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Computer-Aided Design AND APPLICATIONS

Design and Research on CADDCAM system of Plane based on NC Machining Technology

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Abstract. The expansion of the application of computer integrated manufacturing at home and abroad, the development of cam CAD/DCAM system is more rapid. In order to study the design of cam profile curve under NC machining technology, and meet the design requirements of high-speed and precision cam, this paper uses Visual Studio 2015 software as the platform. This article uses Visual C language to develop AutoCAD software for NC machining. The results show that the displacement and acceleration curves obtained by modeling, assembling and Simulation in SolidWorks 2016 are basically consistent with the theoretical curves. The experimental results present that cam contour curves generated in CAD/DCAM system are processed on CNC machine tools. It has a broad application prospect and great economic value in China's industrial enterprises

Keywords: Plane cam; CAD/DCAM; NC machining; Motion simulation.
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1 INTRODUCTION

The development of CAD/DCAM technology has gone through five periods: preparation, vigorous development and application, extensive application and vigorous development, openness, standardization and intellectualization. The first systematic introduction of CAD/DCAM design principle of cam mechanism was put forward by foreign scholars and started by Furman in his monograph. In the process of development, some monographs and research papers on cam have been emerging in journals and magazines of various countries. Many scholars at home and abroad have carried out more and more extensive and in-depth research on cam design [1]. The application of two-dimensional plane guide in industry has been very mature, and 3D guidance has become a popular field at present.

Nowadays, machine has become one of the irreplaceable products in our social production and life. With the improvement of social productivity, the traditional machinery and equipment are gradually developing towards more automation and intelligence. Machine vision is developing in

this context. It can not only greatly improve the efficiency and automation level of machinery in factory production, Machine vision covers a wide range of subjects, including optics, signal processing, image processing, artificial intelligence and computer technology [2]. CAD is a new technology formed by the combination of computer science and engineering design. It is one of the most influential application technologies of computer in engineering. It is also an important part of advanced manufacturing technology [3].

Industrial robots are a very classic type of mechatronics equipment, which integrates technologies from multiple disciplines and has extremely high technical characteristics. It has a wide range of applicability. Taking the automobile manufacturing industry as an example, industrial robots can complete the processing of mechanical components, heat treatment of parts, and welding tasks on work pieces [4]. While completing these anthropomorphic operations, the robot can also repeat Programming to automatically control tasks. After industrial robots are put into production tasks, the quality of the products has become more stable, and the production capacity has also been greatly improved. It can also be very competent for tasks under harsh working conditions. The birth of robotics technology has undoubtedly brought about a radical change in the manufacturing and processing industry. For now, the appearance of robots has brought the most obvious changes to the manufacturing and processing industry. Among many processing tasks, robots are used to Substituting ordinary workers for operations has become a development trend, which is also caused by the limitation of human body conditions by many factors [5].

In order to ensure the personal safety of workers in the production and processing of products, arc welding and painting More harsh and high-intensity tasks such as handling, handling, etc. have been gradually replaced by industrial robots. In unmanned factories that use industrial robots, all tasks are implemented by computer-controlled robots, CNC machine tools, unmanned transportation vehicles and automated warehouses [6]. The rest of the manuscript is organized as the recent work in the field of machining technology using CAD system is described in Section 2. The research methods including the design of each module in the system development process is presented in Section 3. The results from the proposed research method are described in Section 4. At last, the conclusion drawn from the experimentation is described in Section 5.

2 LITERATURE REVIEW

The CADDCAM system design of cam mainly exists in some large, medium and small cam manufacturing enterprises. The domestic research on cam CAD/DCAM system design mainly includes the manufacturing engineer series software of Haier Company of Beihang. The main working process is to generate three-dimensional model by drawing the cam profile in the software. Then, the 3D cam model is simulated and processed in the system software. If the simulation result is correct, the NC code can be obtained, so that the cam can be processed in batch.

