APEM journal

Advances in Production Engineering & Management
Volume 12 | Number 1 | March 2017 | pp 88–96
https://doi.org/10.14743/apem2017.1.242

ISSN 1854-6250
Journal home: apem-journal.org
Original scientific paper

Automatic high resolution measurement set-up for calibrating precise line scales

Klobucar, R.[a,*], **Acko, B.**[a]

[a]Faculty of mechanical engineering, University of Maribor, Maribor, Slovenia

ABSTRACT

This paper presents a high resolution measurement set-up developed for calibrating precise line scales with measurement uncertainty of less than 0.1 μm over a total length of 500 mm. The system integrates a numerically controlled multi-axis stage, a laser interferometer, and a vision system for detecting line position. The measurement and the analysis processes are completely automated in order to minimize manual labour during the calibration process, but also increase the calibration accuracy. Increasing calibration accuracy leads up to better quality of industrial measurements which is required by modern precision industry. When designing this set-up, special attention was paid to the alignment of the measurement object in the measurement direction, considering the focus of the camera. The aim of this alignment was to reduce Abbe errors in 2 axes to negligible level. In addition, all uncertainty contributions have been determined and evaluated by performing extended experiments in specific measurement conditions. These contributions are presented in the uncertainty budget. The metrological capabilities of the presented measurement set-up were verified by some practical test measurements. Selected results of these measurements are presented in the article. This set-up will primarily improve a standard base for calibration of optical measuring devices. The use of the optical standards in the industry is constantly growing. Indirect users of the results of this research will be all manufacturers of precise products such as automotive and other industries.

ARTICLE INFO

Keywords:
Measurement
Line scales
High resolution measurements
Measurement uncertainty

**Corresponding author:*
rok.klobucar@um.si
(Klobucar, R.)

Article history:
Received 15 September 2016
Revised 27 February 2017
Accepted 1 March 2017

References

[1] Koops, R., Mares, A., Nieuwenkamp, J. (2010). A new standard for line-scale calibrations in the Netherlands, *Mikroniek – Professional Journal on Precision Engineering,* Vol. 50, No. 4, 5-12.
[2] Meli, F. (2013). Calibration of photomasks for optical coordinate metrology, *Physikalisch-Technische Bundesanstalt (PTB)*, No. 8, 1-12, doi: 10.7795/810.20130620C.
[3] Kajima, M., Watanabe, T. Abe, M., Takatsuji, T. (2015). Calibrator for 2D grid plate using imaging coordinate measuring machine with laser interferometers, *International Journal of Automation Technology*, Vol. 9, No. 5, 541-545, doi: 10.20965/ijat.2015.p0541.
[4] Flügge, J., Köning, R., Weichert, Ch., Häßler-Grohne, W., Geckeler, R.D., Wiegmann, A., Schulz, M., Elster, C., Bosse, H. (2009). Development of a 1.5D reference comparator for position and straightness metrology on photomasks, In: *SPIE Proceedings, Photomask Technology 2008*, Vol. 7122, Monterey, CA, USA, doi: 10.1117/12.801251.
[5] Acko, B. (2012). Final report on EUROMET key comparison EUROMET.L-K7: Calibration of line scales, *Metrologia*, Vol. 49, doi: 10.1088/0026-1394/49/1A/04006.
[6] Lassila, A. (2012). MIKES fibre-coupled differential dynamic line scale interferometer, *Measurement Science and Technology*, Vol. 23, No. 9, doi: 10.1088/0957-0233/23/9/094011.

[7] Leach, R. (2015). Abbe error/offset, In: Laperrière, L., Reinhart, G. (eds.), *CIRP Encyclopaedia of Production Engineering*, Springer, Berlin, Germany, 1-4, doi: 10.1007/978-3-642-35950-7_16793-1.
[8] Klobucar, R., Acko, B. (2016). Experimental evaluation of ball bar standard thermal properties by simulating real shop floor conditions, *International Journal of Simulation Modelling*, Vol. 15, No. 3, 511-521, doi: 10.2507/ijsimm15(3)10.356.
[9] Družovec, M., Ačko, B., Godina, A., Welzer, T. (2009). Robust algorithm for determining line centre in video position measuring system, *Optics and Lasers in Engineering*, Vol. 47, No. 11, 1131-1138, doi: 10.1016/j.optlaseng.2009.06.017.
[10] Newport Corporation. Air bearing solution guide, from *https://www.newport.com/g/air-bearing-solution-selection-guide*, accessed December 2, 2016.
[11] Köchert, P., Flügge, J., Köning, R., Weichert, C., Guan, J. (2013). Redetermination of the abbe errors' uncertainty contributions at the nanometer comparator, In: *Proceedings of the 9th International Conference on Measurement*, Smolenice, Slovakia, 171-174.
[12] EA-4/02. Evaluation of the uncertainty of measurement in calibration, from *http://www.european-accreditation.org/publication/ea-4-02-m-rev01-september-2013*, accessed November 22, 2016.
[13] Acko, B., Brezovnik, S., Crepinsek Lipus, L., Klobucar, R. (2015). Verification of statistical calculations in interlaboratory comparisons by simulating input datasets, *International Journal of Simulation Modelling*, Vol. 14, No. 2, 227-237, doi: 10.2507/IJSIMM14(2)4.288.
[14] Acko, B., Sluban, B., Tasič, T., Brezovnik, S. (2014). Performance metrics for testing statistical calculations in interlaboratory comparisons, *Advances in Production Engineering & Management*, Vol. 9, No. 1, 44-52, doi: 10.14743/apem2014.1.175.