STATIONARY AND MOBILE MAGNETIC PARTICLE TESTING BY THE EXAMPLE OF PIPES AND RAILWAY WHEELS INSPECTION

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Magnetic particle testing (MT) is one of the oldest and simplest Non Destructive Testing (NDT) methods but at the same time the most sensitive, reliable and effective one for the surface inspection of ferromagnetic objects [1,2]. By parts production and routine maintenance both stationary and mobile MT equipment is needed. The subject of this paper is the application of different magnetic particle testing techniques by the example of pipes and railway wheels inspection. By stationary equipment application the contactless magnetization of surfaces under test is being performed by means of special solenoidal coils, what allows to detect surface defects of any direction. The new hand yokes or cross yokes with integrated UV or white light sources are being used for mobile inspection. The tangential field strength on the test surfaces is more than 24 A/cm. This equipment application allows to detect fast and reliably surface defects with a width less than 2 µm.

Pipe inspection

Round shaped material such as pipes, rods and bars have been generally inspected by automatic inspection systems (ultrasonic, eddy current, flux leakage systems) with high throughput rate. But in spite of all advanced developments of such automated systems, the magnetic particle inspection has kept its importance, for example for locating of discontinuities detected by automated systems, at their repair stations in the production flow.

For this purpose Helling GmbH has developed ZER-O-MAT® equipment - a magnetizing and inspection system, which enables the user to find surface flaws of multidirectional orientation within shortest time (See Picture 1). As this system is designed as a compact unit, it can be easily integrated into a conveyor (combined for axial transportation and for stationary rotation) at the customer production line.

The dimensional range extends from ∅ 20 up to about 660 mm, for which several specially designed solenoidal magnetizing coils with adequate dimension are to be used.

Specific advantages of this magnetizing technique are:

- ✓ ZER-O-MAT®-coils are open to the top; repair grinding and re-inspection can be performed on-site directly
- ✓ Contact-free magnetization (i.e. no arc burns)
- ✓ Detection of surface discontinuities with multidirectional orientation
- ✓ Short cycle time
- ✓ Demagnetization not necessary (AC-magnetization)

Picture 1. ZER-O-MAT® magnetizing and repair station

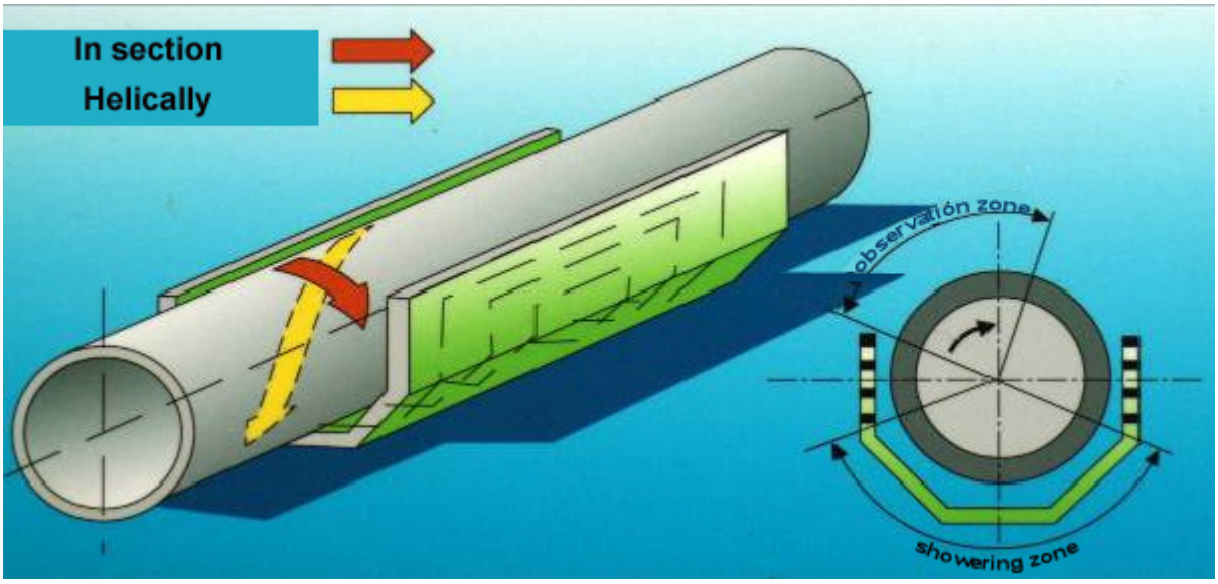
Besides the use for local inspection at repair stations, this technique can be also used for full length inspection of tubular products and in both cases immediate repairing after the (re-)inspection is possible. Picture 2 shows ZER-O-MAT-equipment in the finishing line of a tube mill.

