100% EDDY-CURRENT TESTING ON WIRES AND BARS FOR QUALITY ASSURANCE

FOERSTER

DIVISION TS

... a Division of the FOERSTER Group

Competence and world-wide presence are the crucial factors.

The heart of Division TS beats in Reutlingen, Germany. This is where the automated test systems, operating on the basis of electromagnetic methods, are developed, manufactured and delivered to destinations throughout the world in the metal-producing and metalworking industry. Reutlingen is also the location of the Central Sales Department which serves the needs of customers in over 60 countries with subsidiaries and exclusive sales companies.

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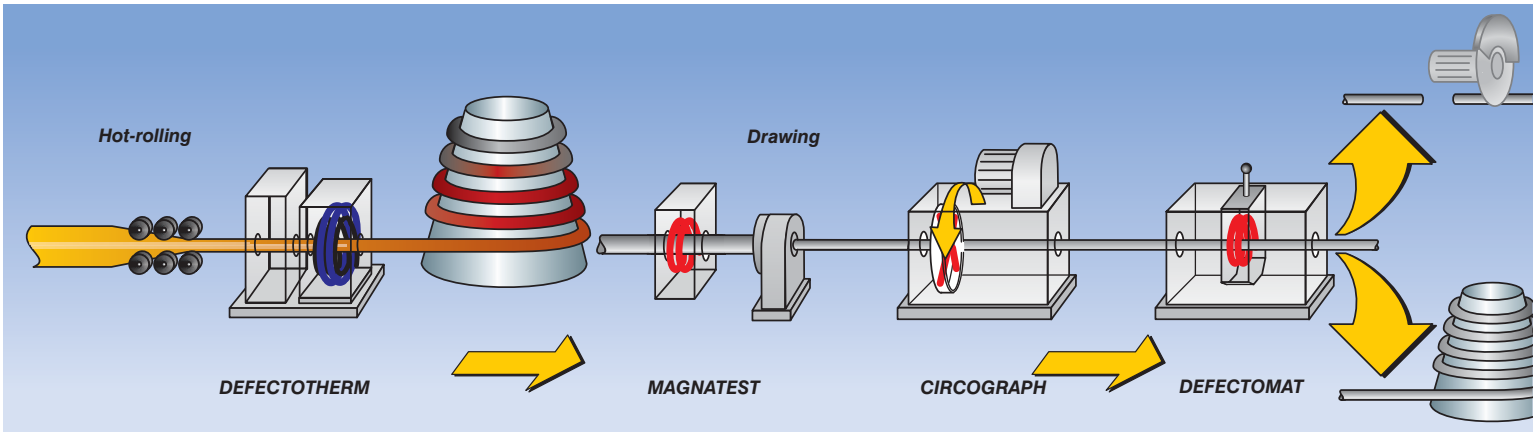
The Divisions present themselves on the FOERSTER® Group web pages. These pages also outline the historical development which has led to today's worldwide presence of FOERSTER systems. Those who visit the web pages can access the technical documentation and can find a contact near to them in the country list.

The eddy-current method is used at virtually all stages of production when manufacturing wires and bars:

- ***In the case of rolled wire with cooled, encircling Therm coils at temperatures up to 1,200° C and at wire speeds up to 150 m/s directly on the rolling mill.***
- ***In the case of drawn material with through-type coils and rotating probes either as alternatives or together as a complementary system directly on the drawing line.***
- ***In the case of finished products in rewinders or finishing section for final inspection.***
- ***Upstream of wire-processing machines for direct segregation of finished parts from sections detected as flawed.***
- ***In the case of lamp filament wire made of tungsten and molybdenum with special-purpose sensors operating in the diameter range 80 µm to 2.5 mm on the drawing line and in rewinders.***
- ***Grade verification with MAGNATEST.***



