TRIOPTICS

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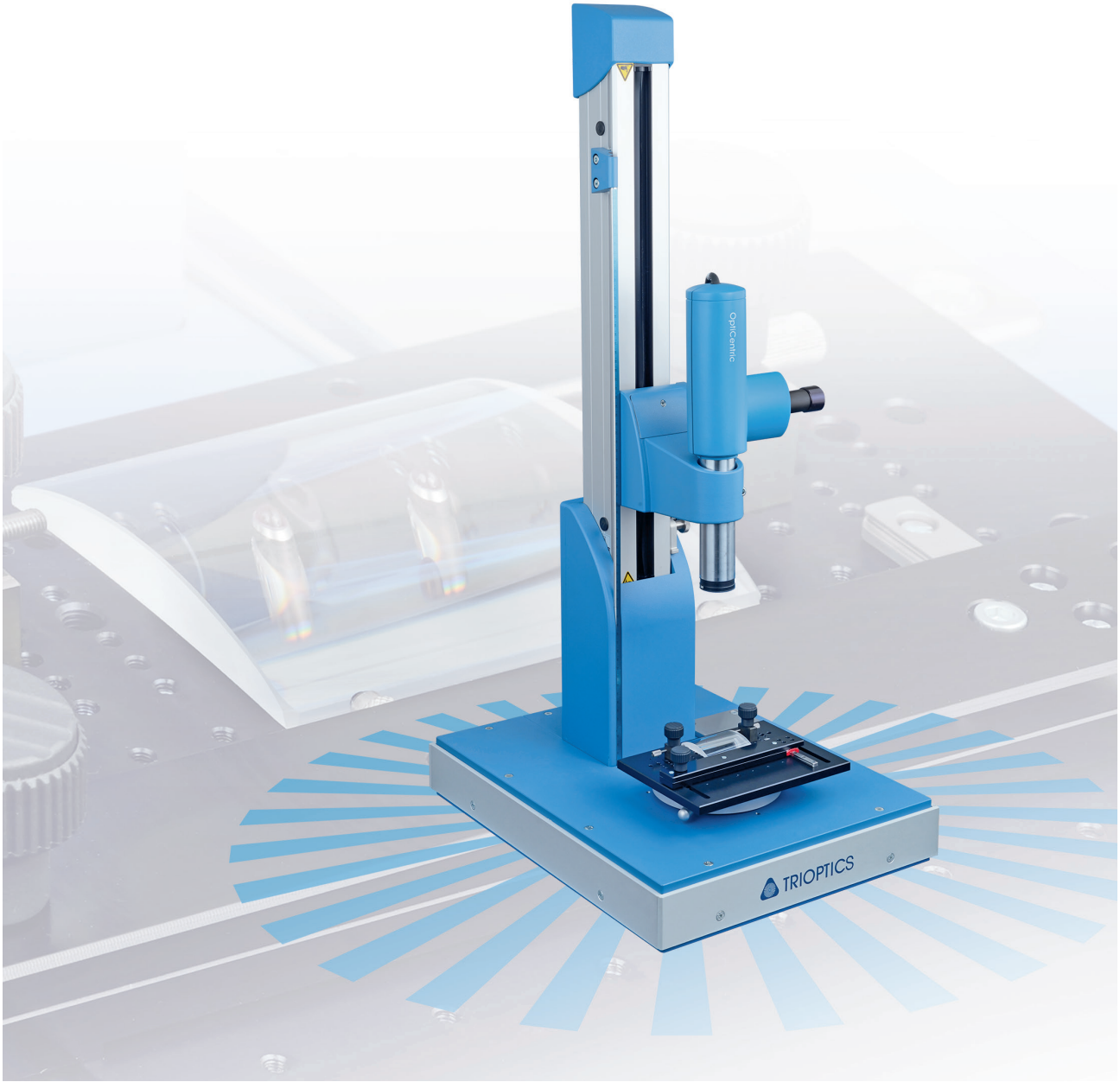
Measurement of Cylinder Lenses: Contact-Free Flexible and Fast with

OptiCentric®



OptiTest

OptiSpheric

OptiCentric

OptiAngle

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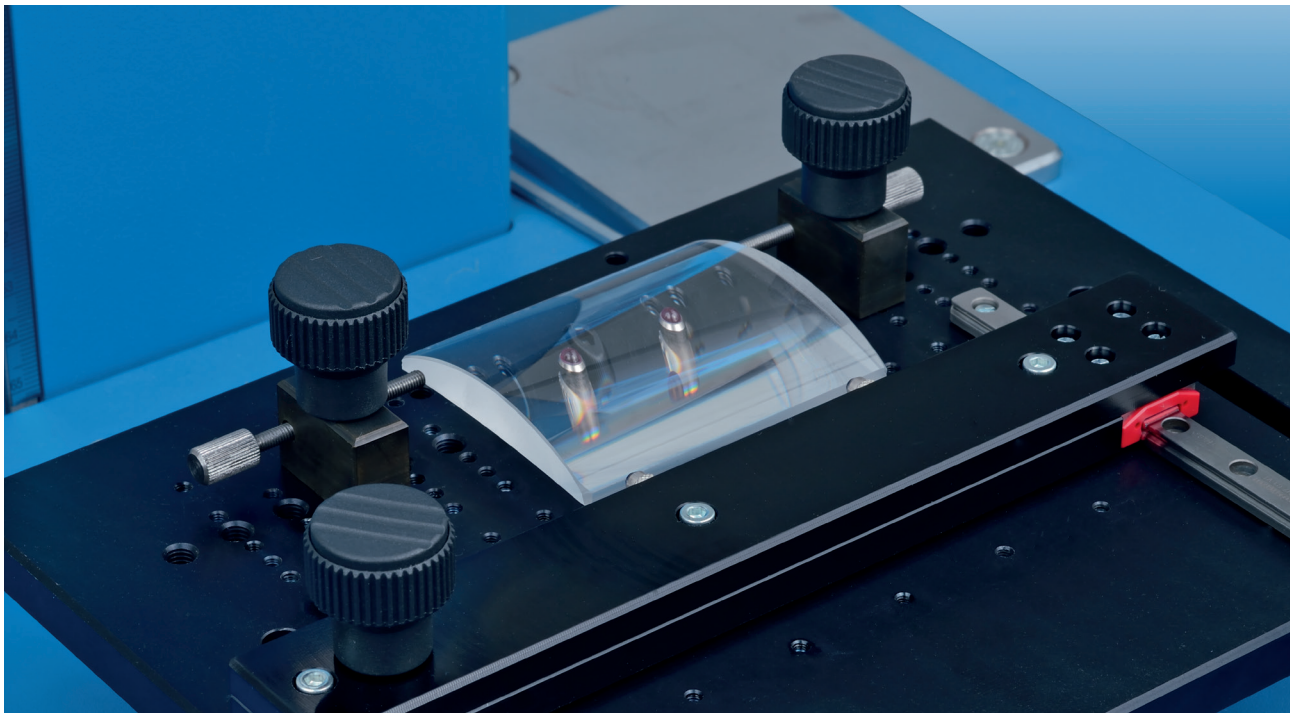


