Form Talysurf® PGI **NOVUS** and **Metrology 4.0** software

# Advanced measurement of spherical bearings

James Porter, Applications Engineer

## Spherical bearings

**Spherical bearings are widely used to permit angular rotation about a point in two orthogonal directions. Typically, spherical bearings support a rotating shaft that must move both rotationally and at an angle. Spherical bearings must work in situations where the rotational axis of the shaft changes whilst rotating.**

Properties of spherical bearings include large radial and thrust loading capacity in both directions. They are used in industries that range from heavy construction machinery to electric vehicles.

### Special features of a spherical bearing include:

- Low friction
- Robust
- Long service life
- High load capacity
- Accommodate misalignment in assembly

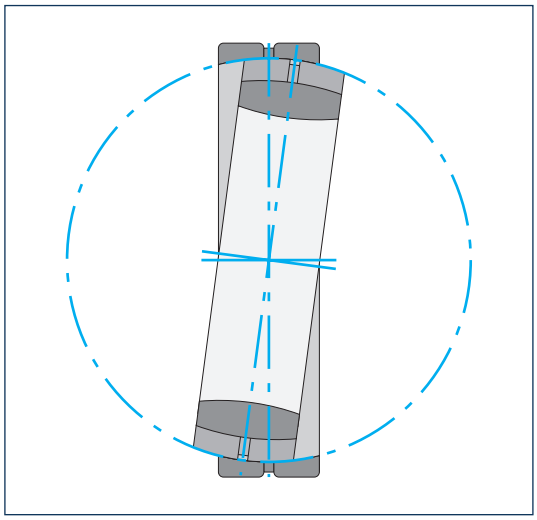

Figure 1 - Schematic showing the change in axis of rotation.

*"The NOVUS gauge provides the ability to measure diameter, included angle, surface finish in a normal and inverted direction with the same speed and accuracy.*

*Through this development, Taylor Hobson has addressed challenges faced day-to-day by bearings manufacturers."*

Greg Roper
Surface Product Manager

## Challenges

### 1. Form, radius and surface finish on both surfaces

Spherical bearings are often used in applications where high load capacities are present. In scenarios such as these, it is important that the bearing assembly can cope with these loads. If the radius clearance of the mating part is exceeded by the interference fit, the bearing will become excessively loaded. This results in a rapid temperature increase that leads to high wear rate and fatigue. Inspection of radius is crucial to ensure correct clearance in the bearing assembly.

Surface finish is another important characteristic to inspect, ideally surface finish, form and radius should be obtained from the same measurement. This means it is necessary to have a gauge with a large enough range to measure the form with a detailed resolution to capture the surface finish.

Once the measurement of the bearing race has been completed, the correct analysis region needs to be defined so that the analysis of form and radius can be done. This also needs to be automatic to make sure the process is repeatable. This is outlined on the design of the bearing and is usually denoted as an angular position or by horizontal regions along the arcs.


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### 2. Raceway diameter

Diameter of the raceways is of big concern to manufacturers. This will have an impact in the way the assembly is mounted together. If there is no control of diameter the bearing will not function as intended.

For accurate measurements of raceway diameter, the measurement instrument will require a measurement datum in the Z direction. Typical tolerances for raceway diameter are ~1-5 µm and rely on the need for a precision datum and dedicated diameter calibrations.

A further requirement for measurement of diameter is a stable measurement platform where the relationship between the two stylus tips is precisely known and where the gauge is accurately aligned. All these factors, if not addressed, will have a detrimental impact on the diameter.

### 3. Alignment

For accurate measurement of form and radius along the spherical bearing using a surface profilometer, it is crucial that the part is correctly aligned to the measurement axis. Any misalignment will introduce measurement errors as the stylus will not track the true shape of the profile.

The alignment must be automatic as operator influence will affect the reliability of the setup. The routine will require automated stages that can achieve the required accuracy. These stages will need to have the positioning accuracy to both calculate and then rotate the component so that it is in line with the measurement axis.

## Solutions provided by Form Talysurf® PGI NOVUS and Metrology 4.0

### 1. Accurate measurement of form, radius and surface finish

Form Talysurf® PGI NOVUS provides excellent form and surface finish capability from a single measurement on both sides of the part. The dual-bias functionality with 20 mm of range provides an exceptional resolution down to 0.2 nm. This allows surface finish and form to be analysed from just one measurement.

