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Research on the System of Blade Machining Path Planning Based on UG Secondary Development

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Abstract: Blade's surface belongs to the high free surface, how to improve the surface's machining accuracy and machining efficiency have always been a difficult problem in blade surface's machining manufacturing. Study work makes a plan to the machining path of different types of blade surface by residual supreme court and through the secondary development module of UG platform and strong programming function of VC ++, successfully achieved the extracting information of blade surface's normal vector, curvature and other key information, what's more, it realizes the surface machining path planning according to the equivalent scallop height method. The result indicates that: through the blade surface machining path planning of blade machining system based on UG platform development, it can achieve an intelligent planning of blade machining based on different machining parameters and ensure the surface machining precision.

Key words: Surface machining, UG secondary development, path planning, curvature

INTRODUCTION

The blade is widely used in steam turbine and engine's manufacturing which is typical complex surface with free shape (Yue, 2012). As curvature distribution of the complex surface is irregular and the machining path planning is under the influence of curvature, it must extract curvature information of CAD model in the planning process of tool path, then planning tool machining path according to the curvature information. Since, the 1980s, there have been many researchers, who had done a lot of research on tool interference problem in complex surface machining process. But most of them arranged for conducting the interference check and path planning at the same time which not only increased the difficulty of interference checking and generation of tool path, but also made the whole machining planning slow and difficult to operate which was also limited to the local interference checking with few study done on the whole interference. Adopted interference check method made the check process simple and quick and applied in three kinds of commonly used tool bodies, generating the tool path with no interference based on the results of interference checking (Liu *et al*., 2010; Gao *et al*., 2011).

With the rapid development of computer technology and modern design theory and method, 3D design software, especially the popularization of Unigraphics in mechanical parts and products design, path planning for surface machining in three-dimensional software, especially in the UG, drawing becomes more and more important. In this study, by using UG secondary development technology, doing feasible planning for machining path of complex surface, through the analysis of surface curvature, curvature radius, judging of row spacing and solving the interference problem in manufacturing process, making use of obtained relevant parameters, doing machining path planning, it ensured machining quality and achieved the desired effect.

TOOL PATH PLANNING BASED ON SURFACE MACHINNING'S EQUIVALENT SCALLOP HEIGHT

Calculation of scallop height: There are quite many theoretical calculation methods of scallop height, like the approximate formula, the unified formula. Different machining plane object is corresponding to a different calculation result (Yan *et al*., 2003). This study emphasized on milling machining of ball end tool with free surface without considering the condition of ball end tool milling the plane and the inclined plane. In order to simplify the calculation results, ignoring the effect of feed rate and minimum step size restrictions of machine tool. The free surface is divided into convex surface and concave surface, when doing the surface machining path planning. Firstly, it needs data that UG reads the blade surface's curvature and surface normal, depending on the data of surface to determine the type of surface.

Convex surface machining condition: The curvature of the surface is not considered in programming, convex surface machining condition is shown in Fig. 1 (a); it can get the convex surface's machining scallop height:

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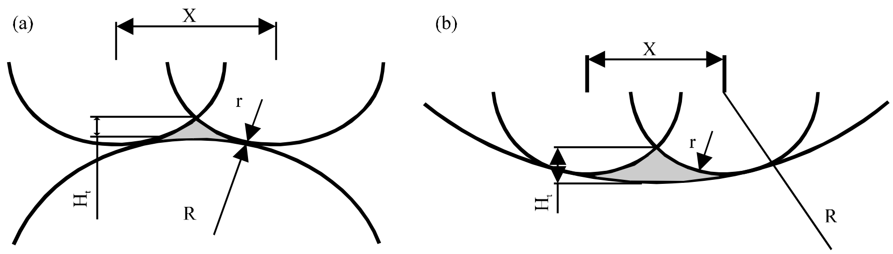

Fig. 1(a-b): Calculation diagram of convex and concave surface scallop height

$$H_t = \sqrt{(R+r)^2 - (\frac{X}{2})^2} - R - \sqrt{r^2 - (\frac{X}{2})^2}$$

In this equation, R indicates workpiece surface's curvature radius.

Concave surface machining condition: Concave surface machining condition is shown in Fig. 1b, concave surface increases the actual scallop height, making the surface quality is even bad; it can be concluded from Fig. 1b:

$$H_a = R - \sqrt{(R-r)^2 - (\frac{X}{2})^2} - \sqrt{r^2 - (\frac{X}{2})^2}$$

It can be seen from Fig. 1, under normal circumstances, the concave and convex of surface has little effect on the results, but when curvature radius is close to the tool radius, it can rapidly amplified the error. When tilted 60 degrees or more, the error increases more quickly than in the condition of 45 degrees. Therefore, in machining path planning of blade convex and concave surface, according to the different curvature radius on the blade surface, we can calculate the scallop height when machining. Setting a threshold value of scallop height when doing machining path planning, according to the data of tool radius and curvature radius, by controlling the step, to realize the control of scallop height, we can achieve the control to the surface machining quality.

