



Modeling in Mechanical Engineering CAD Technology

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Abstract. Screw is an important part in the mechanical field, and plays a significant role in variety of applications. Because of its complex and changeable shape, the design and processing of the screw are difficult. In order to improve the design and production efficiency of the screw, the CADD/CAM system of the screw is studied. Based on UGNX8.0 software, visualstudio2010 is used as a programming tool, and the secondary development tools of NX Open, Block UI Styler and Men-u Script are used to achieve the development of screw CADD/CAM system. The objective of this article is to describe the research on integrated CAD system for designing trajectory of screw manufacturing. The main functions of the system include quickly creating a three-dimensional model of the screw, reading the parameters of the three-dimensional model of the screw, and solving the tool trajectory when the screw is processed by internal whirlwind milling. Finally, through relevant examples, the function of the developed screw CADD/CAM system is verified.

Keywords: Screw; CADD/CAM, 3D-model; Tool path solution

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1 INTRODUCTION

As an important part of many mechanical products, screw has a wide range of applications in the mechanical field [1]. Because of the different forming mechanism of the spiral surface profile of different screws and the complicated and changeable profile, the processing of the screw is becoming more and more difficult [2]. Computer-aided design and manufacturing (CADD/CAM) technology is the basis of digital and information manufacturing technology [3], and has a wide range of applications in screw design and manufacturing. Scholars have done a lot of research on screw CADD/CAM technology [4], [5]. Authors have developed the parametric design system of the

two-dimensional parts drawing of the extrusion screw by using the SolidWorks secondary development principle based on the Visual Basic 6.0 environment and the method of transferring screw parameters through the Access database [7]. In other reported work authors have uses UG as the development platform and Visual C++ 6.0 as the programming tool. Through the Access database, the relationship data table is established to realize the parametric design of the extruder's ordinary screw BM screw, pin screw and barrier screw. After the user enters the screw parameters, the three-dimensional modeling of the screw can be completed in a short time [16]. Another work is carried out secondary development in ProE software, and realized the three-dimensional modeling parametric design system of single screw element [17]. Authors have conducted related research on special-shaped screw CADD/CAM, and discussed several special-shaped screw modeling and processing methods [18]. At present, there is no dedicated CADD/CAM system with complete functions from the rapid creation of the screw model to the solution of the tool path in the screw machining process. On the basis of previous research, this article aims at the screw model design and whirlwind milling processing method, hoping to solve the above problems, and develop a special CADD/CAM system. In order to realize the screw CADD/CAM system, this article chooses UGNX8.0 software as the platform, comprehensively uses NX Open, Block UI Styler and Men-u Script secondary development tools, uses C++ as the programming language, and combines visual studio2010 as the tool [19].

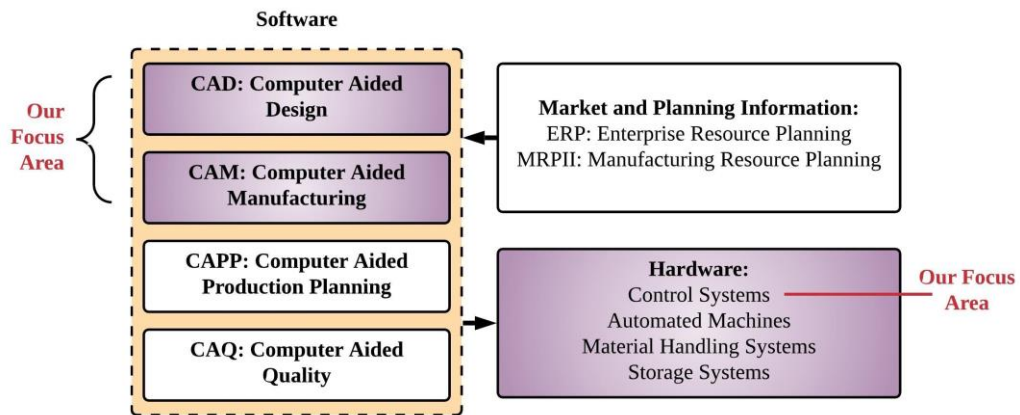


Figure 1: Integration among the automation and control system.

