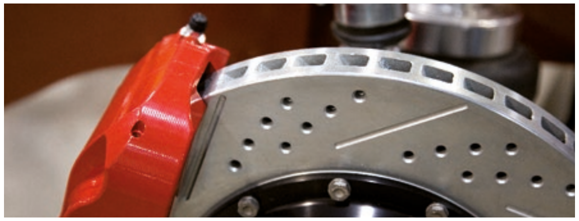
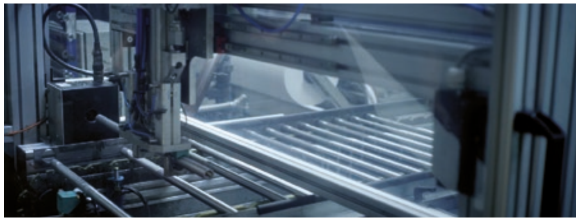
AUTOMOTIVE INDUSTRY

Process-integrated quality assurance for metal components.

FOERSTER



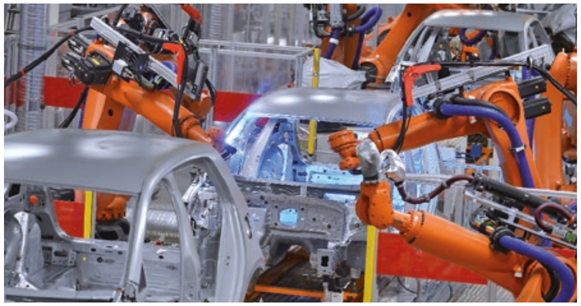


Ensuring the quality of your components

Automotive suppliers face huge challenges due to the ever-increasing quality expectations of the automotive industry. In order to meet these high demands, there's no way around it: Modern production lines must continuously control the quality of the individual components – as they are fabricated. Besides providing rock-solid reliability, it's important that the inspection process be highly automated with a throughput speed adapted to the line, to prevent negative impact on production.

FOERSTER offers various test and measurement systems to examine components for cracks and defects, as well as to determine their material properties, in both classic and electric-drive automotive manufacturing. New drive technologies demand new solutions in quality testing: With FOERSTER test and measurement equipment, you're ideally equipped for the future.

FOERSTER instruments and systems are used wherever absolutely reliable, objective and economical testing is required. Plus, the test results are fully documented for quality assurance purposes. In close coordination with its customers, FOERSTER develops the optimum solution to meet individual requirements. Come with us now to see how!



Machined components

Continuous developments in the automotive industry place incredible demands on the materials used. Even in the machining phase, the parts being fabricated are subject to strong forces that can cause material defects. To catch such production-related faults at an early stage, FOERSTER test equipment can conduct 100% inspections of your components – and then monitor the subsequent tempering process to ensure that they are properly hardened.

Versatile applications

As diverse as the individual components are, so are their testing requirements. Because of its broad portfolio of probes and automation solutions, FOERSTER is well-positioned to respond to unique situations individually.

Application examples:

- Turned parts
- Valves
- Valve sleeves
- Valve seats
- Piston rods / pins
- Nozzle cap nuts
- Needle- / ball bearings
- Bearing- / tapered rollers

Turned parts

Turned parts are used wherever the fit must be accurate within micrometers. As components become ever smaller, ever lighter and – at the same time – more efficient, 100% crack and microstructure testing is required. This is where our MAGNATEST and STATOGRAPH test systems show their strength. The sensitive probes detect even the finest cracks and sense the smallest structural differences. To this end, the turned parts are either passed through an encircling coil or are scanned with fixed probes at the critical spots.

Injection components

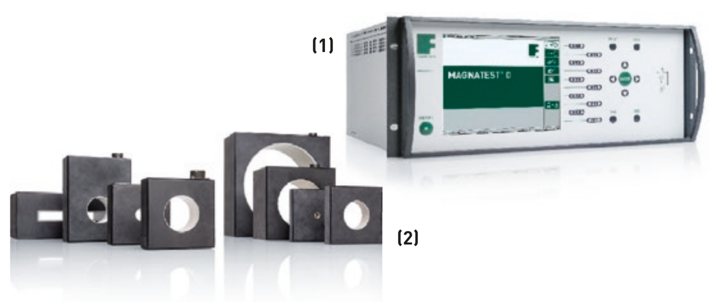
Common-rail fuel injection systems as found in combustion engines generate enormous internal pressures. So that the tubes (rails) withstand this extreme load, they are treated in an autofrettage process.

Using the MAGNATEST D test instrument and an encircling coil, the injection systems are tested after autofrettage to determine whether it was carried out correctly. Depending on the test result, the workpieces are automatically sorted as either 'good' or 'bad' parts.

Valves / valve seats

The inlet and outlet valves are among the most thermally and mechanically stressed parts of an engine; even the smallest of cracks can lead to valve failure. In combined crack and hardness testing, fixed crack-test probes completely scan the critical areas of the component. To determine whether the valve end – which is subject to particularly high loads – has been correctly hardened, an encircling test coil is used in combination with the MAGNATEST D instrument.

(1) MAGNATEST® D
(2) Encircling coils



Piston rods / pins

At high revolutions per minute (RPMs), piston pins must withstand extreme stress. In order to avoid piston failure, the raw materials from which they're made must be flawless.

To ensure this is the case, each part is inspected for cracks as it passes by during production. FOERSTER's automated testing system ROTO-PUSH was developed especially for this purpose: Fast-rotating probes guarantee seamless surface inspection of the test parts and high material throughput.

Nozzle cap nuts

The nozzle nut is an important component of fuel injectors: It secures the nozzle body to the injector body. A part that plays such a demanding role in the engine can tolerate absolutely no material defects. For this reason, 100% inspections for cracks and microstructure are essential to ensuring the proper functionality of the injection system.

The STATOGRAPH test instrument, equipped with either a standard probe or a FLEXPROBE, is ideal for detecting cracks in nozzle cap nuts. The microstructure is then examined using the MAGNATEST.