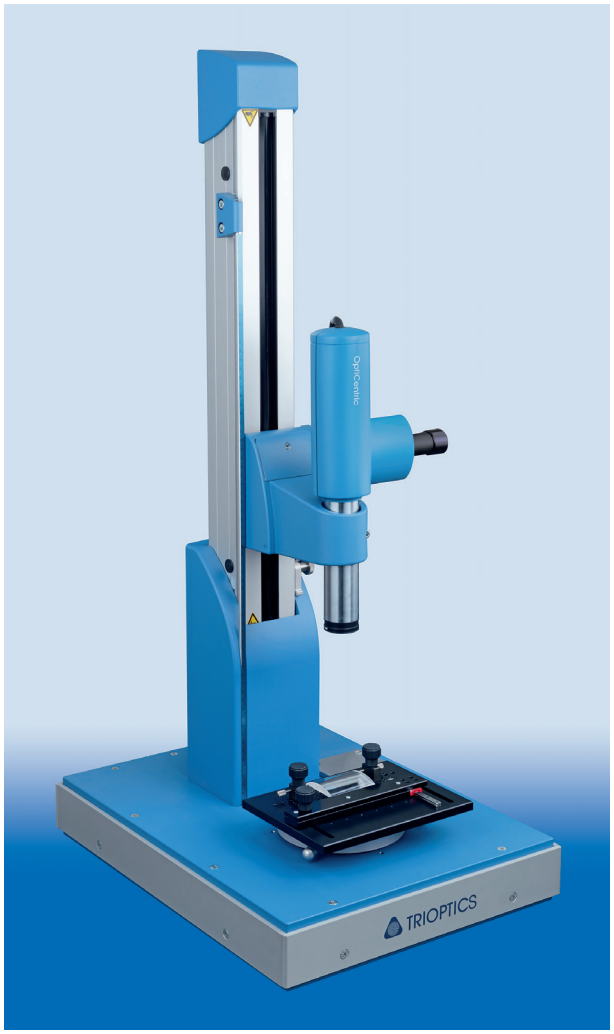
OptiCentric® Systems for Cylinder Lenses

Contactless, Flexible and Fast

OptiCentric® measurement systems are global leaders in centration measurement of single lenses and complex lens system. Many do not know that OptiCentric® systems are also capable of measuring cylinder lenses.

Although, their advantages become obvious, when compared to tactile measurements that are commonly used for cylinder lenses:

Whether it be wedge, angle or centering errors of a cylinder lens that are to be determined, there is only one compact OptiCentric® system needed to measure these and further parameters more quickly and exactly than with systems established on the market.



OptiCentric® 100 measuring a cylinder lens

Since cylinder lenses are manufactured in various designs - they vary in their surface and footprint -, a measurement system must be flexibly adjustable to the different designs.

OptiCentric® has been successful in coping with this metrological challenge by means of the CylinderCheck module. This extension for OptiCentric® particularly adapted to cylinder lenses consists of a software update and a sample holder for cylinder lenses. The stable and highly precise designed sample holder is flexibly adjustable to the various forms of samples and measuring tasks.

Generally, OptiCentric® systems are designed modularly and are flexibly adjustable to the respective measuring task. Please read our OptiCentric® product brochure for further information about products of the OptiCentric® series.

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Characteristic Features of Cylinder Lenses

The challenges associated with the measuring of cylinder lenses lies in the various forms in which lenses are manufactured. They vary in their surface and footprint as well as their mount type.

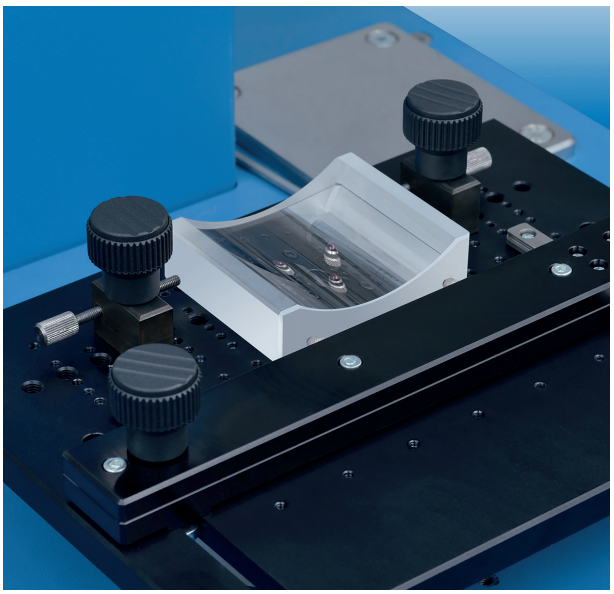
The forms relevant to the field of measurement technology are listed in the following section.

Characteristic Forms of Cylinder lenses

Just as spherical lenses, cylinder lenses are roughly divided into categories according to their two optical surfaces. The following types of lenses can be distinguished:

- Cylindrical – flat
- Cylindrical – spherical
- Cylindrical – cylindrical

Mostly, cylindrical lenses are used that are flatly processed on one side, also because cylindrical flat lenses can be metrologically characterized much easier. However, also other forms of cylinder lenses as well as lenses can be measured with the OptiCentric® systems. Since cylinder lenses do not possess a rotational symmetry around an axis, the outer contour of the lens is often not rotationally symmetric. Thus, they can be further divided into:


Cylinder lens on holder

- Lenses with a square footprint
- Lenses with a round footprint

Upon every measurement, the specific lens type plays a crucial role. Depending on the design of the cylinder lens and the measuring task, various sensors and evaluation programs must be implemented to check the accuracy with which the lenses were manufactured. Essentially, all kinds of cylinder lenses can be measured with the OptiCentric® systems.