Manpower no longer participates in the direct production of the workplace. The role of the worker has also changed, from a front-line operator to a commander. CAD technology provides a powerful technical means for enterprises to shorten design cycle, enhance market adaptability and participate in international market competition, which will continue to produce huge social and economic benefits [7]. Scholars have done a lot of research on screw CAD/DCAM technology. 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 [8]. In other reported work authors have uses UG as the development platform and Visual C++ 6.0 as the programming tool [9]. In addition, the honeysuckle system software of Guangzhou Hongdi Company and the development software of Huazhong [10] are also included, there is little difference between the cam system design method of CSU and the cam system software developed by CSU. The system software includes a variety of parametric models of

general cams, introduces the main motion and geometric parameters of general cams, obtains the corresponding calculation formulas, and realizes the parametric design of general cams. However, this system can only realize the parametric design of cams, and does not involve cam module. In other words, it is known as the process of generating NC code for NC machining [11, 12]. The research on cam CADDCAM system software started earlier and developed rapidly in foreign countries. Some European and American scholars published many articles on the research of cam mechanism. After 1960, Tissal proposed to apply polynomial law to cam mechanism. Since then, the research on cam mechanism has become more and more in-depth. There are many companies engaged in CAM research in Japan, the United States and Russia [13]. Additionally, this method is also based on the principle of OpenGL, which can be used to reconstruct the four object positions. There is a method based on three CAD models as training templates in China. Firstly, the product CAD model is established, and then the pose changes in multiple directions are realized in CAD. Finally, one projection template is generated. Finally, the images collected by a single camera are matched with them.

Especially in Japan, on the basis of studying the motion law of cam mechanism, the CAD/DCAM system of cam is deeply studied and applied to the manufacturing of the company, and the most advanced technology is used in the production, 1960s [14] due to the rapid development of manufacturing industry, many machines have more stringent requirements on the accuracy of cam mechanism. The ordinary reverse rotation method is cumbersome and does not have generality, which reduces the efficiency. In particular, cam cannot achieve the precision of cam contour design by CAD software. For some CNC machine tools, it must be realized [15, 16].

The major contribution of this study that a kind of cam CAD/DCAM system software based on C++ language is studied. According to the requirements of cooperative enterprises, the design of variable parameter planar groove cam CAD/DCAM system is emphasized.

3 RESEARCH METHODS

3.1 Design of Each Module in the System Development Process

The main contents of the two modules are cam contour automatic generation module. Before the design of cam CAD/DCAM system, the design idea of the system should be clear, including the design method, design process, etc. the research object of this paper is the plane cam, specifically the ordinary plane disc cam and the plane groove cam. The purpose of this paper is to design a CAD/DCAM system integrating design and manufacturing [17] CAD/DCAM system includes a lot of contents, such as the generation of theoretical contour nodes of cam, the data calculation of actual contour nodes, and so on. The system can greatly shorten the design cycle of cam and improve the efficiency under the premise of ensuring the accuracy of the cam contour curve.

Figure 1 depicts the technological scenario of an adopted methodology. The adopted methodology is beneficial for the industrial scenario with same kind of characteristics but it follows different IT system. Essential part of the adopted methodology is CAD system which is used as a product data authoring tool, manufacturing authoring tool, rules customization tool and cam which is used as manufacturing process tool. The software is utilized for testing the compatibility of the design but still further work is required for the investigation of interoperability among various systems. The tool is designed and tested among the company engineers and technologists in corporation. The experimental results present the quantitative improvements in terms of less time competition and high cost saving also these parameters depend upon the complexity of product.

3.1.1 Basic requirements of the system

The calculation of plane cam profile design is complex. If the traditional design method is used, the design cycle of cam will be long, the efficiency will be low, and the accuracy cannot be guaranteed. Moreover, if the CAD/DCAM system is not integrated, there will be a big problem in data information sharing. Because the purpose of this system is to develop a CAD/DCAM system of planar cam, to realize the parametric design of cam, so as to simplify the complicated work in the

design process and shorten the design cycle of cam, so the system must be designed with simple, convenient and flexible man-machine interface.

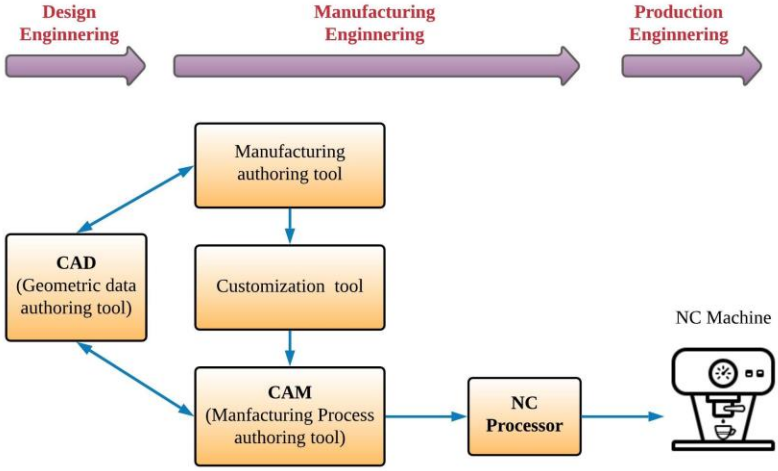

Figure 1: Technological scenario of proposed methodology.