Ball bearings / roller bearings

At high RPMs, bearings are subject to huge loads. As a result, any existing cracks can grow and break out, resulting in the failure of the bearing. Causes include material mix-ups, insufficient hardness as well as errors in the heat treatment and polishing process. In order to catch such defects at an early stage, the microstructure of the ball is tested for electrical conductivity and magnetic permeability using the MAGNATEST test instrument and a highly sensitive coil. The STATOGRAPH test instrument is used to test for cracks on the end faces of the inner and outer rings of the bearings. In this way even the finest cracks become visible.

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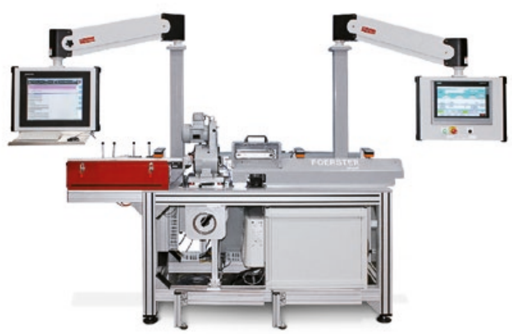

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(1) ROTO-PUSH
(2) STATOGRAPH® CM+
(3) Probes
(4) FLEXPROBES

Forged and formed parts

During solid forming of steel into automotive parts, fine cracks can occur at critical points, even with the best planning. The proven test instruments from FOERSTER examine these locations minutely in order to detect component faults as early as possible – well before they become noticeable or cause damage. In addition, our test equipment monitors the microstructure quality and tempering so you can keep a close eye on whether your components meet your customers' high requirements.

Application examples for forged and formed parts:

- Gear racks
- Wheel hubs
- Crankshafts
- Camshafts
- Drive shaft cams
- Tripod joints
- Constant velocity joints
- Universal joints
- Toothed gears
- Beveled gears
- Gear parts
- Common rails
- Con-rods
- Control arms, wishbones

Gear racks

To determine the hardening depth of gear racks, FOERSTER offers both a semi-automated random sample test and a 100% test using its MAGNATEST D plus an encircling coil. In this combination, several test points on the rack are checked for hardness quality. The hardening depth is displayed separately for each tested point. The inspection is triggered automatically by electronic positioning monitoring when the part arrives at the test position. An interface to the superordinate quality management system ensures complete documentation of the test results.

Constant velocity joints

As safety-relevant components, the shafts of CV joints require a hardness check. With the MAGNATEST D and an encircling coil or internal test probe, the hardness of both the shaft and the bell is non-destructively measured. Exact adaptation to the component's geometry makes this test highly reproducible.

The MAGNATEST D uses high-performance harmonic evaluation, to reduce interference factors like geometric part tolerances or temperature influences, thus achieving long-term stable results.

Cams / camshafts

FOERSTER offers fully automated, 100% testing for microstructure and cracks on forged and sintered cams. For crack detection, the STATOGRAPH tester is combined with MECA probes and standard probes. This makes it possible to check several critical areas simultaneously. In addition, a magneto-inductive microstructure test can be performed using an encircling test coil.

We also test entire camshafts – completely automatically – for hardening cracks. Scanning of all the camshaft surfaces is conducted using up to eight MECA probes as the piece is rotated.

(1) MAGNATEST® D
(2) Encircling coils
(3) STATOGRAPH® CM+
(4) MECA Probe

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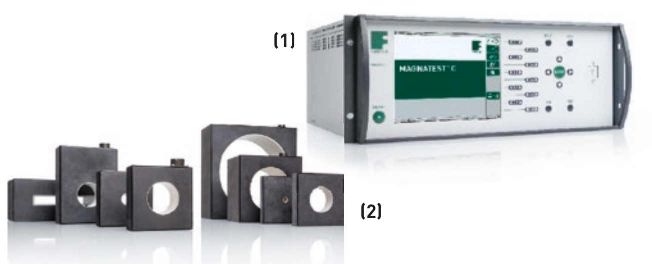

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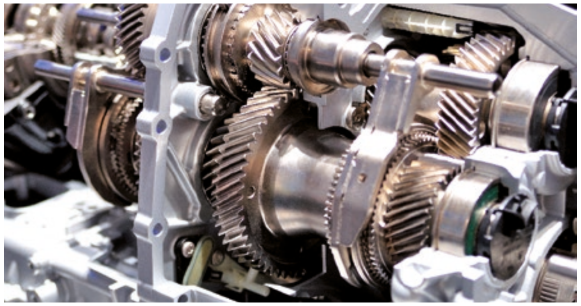


Toothed / beveled gears

FOERSTER has developed an automated robot cell for efficient crack detection on forged gear components. A STATOGRAPH test instrument is installed in the cell to evaluate and document the test signals.

Flexible probes are used to ensure that the complex geometric surface of the gears is tested as sensitively as possible. The robot cell can be integrated into the inspection process or used offline.

Transmission parts

Transmission parts are subject to severe stresses due to the constant changes in load. FOERSTER supports the quality assurance of these parts as well with its non-destructive test systems. The STATOGRAPH test instrument, coupled with one contour-tracking and two fixed eddy current probes, is ideal for crack testing of the gear shafts; this checks them for both longitudinal and transverse cracks.

To assess the tempering, an encircling MAGNATEST test coil is positioned at the shaft end.

Control arms / wishbones

Control arms and wishbones in a car suspension transmit the transverse forces between the wheel and the chassis. These components are subject to substantial stress, which is why it's essential that the raw materials be flawless.

Especially in the milled holes of control arms, cracks can occur in the material surface, which negatively affect the material quality. But using the STATOGRAPH test module and a rotating double-axis probe, the defects are caught before they can cause problems.

(5) Crack-testing system
(6) STATOGRAPH® CM
(7) Probe
(8) FLEXPROBES

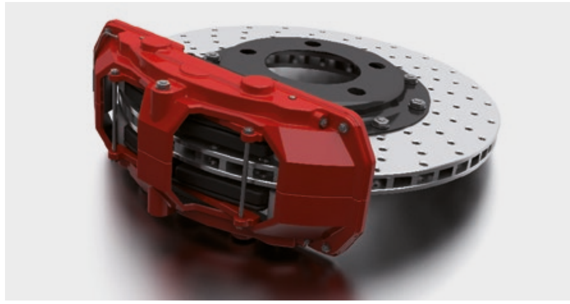
Cast and sintered parts

In a foundry, the various materials and components are subjected to different processes. FOERSTER's test equipment makes 100% testing possible, in order to prevent material mix-ups and ensure that no incorrectly tempered parts are delivered to the customer. The test results also make a statement about the casting quality and therefore contribute to comprehensive process control.