Picture 2. Pipe delivery to magnetizing station (left). Pipe inspection under UV radiation (right)

Of course, the use of this magnetizing technique is not limited to round shaped products. It can also be applied for inspection of stock and bars with other than round cross sections, i.e. square, rectangular or even irregular shape. Specially designed conveying systems for axial transportation as well as for turning the material are required.

Essential part of ZER-O-MAT®-equipment is the U-shaped solenoidal coil, which enables a contactless multidirectional magnetization (0° - 180°) of the pipe.

For magnetization and inspection the tube - after "dipping" into the ZER-O-MAT®-coil – is getting turned (see Picture 3). If now the magnetizing current is switched on, the pipe surface over the length of the ZER-O-MAT®-coil is being magnetized in axial and circumferential direction. Due to showering the tube with magnetic particle suspension at the coil bottom (while the magnetizing current is "on") surface discontinuities will cause magnetic particle indications which can be observed and evaluated in the turning-position above the coil.



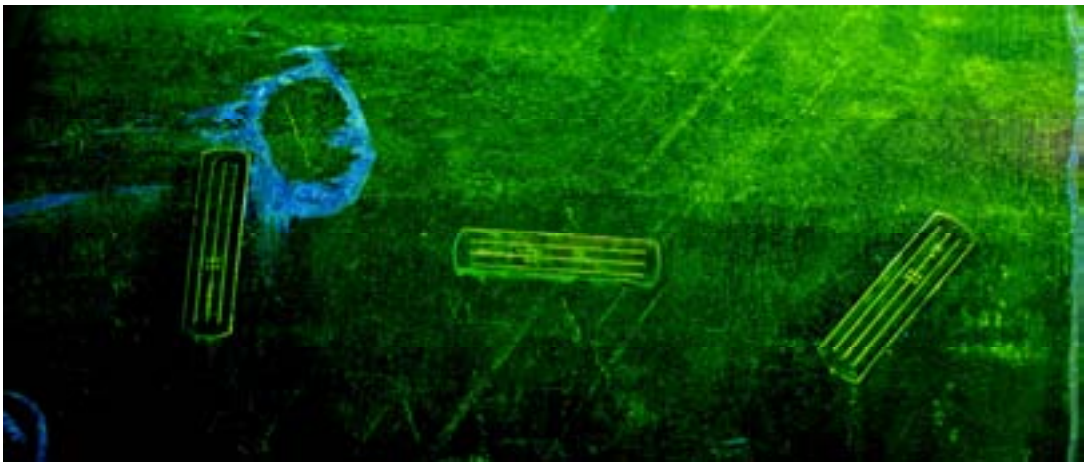
Picture 3. Pipe position in the magnetizing coil.

If not just a tube section but the complete surface of the tube shall be inspected, the tube must be helically moved through the ZER-O-MAT®-coil – as indicated by the yellow arrow in Picture 3. In this case the layout of the magnetizing system must be designed for 100% turn-on time.

ZER-O-MAT®-coils are operated with AC-current. This means that due to the skin-effect just a surface layer of the material under inspection is being magnetized. Therefore no demagnetization is necessary after inspection.

The ZER-O-MAT® is equipped with up-to-date, high power ZERO Slim Line UV LED lamp with determined wavelength of 365nm. The lamp is vibration resistant and insensible to electromagnetic fields. Having no warm up time the lamp shouldn't be on all shift long, but can be switched on/off at any time if necessary.

Of course, for the practical application, the strength of the magnetizing current and the distance between tube surface and the inside surface of the ZER-O-MAT®-coil are important factors for good performance. By proper use it is ensured that, at any place of the tube surface, tangential field strength of min 2,4 kA/m is attained. The quality of the applied magnetic particle suspension is also important for successful detection of discontinuities. Picture 4 shows indications of a natural defect and of Burmah Castrol II artificial defects resulted under proper testing conditions.