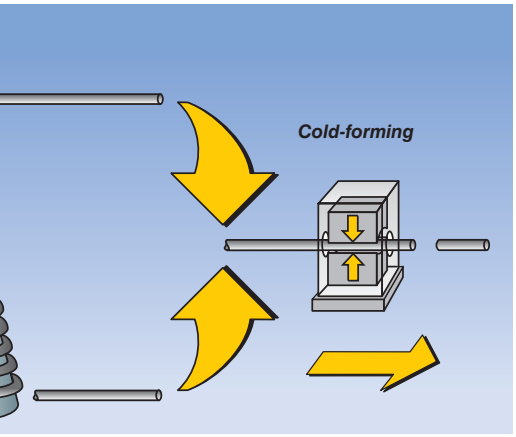
EDDY-CURRENT TESTING

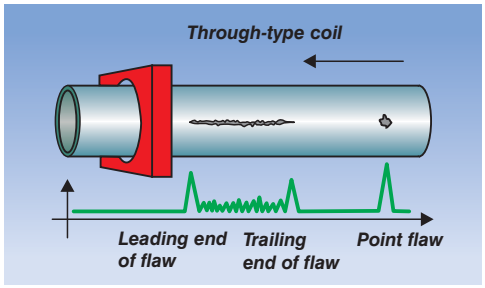
Wires and bars are tested using the eddy-current method at virtually all stages of production.

Since the eddy-current method acts non-destructively at production speed, it can be integrated in the production process. This surface flaw test method is used at an early point for optimum control of the manufacturing process on the one hand and for immediate segregation of flawed material on the other hand for cost reduction at other stages of production.
Two methods are used:

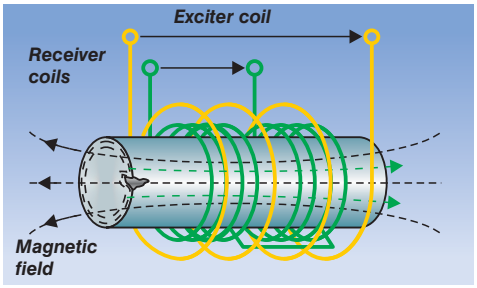
- encircling through-type coils
- rotating scanning probes

Both methods can be used either as alternatives or jointly, to complement each other, in the case of round material cross-sections. It is mainly sensor systems in a differential array which are used for surface flaw testing in order to achieve the required high flaw resolution. The differential array always lies in the scanning direction, i.e. in longitudinal direction of the material in the case of through-type coils and in circumferential direction in the case of rotating scanning probes. This results in the specific sensitivity for different flaw types. Thus, the encircling through-type coil is particularly sensitive to short longitudinal flaws, transverse and local flaws, such as holes, eruptions, shells and heat cracks. By contrast, the rotating scanning probe is particularly sensitive to open longitudinal flaws on the surface, such as laminations, seams, stress cracks and drawing flaws.

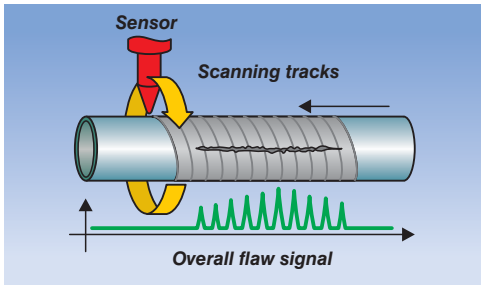




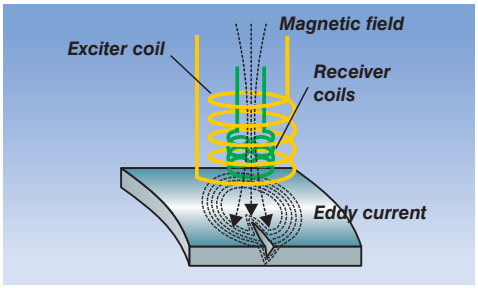
Semi-finished products, such as wires and bars, are tested for local crack-like and hole-like flaws with encircling through-type coils. A crack disturbs propagation of the eddy currents generated in the material under test, and the related flaw signal is produced in the receiver coil.



The differential through-type coil detects hole flaws and transverse flaws in addition to longitudinal flaws on the basis of their depth gradient.



Principle of the eddy-current probe: the surface of semi-finished products is scanned with sensors.



Signal generation when testing with rotating sensor.

Test systems

Various configuration levels are available: from the simple eddy-current module operating as a Go/NoGo unit with a PLC through compact units operating independently to multi-channel system solutions allowing network integration.

The right solution for any application: From the single-channel module for eddy-current testing with through-type coils through the compact instrument for automatic test operation to the Windows®-based instrument system for uncompromising network integration. The range of FOERSTER products combines hardware, software and system know-how to provide an efficient and economical overall solution in the field of quality assurance.

