The Japan Society for Precision Engineering

Introduction of JSPE Best Paper Awards 2019

1. Consolidated Chatter Stability Prediction Model Considering Material Removing and Ploughing Processes

Takehiro HAYASAKA, Hongjin JUNG, Kensuke AZUMA and Eiji SHAMOTO

Precision Engineering, Vol. 59, pp. 120-133

A novel consolidated model is proposed to realize the analytical prediction and better understanding of the critical stability determined by regenerative chatter, frictional chatter, process damping, rake angle fluctuation, and 'mode coupling' (mentioned by Tlusty), in which the material removing and ploughing processes are considered. In the history, frictional chatter and process damping have been modelled separately and differently, which has impeded the complete understanding of the effect of the ploughing process fluctuation. In contrast, the two phenomena are uniformly and simply formulated in the proposed model, where the ploughing process fluctuation acts as either an excitation or damping effect depending only on the vibration direction and the direction of the dynamic ploughing force. Furthermore, it is consolidated with the regenerative effect, the fluctuation of the rake angle, and 'mode coupling' which also affect the actual cutting process. According to the proposed model, the relation between the vibration direction and the direction of the dynamic forces is clarified which makes it possible to better understand the multiple self-excitation/damping phenomena and their effect against the chatter stability. The proposed model is verified through analytical observations and cutting experiments.

2. A Lightweight Interpolation Algorithm for Short-segmented Machining Tool Paths to Realize Vibration Avoidance, High Accuracy, and Short Machining Time

Takehiro HAYASAKA, Kazuaki MINOURA, Kousuke ISHIZAKI, Eiji SHAMOTO and Burak SENCER

Precision Engineering, Vol. 59, pp. 1-17

A computationally efficient FIR-filtering based path-smoothing algorithm which simultaneously realizes vibration avoidance, high accuracy, and short machining time is proposed in this paper. Unlike the case of long G-line blocks where only the adjacent blocks affect the cornering error of a specific corner, more than two blocks affect the error in the case of short-segmented blocks. To satisfy the tolerance error, point-to-point (P2P) technique can be applied, but its machining time will be excessively elongated due to full stops at each corner. Alternatively, motions with the delay times of FIR filters fully-overlapped, which are available on commercially-installed NC systems, can realize short machining time, but they cannot satisfy the tolerance error due to the filtered trajectories accompanies by high speed. Other methods such as spline fitting may satisfy the tolerance error and realize short machining time, but they will allow vibration of the machine tool structure since these motions are not allowed to be filtered for satisfaction of the tolerance. Therefore, no method exists which realizes vibration avoidance, high accuracy, and short machining time all at the same time. For the first time in the literature, a method is proposed which realizes all of the above requirements. The proposed algorithm bases on a kinematic smoothing scheme where no spline-fitting based geometric smoothing is required, and the blended path geometry is only controlled by optimizing the feedrate (speed) profiles along a span of short G01 and G02/G03 moves. FIR filtering is applied to avoid the inertial excitation of the machine tool structure, and a novel "block splitting" method is proposed to keep elongation time of the G-line blocks the minimum. The effectiveness of the proposed method is validated through a series of experiments by comparison with conventional methods.

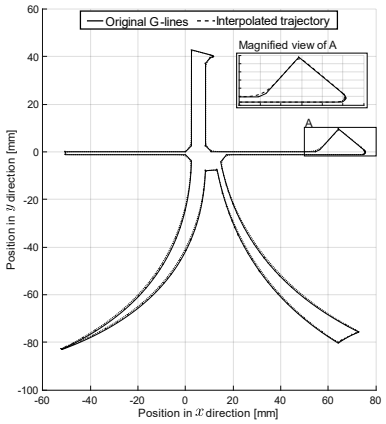

Fig. 1. Original tool-path (G-lines) overlaid with the interpolated trajectory.

3. Fabrication of Microneedle using Poly Lactic Acid Sheets by Thermal Nanoimprint

Shingo TERASHIMA, Chikako TATSUKAWA, Masato SUZUKI, Tomokazu TAKAHASHI and Seiji AOYAGI

Precision Engineering, Vol. 59, pp. 110-119

A biodegradable PLA (poly-lactic acid) microneedle having high aspect ratio of over 10, e.g., 100 μm in diameter and 1,000 μm (1 mm) in length, was successfully fabricated using thermal nanoimprint method first in the world. First,

optimal conditions for fabricating a conical shape, which is assuming a microneedle tip, were preliminarily investigated. Both in vacuum and under atmospheric pressure, pressure of 20 MPa and temperature of 160 °C were necessary. Next, fabrication of a long microneedle was investigated. As compared to the conical shape, higher pressure of 25 MPa and higher temperature of 166 °C were required. By adjusting the releasing temperature around 98 °C, fabrication of a long microneedle having a smooth surface and no deformation, e.g., no bending, was successfully achieved. It was confirmed that the needle surely can puncture the skin and bloodvessel of a mouse.

