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Ball and Hole plate development for evaluation of µCMM

O Kruger , F v d Walt and P Greeff

NMISA PO BOX X34 Lywood Ridge 0040 Pretoria, South Africa,
Corresponding author: Oelof Kruger

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Abstract

The Paper will discuss various processes and findings which were used in the development of ball plates and hole plates to be used in the performance evaluation of µ CMMs.

The criteria for the design was at first to develop a ball plate for the evaluation of a µCMM. During the experimental phase it became clear that the ball plate could be used with the probe of the µCMM but not with the µCMM vision system. The design had to be changed to a hole plate to be able to be measure by the vision system as well as the µprobe.

The paper will discuss the development of the two plates as well as the calibration of the ball and hole plates. The paper will also discuss the measurement results obtained for the µCMM when measuring the ball and hole plate.

INTRODUCTION

Various co-ordinate measurement systems such as Co-ordinate Measuring Machines (CMMs), Articulate Arm Co-ordinate Measuring Machines (AACMMs), Laser Trackers and Photogrammetry Systems, are used in industry to perform measurements on manufactured components to determine the dimensional quality of the components (deviations from design data). It is thus of vital importance to evaluate the performance capability of a co-ordinate measurement system which is used to determine the functionality of the manufactured components, as well as for process control and quality assurance purposes. Traditionally CMMs are evaluated with end standards, ball bars and calibration spheres [1, 2] or ball and hole plates [3, 4 and 5].

At the NMISA a Mitutoyo micro-CMM, which have a 35 µm diameter touch probe and a vision/camera system (see figure 1), used to measure various micro-parts and for the calibration of standards, for example: hardness indenters, acoustic microphones and optical apertures [6]. Methods and standards are required for the evaluation of this micro-CMM. This poster explains various concepts for these standards, with the advantages and disadvantages of the different designs.

CRITERIA FOR A TWO DIMENSIONAL STANDARD TO BE USED FOR EVALUTION OF MICRO CMM

A set of minimum criteria for an artefact to be used as a standard for the evaluation of a micro-CMM has been compiled. Artefacts should adhere to the following:

1. The artefact must be stable: long term stability ensure stable values between calibration periods.
2. Must be measurable with a micro-probe and a vision system (for the evaluation of both systems). Sharp edges are required for contrast, for optical edge detection.
3. Must have geometric features, for example roundness. This is important if the calibration points and the points used for evaluation are not exactly the same.
4. Must have a well established thermal expansion coefficient (for correction to the reference temperature of 20 °C) or alternatively, have a very low thermal expansion coefficient.
5. The overall dimensions of the artefact must be approximating 100 mm in length as this will cover most µCMM measuring volumes.

ARTEFACTS DESIGNS

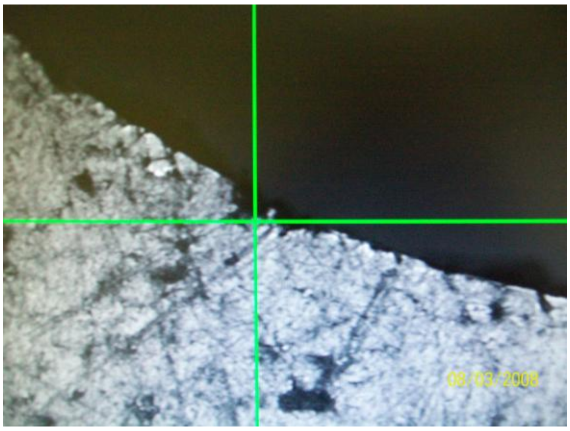
Various concepts were investigated:

1. Machined Hole Plate
2. Cylinder Plate
3. Ball Plate
4. Insert Hole Plate

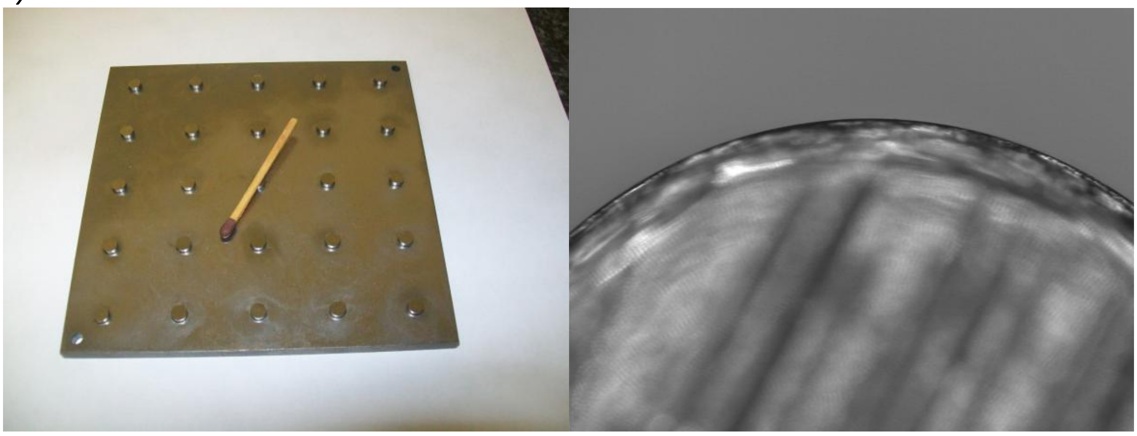
A ball designed by the Physikalisch-Technische Bundesanstalt (PTB)/ Zeiss was initially considered, but it was decided to develop new artefacts, based on the criteria in Section 2.2. The PTB design ball plate cannot be calibrated by both vision and a micro-probe. Also the plate is not ideal for the calibration using the reversal technique as the spheres is not symmetrical placed on the plate.

HOLE PLATE AND CYLINDER PLATE

A hole calibration plate was machined by drilling holes in a plate. The geometric features (the roundness and edges required by the vision system) of the holes could unfortunately not be machined accurately enough (picture 1) with the rough edges not able to be measured accurately with the vision system. Pins were insert, with these pins were centre less grinded to higher roundness accuracies and which could be measured with both the micro-probe and vision system (Picture 2). The disadvantage of this system is that the plate could not be calibrated using the reversal technique [7] as the exact same position could not be probe with the plate in the 0° setup and the 180° (flipped) setup.



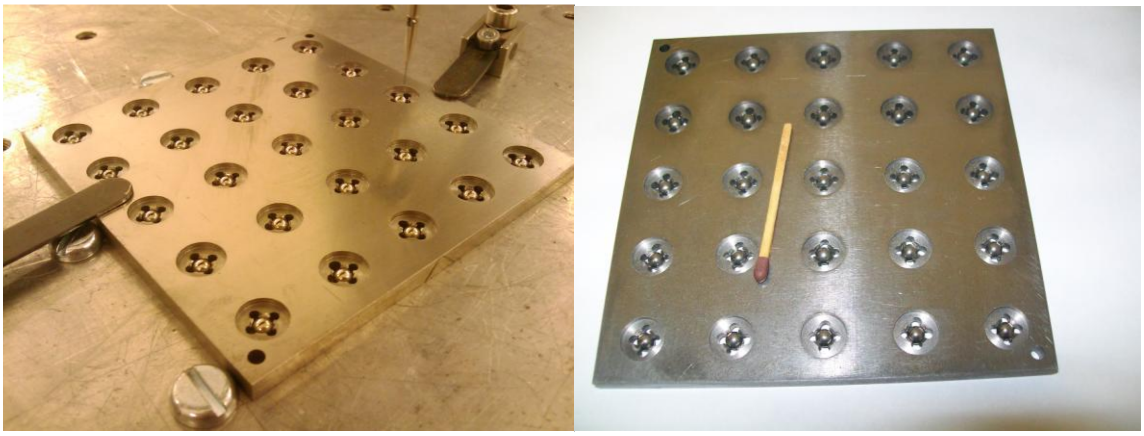
Picture 1: Hole of normal plate which show poor edges and cannot be used with vision system.



Picture 2: Cylinder plate with good edges which can be calibrated both with tough probe and vision system but cannot be calibrated using reversal technique.