3.1.2 Functional design and stability requirements of the system

The design of the system should analyze the whole process of the system design according to the user's requirements, so as to ensure the relevant functions that the system can realize. In the process of cam design, it is necessary to take into account the basic function of cam design, such as the generation of cam's basic data and the generation of cam's contour automatically in the process of NC software development. Therefore, the system has strict requirements for the overall response time, data processing accuracy and work efficiency of the system.

3.2 Automatic Generation Module of Cam Profile

In the automatic generation module of cam profile, for the center cam and flat top cam, the theoretical contour line of cam is the actual contour line of cam; for roller cam, the actual contour line of cam is obtained by the offset of theoretical contour line of cam by a roller half diameter; for groove cam, the theoretical contour line of cam is the actual contour line of cam,[10]also necessary to offset the theoretical profile to get the inner contour curve and the outer contour curve of the cam. No matter what kind of cam is, as long as the motion law of the follower is converted into the C # language code that can be recognized by the computer, the user only needs to input the relevant parameters in the interface, that is, to input the basic size data of the cam mechanism. In the program, the node coordinates of the contour curve of the cam can be generated by computer calculation. The contour curve of the cam can be obtained by connecting these coordinates with the spline command.

For roller cam, the node offset is also needed. According to the relevant mathematical expression, the theoretical contour line is offset by using the offset function to get the actual contour line. The specific principle is as follows: the points obtained when drawing the theoretical contour line of the cam are put into a point set, and then the new point set is obtained by adding spline (Zuobiao, start point). Since there is no direct definition of offset algorithm in C, it is necessary to define it before use.

The code of defining offset algorithm is as follows:

Public static double [] pianyi();

The offset function needs to be calculated and written into C ○ɔ in the form of code

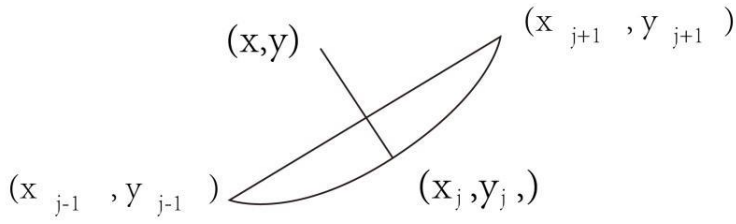

Figure 2: Schematic diagram for solving the offset function.

For calculating the coordinate point (x, y) after the offset of point (x (m29), yj) in Fig. 2 is as follows:

$$\begin{aligned} \tan\theta &= \frac{x_{j+1} - x_{j-1}}{y_{j+1} - y_{j-1}} \\ x &= x_j - R\cos\theta \\ y &= y_j - R\sin\theta \end{aligned} \tag{1}$$

θ is the angle between the connecting line of (x_{j-1}, y_{j-1}) and (x_{j+1}, y_{j+1}) and the horizontal line. The θ value obtained from Tan θ formula is substituted into the formula X and Y. R is the offset distance and the size is the length of roller radius.

For the grooved cam with a specific law, after the cam profile is obtained by converting the formula into code, the cam profile needs to be offset to obtain the cam inner contour and the cam outer contour. The offset distance should be determined according to the size of the required cam and the width of the groove. The NC machining method of the grooved cam is roughly the same as that of the ordinary disc cam, but the offset process plays an important role in generating the NC code of the NC machining of the planar groove cam because it determines the size of the tool radius and the choice of tool feeding mode in the process of NC machine.

3.3 Connection Between Development Platform and Auto CAD

Many kinds of application programs can be created by using C on the development platform of Microsoft Visual Studio. In the development of this system, it is necessary to establish windows form application program. The development process of the system is the secondary development of Auto CAD with C ○ɔ language, which needs to connect the development platform Microsoft visual studio with Auto CAD. This is the key of CAD/DCAM system development.

