

Automatic Vickers Case Depth Measurement

Arnold Horsch

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History of Automatic Hardness Testing



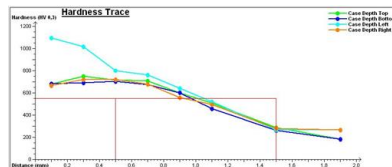
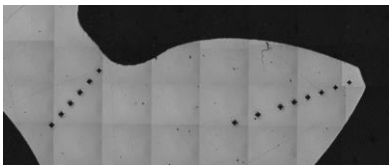
Full automatic
ecoHARD® Case Depth Measurement System
from AHOTEC® e.K., 2001

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Actual situation of automatic Vickers case depth measurement

- Carburizing depth = **CHD**
- Nitriding depth = **NHD**
- Surface hardness depth = **SHD**



**CHD measurement on Gears,
with evaluation curve**

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Actual situation of automatic Vickers case depth measurement

- Different Full Automatic Vickers Systems are on the market
- All of them are working with Image Analysis
- There is no standard which regulate the evaluation with image analysis systems clearly!
- ISO 6507 is regulating manual measurement
- ASTM 384 is mentioned in paragraph 10.8.5, there are no conditions how to do it

Practical example



Diesel injectors

Measurement on certain areas 0,05 mm under the surface
Tolerance Vickers Hardness **750⁺¹⁰⁰ HV0,5**

Automotive supplier ask for a daily check of hardness tester
with a 760 HV 0,5 testblock.

Allowed uncertainty **± 8 HV** from the nominal value

Rules from the ISO 6507-2

Accuracy of the optical measuring device

	Resolution of the measuring device	Repeatability of the measuring device
Indentations < 0,040 mm	0,0002 mm	0,0004 mm
Indentations > 0,040 mm	0,5 % of d	1 % of d

d = measured indentation diagonal

Maximum permissible deviation by HV 0,5

Method	Maximum permissible deviation of the hardness testing machine in ± in %															
	Hardness HV															
	50	100	150	200	250	300	350	400	450	500	600	700	800	900	1000	1500
HV 0,5		4		5		5		6		6	7	7	8	8	9	11

Repeatability of the testing machine

Testblock value	Repeatability of testing machine max.			
	d ¹⁾		HV 0,2 to < HV 5	
	HV 0,2 to < HV 5	Testblock value	HV	
> 225 HV		350	28	
		600	48	
	0,04 d	750	60	

¹⁾ d is the average of 5 diagonal measurements

Rules from the ISO 6507-2

What does this shows for **750⁺¹⁰⁰ HV0,5?**

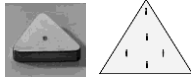
A Vickers value from 750 HV0,5
 has a possible scattering from ± 8% by 800 HV is
736 up to 864 HV,
 this is a total range from **136 HV,**
 by a possible repeatability from
60 HV in this range.

Note this are the numbers for the calibration of the machine.

TASK

To obtain accurate and reproducible results the following experiment was conducted:

- Set 25 indentations in 5 certain areas on a MPA Test block



- Manual measuring of the test block on video screen, with 1 operator, all measurements with new focus. iteration loop of this measurement 10 time of each indentation, to see the repeatability, all measurements with new manual focus
- Automatic evaluation with ecoHARD® VA software, iteration loop of this measurement 10 time of each indentation, to see the repeatability, all measurements with new auto focus
- Repeat the measurement consecutively
- Measurement under **Industrial environment** in a 3 shift operation, on 3 different machines over a period from 1year, every week

TASK

Here are several important questions to answer:

- Is there a different between manual and automatic measurement with image analysis
- Is there a different between the 3 considered machines
- The repeatability of the testing machines all over all
- The repeatability of the image analysis system
- The repeatability of manual evaluation
- What's happen with the long term stability off the results

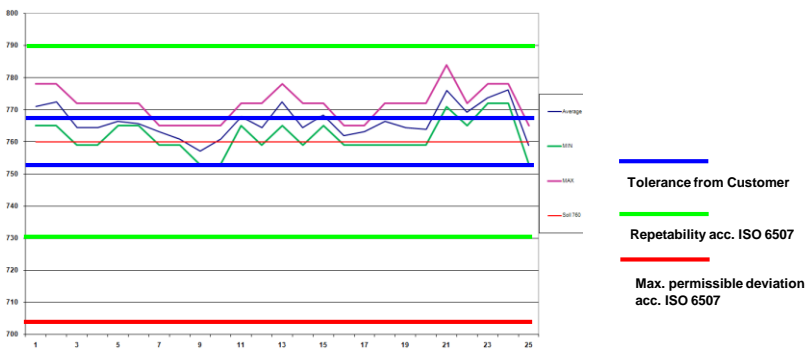
Possible influences for the result

- Problems with autofocus
- Not correct algorithm for evaluation
- Vibrations from outside
- Illumination changes

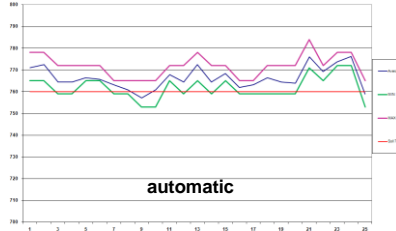
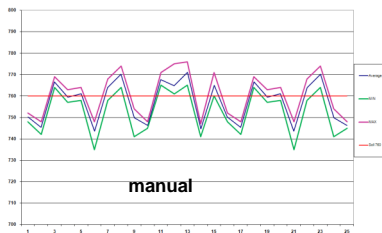
Results manual evaluation