For a description of the centering error of cylindrical lenses a reference axis must be chosen. This can, for example, be the reference edge at the lens or a chamfer on a mechanical mount, into which the lens was inserted. Therefore, the mount is another distinctive feature by which a cylinder lens can be classified

- Unmounted lens
- Mounted lens

Metrological Challenges Associated with the Measuring of Cylinder Lenses

Due to the asymmetry of cylindrical surfaces, quality tests of cylinder lenses are considerably more complicated than those of spherical lenses. The center of curvature of a spherical surface is clearly defined by its position that can be easily determined.

However, a cylindrical lens surface shows a radius of curvature only in one direction. In the case of cylinder surfaces, the center of curvature characteristic for spherical surfaces therefore represents a line – here called cylinder axis. This is one reason why the measurement of cylinder surfaces is more complicated than

the measurement of spherical lenses. For the evaluation of this cylinder axis, not only its position, but also its alignment must be measured.

In the direction of the uncurved lens surface, a cylinder surface reacts just like a plane surface. Therefore, not only errors known from spherical lenses occur during the complete characterization of all attributes of cylinder lenses, but also typical errors known from plane optics. These lens attributes increase the metrological complexity.

For a better demonstration of the characteristic features of cylinder lenses, the position of the cylinder axis is generally referred to as apex line. This line corresponds to the cylinder axis projected along the optical axis on the lens surface.

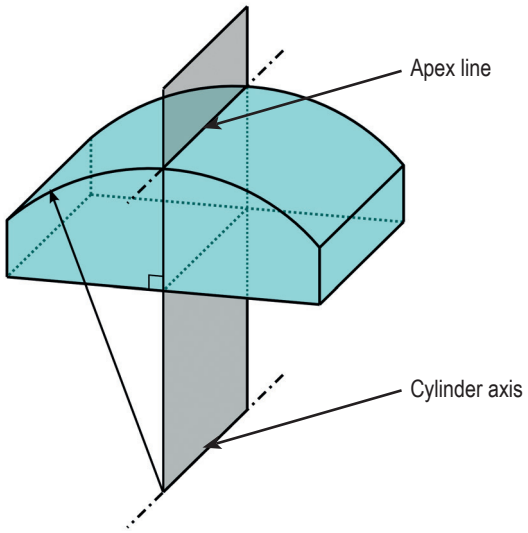


Fig. 1: Typical parameters of a cylinder lens

Measurement Principle of OptiCentric® Systems

The precise centration and alignment of a lens is decisive for the image quality of the optical system. A centration is incorrect, when the optical axis is not in accordance with the reference axis with regard to position and direction. Additionally, centration errors occur during cementing, adjusting and mounting of lenses. Therefore, the high requirements to optical systems are optimally fulfilled, when all steps concerning production have a common concept and are integrated in a measurement and production system.

Therefore, the basics of centration measurement are introduced in the following section.

Centration Measurement Spherical Lenses in Reflection and Transmission

A prerequisite for the measurement of a lens is its precise alignment to a reference axis. This axis usually corresponds to the rotation axis and is decisive for a precise centration measurement.

Furthermore, the centration of a lens can be measured according to two different methods. These are measuring in reflection and transmission. Since cylinder lenses are exclusively measured in reflection, only this measuring method will be explained in the following.

Centration Measurement of Spherical Lenses in Reflection

For the measurement in reflection, an OptiCentric® system is used that is equipped with an autocollimator measurement head with reticle and a corresponding head lens.

For the measurement, the measurement head with a corresponding head lens is focused on the center of curvature of the lens surface to be examined. The reflected image of the ret-

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icle is observed by a CCD camera integrated in the measurement head and evaluated by means of the software.

If a centration error occurs, the image shows a circle, while the sample rotates around the reference axis. The center of the mentioned circle lies on the reference axis. The radius of the circle is proportional to the centration error and indicates the distance to the radios of curvature. If the centration error is to be described as an angle, it is generally referred to as surface tilt error with regard to measurement in reflection.

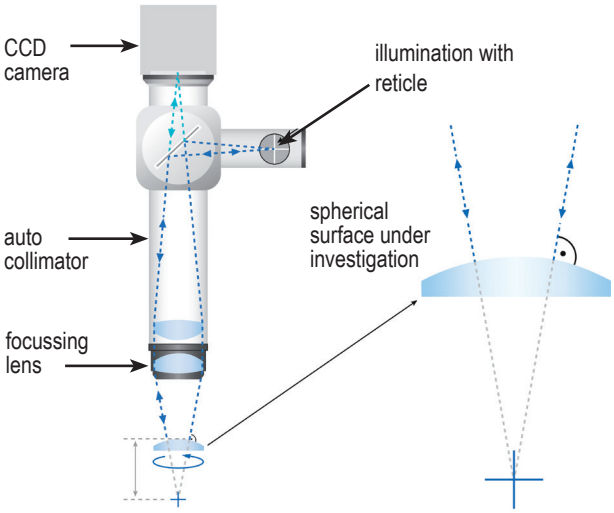


Fig. 2: Measurement in reflection

Measuring Cylinder Lenses

OptiCentric® Demonstrates its Flexibility in Application

The OptiCentric® series is not only suitable for centering tests of spheric surfaces, but also for the measurement of cylinder lenses. Due to the asymmetric geometry of cylinder lenses, it is required to measure more parameters. In some cases, this requires additional sample holders or special reticles in the autocollimator used. Therefore, several characteristic measuring tasks and the respective required OptiCentric® configuration will be shown in the following section.

A cylinder lens is positioned on a holder

Measuring Wedge Errors in Cylindrical Single Lenses

Measuring task: The wedge error between plane and cylinder surface is determined with an OptiCentric® system. The longer the chosen focal length of the autocollimator, the more exactly the measurement result will be. To place and to align the lens on the OptiCentric® system, the TRIOPTICS sample holder for cylinder lenses is used.

