THE USE OF A μCMM IN THE CALIBRATION OF HARDNESS INDENTERS

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Abstract – In order to perform traceable hardness measurements using Rockwell Hardness Indenters, the indenter must conform to the requirement of ISO 6508-3 standard. The standard defines specifications for the geometric parameters for this type of indenter. Conformance to this standard is of particular importance to all calibration laboratories which operate in accordance with ISO/IEC 17025. At present there is no facility in South Africa with the capability of calibrating indenters for conformance to ISO 6508-3. This situation is being addressed through a series of studies currently being conducted at the National Metrology Institute of South Africa.

The following parameters are calibrated using the μCMM.

ISO 6508-3 specifies a radius of 200 μm with an uncertainty of ± 5 μm for Rockwell Hardness Indenter tips.

Also specified in the ISO standard is the cone perpendicularity between the axis of the diamond cone to the axis of the indenter holder, with a specification of ± 0,03°.

The last part of the ISO standard which was investigated states: "The surface of the cone and the spherical tip shall blend in a truly tangential manner."

All these parameters were measured and associated uncertainties calculated to prove conformance with ISO 6508-3 for the calibration of hardness indenters.
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Keywords Rockwell hardness, ISO 6508-3, μCMM

1. INTRODUCTION

In mechanical testing, hardness testing is one of the vital tests for the evaluation of products. For metals the most widely used method is Rockwell hardness. Rockwell and specifically Rockwell C are determined by measuring the depth of penetration of an indenter under a specific load. From this it is clear that the form of the indenter is critical in repeating the penetration depth.

It is therefore of vital importance that the geometric parameters are specified in the ISO standard for Rockwell hardness measurements. ISO 6508-3 describes the tolerance specification for the geometric parameters of the Rockwell hardness indenter. The most important geometric parameters being; i) radius of the sphere, ii) straightness of cone flank, iii) cone angle and iv) holder versus cone axis alignment.

Over the past few years the research conducted by most international NMIs (National Metrology Institutes), into these geometric parameters, was mainly focussed on using a Form Taly surf from the Taylor Hobson [2]. This was also the case at NMISA where research was performed in measuring indenters using a Form Taly surf with good results [3,4]. A μCMM (coordinate measuring machine) was commissioned at NMISA and the decision was taken to investigate the possibility of performing the measurements of Rockwell hardness indenters using the μCMM in place of the Form measuring machine.

2. μCMM SET UP

The μCMM has a μprobe with a diameter of only 35μm, which makes it ideal for the measurement of the hardness indenters.
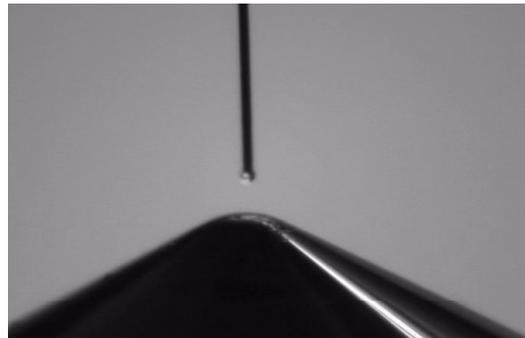

Figure 1: The hardness indenter to be measured with the μprobe directly ahead.

The instrument was installed at NMISA during 2006 where it was commissioned for the measurement of micro parts. The commissioning involved various test methods which are based on ISO 10360, a performance verification standard for CMMs.

ISO 10360 was developed for the verification and re-verification of CMMs, but with the small probe of the

μCMM, this specification required modification to be used for the verification of the μCMM. The manufacturer did not specify volume accuracy for the μCMM, but only a repeatability of better than 20nm.

The μCMM was verified for performance accuracy against the modified ISO 10360 which entails the measurement of gauge blocks and a sphere. The accuracy specification for general measuring was found to be better than ±0,8 μm over a working volume of 50 mm.

However for the calibration of a Rockwell indenter each parameter was verified separately.

3. MEASUREMENT OF RADIUS OF INDENTER

ISO 6508-3 specifies that the radius of a Rockwell hardness indenter must be 200 μm, with a specification of ±5μm. Most of the research into the calibration of hardness indenters was in this measurement [1].

For the verification of the radius measurement, a 1 mm diameter standard sphere was used. The sphere was calibrated using a conventional diameter measuring machine and a roundness measuring machine. The accuracy of the diameter measurements were ± 0,4 μm.
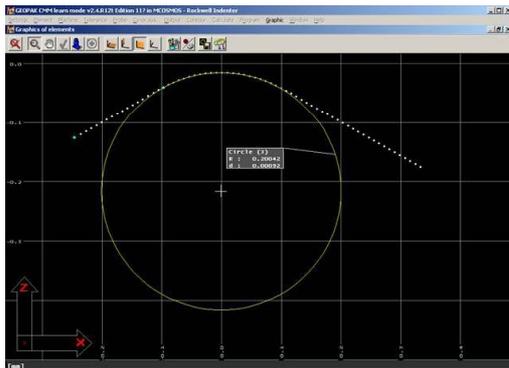

Figure 2: Measurement of radius of sphere of indenter. These measurements are also used for the cone flank angle.

