IMEKO 2010 TC3, TC5 and TC22 Conferences
Metrology in the Modern Context
November 22~25, 2010, Pattaya, Chonburi, Thailand

RESULTS OF THE BRINELL HARDNESS PROFICIENCY TEST AND THE IMPORTANCE OF STANDARD INDENTATION

Gunwoong Bahng[1], Nae Hyung Tak [2], Jong Soo Chung [3], Sang Bo Bae [4]

[1,2] Korea Research Institute of Standards and Technology (KRISS), Daejeon, Korea,
[1] gwbahng@kriss.re.kr, 2 nhtak@kriss.re.kr
[3,4] Korea Heat Technology Ltd. (KHT), Jeon Ju, Korea,
[3] jameschn@kornet.net, 4 sangbonet@hanmail.net

Abstract – Measurement of indentation diameter is a very important factor in Brinell hardness as it can determine the reliability of the result. It is because of the ambiguous boundary line due to the pile up around the indentation. To evaluate the capability of indentation measurement, we prepared Brinell indentation hardness blocks and performed the proficiency test. Participating test laboratories have reported that deviation increases at the nominal diameter of 3 mm or larger. The result of this study indicates that this was because of the generation of up to 0.02 mm deviation or higher uncertainty at the same indentation if the definition of measurement reference is different or unclear when measuring the diameter of indentation with large pile up. We provided Brinell hardness blocks with reference indentations to the participating laboratories which observed the problem in the proficiency test. After retesting, deviation was observed to improve by up to 90 %, thereby proving the importance of applying the reference indentation CRM in Brinell hardness measurement.

Keywords : hardness, reference indentation, Brinell

1. INTRODUCTION

To obtain reliable results in a Brinell hardness test, high-performance testing equipment is essential. However, as the reliability of Brinell hardness measurement is also greatly affected by other factors such as the skill set of the operator and the test procedure, more strict definition and standard for the measurement procedure are needed. For example, industrial sites often face problems as different measurement results are generated depending on the operator, and there are large deviations in terms of equipment calibration between the operators. However, it is difficult to find a solution for this problem. Considering the situation, the current ISO standard is somewhat unsatisfactory in terms of the details of indentation measurement. This paper describes the process and results in proficiency test using Brinell hardness blocks with indentation diameter of 2.0 mm ~ 4.2 mm prepared by KRISS. Also, improvement in measurement after using Brinell reference indentation blocks is reported.

2. PROFICIENCY TEST OF INDENTATION OF BRINELL HARDNESS

The preliminary survey conducted before the indentation measurement indicated that the sizes of the Brinell indentations most widely used by Korean industries are in the range of 2 mm ~ 5 mm. In fact, those with an indentation diameter of less than 4.5 mm are most frequently used. Based on the result of the survey, Brinell hardness specimens with six range of diameter of indentation used for the skill set test was prepared. Figures 1 and 2 are pictures of the Brinell hardness blocks manufactured for the indentation measurement test. Table 1 shows the result of calibration of the indentation obtained by KRISS. This value was used for the evaluation of proficiency test. As shown in the pictures, the indentation section and number were marked on the surface of the specimen to make it easier to identify them. Furthermore, a reference line was created to find the indentation or align the measurement direction. The corners of the indentation must be clearly visible when observed through the measurement equipment (such as a microscope) and there must be no scratches or distortion. The surface was polished with diamond paste to ensure that the surface roughness was 2 ㎛ Ra or lower. The external dimensions were 50 mm or 65 mm in diameter and 15 mm in thickness. Twenty-seven calibration and testing laboratories certified by KOLAS, Korean accreditation body, participated in the proficiency test.

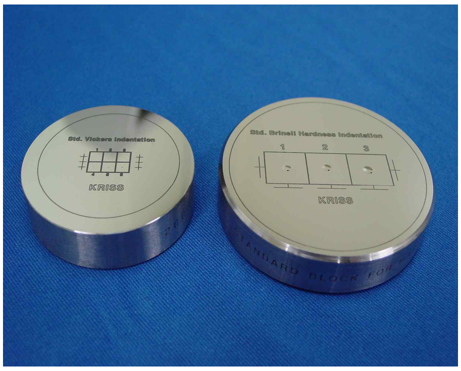


Fig. 1. Specimens of proficiency test for Brinell hardness indentation measurement.

Fig. 2. Specimens of proficiency test for indentation measurement with transport case.

Table 1. Calibration results of the indentation of Brinell hardness blocks by KRISS.

Serial No.	Indentation No.	Diameter (mm)		Uncertainty (mm)	
		d1	d2	d1	d2
14070081	1	2.191	2.193	0.0012	0.0012
	2	2.491	2.495	0.0012	0.0021
	3	2.849	2.851	0.0014	0.0011
30510723	4	2.982	2.983	0.0020	0.0021
	5	3.244	3.251	0.0014	0.0012
	6	4.205	4.211	0.0012	0.0022

3. RESULTS OF THE PROFICIENCY TEST

3.1 Evaluation of the Measurement Result

3.1.1 Deviation

The deviation was calculated as in (1),

$$d_{dev.} = \overline{X}_{lab} - \overline{X}_{KRISS} \qquad (1)$$

where, $d_{dev.}$: deviation,
$\overline{X}_{lab}$: average of participant,
$\overline{X}_{KRISS}$: average of KRISS.