Results automatic evaluation



Results



Intensities	a	b	c	d	e	f	g	h	h	Average	Min	Max
1	750	752	749	748	751	750	751	750	750	751	750	752
2	747	742	742	743	746	746	748	748	748	745	745	742
3	765	764	766	767	768	765	767	768	769	769	767	764
4	759	759	759	759	759	759	757	757	761	761	761	763
5	758	762	760	759	764	762	766	761	761	764	761	768
6	746	745	746	745	746	746	748	744	735	737	743	744
7	753	752	756	755	752	746	745	745	748	754	750	758
8	770	772	769	771	774	775	775	773	765	764	770	774
9	750	752	753	752	754	752	753	741	746	745	750	754
10	746	745	746	746	746	746	746	747	747	749	746	748
11	766	766	766	767	769	769	769	771	768	774	769	776
12	776	763	761	761	765	765	765	763	764	766	764	765
13	764	766	771	771	771	773	772	771	776	774	771	776
14	741	744	744	743	744	747	745	746	746	747	745	747
15	762	769	762	764	769	765	765	771	767	768	765	771
16	750	752	749	748	751	750	751	750	750	751	750	748
17	747	742	743	744	746	748	748	748	741	745	742	748
18	765	764	766	767	768	766	767	768	769	769	767	764
19	759	759	759	759	759	759	759	761	761	761	760	759
20	758	762	760	759	764	762	760	761	761	764	760	764
21	746	746	746	746	746	746	746	746	756	757	746	755
22	763	762	766	766	766	766	766	768	768	768	764	768
23	770	772	769	771	774	775	773	773	768	764	770	774
24	750	752	753	752	754	752	753	741	746	745	750	754
25	760	745	749	749	749	749	749	749	749	749	745	748
Average	757	758	758	757	758	758	758	757	757	756	757	757
Min	741	742	742	743	744	746	745	741	735	737	743	744
Max	775	772	771	771	774	775	773	773	776	776	774	774

Intensities	a	b	c	d	e	f	g	h	h	Average	Min	Max
1	772	772	766	772	778	765	778	772	765	772	769	778
2	772	778	772	772	772	766	772	778	765	778	767	785
3	765	765	766	765	766	769	769	772	769	766	765	769
4	772	766	768	766	769	765	766	765	765	765	765	766
5	765	766	766	766	766	766	766	772	766	765	765	766
6	765	766	766	766	766	766	766	766	766	766	766	766
7	765	766	766	766	766	766	766	766	766	766	766	766
8	759	758	758	759	765	765	759	759	759	765	759	765
9	763	763	766	765	766	766	766	766	766	766	763	765
10	759	765	758	759	765	765	765	765	765	765	763	765
11	772	772	766	766	766	766	766	766	772	765	772	778
12	765	759	766	765	766	766	766	766	772	765	765	769
13	766	772	772	772	778	772	766	778	772	765	772	778
14	765	759	766	765	766	766	766	766	772	765	765	769
15	765	766	766	771	773	765	766	772	778	772	765	778
16	759	768	769	769	769	769	769	769	769	769	766	769
17	760	759	766	766	766	766	766	766	766	766	763	769
18	765	772	772	772	766	766	772	766	766	766	765	769
19	766	766	766	766	766	766	766	772	769	766	765	769
20	759	759	769	766	766	772	766	766	766	766	765	769
21	772	764	778	772	771	772	778	778	778	778	778	778
22	765	766	772	772	766	772	766	772	772	772	772	778
23	772	778	778	778	778	778	778	778	778	778	778	778
24	778	772	772	772	778	778	778	778	778	778	778	778
25	772	772	772	772	778	778	778	778	778	778	778	778
Average	765	768	768	768	768	768	768	767	767	767	767	767
Min	753	753	759	753	759	759	759	759	756	753	753	753
Max	778	784	778	778	778	778	778	778	778	778	778	778

Discussion about the asked

daily check of hardness tester with a 760 HV 0,5 testblock
allowed uncertainty ± 8 HV from the nominal value

$d = 0,0347 \text{ mm} = 770 \text{ HV } 0,5$

$d = 0,0349 \text{ mm} = 761 \text{ HV } 0,5$

Range 17 HV + 9HV - 8 HV

$d = 0,0351 \text{ mm} = 753 \text{ HV } 0,5$

Accuracy of the optical measuring device

	Resolution of the measuring device	Repeatability of the measuring device
Indentations < 0,040 mm	0,0002 mm	0,0004 mm
Indentations > 0,040 mm	0,5 % of d	1 % of d

d = measured indentation diagonal

**The uncertainty of the calibration machine (MPA)
for the named test block is by 760 HV 0,5 = ± 19 HV**

Conclusion

- A asked accuracy on a testblock from ± 8 HV from the nominal value is smaller then the range which we've for the optical fault
- The 3 used machines are all in the ISO 6507, the average by all measurements is in $\pm 2\%$
- The results from the used 3 machines are over 1 year stabil
- The measured values shows that we're closed to the uncertainty of the calibration machine
- We're in a endless discussion about nothing, if we not get a MSA method

Outlook

- **We've to improve a MSA method for low load Vickers measurement**
[still on the way with the VDI Chapter 3.23](#)
- **A standard for the automatic evaluation is needed**
- **We'll extend the round robin test to other manufacturer machines to see what's happen there**

Thanks for your attention