Figure 1 represents the integration between the control system and automation tools. The integration takes place for automatic and seamless communication of data among CAD cam design along with the more advanced control system. The NX Open is an object-oriented interface of NX, which supports multiple development languages (VB, C++, Java and C#, etc.), with good scalability and powerful functions. The JA file recording function of UGNX8.0 software can be used to record the operation [7]. This function can be used to quickly and quickly carry out secondary development. NX provides a dedicated module Menu Script for customizing menus. Use the Menu Script tool to generate your own menu, replace the UG menu, and also realize the editing of a UG menu and generate your own menu. The special dialog box design tool Block UI Styler owned by NX can almost meet all the interfaces required by NX secondary development, and after the dialog box design is completed, code templates can be automatically generated to facilitate users to write programs.

The rest of the manuscript is organized as the recent work in the field of manufacturing of screw using CADD/CAM system is described in Section 2. The modular design and the function of CADD/CAM system is presented in Section 3. The development steps of screw CADD/CAM system is described in Section 4. Section 5 describes the function realization of CADD/CAM system for screw

manufacturing. Further in section 6 the system application examples are discussed which is followed by the conclusion in Section 7.

2 LITERATURE REVIEW

In the past research, the application of two-dimensional parametric CAD technology combined with the design of bridge crane makes the design idea relatively perfect, and solves the problem of repetitive work encountered by designers in the process of bridge crane design. Jayanti et al. [8] used Auto CAD to study the gantry crane and realized the parametric design and parts design. Sinha et al. [9] used full parameter design, and developed a professional CAD design software for general bridge crane by using Auto CAD. The software provides parametric drawing of various series and models of general bridge crane. Patalano et al. [10] developed a CAD design system for bridge crane on the platform of Auto CAD two-dimensional design software. On the basis of drawing, structural analysis was added and parametric optimization design was carried out by orthogonal grid method. The combination of optimization analysis and two-dimensional parametric drawing was realized.

Camba et al. [11] applied the modular design and 3D parametric CAD technology to the design and development of gantry crane, and proposed the management method of modular design in the design of gantry crane and the 3D parametric design method for the module of gantry crane. Chang et al. [12] and others studied the three-dimensional parameterization method of bridge crane and gantry crane through the secondary development of solid works 3D drawing software. At present, there is no dedicated CADD/CAM system with complete functions from the rapid creation of the screw model to the solution of the tool path in the screw machining process. On the basis of previous research, this article aims at the screw model design and whirlwind milling processing method, hoping to solve the above problems, and develop a special CADD/CAM system. However, when using the finite element software to carry out the finite element modeling analysis, it is necessary to reconstruct the three-dimensional model to make the product more visual, which leads to the lengthening of the development cycle. Recently, some scholars have studied the dynamics of crusher and the dynamic balance of ring hammer by means of measurement test.

In the end, the computer program is written to change the number of dynamic balance equipment. The automatic balancing method is advanced, scientific and effective. Starting from the actual production, through the analysis of single plane dynamic balance and double-sided dynamic balance, the life of the ring hammer can be prolonged by more than one time by using this method. The cost of replacing the ring hammer is greatly saved, and the economic benefit is very obvious [13]. Recently, some scholars have studied the dynamics of crusher and the dynamic balance of ring hammer by means of measurement test. However, there are few researches on the motion simulation and finite element analysis and optimization of crusher by modern design optimization methods [14]. The time of analysis, calculation and design can be greatly saved by using the means of motion analysis and finite element analysis, and the motion track, stress situation and vibration state of crusher can be clearly displayed. At the same time, we can make full use of the results of correlation analysis to carry out rapid and efficient structural optimization design of the crusher, in order to improve the comprehensive performance of the crusher, and also provide reference for the improvement and optimization of similar crushers [15].

3 MODULAR DESIGN AND FUNCTION OF SCREW CADD/CAM SYSTEM

The system adopts a modular design method that can shorten design time and improve design efficiency. As shown in Figure 2, according to the modeling and processing characteristics of the screw, the screw CADD/CAM system is divided into three modules: screw parametric design module, screw model reading module and tool path solving module.

