Parameter Storage for complex Magnetic Particle Testing Machines

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Summary

Stationary testing machines for magnetic particle surface crack detection are widely used to check safety parts in automobile and aircraft production and maintenance. Most often these testing machines carry two magnetization units in order to perform a combined test for cracks of all directions within one test cycle. Both magnetization units can be adjusted independently from each other. So you can accomplish optimum test parameters for nearly all component geometries.

The test parameters are selected within the electrical control unit. Until now, it has been considered sufficient if test parameters could be set via simple control dials. Hence simple and comprehensive operation was considered as most important for the users.

Figure Test Machine with 2 Contacts. Universal test bench with 2 magnetization circuits and conventional electrical control.

But with increasing automation of the testing procedures, in turn the test machines become more and more complex. In order to compensate for this, the electrical components of the electrical controls have seen big improvements within the last years. Modern controllers, e.g. on the base of the Siemens S7, allow the use of small comfortable touch panels. Herewith the need for comfortable operation and the increasing complexity of the test machine can be brought in line.

Within this paper, various examples are presented which demonstrate the usefulness of the DEUTROFLUX MEMORY parameter storage unit:

- DEUTROMAT Machine with chain conveyor and supervision of chain allocation or chain position respectively.
- DEUTROMAT Machine with multiple contacts, activation and control of currents/fields for each contact.
- DEUTROFLUX UWS Machine for large pistons with automated monitoring of the crack test fluid (by means of the patented FLUXA-Control module).
- DEUTROFLUX UWS Machine for testing of railway axles with Ethernet-Connection to the customer's data base.

DEUTROFLUX MEMORY Parameter Storage for Magnetic Particle Crack Detection

Newly introduced operator panels (touch panels) allow simple entering of data by hand or pen. The menus are often organized in multiple levels in order to guide the user through the subsequent steps - especially when complex operations have to be accomplished. Many machines are used for serial tests on parts with always identical parameter settings which can then be retrieved. These component-specific parameter settings are defined by the NDT supervisor: A thorough magnetization is accomplished at optimum throughput speed. The level of access by the operator can be precisely controlled either using password protection or pin code in order to avoid improper operation. The often found practice to write the set-up parameters on a slip of paper and deposit it aside of the machine is now history!

Figure Touch Panel. Operating panel of the parameter store with input by hand (A) or by pen (B).

With the storage unit the following parameters can be set or recorded (customer- or component-specific):

- Part identification (reading of barcode scanner data, if applicable)
- Operator identification (by name, safeguarded via password or pin code)
- Cycle times (spraying process, magnetization), timing for mechanical movements (clamping) within the machine
- Unit counter
- Input of defect findings
- Go/No-Go statistics
- Additional documentation (date and time of test, operator’s name, further text comments)
- Shift protocol
- Remote diagnosis via modem
- Quality status of crack test fluid (in combination with FLUXA-Control)
- Language selection
- Setting mode (mechanic, pneumatic, magnetic)
- Input of additional controls (e.g. periodical UV intensity check, field strength measurement, control of residual light)
- Ethernet interface for remote transmission to customer’s data base

Figure Switch-over of Language. Comfortable operation in native language by electronic switch-over

Conventionally equipped machines carry analogue displays mounted into the control cabinet. This allows control of current and field strength in a simple manner. Displaying of digital figures would be not good enough to supervise the fast changes during the test cycles. A coloured bar graph display has proven to be practicable with marking of tolerance bands. All values are controlled and automatically re-adjusted which is not a trivial task in multiple contact machines due to reciprocal influences by the individual field circuits. If a machine operates more than two magnetization circuits, additional bar graphs are displayed.

