Application Note MS08

Ultra precise contactless detection of bearing errors with the FPS3010

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Error motions of rotating objects are of major interest in high precision mechanical engineering. In case of a high speed spindle, even sub-nm deviations from a perfect rotation can create undesired vibrations or error movements. Monitoring error motion with sub-nm resolution is therefore of prime necessity from state of the art mechanical engineering to nanotomography research. The main challenge always remains: how to minimize the error motion? attocube's interferometric plug-and-measure solution now answers this unmet need!

In any application requiring the rotation of a mechanical part or sample with highest accuracy, the major problem is always the same: is the error motion of the rotation axis – see Figure 1 – well defined and known?

A typical application is to consider the concentricity of a drive spindle for manufacturing purposes: A shaft eccentricity directly creates imbalance. As soon as the mass and/or the rotational speed increases, not only the accuracy of the machined parts is jeopardized, but instrument instability may also lead to increased wear and tear. The same goes for nanotomography: a typical high resolution crystallographic analysis in a synchrotron requires perfect knowledge of the crystal center of rotation. Any errors or drifts lead to significant inaccuracies in data analysis [1]

To solve the issue, get to know it.

In order to eliminate inaccuracies, first they need to be characterized. The ideal measurement scheme exploits a non contact, compact, plug-and-play solution. Usually for linear displacement sensing, the first choice is an interferometric approach due to its long range, sub-nm accuracy. However, it typically requires flat target implementation whereas monitoring rotation means measuring on curved surfaces. Therefore, up to now, error motion characterization setups consist of invasive sensing solutions – e.g. capacitive sensing for nanotomography or even contact CMM characterization for mechanical engineering. Thanks to recent innovations, attocube further enlarges the traditional linear displacement interferometric sensing field to strongly curved surfaces.

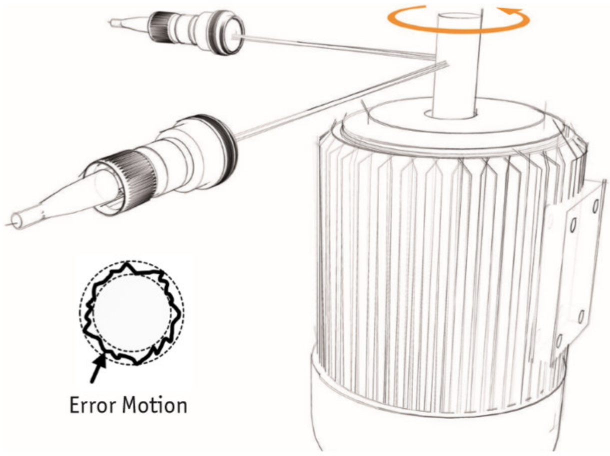

Figure 1: Schematic setup for measuring error motions of a rotating object. A shaft is rotated while its error motion perpendicular to the rotation axis is simultaneously monitored by two interferometer heads. Note that different sensor heads are available for objects of different size.

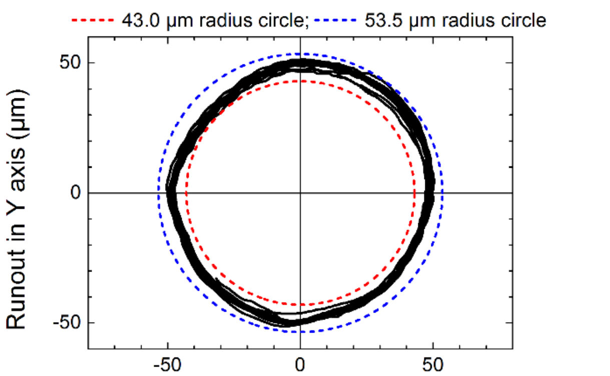

Figure 2: Error motion (black) measured while rotating the cylinder, showing errors over µm range with sub-nm resolution. The central red line indicates the average position (corrected for eccentricity), while the dotted lines indicate an error of 5 µm each.

attocube's non-contact sensing solution

In the following, the in-plane displacement of the 10 mm diameter shaft of an electromagnetic motor is monitored. On the drive shaft, a commercially available fine polished cylinder is mounted. Thanks to its high alignment angle tolerance, two attocube interferometric sensor heads are easily aligned and the characterization can start immediately. On top of that, the fiber based XS sensor heads allow *in situ*, space restricted, and extreme environment operation.

In this application, an electrical motor is driven at 2160 rotations per minute (RPM) and the two attocube interferometers measure the error motion of the cylinder perpendicular to the rotation axis. After correcting the data for the eccentricity of the rotation axis, synchronous and asynchronous errors can be directly characterized as in Figure 2.

attocube's FPS3010 user-friendliness finally opens up subnanometer error motion correction even to non-experts in interferometry. More detailed documentation on the attocube FPS3010 laser based interferometer system can be found at www.attocube.com.

References

[1 Jungdae Kim, et al., Rev. Sci. Instrum. 84, 035006 (2013)