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THE INFLUENCE OF MAGNIFICATION ON QUALITY OF MICROHARDNESS TESTER CALIBRATION

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ABSTRACT
The objective of the article is to analyze the influence of the magnification of the indentations measuring device on the results of indirect calibration of microhardness tester. The results were evaluated in accordance with STN EN ISO 6507-2:2005. The decreasing of maximum error (E_{rel}) and uncertainty of calibration (U_{rel}) with increasing of magnification was observed.
KEYWORDS:
micohardness, calibration, uncertainty

1. INTRODUCTIONS

Due to its specificity, microhardness test is used to observe changes in hardness on the microscopic scale. It is one of the best tools for understanding the mechanical properties of metals and their alloys. This method is appropriate for determination of subtle samples or thin layers hardness and identification of individual phases in metallography.

Regular basis of the microhardness test is the Vickers method. The tester is usually a part of optical microscope. Like in any test of mechanical properties, there is obvious requirement for reliability of measurement results, which is unthinkable without sufficient quality of measurement process.

Metrological confirmation shall be designed and implemented to ensure that the metrological characteristics of the measuring equipment satisfy the metrological requirements for the measurement process. Metrological confirmation comprises measuring equipment calibration and measuring equipment verification [1].

Calibration is a set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system and the corresponding values realized by standards or certified reference materials (CRM)[2].

A perfect measurement would obtain the true value of quantity. But it is, by nature, indeterminable because a perfect measurement cannot be performed. The final corrected result of a value is an estimate of the true value. The measurement uncertainty is a parameter that characterizes the dispersion of the values that could reasonably be attributed to the result of measurement. Testing laboratories shall have and shall apply procedures for estimating uncertainty of measurement or calibration.

The quality of indirect calibration of microhardness testers is affected, for example by quality of appraisers, used CRM (uncertainty, hardness), construction of tester [3]. The purpose of present investigation is to examine the influence of the magnification on the results of indirect calibration of microhardness tester.

2. EQUIPMENT AND METHOD

The calibration of microhardness tester Hanemann, Mod D32 (manufactured 1988, a part of microscope Neophot 32) was carried out by one appraiser in accordance with standard STN EN ISO 6507-2:2005 [4] and recommendations [5][6]. The certified reference material (CRM) in form of hardness reference block with specified hardness H_c = 195 HV0.05 and standard uncertainty u_{CRM} = 4 HV0.05 was used for calibration. The places of five indentations were sited along the radius (from the centre to the rim) of CRM in equidistant intervals. The test force (load) was 0.4903 N (50 g) with application time 15 seconds. The magnification of calibrated microhardness tester (object lens) is 32×

and that of indentations measuring device (eyepiece) is 15×. Overall magnification, adjusted by optical system of microscope, was between 384× to 960×.

A general rule of thumb is that the effective resolution - discrimination d* (the value of the smallest scale division – graduation of indentations measuring device in HV0.05, comparable to s_H, also in HV0.05) of tester ought to be at least one - tenth the process variation - standard deviation s_H [7].

$$d^* = \left| \frac{HV0.05_5 - HV0.05_1}{d_5 - d_1} \right| \tag{1}$$

where d_1 and d_2 are mean values of length of two diagonals of "the most hard" ($HV0.05_5$) and "the most soft" ($HV0.05_1$) indentations. Large correlation was observed between magnification and discrimination d* (r = 0.9455). If we compare equivalent values of s_H and d* listed in table 1, calibrated tester does not satisfy condition of effective resolution.

Table 1. The values of magnification, s_H and d*

Magnification ×	384	384	480	480	480	600	600	768	768	768	960
s_H (HV0.05)	4.66	10.19	10.29	8.45	7.12	3.58	8.84	10.49	13.19	10.49	6.32
d* (HV0.05)	6.30	6.26	5.65	5.10	5.83	4.36	4.89	4.20	4.12	4.26	3.19

3. EXPERIMENTAL

For indirect calibration of microhardness tester is not a problem to meet the requirements for repeatability r_{rel} and maximum relative error E_{rel} of the tester as a rule. The problem is a requirement for the maximum permissible deviation of the tester including measurement uncertainty, which is equivalent to relative expanded uncertainty of calibration U_{rel} (coverage factor k = 2).