The screw parametric design module can quickly realize the three-dimensional modeling of the screw. The user can quickly generate the required screw model after inputting the screw

parameters and the parameters of the screw shaft section line. The read rod model module is used to obtain screw parameter information. Users can use this module to read the screw model to quickly understand the parameters of the screw model, and it is convenient to solve the tool path. The tool trajectory solving module is used to solve the tool trajectory of the internal whirlwind enveloping milling of the screw. The user can display the tool trajectory after inputting screw parameters, screw shaft section line parameters and screw machining tool parameters in this module.

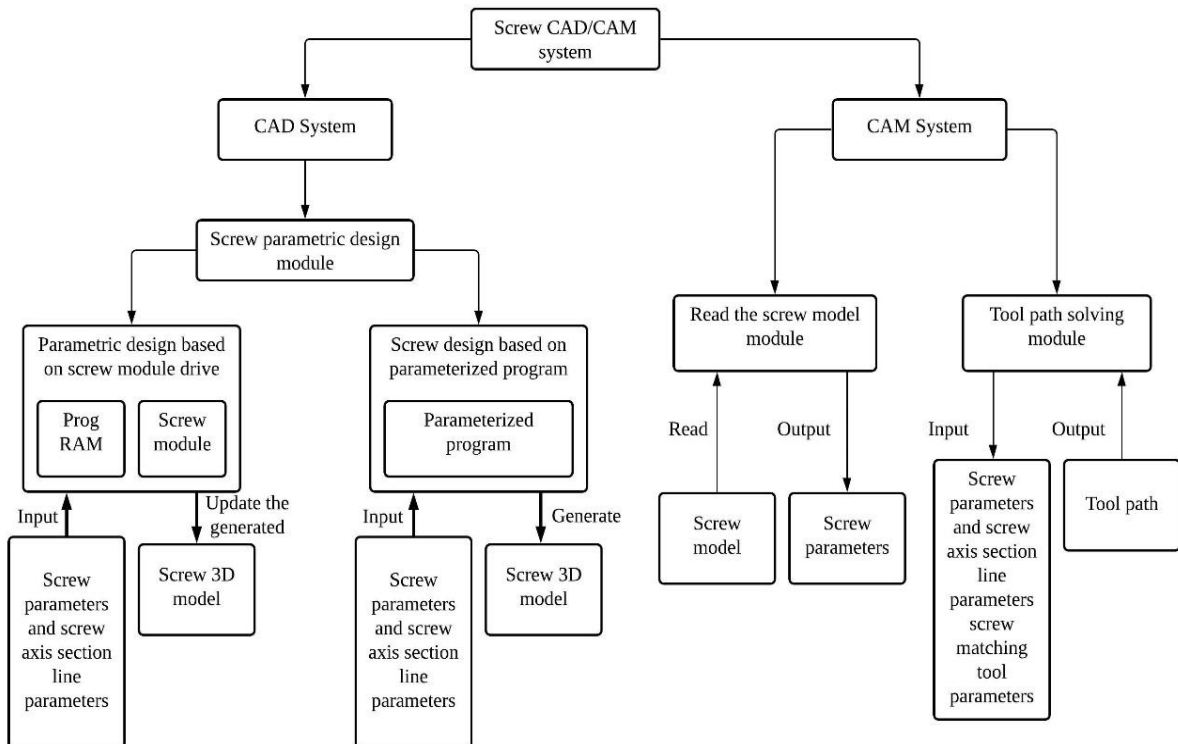


Figure 2: System structure function diagram.

4 SCREW CADD/CAM SYSTEM DEVELOPMENT STEPS

As an application in the UG environment, the development of the screw CADD/CAM system follows the common steps of secondary development, including environment configuration, Menu Script menu production, Block UI Styler dialog box design, program framework creation, and program writing and debugging, etc., which are complete. The development process is shown in Figure 3.

First create a user variable named "UGII_USER_DRI" to point to an absolute path. Create two folders application and startup under this path. Create a text document under the startup folder, and write the menu content in the Menu Script script language. Saved in .men format, UG will be automatically loaded after startup.