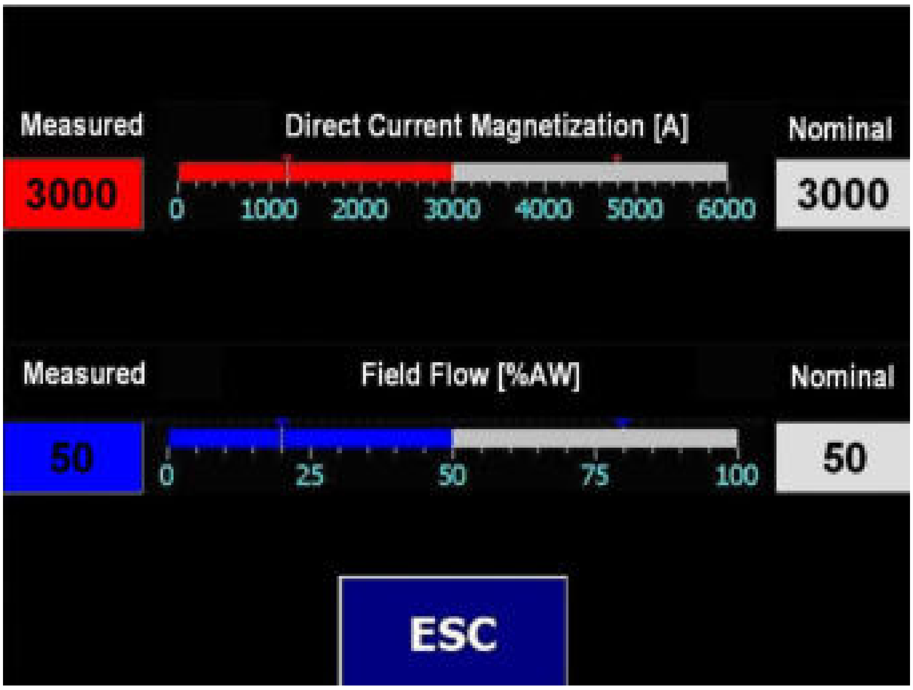

Figure Field Supervision. Both magnetizing circuits are controlled separately and visualized via bar graph display.

DEUTROMAT Test Machines with Chain Conveyor

In order to obtain high throughput, machines with automatic transportation of components are often used. Usually, one piece is tested per cycle. Typical test cycles last 10 seconds. Depending on the required throughput, several stations for magnetization are employed. Machines for testing eight components per cycle were realized so far. According to the component geometry, testing is carried out in horizontal or vertical position. Surface areas where crack test fluid could be accumulated (puddles in sinks) must be avoided in order to inspect the entire component surface. The chain is equipped with fast exchangeable supports for all relevant component geometries. There are also solutions at hand with a motor-driven adjustable clamping length (or component length, respectively).

The machines are manually or automatically loaded. Manual loading is often complemented by a visual check. The magnetization station is entirely encapsulated for splash protection and to avoid reaching into the machine during the test. The evaluation station is connected to the outlet conveyor where the visual evaluation and sorting process is run manually. Automated camera-based sorting is still under investigation but in most cases not used. For high throughput requirements, the use of several inspectors using a turn-table is recommended.

Figure Machine with Chain Conveyor. The components (wheel hubs) are fed from left to right through the encapsulated test machine. The parameter storage serves not only as control unit of the testing process. The proper position of the chain is monitored and is corrected if necessary. At the inlet of the test machine light barriers are mounted for checking the loading state. The transport and the testing process are only started when the chain is completely filled. At the outlet the observation cabin is shown (still without curtain).