These days – because it presents an economical alternative to conventional casting processes – more and more complex components are produced by sintering. But also here, it's important to monitor the material quality both before and afterwards, so that only perfect components are used.

We can test the following types of components, among others:

- Brake discs
- Brake calipers
- Cylinder liners
- Crankcases
- Pistons
- Sintered parts made of iron



Brake discs

To check the surface of brake discs for longitudinal, point and transverse defects, FOERSTER offers a fully automated, inline, 100% crack inspection. For this purpose, the eddy current test instrument STATOGRAPH is used in combination with highly sensitive probes. The test examines defined, error-prone zones of the braking and mounting surfaces on the outside and inside of the disc.

With the innovative STATOVISION software, even the finest cracks located directly on drill holes or milled features – previously undetectable – can be made visible by suppressing known interference signals.

Brake calipers

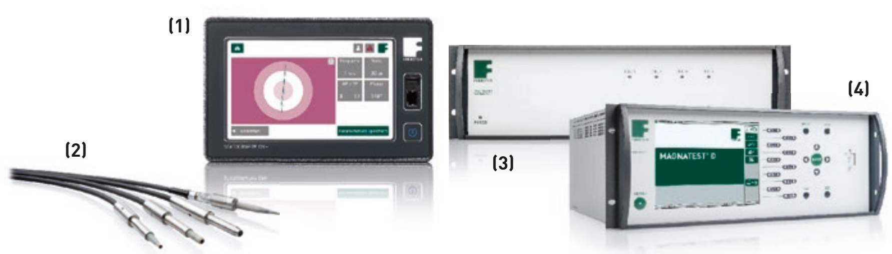
To monitor the quality of brake calipers, the parts undergo magneto-inductive material and microstructure testing. The MAGNATEST D uses high-performance harmonic evaluation to enable reliable and responsive testing of the microstructure, e.g. to check for cementite content.

A powerful amplifier ensures that the component in the test coil is exposed to a very strong alternating magnetic field. The resulting hysteresis curve is a sensitive indicator for a variety of material properties.

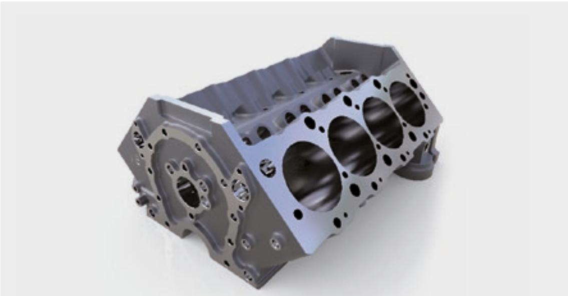
Pistons

Engine pistons have a special shape that makes testing them with conventional probes very difficult. However, as surface-exposed inclusions often occur in pistons, it's necessary to conduct a comprehensive inspection of the surface, especially in the undercut.

For reliable inspection of this area, FOERSTER has developed a special array probe that features eight sensors connected in parallel. When this probe is used in combination with a STATOGRAPH module, it enables high-resolution testing of the undercut for cracks and inclusions.



(1) STATOGRAPH® CM+
(2) Probes
(3) MULTIPLEXER MAGNATEST® D
(4) MAGNATEST® D



Cylinder liners / crankcases

Coated cylinder bores and cylinder liners in engines fulfill an important function. They ensure that the piston runs optimally. If the material surface is damaged by defects like cracks, this can impair other engine components and potentially lead to engine failure.

The STATOGRAPH eddy current test instrument is used in conjunction with a rotating, longitudinally guided eddy-current sensor to test the cylinder bore and/or liner. This is driven by the rotating head R2, and it scans the inner surface without ever making contact. This makes it possible to find open cracks and pores, as well as other hidden defects located just below the surface.

Even Nikasil® cylinder liners can be checked for cracks, pores and bonding defects using the special, rotating eddy-current sensor. This determines whether the 60-80 µm thick coating applied to the surface of the cylinder bore is sufficiently adhered to the base material.

Sintered parts made of iron

For economic reasons, components with complex geometries are often manufactured by sintering. Magnetically soft components such as housings and connecting elements, as well as mechanically stressed parts in the drive and aggregate area, are commonly manufactured this way. The quality of the FE powder, its grain size and the uniformity of its distribution before and after the sintering process are all decisive for the subsequent mechanical properties (e.g. strength and wear) of the sintered components: These parameters correlate to the coercive field strength. With the KOERZIMAT, the entire production process can be monitored, from assessing the powder to evaluating the sintering process itself.

(1) Rotating head R2
(2) KOERZIMAT® 1.097 HCJ

(1)

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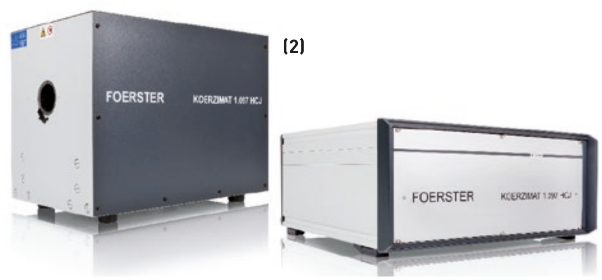
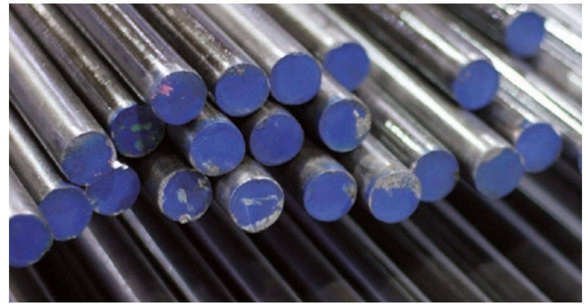


Components for electric drives, actuators and sensors

The rapid development of electronic drives has brought with it new tasks and challenges in quality testing. Corrosion resistance and the mechanical properties of the components are no longer the only critical factors. The material's interactions with electromagnetic fields has also become increasingly important.

