Automatic Centring and Bonding of Lenses

Stefan Krey*, J. Heinisch, E. Dumitrescu
TRIOPTICS GmbH, Hafenstrasse 35 – 39, D-22880 Wedel, Germany

ABSTRACT

We present an automatic bonding station which is able to center and bond individual lenses or doublets to a barrel with sub micron centring accuracy. The complete manufacturing cycle includes the glue dispensing and UV curing. During the process the state of centring is continuously controlled by the vision software, and the final result is recorded to a file for process statistics. Simple pass or fail results are displayed to the operator at the end of the process.

Keywords: lens, automatic centring, automatic bonding

1. INTRODUCTION

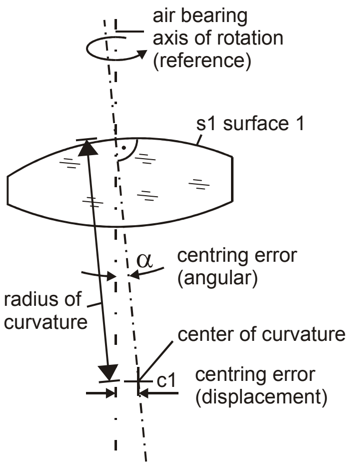

Figure 1: Definition of a centring error with respect to a reference axis.

Modern consumer oriented objective lenses rely more and more on glue bonded components which save space and weight due to the abandonment of bulky screwed retaining rings. Glue bonding is especially suitable for the automatic centring and mounting of lenses since the mechanical forces to the lens are small and predictable. Although automated glue bonding is an established technology in assembly lines, it is not yet very often used in combination with lens centring. In contrast, low-cost consumer optics as well as precision optics mostly consist of tightly toleranced individual parts which can be mounted without any further alignment. However, if the bonding is combined with an automatic centring process the costly pre-centring of the individual lenses can be avoided, making the fabrication process much cheaper.

This paper describes the bonding of a lens or a doublet into a lens barrel which might be an objective lens housing or the housing of a sub-assembly of a group of lenses. For this purpose the lens barrel is precisely centered to the rotation axis of an air bearing using a precision self centring chuck[1]. During the rotation of the air bearing the centring error of the lens inside the barrel is measured with an autocollimation telescope. The autocollimation telescope measures the surface tilt angle of the top lens surface according to the ISO standard[2]. When the centring error is determined a piezo pusher shifts the lens to reduce this error below a certain threshold value. If this is achieved, an UV light source is switched on to cure the glue which has been put around the lens. To our knowledge this is the only machine of its kind that fully accomplishes this task of automatic centring and bonding a lens to a barrel.

The definition of the centring error relative to a defined reference axis according to ISO[2] is illustrated in Fig. 1. The reference axis is given by the very stable axis of rotation of an air bearing. The lens barrel is aligned to this axis, so that the axial and radial run-out errors are below a certain value, usually less than 1..2 μm. This can be repeatedly accomplished using a precision self centring chuck which clamps the lens barrel at a reference surface. The centring error is measured in a standard way with the autocollimation telescope and an additional focusing lens that focuses into the center of curvature c1 of the top lens surface s1.

