DEVELOPMENT OF A LASER-GUIDED DEEP-HOLE MEASUREMENT SYSTEM: ADJUSTMENT TO A SMALL SIZE

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INSTRUCTIONS
Deep holes are bored with the meter-, millimeter-, and micrometer-level diameters in engineering. Their lengths can be several tens of meters to as short as a few micrometers. Examples of holes with large 100-millimeter-level diameters and meter-level lengths are the rotation shafts of jet engines, generators, and high-speed trains; the large cylinder used in plastic injection molding; the cylindrical liners of ship engines; and cannons. Holes with normal 10-millimeter-level diameters and lengths of several hundred millimeters are used for the main spindles of machines, the small cylinder in plastic injection molding, the tube sheet for heat exchanger, and guns.

Accurate measurement of the diameter, roundness, cylindricity, and straightness of a deep hole is essential for improving the performance of products. However, existing systems have drawbacks to precisely measuring holes with large-length-to-diameter ratios, which require multiple measurement devices. In order to accurately evaluate the parameters of such deep holes with 100-millimeter-level diameters and meter-level lengths, using a single device, a laser-guided deep-hole evaluation probe was developed [1-2].
In this study, the guided system is applied to holes with normal 10-millimeter-level diameters and lengths of several hundred millimeters. A measurement system that can measure a small size hole with a diameter of 17-21 mm and length of 1,000 mm is constructed, and the performance is tested.

EXPERIMENTAL PROCEDURE

Experimental Apparatus
Figure 1 shows a measurement unit that consists of a pentaprism, corner cube prism, and stylus. Figures 2 and 3 show a measurement probe and its sectional view, respectively. The measurement unit is rotated by a DC motor through a reduction gear, coupling, and flange shaft. Figure 4 shows the deep-hole measurement system. The workpiece 2 with a length of 800 mm is fixed on a machine table. The hole wall is scanned spirally by rotating the measurement unit and feeding the workpiece. The up and down movement of the stylus is detected by a laser interferometer 4, which is placed in front of the measurement unit via the pentaprism 11 and corner cube prism 12. The laser diode 8 is located at the back end of the measurement probe in order to detect the position and inclination of the measurement unit. A laser beam reaches optical devices CCDδ 5 and CCDi 6. The position shows a hole deviation.

Experimental Procedure
The experiment is carried out under the following conditions. Rotational speed of the measurement unit \( N = 6 \text{ rpm} \), Feed of the table \( f = 5 \text{ mm/rev} \).

EXPERIMENTAL RESULTS
The measurement system can measure accuracy up to a depth of 400 mm. Figure 5(a) and (b) shows spirally scanned hole wall near a depth of 224 mm and roundness curve at a depth of 224 mm, respectively. In this experiment, the diameter of the laser beam of the laser interferometer is 2 mm. When it is changed from 2 mm to 3 mm, the system can measure depths of up to 1,000 mm.

CONCLUSION
A measurement system that can measure a small hole with a diameter of 17-21 mm and length of 1,000 mm is constructed. As a result of the performance test, it is cleared that it can be used to measure the hole accuracy.

REFERENCES