Components for electric drives must be made from materials that are easily magnetizable, so that the electromagnetic system operates quickly and consumes as little energy as possible. With our instrument KOERZIMAT, material properties such as coercive field strength can be determined accurately, which helps ensure precise switching of electromagnetic high-performance injection systems, for example.



Process monitoring in component production

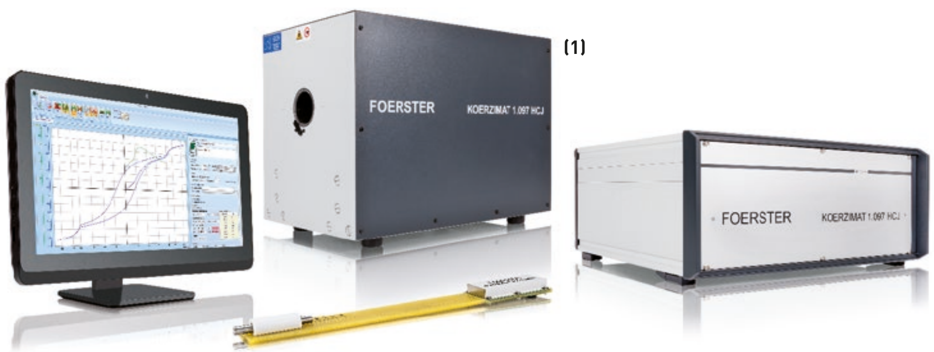
In the manufacture of components for electromagnetic actuators, cold forming processes like punching, bending and machining create internal mechanical stresses in the material. These lead to an increase in the dissipation of electromagnetic power, which correlates with the magnetic material property coercive field strength.

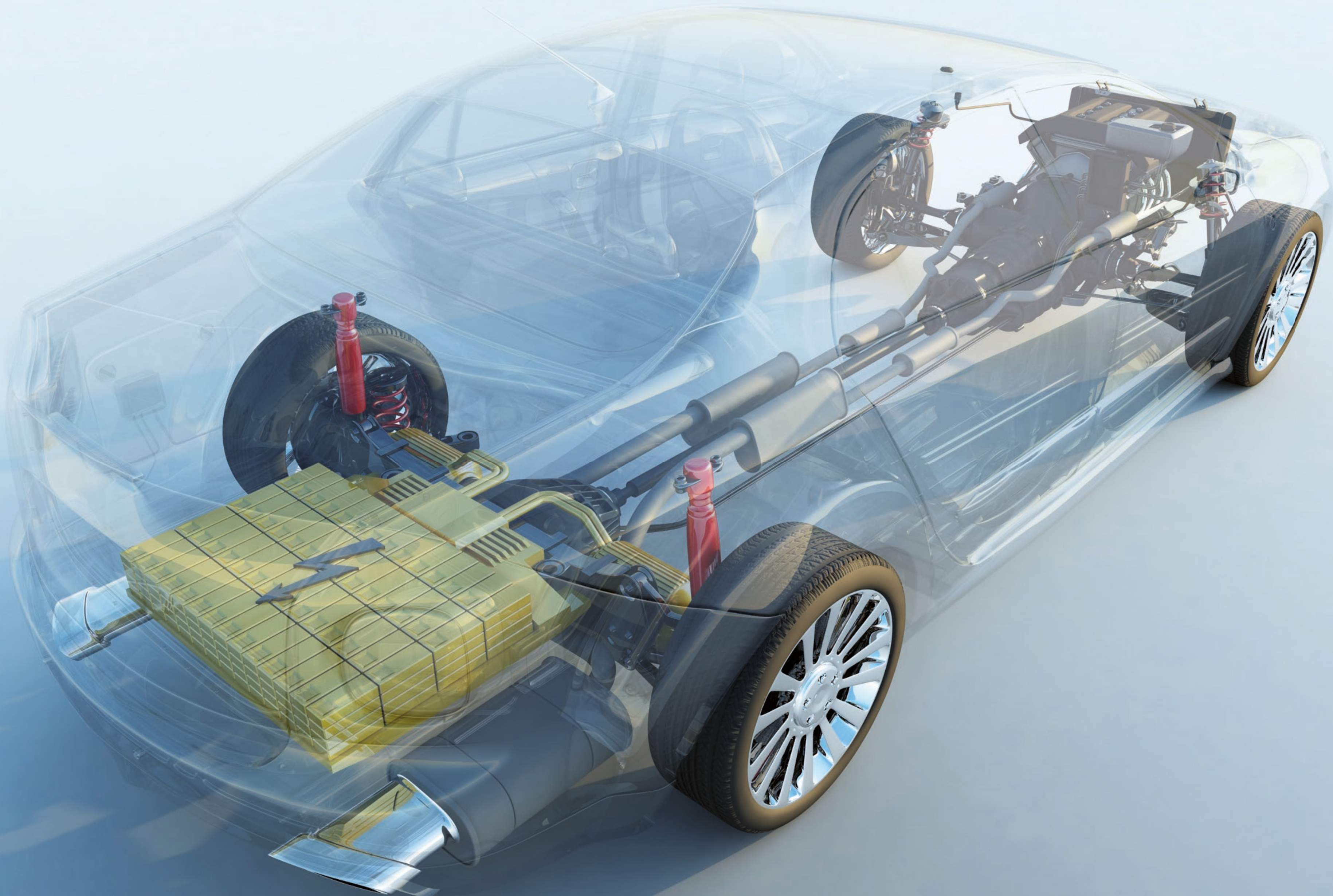
The original condition of the material can be restored by proper heat treatment. For this reason, the KOERZIMAT HCJ is used to measure the coercivity both before and after the final annealing, in order to monitor the material properties in the production process – so that countermeasures can be taken, if necessary.

Qualifying raw materials

Because the electromagnetic properties of the raw material are decisive for the performance of the finished electromagnetic actuators, the KOERZIMAT determines the material's entire magnetic hysteresis, including all key parameters. This makes it possible to qualify it as suitable – or not. The inspection can be conducted either directly while producing the raw material or as part of an incoming goods inspection before further processing. Either way, the material quality is continuously monitored and documented.

