

THE APPLICATION AND EFFECTS OF THIN SHEET HARDNESS REFERENCE MATERIALS WITHOUT AGING EFFECT

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Abstract – Hardness test methods are widely used in mechanical properties test area. While reference materials are essential important tools to control test accuracy or uncertainty. According to current test method standards, the thickness of hardness reference materials must be not less than 6 mm for Rockwell hardness or not less than 5 mm for Vickers hardness. To measure thinner sample which is commonly used in industry, and to guarantee the test results, a thin sheet reference sample is demanded.

Keywords: hardness test, uncertainty, reference material

1. INTRODUCTION

Hardness test methods are widely used in mechanical properties test area. Normally before measure test specimens, a reference block is measured to confirm the hardness machine is in good condition. The hardness reference blocks are essential important tools to control test accuracy or uncertainty. According to current test method standards, the thickness of hardness reference materials must be not less than 6 mm for Rockwell hardness or not less than 5 mm for Vickers hardness. Meanwhile there are some laboratories measure specimens which are much thinner than 5 millimeters.

To keep the test results reliable, some laboratories use SPC (Statistical Process Control) method to check if hardness machines are in good condition with the control charts. In these laboratories, the reference materials are used in certain time interval and to check if the hardness data are stable. For SPC and for comparing with different hardness machines, the demand for reference materials without aging effect and with same nominal value is easy to be understood.

The common industry tests force us decide to make quasi- reference materials with steel sheets. One example of acceptance test for a new hardness machine, comparing new machine and old one with normal brazen reference block, there is only 0.2 HRF difference with two machines, but there is more than 20 HRF difference with same steel thin sheet specimen. With careful check, it's found that the diamond plate is not seated perfectly. This unusual example shows that normal reference block can not guarantee the accuracy of machine to measure thinner specimens. Because the normal reference block with more than 5 mm thickness is not sensitivity for imperfect of tester anvil.

2. THE DEMAND FOR THIN SHEET HARDNESS REFERENCE MATERIALS WITHOUT AGING EFFECT

Although there are reference blocks with not less than 5 mm thickness, these reference blocks are not effective enough to control the test quality of hardness machines which be used to measure thinner specimens. It's found twice times in two laboratories for example that when measure normal reference block the error is less than 1 HRB while measure thin sheet quasi-reference specimens the error is more than 3 HRB. With careful check on the machines, some small imperfect spots on the anvil were found out. A trial to put a hardmetal blade with two parallel faces as a mat on the anvil and measure the thin sheet quasi-reference specimen again, the error is less than 1 HRB. A more extreme example has mentioned in the introduction. Considering these examples, it is easy to understand that normal reference blocks are not sufficient to control accuracy of hardness measurement for thin sheet specimens.

Based on historical measured data, a guess can be obtained that generally the thinner the specimens the more sensitivity on anvil of hardness machine. To prove the guess, a superficial hardness machine with two anvils (one hardmetal anvil, another diamond anvil) is used to measure different thickness specimens. For 0.23 mm and 0.98 mm thickness specimens, tests on scale HR30T are performed with different anvils, the results are listed in table 1. Similar tests are performed on scale HR15T, the results listed in table 2.

It can be seen that the difference of thinner specimen with different anvils is larger than the difference of thicker specimen. The results of measurement are same as expected. That is the thinner the specimens the more sensitivity on anvil of hardness machine. So to control the accuracy of measurement, the thickness of reference materials shall be not more than thickness of specimens to be measured.

There are limited durations of validity for hardness reference blocks in the current standards[1, 2, 3]. That seems the reference blocks having aging effect that is nominal hardness values will be change after a limited time. If that is true, this is a problem for inspection of stability of hardness machine for long time.

Usually each hardness reference block is given a nominal value according to measurement result on itself with reference hardness machine. Even a lot of hardness reference blocks made with same material and same

Table 1: effects of anvil on different thickness specimens for HR30T

Specimen No.	Thickness mm	Anvil materials	Measured values					Average
B9	0.23	Hard metal	59.0	59.4	59.0	59.2	58.6	59.0
		diamond	58.0	58.2	58.0	58.0	58.2	58.1
24B-7	0.98	Hard metal	38.0	39.4	37.8	39.2	39.6	38.8
		diamond	39.0	39.2	39.0	39.0	38.8	39.0

Table 2: effects of anvil on different thickness specimens for HR15T

Specimen No.	Thickness mm	Anvil materials	Measured values					Average
L4	0.23	Hard metal	82.0	81.4	81.4	81.8	82.0	81.7
L4	0.23	Diamond	81.8	81.6	81.8	81.8	82.0	81.8
24B-7	0.98	Hard metal	70.8	70.8	70.4	70.8	71.2	70.8
24B-7	0.98	Diamond	70.8	70.6	71.4	71.0	70.8	70.9
A6	0.15	Hard metal	86.4	86.6	86.4	86.8	86.6	86.6
A6	0.15	Diamond	86.2	86.2	86.4	86.0	86.4	86.2

technical parameters may be given different nominal values. There is an advantage of this method for it reduces the uncertainty of nominal value on material uniformity. It is not convenient to compare results between many laboratories. If it is possible to make a batch of reference specimens with very uniform materials and to give a same nominal value to the specimens, the reference specimens will be very helpful to compare results between many laboratories.