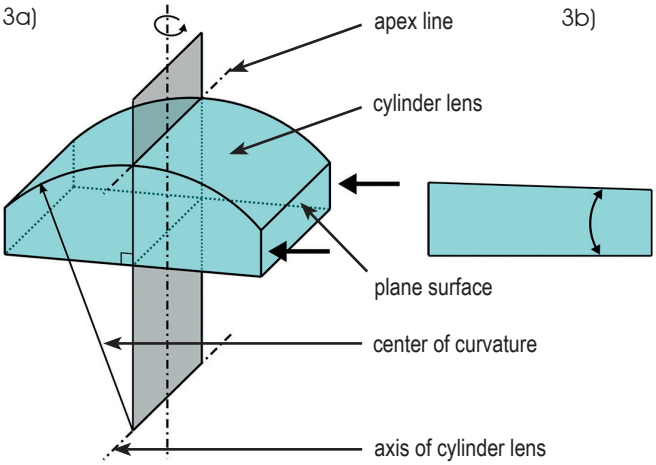


Fig. 3a: Cylinder lens with a wedge error between plane and cylinder surface; Fig. 3b: Side view

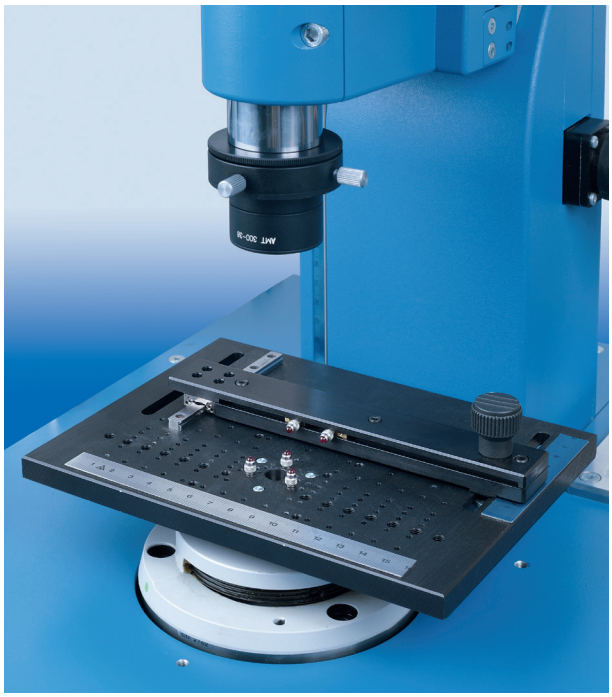
Measurement: For the measurement, the sample holder with the cylinder lens is coarsely aligned under the autocollimator of the OptiCentric® instruments. The cylindrical single lens is then measured with collimated light.

To determine the wedge error of the lens, the parallel beam path of the unfocused autocollimator is directed to the cylinder surface. Two reflexes become visible on the camera image; one from the front and one from the back side of the lens. The wedge angle between the front and the rear lens surface can be concluded from the distance between the two reflexes.

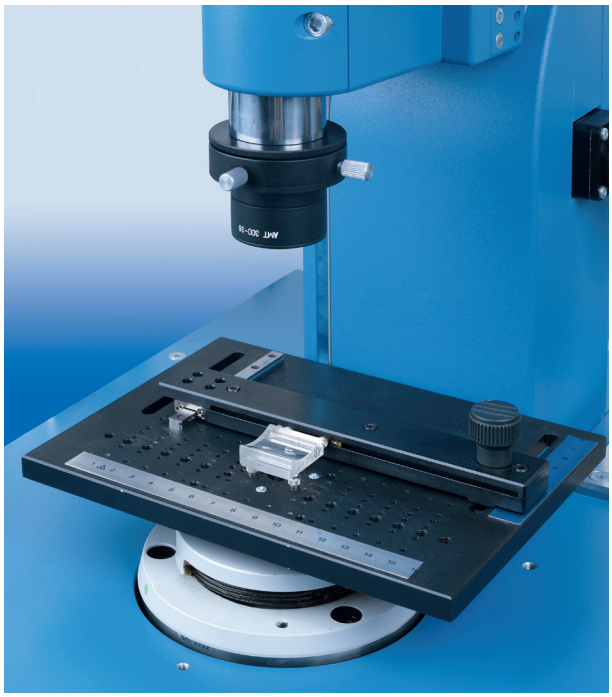
Advantages of the measurement: Through the use of an autocollimator with a long focal length, a high measurement accuracy of the wedge angle is achieved. The measurement is tolerant to small misalignments and measuring speed is very high, since the autocollimator does not have to be moved between the measurements.

Measurement accuracy depends on the focal length of the autocollimator used. An autocollimator with a middle focal length makes it possible to reliably determine the wedge angle to 3°.

Recommended OptiCentric® systems: OptiCentric® 100, OptiCentric® 300 depending on the respective size of the sample holder. Each measurement system comprises a sample holder for cylinder lenses and a software package for measuring cylinder lenses.



Holder for cylinder lenses



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Measuring the Distance between the Apex Line and a Reference Edge on Square Cylindrical Single Lenses

Measuring task: The distance between the apex line and a reference edge is determined with an OptiCentric® measurement system. This measurement is also referred to as centration error measurement on cylinder lenses.

For the measurement, the OptiCentic® measurement system focuses on the cylinder axis. The camera image on the screen shows the cylinder axis, whose position is evaluated.

The lens is then rotated by 180°, so that the edge facing the reference edge is in contact with the ruby balls. The position of the shown cylinder axis is evaluated once again. The distance between the apex line and the reference edge is determined by the given width of the lens and the measured positions of the cylinder axis.

