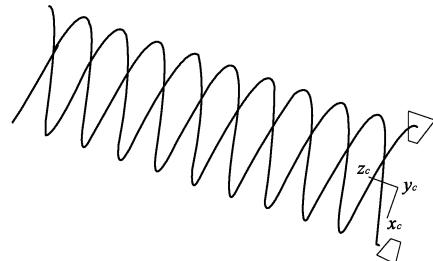


图9 蜗杆的两条截面线和螺旋线

(3) 采用扫描切除的方法获得蜗杆实体,之后完成其他特征的绘制,如图10所示。

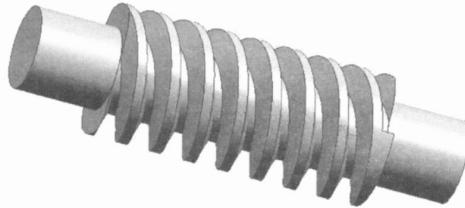


图10 蜗杆三维模型(此蜗杆头数为2)

3.2.2 建模的主要程序

/ * 扫描生成蜗杆的第一个头数齿槽 */

UF-CALL (UF-MODL-create-sweep (&guide, §ion, &spine, &orientation, &scaling, &alignment, &inter, &body-type, boolean, tol, &sweep-body)) ;

/ * 扫描出蜗杆的第二个头数齿槽 */

UF-CALL (UF-MODL-create-sweep (&guide, §ion, &spine, &orientation, &scaling, &alignment, &inter, &body-type, boolean, tol, &sweep-body-2)) ;

3.3 蜗轮三维建模

3.3.1 建模方案

对于蜗轮来说,先根据数学模型绘制相应的曲线,扫描得到蜗轮齿槽实体,但需要注意的是:需要分两次扫描才能得到单个齿槽。

(1) 确定蜗轮的基本参数,包括模数、蜗轮齿数、轴向齿距、螺旋角等。

(2) 创建蜗轮的初始毛坯,并旋转当前工作坐标系,(如图11所示)。

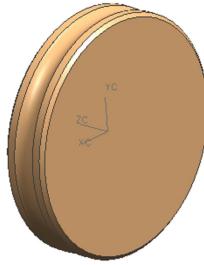


图11 蜗轮毛坯

(3) 绘制两条蜗轮分度圆螺旋线,扫描生成蜗轮单个齿槽实体,然后通过复制旋转,并运用实体减操作得到全部轮齿,之后完成轮毂、轴孔、键槽等特征的绘制。至此就完成了整个蜗轮的三维建模过程,如图 12 所示。

3.3.2 建模的主要程序

```
/ *生成第一段螺旋线 */
UF-CALL (UF-CURVE-create-joined-curve (loop-list1 ,
creation-method ,&guide-one ,&status)) ;
```