To meet the requirements on guarantee thin specimens hardness test, authors and colleagues made some sheet quasi-reference specimens. These specimens are with same nominal hardness value and without aging effect.

3. THE DATA OF SHEET QUASI-REFERENCE SPECIMENS

A batch of quasi-reference sheet hardness specimens were made with same material and same technical parameters. According to multi-laboratories regular measurement results, the nominal value or arithmetic average value and the average value of standard deviation of each measurement (3 hardness values) can be calculated. The results also give a proof that the reference sheet hardness specimens without aging effect. That is the hardness value will not change with time prolonging.

The arithmetic average value and the average value of standard deviation of each measurement of the reference sheet hardness specimens for HRBm, HRFm, HR30T, HR15T are listed in table 3. "HRBm" means measurement condition is same as "HRB", but there is appearance of

indentation on back of the test pieces. "HRFm" is similar.

According to multi-laboratories regular measurement data, the tendency of the sheet reference specimens is drawn in fig. 1.

In fig.1, the abscissa denote year and month and vertical axis denote hardness value. Each point is average values measured by multi-laboratories. Although there is a little bit fluctuation on the curve of hardness with time, there is no increasing tendency of hardness with time. Aging effect is based on diffusion or stress relaxation, generally it is exhibited evidence at beginning and then went to slow down with time prolong. As there is proof that the sheet reference specimens without aging effect in more than 3 years; it can be expected that the sheet reference specimens will not appear aging effect in much longer time.

4. DISCUSSION AND CONCLUSIONS

As sheet reference specimens can reveal imperfections of anvil which can not reveal with normal reference blocks, a sheet reference specimen is needed for checking hardness machine to measure sheet specimens. Generally to reveal imperfections effectively, the thickness of reference specimen should not more than specimens to measure.

As the complexity of hardness measurement and variety of factors which influence the measure results, it is not reliable for sheet specimen measurement to check hardness machine only with normal reference blocks. A convenience method is to check the hardness machine with sheet reference specimen.

No aging effect sheet reference specimens not only can

Table 3: the nominal values and average of standard deviation of reference specimens

	HRFm	HRBm	HR15T	HR30T
arithmetic average value	77.0	34.5	71.6	39.5
average value of StDev	0.25	0.35	0.31	0.37

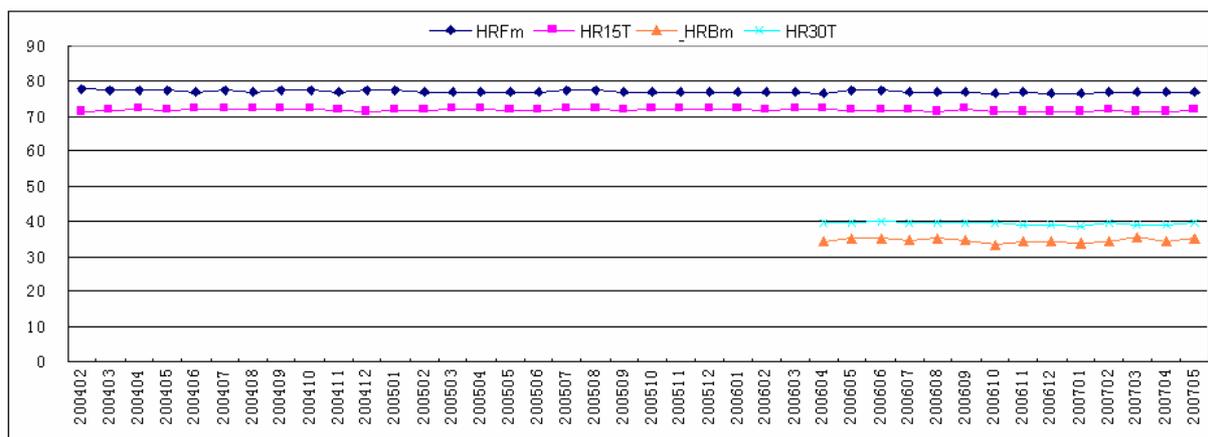


Figure 1 Hardness value tendency of the sheet reference specimens

meet the requirement of checking hardness machines to measure sheet specimens, but also can overcome the limit of validity. They can be a useful tool to monitor the stability of hardness machine in long time.

As the material to make sheet reference specimens is very uniform in chemical composition and mechanical property, it is possible to give a same nominal hardness values for a lot of sheet reference specimens. These specimens will be easy to do comparing test by many laboratories and monitoring multi-laboratories hardness machines in same time.

Sheet reference specimens can reveal imperfections of anvil which can not be found with normal thickness more than 5 mm reference blocks, on the contrary there is a question if is there a problem to check hardness machine to measure thick specimens with thinner sheet reference specimen? The question has not answer completely till now; the problem is that hardness machine which can get correct results for thick specimens may be judged as not acceptable one with sheet reference specimen.

There are advantages and disadvantage to give same nominal values for a lot of reference specimens. The advantages are easy to use and compare; while disadvantage is increasing the uncertainty of nominal value for reference specimens.

It needs to consider again on thickness of reference blocks in future version of standards, such as ISO 6508-3.

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