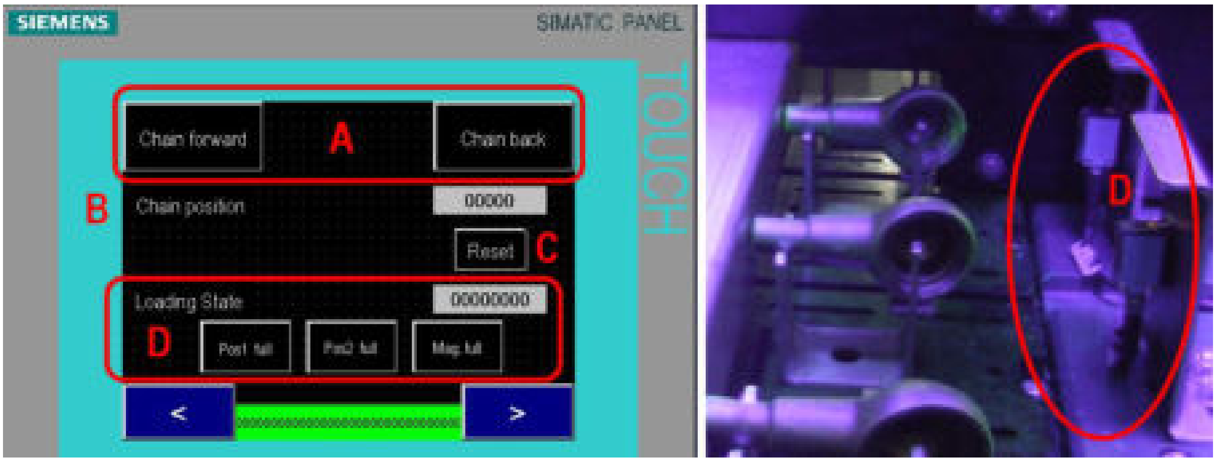

Figure Chain Control. Proper position and the loading state of the chain are controlled.

DEUTROMAT Test Machine with Multiple Contacts

Complex shaped components should be tested in multiple-contact machines. Testing these parts in 2-contact-machines would not only elongate the testing time but would also lead to high background fluorescence and reduced contrast (due to spraying and magnetizing several times and collecting more and more magnetic particles on the component surface). An electrical current and a magnetic field are fed into each "leg" of the component. In order to reach an uniform magnetization on the entire component surface, field strength measurements are accomplished and/or test samples are used carrying artificial or natural flaws. This empirical process requires a lot of knowledge and experience in configuring the crack detection machine.

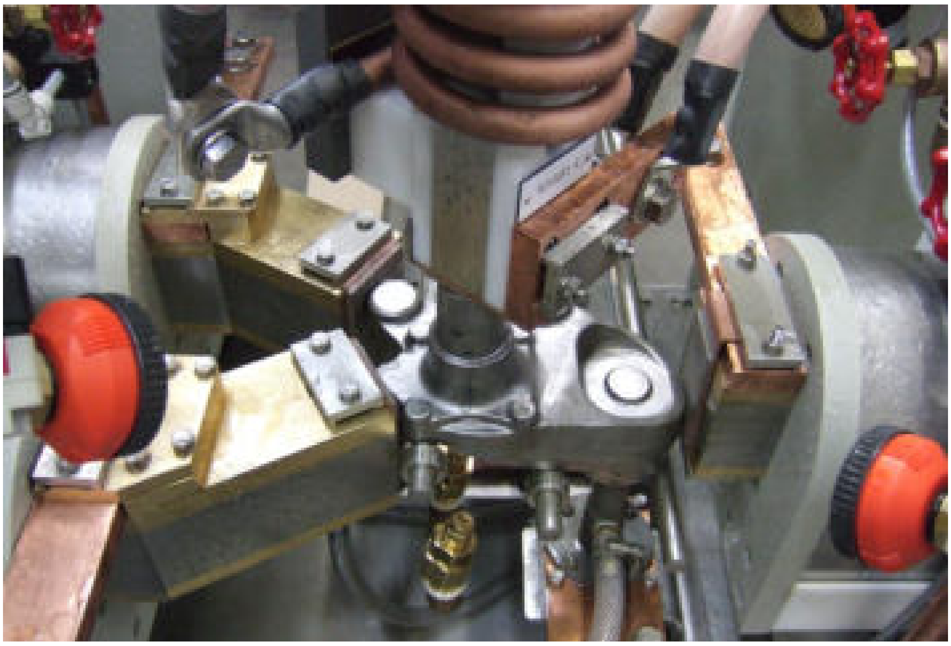

Figure Multiple Contact Testing. Testing of a forged part with three horizontal and one vertical contact

When finally the optimal field parameters have been found for the component under test, the results can be stored in the machine using the parameter storage unit. Thus, erroneous set-up and operation is ruled out. The contacts can be flexibly positioned and therefore allow the testing of many components with different geometries in the same testing machine. In addition, individual contacts can be switched off if not required for a component. The activation or disabling of contacts is also accomplished via the control mask.

Figure Multiple Contact Control. The strengths of electrical current are entered for all four contacts.

The contacts can be activated or disabled separately (K1 through K4 fields). The field strengths and clamping times per contact are controlled in additional menus. Deviations from the set-points are automatically monitored.