Tool Path planning:

- **Calculation of machining step:** The machining step refers to the distance between two consecutive cutter contact points, determined by the chord deviation not exceeding the permissible maximum machining error. Making L_i is the tool path length of paragraph i that is to say, the distance between two consecutive cutter contact point C and C before and after, ρ_i is the curvature radius on the i props contact surface of points C and C, δ is the allowed maximum chord deviation, so the machining step can be calculated by the following equation:

$$L_i = \sqrt{8\rho_i\delta}$$

- **Determining machining step:** The machining step is the interval between two adjacent tool paths. Though the large machining step, it can accelerate the machining efficiency, but it may leave the high chip residue, affecting the roughness of machining surface. Approximation equation of ball end cutter step is:

$$l_p \approx \sqrt{\frac{8\rho_i Rh}{\rho_v \pm R}}$$

In the equation, ρ_v indicates the curvature radius in the direction of step, R indicates ball end cutter radius, h indicates scallop height in machining, the sign ± depends on that the free surface is convex or concave in the step direction. Other tool of machining types can also conclude machining step relationship similar to this.

- **Implementation of path algorithm:** When the possible interference area of free surface is designated in using a tool to machine, free tool path arrangement with no interference can be carried out according to the following steps:

Step 1: Firstly, determine a parameter free surface contact CC path direction for the tool which also means, the boundary line of another surface parameters for the first bar cutter contact path CC

Step 2: According to the known maximum chord deviation, on each cutter contact CC path interpolation calculation deviation requirements, meet the minimum number of props contact point CC

The spatial parameters of a cutter contact path a cutter contact point can be determined by the equation:

$$u_i = u_{i-1} + \frac{L^{cc}}{\left\| \frac{d}{du}(P^{cc}) \right\|} = u_{i-1} + \frac{\sqrt{8\rho\delta}}{\left\| \frac{d}{du}(P^{cc}) \right\|}$$

ρ indicates curvature radius in the cutter contact path CC direction

step 3: Bias cutter contact point CC, get the cutter location

- Calculate the radius of each cutter contact point (CC). and calculate the step distance Δ_{vi} at this contact point (CC). Through the comparison of the cutter contact path CC on all of the cutter contact point CC step, to the minimum as the right step down a path distance. The cutter contact each tool CC path on the contact point CC step can have the following equation:

$$\Delta v_i = \frac{l_v}{(n \times t)\bullet\frac{\partial S}{\partial v}} = \frac{\sqrt{\frac{8\rho_v Rh}{\rho_v \pm R}}}{(n \times t)\bullet\frac{\partial S}{\partial v}}$$

In the equation, l_v indicates type-step to increase the length, according to Eq. 2 to calculate:

$$t,\frac{\partial S}{\partial v}$$

The fifth step, repeat the second step to the fourth step, until the step parameter space (V) to another boundary.

The final arrangements for the tool path, the interference area out of identified, so as to generate interference free tool path, In this study work, wherein the tool radius 12, deviation value is 0.08, the residual height is 0.01.

PROGRAM DESIGN AND OPERATION RESULTS

Menu and dialog box design based on UG platform: UG software for the two development tool users not only can be used independently, but also can call each other tools and development results which greatly expanded the tool has the function, convenient for the user to develop two times. The relationship between them as shown in the Fig. 2: Menu Script developed by the menu can be and User Tools development of the dialog box call each other; Menu Script developed by the User Tools menu and dialog box you can call the UI Styler development of the dialog box; Menu Script, User Tools and UI Styler development of the dialog box you can call the GRIP program and API program. Between GRIP program and API program can call each other (Song, 2012). In addition, the use of UG two development tool must set the appropriate environment variables, so you can find these files, the implementation of the corresponding procedures.

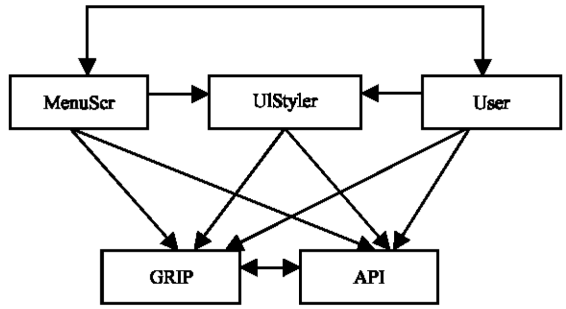

Fig. 2: Secondary development tools relationship diagram

Project settings and configuration path: Select the menu command, engineering)>settings, in the pop-up dialog box, the Setting For drop-down list box is set to the value Win32Debug. In the Link tab, the output DLL file path for the D:\user\Startup\cutlocating.dll", in the" object/library module", enter the UG library file liufun.lib and libugOpenint.lib. In the Debug options, in/debug dialogue text box input/C:\ProgramFiles\UG II\ugraf.exe\UGS\NX 4. Select the menu command, select tools->, pop/selection dialog. Select/directory, respectively in/show directory menu option for two Library files and Include files to add the UG root directory path to the UGOPEN folder "${UG II BASE DIR}\UGOPEN".