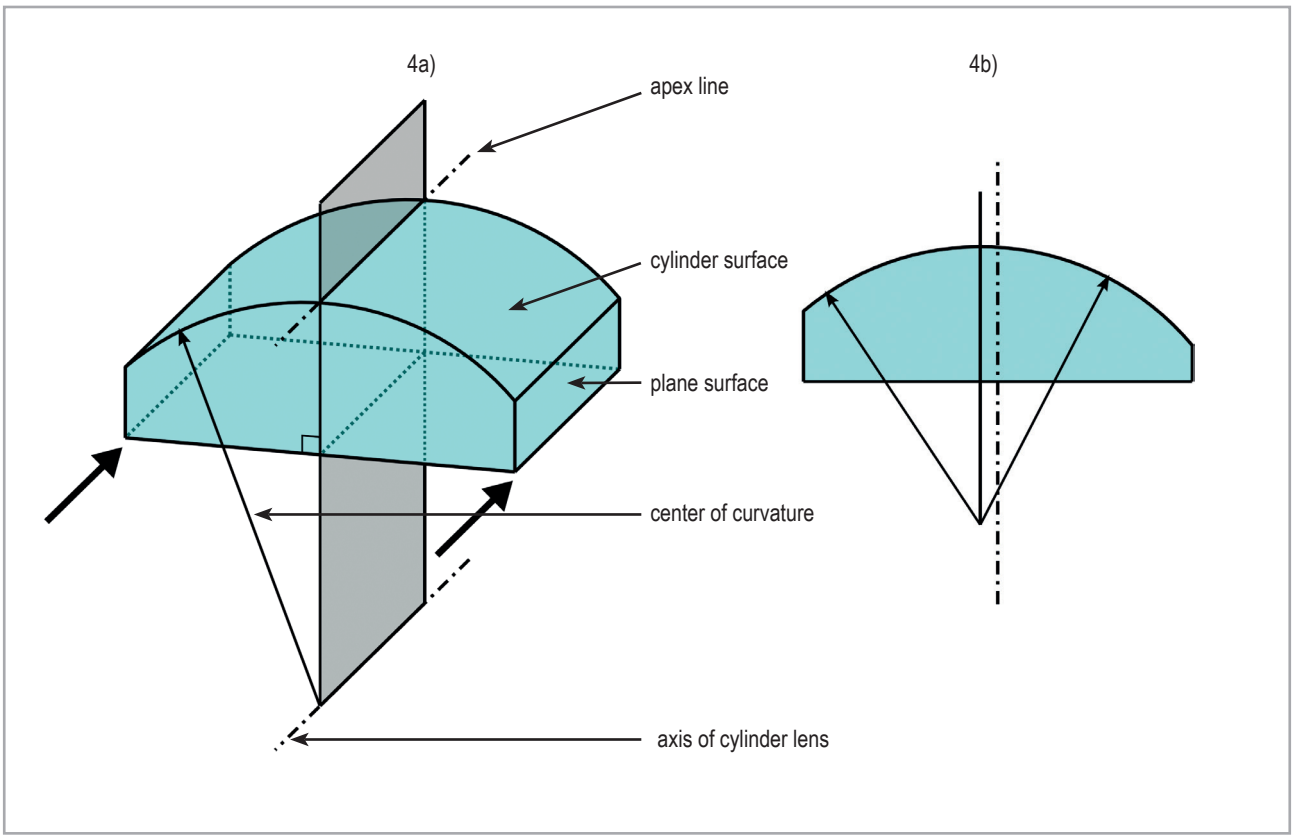

Fig. 4a: Measuring the distance between the apex line and a reference edge; Fig. 4b: Side view, vertical axis through the cylinder axis and plane surface deviates from the symmetry axis.

Measurement: A sample holder set on the standard interface of the OptiCentric® instruments is required for measuring the distance between the apex line and a reference axis. At the same time, the cylindrical lens is positioned on three ruby balls with its plane surface and aligned to two ruby balls with its reference edge.

Advantages of the measurement: Measurement is carried out manually and can therefore be used variably for a wide range of cylinder lenses. Since the existing standard interface is used for the sample holder, it is possible to upgrade an existing system.

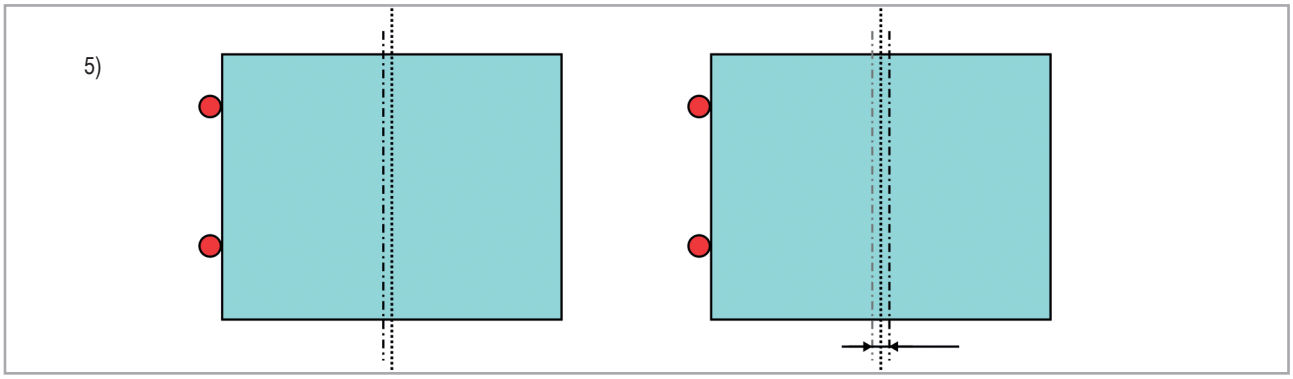

Fig. 5: Measuring the distance between the apex line and a reference edge on the CylinderCheck module (the red points are the strokes of the CylinderCheck module from the ruby balls/ the dotted line is the center of the cylinder lens / the shorter line are the measured cylinder axes)

Recommended OptiCentric® systems: OptiCentric® 100, OptiCentric® 300 depending on the respective diameter of the sample holder. Each measurement system comprises a sample holder for cylinder lenses and a software package for measuring cylinder lenses.

Measuring the Angle between the Apex Line and a Reference Edge of a Square Cylindrical Single Lens

Measuring task: The angle between the apex line and a reference edge of a cylinder lens is determined with an OptiCentric® system.

Measurement: Measurement is performed with the same sample holder used for centration error measurement. For this purpose, the distance from apex line to reference edge is successively measured from two separate positions. The angle between the apex line and the reference edge can be concluded from the deviation in the distance of apex line measured from the two positions.

Alternatively, a sample can also be positioned on a motorized linear air bearing. If the sample is moved, the position can be determined spatially resolved via the distance sensor. This

