Fabrication on Prototype of Depth Calibration Standard Machine for Elastomer Hardness Tester

K Mongkolsuttirat[1] and T Sanponpute[1]

[1]Hardness Laboratory, Mechanical Department, National Institute of Metrology (Thailand), Pathumthani, 12120 Thailand

Abstract. The prototype of depth calibration standard machine was fabricated to calibrate the depth of indentation for elastomer hardness tester. According to ISO 18898, ASTM D2240 and ASTM D1415, the measurement of indentation depth by a measuring device comprising a length-measuring system shall be in reference with the pressure foot of the elastomer hardness tester. Nation Institute of Metrology (Thailand); NIMT develop the depth calibration standard which can measure the indentation depth with always reference at the surface level of pressure foot of the hardness tester at each hardness scale. The calibration of the prototype of depth calibration standard machine was performed to provide the accuracy of the measurement of the machine which can be a suitable standard machine for depth of indentation within 1 µm complied with the requirement of ISO and ASTM standard. Furthermore, the prototype of depth calibration standard machine was validated to another NIMT method, which used the two length-measuring systems. The comparison results between 2 methods showed in a good agreement within 2 µm.
Therefore, the NIMT prototype of depth calibration standard machine can be used as a depth calibration standard for elastomer hardness tester provided the required accuracy of measurement complied with ISO 18898, ASTM D2240 and ASTM D1415.

1. Introduction

Elastomer hardness tester is most commonly used to measure the hardness property for rubber/elastomer, soft and hard plastic and foam. The requirements for calibration of elastomer hardness tester consists of 4 main parameters. 1) Indenters and pressure foot, 2) depth of indentation, 3) force and 4) testing cycle according to the international standard (ISO 18898 [1], ASTM D2240 [2], and ASTM D1415 [3]).

This research focused only the calibration of depth of indentation. The depth of indentation was calibrated by an indentation-depth measuring device comprising a length-measuring system. However, during the calibration, the pressure foot of the elastomer hardness tester can be moved proportional to the applied force from the indenter.

From NIMT investigation for single column calibration stand as shown in figure 1, it was found that there was a part of the stand that provided the largest deformation at approximately 80 µm. The deformation can cause the depth calibration of elastomer hardness tester error especially at the lower hardness, and cause the highest error at approximately 35 µm as shown in figure 2. The error was obviously huge compared to the tolerance of the standard at 20 µm. It ensured that the deformation of calibration stand can affect the calibration results.

Figure 1. The depth calibration setup using single column calibration stand.

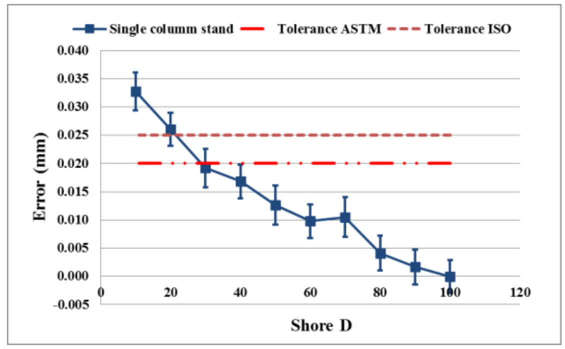

Figure 2. The error of depth calibration result.

NIMT solved the problem for the depth calibration system by using double column calibration stand with two concepts. The first concept was focused on the depth compensation due to the deformation of calibration stand. A laser measuring device was used for measuring the indentation depth with laser beam reference at floor. Another laser measuring device was installed to define the movement of the elastomer hardness tester due to the deformation of the stand in order to compensate for determining the real indentation depth as shown in figure 3. The second concept was focused on the elimination on the deformation of calibration stand. The prototype of depth standard machine was fabricated using linear scale to measure the indentation depth by using a support plate attached to the pressure foot to always refer the pressure foot of elastomer hardness tester as shown in figure 4.

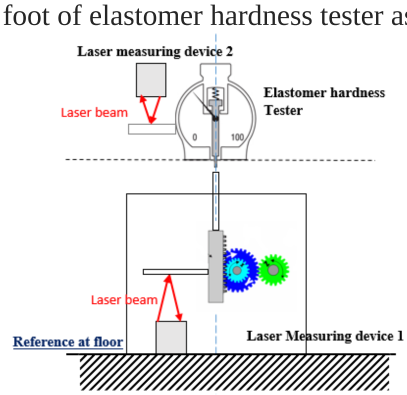

Figure 3. The depth calibration setup using two length measuring systems.

