The Japan Society for Precision Engineering

Introduction of JSPE Numata Memorial Paper Awards 2020

This award is presented to authors who have published innovative papers in the fields of measurement, processing, and control as a reward for their efforts and dedication and to motivate them to conduct further research.

● ***Design optimization of a non-orthogonal two-axis Lloyd's mirror interferometer for fabrication of large-area two-dimensional scale gratings***

Yuki SHIMIZU, Kazuki MANO, Hiroki MURAKAMI, Shunsuke HIROTA, Hiraku MATSUKUMA and Wei GAO

Precision Engineering, Vol. 60, pp. 280-290

An optimized beam expansion assembly is newly designed for a non-orthogonal two-axis Lloyd's mirror interferometer to fabricate large-area two-dimensional (2D) diffraction scale gratings in a small-scale manufacturing facility or a research laboratory. Theoretical calculations are at first carried out to quantitatively estimate the influences of the coherence length and the Gaussian light intensity distribution of a collimated laser beam, which is projected onto a mirror-substrate assembly for the generation of interference fringe fields on a substrate.

Design optimization of the interferometer is then carried out in such a way that a beam shaper, which contributes to obtain a flat-top light intensity distribution in the collimated laser beam and is expected to reduce the amplitude deviation of the developed pattern structures as well as the pattern exposure time, is integrated into the beam expansion assembly. The feasibility of the newly developed beam expansion assembly is demonstrated through fabricating a 100mm×100mm 2D scale grating having pattern structures with uniform amplitude of approximately 500 nm and a short period of 1 μm.

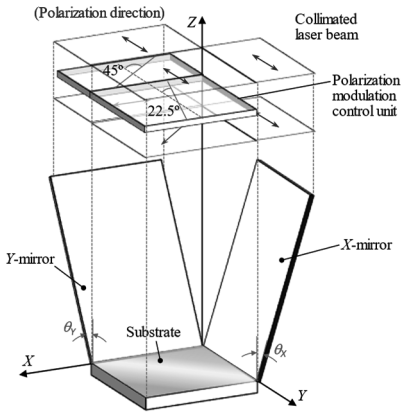

Fig. 1. Non-orthogonal type of mirror-substrate assembly for two-axis Lloyd's mirror interferometer with a polarization modulation control

● ***Influence of tool eccentricity on surface roughness in gear skiving***

Zongwei REN, Zhenglong FANG, Go KOBAYASHI, Toru KIZAKI, Naohiko SUGITA, Tsukasa NISHIKAWA, Junshi KUGO and Eiji NABATA

Precision Engineering, Vol. 63, pp. 170-176

Gear skiving is a state-of-the-art technique for machining internal gears with high efficiency. Numerical simulation method being able to analyze the eccentricity error e of cutter is critical to the understanding on the formation of surface roughness in skiving process. In this work, we proposed a novel Z-map-based numerical model to calculate the surface of gear flanks with eccentricity errors up to 9 μm. Correlation between eccentricity error and gear flank profile was clarified by numerical simulation and supported by experimental verification. The results show that the eccentricity error imposed a low-frequency motion during the generation of scallop height, leading to a surface roughness with a maximal error about four times that of the theoretical roughness. The e-induced scallop height became the majority factor account for variation of surface roughness when e exceeds 1.4 and 2.3 μm for feed rates of 0.4 and 0.8 mm/rev, respectively. The experimental result further supported the capability of proposed simulation model in providing detail surface features of gear flanks in skiving process.

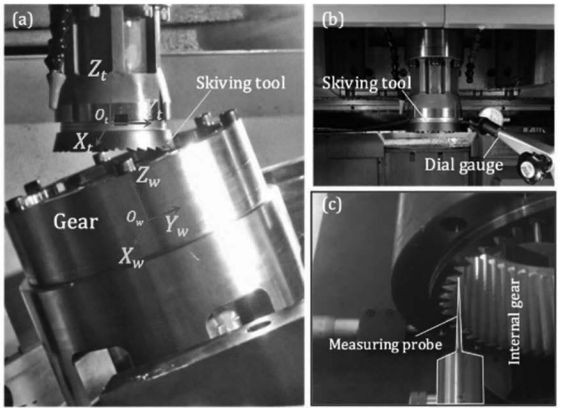

Fig. 2. Experimental setup and measurement of the internal gear

Kudan Seiwa Building, 1-5-9 Kudan-kita, Chiyoda-ku, Tokyo 102-0073, Japan
Phone: 81 3 5226 5191, Fax: 81 3 5226 5192, http://www.jspe.or.jp

Introduction of JSPE Takagi Awards 2020

This award is presented to authors who have published highly innovative papers that have high industrial values in the precision engineering field and whose content has been implemented in the industrial field, with the aim of promoting the industrial activities in the field of basic precision engineering technology.