(1) KOERZIMAT® 1.097 HCJ
(2) J-Sensor

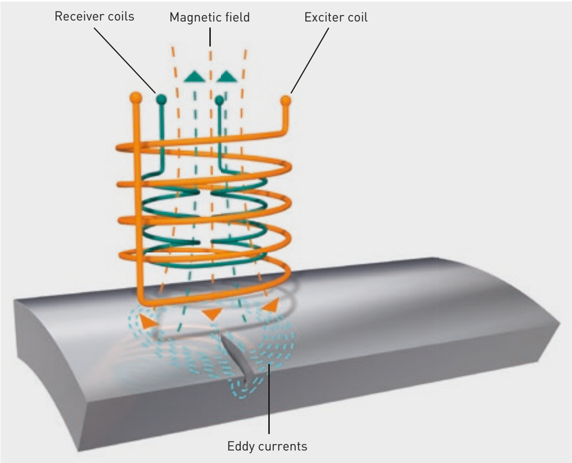




Surface crack testing

Non-destructive testing using the eddy current method

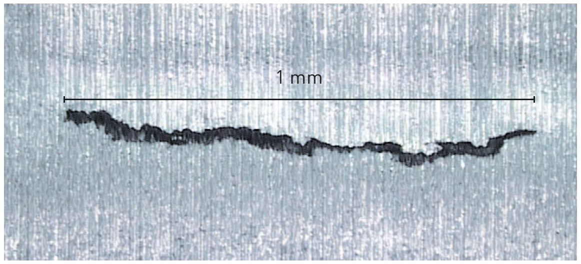
The keen attention paid to quality these days – not to mention the risks associated with product liability – increasingly necessitates 100% inspections of components. The eddy current method according to DIN EN ISO 15549 is a non-destructive and non-contact method for material testing. It detects surface defects such as cracks, overrolling, pores or cavities and works quickly, reliably and economically. A magnetic field is generated using an excitation coil, which induces high-frequency eddy currents in the material. The resulting signal is usually recorded with a differential measuring coil. This received signal is evaluated against the amplitude and phase shift relative to the exciter signal, exposing even the smallest defects in the material.



The principle behind eddy current testing

Testing for cracks in the material

For crack detection, the test specimen is mechanically rotated and scanned by a fixed probe, or a rotating probe scans the stationary sample. As long as there is no damage in the material, the eddy currents flow through evenly, because the electrical resistance is homogeneous. But if there's a crack somewhere, the eddy current density shows up as different from that of an undamaged part. This change is recorded and displayed as an error signal.



Natural cracks in turned surfaces

Testing with the STATOGRAPH®

Eddy current testing for material cracks requires the appropriate evaluation electronics and probes adapted to the testing task. Depending on the test situation and test object, the STATOGRAPH family of test instruments offers the right system for this purpose.

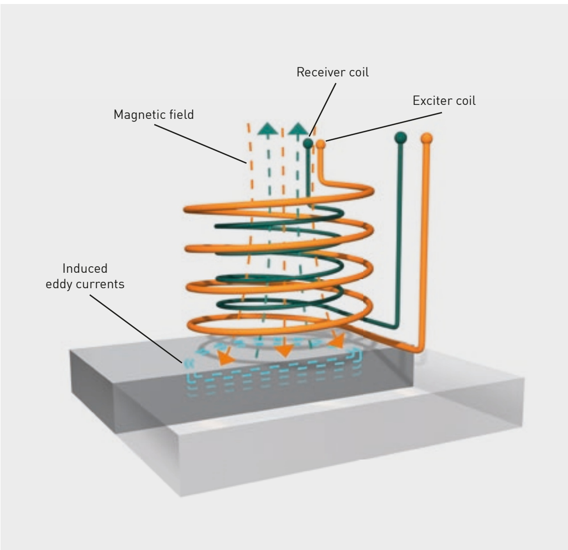
We offer many standard and shape-matched probes for special applications. The choice of probe depends on the component geometry, the cycle time and the defect specification.

(1) STATOGRAPH® CM
(2) STATOGRAPH® CM+
(3) Probes
(4) FLEXPROBE

Material and microstructure testing

Magneto-inductive method

The magneto-inductive method also works with electromagnetic alternating fields, because their wide frequency range allow them to be used for different testing purposes. While the high-frequency test reveals material cracks, the low-frequency magneto-inductive test enables greater penetration depths and thus provides information about the sample's tempering. Material and/or microstructure tests can be employed to prevent material mix-ups or to determine the quaity of the tempering. Typical sorting criteria include alloy content, surface hardness, hardness depth, strength and microstructure.



The principle behind magneto-inductive testing

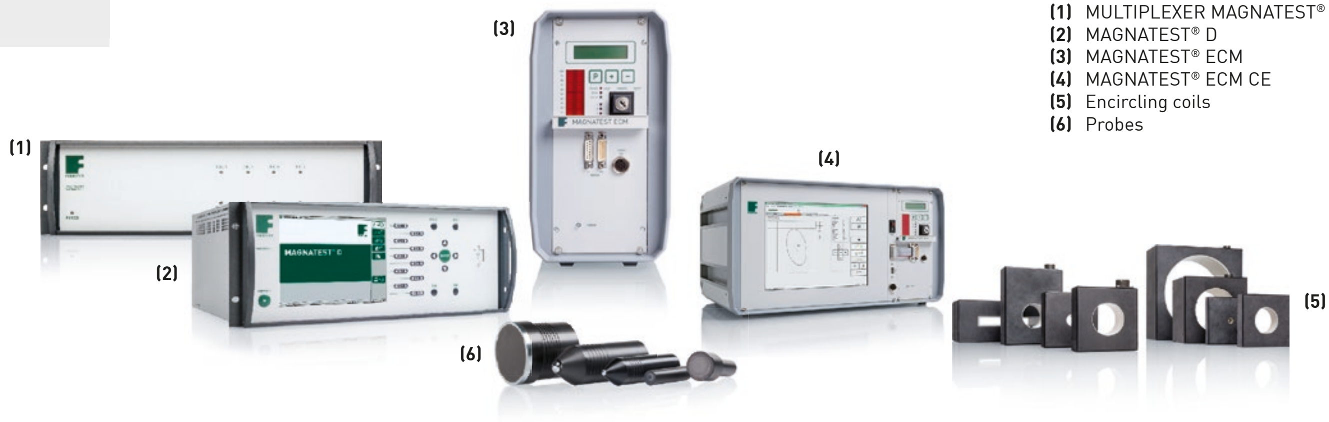
Testing for material properties

To test for material properties, the specimens usually pass through an encircling test coil, where low-frequency eddy currents are induced into the material. The test voltage recorded by the sensor is a result of the specimen's magnetic and electrical properties; the voltage value is graphically displayed as the measuring point.