The unique ability to automatically adjust the stylus force ensures measurements in normal and reverse bias meet the ISO recommendations for stylus tip pressure. The automatic stylus force allows the stylus to part interaction in normal and reverse bias measurements to be consistent to one another. This is necessary when comparing measurements on both sides of the bearing.

The analysis region of the spherical bearing is often defined as either X distances from the centre or by an angle around the arc (Figure 2). Taylor Hobson's Ls Arc Auto analysis allows automatic evaluation of the desired regions. The radius and form are then automatically evaluated. This utility allows fast analysis of the measurement and ensures the correct areas are inspected every time.

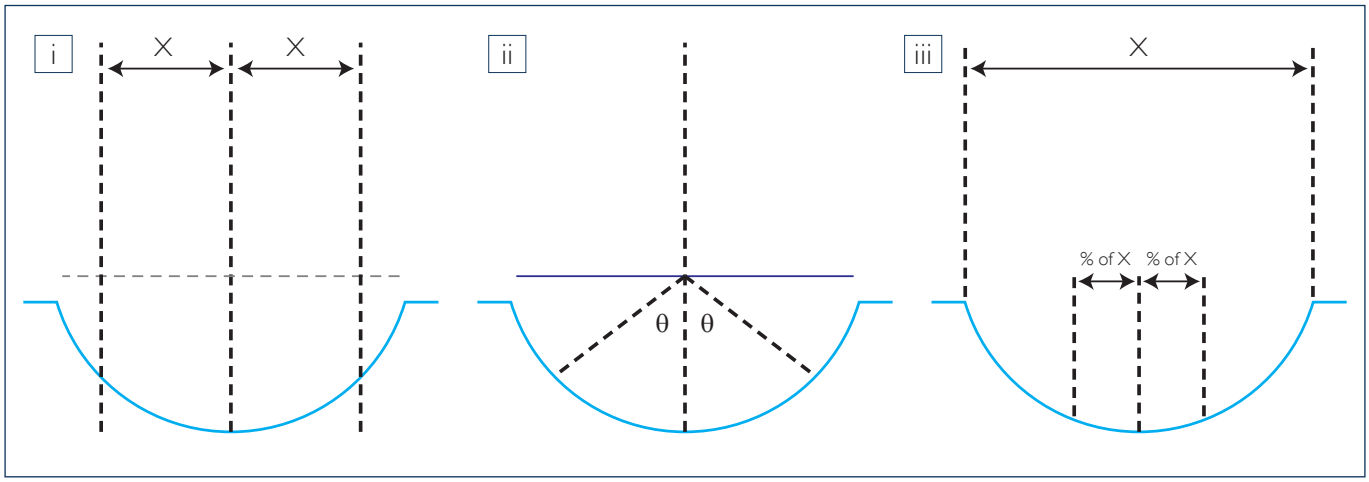


Figure 2 - Inspection areas can be defined as either,
i) Horizontal distances from the midpoint or ii) angular positions around the arc or iii) percentage of arc extraction.


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## Ls Arc Auto – fast, automatic analysis for raceway form and radius*

**Ls Arc Auto analysis allows automatic analysis of bearing raceways.**

1. Profile levelling – the shoulders of the raceway are automatically detected and then these are levelled.
2. The profile fitting regions are chosen, these can be horizontal distances, angular positions or can be defined as percentages.
3. Form removal is then applied, either by optimising the radius or by using the design radius.

