Research in Mechanical Engineering and Material Science

Edited by
Zhongjun Hu

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Research in Mechanical Engineering and Material Science

Selected, peer reviewed papers from the
2013 International Conference on
Mechanical, Material Engineering
(MME 2013),
November 23-24, 2013, Shiyan, Hubei, China

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Zhongjun Hu

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Preface

2013 International Conference on Mechanical, Material Engineering (MME2013) will be held on November 23-24,2013,at Hubei University of Automotive Technology, Shiyan ,Hubei, China. And it will last for two days.

This conference will provide a platform to discuss Mechanical, Material Engineering, Industrial Engineering and their application, with participants from all over the world, both from academia and from industry. Its success is reflected in the papers received, with participants coming from several countries, allowing a real multinational multicultural exchange of experiences and ideas.

The conference has so far been an important event and has attracted many scientists, engineers and researchers from academia, government laboratories, and industry internationally.

A total of 236 contributions were presented at the meeting, orally or as a poster. After a rigorous and time consuming refereeing procedure, 139 contributions could be published in the conference proceedings now in front of you. Herewith we would like to thank all reviewers for their time spent on the manuscripts!

The conference proceedings will be published by APPLIED MECHANICS AND MATERIALS,issn: 1662-7482.Which will Indexed by Elsevier: SCOPUS www.scopus.com and Ei Compendex (CPX) www.ei.org/. Cambridge Scientific Abstracts (CSA) www.csa.com, Chemical Abstracts (CA) www.cas.org, Google and Google Scholar google.com, ISI (ISTP, CPCI, Web of Science) www.isinet.com, Institution of Electrical Engineers (IEE) www.iee.org, etc.

We are looking forward to welcoming you all in Shiyan , November 23-24 2013 , and hope your stay will both be rewarding and enjoyable!

The Editors
2013.11.23

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CHAPTER 1:

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Research of Line Contact Rotate-milling about Space Ruled Surface

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Keywords: ruled surface; line contact rotate-milling; motion analysis and realization; precision analysis;

Abstract. For there are small contact area between tool and workpiece, low machining precision, and poor quality of face in point-milling, point-milling and line contact milling used in processing are analyzed on this paper. Line contact rotate-milling using which the workpiece is processed as the profile laws is shown, the realization method of line contact rotate-milling is discussed in milling various surfaces, the movement to processing the various surfaces is studied, and the movement function is analyzed. Next, the factors affecting the machining accuracy are analyzed, and the main factors - the geometric errors are analyzed and integrated. Then the error model is created in differential analysis, the output accuracy is analyzed in "Matlab". To point-milling, the line contact rotate-milling is the method of processing based on face. In this processing, the way of no profile theory-error is taken, the tool contact length with the workpiece is increased, axis as few as possible and even single-axis is taken, and the accuracy of processing is improved.

Introduction

The ruled surface is a straight line set, which is generated by the movement of the straight line in space. For its special geometric properties, it is widely used in the engineering of the wing, turbine impeller, blade class parts of the fluid machine, etc. [1]. Currently, the finishing of the complex workpieces having ruled surface characteristics is done by 5-axis CNC machine tools using the general ball tool, arc-shaped tool, and drum-shaped tool, etc. In the traditional five-axis machining, the tool is contacted with the workpiece on the point and its small neighborhood in the processing area, the tool path is planned in point-line, and tool-position computing is simple, so this method is versatility and can be used for the processing of the arbitrary curved surfaces. However, this processing method has the following disadvantages: firstly, because the contact area between the tool and the workpiece is theoretically a point, the contact area is very small, so the processing efficiency is low; secondly, there is the theoretical approximation error, and machining accuracy is limited by the machine precision and interpolation accuracy; thirdly, for the curvature of the contact point in each of the contact area between the tool and the workpiece is inconsistent, cutting speed on each point of the cutting edge is inconsistent, and eventually a deterioration in the quality of the machined surface is caused.

So, in order to improve processing accuracy and efficiency, there have been studies about the processing methods for example: belt polishing, WEDM surface machining ,line contact milling (side milling, face milling) processing methods etc. [2-7]: Sorby, Tonnessen, Torjusen,et al. [4] proposed the high-speed line contact machining tool and cutting method based on the tool life and cutting force; Larue, Anselmetti[5] proposed the error calculation method of line contact machining; Menzel, Cornelia [6] proposed the cutter path planning method based on three-point cut-touch side milling by the error analysis; Li Chenggang [7] proposed the design method of quadratic NURBS surfaces by using the least squares method.