Picture 4. Indications of a natural defect and Burmah Castrol II artificial defects on a pipe

In the field the pipe inspection can be carried out using a cross yoke. The Helling KMU 8/42 Cross Yoke is an ideal solution for inspection of pipe weld joints (See Picture 5). The cross yoke has been fed by 2 equipotent alternating currents with 90°phase shift, what results in rotating magnetization vector, whose field strength is equal in all directions. This

magnetization technique enables detection of discontinuities of every orientation. In practice it means: simultaneous indication of longitudinal, transversal and oblique cracks in the course of only one operation. Therefore the KMU 8/42 Cross Yoke is especially appropriate for inspection of lengthy welded joints, for example in pipe manufacturing, tank and pressure vessel building or ship building. The long-duration duty cycle of up to 60% advantages the application in these production fields.

Picture 5. Pipe weld joint inspection using KMU 8/42

The magnetic field has been applied into the part under test over a short air gap. Thereto the yoke poles are provided with adjustable castors. The castors maintain a constant air gap between the poles and the part surface and enable the yoke to be moved easily. The assembled Cross Yoke reaches tangential field strength of 32 A/cm and lifting strength of 300 N. Even with the air gap of 5 mm the tangential field strength is still more than 24 A/cm.

The KMU 8/42 Cross Yoke is completely sealed, being fed by an additional transformer with 2 x 42 V alternating voltage and possesses the IP 54 protection class. The transformer meets criteria of the IP 23 protection class and requires the primary voltage of 3 x 400 V.

The KMU 8/42 can be also equipped with additional UV or White Light LED Sources which enable a simultaneous irradiation (illumination) of the working area during the testing with fluorescent or colour magnetic particle powder (Picture 6). The network independent

inductive light sources allow getting the optimal homogeneous irradiation (illumination) field in the middle of the working area.

Picture 6. KMU 8/42 with inductive White (left) and UV (right) LED Light Sources

Railway wheels inspection

The railway wheels are dynamically loaded parts relevant to train operation safety. Therefore the inspection of their running order is very important. Along with ultrasonic and eddy current inspection the magnetic particle testing by means of stationary and hand devices has been carried out as well.

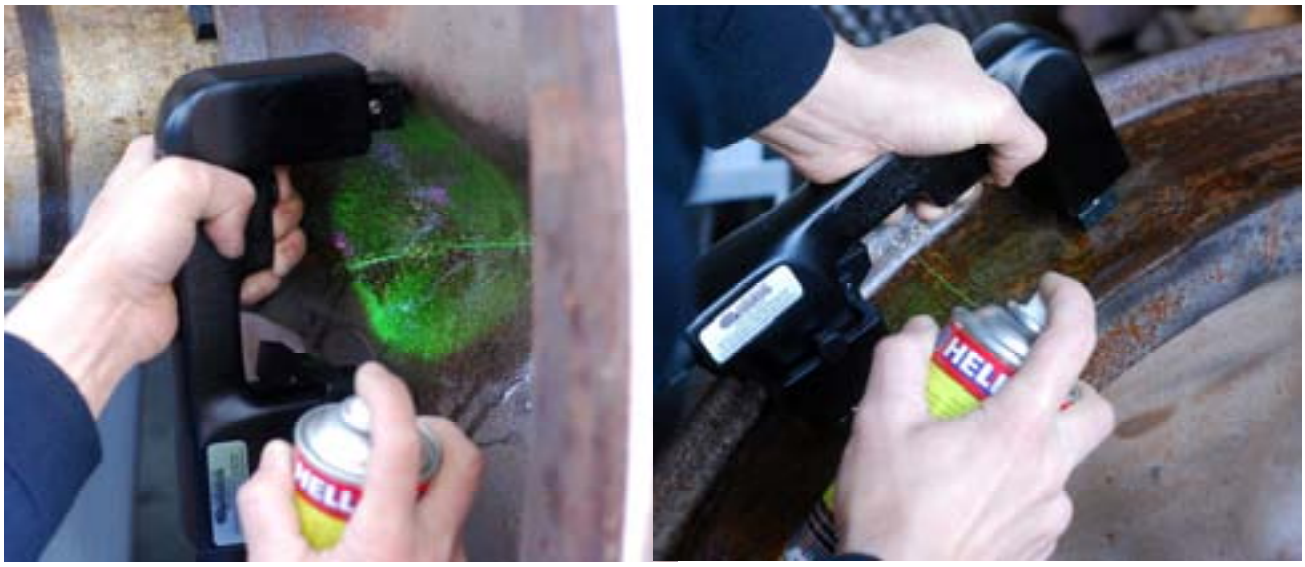
The Helling MT-Device is designed for detection of surface defects of any orientation on railway wheels (Picture 7). The device is appropriate for inspection of ready-mounted wheel pairs at train overhaul plants as well at railway wheels manufacturing works. The specially designed trapezoid coil enables the contactless magnetizing of the complete wheel surface with the exception of wheel hub inner face at the wheels with diameter from 700 to 1200 mm. The coil is equipped with a showering arrangement for magnetic particle suspension which has been supplied by a mixing pump from a 40L container.

