Äpre™

Application Note

How to Measure a Sphere

Tools Needed

- Interferometer
- Transmission or Fizeau Sphere (TS)
- Alignment Flag (optional)
- 5 axis mount with 3 Jaw Chuck or equivalent
- Alignment rail (optional)
- Optical surface to be tested
- Spherical lens to be tested

In Brief

Measuring a sphere is a basic interferometer measurement.

This application note teaches how to measure a spherical surface and introduces setup procedures common to all spherical type parts measurements.

Setup

Transmission or Fizeau Sphere (TS)

Precise alignment of the TS is required to minimize errors. A misaligned TS, when the TS optical axis has tilt relative to the optical axis, will cause the returning beam to pass through the interferometer off axis. Off axis beams pick up retrace errors lowering the measurement accuracy. This is especially important with continuous zoom imaging systems yet not as critical in ÄPRE's S-Series interferometers.

Please refer to the Application Notes:"How to Align a Transmission Flat/Sphere" and "Selecting a Transmission Sphere" to select the best matching TS f/# for the spherical lens surface to be measured.

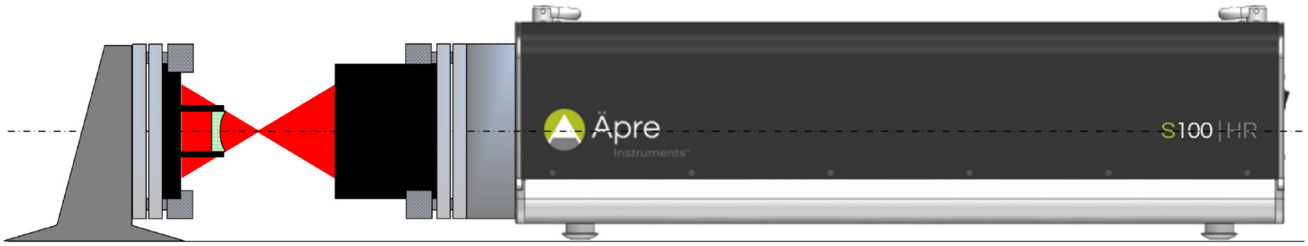

Figure 1: Basic Setup for measuring a concave sphere

Figure 2: Basic Setup for measuring a convex sphere

Test Part Alignment – Concave Part

1. Switch to the alignment mode and refer to figure 1
2. If in the cats eye position move the test surface AWAY from the TS
3. Place the alignment flag at the focus of the transmission sphere.
   a. An alignment flag is an adjustable beam block with a hole in it. It makes alignment of the concave part easier. Simply poke a hole in a white card to make one.
4. Align the test beam to pass through the hole
5. Align the test part so that the reflected beam returns through the alignment flag hole.
   a. By moving the test part along the beam (Z) and across the beam (X and Y) the return beam can be sent back through the hole.
6. Switch the interferometer into the live fringe view mode
7. Move the test part in X, Y and Z until fringes are observed.
   a. NOTE: With a spherical surface tip and tilt are not adjusted except for gross alignment.
8. Translate the test part in X and Y using the 5-axis mounts fine adjustment screws to minimize the vertical fringes to make the fringes circular (see figure 3)
9. Now adjust the 5-axis mount's Z axis until the fringes are null.
10. The concave part is now aligned

Figure 3: Power interferogram

Test Part Alignment – Convex Part

1. Switch to the alignment mode and refer to figure 2
2. Switch the interferometer into the live fringe view mode
3. If in the cat's eye position move the test surface TOWARDS the TS
4. Move the test part in X, Y and Z until fringes are observed.
5. Translate the test part in X and Y using the 5-axis mount's fine adjustment screws to minimize the vertical and horizontal fringes to make the fringes circular (see figure 3)
   a. NOTE: With a spherical surface tip and tilt are not adjusted except for gross alignment.
6. Now adjust the 5-axis mount Z axis until the fringes are null.
7. The concave part is now aligned

Test Part Focus

Focusing the interferometer is important to achieve accurate measurements. Please refer to the application note, "Focusing an Interferometer."

Measurement

- Click the measurement icon to start a measurement
- Averaging might be desired, especially if the environment produces some vibration or air-turbulence
  — Expect noise reduction proportional to a square root of the number of measurements
  — The improvement limit is when interferometer variability dominates the measurement
- In the software analysis, for a sphere nominally only remove TILT and POWER
  — Removal of more terms are often used to investigate higher spatial frequency errors
- Set the clear aperture to report the specified area of the spherical surface
  — Set either the auto-aperture for circular parts, manually create an include mask to include the clear aperture or set the erosion filter to remove unwanted edge errors and pixels outside the clear aperture

Report

With REVEAL you can now click on reports and print out a standard or custom report of the measurement results.

Potential Measurement Challenges

Focus Range within the Spherical Cavity Determines the Range of Measureable Parts

The region where focus is achievable with a TS is limited by the interferometer's range of focus and the f/# of the TS. See figure 5 as an example. The interferometer typically has ±2 meters focus range. In the image space of the TS this translates into a region starting at the reference surface and ending BEFORE the TS focus (cat's eye position) and then beginning again a distance AFTER the focus position and ending a further distance beyond this.

NOTE: The useful range of radii that a TS + Interferometer combination can measure is defined by this disjointed measurement space. (see figure 4)

When measuring outside this focus region errors occur, including:

- Surface deformation at the edges of the lens
- Surface deformation at dust and artifacts in the interferometer and on the test surface
- Loss of fine surface detail

The most common error is measuring parts too small for the interferometer and thus in the region near the TS cats eye position. Since the parts are small the edge diffraction errors cover a large percentage of the parts surface.

Each TS + Interferometer has it own best focus region that must be found empirically, though a "rule of thumb" is the surface radius of curvature should not be less the 20% of the TS distance from the reference surface to the focus position.

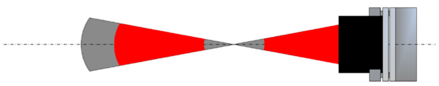

Figure 4:
Red shows approximate TS focus range

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For more information contact us at:

Äpre Instruments, Inc.
Tucson, AZ

sales@apre-inst.com

apre-inst.com