Using the Block UI Styler dialog box design tool, the user can select the corresponding block catalog and add it to the dialog box to be designed [16]. After the dialog box design is completed, select the code generation language as C#. After naming and saving, two files, .dlx file and .c# file, will be automatically generated, and the .dlx file will be under the application folder.

from the line. The parametric design method based on the graphic template has the advantages of flexible parameter modification, small amount of program code, and fast compilation and linking, but its functions are limited. Although the design method based on parameter program has a large amount of program code and is not easy to compile, its function is more powerful. Each method can be implemented through NXOPEN API programming.

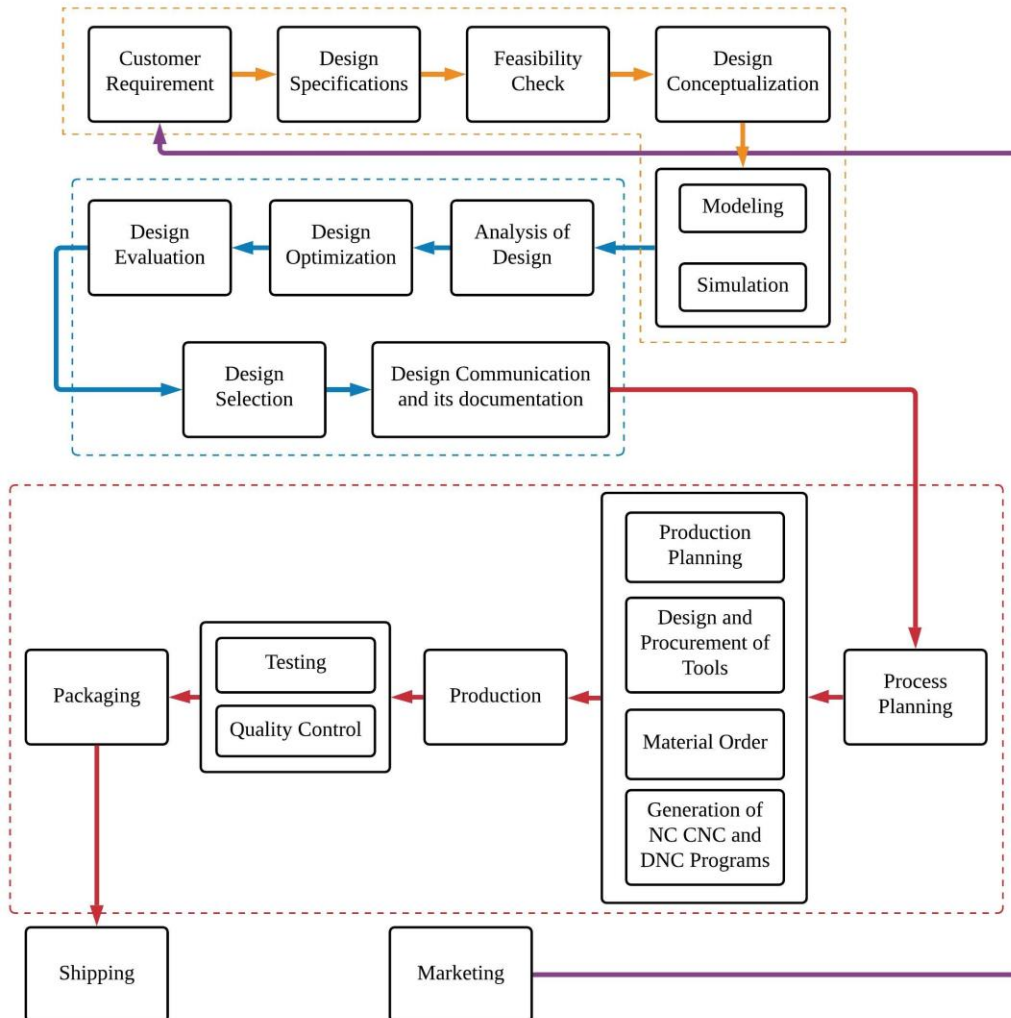


Figure 4: Manufacturing Process of Screw.

