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A adaptive compensation processing method of aeronautical aluminum alloy thin walled work piece

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ABSTRACT *: For the machining of large thin work piece, this paper proposes a adaptive compensation processing method based on the thickness measuring device. This method first by using CMM obtain the actual coordinates of cutter location point after rough machining, and then adaptive obtain thickness measuring point. Thickness measuring device are used to get the actual work piece thickness values of the measuring point, and interpolation to obtain the actual thickness values of all CL points, then obtain compensation value of all CL points by compared the thickness value and the ideal value. Finally to thin wall grid machining as an example show that this method can effectively ensure the machining accuracy*.

Keywords - *thin work piece machining, adaptive obtain, compensation value, compensation machining*

I. INTRODUCTION

Due to the thin-walled workpiece easily deformation by the cutting force, then leading to some material left and have machining error. The more thin workpiece is, the serious machining error is. In actual processing, in order to ensure the quality of processing, often need to carry out compensation on the workpiece machining error.

In terms of ensure the precision of thin-walled parts processing, many scholars have done a lot of research. BUDAK E [1] established model of thin-walled parts processing force, analyzed the deflection of the workpiece when machining and ensure the machining quality by thickness compensation. CHEN [2] established fast simulation platform for deformation of thin-walled parts in processing by using the finite element method and genetic algorithm to calculation deformation value in processing, then to compensation machining after obtain the deformation value. ZHANG [3] established the model of the deformation surface based on B-spline, and forecast the machining deformation. HU [4] obtained good cutting parameters by simulation calculation, so as to ensure the machining accuracy. BI [5] considering of the workpiece machining processes, set up the whole process of thin-wall parts machining and analyzed the stress of different processing , and ensure the machining accuracy by controlling the residual stress. Li [6] analyzed the cutting depth and the residual stress on the impact of machining deformation, and control the machining deformation by controlling the cutting depth and the residual stress. Comprehensive above the research content, in view of the thin-walled parts processing precision control strategy is mainly divided into two aspects: 1, analysis the influence factors of machining deformation of workpiece and forecast machining deformation, then to compensate the deformation. 2, analysis of the residual stress inside the different period of workpieces on the impact of machining, thus ensure the machining accuracy by controlling the residual stress. Summarize the above processing deformation control method, is mostly simulation deformation of workpiece in the machining, and determine the compensate value after deformation.

This paper use the CMM establish the workpiece model that after rough machining, and adaptive obtained thickness measurement point through the model, get the actual workpiece thickness values of the measuring point by thickness measuring device, and interpolation to obtain the actual thickness values of all CL points, then obtain compensation value of all CL points by compared the thickness value and the ideal value. Finally to thin wall grid machining as an example show that this method can effectively ensure the machining accuracy.

II. ADAPTIVE FOR THICKNESS MEASUREMENT POINT

The actual thickness values of workpiece need to be obtained before compensation processing, however, because the quantity of CL point is too much, it is not reality to measure thickness for each point. So, it is need to sample in the CL points for a limited number of thickness measurement point, and get the actual workpiece thickness values of the measuring point by thickness measuring device, then interpolation to obtain the actual thickness values of all CL points.

In general, there are two methods of access thickness measurement point. The one method is obtained from CL points With a large step and row spacing sampling, the advantage of this method is have a high precision, but the disadvantage is need too more time and have a low machining efficiency. The other method is obtained according to the characters of the shape of the processed workpiece, the advantage of this method is have a high efficiency, but the disadvantage is have a low machining precision.

In order to ensure accuracy under the premise of improving efficiency, this paper put forward a method of adaptive obtain thickness measurement point, the main access process as shown in the fig.1.

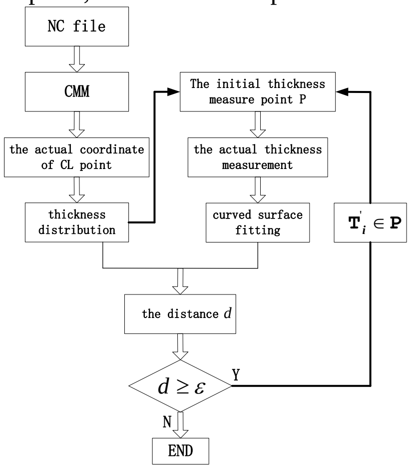


Fig.1 obtain of the thickness measurement point

2.1 obtain the actual coordinate of CL point

In theory, the coordinate of CL point after rough machining can obtained by remove the machining allowance, however, due to the machining error, the coordinates of CL points obtain again.