The various hardness states, alloy constituents or microstructure conditions exert an impact on the receiver currents, thus allowing conclusions to be drawn about the material properties of the test piece.

The MAGNATEST® series

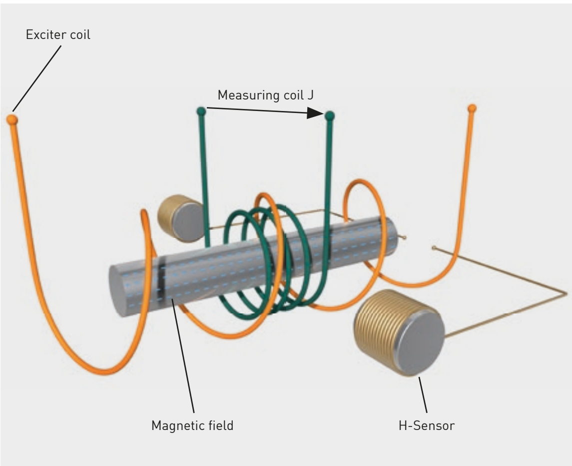
Depending on the application area and test specimen, the MAGNATEST instrument family offers the right system for magneto-inductive microstructure and material testing of metallic components. Various coils and probes round off the extensive product portfolio.



(1) MULTIPLEXER MAGNATEST® D
(2) MAGNATEST® D
(3) MAGNATEST® ECM
(4) MAGNATEST® ECM CE
(5) Encircling coils
(6) Probes

J(H) hysteresis

The open magnetic circuit method provides a quick way to determine the total DC magnetic hysteresis of magnetically soft materials under industrial conditions. Using the precise J-coil, the raw material from which the electromagnetic actuators (e.g. common-rail injection) are made is tested for key parameters. The H-sensors precisely determine the coercive field strength H_{cJ} of the finished components.

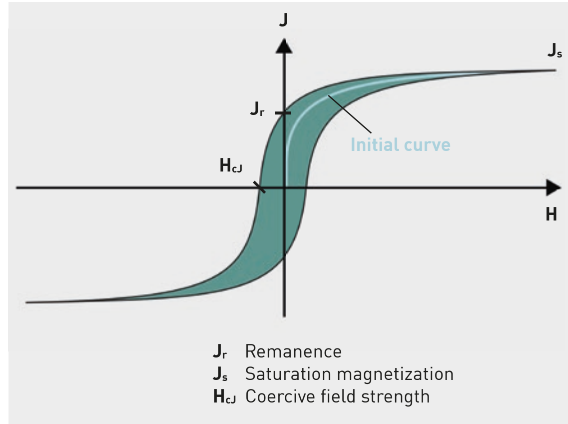


The principle behind determining magnetic properties

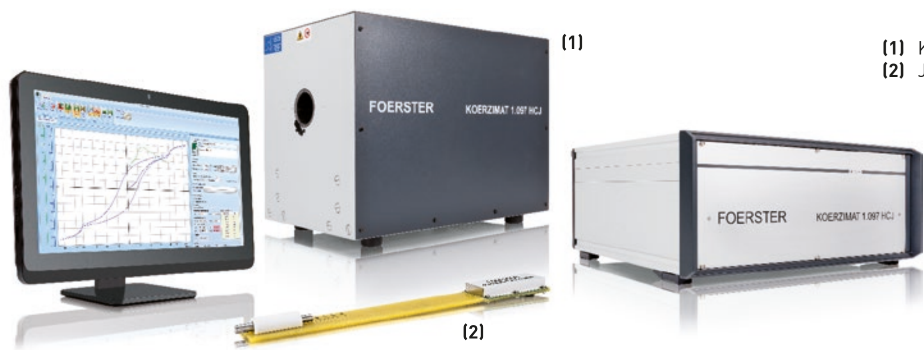
The total J(H) hysteresis represents the resulting energy losses (remagnetization losses) of the component while the actuators were operating. The coercive field strength H_{cJ} is also an important indicator here.

The relative permeability μ_r (slope of the initial curve) characterizes a dynamic behavior of the component in the magnetic circuit. The higher the relative permeability μ_r, the faster the components in the electromagnetic system can be magnetized, which contributes to increasing the system's dynamics.

These magnetic parameters can be greatly altered during fabrication of the actuator components by cold forming processes such as mechanical machining, stamping or forming, as well as by heat treatments (final annealing). Since some of these magnetic properties should be retained by the component, the KOERZIMAT is a suitable measuring system for monitoring the values J(H), μ_r and H_{cJ}.



