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# Hardness testing on case- and induction-hardened samples as part of the heat treatment process

## Introduction

Heat treatment is an essential method to influence work piece characteristics. Many industries focus on reliable part design, e.g. by reducing material weight and work piece size while still maintaining high wear resistance on the outside of the material and tenacity in its core to avoid breaking parts. Many heat treatment shops are specialized in "case hardening" or "surface hardening" processes. With case hardening work pieces are carburized, hardened and finally tempered – a hard and wear-resistant surface is produced whilst the core remains relatively soft with a smooth passage between the two areas. Case hardening is typically used e.g. for gears of gearboxes. For hardness testing of case-hardened parts, the "CHD" value is evaluated by setting several hardness test points throughout the cross section of the hardened part. The CHD value describes the hardening depth in millimeters from the surface where the hardness changes from hard to soft. Standards like ISO 2639 define the requirements of the CHD test (test point distances, Vickers test method, etc.). The CHD limit hardness value is defined as fixed hardness usually at 550 HV.

In contrast to case hardening, the chemical composition of the surface layer is not changed with surface hardening. The objective is to achieve a fully martensitic structure at the surface region, usually after induction or laser hardening, whilst the core of the material remains unaffected by any hardening influence. Surface hardening is frequently used for shafts like crankshafts or camshafts. SHD hardness testing looks at the limit hardness as a flexible value: the limit hardness is defined as percentage value from the surface hardness of the part.

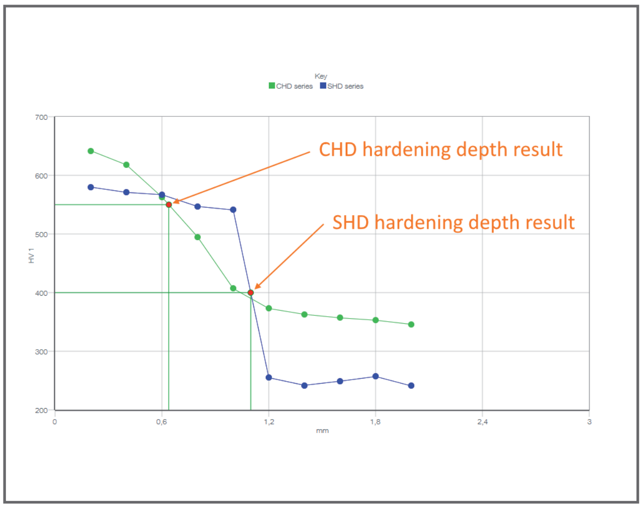


Figure 1: Difference between CHD and SHD hardened workpieces. 10 test points in the cross section of the hardened zone; 0,2 mm test point distance each: the case-hardened part hardness curve is steadily decreasing while the hardness difference of the surface-hardened part changes rapidly. In both test procedures the shape of the curve and the general depth of the evaluated result value indicate the hardening process quality.

## Requirements for hardness testers in heat treatment shops

Though the hardening process is quite complex involving large furnaces and hardening machines, the required hardness tests should be executed quickly and ideally close to the hardening process. These are the most important requirements for hardness testers in the heat treatment process:

- Automation
- Reduced the operator influence
- Simple operation
- Covering many varieties of work pieces
- Time-saving work with program templates
- Integration into production systems (Order management systems)
- Import of process sheets and work piece data
- Automated data export and result assessment
- Machine availability

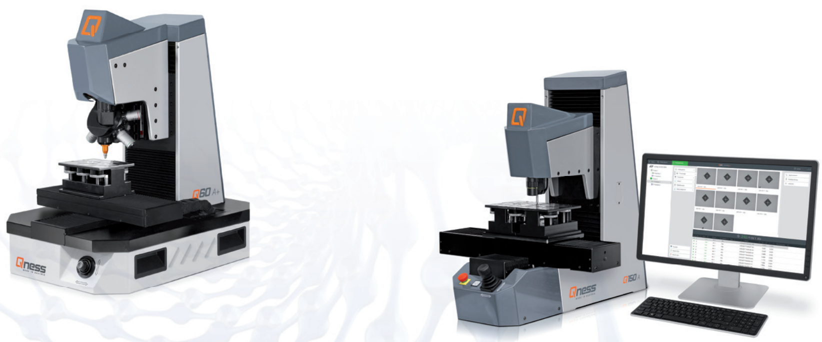

Figure 2: QNESS Q10/30/60 and Q150 A and A+ hardness testers

## Work pieces

The work pieces are always in the center of the hardening process: most of the hardening shops are suppliers for other companies – therefore, they must be capable of manufacturing an extraordinarily large spectrum of parts and the hardness tester must cover the same range. Versatile hardness testers should be able to fix mounted as well as unmounted samples and large as well as small samples. The user should have the possibility to use prisms, vices and magazines – large testing areas on the hardness testers are required as well as clever clamping solutions.