● ***Judgement of Trafficability of Construction Machinery Based on Estimation of Soil Parameters from Spectral Images***

Shota CHIKUSHI, Norihiro YAMAUCHI, Yusuke TAMURA, Hiroshi YAMAKAWA, Keiji NAGATANI, Hiromitsu FUJII, Takumi CHIBA, Shingo YAMAMOTO, Kazuhiro CHAYAMA, Atsushi YAMASHITA and Hajime ASAMA

(Fujita Corporation)

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In the event of a disaster, unmanned construction with remotely operated construction machinery is critical for quick disaster recovery. Those machines can weight up to several tons and can easily sink on inadequate soil. Therefore, it is important to judge the trafficability of remotely operated construction machinery at a disaster site. In this research, we propose a non-contact method for judging trafficability. The proposed method classifies the soil type and estimates the water content using spectral images. The cone index is then estimated and the trafficability is judged from the cone index. As experiment, we judged the trafficability for a real construction machine using the proposed method. The results showed the effectiveness of the proposed method based on soil type classification and water content estimation.

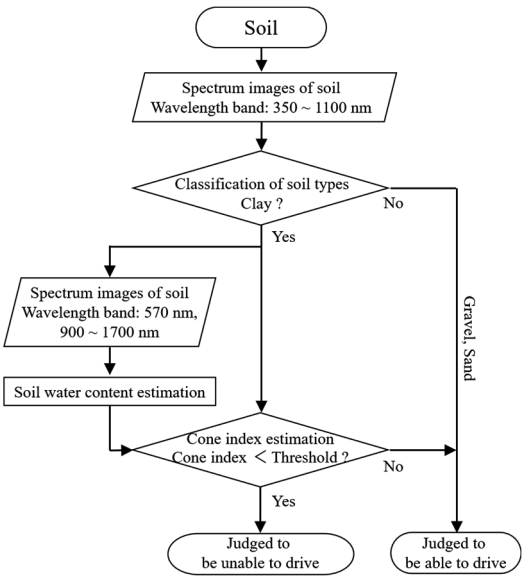

Fig. 3. Flowchart of trafficability judgment

● ***Suppression of tool damage in ultraprecision diamond machining of stainless steel by applying electron-beam-excited plasma nitriding***

Hiroshi SAITO, Hongjin JUNG, Eiji SHAMOTO, Yasuhiro HARA and Tamio HARA

(Yamagata Research Institute of Technology)

Precision Engineering, Vol. 63, pp. 126-136

Mirror surface machining of stainless steel with single-crystalline diamond tools is proposed in this study by applying a new nitriding method, called electron-beam-excited-plasma (EBEP) nitriding, to workpiece surfaces as pretreatment. It is well known that mirror surface finish of steel workpieces by conventional diamond cutting is unachievable owing to rapid tool wear. Nitriding of steel workpieces has been one of the several attempts to prevent the rapid tool wear of diamond tools. It has been reported that the rapid tool wear is caused by thermochemical interaction between diamond and steel, and that the wear can be greatly reduced by nitriding of steel. However, hard compounds formed on the outmost surfaces of workpieces by the conventional nitriding methods can cause micro-chippings of cutting tools. The authors has recently developed a new nitriding method called EBEP nitriding, in which a high dissociation rate for nitrogen molecules is achieved using the electron-beam-excited-plasma, and iron-compounds-free nitriding has been realized. Therefore, the EBEP nitriding is applied to a typical mold material, modified AISI 420 stainless steel, aiming at suppressing the micro-chippings as well as the thermochemical tool wear during diamond cutting of the stainless steel. The conventional ion nitriding and the gas nitrocarburizing are also applied to the same stainless steel in comparison. Chemical components of the nitrided workpiece surfaces are analyzed by an electron prove micro-analyzer (EPMA) and an X-ray diffraction (XRD) in advance, and turning experiments are conducted with single-crystalline diamond tools. Subsequently, changes in cutting forces and roughness of finished surfaces and tool damages after the turning experiments are evaluated. Finally, mirror surface machining by using the EBEP nitriding is demonstrated, and its advantages and disadvantages in the diamond cutting of stainless steel are summarized in comparison with the conventional nitriding methods.

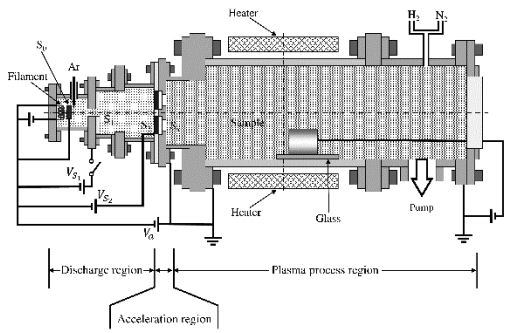

Fig. 4. Schematic drawing of electron-beam-excited plasma (EBEP) nitriding apparatus