효율적인 마이크로 버 측정시스템 개발

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Development of Effective Measurement System for Micro Burrs

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ABSTRACT

Burr is an undesirable projection as result of plastic deformation. Burr minimization and effective deburring process are required strongly to reduce the cost of the parts. In doing these efforts, the precise burr measurement must be provided for the efficient process. For this purpose the conoscopic holography sensors are selected before. However, it has been very difficult to measure micro burrs less than 10 µm due to their tiny and sharp geometries as well as the effect of ambient vibration during scanning. A new micro burr measurement system using high precision Conoprobe sensor and XY table can measure the micro burrs which is less than 10 µm. Experiments were carried out showing that micro burr around 10 µm was successfully measured and analyzed.

Key words : Micro burr, deburring, burr measurement

1. Introduction

Burr measurement methods can be classified into contact and non-contact method. In contact method, some difficulties are confronted due to the irregular and sharp shape of burr. When height gage is used for measuring burr height, plastic deformation at the tip of burr reduced the height due to the spring force in ductile materials. When stylus is used, the probe is liable to be broken due to the sharp edge of burr. In this research, non contact method are applied.

Previous experiments [2] showed that conoscopic holography method using laser is the most proper technique to measure burr whose height is less than 20 µm when compared with triangulation and interferometry methods. Our measurement system is based on this kind of sensor, Conoprobe sensor. In addition, precision XY table is used for precise scanning and a software including two modules for controlling the system and 3D visualization is developed. The software can calculate average burr height, width and the volume of the burr to be removed. In this paper, the process for building measurement devices and calculation for micro burr is introduced.

2. Development of the measurement system for micro burr

2.1. Characteristics of the conoscopic holography method

In classic holography, an interference pattern is formed between an object beam and a reference beam using a coherent light source. The object beam and the reference beam propagate within the same velocity but follow different geometrical paths. In conoscopic holography, however, the separate coherent beams are replaced by the ordinary and extraordinary components of a single beam traversing a uniaxial crystal. This produces holograms with fringe periods that can be measured precisely to determine the exact distance to the point, even with incoherent light. The conoscopic module is composed of two disc-type polarizers, uniaxial crystals between discs, and CCD as shown in Figure 1. The first polarizer disc splits the reflected beam into two orthogonal beams. Each beam passes through the birefringent medium with different velocity due to the different refraction behavior. The second polarizer merges the ordinary beam and extraordinary beam. Phase difference is caused by the difference in velocity due to the different refraction that produces the interference fringe recorded in CCD. The height of the object can be calculated by measuring the diameter of the concentric circle of the interference fringe.

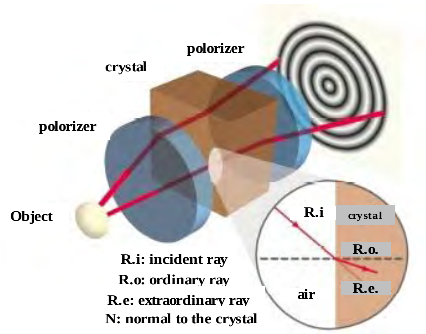

Fig. 1 Schematic illustration of conoscopic module.

In a conoscopic holography Conoprobe sensor, the objective lens can be changed according to the size of the burr. For our experiments, two kinds of lenses with 25 mm and 16 mm focal length. Beam spot size, 22μm and 3.5μm respectively, is another main factor affecting measurement accuracy.

2.2. Specification of the burr measurement system

The measurement system is composed of Conoprobe sensor, stepmotors driven XY table with high precision leadsrews (resolution 1.5 μm/step). Table controller and sensor controller and are connected to a host PC via RS-232 and LPT ports (Fig. 2).

The probe scans by taking point measurements. Each measurement is generated by a pulse from its controller. We can either define the measurement resolution in two ways, timing trigger or external trigger. In timing mode, the pulse for measurement is generated at a preset frequency, while in external signal mode, it is based on an external pulse (usually from a motor's encoder) (Fig. 3).

