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A Parallel Error Separation Method for the On-line Measurement and Reconstruction of Cylindrical Profiles

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HIGHLIGHTS

► The first-order harmonic of roundness profile and spindle's radial error motions are separated.

► Spindle's radial and tilt error motions and probe carriage's straightness error motions are removed.

► Least squares center of the cross-section profile is determined by the outputs of the five probes.

► A curved median line of the cylinder is fitted through the least squares centers.

► Reconstruction conforming to the mathematical definition of the cylindrical profile is realized.

ABSTRACT An innovative parallel error separation technique for on-line measurement and reconstruction of cylindrical profile is presented. A five-probe system configured to target three adjacent cross sections of the cylinder is proposed to simultaneously execute the three-probe roundness error separation and three-probe straightness error separation. The curved median line is determined by fitting through the least squares centers of circular cross-sectional profiles. The cylindrical profile conforming to the mathematical definition can then be reconstructed for the cylindricity error evaluation. Theoretical analysis and numerical validation have been performed. The results verify that the spindle's radial and tilt error motions as well as the probe carriage's straightness error motions are removed, and the least squares center of each cross-sectional profile of the cylinder is accurately extracted even if the spindle's error motions are not repeatable in each rotation. This method has thoroughly solved the inherent problem in conventional multi-probe error separation techniques: the suppression of the first-order harmonic in separating the cross-sectional profile of the cylinder and the error motions of the spindle.

KEYWORDS On-line measurement; Reconstruction; Cylinder; Form error; Error separation technique

1. Introduction

Large-scale precise rollers are large structural parts in cylindrical form widely used in manufacturing to produce large-size objects, such as flat panel displays, solar cells, super calendar papers, and automobile steel sheets. The roller surface has inherent form error components, such as cylindricity error, out-of-roundness, generatrix straightness and taper angle, which are incorporated in the products, and cause