CIRP Interlaboratory Comparison of Coordinate Measuring Machines using an Optomechanical Hole Plate - Final Report - DTU Orbit (02/01/2019)

An interlaboratory comparison on mechanical and optical coordinate measuring machines (CMMs) was organized by the Centre for Geometrical Metrology (CGM), Department of Manufacturing Engineering and Management (IPL), Technical University of Denmark (DTU) and carried out within Collège International pour l'Etude Scientifique des Techniques de Production Mécanique (CIRP). The project was carried out in the period from August 2002 to November 2004. In the project, 15 research laboratories were involved from 9 countries: Belgium, Denmark, Germany, Italy, Poland, Spain, Switzerland, United Kingdom, USA. A total of 23 CMMs (12 mechanical and 11 optical) were used to measure an optomechanical hole plate designed and manufactured by DTU. A measurement procedure was sent to each participant together with a plate to be measured. The measurement procedure refers to the German DKD guideline, using the reversal method with traceability achieved by a comparator measurement. Using the optomechanical hole plate, the measurement procedure can be carried out on optical as well as mechanical measuring machines. Circulation started in March 2003, and was completed in September 2003, with three optomechanical hole plates being circulated at the same time. A smooth and timely circulation was obtained. The measuring procedure was reported by all participants to be followed without problems. A report was produced for each participant where the results of the single participant are analysed and compared with the reference values provided by CGM, using mechanical calibration according to the DKD guideline. An expanded uncertainty \( U = 1.2 \, \mu m \) was used by CGM. The reference values were verified after circulation within the measuring uncertainty. The optomechanical hole plate has proven to be a suitable artefact for both mechanical and optical CMM measurements. The construction of the plates has shown a good stability through the approx. 6 month circulation, even though the plates have been measured mechanically, using touch probes. Only a problem was experienced: some holes on a plate showed a calibration difference of about one micrometer after circulation. This is probably due to some sensitivity of the plate to clamping, which otherwise has not been a problem. This observation has led to an additional instruction following the plate of not using clamps. From the results from the comparison, it can be expected that the optomechanical hole plates can be calibrated using the DKD procedure with an uncertainty in the range between 0.5 \( \mu m \) and 2 \( \mu m \). Using the hole plate, it is possible to compare the performance of measurements obtained using optical and mechanical CMMs. Optical CMM measurements can be divided into two groups. A group leading to deviations larger than 2 \( \mu m \), and a group with deviations that are comparable to those using mechanical machines. All but one laboratory could perform reversal measurements. Transfer of traceability was established as follows: 8 using gauge blocks, 2 laser interferometers, 1 zerodur hole plate, 2 callipers, and 1 quartz standard. Out of the 23 measurement campaigns, 5 optical and 2 mechanical machines were not provided with establishment of traceability. The optomechanical hole plate is a suitable reference artefact providing traceability of CMMs, in particular optical CMMs which seem to lack available artefacts. A comparison of measurements in a single plate position shows agreement with reference values within the reference uncertainty. This comparison shows that optical measurements, generally speaking, can be as good as mechanical ones.

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