Compared to the traditional point-contact machining, the contact length between tool and workpiece is increased in line contact machining, then this is a surface-based processing. While, in the line contact machining based on WEDM, the processing efficiency is low, and there is the metamorphic layer on the surface of the work piece after processing. In the current line contact machining based on 5_axis CNC, the rotary axis is fixed or the radius of gyration is fixed about rotary feed, therefore the processing route is mainly planned by point-line. So, even a simple space plane also requires a large number of tool position data. When there is spiral surface or space tapered surface on the surface of the workpiece, the surface approximation and multi-axis are more needed, so the approximation error and nonlinearity error is inevitable.

In the line contact rotate-milling, the research about directly finishing theoretical profile of developable ruled surface is first carried out, and the method with no profile theory-error is applied in processing. The tool axis is always moving in the offset surface which is "r" away from the processing surfaces, the stimulation of turning and milling is done directly through arc feed instead of circular interpolation, a composite machining of turning and milling is formed by using the rotary cutting movement of tool flank and rotary feed motion. and the machining having the high efficiency and precision is realized.

Movement Realization of Line Contact Rotate-milling

The principle of line contact rotate-milling is illustrated in Fig. 1. In processing, the machined surface is made up of the enveloping motion of the tool side-edge. We define: machined surface is the surface which will be milled; the guide moving lines is the curve by which the tool movement is guided; the check surface is the end position for each cutting. Because the machined surface after line contact rotate-milling can only be ruled surface, in machining non-ruled surface, the non-ruled surface is approximated in use of ruled surface. So, according to the specific circumstances, a sideline "$P_Q(u)$" of Ruled Surface is selected as a guide line, the tool side edge is very contacted with machined surface. When the contact point at the bottom of tool is moved to the check surface, the processing of ruled surface is completed.

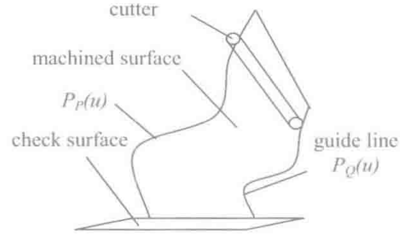

Fig.1 Diagram on line contact rotate-milling

Achievement on ruled surface machining. If each one of a family of straight lines which is in existence is all in the curved surface "S", the "S" is called a ruled surface.

If the "$P_Q(u)$" and "$P_P(u)$" are used to respectively express as two baselines of a ruled surface the equation of ruled surface can be defined as:

$$r(u,v) = (1-v)P_Q(u) + vP_P(u) \quad (1)$$

A ruled surface includes a developable ruled surface and a non-developable ruled surface, the developable ruled surface includes a cylinder, a tapered surface, and a tangent surface. Because the processing of tangent surfaces requiring five-axis is similar to non-developable ruled surfaces, now the discuss of line contact rotate-milling is focused on the cylinders, cones, and the developable ruled surfaces which can be decomposed into the cylinder and cone.

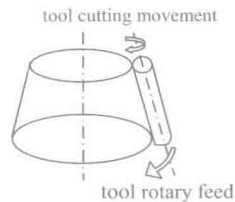

Fig.2 Diagram on milling cone

(1) In formula (1), when PQ(u) is a certain point "r0", the formula (1) is converted to the taper equation: $r(u,v) = P_Q(u) + v(r_0 - P_Q(u))$ (2)

When the surfaces are milled, the tool axis vector is consistent with the straight generatrix vector of taper surface through the control of B, C axis; by controlling the feed of X-axis and Y-axis feed of workbench and the W-axis feed of tool, the bottom edge of tool is always contacted with the baseline (the guide lines). The tool axis is always running in the equidistant surface of the machined surface:

$$r^*(u,v) = P_Q(u) + v(r_0 - P_Q(u)) + Rn(u) \quad (3)$$

Especailly, when an angle which is formed between the connection line between $P_Q(u)$ and r_0 and a line over r_0 is remained unchanged, the ruled surface is cone, the angle is the half-cone angle. The milling of cone is illustrated in Fig. 2. First, the rotary feed axis of tool or table is adjusted to have a