The Figure 4, represents process of manufacturing of screw where the realization process of product is divided into two main stages that is design and manufacturing. The process of design initiates with the identification of customer demand and the variables needs to be improved which are analyzed by the marketing personal after receiving the feedback from customers. Once the information about the design is received the specifications of design are formulated. Thereafter feasibility e of the relevant design is studied and the detailed design and its analysis he is achieved. The detailed analysis of the design involves the conceptualization of product design drawing and sketches with the geometrical modelling. The quality check from the observed results of these activities is directly correlated with the analysis quality and the platform utilized for the analysis. After the analysis, manufacturing process initiates from the production planning which

utilizes the process of design and presents outcome of the actual product. The process planning is the stage which includes the activities such as planning of production, material and selection of machine. The process planning also includes planning for all the processes that is utilized during the manufacturing of the screw. At last, the screw that passes the quality check and inspections are further assembled for testing packaging, labelling and shipment.

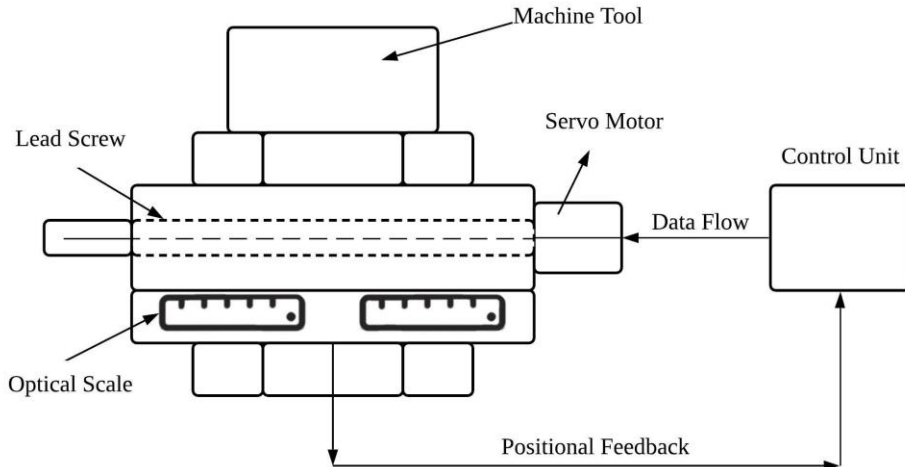


Figure 5: Machine structure for the design measurement.

Figure 5 represents the structure of machine tool for the measurement of position of screw. The lead screw is fixed in machine tool and its dimensions are measured through the optical scale. The control unit controls the flow of data through the regular positional feedback from the machine tool. Combining the shape of the screw and the actual situation, the screw design of complex shape is more inclined to adopt the parametric design method based on graphic template, and the screw design of simple shape can adopt the second method. The two methods are introduced below.

5.1.1 Parametric design based on screw template

The parameter design based on the screw template adopts a combination of three-dimensional model and program control, and modifies the expression of the components and then modifies the model. According to the design requirements of the components, the model is established in advance, and a set of design parameters that can completely control the shape and size of the model are established. The parametric program is programmed for these parameters to realize the query and modification of the design parameters, and update the model according to the new parameter values. Specific steps are as follows:

- Create a screw template. Use UG to create a parameter-driven three-dimensional model of the screw, which contains the basic design intent and topological features of the design object, and uses expressions to associate the parameters. The screw template and its modeling method established in this paper are shown in Figure 6. The spiral groove of the screw template is composed of a spiral groove spline and a spiral groove flat bottom, as shown in Figure 7. The screw template determines that the number of points of the spiral groove spline curve is 18, the spiral groove flat bottom is a straight line segment, and the continuity at both ends of the spiral groove flat bottom is G0 continuous.
- According to the given parameters, a new three-dimensional screw model is generated on the basis of the screw template. Through related programs, edit the expression parameter values in the screw template file, and then drive the system to generate a new screw three-dimensional model. The dialog box for user-specified parameters, where the number

of value points in a half cycle of the spiral groove is the number of value points for determining the spiral groove spline curve.