In Visual Studio 2015, select Windows Forms application under C template, right-click single machine to select "reference" in "Solution Explorer", select autocad017 type library and Auto CAD object DBX common 22.0 type library in com library, Set the "embedded interop class" under the "attribute" to "false" and add the "using Auto CAD" instruction. Global variables such as "Acad app" should be set in the program code to pave the way for the connection between visual studio 2015 and autocad2017 platform, so as to start the autocad017 software.

```
publicpartialclassForm1: Form
{
```

```
Public AcadApplication AcadApp;
publicForm1()
    {
        Initialize Component();
    }
        Launch CAD ()
    {
        AcadApp=new AcadApplication();
         System.Threading.Thread.Sleep(1000);
         AcadApp.Application.Visible=true;
    }
  }
```

Usually, the system reads the code quickly, but the process of opening Auto CAD software is slow. Therefore, when AutoCAD 017 is not fully opened, the program cannot be recognized in a short time and cannot carry out the next step of calculation. To solve this problem, a specific line of code can be added to the code connected between the two platforms: system. Threading. Thread. Sleep (1000); Thread. Sleep(), through this line of code, the current thread can be dormant for a certain period of time. The number 1000 in brackets represents the sleep time, with the unit of millisecond. The sleep time of 1000 milliseconds is enough for other threads to complete the preparatory calculation work, thus successfully starting the Auto CAD software [18].

4 RESEARCH RESULTS

Through cam CADDCAM system software, we can get the actual profile of the cam and the NC code of the cam to be processed. From the function of the software, whether from the user interface, or from the user's operation to the final use of the software, it can meet the needs of users. Although the purpose of the software can be achieved, but whether the generated cam profile is accurate or not. This chapter is the motion simulation analysis to verify the accuracy of cam profile curve. In the process of cam mechanism modeling and motion simulation analysis, it is necessary to select a suitable modeling and motion simulation software. Adams, solid works, UG, Pro-E and so on are commonly used software which can realize 3D modeling and motion simulation analysis. ADAMS software is a powerful simulation software, which can simulate statics, kinematics and dynamics. However, ADAMS software is more troublesome in 3D modeling, such as the drawing of parts and the assembly of parts. The motion simulation of many mechanisms needs to be drawn in other three-dimensional modeling software and imported into ADAMS software after assembly.

Although UG, Pro-E and solid works are not as powerful as ADAMS software, the simple motion simulation analysis of cam mechanism studied in this paper can still be realized, and these three software products are widely used and simple in three-dimensional modeling. Solid works is the most widely used in enterprises, and the motion simulation of Solid Works software is relatively simple and easy to operate. Therefore, the solid works software is finally selected for the three-dimensional modeling and motion simulation analysis of cam mechanism, and the assembled structure is analyzed in motion of Solid Works software.

4.1 Plane Simulation of Cam Mechanism

After that, click the motion button of the cam shaft, and then click the motion simulation button to form the motion of the cam shaft, If the cam moves according to the correct motion law, you can click the result and diagram button. If the cam motion law does not meet the requirements, it needs to be further modified in the coordination until the cam can move according to the correct

motion law. Click the result and diagram button and select the push rod as the research object to generate the linear displacement curve and linear acceleration motion curve, As shown in Fig. 3 and Fig. 4, the movement law of the push rod reflects the cam profile curve law of the planar cam mechanism.

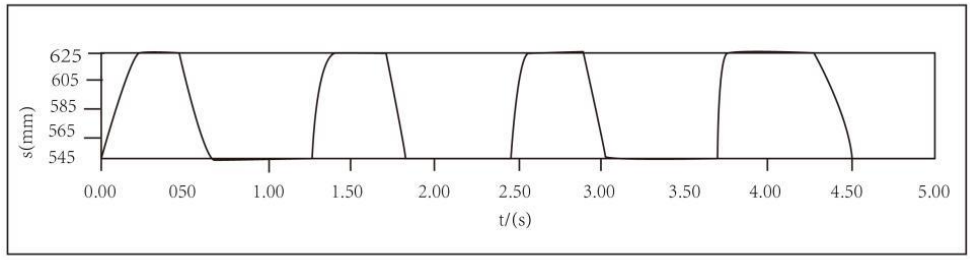

Figure 3: Linear displacement curve.