The sphere was then also measured on the μCMM and the diameters between the two machines agreed to within 0,5 μm [5]. This difference added to the uncertainty of the calibration of the sphere using the conventional method, proving that the μCMM is able to measure small diameters to with ± 1 μm. This is 5 times more accurate than the specification required in the ISO 6508-3 specification.

4. MEASUREMENT OF STRAIGHTNESS OF THE CONE FLANKS

The measuring capability of the μCMM for measuring straightness was verified by the measurement of an optical flat at an angle to simulate exactly the position of the cone.

The straightness of the optical flat was measured to be 0,18 μm. This added to the uncertainty of the straightness measurement using a Zygo flatness interferometer proving that the μCMM was capable of measuring the straightness of the cone sides to better than ± 0,2 μm.

This is only 2,5 times better than the specification required in the ISO standard.

5. MEASUREMENT OF CONE FLANK ANGLE

According to the specification the cone must have a mean included angle of 120° ± 0,1° (6 min). For each measured section the specification only requires ± 0,17°.

For this measurement a calibrated angle was used from a polygon which was measured using the μCMM and the results agreed to within 2 min. The uncertainty of the calibration of the angle using an interferometer Moore index table was better than 10" which does not contribute significantly to the uncertainty of verifying the angle measuring capability of the μCMM.

The angle measuring capability of the μCMM is estimated to be ± 2 min, which is 3 times better than what the specification requires.

6. MEASUREMENT OF INCLINATION OF CONE RELATIVE TO THE INDENTER HOLDER

The specification also requires that the cone angle must be within 90° ± 0,3° of the indenter holder. For this an optical flat was used as the seating reference for the indenter for this measurement, simulating the indenter holder.
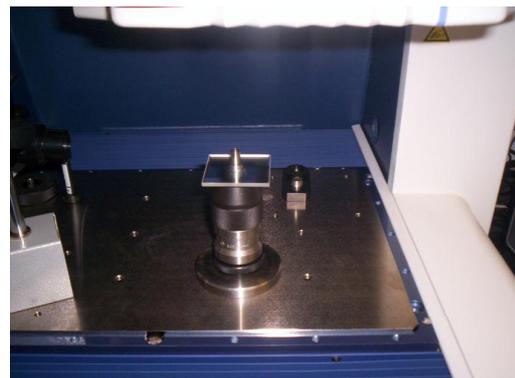

Figure 3: Indenter clamped down on optical flat.

The verification was performed the same way as the cone flank angle, but a 90° angle standard was measured. The same accuracy was achieved of ± 2 min.

7. MEASUREMENT OF TANGENT BETWEEN THE SPHERE AND THE CONE

The specification only requires that the cone and the spherical tip blend in a truly tangential manner but with no specified tolerance.

A method for this was investigated whereby the centre of the sphere is calculated from the measured points on the surface of the sphere. From this centre point two lines were constructed to be perpendicular to the lines measured on the cone.
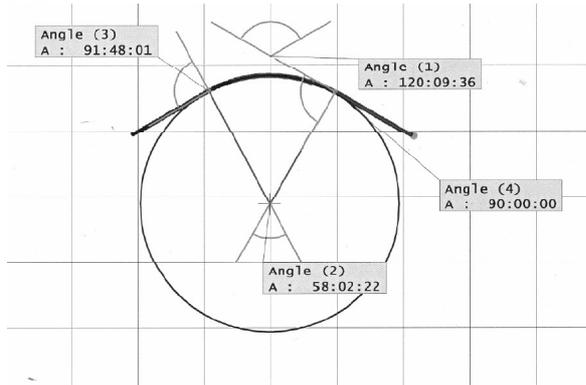

Figure 4: Measurements of true tangent.

If the cone blended in a truly tangential manner to the sphere, the angle should be exactly 90°. The measurement result indicated one angle was 90° but the other nearly 2° away from 90° as can be seen from figure 4.

Another method which was investigated was to measure the arc length (L) of the radius of the sphere. For the cone to blend in the true tangential manner, this arc length is calculated according to (1) and must be 418,8 μm. The arc length can be measured but it is very difficult to determine the exact point where the cone blends with the sphere.

$$L = \frac{2r\pi}{3} \qquad (1)$$

Either of these two methods can perform the measurements but an accuracy will have to be included in the specification.

8. ROUNDNESS OF CONE

The out of roundness of the cone shall, according to the specification, not exceed ± 0,004 mm (4μm).

The roundness capability of the μCMM was also verified using the 1 mm sphere.

The sphere was calibrated for roundness using a Talyrond 252 roundness measuring machine to an accuracy of ± 0,1 μm. The same circumference was measured for out of roundness using the μCMM and a ± 0,48 μm value was obtained.

This value added to the uncertainty of the calibration resulted in a value total of ±0,6μm achievable by the μCMM.

9. CONCLUSION

The measurements performed using a μCMM proved a good alternative for the Form Taly surf measuring machine in calibrating hardness indenters. The μCMM versatility makes it attractive as all the measurements can be performed in one setup in addition, the parameters, tangent and cone angle relative to holder axis, which can not be measured on a Form Taly surf measuring machine.

The measurement accuracy of the Straightness and the angle measurements for the cone are large compared to the accuracy of the specification.

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