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STABILITY OF ROUNDNESS MEASUREMENT SYSTEM

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Abstract: *In order to improve measurement capabilities and to ensure good foundation for further research in the field of roundness measurements National laboratory for length has implemented several modifications on a commercially available roundness measurement device Mahr MMQ3. Furthermore, dedicated measurement software which includes all modern algorithms for out of roundness error calculation has been developed. These improvements to the measurement system provide a new possibility to perform a large number of consecutive measurements over extended time period. Result of those measurements provides insight into temperature and mechanical stability of the measurement system.*
Mechanical stability and temperature influence by the means of temperature drift are discussed.
Keywords: *Roundness, consecutive measurement, repeatability, temperature and mechanical stability*

1. ROUNDNESS MEASUREMENT SYSTEM

Laboratory uses Mahr's MMQ3 rotating spindle roundness measurement device to measure out-of roundness deviation (ISO/TS 12181) The device has a single inductive contact probe. According to the manufacturers specification its resolution is 100 nm with rotating speed of 5 rpm. Measurement ranges are from ±1 mm to ±3 µm. The signal from the probe is processed via amplifier electronics and then displayed on an analogue readout or printed out. The signal from the probe is routed to a data acquisition card, and then processed on a PC (Horikawa et al., 2001).
Measurement software, developed in-house, allows extensive roundness data manipulation, such as out-of-roundness measurement (Moroni & Petro, 2008), averaging, incomplete profile measurement, filtering, spectral analysis, multi-step spindle error separation (Whitehouse, 2002) and possibility of performing automated consecutive measurements.

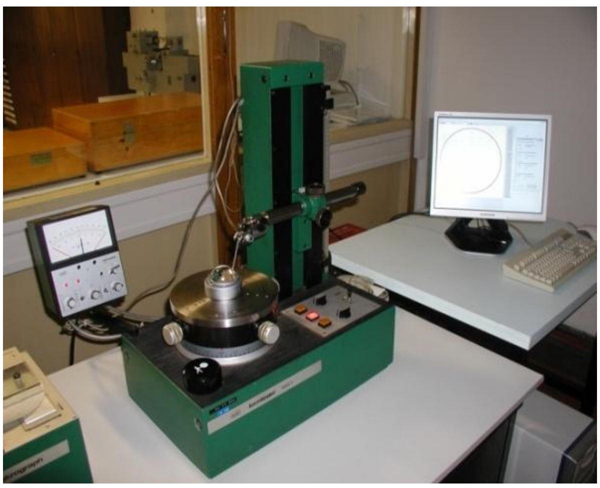

Fig. 1 Roundness measurement system

2. MEASUREMENT

In order to determine stability of roundness measurement system a set of consecutive measurements has been obtained.
The glass sphere standard was used as the measuring object.
Measurement set contains 350 measurements performed in time period of 2.5 hours. Result of measurements with ambient temperature oscillations are given in Fig. 2. and Fig. 3.
Variations in results of consecutive measurements can be attributed to mechanical and temperature stability of the measurement system.

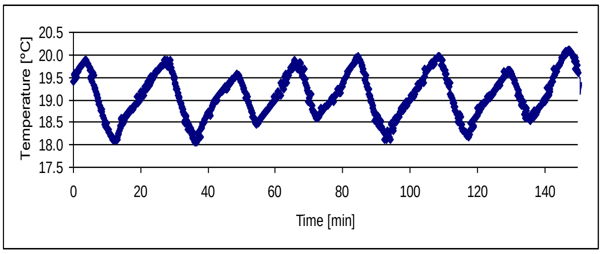

Fig. 2. Ambient temperature

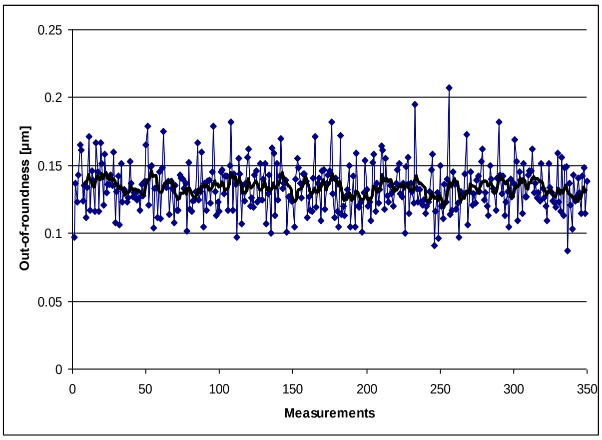

Fig. 3. Measurement set preformed in 2.5 hours

3. MECHANICAL STABILITY

As shown in Fig. 3. Temperature influence on measurement stability is superimposed on mechanical, and toward to separate these influences another set of measurements were obtained, but this time without rotation of the spindle. This static test excludes all errors due to spindle motion and results given in Fig. 4. and Fig. 5. are product only of temperature and mechanical (in)stability.

Fig. 4. represents measurements which have been done immediately after measuring object is clamped and centre. It can be notice that even after long period of time system is not stable.

Smaller oscillations within 0.5 µm can be explained by temperature oscillation and large negative trend by mechanical instability.
This leads to the conclusion that the out-of-roundness measurements should not commence without checking the mechanical stability first. Fig. 5. shows the results of static measurement when mechanical stability is achieved.