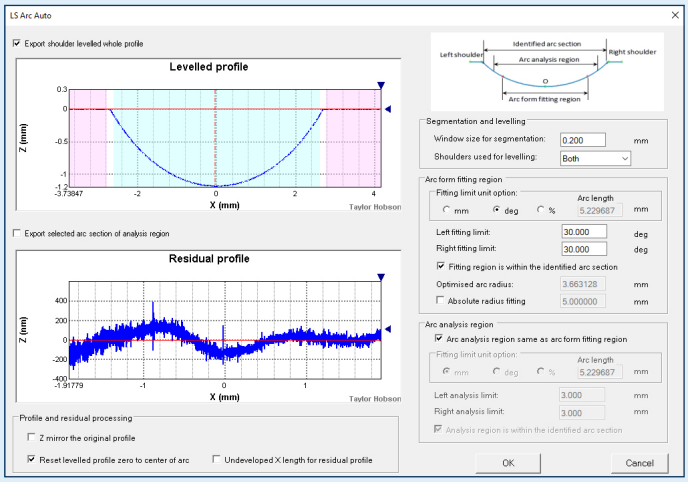


Figure 3 - Ls Arc Auto interface.

## 2. Both sides for raceway diameter

The dual bias gauge combined with the new high precision column delivers unparalleled diameter measurements to sub-micron accuracies. This capability is critical to manufacturers of spherical bearings. Along with diameter, form, radius and surface finish can be obtained on both sides of the bearing using the Form Talysurf® PGI NOVUS' dual bias capability.

The Taylor Hobson calibration artefact allows normal bias calibration, reverse bias calibration and a unique tip to tip calibration. The latter ensures accurate diameter measurements as it calculates the vertical distance of the tips as well as the stylus tip offsets in the X and Y direction. The offset values are used to ensure the tip is on the crest of the component (see Figure 4).

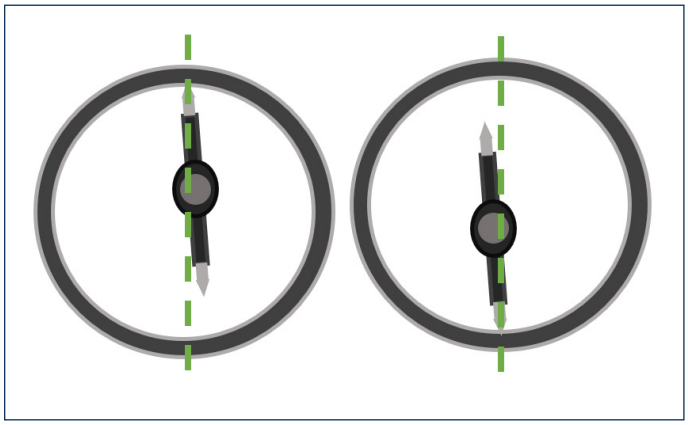

Figure 4 - When measuring diameter, it is critical that the tip is on the crest of the part. Metrology 4.0 software can automatically offset the stylus to ensure this requirement is met.

## 3. Alignment

It is important to capture the true profile of the spherical bearing. To ensure this, the component should be correctly aligned to the instrument axis. This is particularly important for bearings of small diameter.

The Form Talysurf® PGI NOVUS system achieves this rapidly by use of high accuracy (Y and rotary) stages with an automated alignment routine. Having the bearings correctly aligned using an automatic routine increases accuracy, repeatability, reproducibility and throughput as there is no operator interaction required.

Accurate form and diameter measurements on a spherical bearing can only be achieved following correct alignment.

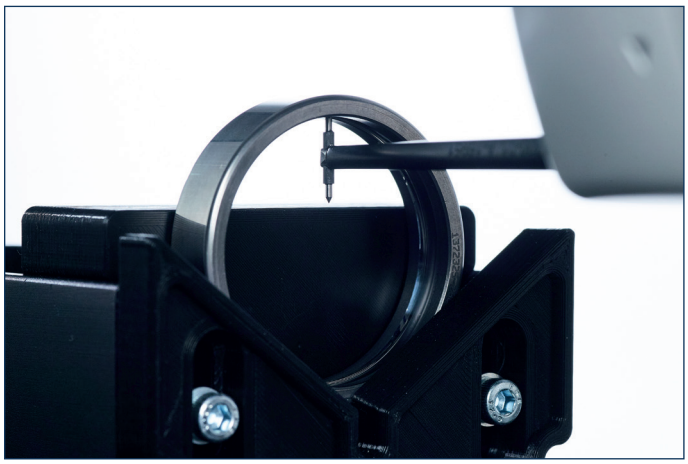

Figure 5 - Reverse bias measurement on the top surface of the spherical bearing using reverse bias.

* There is an option for defining the arc analysis region this can be different to the form fitting region.