2. INSTRUMENT DESCRIPTION

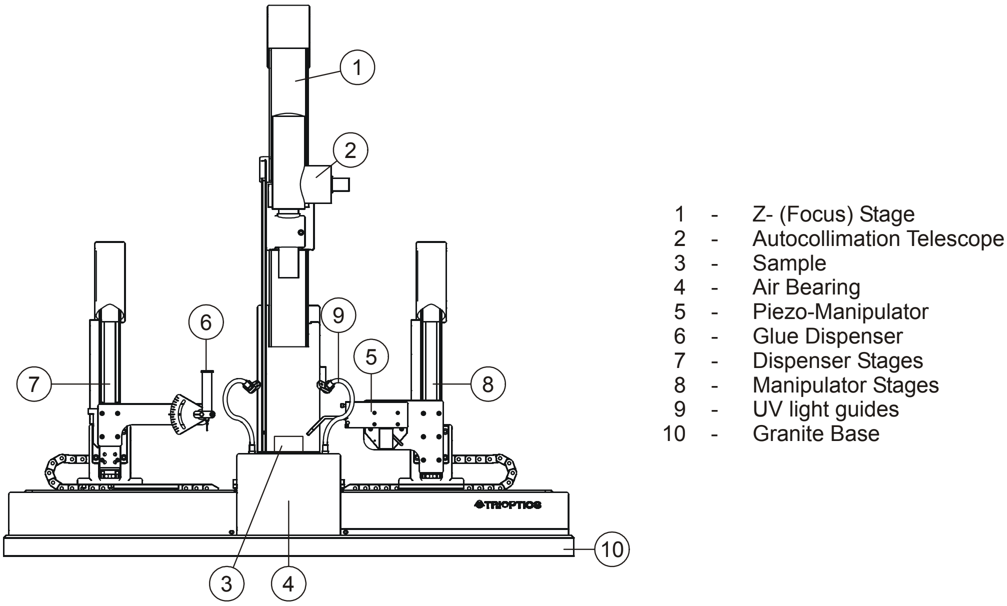

Figure 2: Drawing of the main components of the bonding station.

The complete centring and bonding station is shown in Fig. 2. The measurement of the centring error is done with the autocollimation telescope (2). It is mounted to a motorized vertical stage (1) for focusing to the lens' center of curvature. The sample is clamped inside a precision self centring chuck (3) which is mounted on top of the air bearing (4). These components build up a standard TRIOPTICS OptiCentric® system for measuring centring errors. Attached to it are two similar 2-axis stages (7) and (8) that are used for moving the glue dispenser (6) or the piezo pusher (5) to the sample. These stages consist of a horizontal and a vertical linear guide operated by stepper motors. The instrument is mounted on a stable granite base isolated from the ground by air dampers. The centring and bonding station is controlled by a standard personal computer with an integrated software package that automates the complete bonding process. The dispensing time is controlled with msec accuracy for repeatable gluing results.

3. BONDING PROCESS

All components of the centring and bonding station are operated from the control software. The software uses a batch command language to control the stage positioning, glue dispensing, lens alignment and UV curing. A teach-in procedure allows the easy programming of all positioning steps. The basic alignment process using a single-axis piezo pusher is illustrated in Fig. 3. A single axis alignment procedure was chosen as the most flexible setup for a large variety of different lens and barrel combinations. After performing a centring measurement, the software displays the surface reflex image of a crosshair reticle and the target center position. A vector displays the direction of the centring error and its length is a measure for the magnitude. For the alignment the software rotates the sample so that the vector is directed towards the pushing piezo tip. The piezo tip is then moved forward to the lens until a slight position change of the reticle image is noticed by the software. This touching position and the resulting centring error are taken as start values. The piezo then pushes the lens forward for reducing the centring error. Due to the microscopic friction situation between lens and barrel it might happen that the lens does not move directly to the center target but in a different direction. So usually one or two additional correction steps have to be made depending on the quality of lens and barrel. A centring tolerance of 5 µm typically requires only one correction step. When lowering the allowed tolerance to 3 µm usually 2-3 retries are necessary. Sub-micron centering errors could be repeatedly achieved when setting the allowed number of retries to 8. The overall cycle time for a centring process is typically between 90 and 120 seconds including manual loading and unloading of the sample. This speed could be increased when the lens is moved directly to the centered position. However this would require a 2-axis piezo manipulator and a more complex and less universal grabber which is able to hold the lens during alignment.