Schematic representation of the J(H) hysteresis



(1) KOERZIMAT® 1.097 HCJ
(2) J-Sensor


TEST
SETUP
PROJECT
Ready
Cal Part
Error
FOERSTER
STATOVISION®
Testing
FOERSTER
STATOGRAPH® CM

New dimensions in component testing

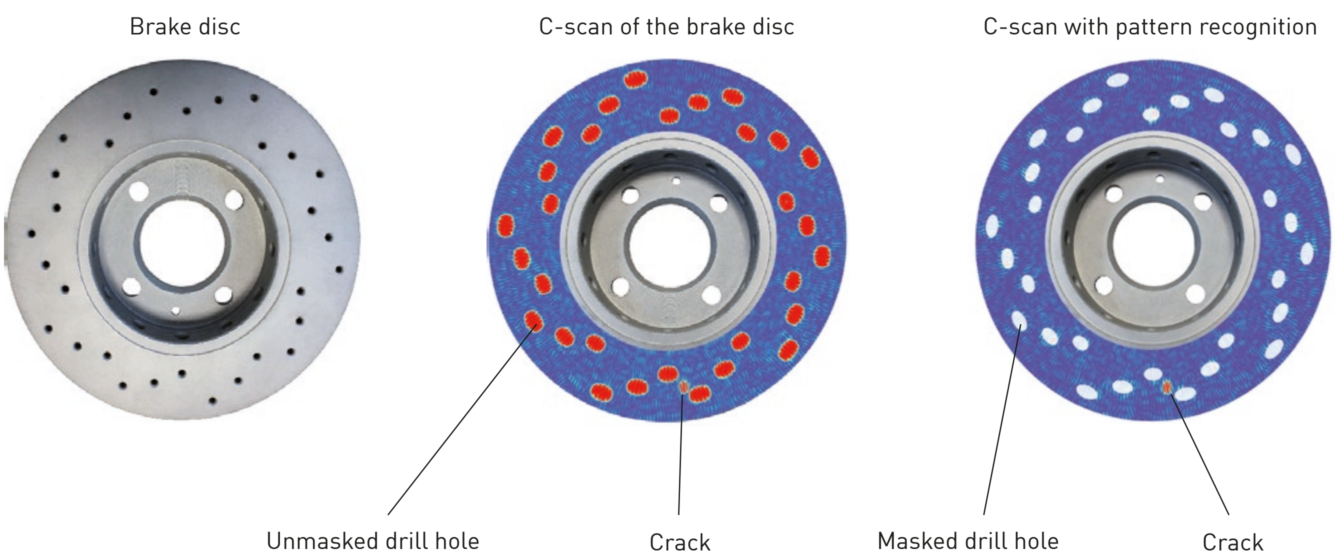
With STATOVISION, FOERSTER offers an innovative software solution for the detection and visualization of defects that were previously undetectable. Intelligent filter algorithms make it possible to suppress interference signals and thus solve new testing tasks. Until now, components with cavities such as drilled holes and grooves posed quality-testing challenges for manufacturers, as the recesses caused serious interference in the signal.

These samples could only be inspected if large regions were blocked out – meaning that those areas were simply not checked. If, for example, a drilled brake disc had any cracks in or near the drill holes, they went undetected during the testing procedure.

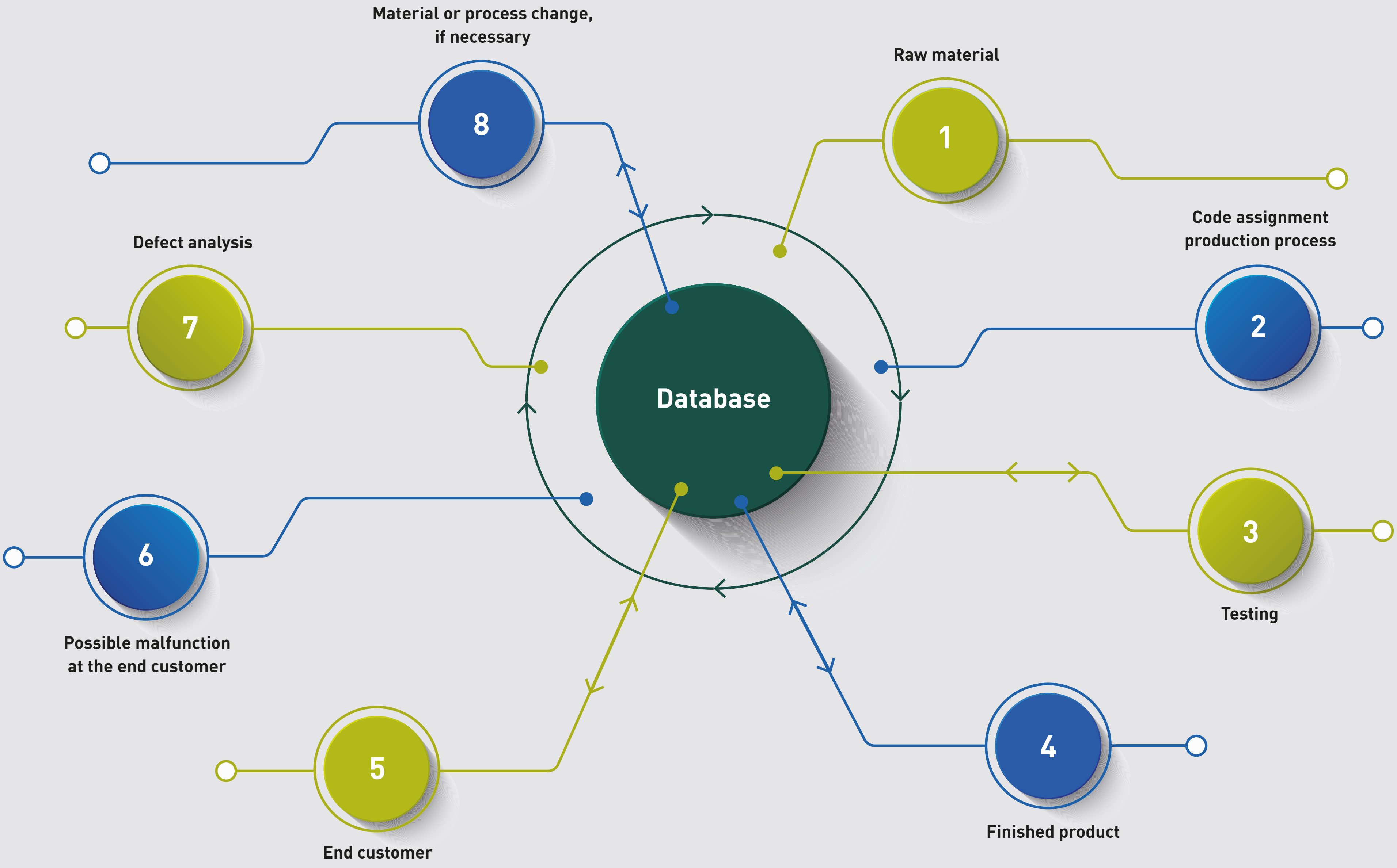
The STATOVISION software "learns" about such interfering contours as drill holes, grooves or milled features. In the following examination during production, these learned areas are then intentionally suppressed (masked). This makes it possible for the first time to reliably detect and display cracks or other surface defects that are located near or between the drill holes.