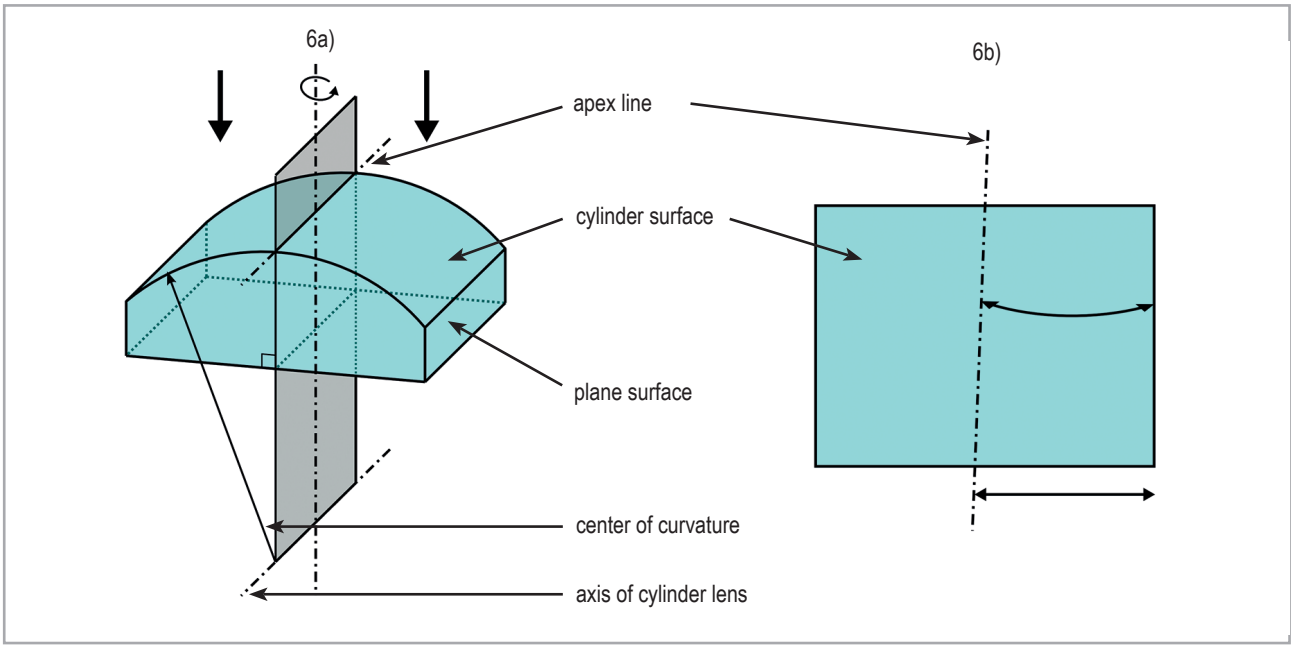

Fig. 6a: Measuring the angle between apex line and reference edge; Fig. 6b: Top view, apex line and reference edge do not run parallel to each other

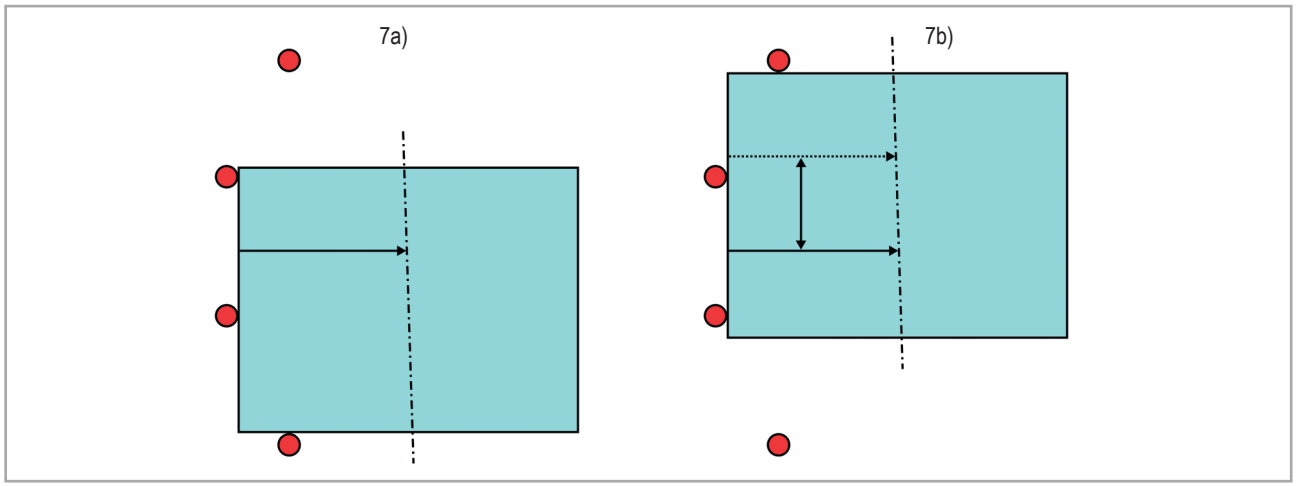

Fig. 7: Two measurements are carried out. The position of the cylinder axis is first measured from one and then from another position. The angle between the cylinder axis and the lateral lay-on edge is measured from the distance of the measured positions and the distance of the strokes.

means that an existing curvature of the cylinder axis can be determined.

Advantages of the measurement: Measurement is carried out manually and can therefore be used variably for a wide range of cylinder lenses. Since an existing standard interface is used for the sample holder, it is possible to upgrade an existing system with a sample holder and software.

Recommended OptiCentric® systems: OptiCentric®100, OptiCentric® 300. Each measurement system comprises a sample holder for cylinder lenses and a software package for measuring cylinder lenses. As a matter of course, it is possible to upgrade an existing system.

OptiCentric® 100 while measuring a cylinder lens

Measuring Double Cylindrical Single Lenses

Measuring task: Measuring the relative angle of rotation (azimuth) between the upper and bottom side of the double cylindrical lens. For this measuring task, an OptiCentric® Dual system with a point-shaped light will be used. It possesses two calibrated measurement heads, so that the upper and bottom side of a lens can be measured simultaneously.

Measurement: A prerequisite for this measurement is the calibration of the angle of rotation between the two autocollimators, i.e. the angle of rotation of the autocollimator reticle crosses are defined to each other. This calibration is carried out without a head lens.

Subsequently, the head lenses are inserted and the lens is positioned on its holder. The measurement is now carried out by evaluating the angle of rotation of the reflexes of the cylinder axes to each other. The measurement can be used for lenses whose cylinder surface is rotated by 90° to each other as well as for cylinder lenses whose cylinder surfaces are not rotated against each other.