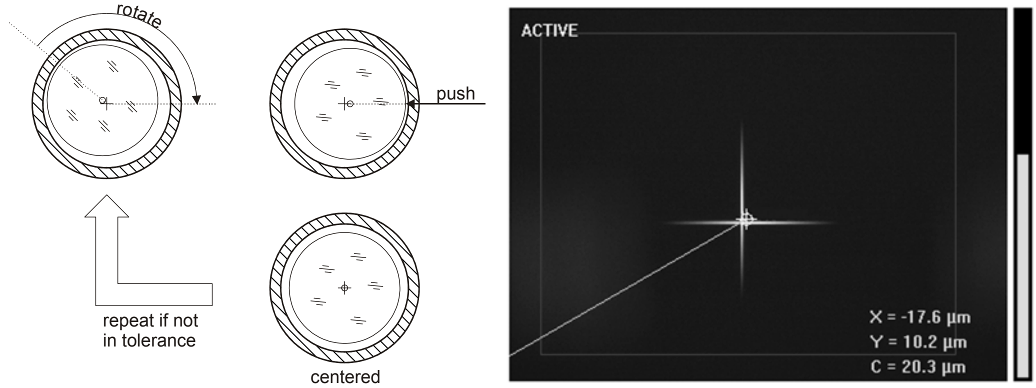

Figure 3: Left: principle of lens alignment using a single-axis pusher. Right: Camera image of the autocollimator showing surface reflex, vector of centring error, and x-, y- and total centring error values in microns.

A typical alignment and bonding process consists of the following steps. I. The barrel with the loose lens is inserted into the self centring chuck, II. The dispenser moves forward to the lens until the dispensing needle has about 1/10 mm distance from the gluing position. III. The glue dispensing is started for one complete sample revolution. Some adjustable extra time compensates for the pressure build-up time in the dispenser. IV. The dispenser moves away. V. The piezo-pusher moves to the lens until its tip is about 0.1..0.3 mm away from the lens edge. VI. A centring error measurement is performed by focusing the autocollimation telescope to the surface's center of curvature and by doing one sample revolution. VII. The alignment process is started. VIII. If the residual centring error is below a defined threshold, the piezo pusher is removed. IX. The UV light source is switched on for curing the glue while the sample rotates. X. A final centring measurement is made for storing the bonding result in a certificate. Thanks to the flexible batch programming, the routine can be also programmed in a way that the lens is first centered without glue and the glue is put around the lens afterwards. Figure 4 further illustrates the centring and bonding process for a non-centered lens to the lens barrel.

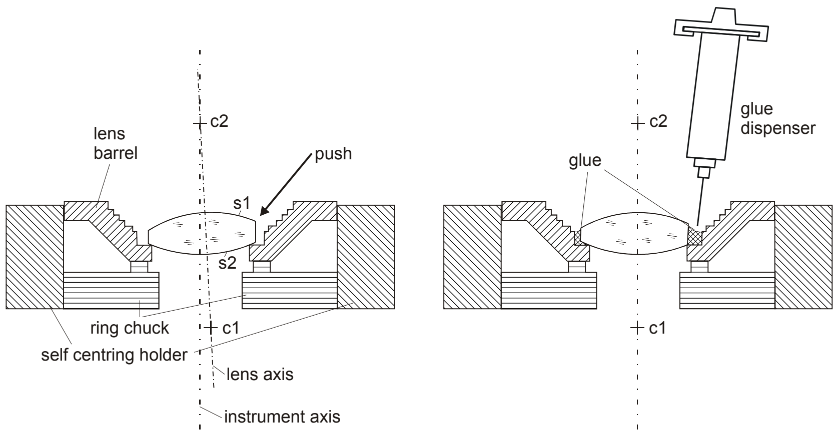

Figure 4: Principle of aligning a non centered lens to a lens barrel. Left: Lens axis is not aligned to the reference (=instrument) axis. Right: Lens axis is aligned and bonded to the barrel. The coincidence of the barrel axis with the instrument axis is realized by an accurate alignment of the self centring holder to the supporting air bearing.

REFERENCES

1. Schunk precision self centring chuck – http://www.schunk.com
2. ISO 10110-6:1996, Optics and optical instruments – Centring tolerances