carat 940

Hardness Testing and Image Evaluation
Whatever you need for quality testing and material analysis, ATM has it all: As a manufacturer of high-quality machines for materialography (metallography), we offer the most comprehensive solution for your needs. We not only supply a wide range of instruments but also accessories, consumables, complete laboratories and tailor-made special-purpose solutions.

Our innovative cut-off machines, mounting presses, grinders, polishers/electrolytic etchers, as well as hardness testers and analysis systems provide maximum reliability and flexibility. Thanks to the most advanced engineering technologies and manufacture of components in our own factory, we are able to fulfill individual customer requirements by adapting our instruments to their needs.

Our R&D department for hard- and software works in close cooperation with our customers to ensure continuous optimization of our products.

Customers in more than 30 countries appreciate our comprehensive sales and service network as well as direct communication with our experts.

To provide you with solutions of consistently high-quality we rely on the expertise and creativity of our qualified and dedicated long-standing employees.
The continuous development and improvement of machines and products require high quality materials resistant to strong mechanical impact. Production components should therefore possess defined toughness or wear characteristics. Properties defined by the developer for the particular application area of the product have to be tested especially in the case of vital components in the manufacturing process. Examinations, for example hardness testing, not only have to be carried out quickly and in-process but should also be reproducible. Hardness testing equipment is used for quality control in production processes but also in R&D laboratories and for failure & damage analysis. Because quality deviations in components may lead to safety risks, implementation of a precise, reliable and, as far as possible, automated measuring device for hardness testing is a crucial prerequisite for premium product quality.

Micro & Macro Hardness Testing
Flexible & reproducible

1.) Hardness testing on a double fillet weld with standard template
2.) Carbon steel with Ferrite / Perlite, 200:1
3.) Vickers indentation, viewed with polarisation (Leica DM 8000 M)
Hardness Tester with High Resolution Objectives for wide-ranging Measurement Tasks

The high flexibility of CARAT 940 allows automatic testing on up to 8 prepared samples. In the time the hardness tester performs its measuring tasks, the operator can make use of the time for other tasks. After a successful series of hardness tests, the results are automatically transferred into the reporting templates (individually compatible). The integrated measurement software enables easy manual measurements on prepared samples (e.g. A-dimension, layer thickness measurements etc.) and collection of further structural properties without the need of an additional microscope.

The very latest technologies and intuitive operation provides the CARAT 940 with excellent capabilities for hardness testing and optical analysis of microstructure. The indenter is not integrated into the objective revolver, which accommodates up to 6 objectives (25 to 1000-times magnification). The robust basic unit can be configured to optimum functions with a number of software modules and CARAT sample mounting systems to meet your needs and is ideally suited for the evaluation of microstructures.

1.) CARAT 940 with 8-time revolver for automated multiple measuring and status display for operational status of the appliance
2.) Direct, revolver-independent coupling of the indenter to the force measurement system guarantees high precision and accuracy in measurement
3.) Self-levelling CARAT clamping system
Hardness tester CARAT 940

- Micro-processor driven load cell
- Fully automatic hardness testing
- Manual testing possibilities
- Robust cast-Aluminium construction
- Overview camera
- Objective and illumination identical with brightfield microscope
- Testing methods:
  - Vickers: HV 0.05 – HV 50 (DIN EN ISO 6507, ASTM E-384)
  - Knoop: HK 0.05 – HK 2 (DIN EN ISO 4545, ASTM E-384)
- Standardized result documentation

PREMIUM QUALITY
MADE IN GERMANY
The design of the CARAT 940 allows use in a wide range of testing environments. Robust and space-saving, it finds application not only in the lab, but also in fabrication and quality management.

**Automatic X/Y coordinate stage**
- Travel max. 250 x 100 mm, resolution 0.1 μm
- Individual positioning for samples (up to 8 mounted samples)
- Max. permissible load 60 kg

**Manual operating elements**
- Dynamic joystick for positioning of the X/Y coordinate stage
- Rapid running key for travelling the testing head in the Z-axis (travel 150 mm)
- Precise focusing by means of fine drive (resolution 0.01 μm)

**Optics**
- Overview camera with 5.0 megapixel CMOS sensor
- High-quality microscope optics with flat plan achromat objectives
- Magnification 25 x-1000 x for hardness testing and microscopic measurements
- Homogenous focused image field based on the Köhler illumination principle
- Individually adjustable aperture diaphragm, USB 3 cameras up to 5 megapixel resolution

**Basic construction**
- Cast-Aluminium body
- Precision guidance systems in the drive axes
- Force measuring system with high quality measurement technology
Preparation Process
Integration of hardness testing & image evaluation

Optical Measurement System
Microscope optics with Köhler illumination & aperture diaphragm

The optical measurement system forms the core component of a reliable hardness testing unit, as well as the precise regulation of force and the software. Through the specially developed optical design, an optimum, evenly spread illumination of the whole image field is achieved with additional increase in depth of focus. Not only does this show significant advantages for contrasted (etched) polished surfaces but it also aids in image analysis during hardness testing. The overview camera integrated in the objective revolver images the whole specimen at once and the individually adjustable aperture diaphragm can additionally optimize the illumination system and adapt itself to every test situation.
Accessories
Hardness test blocks & object micrometer

Repeatability precision and limit deviations of a hardness testing unit should be inspected and documented by the user at regular intervals, and according to the corresponding standards, in order to prove the regular/prescribed operation of the ability to measure correctly. Even within the scope of microscopy, it is often necessary to check the optical measuring system using test blocks.