DEUTROFLUX UWS Test Machine for Checking of Railway Axles

Components with an overall length starting from 900 mm are also tested with two magnetic circuits. One field direction is produced by an electrical current along the component producing a circular field. Longitudinal flaws can be found in this manner. The second field direction to detect transverse flaws is not generated by coils and laminated contacts at the side of the component (as for short components) but using a moving coil travelling along the component. The moving coil is encircling the component and produces a field in axial direction.

Figure Axle Testing. Test machine to check railway axles with test cabin. The roof can be opened pneumatically which allows loading by crane.

Used railway axles are periodically maintained and checked in repair shops after disassembling the wheel set into axle and wheels. Each axle carries its own identification and also every periodical inspection has a well defined number. The test results are documented within a protocol containing all relevant information (name of inspector, test time and date, text comment). Since the decision is normally taken by the inspector, entering the test result is part of an operation menu. In addition, the test machine has been equipped with an Ethernet interface. This allows the NDT supervisor to remotely check all protocols and test results.

Figure Test Parameter for Railway Axles. Important test parameters are stored within the test protocol. The most important information namely the test result has been highlighted by colour in the operation mask.

FLUXA-Control: Test Machine with Automated Monitoring of the Crack Test Liquid

The ability of the crack test liquid to mark flaws is permanently diminished during operation in a stationary test machine. Ingress of dirt and free iron particles (without fluorescent paint) coming off the tested parts degrade the contrast. It is common practice to use test blocks with known crack pattern for a regular check of the crack test fluid. Often this procedure does not yield satisfactory results. Different operators may take varying decisions especially when taking the changing illumination conditions into account. Numerous attempts to automate the process failed because a thorough and regular cleaning of the test block is difficult. In 2007 a newly patented approach (DE 10039725) has been successfully launched after extensive research and is now successfully used in practice. The measurement set-up consists of a glass tube where the crack test liquid is passed through. A magnetized test block is mounted near the tube. It contains two saw cuts as reference flaws. A glass tube can be nicely kept clean in comparison with test blocks which have direct contact to the test liquid. Both saw cuts cause a stray flux and a corresponding indication. Two saw cuts have been used in order to generate redundant measurement information. At two other measurement points the degree of cleaning is monitored and the back-ground fluorescence within the glass tube is supervised. The glass tube is connected to the test liquid circuit of the machine by a bypass and is newly filled every two minutes. An UV-sensitive optics is gauging all four measurement points and transmits the results to the control module. Via adjustable thresholds a luminous display indicates the current condition of the crack test liquid. If desired, the machine can be shut down when the measured values are below the thresholds.

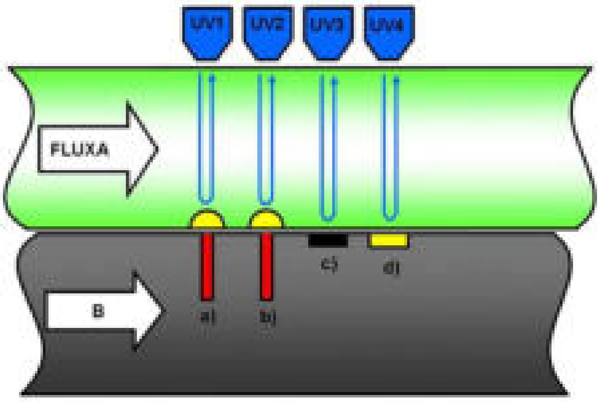

Figure Principle of Crack Test Liquid Monitoring. The measurement set-up contains a glass tube where crack test liquid is passing through. The glass tube is mounted near a magnetized test block. Two crack indications (saw cuts) are regularly supervised (a+b). In addition the background fluorescence is continuously monitored (c) as well as the degree of pollution (d) in the tube.

The measurement unit can be used to equip new machines as well as to retrofit existing machines. At the moment only water-based crack test liquids can be monitored.