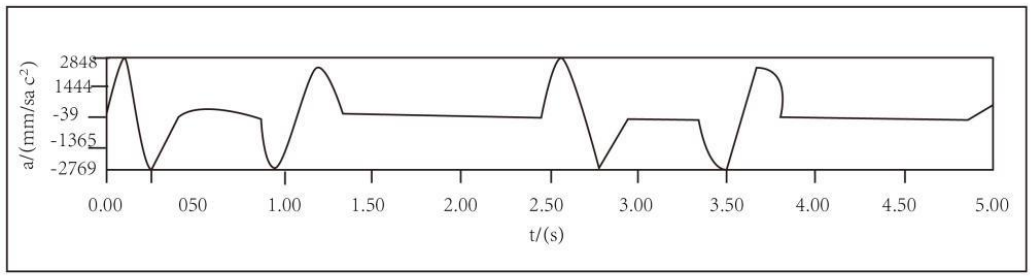

Figure 4: Linear acceleration curve.

According to the linear displacement diagram and linear acceleration curve obtained from the motion simulation of planar groove cam mechanism, the results are consistent with the modified sinusoidal motion law. It can be known that the cam profile generated by the cam CAD/DCAM system can also meet the application requirements.

Figure 5 represents the profiles calculated in terms of displacement velocity and acceleration. Based on the profile parameters the piston should move accordingly in order to reproduce the flow rate. At present scenario the time the flow rate of cycle was absorbed by using combination of CAM and cylinder. The proposed design is robust and is capable for providing the accurate flow at comparatively low construction cost. The chosen geometrical parameters are best considering the constraints which are imposed by the structure. The system is capable of working without jamming although no validation of experimental results is discussed.

4.2 Analysis of Motion Simulation Results

The displacement and acceleration curves obtained are compared with the theoretical curves of displacement and acceleration of corresponding cam profile is discussed in Section 1 and 2. The simulation results show that the cam profile can be automatically generated in autocad2017 by using CADDCAM system software developed in this paper. It can be seen that the cam motion curve and acceleration curve generated by this method are consistent with those of the cam system. The dynamic law should be more stable, which is more suitable for paper feeder in enterprises.

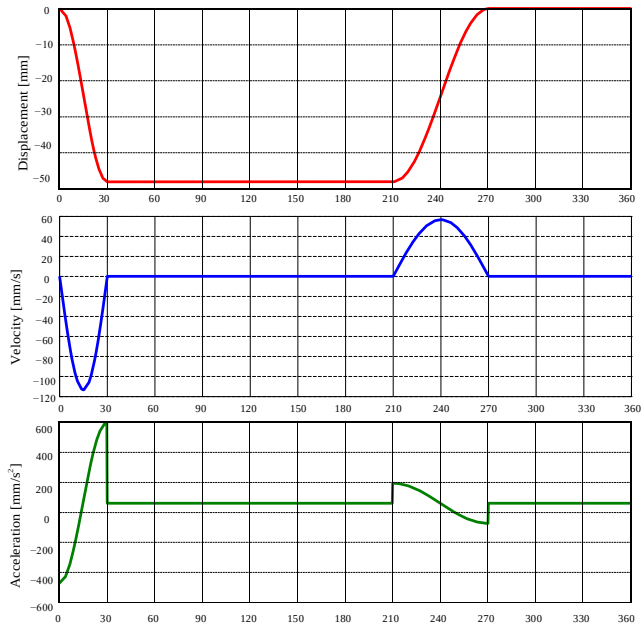

Figure 5: Calculated profiles for displacement, velocity and acceleration.

5 CONCLUSION

With the expansion of the application of computer integrated manufacturing at home and abroad, the development of cam CADDCAM system is more and more rapid. Enterprises can design a development system according to the actual needs in a short period of time to quickly and accurately produce the required products. The cam CADDCAM system developed in this paper can not only change the shortcomings of the traditional design, but also can improve the traditional design. In addition, it can automatically generate a variety of cam profiles with different motion curves in a development system, which not only saves time, but also improves the competitiveness of enterprises and creates great benefits. In order to ensure the accuracy of cam groove and groove, the groove and groove of cam are selected in the software of visual studio. On this basis, the secondary development of autocad2017 is carried out, and a friendly interactive interface is designed for users to use conveniently. The cam design and the programming of NC code automatic generation for cam machining are completed. Finally, the accuracy of the cam profile generated by the CADDCAM system is verified through the 3D modeling and motion simulation analysis of the cam mechanism.

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