Calibration
Accredited & standardized

The CARAT 940 is factory calibrated and labelled with the corresponding certificate before shipment. The official on-site calibration according to the corresponding standards is offered by us in conjunction with an accredited calibration service.
The innovative & versatile Easy Clamping System for cut-off machines has also been adapted for the CARAT 940. The CARAT clamping base can be easily fixed on the stage and is not only the basis for non-mounted samples with quick-clamp 50 and universal clamp, but also for mounted samples for sample holder with diameters from 25 – 50 mm or 50 – 70 mm.

In the clamping rings, the self-levelling system ensures samples fit automatically plan parallel. This minimizes potential damage to the indenter and measurement unit during the testing process and increases the accuracy of measurement. The stage of the standard CARAT accommodates up to 3 CARAT Easy clamping bases for 6 samples, the larger stage (optional) offers space for 4 clamping bases with 8 samples.
ATM CARAT Software
Complex testing tasks quickly & easily solved

Practical orientated and user-friendliness compose the basic foundation of ATM CARAT software and offer client-related solutions for hardness testing and simple measurement tasks. With assistance from programmable testing templates, it is possible to plan & carry out a complete hardness test with only a few steps and automatically generate documentation.

All templates for testing and documentation are reusable and can be customized or adapted depending on the task. The CARAT 940 software with professional calibrated optics enable geometric measurements in brilliant images. These can then be archived together with the measurement results, e.g. for documented measurements of layers or welded seams.
Modular Software Packages

CARAT-Inspect: Grain size analysis, coating thickness measurement, phase analysis

Inside the CARAT software there are many different tools for hardness testing and measurement tasks available. These are available in separate software packages which allow configuration of an affordable and easy to use software solution for simple tasks, but also the ability to provide a full version with advanced functions. By updating the software at any time it is possible to integrate additional functions into the software as new testing tasks arise.

Hardness Curves

Measurements going deep

Standard testing procedures for the determination of hardness curves (CHD, NHD; Sinter-CHD) create the prerequisites for rapid single & series testing. Testing results that fall outside pre-defined tolerance specifications are clearly presented in the reporting documentation, simplifying the quality evaluation of tested samples.
Hardness Testing
Welded seams according to DIN EN ISO 9015-1

Templates which can be individualized for butt & fillet welds enable a quick entry into welded seam measurement. If the transitions between the basic material, the heat-affected zone (HAZ) and the welded seam are well contrasted, then a start can be made directly after the usual testing configuration.

Regular Test Grid
Tool for 2-dimensional hardness curves

The measurement objects available in the software can be offered for complicated hardness measurements with many testing points. They enable the measurement of hardness curves in the zone with graphic presentation of the results and are therefore an excellent tool for examinations of the homogeneity of welded samples.
Measurement Tools
Simple instead of complicated

The calibrated optical system and the measurement tools integrated into the software allow a combination of hardness testing and measurements of geometries or structure constituents. The software allows hardness curves and the connecting layers to nitrided samples to be recorded and documented with the same testing unit, and to perform an examination of the A dimension and the hardness at welded seams within the framework of a metallographic examination.

Structure Evaluation
Interpretation with CARAT 940

1.) Microstructure AlSi, polished, brightfield, magnification 200x

2.) Heat-treated steel C45, Tempered structure Martensite / Bainite, etched with 3% alcoholic nitric acid (Nital) brightfield, magnification 500x
Measurement Results

Documentation & evaluation in a few clicks

Documentation of the measurement results in accordance with stipulations and standards is often the most important component of the testing procedure. A report generator integrated into the software offers the possibility to create user-defined documentation, which can be edited and stored. Data collected during the measurements in the form of measured values, calculations, texts, images and graphs are displayed in the configured test report at the desired location.

The test report or single illustrations and results out of the software can be printed, saved or further edited via different export functions in databases or programs.