The MT Device has a stable metal frame with dimensions of 2000x2000x2850mm with a lifting device for magnetizing coil. The control desk with status indication and warning system has an integrated six-step transformer for magnetizing current adjusting. The tangential field strength on the wheel surface is more then 25 A/cm.

Picture 7. MT Device for railway wheels testing at a train overhaul plant

The electrical drive motor with a frequency converter and brake enables the three-speed rotation of a wheel pair by testing. The inspection is to be made with a fluorescent water-based magnetic particle suspension using UV radiation.

The inspection of the wheels can be also fulfilled using hand magnetizing devices. When working with fluorescent magnetic particle suspension the hand yokes can be fitted out with the network independent inductive UV Light LED Source mentioned above.



Picture 8. Wheel testing by means of hand magnetizing devices equipped with UV Light Sources

Its swivel head lets adjust the irradiation angle depending on poles distance and yoke leg length in order to get an optimal homogeneous UV irradiation field in the middle of the working area (Picture 8).

Picture 9.
UM-10 lifting test with TB10 test blocks

For complete operator mobility the portable DC Hand Yokes are indispensable. The portable UM-10 / HANSA – DC Hand Yoke is battery powered and hereby network independent direct current magnetizing device (Picture 9). The device has been fed by a high power Li-Ion battery pack sufficient for continuous working time of about 4 hours. The carrying case for the battery pack can be fastened quickly at the waist-belt. The pull off strength by poles distance of 135 mm is > 27kg (265 N). According to ASTM E1444 min. 22,5kg (225 N) are required.

Documentation

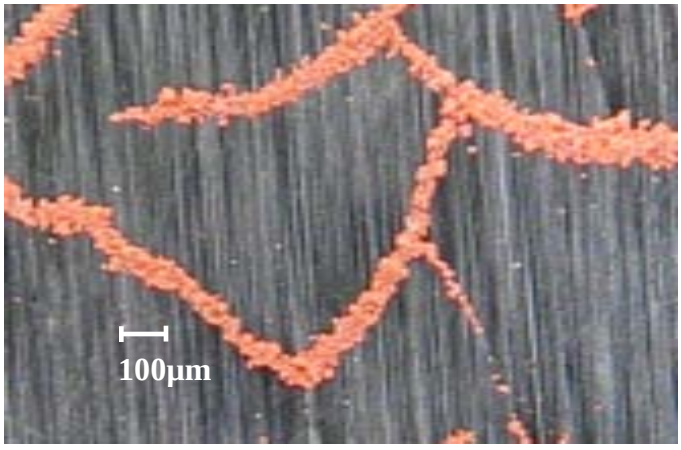
The portable X-Loupe microscope camera (Picture 10) is irreplaceable for precise, fast and traceable documentation. This is a modified Canon IXUS camera with attachable battery module and three interchangeable lenses – of 60x, 100x and 150x magnification.

Picture 10.
Helling X-Loupe microscope camera

The lenses incorporate an adjustable LED light. This feature solves the most challenging illumination problems when taking micro photography. The X-Loupe is completely independent of all exterior light sources and can be used under any light conditions.

Moreover the microscope camera can be combined with an UV lens, which enables defects estimation and further documentation under UV light.

The X-Loupe captures images of objects in the range from 15 mm to 0,005mm, making it possible to identify microscopic details that need attention, and via image management software making them available to customer within minutes. The software enables to transmit high definition images where observations, comments as well as measurements are included within the image. The image can then be sent as a JPEG file or as a detailed Excel spreadsheet.



Picture 11. Cracks indication after treatment with MEF 515 magnetic particle suspension

As an example Picture 11 shows cracks indication after treatment with MEF 515 magnetic particle suspension which is fluorescent under the day light. This microscope camera makes it possible not only to get high resolution pictures but also to estimate defect geometry.

References

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