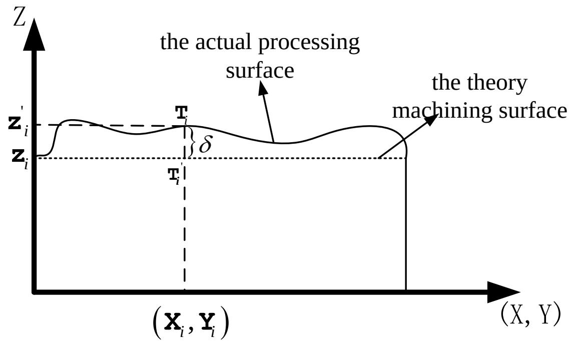


Fig.2 Actual processing surface map

CMM is currently one of the most commonly used non-contact measuring equipment, the CMM measurement point is through to the workpiece machining cutter locus for sampling. firstly, the sampling point is obtained at a large step and row spacing for CL points. Set Z to be the feed direction, Use the CMM to sampling site measurements and get a series value of corresponding to , then   is actual coordinates of CL points as shown in table.1.

table.1 part of the measurement data by CMM

T_i			$Z_i^{'}$
X(i)	Y(i)	Z(i)	
6.16	3.30	16.61	16.53
6.24	5.47	16.32	16.49
6.33	7.61	16.61	16.51
6.40	9.79	16.47	16.47
6.49	11.96	16.53	16.53
6.57	14.13	16.53	16.53

2.2 thickness measuring device

In order to achieve high efficiency and high precision measurement of workpiece machining cutter locus, this paper proposes a thickness measuring device based on the principle of ultrasonic thickness. As shown in fig.3, the thickness device includes four parts.

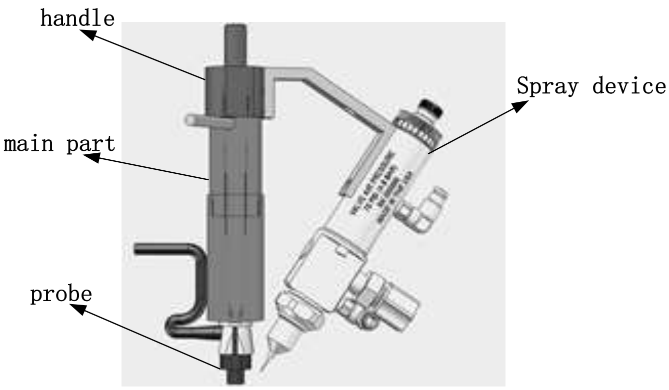


Fig.3 the thickness measuring device

2.3 the initial of thickness points

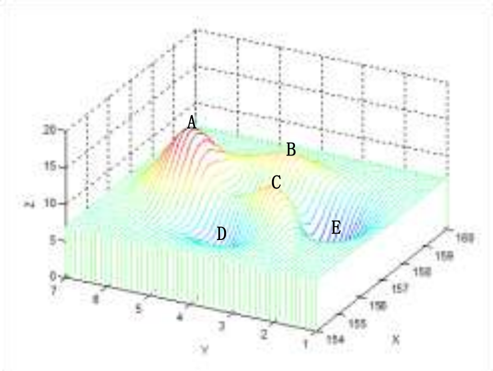


Fig.4 obtain the initial measurement point

Suppose the ideal thickness of workpiece is 7 mm, then obtained the actual coordinates of measuring point by the CMM, and analyze the actual workpiece thickness distribution, as shown in fig.4. by the analysis on the workpiece in A, B, C, D, E place for machining deformation and exist error, lead to actual value more thick than the ideal. So, set A, B, C, D, E as the initial thickness measurement point.

2.4 obtain of the thickness measurement point

When the initial thickness measurement point $\mathbf{P}_i(\mathbf{X}_i, \mathbf{Y}_i, \mathbf{Z}_i)$ is determined, and obtained the actual thickness value $\mathbf{h}_i^{'}$ of point $\mathbf{P}_i$ by use of thickness measuring device. Next, the surface $\mathbf{S}(\mathbf{u},\mathbf{v})$ is interpolated by NURBS.

$$\mathbf{S}(\mathbf{u},\mathbf{v}) = \frac{\sum_{i=0}^{n}\sum_{j=0}^{n}\mathbf{N}_{i,p}(\mathbf{u})\mathbf{N}_{j,q}(\mathbf{v})\mathbf{w}_{i,j}\mathbf{P}_{i,j}^{'}}{\sum_{i=0}^{n}\sum_{j=0}^{n}\mathbf{N}_{i,p}(\mathbf{u})\mathbf{N}_{j,q}(\mathbf{v})\mathbf{w}_{i,j}}, 0 \le \mathbf{u},\mathbf{v} \le 1 \tag{1}$$

where $\mathbf{P}_{i,j}^{'}$ is control grid of two directions, $\mathbf{w}_{i,j}$ is weight value and $\mathbf{N}_{i,p}(u)$ and $\mathbf{N}_{j,q}(v)$ are basis functions defined in U and V.

III. OBTAIN OF THE AMOUNT OF COMPENSATION

As shown in fig.5, when the actual thickness is obtained, then obtain all the actual thickness values of CL point by use of inverse distance interpolation method.