1.) CSV-Export of hardness testing results in Excel
2.) Report CHD-Hardness profile
3.) Report microstructure examination
# Software packages

## CARAT-Inspect

### Coating thickness measurement
- Live image capturing / Loading and recalibration of stored images (PNG, JPG, TIFF, BMP)
- Preprocessing filters (e.g. Blurring, Sharpen, Normalize)
- Object definition by gray and / or color threshold
- Morphological filters
- Selection of image objects by predefined measures
- Measurement of coating thickness according to DIN EN ISO 1463
- Output of the coating thickness in terms of statistical quantities (e.g. mean, standard deviation, median, minimum, maximum) in tabular or graphical fashion
- Two preinstalled coating thickness measurements as favorites

### Phase analysis
- Live image capturing / Loading and recalibration of stored images (PNG, JPG, TIFF, BMP)
- Preprocessing filters (e.g. Blurring, Sharpen, Normalize)
- Object definition by gray and / or color threshold
- Morphological filters
- Selection of image objects by predefined measures
- Automated image object measurement
- Measurement of phase fractions according to ISO 9042 and ASTM E562 - 11
- Output of analysis results in terms of the relative/absolute area in tables or graphs
- Statistical quantities (e.g. mean, standard deviation, median, minimum, maximum)
- Preinstalled phase analysis as favorite

### Grain size analysis
- Live image capturing / Loading and recalibration of stored images (PNG, JPG, TIFF, BMP)
- Preprocessing filters (e.g. Blurring, Sharpen, Normalize)
- Object definition by gray and / or color threshold
- Morphological filters
- Selection of image objects by predefined measures
- Automated image object measurement
- Measurement of phase fractions according to ISO 9042 and ASTM E562 - 11
- Output of analysis results in terms of the relative/absolute area in tables or graphs
- Statistical quantities (e.g. mean, standard deviation, median, minimum, maximum)
- Two preinstalled grain size analyses as favorites

## Hardness testing module

### Fully automatic and manual image evaluation and hardness calculation
- Compile single measurement points and series thereof
- Adjust test objects visually or parametrically
- Adaptation and rotation of the CHD (i.e. NHD measurement series)
- Set axis to edge line of the CHD-/NHD-measurement series (Standard 90 °)
- Allocate different indentation features (planned, finished and faulty print)
- Import and save already processed measurement sequences for reproduction
- Misalignment of a sample through targeted sequences and focusing correct more measurement points
- CHD-Measurement series: define point shift 1- or more paths
- Sinter measurement series
- Define tolerance field for hardness- as well as CHD curve
- Circle (i.e. circular segment) with concentric auxiliary circles
- Spot group for hardness testing
- Colored presentation of measurement results in overview image

### Free-handed measurement series module

#### Hardness testing along a polygon line
- Freely select number of spots and angle of the line segment
- Adjust misalignment (e.g. to sample edge)
- Relocate points singly, attach or delete

#### Regular test grid

#### 2-dimensional hardness sequences
- Up to 6,000 testing points
- Adjust number of points and separation adjustable
- Speeding up the testing process through calculation in background
- Colored 2D presentation of measurement results

## Welded seam module

### For hardness testing at welded seams (butt weld, fillet weld and double fillet weld)
- Adjust the 5 zones of the test line in number of points, length and alignment (left & right flush, middle)
- Show standard tolerance of edge distances with border help lines
- Change fillet weld tool outside angle
- Results will be issued with labelling of the zones in the evaluation

### Software packages
### Technical Data CARAT 940

#### Hardness tester CARAT 940

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test method</td>
<td>Vickers, Knoop</td>
</tr>
<tr>
<td>Loading range (DIN EN ISO 6507 + ASTM E-384) (DIN EN ISO 4545 + ASTM E-384)</td>
<td>HV 0.05 – HV 50 HK 0.05 – HK 2</td>
</tr>
<tr>
<td>Total testing range</td>
<td>1 g – 50 kg</td>
</tr>
<tr>
<td>Max. loading CARAT stage</td>
<td>60 kg</td>
</tr>
<tr>
<td>X-axis (coordinate stage)</td>
<td>160 mm or 250 mm</td>
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<tr>
<td>Y-axis (coordinate stage)</td>
<td>100 mm</td>
</tr>
<tr>
<td>Z-axis</td>
<td>150 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>~ 65 kg</td>
</tr>
<tr>
<td>W x H x D</td>
<td>375 x 650 x 670 mm</td>
</tr>
<tr>
<td>Electrical connection data</td>
<td>100 – 240 V, 50/60 Hz (1 Ph/N/PE)</td>
</tr>
<tr>
<td>Overview camera</td>
<td>5.0 Megapixel (2464 x 2056 px), USB 3.0, CMOS camera</td>
</tr>
<tr>
<td>Optic</td>
<td>Microscopic measurement system with digital CMOS camera</td>
</tr>
<tr>
<td>Objectives</td>
<td>Infinite corrected plan achromat objectives</td>
</tr>
<tr>
<td>Illumination</td>
<td>Köhler LED illumination and aperture diaphragm</td>
</tr>
<tr>
<td>Illumination type</td>
<td>Brightfield</td>
</tr>
<tr>
<td>Magnification</td>
<td>25 x – 1000 x (25 x / 50 x / 100 x / 400 x / 500 x / 1000 x)</td>
</tr>
<tr>
<td>Camera resolutions</td>
<td>1280 x 1024 px, 1600 x 1200 px</td>
</tr>
<tr>
<td>PC System</td>
<td>Micro-PC-System incl. full-HD 23&quot; Touch-Screen, rem. keypad &amp; mouse, Windows op. system</td>
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</tbody>
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