Due to the limitation of the screw template, the maximum number of value points is 18. When the number of value points is greater than 2, and the width of the spiral groove flat bottom is 0, the screw template is updated to another type of twin screw; when the number of value points is 2, and the width of the spiral groove flat bottom is not 0, the screw template changes. It is a trapezoidal twin screw; when the number of value points is 2, and the width of the flat bottom of the spiral groove is 0, the screw template becomes a triangular twin screw. Therefore, the screw types generated by users using this screw template are only the above 4 types at most.

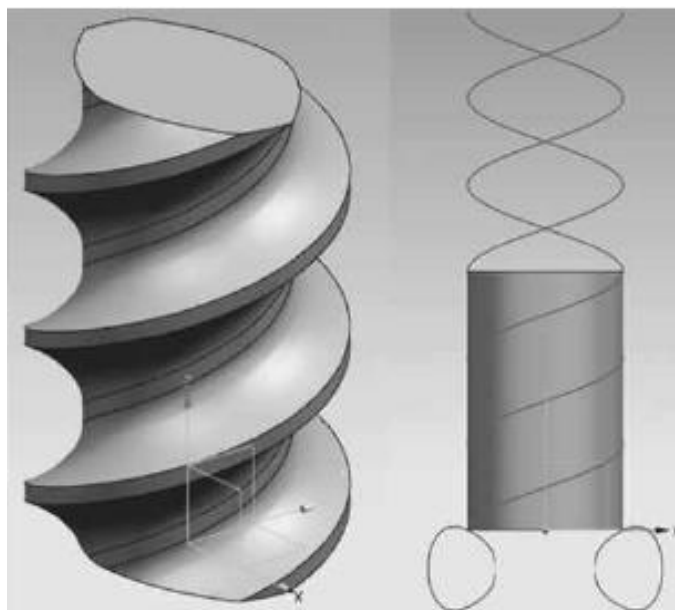


Figure 6: Screw template and its modeling method.

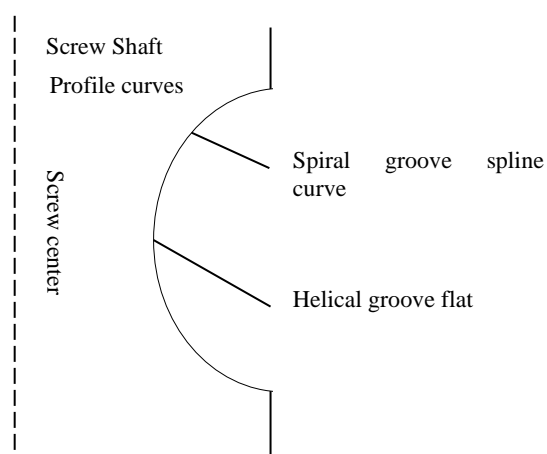


Figure 7: Screw template shaft section.

5.1.2 Screw design based on parametric program

The program idea of using the design method based on parameterized program to quickly construct the three-dimensional model of the screw is:

- Insert the circle and spiral expression according to the screw size parameters, and use the law curve (Law Curve Builder) to generate the circle and spiral.
- Generate a spline (Studio Spline Builder Ex) according to the coordinates of the axial section line type value point of the screw, combine the flat bottom width of the spiral groove to establish a datum plane (Datum Plane Builder), and the spline is mirrored based on the datum plane (Mirror Curve Builder Ex.) One, and then connect (Associative Line Builder) and Bridge (Bridge Curve Builder) two splines to generate a closed curve.
- Extrude the generated circle according to the length of the screw (Extrude-Builder), so that the closed curve is swept along the spiral (wept Builder) S, Generate a sweep body, then rotate the sweep body along the Z axis (Move Object-Builder) 180 degrees and copy one.
- The cylinder calculates the difference between the two swept bodies (Boolean Builder) to generate a three-dimensional model of the screw.