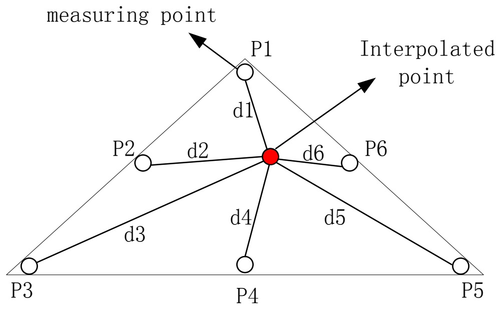


Fig.5 interpolation of CL point by IDW

The interpolation process as follows:

1, Obtain the thickness measure point $P_k = (X_k, Y_k), k = 1, 2, \ldots, 5$ at first, and the actual workpiece thickness value F_k is got by the thickness measuring device.

2, To define the interpolation function as:

$$f(x,y) = \begin{cases} F_k, d_k = 0 \\ \sum_1^n w_k(x,y) \cdot F_k, d_k \neq 0 \end{cases} \quad (2)$$

where $w_k(x,y) = (\frac{1}{d_k})^2 \Big/ \sum_1^n (\frac{1}{d_k})^2$, and the distance of interpolation point is defined as $d_k = \sqrt{(x - x_k)^2 - (y - y_k)^2}$.

3, Get the actual thickness f_i of all the interpolation point through $f(x,y)$.

Get the actual thickness f_i of all the interpolation point, and compared thickness of the actual value with the ideal value, then get the the amount of compensation.

IV. APPLICATION

As shown in fig.6, in order to verify the validity of the method proposed in this paper, the workpiece is machined the accuracy is analyzed.

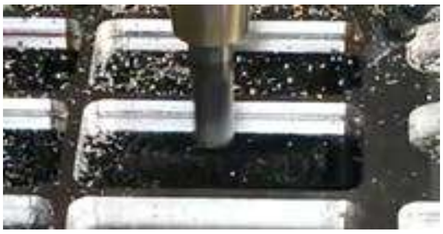
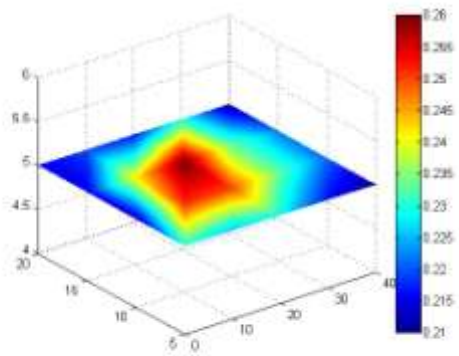
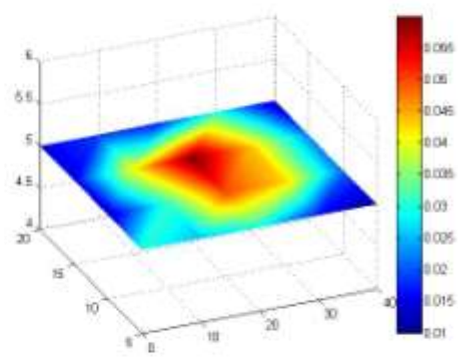


Fig.6 workpiece machining

Based on the analysis of point data, machining error distribution maps of two groups are obtained. By comparing Fig. 7(a) and Fig. 7(b), the machining error of blade reduces significantly group 2.The maximum error value decreased from 0.26 mm to 0.05 mm. The results indicate that the proposed method is effective in decreasing geometric error of five-axis machine tool.



(a) The machining error without optimization



(b) The machining error with optimization

Fig. 7 The machining error with and without optimization

V. CONCLUSION

Relative to the method of predict the workpiece deformation, this paper put forward a method of adaptive compensation based on ultrasonic thickness measuring device. The compensation value of all CL point is obtained by a finite number of point. The method does not need to modeling and avoid the poor model accuracy influence the machining precision. The experiment proved that the method can effectively ensure the machining precision of thin-walled parts.

REFERENCES

[1] BUDAK E, ALTINTAS Y. Modeling and avoidance of static form errors in peripheral milling of plates[J]. International Journal of Machine Tools＆Manufacture.1995, 35(3) : 459—476.

[2] CHEN Weifang, CHEN Hua, LOU Peihuang etal. Fast simulation platform on machining deflection control of thin—walled workpiece[J]. Computer Integrated Manufacturing Systems.2009,15(2):321-327.

[3] ZHANG Xiaofeng. ZHOU Kai, LU Junbai. Forecast and control of thin wall part of aircraft's deformation during based on B-spline[J]. JOURNAL OF MACHINE DESIGN.2010,27(4):44-50.

[4] HU Quanwei, QIAO Lihong, ZHANG Hongwei. Optimization of Thin—walled Part Milling Parameters Based on Finite Element and Orthogonal Dominance Analysis[J].JOURNAL OF MECHANICAL ENGINEERING. 2013,49(21):176-184.

[5] BI Yunbo, KE Yinglin, DONG Huiyue. Finite element simulation and analysis of deformation in machining of aeronautical aluminum alloy thin walled workpiece[J].Journey of Zhejiang University.2008,42(3):397-402.

[6] Beizhi Li, Xiaohui Jiang, Jianguo Yang, et al. Effects of depth of cut on the redistribution of residual stress anddistortion during the milling of thin-walled part [J]. Journal of Materials Processing Technology,2015,216(1):223-233.