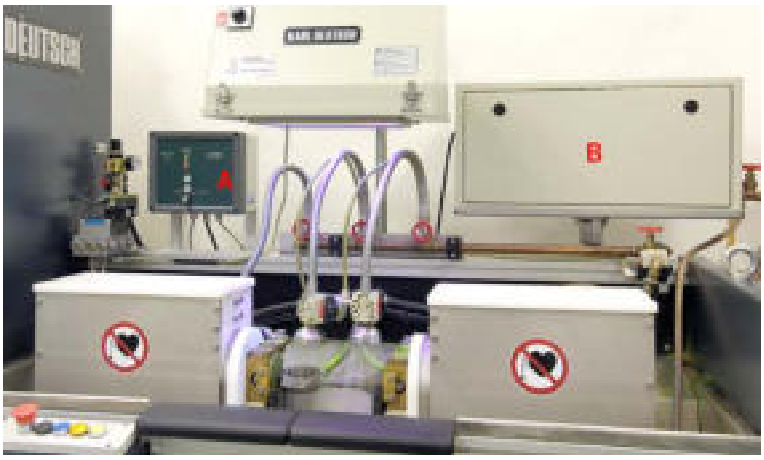

Figure Test Machine with Crack Test Liquid Control Unit. The operation and display module (A) indicates via coloured bar-graph representation the quality of the crack test liquid. The measurement module (B) is also mounted directly to the machine.

A test machine with integrated FLUXA-Control has been realized for the inspection of large piston heads. The special challenge was to find the right crack test liquid for the components which are contaminated with cooling lubricant during mechanical machining. A special recipe was developed which ensures an optimal wetting even for such complicated cases. The parameter storage unit DEUTROFLUX MEMORY regularly logs the condition of the crack test liquid within the shift protocol.

According to the big dimensions of the components here also a machine with moving coil has been selected. A turntable allows the comprehensive observation of the components within the machine. After accomplishing the test the inspector pulls the turntable out of the machine. The components can be rotated on two axes to observe all surfaces. For the approval procedure of the testing machine artificial flaws have been implemented in many surfaces to check for optimal magnetization.

A second machine checking the corresponding bottom parts of the pistons has also been supplied to the same customer.

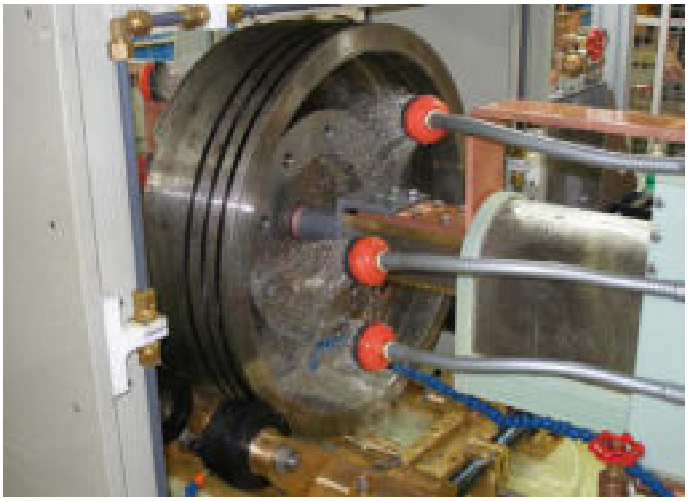

Figure Testing of Piston Heads. Component during spraying.

Literature about Magnetic Particle Testing

[1] V. Deutsch, W. Morgner, M. Vogt: Magnetpulver-Rissprüfung - Grundlagen und Praxis (Magnetic Particle Testing – Basics and Practical Applications), VDI publishing house, Duesseldorf, 261 pages, 1993.

[2] V. Deutsch, M. Vogt, M. Platte, V. Schuster: NDT Compact and Clear, Volume 3: Magnetic Particle Testing, Castell publishing house Wuppertal, 55 pages, 1999.

[3] V. Deutsch, W. A.K. Deutsch, W. Morgner, V. Schuster, R. Wagner, M. Vogt, F. Bartholomai: Magnetpulver-Rissprüfung - Grundlagen und Praxis (Magnetic Particle Testing – Basics and Practical Applications), Castell publishing house Wuppertal, in preparation.

Figure Literature. Books about Magnetic Particle Testing published by KARL DEUTSCH.