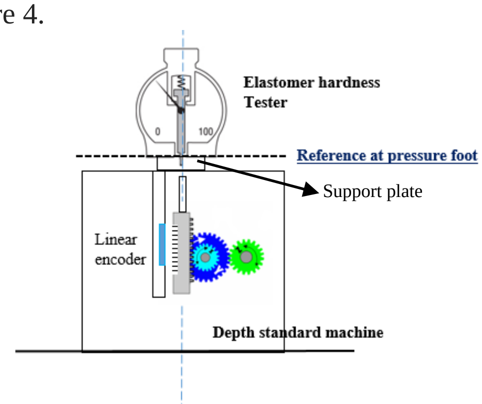

Figure 4. The depth calibration setup using the prototype of depth standard machine

2. Experimental Plan

This research started from the design and fabrication of depth calibration standard machine. The main concept of depth calibration standard machine was to measure the indenter extension of elastomer hardness tester referenced to the pressure foot. Once the machine was fabricated, the calibration of the prototype of depth calibration standard machine was performed by using Laser Doppler Displacement Meter to provide the accuracy of the measurement. Furthermore, the calibration results of depth of indentation for elastomer hardness tester by using the depth standard machine and two length measuring devices were compared.

3. Design and fabrication for the prototype of depth calibration standard machine

The linear scale model ST34 was used to measure an indenter extension for elastomer hardness tester. The effective range was approximately 25 mm which covered the operation range of most elastomer hardness testers. The depth calibration standard machine was designed to have the support plate to always attach the pressure foot of the hardness tester during the depth calibration. The measuring axes connected to the linear scale was used to displace the indenter vertically. The schematic design and the final assembly were shown in the figure 5 and 6.

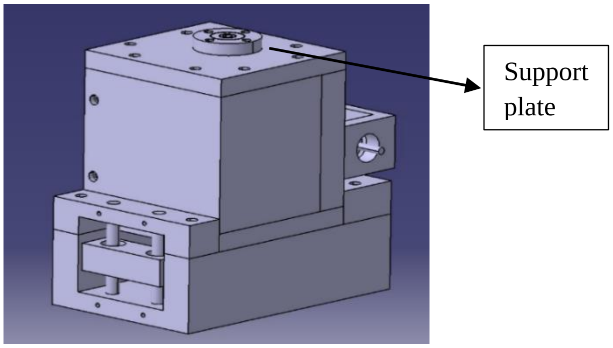

Figure 5. The schematic design of the prototype of depth standard machine.

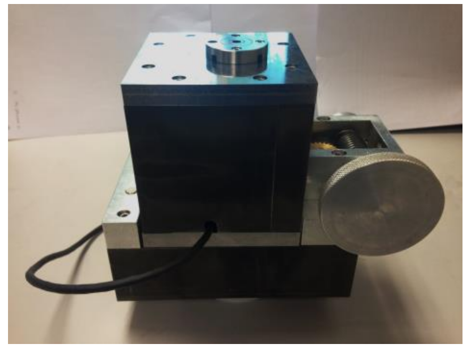

Figure 6. The final assembly of the prototype of depth standard machine.

4. Results and discussion

4.1 Calibration of the prototype of depth calibration standard machine

The prototype of depth calibration standard machine was calibrated by Laser Doppler Displacement Meter as shown in figure 7. The accuracy of the standard machine was within ±1 μm as shown in figure 8. Its accuracy met the requirement for measuring instruments used for calibration according to ISO18898, ASTM D2240, and ASTM D1145.

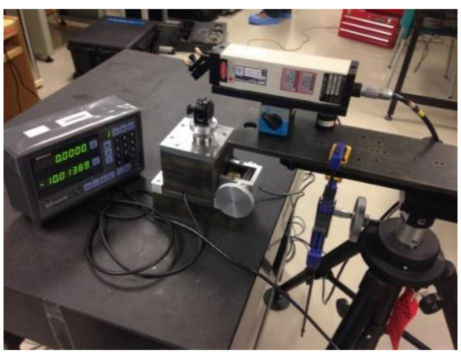

Figure 7. Calibration setup for depth calibration standard machine.