A high-resolution C-scan clearly displays the quality of the component's surface. Defects can thus be located precisely.

The data is saved in order to produce the kind of comprehensive statistics and complete documentation that ensure traceability. Thus, disruptive impacts inherent to the production process (e.g. tool wear) can be detected and eliminated early on to prevent high reject rates.



PROCESS OPTIMIZATION



Comprehensive product documentation for continuous traceability

The demands placed on finished products – and therefore the quality assurance process – are constantly increasing; this plus the need for traceability in the event of damage make comprehensive product documentation indispensable. This no longer applies just to the final manufacturing process but starts with the manufacturing of any subcomponents.

Right at the start of production, the raw material is given an identifier that makes it possible to trace a component back to it definitely. This identifier is saved; all subsequent production and testing processes then refer to this code. Every step of the value-added process is documented, including all equipment – machines, tools, etc. – used along the way. Ideally, these documentation processes all run automatically. This part identification is also read in during non-destructive crack and microstructure testing with FOERSTER testing equipment; the specific testing process is exected and the test results are documented accordingly.

Should a finished product show a malfunction at the customer or in a subsequent step of the value chain, the product life cycle can be traced back to this point – which can be useful for error analysis or for optimization of the process flows. If, for example, the same defect patterns come up frequently during crack testing, the defective parts can be specifically evaluated. In addition, potentially damaging factors such as worn tools or substandard raw materials can be identified and eliminated.

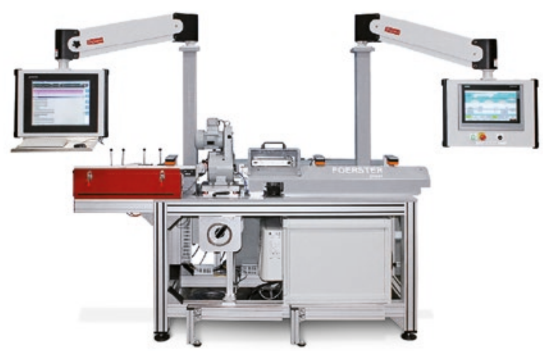
FOERSTER test equipment supports you in comprehensive quality control so that you can get the most out of your processes.

Your system provider for fully automated testing systems

Automation solutions from FOERSTER

The automotive industry is characterized by a high degree of automation. In order to guarantee smooth production processes, we've tailored our services to your needs, which is why we sell both individual test instruments and fully automated testing solutions for manufacturing – including all the machinery. These are developed and manufactured in close cooperation with our customers; our focus is always on your application and your requirements.

After you consult with our product and sales specialists, they create a concept tailored to your needs. Then, for the manufacturing process itself, we collaborate with competent machinery manufacturers to achieve the best possible solution for you. We also cooperate with mechanical suppliers who already know the characteristics of the component and have experience handling them, when suggested by our customers. And even after the line has gone into production, we gladly help you start the test system up; we're there for you if you ever have questions.



ROTO-PUSH - Test system for cylindrical components like piston rods

Fully automatic multi-channel crack testing system with automatic loading of the test piece buffer

FOERSTER offers solutions for all your technologies

Application Laboratory

Our specialists in the Application Laboratory are there to provide comprehensive technical advice to our customers. Equipped with the very latest test equipment, the lab is perfectly suited for testing out new application scenarios. They carry out various tests based on samples provided by the customer. Depending on the test results, the best possible solution is defined – both for the technical equipment and for the setting of parameters. Our application specialists have a wide range of technical knowledge and can provide comprehensive support in finding specific solutions. Of course, we'd also be happy to help you on site.

We offer the following services:

- Practical advice on applications
- Executing feasibility studies
- Development of customized solutions under conditions like yours
- Optimization of the configuration parameters

Training

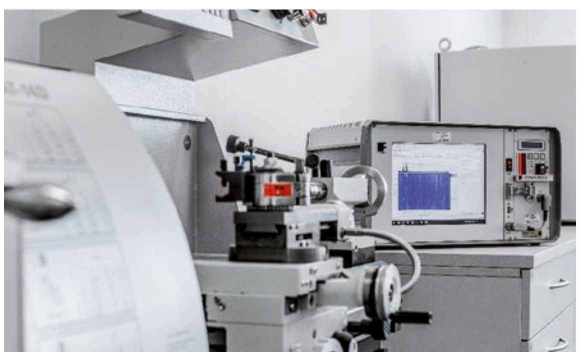
We offer comprehensive product training courses for operators and users so that you can make optimum use of your test instruments – starting on day one. Our courses concentrate on the practical handling of FOERSTER test electronics and sensor systems. A central focus is on configuring the most important parameters to adapt the system to the test line and inspection task at hand.

In addition, in-depth training courses are also offered for service and maintenance. The training content can be modified to suit an individual customer's needs and delivered on-site at the test line in question, if desired, or it can take place in our training center in Reutlingen.

Service

When it comes to FOERSTER test instruments, our customers count on top quality. In order to meet these expectations, an experienced service team and highly skilled engineers are available to perform on-site service and maintenance and, as necessary, to offer prompt and effective assistance.

And when problems occur outside normal working hours – FOERSTER has a 24/7 service hotline that can be reached 365 days a year. The FOERSTER service specialists there can start systematic error analysis right on the telephone. In the case of software installation or configuration questions, remote access often helps clear up problems immediately so that the instrument is quickly ready for use again.



FOERSTER

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- FOERSTER Italia S.r.l., Italy
- FOERSTER Russland AO, Russia
- FOERSTER Tecom, s.r.o., Czech Republic
- FOERSTER (Shanghai) NDT Instruments Co.,Ltd.,China
- FOERSTER Japan Co., Ltd., Japan
- NDT Instruments Pte Ltd, Singapore
- FOERSTER Instruments Inc., USA