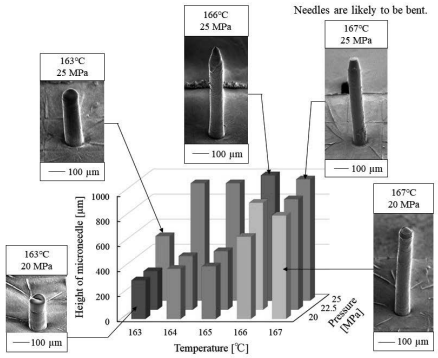

Fig. 2. Height of fabricated microneedle with respect to temperature and pressure in case releasing temperature is 100 °C.

Introduction of JSPE Takagi Awards 2019

1. Development of Desktop CNC Lathe with Pipe Frame Structure

Naohiko SUZUKI, Yoshitaka MORIMOTO, Yoshiyuki KANEKO, Kenichi HIROSAKI and Yuichi OKAZAKI

(Takamatsu Machinery Co., Ltd.)

J. JSPE, Vol. 85, No. 2, pp. 189-196

While many components used in automobiles, household electric appliances, etc., are becoming more compact, the size of most machine tools used for machining such components remains unchanged. Therefore, to improve the efficient use of factory space and economical use of energy, machine tools are required to be compact adopting to the size of workpieces. Therefore, in spite of the many requirements of the market related to the miniaturization of machine tools, a miniaturized NC machine tool has not been widely regarded. The conventional structure of machine tools such as a cast body or welded steel plate body is recognized as being the best. This preconception is one of the obstacles to solving this problem. We have developed a new CNC lathe with a pipe frame structure. This structure is expected to enable the miniaturization of machine tools while ensuring sufficient space for the discharge of cutting chips. In this structure, the heat transfer between the pipe elements and connecting blocks strongly affects the axial displacement of the pipes. In this paper, we investigated fundamental performance of the developed lathe, and machined workpieces precision by comparing those of conventional lathes.

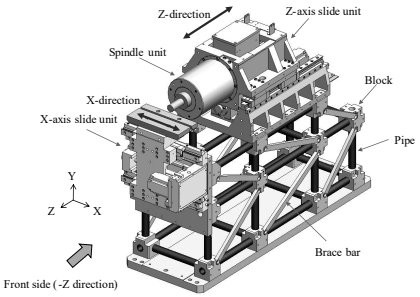

Fig. 3. Structure of newly developed pipe frame CNC lathe.

2. Application of a Novel Woven Metal Wire Tool with Electrodeposited Diamond Grains for Carbon Fiber Reinforced Plastics Core Drilling

Koki SUZUKI, Rei KOYASU, Yukihisa TAKEDA and Hiroyuki SASAHARA

(Heiwa Sangyo Co., Ltd.)

Precision Engineering, Vol. 56, pp. 386-394

Drilling into carbon fiber-reinforced plastics (CFRP) with conventional tools often results in defects like delamination, fiber pull-out, etc. In order to achieve high-quality CFRP hole machining, we developed a new woven metal wire tool (WMW tool) based on core drilling, with electrodeposited diamond grains. Using this tool, we conducted 20-mm diameter core drilling on a CFRP plate with grinding fluid supplied from the inner side of the WMW tool at the grinding point. The new tool also removes chips easily. The method produced high-quality holes without delamination or burr at the entry or exit at a practical feed rate of 100 and 300 mm/min. Although wear was observed on the tip of the wire mesh, new diamond grains appeared at the tip, so that the tool exhibited a self-sharpening effect. The newly developed MWM tool achieved a drastic reduction of chips and superior machined surface at the same time in CFRP drilling.

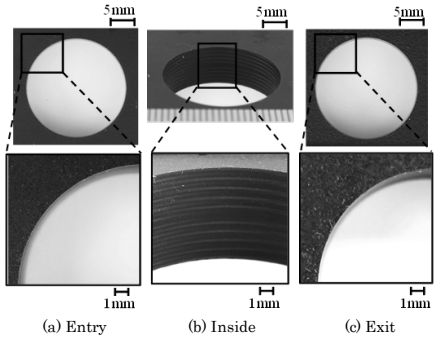

Fig. 4. Machined surface.