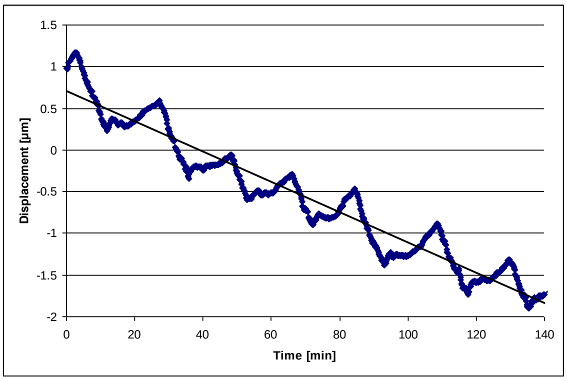

Fig. 4. Static measurements – mechanical instable system

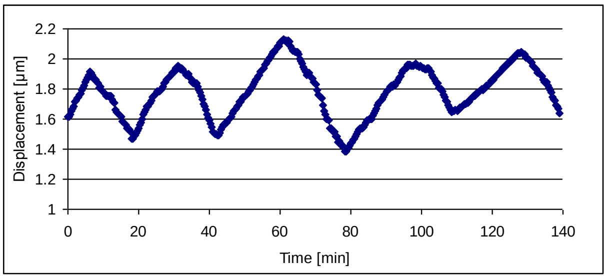

Fig. 5. Static measurements – mechanical stable system

4. TEMPERATURE STABILITY

During the measurement shown in Fig. 2. there was a noticeable oscillation in the ambient temperature, with maximum amplitude of 2 °C. Furthermore this oscillation pattern is much smaller but noticeable in calculated out-of-roundness error (Fig. 3.) (Thalmann, 2005.) In order to have better insight into temperature influence, more static measurements have been obtained but this time in time period of 12 seconds which corresponds to the time required for one revolution of the spindle.
Measurements shown in Fig. 7. were made before the thermal shield is placed on the measuring device. Emphasized trend can be noticed and it is direct manifestation of oscillation in ambient temperature. After thermal shield is placed on the measuring device oscillation in ambient temperature was decreased at the level of 0.5 °C which is shown in Fig. 6.
Measurements shown in Fig. 8. were made whit thermal shield. Growing trend form the Fig.7 is reduced to the minimum level.
Oscillation within 0,05 µm can be attributed to the electronic stability which will be investigated in future work.
In case of temperature oscillations under 0.5 °C and without any large gradients, temperature influence on out of roundness error can be neglected due to short acquisition period of just 12 seconds.

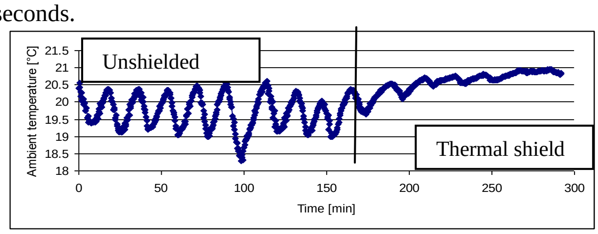

Fig. 6. Ambient temperature

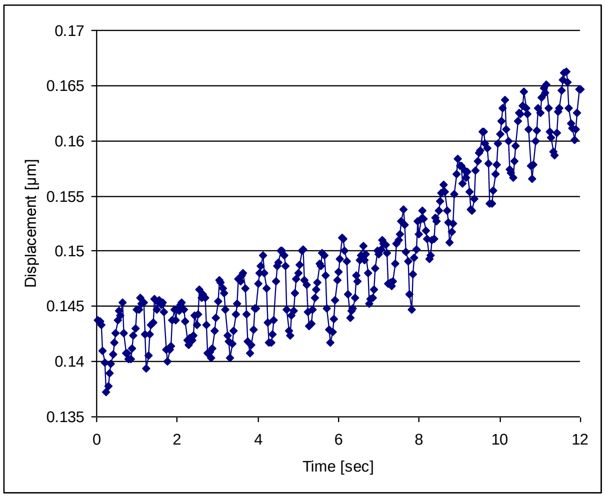

Fig. 7. Static measurements without thermal shield

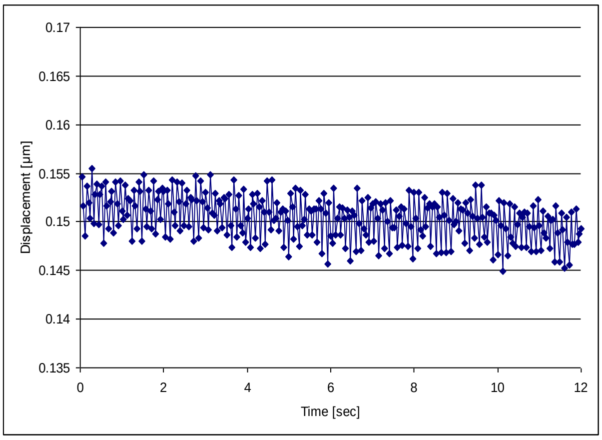

Fig. 8. Static measurements with thermal shield

5. CONCLUSION

Modifications made on roundness measurement system enable National laboratory for length to perform a large number of measurements over extended time period.
Those measurements can provide a deeper insight into stability of measuring system and most of all, a possibility to better determine influences on roundness measurements.
Mechanical and temperature stability were taken as an example of influences which can be adequately explained using such methods. Those influences to roundness measurement system were shown in detail.

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