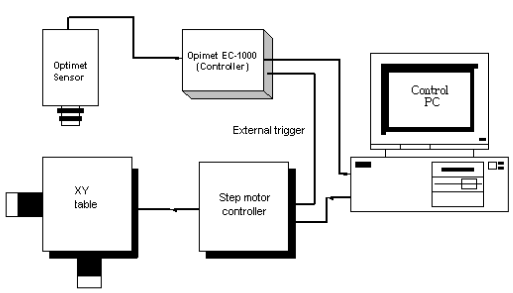

Fig. 2(a) Layout

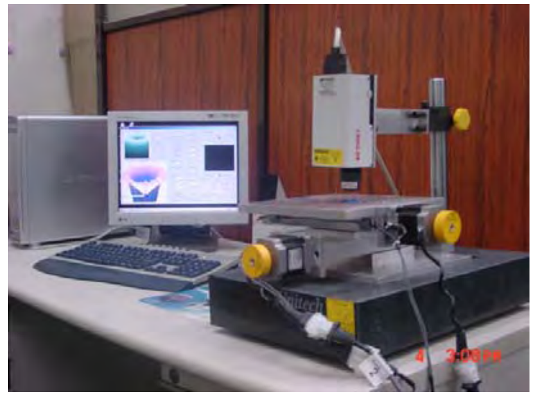

Fig. 2(b) Photograph

It's clear that measurement signal is stable only if it is taken between two consecutive step movements because vibration is smallest during that time. For this reason, timing method has disadvantages due to the relative mismatch between the sensor controller timer and that of XY table controller. In another hand, external trigger via direct connection from the table controller to the sensor controller method is prefer when accuracy is needed.

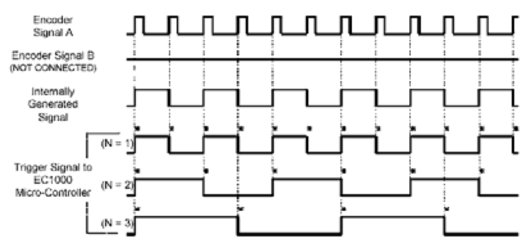

Fig. 3 External pulse from phase A of a encoder triggers measurements

Based on the controllers's API functions, the program's control module was developed on MFC so that we can define scan parameters : area, feed velocity, sampling rate… It also support functions for probe navigation, on-line display, and estimation of scanning time (Fig. 4). Burr height is measured as a z-value at each point while x,y coordinate are derived from motors' position. From the tuple (x,y,z)s of measured data, filtering and checking of the signal/noise ratio (Snr) are necessary for 3D representation. If Snr is less than 45%, the signal is considered an error due to the diffused reflection on the surface.

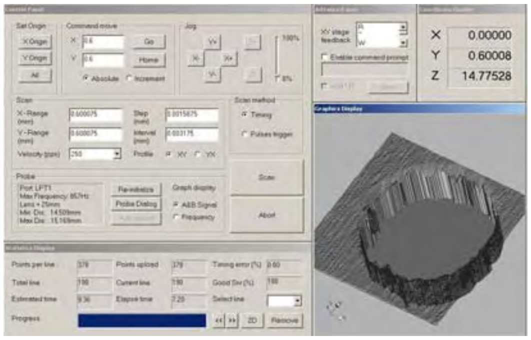

Fig. 4 Control module of the software

2.3. Visualization and analysis of burr data

The program's computation module was written using VC++ and OpenGL to visualize scan result and analyze burr geometry. Scanned surfaces are represented in color mapping 3D graphics. From the 3D image, users can create many 2D cross section views in both X and Y directions at specific locations (Fig.5)

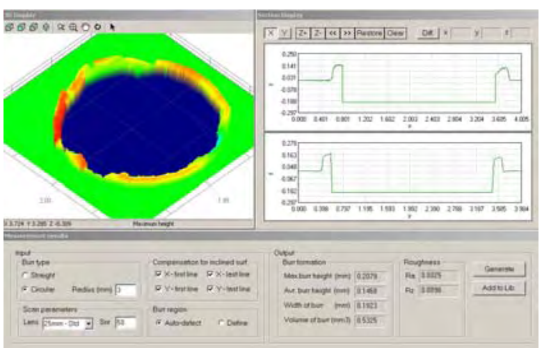

Fig. 5 Computation module of the software

To obtain reliable micro burr data the surface should be compensated before analyzing because in most cases, the workpiece couldn't be placed in absolutely horizontal plane. The function for compensating also works well on the burr formed on inclined surface. Compensation algorithm is based on Least Square Fitting [3] methods.