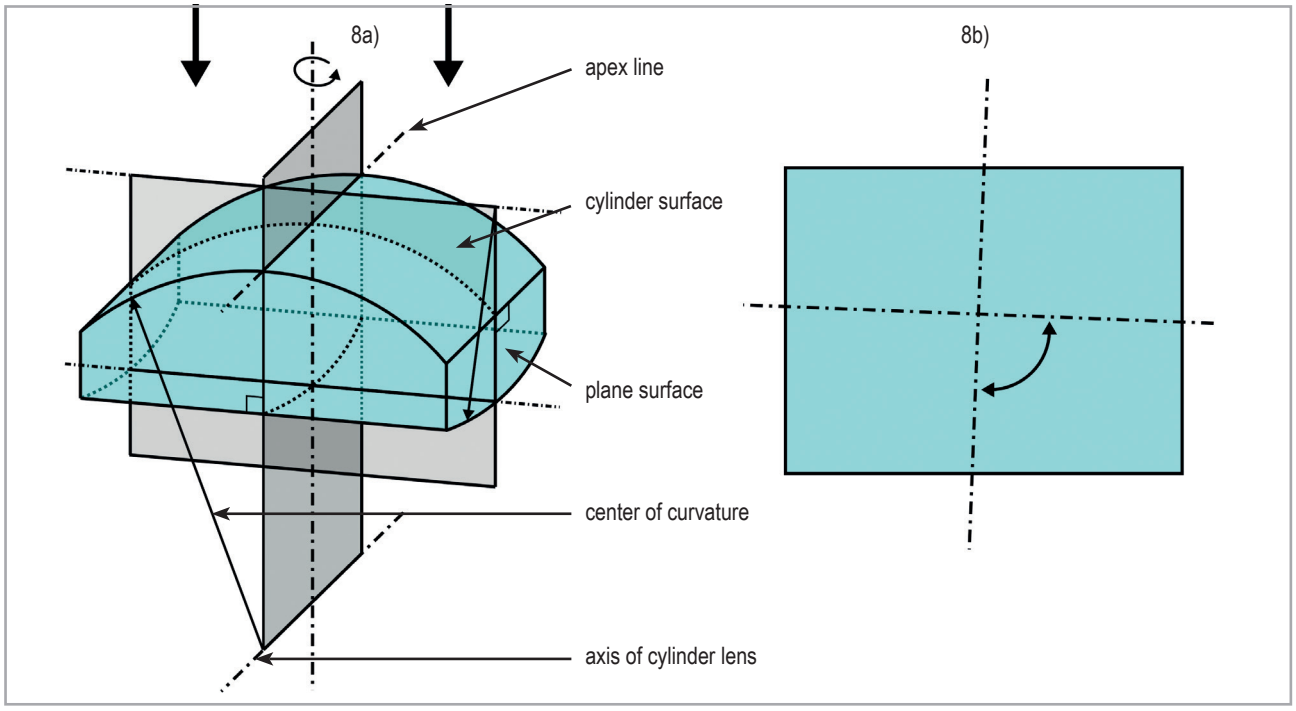

Fig. 8a: For the measurement of the relative angle of rotation, the cylinder axes are measured;
Fig. 8b: The topview on the lens shows the position of the cylinder axes in relation to the plane bottom side of the lens

The measurement is carried out with an accuracy of 1 minute of angle. Its accuracy depends on a thorough calibration.

For each measurement, one autocollimator is focused on the upper and lower cylinder surface. The OptiCentric® Dual system now measures the azimuthal angle position of the apex line of the upper and bottom side of the lens. From the position of the cylinder axes, the angle can be evaluated on the camera image of the two autocollimators.

Advantages of the measurement: Simple, flexible and type-independent quality tests of double cylindrical lenses with an established OptiCentric® Dual system.

After the upgrade for cylinder lenses, the measurement and the evaluation of the results can also be carried out with an already existing system of the customer.

Recommended OptiCentric® systems: OptiCentric® 100 Dual, OptiCentric® 300 Dual including a software package for cylinder lenses.

As the case may be an existing system needs to be adapted (depends on the Sample).

OptiCentric® 100 Dual

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Mounting Cylindrical Single Lenses

Measuring task: The angle of the apex line to a reference in a mounted lens will be measured with the OptiCentric® system.

Measurement: During the mounting of lenses with cylindrical surfaces, the angle of rotation of the lens (azimuth) must be precisely aligned to a mechanical reference, e.g. a slot in the lens mount. For this purpose, the lens is coarsely aligned on a tiptilt-table. The lens is then rotated in such a manner that the reference mark used points to the desired direction. This depends on the design of the lens.

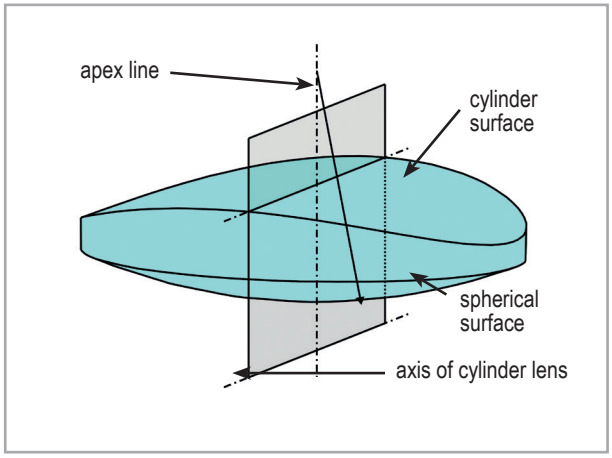
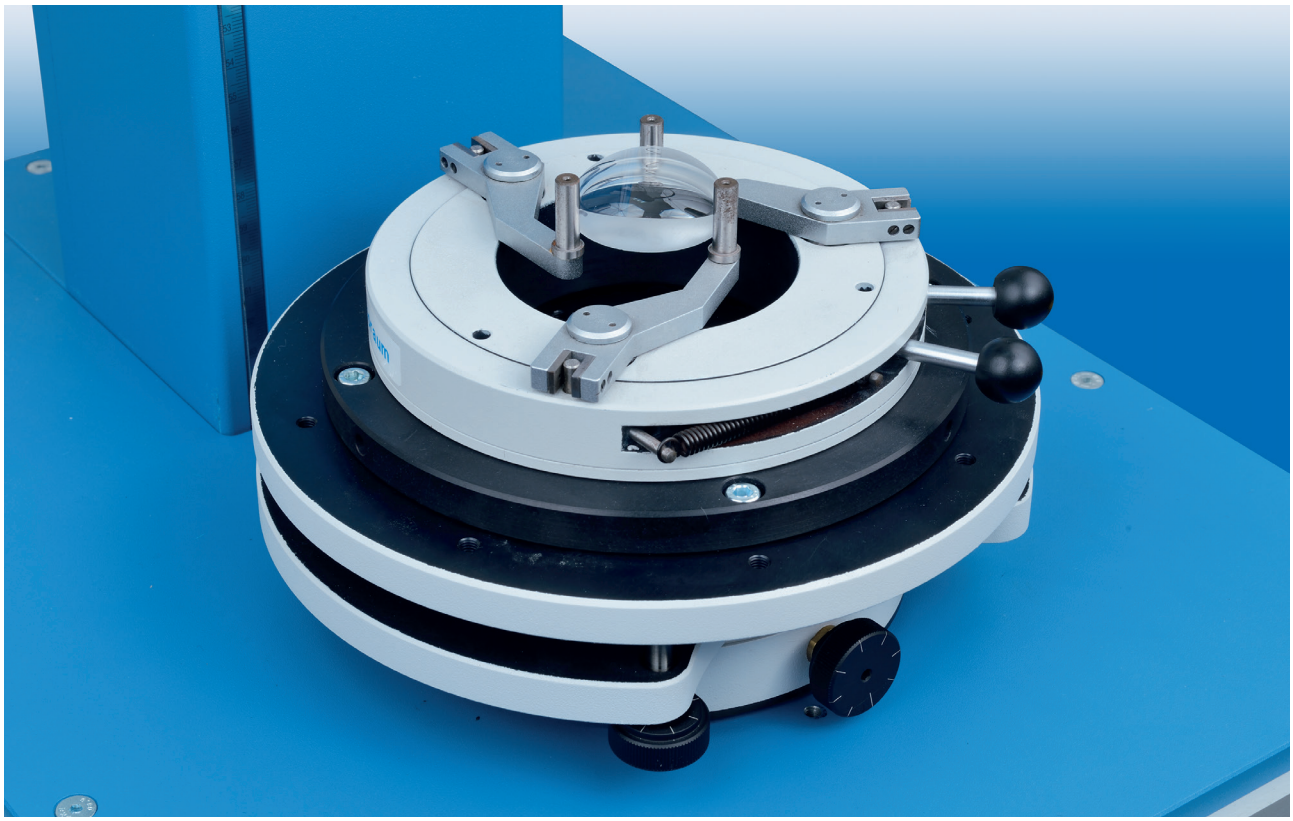