BALL PLATE

A ball plate was manufactured, but significantly smaller than the KOBA ball plate[8], a different method had to be used to secure the balls in the plate. The balls have high accuracy roundness parameter and with the advantage that the same position can be probe from the top and bottom position required, it can be calibrated using the reversal technique [7]. The ball plate (picture 3) could not be measured using the vision system though, since a clear edge could not be detected with the camera.



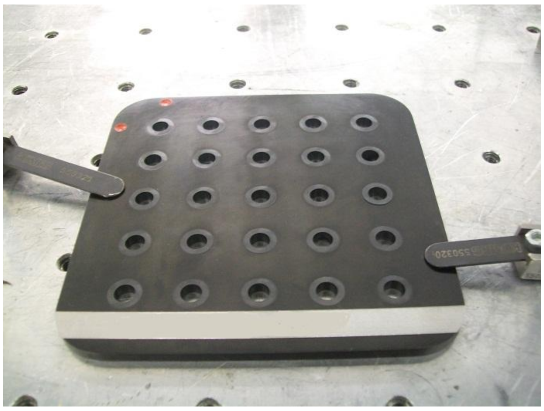
Picture 3: Ball plate

HOLE PLATE WITH CERAMIC INSERTS

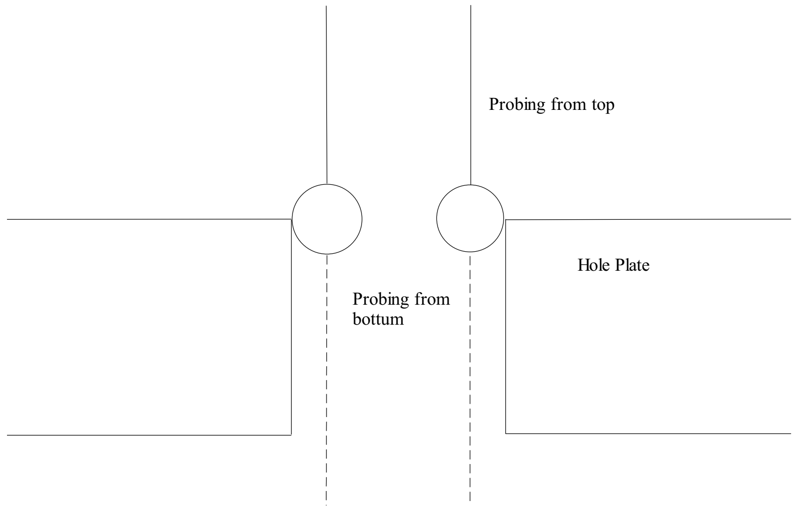
The final design was a hole plate with cylinder inserts (see figure 4). These inserts were manufactured to a higher geometric accuracy compared to that achieved by the drilled holes. The ceramic inserts were grinded to achieve high accuracy roundness, yet measurement revealed that the roundness value was only in the range of 1 µm, which still must be improved.

Fast mature steel was used for long term stability. The long term stability, however, must still be verified and will be monitored over the next few months. The thermal expansion coefficient is also well established and is obtained from the manufacturer but will be verified.

The plate was designed with the practical implementation of the reversal technique in mind. It is only 4 mm thick, this ensures that the features can be reached from both sides. The exact measuring point can be reached form the top and the bottom (if the plate is turn 180°) (figure5). This is



Picture 4: Hole plate with ceramic inserts.



Picture 5: Hole plate, showing measuring positions form the top and the bottom being the same.

CONCLUSION

The impact of evaluating CMMs and µCMMs are well documented. Standards for µCMMs are, however, not so commonly utilized as larger CMMs. Investigating various designs led to the development of the hole plate, which fulfil all the criteria in section 2. This design, while still under final validation eg, long term stability, meets the requirements for a performance standard best of the alternatives investigated.

However if only the probe of the µCMM requires evaluation, then the ball plate is the ideal artefact to use.

Long term stability for both the ball plate and the hole plate is still under investigation before performance evaluation of the µCMM at the NMISA can commence.

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