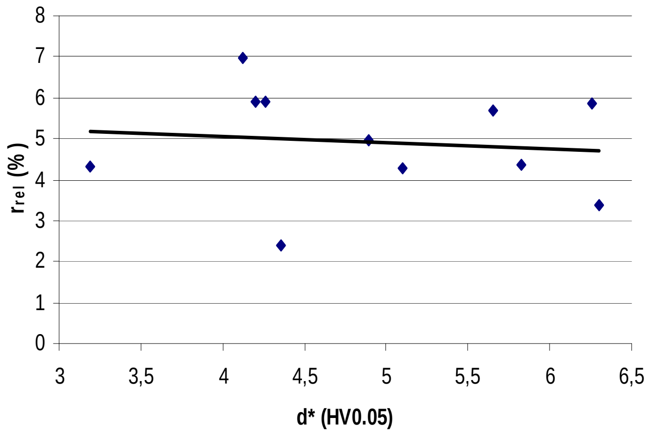

Figure 1. The relationship between d* and r_{rel}.

The repeatability r_{rel} is a function of variance and is affected by magnification only trivially (r = 0.1118), fig. 1. On the contrary, the values of the maximum error E_{rel} (0.5286), fig. 2 and uncertainty of calibration U_{rel} (r = 0.3345), fig. 3, both decrease inversely proportional with growing magnification or discrimination d*, the value E_{rel} is affected more significantly.

The quality of the metallographic specimen preparation (chemical or mechanical polishing, etching) and its character (the phases of microstructure) limits the maximal magnification in regard to CRM and also measured samples.

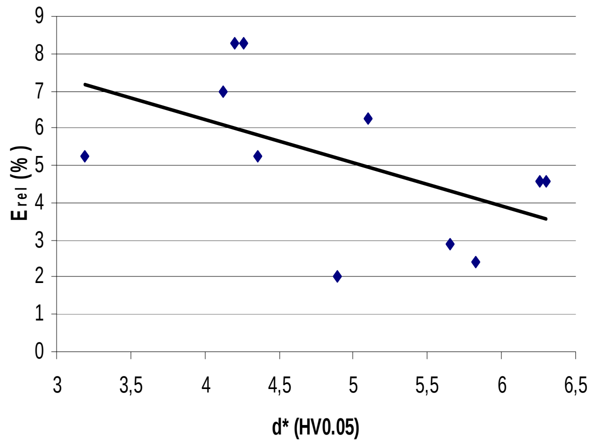

Figure 2. The relationship between d* and e_{rel}.

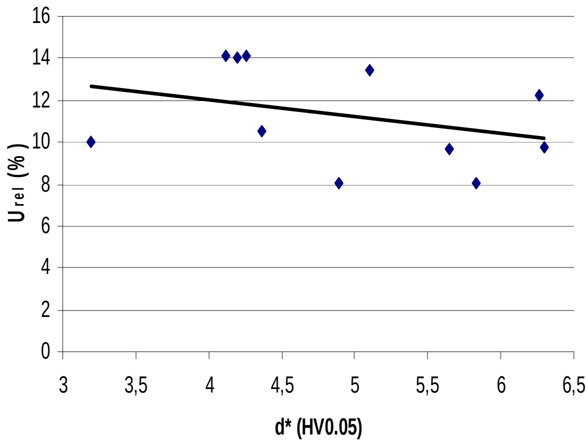

Figure 3. The relationship between d* and U_{rel}.

4. CONCLUSION

The results obtained are summarized as follows:
1. Independently of magnification, calibrated tester does not satisfy condition of effective resolution.
2. The decreasing of E_{rel} and U_{rel} of the calibration is proportional to increasing applied magnification.
3. The magnification is limited by construction of used microscope and by quality of metallographic specimen preparation.

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