A sample wizard dialog interface made by the Block UI Styler dialog design tool. The user selects the screw style, inputs the screw parameters and the screw axial section line information in turn to generate the screw three-dimensional model. The "Select Style" column includes three types of screw rotation, single and double, and conical or cylindrical. The "Screw Parameters" column includes the major diameter, length and lead of the screw. The number of system setting type value points is at least 2 and at most 20. The continuity at the flat bottom of the spiral groove is determined by the tangent direction of the first value point (Tangent Direction), G0 is continuous without processing, and G1 is continuous, that is, its tangent direction is set to (0,0,1).

5.2 Read Screw Model Module

The user uses the read screw model module of the screw CADD/CAM system to open the screw model that needs to read the parameters, and then the parameter information of the screw can be displayed.



Figure 8: Example of reading screw model.

The basic principle of reading the screw model is to obtain all the features (Feature) of the screw in the UG workspace through the program, and then gradually obtain the names (GeeatureName) and expressions (GetExpres-sions) of these features, and finally output the name and Control the description of the expression (Expression) and the name and value (Equation) of the expression (Ex-pression). An example of reading the screw model module is shown in Figure 8, which is a three-dimensional screw model (52).

5.3 Tool Path Solving Module

There are many screw processing methods, and the resulting tool paths are different. The tool path calculated by the tool path solving module of the screw CADD CAM system refers to the tool path in the process of screw milling by the internal whirlwind envelope. A sample wizard dialog box made with the Block UI Styler dialog box design tool. The user enters the screw parameters, axial section line parameters and tool information according to the steps and clicks the "Finish" button to display the tool path information.

The specific method for the system to obtain the tool path is the tool path solving axis section method. Set the center point of the tip of the internal whirlwind milling tool P_n . The coordinates are (x_n, y_n) , the radius of the tool tip arc is r_0 , The installation angle of the inner milling cutter head is δ , then the projected tool nose ellipse model curve can be expressed as:

$$Y = y_n - \cos \delta \sqrt{(r_0 / \cos \delta)^2 - (X - x_n)^2} \quad (5.1)$$

The tool path solving module automatically performs cubic uniform B-spline curve fitting on the screw shaft cross-section type value point coordinates input by the user. The specific principle is to inversely find the control points of the cubic uniform B-spline based on these type value points, and then find the equation of the cubic uniform B-spline curve based on these control points, that is, the equation of the screw shaft section profile curve, which can be written in the following form:

$$\begin{cases} x(t) = A_0 + A_1 t + A_2 t^2 + A_3 t^3 \\ y(t) = B_0 + B_1 t + B_2 t^2 + B_3 t^3 \end{cases} \quad 0 \leq t \leq 1 \quad (5.2)$$

Suppose the tangent point of the curve and the cross-sectional profile curve of the screw shaft (fitted cubic uniform B-spline curve) is P_n , then the two curves are in P_n . There are the same common tangents, so the following relationships exist:

$$\frac{dY}{dX} = \frac{dy(t)}{dt} / \frac{dx(t)}{dt} \quad (5.3)$$

The tool path solving module selects different values equidistantly on each segment of the B-spline curve; the value is determined by the user, that is, the "number of points for each segment of the B-spline" input box. After the t value is determined, the points on each segment of the B-spline curve are determined, and these series of points are set as the tangent points of the screw shaft section profile curve and the projected tool nose ellipse model curve. $P_n(x, y)$. For example, when

the "number of points for each B-spline" is 3, the schematic diagram is shown in Figure 9. will P_n The coordinate value of is led to solve the equation set consisting of equations (1) and (3) to obtain the center of the projected tool nose ellipse model, which is the tool nose center point 0 coordinate of x_n, y_n .

The process of using the axial section method to solve the tool trajectory, the workpiece rotates at a uniform speed and equal step angle during each rotation, and the axial feed motion of the cutter head along the workpiece axis section is also a feed motion of equal step. After

machining a shaft section groove, the workpiece must be rotated through a step angle. According to the formation principle of the spiral surface, it can be known that the cutter head must have a corresponding axial feed

The axial feed distance to ensure the generation of the spiral surface 2, therefore, the NC processing code C, X, Z interpolation information in the CNC programming of the internal whirlwind milling screw can be expressed as:

$$\begin{cases} C = n.\Delta\varphi \\ X = y_n - r_0 + \frac{d}{2} \\ Z = n.\Delta z + \frac{C.P}{360} \end{cases} \tag{5.4}$$

among them, $\Delta\varphi$ Is the step angle, d is the bottom diameter of the screw, p is the lead of the screw, Δz It is the feed step of the cutter head along the axis of the work piece.