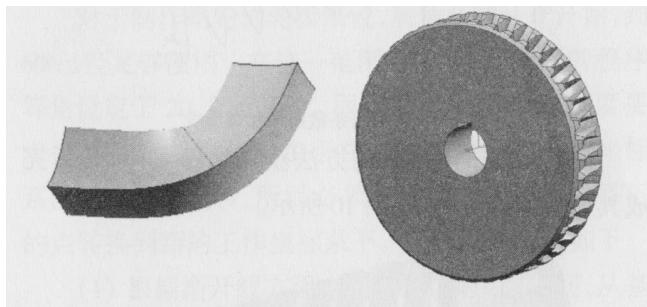


图 12 蜗轮单个齿槽实体和蜗轮三维模型

```
/ *生成第二段螺旋线 */
UF-CALL (UF-CURVE-create-joined-curve (loop-list2 ,
creation-method ,&guide-two ,&status)) ;
/ *生成齿廓曲线 */
UF-CALL (UF-CURVE-create-joined-curve (loop-list4 ,
creation-method ,&section-all ,&status)) ;
/ *扫描生成蜗轮的半个齿槽 */
UF-CALL (UF-MODL-create-sweep ( &guide ,&section ,
&spine ,&orientation ,&scaling ,&alignment ,&inter ,&body-
type ,boolean ,tol ,&sweep-body-one)) ;
```

```
/ *生成蜗轮的另外半个齿槽 */
UF-CALL (UF-MODL-create-sweep ( &guide ,&section ,
&spine ,&orientation ,&scaling ,&alignment ,&inter ,&body-
type ,boolean ,tol ,&sweep-body-two)) ;
```

```
/ *复制旋转单个齿槽实体 */
for (t = 1 ;t < m-GearNum ;t + +)
{ rp3 = t * 360.0/ m-GearNum; // 旋转角度
uf5945- (origin ,directon-plane ,&rp3 ,rr4 ,&ir5) ;
//生成旋转矩阵
uf5947- (rr4 ,&sweep-body-one ,&count ,&copy-Flag ,
```

```
&layer ,&curveFlag ,&gearnun[ ii ] ,NULL ,&resp) ;
// 复制旋转半个齿槽实体
uf5947- ( rr4 ,&sweep-body-two ,&count ,&copy-Flag ,
&layer ,&curveFlag ,&gearnun[ ii + 1 ] ,NULL ,&resp) ;
// 复制旋转另一半齿槽实体
ii + = 2 ;}
/ *切除所有的齿槽实体 */
UF-CALL (UF-MODL-subtract-bodies ( * resulting-bod-
ies ,sweep-body-two ,&num-results ,&resulting-bodies)) ;
for (t = 1 ;t < m-GearNum ;t + +)
{ UF-CALL (UF-MODL-subtract-bodies ( * resulting-
bodies ,gearnun[ jj ] ,&num-results ,&resulting-bodies)) ;
UF-CALL (UF-MODL-subtract-bodies ( * resulting-bod-
ies ,gearnun[ jj + 1 ] ,&num-results ,&resulting-bodies)) ;
jj + = 2 ;}
```

4 结束语

研究了基于 UG NX 平台的蜗轮蜗杆参数化建模方法,并使用 VC 编制程序,实现了机械设计中对蜗轮蜗杆的选型、设计计算和三维建模。程序采用界面向导型设计方式,设计者可以快速完成蜗轮蜗杆的设计;且强度计算与三维模型准确可靠,提高了设计效率。为后续的运行分析、力学分析、虚拟装配等奠定了良好的基础,具有较高的工程实用价值。

参 考 文 献

- [1] 谭加才,朱理. 基于 Pro/E 的蜗杆蜗轮参数化造型及运动仿真[J]. 设计与研究, 2005,(5):41 - 42.
- [2] 林莉. 基于 UG 的齿轮参数化设计[J]. 机械制造与研究, 2006,35(3):76 - 81.
- [3] 付本国,张忠林,周家庆,等. UG NX 4.0 三维造型设计应用范例[M]. 北京:清华大学出版社,2006:139 - 151.
- [4] 潘良贵,纪名刚. 机械设计(第七版)[M]. 北京:高等教育出版社,2001:235 - 269.

收稿日期:20070725 收修改稿日期:20071011

基金项目:国家科技攻关项目(2005BA201A83- 01)与合肥制造业信息化专项支持(2004—2005)

作者简介:周卿(1983-),男,江西宜春人,硕士研究生

ables and iterative process exhibits sensitive dependence on initial guess point. The property of chaos serials produced by one dimensional simple chaotic mapping method with infinite collapses and even symmetry in finite interval was analyzed. For the first time, a new method to find all solutions based on utilizing one dimensional chaotic mapping method with infinite collapses and even symmetry to obtain locate initial points to find all solutions of the nonlinear questions was proposed. The numerical examples in linkage synthesis and approximate synthesis show that the new method is correct and effective.