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## Unparalleled diameter accuracy and repeatability – validation

Repeat measurements were conducted on an internationally traceable ring gauge standard of 55 mm in diameter. The ring gauge was selected to represent a typical spherical bearing. The graph below (Figure 6) shows typical results from diameter measurements on Form Talysurf® PGI NOVUS. The diameter error is ~ 0.5 µm and demonstrates the excellent diameter capability of the system.

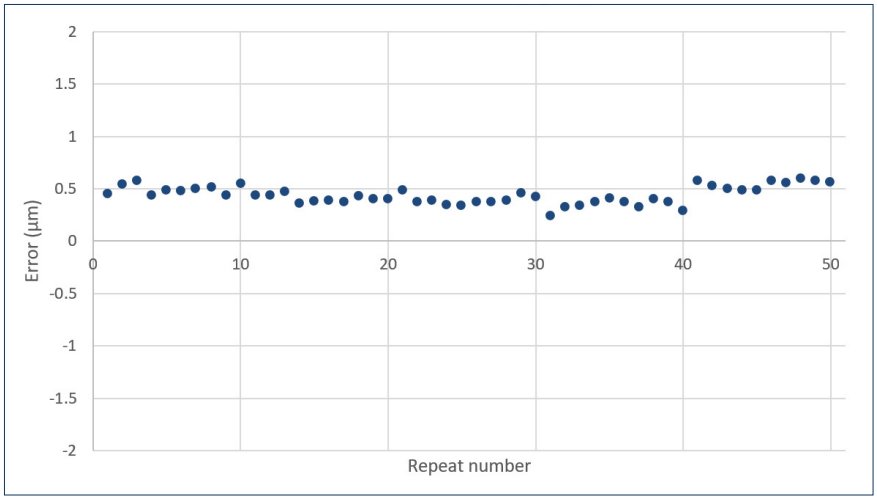


Figure 6 - 50 repeat measurements showing typical diameter results.

## Results

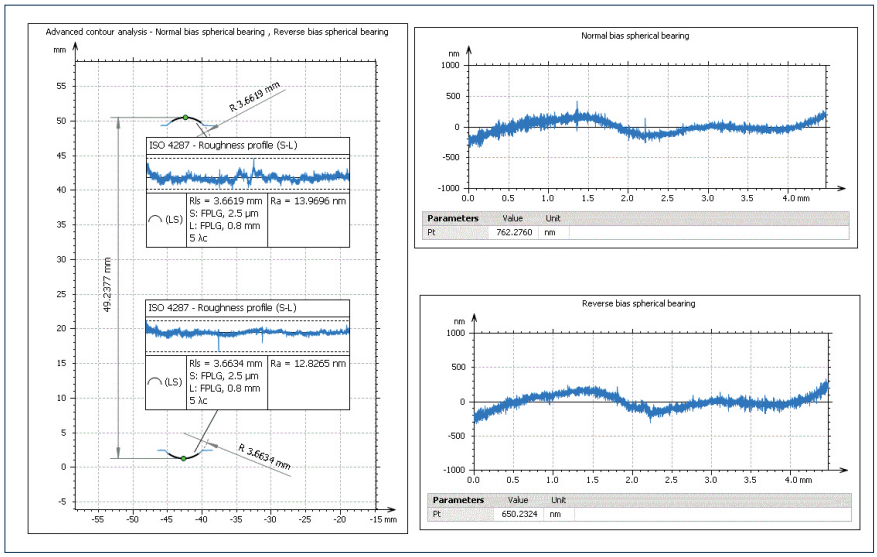


Figure 7 - Full analysis of spherical bearing including, diameter, radius, surface finish and form

## Summary

Form Talysurf® PGI NOVUS and Metrology 4.0 software collectively give the optimum solution for measurement of spherical bearings. The dual bias gauge combined with the new high precision column delivers unparalleled diameter measurements to sub-micron accuracies as well as excellent radius and form accuracy.

The dedicated Ls Arc Auto analysis provides fast analysis of bearings to match the design of the bearing. Typical diameter results on a traceable standard show excellent performance and confirm the excellent accuracy and repeatability for the application – results which cannot be achieved using conventional profilometers.

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