Projection knife tip model

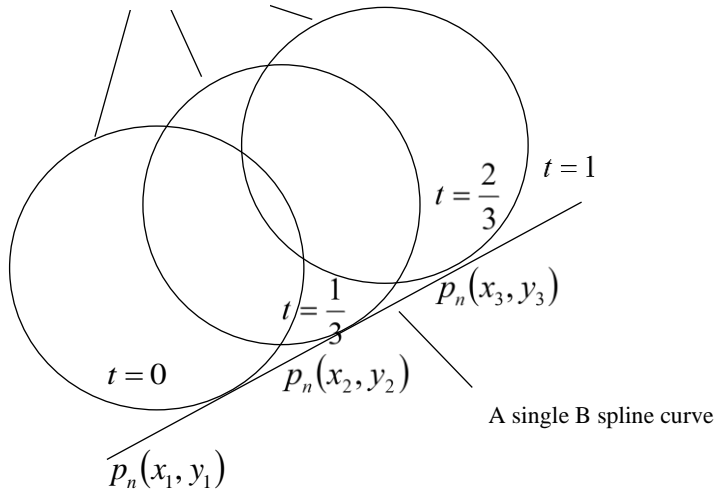


Figure 9: Schematic screw model.

6 SYSTEM APPLICATION EXAMPLES

A right-handed double-head extrusion screw with a lead of 48mm, an outer diameter of 35.6mm, a bottom diameter of 23.6mm, a screw edge width of 2.88mm, a spiral groove flat bottom width of 3.12mm, a screw length of 48 mm, and a screw shaft section (Spiral groove part) The effective value point of half cycle is shown in Table 1.

X (mm)	Y (mm)
11.8	-9
11.815	-85

11.861	-8
11.938	-7.5
12.046	-7
12.186	-6.5
12.36	-6
12.57	-5.5
12.815	-5
13.1	-4.5
13.424	-4
13.8	-3.5
14.204	-3
14.666	-2.5
15.178	-2
15.745	-1.5
16.369	-1
17.053	-0.5
17.8	0

Table 1: Effective value point data of screw shaft section.

The number of points for each B-spline segment is 3, and the two ends of the spiral groove flat bottom G1 are continuous. The process parameters of the internal whirlwind milling screw are set to a cutter head installation angle of 23.2° , the diamond blade tip arc radius is 1.6mm, and the internal milling cutter head's gyration radius is 60mm.



Figure 10: Three-dimensional model of screw.

Open UG NX 8. 0, there will be a customized screw CADD/CAM system menu in the menu bar. According to the above information, the screw 3D model established by the screw design method based on the parameterized program in the screw parameterized design module of the screw

CADDCAM system is shown in the Figure 10. The tool path solving module is used to solve the corresponding tool position data in the screw machining process.

7 CONCLUSION

This article introduces in detail the development platform, programming connection and development steps of the screw CADDCAM system; deeply narrates the modular structure and functions of the CADDCAM system; finally, through an example of a typical screw part, the application of the CADDCAM system is introduced. The screw CADDCAM system initially realizes the integration from screw design to processing, and significantly improves screw design and manufacturing efficiency. The focus of future research is to simulate the screw processing process. The advancement in CAD system have evolved as a 3D CAD which ultimately leads to the development of smart models. This article summarizes recent research done in the CAD modeling along with its application towards computer aided engineering. The three-dimensional model of the screw is created very quickly, and then by reading the parameters of the three-dimensional model of the screw, tool trajectory is sorted when the screw is processed by internal whirlwind milling. The functioning of the developed screw CADDCAM system is verified through various examples which is observed superior in comparison with other state of art approaches.

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