Key words: Chaos mapping Linkage mechanism Nonlinear equations

Position Analysis on the 3 - PSS/S Three - rotational Parallel Manipulator Che Linxian(15)

Abstract A novel 3 - DOF spatial 3 - PSS/S parallel manipulator with 3 - rotation has been put forward according to the theory of the structure synthesis for parallel robot mechanisms. By means of three constraint kinematical branches of PSS with sliding pairs and one middle global hinge, the moving truncated pyramid is linked to the fixed truncated pyramid of the manipulator. The moving element is the regular pyramid with three perpendicular edges one another, and the three actuator axes of the guide - way on the fixed element are perpendicular one another. The complete closed form formulae of positive and reverse positional solution to the mechanisms are given out based on the coordinates transfer method. Finally, the living example shows that the theoretical analysis is right.

Key words: Parallel manipulator Structure analysis Positive positional solution Reverse positional solution

The System Development of Worm Transmission Parametric based on G/ OPEN API Zhou Qing , Zhao Han , Wu Zhenhua , Zhang Jianguo(25)

Abstract A method to exploit worm gear and worm parametric system with UG/ OPEN API was introduced. Under the VC environment, worm gear tooth contact strength and tooth root bending strength were checked, and a database system about worm gear and worm material and characteristic parameters were also established. Taking Archimedes worm parametric system as example, the key technique to build the 3D parametric modeling with UG/ OPEN API was discussed.

Key words: Worm gear and worm Strength design Database system UG/ OPEN API

Modeling and Dynamic Simulation of Three - ring Type Gear Reducer Wang Ailun , Chen Yingjie(29)

Abstract A bond graph of the transmission of three - ring type gear reducer is modeled and its system state equation are obtained, the dynamic simulation analysis is carried out and the regulation and relationship of the system for the state variable are acquired. Therefore the dy-

namic properties and gearing features of this system are revealed comprehensively. It is a good reference to the further research of this kind of reducer, such as optimization and diagnosis.

Key words: Three - ring type gear reducer bond graph state equation simulation

The Design of the Transmission Lever of no Hysteretic Error in Double - disc Measuring Apparatus of Involutes Tooth Profile ...

..... Li Shuwei ,Ma Yong , Lou Zifeng(31)

Abstract The technology of involutes tooth profile measurement for master gear is important and difficult in its all precision indexes. The double - disc measuring apparatus of involutes tooth profile was provided with high accuracy. The principle of the measuring apparatus was introduced and analyzes the feasibility of "The Transmission lever of no hysteretic error" which was used in the Measuring Apparatus was analyzed. In conclusion, it was proved very sensitive to micro - error and can feel content to the measuring apparatus of involutes tooth profile in benchmark step. Benchmark.

Key words: Involutes tooth profile Error Measuring apparatus Measuring of master gear

The Optimization Design of Spring Parameters for a Bionic Flapping - wing Mechanism ... Wang Dayan , Xie Jin , Chen Yong(34)

Abstract Flapping - wing mechanism with springs can reduce the shock on motor that caused by load fluctuation. It is shown that the parameters of springs should be relevant to the flapping frequency for giving full play of spring. The selection of spring parameters is crucial in the design of flapping - wing mechanism. A method of spring parameters optimization design is presented, and a curve to approach stiffness of spring with respective to each frequency of flapping is also given.

Key words: Flapping - wing mechanism Spring Spring parameters Optimization design

Optimal Design of Three - stage Planetary Gear Reducer

..... Guan Hongjie , Zhang Nianhuai , Liu Baoguo(38)

Abstract Total transmission ratio of 2K - H three - stage small module planetary gear train is distributed optimally according to working accuracy and manufacture economical efficiency. Optimal design of three - stage planetary gear train is transformed into that of single - stage planetary gear train. The mini - volume of whole mull - stage planetary gear is also transformed into that of the single - stage. The mini - volume of sun gears, planetary gears and internal gears in various stage is regarded as optimal objective, optimal mathematical model is established. By using the sequence unconstrained minimization technology method, and the most optimization plan is chosen.

Key words: Small module Mul - stage planetary gear train Sequence unconstrained minimization technology

Finite Elements Simulation of Precision Forming Process of Univer-