Hot wire

Rough conditions on rolling mills

Requirements applicable to the test systems: the sensor system must be rugged so as to withstand the conditions of high temperatures up to 1,200° C and of high speeds up to 150 m/s.

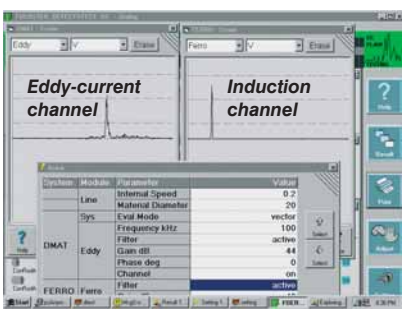
The T 60 sensor system has a modular design. Special-purpose guide elements steady the wire and ensure that it is guided as centrally as possible. Water-cooled coils and guides are available from 5 to 65 mm.

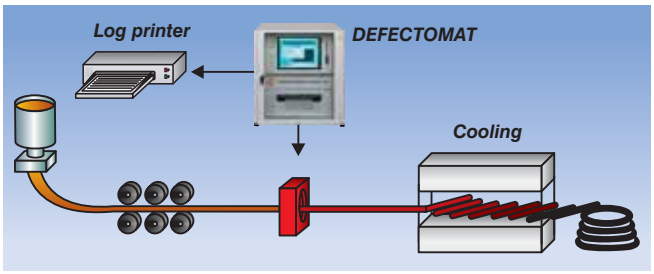
The large quantity of data produced owing to the high testing speed makes statistical evaluation of the test results practical. Single events are combined to form wire sections whose lengths can be preselected. A quality figure whose computation algorithms can be set individually is computed from the section results. Result displays from the individual rolled wire with its sections and the quality figures of the last rolled wires indicate the trend at a glance and thus also allow conclusions to be drawn as regards the quality of the rolling process.

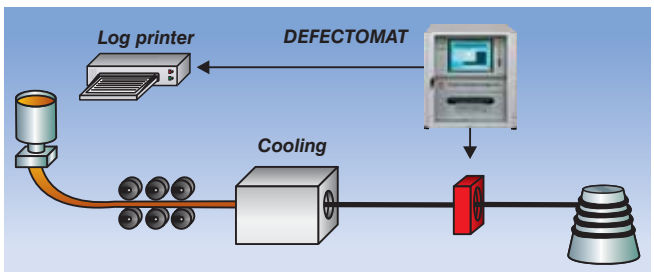
Cast-rolling

Eddy-current testing on copper wire

It is state-of-the-art that continuous cast-rolling plants for production of copper wire be fitted with eddy-current test instruments. Mostly, the DEFECTOMAT with an additional induction channel (FERROMAT) is used, simultaneously detecting ferrous inclusions with the same encircling through-type coil. The two recordings show the result of the simultaneous test: the surface damage is recorded on the eddy-current channel and ferrous inclusions are recorded on the Ferromat channel. Testing is performed in hot material condition with Therm coils or downstream of the cooling section with standard coils, depending on the type and arrangement of the cooling method. Please refer to the basic sketches.







Additional DC magnetisation is required for FERROMAT-testing. This boosts the induction effect of the iron particles. Copper wires are also tested in many cases at the various drawing stages down to very small wire dimensions with DEFECTOMAT and/or FERROMAT. Depending on the test result, a decision is taken at intermediate drawing steps as to whether a further drawing process may occur or whether the wire has reached its final diameter for instance.

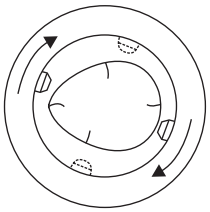
SCALPING AND DRAWING

Highest flaw detection in wire processing

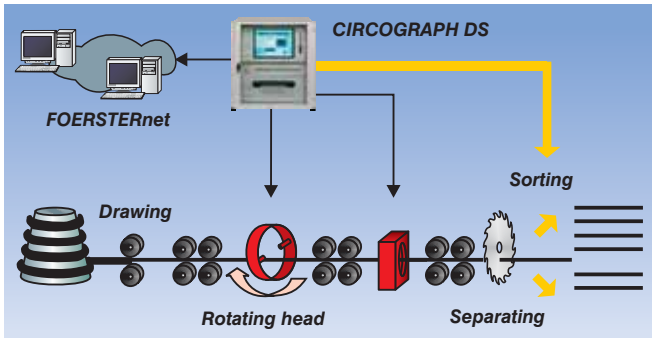
The use of fully automatic eddy-current test systems has also established itself as an important element of quality assurance in the drawing plant. Even under rough ambient conditions with direct installation in the machine area, flaw testing with encircling through-type coil andor rotating scanning probes has proven eminently suitable for the job. The modern DEFECTOTEST DS 2000 systems offer all preconditions for uncompromising integration in existing networks of the production system and quality assurance, including user-specific documentation.