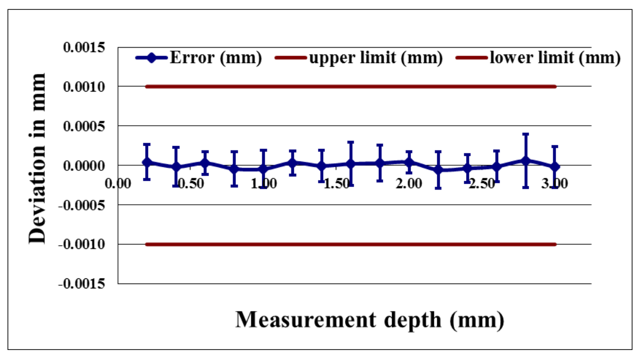

Figure 8. Calibration results of depth calibration standard machine.

4.2 Calibration results of depth of indentation for elastomer hardness tester

The depth of indentation for elastomer hardness tester was calibrated with 2 methods. The first method by using two length measuring devices was set up as figure 9. The second method by using the fabricated prototype of depth calibration standard machine was set up as figure 10. The weight set 10 kg was used to set the beginning position (tare 0) for depth standard machine when the measuring axes and the support plate were in the same level. It was also to ensure that the pressure foot of the elastomer hardness tester and support plate of depth standard always contacted during calibration. The measuring axes of the depth standard machine and of the hardness tester to be calibrated shall be in alignment and dispose vertically. The calibration was performed by adjusting the indenter extension of the hardness tester in accordance with its scale indication from 100 shore to 0 shore in steps. The calibration results between two methods gave the consistent results within 1 μm in the hardness range of shore 100 to shore 0 and within 2 μm in the hardness range shore 20 to shore 10 which was in the acceptance range of standard. Figure 11 presented the calibration results between 2 methods compared with the depth calibration result on single column calibration stand.

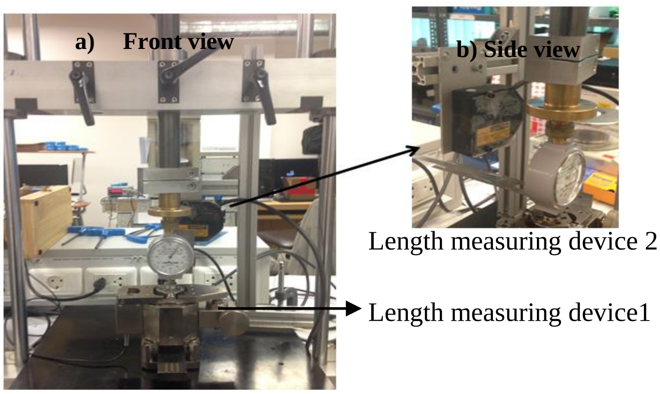

Figure 9. The depth calibration setup using two length measuring systems a) front view b) side view.

Figure 10. The depth calibration setup using the prototype of depth calibration standard machine.

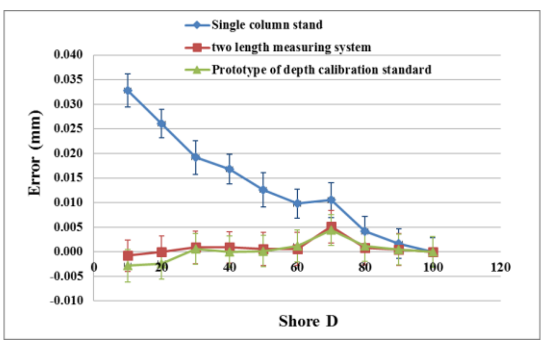

Figure 11. Comparison results between two methods: 1) two length measuring devices and 2) the prototype of depth calibration standard machine compared with the depth calibration results on single column calibration stand.

5. Conclusion

The calibration of depth of indentation for elastomer hardness tester can be carried out by two methods: 1) two length measuring devices or 2) the prototype of depth calibration standard machine. However, since using two length measuring devices was difficult to set up and need more calibration to have the traceability to SI unit. Therefore, the prototype of depth calibration standard machine was fabricated and designed to measure the depth of indentation referred to the elastomer pressure foot during the calibration complied with ISO 18898, ASTM D2240 and ASTM D1415. However, the prototype of depth calibration standard machine required self-alignment to ensure its support plate and the pressure foot of elastomer hardness tester fully attached during calibration. The further experiment should be investigated.

References

[1] *ISO 18898, Rubber- Calibration and verification of hardness testers, 3rd edition*, 2016.
[2] *ASTM D2240-15, Standard test method for rubber property- Durometer hardness*, 2015.
[3] *ASTM D1415, Standard test methods for rubber property- International hardness*, 2012.