Dialog design in UG style: Open the software UG, applications->user interface editor, add bitmap and lines button in the user interface editor, creating the dialog box. And set the button's callback function. As soon as the user triggers a dialog box control, the system will response to the message and implement the corresponding callback function. It will save the created dialog and the system will generate three files which are three files of GS.DLG, GS.h, GS.c, respectively. Put the qumianlujing.DLG file in the Application folder under the project folder, through the GrinSim.men code in the file ACTIONS qumianlujing.dlg, you can opened the above got-up dialog box by click the " surface path planning" "Export dialog".

Surface information reading and path planning:

- Firstly, reading the information in the dialogue, read the information such as path planning tool radius and blade surface's normal vector (Fig. 3)

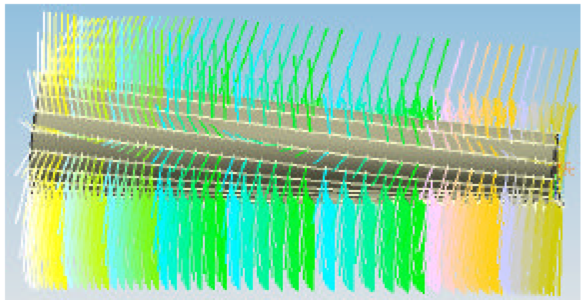

Fig. 3: Information of blade face

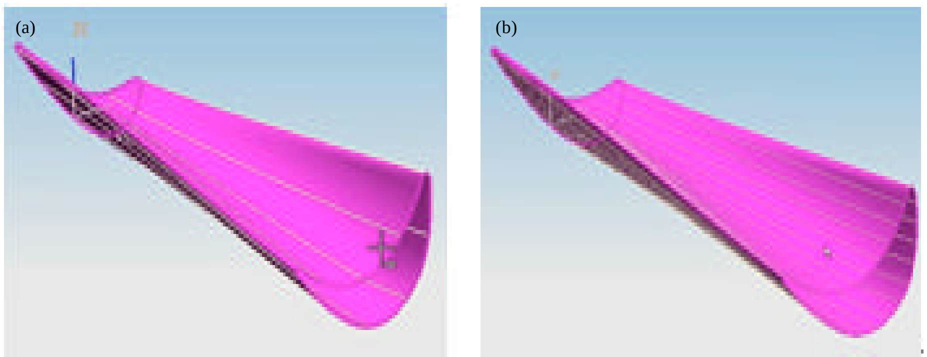

Fig. 4(a-b): A rendering after clicking path planning

```
data.item_id=GS_REAL_TOOLR; /* Get the tool radius control ID in surface path planning dialog box */
UF_STYLER_ask_value(dialog_id,&data); /* Read values corresponding to the tool radius control*/
```

Using the same function, we can read data values corresponding to different ID control, taking that data as surface path planning's parameters

- Create a CycleAll () function, traversal object of UG graphic, obtaining the blade model object tObjBlade;
- Create the main function

```
UF_MODL_create_isocurve(tObjBlade,uv_flag,(double)(i)/(curve_count-1), 0.001,&isocurve_id[i],&isocurve_cnt);
{UF_MODL_ask_curve_props(isocurve_id[0][0],0.0, point, tangent, p_norm, b_norm, &torsion,&rad_of_cur);
UF_MODL_ask_face_parm (tObjBlade, point, param, point);
UF_MODL_ask_face_props (tObjBlade,param,point,u1,v1,u2,v2,unit_norm,radii);
start_vector[0]=unit_norm[0];
start_vector[1]=unit_norm[1];
start_vector[2]=unit_norm[2];
start_point[0]=point[0]+radius*unit_norm[0];start_point[1]=point[1]+radius*unit_norm[1];start_point[2]=point[2]+radius*unit_norm[2];}
```

Start the UG program, the design takes the surface machining of blade as an example, loading the leaf surface graphics.

After loading the graphics, click on the surface path planning button well done in advance in the toolbar, popping the dialog box, according to the surface curvature, curvature radius, scallop height, etc. Calculating the step length, step of surface machining, choosing tool radius, selecting the cutting patterns of surface machining, then filling corresponding parameters in the popping dialog box.

Click on the path planning button, according to already obtained row spacing and step, doing surface machining path planning, its effect is shown in Fig. 4

CONCLUSION

In this study, through the UG secondary development module, it realized the typical blade surface's machining path planning. By taking the scallop height as the objective parameter, it achieved the machining path planning of convex surface and concave surface based on tool radius and radius of curvature. This blade path planning system based on UG platform not only improves the efficiency of surface machining planning, but also ensures the machining error's (scallop height) effective control.

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