Fig. 9a: Spherical round cylinder lens

The OptiCentric® software now allows to determine the so-called "clocking angle", i.e. the angle of the shown cylinder axis. This allows to precisely determine whether the cylinder lens was inserted rotated against the reference.

Advantages of the measurement: The clocking angle is determined within mounted lenses.

Recommended OptiCentric® systems: OptiCentric® 100, OptiCentric® 300, including a software package for cylinder lenses and a MultiLens module.



Round cylinder lenses in holder

Measuring Lens Systems with Cylinder Lenses

Measuring task: The position of cylinder surfaces in a lens will be determined with an OptiCentric® 3D system with a point-shaped light. Thanks to an integrated lowcoherence interferometer, the position of the lens can not only be determined in the rotation plane, but also in the z-axis.

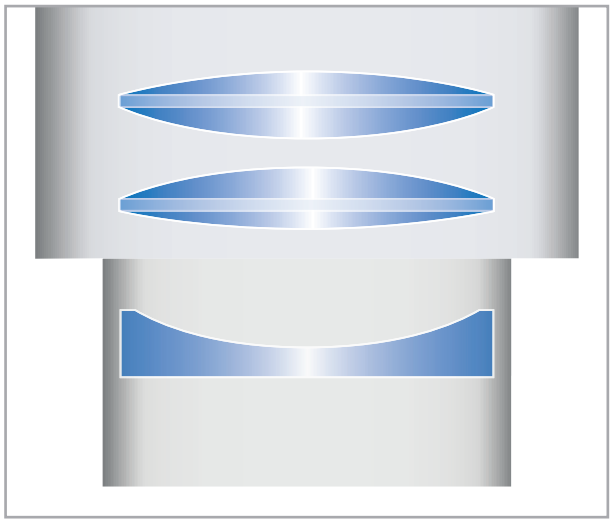
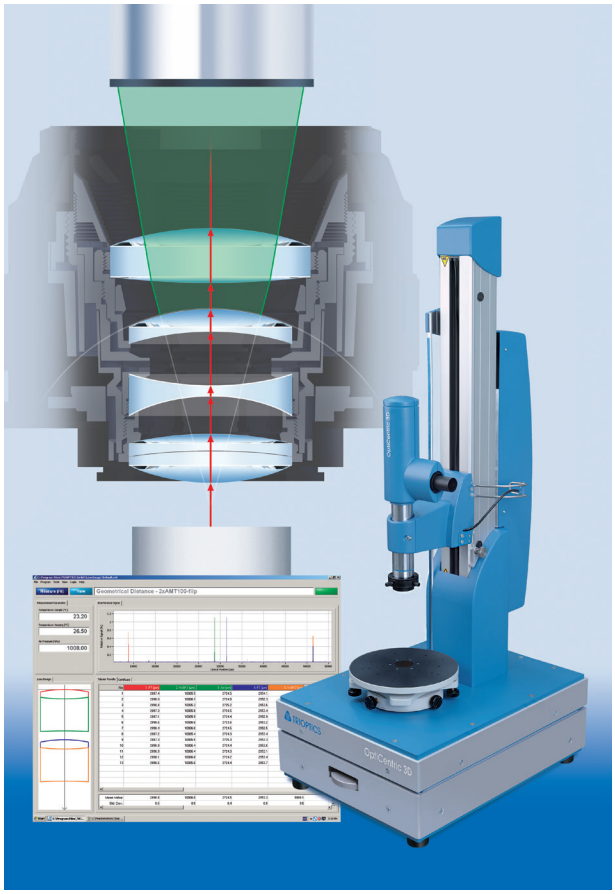


Fig. 10: Cylinder lens inside of an assembled lens system

Measurement: The centering error as well as the distance of the single lens surfaces to each other are to be determined in a lens. The lens is coarsely aligned to the angle of rotation of the air bearing on a tip-tilt-table. During measurement the sample rotates around the angle of rotation of the air bearing and the OptiCenric® system measures the center and line of curvature of the individual lenses. With the help of the MultiLens module of the OptiCentric® software, the position of the center and line of curvature in the direction of x and y can be determined. Then, the optical axis of the lens is aligned to the measurement axis of the OptiCentric® system and the distance of the single surfaces to each other is determined with the help of the OptiSurf® module.

Advantages of the measurement: The system allows a highly precise quality test of already mounted lenses by the definition of the position of the single lenses in a mounted lens independently from the type of lens.

Recommended OptiCentric® systems: OptiCentric® systems with adjusted cold light source.



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