... for valve spring wires

For many years, valve spring wires have been subject to stringent inspection for surface flaws. Detection of longitudinal flaws with depths upwards of 30 µm is state-of-the-art with FOERSTER rotating scanning probes. Non-round, e.g. oval or ovate, wire cross-sections have been in use for some time now in order to enhance the dynamic behaviour of the springs. Here as well, extremely stringent testing quality is demanded. FOERSTER has developed a special electronic system for the CIRCOGRAPH for this purpose, allowing constant test sensitivity regardless of the distance between the rotating scanning probes and the non-round wire circumference, in order to detect the critical surface flaws.



Scheme: Four defects (60 and 100 µm depth) at the non-round wire in the rotating head with four probes.



Test result without and with compensation circuitry.

The optimum installation location for the sensor systems in the drawbench is between horizontal and vertical straightening systems.

Testing steel wires directly in the bull-block machine with CIRCOGRAPH rotating head.

Testing in drawbenches with through-type coils and rotating heads

To a more and more frequent extent, rotating heads are also being used in drawbenches, in addition to through-type coils in order to enhance flaw detection in respect of longitudinal flaws.

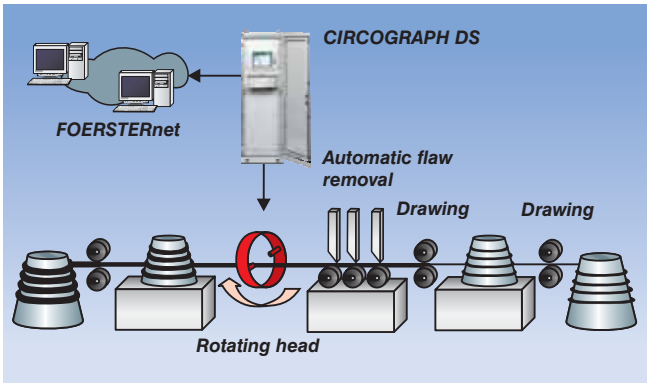
The Ro 35 L and Ro 65 rotating heads are designed to cope with the stringent mechanical demands. L (lever) means sensors of lever design. They are held in test position by centrifugal force. The high speed of rotation ensures testing of the entire wire/bar surface without omission. Testing speeds of up to 4 m/s can be achieved. Generally, both systems, i.e. both encircling through-type coil and rotating sensors, are used in order to provide optimum testing.

Ro 65 integrated in a Schumag drawbench.

Ro 65

Ro 35 L

The special-purpose, funnel-shaped guide system of the Ro 65 facilitates exit and entry of the leading edge of the wire and trailing edge of the wire, in particular in the case of large dimensions.



Automatic removal of the flaws detected with eddy current prior to the drawing process in the case of special-purpose-wires, e.g. made of ball bearing steel, stainless steel or tool steel, leads to a so-called „zero-defect product" for the vehicle industry and in the mechanical engineering and machine construction sectors".

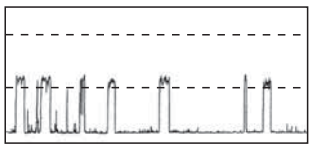
Test of steel wire by Ro 14 and M 22 in recently installed Schumag drawing machine 0B.

Test of steel wire by Ro 20 and M 22, a retrofit in an existing drawing machine with limited space.

Fine wire

The special solution for tungsten and molybdenum

Spiral-wound filaments and the electrical leads to which they are connected



DEFECTOMAT ECM checks wire during rewinding.

on lamps are made primarily from tungsten or molybdenum wire. The wire is manufactured from a sintered base material in a complex process and then drawn to ultra-fine dimensions. Flaws, some of which may be very long may occur during the various forming stages. Such flaws may also occur during further processing on originally flawless wire if it is cropped to form pins. The fissures then occur as the result of cropping chiefly at the ends of the pins. The DEFECTOMAT with encircling through-type coils is used successfully for quality monitoring either online in the drawing process or when rewinding the wire at high throughput speeds of up to 10 m/s or during cropping of the wire pins. Statistical evaluation of the flaws detected is performed during wire testing, and the flawed pins are segregated automatically as they fall through the test coil.