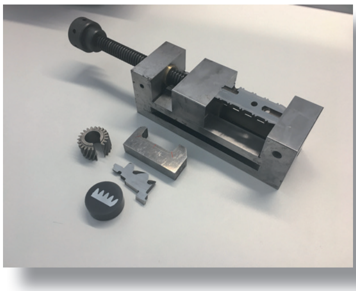

Figure 3: Magazine as clamping solution for same-parts-testing (left)

Variations of different heat-treated parts, embedded and non-embedded (right)

## Hardness testing process

Hardness testing software in general should be easy to operate but also offer a wide range of functionalities. The operating surface should be clearly structured and the program templates for the daily operation should be easily accessible. Visualized features facilitate work with the hardness tester. The program generation and management is usually executed by one or two advanced operators, whereas the production workers simply select the correct program template and press start – thus, operation errors can be minimized thanks to clever software operation design.

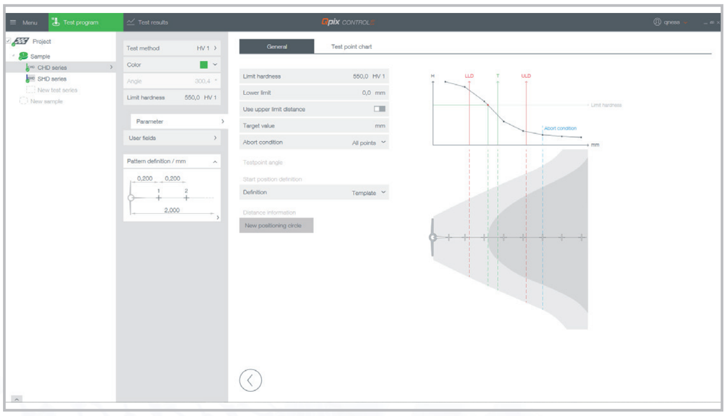


Figure 4: Hardness testing software: setup screen with visualized graphical representation of the setting possibilities

Hardness testing programs may contain hundreds of test point positions. Once applied, the tests can be executed fully automatically by the hardness tester without any assistance. The operator is free to use the time to prepare the next set of samples for hardness testing while the machine is working.

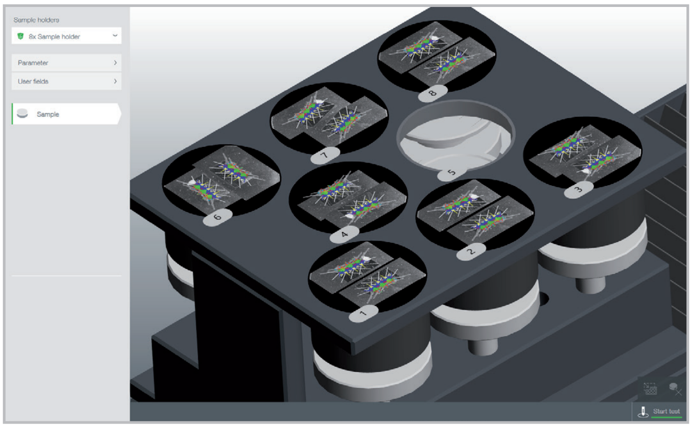


Figure 5: Preview of the hardness testing program in the hardness testing software: each colorized overlay graphic represents a CHD or SHD test point series. In the example the machine would need 3 hours to work off approx. 400 test points.

## Results

Users require either data export to data bases or test protocols. Usually, the reports are directly stored on a network drive or they are linked into some data management system. Automated data export after termination of the test sequences reduces the work and time effort of the operator even more.

Hardness testing report

**Operator:** Qness

**Sample**

| | | | |
|---|---|---|---|
| **Serial No:** | 1258586600 | **Order No:** | AA2018-52564 |
| **Denomination:** | Gear | **Drawing-No:** | 111100015558660 |
| **Material:** | Steel | **Type:** | A3 |

**CHD series**

**Result: CHD 550 HV 1 =** 0,638 mm

**Test points:**

| No. | Hardness | Method | No. | Hardness | Method | No. | Hardness | Method |
|---|---|---|---|---|---|---|---|---|
| 1 | 642 | HV 1 | 2 | 618 | HV 1 | 3 | 563 | HV 1 |
| 4 | 495 | HV 1 | 5 | 407 | HV 1 | 6 | 373 | HV 1 |
| 7 | 363 | HV 1 | 8 | 357 | HV 1 | 9 | 353 | HV 1 |
| 10 | 346 | HV 1 | | | | | | |

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## Conclusion

Hardness testing is indispensable for hardening shops to assess the quality of case-hardened or induction-hardened parts. QNESS hardness testers make this an easy task thanks to the unique Qpix Control2 hardness testing software and its 3D and visualization features. The QNESS Q150A and A+ series comprise high-quality, compact and fully automatic hardness testers suitable even for use in rough production surroundings for Vickers, Brinell or Rockwell. For usage in a laboratory the versatile micro hardness testers Q10/30/60 A and A+ offer automated hardness testing also for low force ranges.