3.1.2 Performance statistics

En value was used for the analysis of performance statistics. The *En* value of each participating agency was calculated as in (2). Participant was judged to have the appropriate skill if the result fell within ± 1.0.

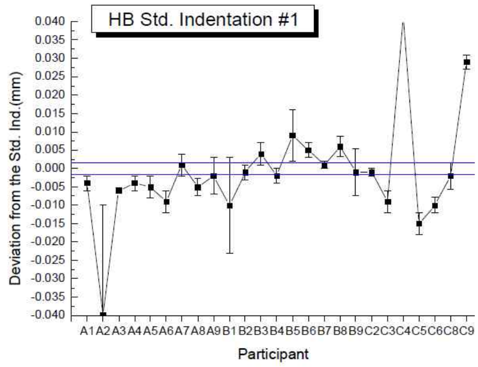
$$En = \frac{d_{dev.}}{\sqrt{U^2_{lab} + U^2_{KRISS}}} \qquad (2)$$

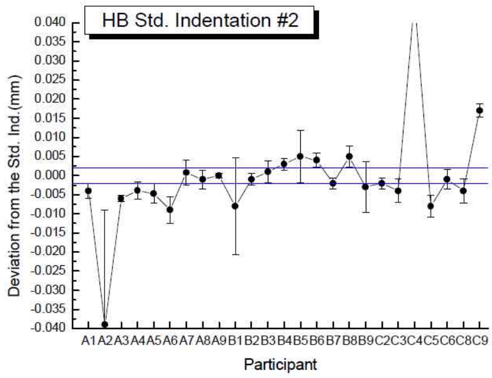
En : *En* value
U_{lab} : Uncertainty of a participants result $\overline{X}_{lab.}$
U_{KRISS} : Uncertainty of KRISS result $\overline{X}_{KRISS}$

3.2 Result of the proficiency test

Five indentation measurements were made in both the X and Y directions. Figures 3 and 4 show the deviations and uncertainties of participating laboratories. They indicate that the deviation began increasing from the point of indentation no. 4 (nominal indentation diameter of 3 mm), which is probably due to the fact that the indentation pile-up at the edge of the indentation became high and thick, thus influencing indentation measurement when the indentation diameter increased to 3 mm or larger, whereas the pile-up had almost no influence on the measurement when the indentation diameter was 3 mm or less. In other words, when there is a heavy pile-up at the edge of the indentation, the location setting of boundary line of the indentation can be easily influenced depending on the definition of the measurement method as well as the performance and adjustment of the microscope, which resulted in deviations among the operators. The standard deviation of participating laboratories calculated by each indentation size was 0.014 mm for indentation no. 1 (nominal diameter 2.2 mm), 0.020 mm for indentation no. 2 (nominal diameter 3.2 mm), and

0.024 mm for indentation no. 6 (nominal diameter 4.2 mm). To convert the values into Brinell hardness within a commercial range of 150 HBW 10/3000 ~ 500 HBW 10/3000, it is equivalent to 1.3 HBW 10/3000 ~ 7.5 HBW 10/3000, with a maximum relative deviation of 1.5 %. ISO 6508-2 specifies the permissible error of Brinell hardness testing equipment as ± 2.0 % ~ ± 2.5 %. Considering this permissible error range, a 1.5 % deviation in the indentation measurement can cause a serious deviation in measurement result and hence the deviation generated by the indentation measurement must be corrected accordingly in order to obtain a reliable calibration result.





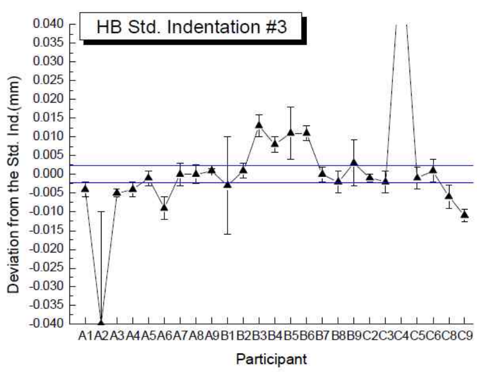
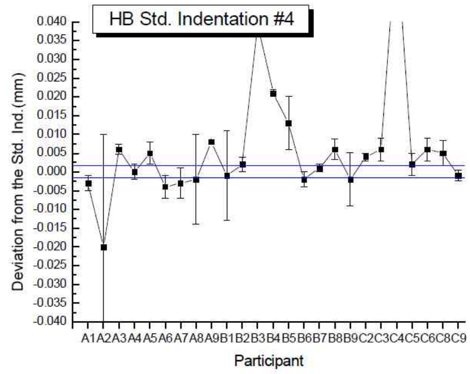
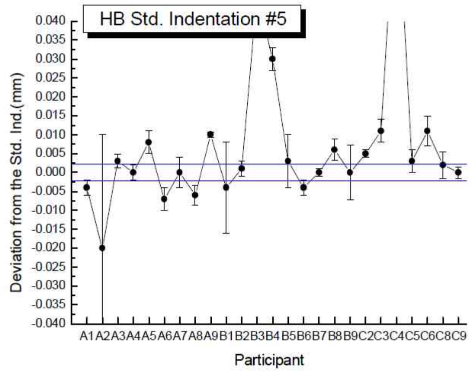