Special-purpose coil system for wire diameters of approx. 80 µm to 2.5 mm.

The DEFECTOMAT circuitry systems are available as a single-channel module or as a multi-channel system operating either on the basis of the absolute and differential method, alternatively resp. simultaneously.

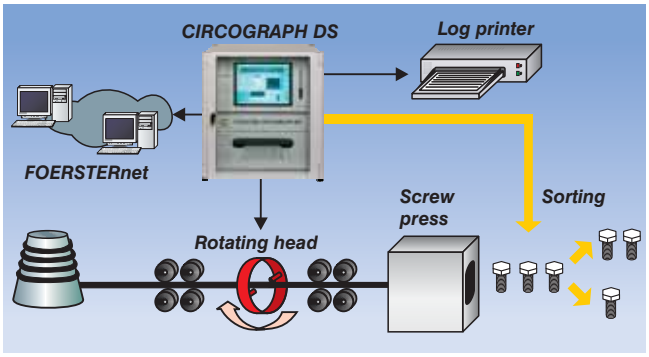
Testing on the drawn wire upstream of cold-forming

Motor vehicle components subject to high stresses, such as bolts and screws, are made from drawn steel wire. The carmaker demands 100% testing with „zero defects“. Eddy-current testing with rotating scanning probes is the most reliable and most efficient method with its extremely high flaw sensitivity and ease of integration.

CIRCOGRAPH tests prior to the bolt or screw press. Finished parts made of flawed wire sections are segregated off downstream of the press.

Test of steel wire by Ro 35 L integrated in a cut-to-length-line.

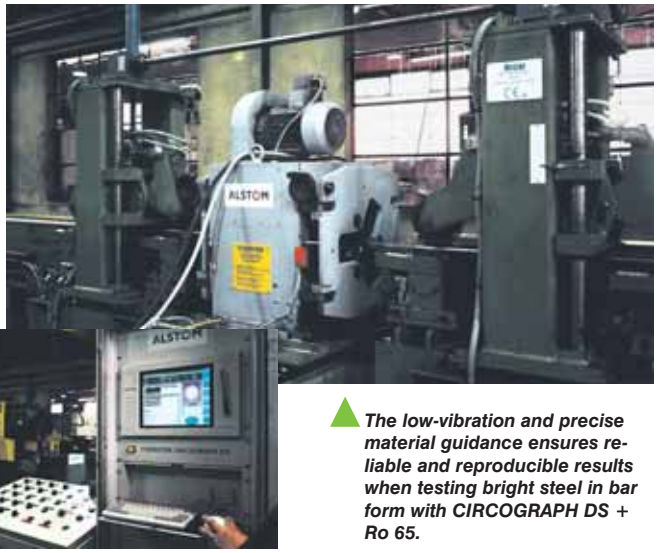
Schematic representation of the test and production process with sorting of the finished parts. The position of a point on the wire detected as flawed is assigned with specific location to the parts manufactured in the press. An automatic part sorting facility which sorts the parts into Go and NoGo parts is activated by this.



Final inspection

Stringent requirements ... for polished stainless steel bars

In the production of ground and polished bars made from ferritic, austenitic steels or titanium, nickel or cobalt alloys, stringent requirements are specified in regard to surface flaws. Compliance with these requirements is achieved by combined eddy-current testing with encircling through-type coil and rotating scanning probes. Precise guidance of the bar throughout the entire dimension range is required for this, allowing vibration-free running in particular for small diameters.



The low-vibration and precise material guidance ensures reliable and reproducible results when testing bright steel in bar form with CIRCOGRAPH DS + Ro 65.

A compact testing section with belt guidance allows testing of polished stainless steel bars in the dimension range 2 – 20 mm with high flaw sensitivity even at a speed of 2 m/s.

Special guide elements in the sensor systems – designed from commercially available drawing dies and supplemented with brushes in the small dimension range – ensure a vibration-free and precise pass of the material.

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