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A contact inspection system for aspheric optical components

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ABSTRACT

We construct a contact inspection system and realize low contact force and high precision measurements for aspheric optical components. The inspection and calibration principles, as well as the reliability of the system are thoroughly studied. Our investigations show that the system could provide low contact force measurement (low than 0.7 mN), fast scanning speed (2 mm/s), and high accuracy (as low as 0.5 μm), being a good option to the contact inspections of aspheric optical components.

1. Introduction

The production rate of aspheric optical components depends strongly on the inspection techniques [1]. For the contact inspection systems (CISs), the contact force, measurement speed, precision are key specifications. Currently, only few convenient CISs are available for aspheric, i.e., the Form Talysurf® (the precision is 0.3 μm, minima contact force is 0.7–1 mN, scanning speed is 0.25–2 mm/s) [2] and Panasonic UA3P® (i.e., for UA3P-4, the precision is 0.05 μm, contact force is 0.15–0.3 mN, scanning speed is 0.01–10 mm/s), the coordinate measuring machine (CMM) (CMM measurement speed is 4–5s/dot, precision is 3–5 μm, contact force is 0.1–0.3 N) [3–5], and the length gauge profiles (LGP) (minima contact force is 0.75N, precision is 1–2 μm, speed even more slow than other two systems) [5] [6]. Typically, for industrial applications, CMM and LGP can hardly meet the requirements of high precision measurements, while other high precision systems (i.e.,UA3 P or Form Talysurf) are still with high costs.

A low cost system with desired specifications (high precision, low contact force and fast inspection speed) for aspheric fabrication is therefore strongly preferred [7]. In this work, using the lever principle, we realized a contact inspection system for aspheric with very low contact force, fast scanning speed and high measurement precision. Our initial studies show that this system is feasible and might have huge application potentials in this area.

2. Principles

The principles of our system are shown in Fig. 1a. It consists of a probe (made by ruby, the probe is fixed on a rail so that it can move along the horizontal direction); a measuring pole (with an arc optical grating); an adjusting nut for the contact force between the probe and testing component; an air bearing and a grating reader. The fabricated system is shown in Fig. 1b.

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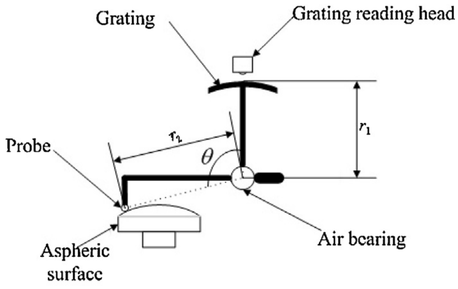

(a)

(b)

Fig. 1. (a) Schematic drawing of the system; (b) The fabricated system.

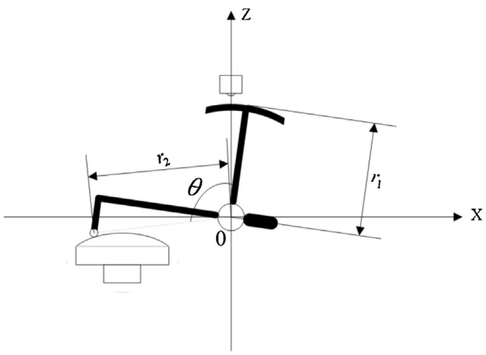

Fig. 2. The coordinate system used for the mathematical model.

The measurement procedures are as follows: (1) at the beginning, by moving the horizontal rail, let the probe apex (needle) contact with the left edge of the component under testing (Fig. 1a and b); (2) Then, we start to determine the center of testing component, by tuning the adjusting gear on the platform and making the reading of apex minima (convex) or maximum (concave); Note that this step should be repeated until the center is found;(3) As long as the center and left edge are determined, we start to move the horizontal rail toward the right direction at a constant speed, until the probe needle is moved to the rightmost side of the component. During the movement of the probe, a data collection card with the function of synchronous latch is used to simultaneously record the current position of rail x_i and the reading of measuring grating z_i. Note that the zero position of the grating is defined as the center of the arc surface. Therefore, the reading data (x_i,z_i) includes the profile information of the component under testing.

3. Measuring model

A coordinate system shown in Fig. 2 is employed to set up the measuring model. The original point is selected as the central rotating point of the air bearing when the horizontal rail is located at the zero point; the Z axis is defined as the line that connecting the central rotating point of air bearing and the zero point of arc grating surface (Fig. 2); X axis is along the right direction as indicated in the Figure. When the grating reading is z_i, the probe rotates an angle of $\theta_i = z_i/r_1$, where r_1 is