After compensation, the surface becomes horizontal. The point whose height is larger than the average peak roughness R_p is regarded as burr. For more accuracy, it is necessary to do computation restrictedly within the region where burr exists. This rectangular region, surrounding the hole, can either be detected automatically or defined by the user in case the surface has too many defects.

Output data of the program are maximum and average burr height, burr volume, and burr thickness which can be added into database. The average burr height and thickness will serve as useful information for deciding deburring conditions. We can also export the scanned data to .DXF or text files which can be imported to other 3rd party rendering softwares.

3. Experiments

Burrs were measured and analyzed using the developed burr measurement system. For large burr formed in drilling hole ∅3mm, standard sensor with 25mm focal length was used to scan the area of $4mm^2$. Step and interval of the scanning were 0.01mm and 0.05mm, feed rate was 800pps, scanning time was about 5 mins in timing mode. Measurement results is as shown in Fig. 5. For micro burrs less than 10μm, high definition 25mm and 16mm sensors were used in pulse triggered mode. Exprimental result on a blanking hole ∅1mm in 0.5mm thin plate with scan parameters $2mm^2$, 1.5μm, 3μm, 250pps, 15 mins respectively is shown in Fig. 6. Average burr height is 9.3 μm and width of burr is 0.05mm.

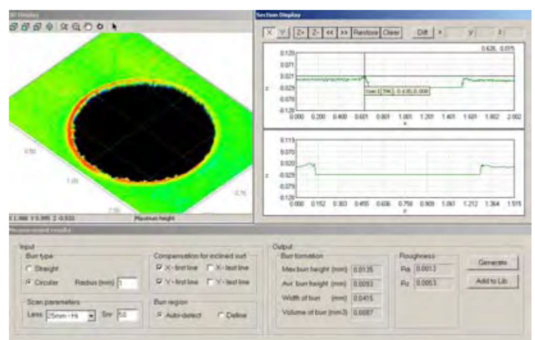

Fig. 6 Micro burr in the blanking hole ∅1mm

Another experiment is carried out on a blanking hole ∅2mm in a 0.3mm thin plate. Scan parameters are $3mm^2$, 1.5μm, 3μm, 250pps, 25 mins respectively. Average burr height is around 6μm. and burr width is 0.013mm (Fig. 7)

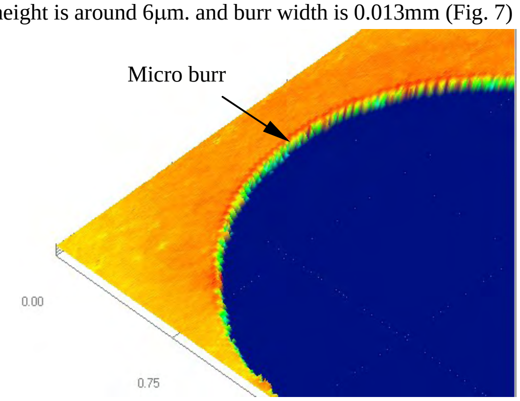

Figure 7 : Micro burr in the blanking hole ∅2mm

For other samples which have micro burr less than 4μm, the system failed to measure precisely due to the effect of residual vibration and laser beam's spot size limit. Also, new system and algorithms to detect micro burrs which has size similar to surface roughness need to be developed.

4. Conclusions

a. A burr measurement system based on conoscopic holography sensor was developed to measure micro burr automatically and analyze burr geometry. It is shown to be effective in measuring the geometry of sharp edges like micro burrs around 10μm in drilling and fine blanking .

b. A stand-alone software was developed to control the system and visualize/analyze the burr data. Control module supports fully functions for probe navigation and online graphics display. Computation module with 3D display and 2D slice cuts provides function to compensate inclined surface. The function of analysis of measured data calculates the maximum and average burr height, volume of burr and average burr thickness. These enable the determination of accurate deburring method and conditions according to the calculated burr geometry.

Acknowledgements

This work was supported by the 2001 National Research Laboratory (NRL) program (M10400288) of the Ministry of Science and Technology.

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