Fig. 3. Results of measurement of Brinell hardness indentations #1, #2 and #3.





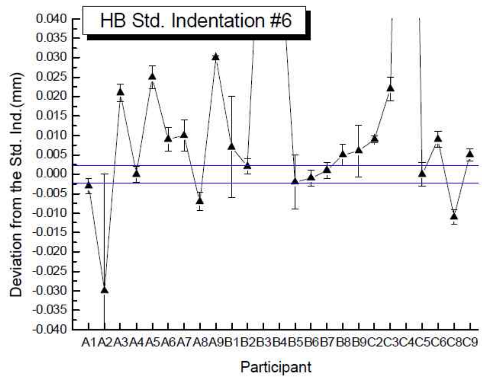


Fig. 4. Results of measurement of Brinell hardness indentations #4, #5 and #6.

3.3 Retest Result

Eight laboratories including A2, B3, B4 and C4, all of which showed a problem in the first round of indentation measurement, were selected for retesting. The retesting procedure was the same as that followed for the first test, except that Brinel indentation reference blocks were provided for the calibration and correction of the microscope. Table 2 and Figure 5 show the result of the retest. They indicate that the degree of deviation improved by at least 24 % and as much as 90 %.

Table 2. Retest results.

Partici pant	Indenta tion Nomina l Value (㎜)	First Test Result		Retest Result		Impro ved Relati ve Deviat ion (%)
		Deviat ion (㎜)	Relati ve Deviat ion (%)	Deviat ion (㎜)	Relati ve Deviat ion (%)	
D1	2.0	-0.009	-0.4	0.007	0.3	24
D2	2.5	-0.024	-0.9	-0.003	-0.1	89
D3	3.0	0.039	1.3	-0.014	-0.5	63
D4	4.3	0.083	1.9	0.019	0.4	77
D5	3.0	0.021	0.7	-0.008	-0.3	61
D6	4.3	0.062	1.5	0.011	0.2	83
D7	2.0	0.029	1.3	-0.008	-0.4	72
D8	3.0	-0.011	-0.3	-0.001	0.0	90

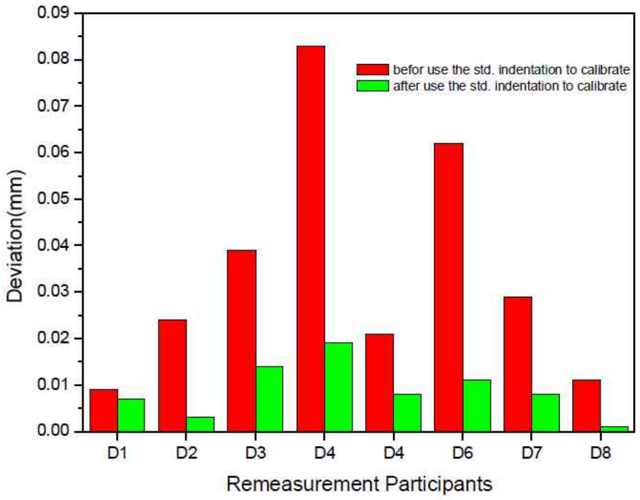


Fig. 5. Retest results.

4. CONCLUSION

The result of the proficiency test in Brinell indentation measurement skill showed that the deviations became larger at the nominal indentation diameters of 3 mm and 4 mm. The standard deviation was less than 0.02 mm. The laboratories which showed poor measurement results were given a specially-manufactured Brinell indentation reference blocks for use in the calibration of the indentation measurement equipment. As a result, all eight laboratories showed an improvement in terms of relative deviation by at least 24 % and as much as 90 %. The result clearly indicates that the use of Brinell indentation reference blocks in the measurement and calibration of equipment greatly improved accuracy of measurement. It also proved to be effective in reducing the systematic error caused by the ambiguous boundary line at the pile-up of indentation, which depends on the material. Therefore, we recommend revising the ISO 6506-2 and 6506-3 standards to use Brinell indentation CRM for the calibration of Brinell indentation measuring equipment in addition to the standard Brinell hardness blocks for calibration of Brinell hardness tester.

REFERENCES

[1] ISO 6506-1/2/3:2005 Metallic materials -- Brinell hardness test
[2] ISO 13528:2005 Statistical methods for use in proficiency testing by interlaboratory comparisons