Tactile scanning behaviour of a micro CMM

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Introduction

Within the European Metrology Research Program a three year project is running to measure high quality optical surfaces of lenses and mirrors. It is the projects' goal to achieve fundamental improvements on the nanometer scale.

The focus of VSL is on the improvement of tactile single-point scanning techniques of microCMMs. A 3D-microCMMs has the advantage of being able to measure almost every object, even those with steep slopes. Challenges are that due to the complex nature of a 3D measurement and the interaction between probe and work piece, no universal measurement uncertainty can be stated.

Tactile probing can be done by static-point probing or by continuously scanning the surface. It has been shown that for static-point probing on the F25 microCMM, probing deviations occur for (strongly) curved surfaces [1]. When scanning additional effects such as stick-slip, synchronization errors come into play. Investigations into the scanning behaviour of the F25 are presented by measurements based on the ISO 10360-4 scanning acceptance test.

Finally, we will discuss how the effects influence the measurement result of aspherical lenses and how optimal measurement strategies can be chosen.

1. The F25 microCMM

The F25 has an aluminum platform which can move in x and y direction on a granite table using air-bearings. The z-axis carrying the probe system is suspended in this platform and can move in the z direction. The measuring volume is 100 × 100 × 100 mm. The position of the platform and the pinole is measured by line scales. More detailed information can be found in refs [2,3].

The tactile probe consist of a passive stylus, with probe tips of 300 or 120 micrometers, connected to a 6.5 mm x 6.5 mm silicon chip membrane with integrated piezo-resistive strain gauges, see figure 1 [4]. The stifness of the probe in z direction is a factor 30 higher than the probe stiffness in x-y direction.

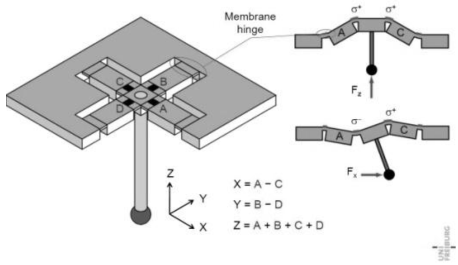

Figure 1: Tactile probe of the F25 (IMT)

2. 3D Scanning measurements on a sphere

To investigate the scanning behaviour of our F25 in 3D we have carried out measurements based on the ISO-10360-4 test on a 4 mm ruby sphere, meaning scanning a sphere along 4 different paths as indicated in figure 2. The measurements were done with a 0.3 µm probe at nominal force of 0.5 mN, a speed of 0.3 mm/s, a point density of 100pts/mm, and a 83.7 µm Gauss filter.

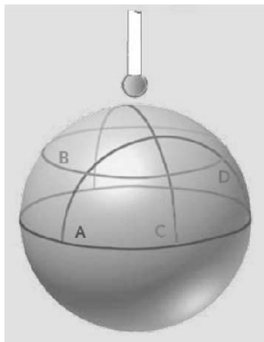

Figure 2: Scanning paths according to ISO 10360-4

1.1 Path A

In figure 3 a measurement of path A (the equator) on the 4 mm sphere is shown. The x, y and z coordinate are plotted separately, as well as the radius calculated from it. Although there is significant fluctuation on the individual x and y coordinates, the calculated radius is much more stable. From this we can conclude that there is some fluctuation of position of the probing-sphere during scanning due to stick-slip or rolling effects of the probing sphere, but that the correct position is measured. Comparing the scanning measurements against the static measurements according to ISO 10360-5[1] we see that there is good agreement.

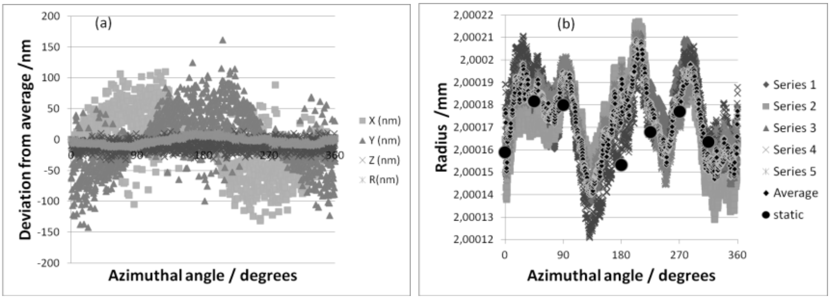

Figure 3: Measurements along path A according to ISO 10360-4

2.2 Path B

Path B is parallel to path A (the equator) at a height of z = 1.28 mm above the equator. The data is processed similarly as for path A. In figure 4 the radius as a function of the azimuthal-angle is plotted. The results of static probing are plotted as well (large dots). Agreement with the static probing is quite reasonable given that the the results are not exactly at the same height (z = 1.14 mm). The observed radius deviation is caused by the anisotropic stiff ness of the probe as explained before [1].

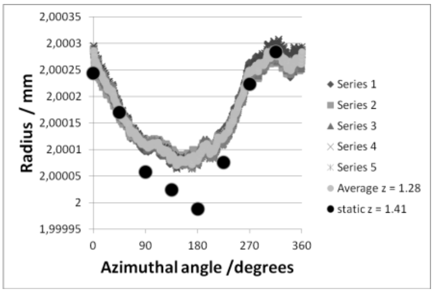

Figure 4: Measurements along path B according to ISO 10360-4

2.3 Path C and D

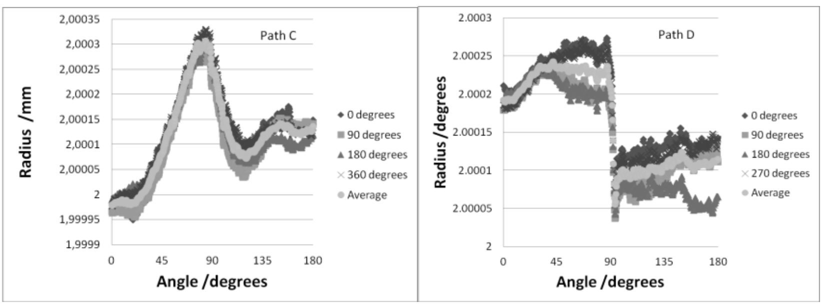

Figure 5: Measurements along path C and D according to ISO 10360-4

Path C is over the sphere at its center, along y = 0 mm, so only x and z vary, see figure 5. The indicated angle is now not the azimuthal-angle but the angle with which the radius vector moves in the x-z-plane. Here we see a combination of the radius deviation effect for path B, combined with a slip of the probe on the top of the sphere. This probaly changes the angle of the probe resulting in an offset in the measured radius at 180 degrees. Path D shows a similar slip effect as observed on the top of path C. The effect seen in path B is less present here.

3. Discussion and conclusion

Scanning measurements based on the ISO 10360-4 tests have been performed with the F25 microCMM. When scanning similar deviations occur as is the case for static probing. These can again be explained by the anisotropic stiffness of the probe, see [1]. An additional effect occurs when scanning over the top of the sphere. Here probably the probe slips, causing a large error in the measurement.

For the measurements of e.g. aspheres with steep slopes it means that in order to reduce the uncertainty contribution of the probe a more extensive probe calibration is needed to correct for these deviations. Furthermore measurement strategies need to be used which prevent the probe of changing direction in z, for example by scanning concentric circles.

Acknowledgments

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References:

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