AC/DC pulses up to 3 x 30,000 A for MT-testing and demagnetization of steel components and industrial applications

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Abstract

HPT Hirsch Prueftechnik GmbH develops and supplies mobile and stationary MT-testing equipment. The equipment utilizes AC/DC Pulse Technology for surface crack detection and demagnetization of steel components for industrial applications. There are several important advantages of MT-testing with AC/DC Pulse Technology. For example, it produces crack indications without false indications for unconventionally large test areas within a very short period of time. Therefore, even large components like forged rings and gears with diameters up to 10 m for wind power plants, shafts, and casted or welded components can be quickly MT-tested and/or demagnetized. This presentation describes different industrial applications of AC/DC Pulse Technology with single and multiple current peaks up to 3 x 30,000 A that perform the MT-testing and demagnetization work applying different magnetization techniques. The magnetization techniques are direct current flow, non-contact coil magnetization with two coils as well as a combined method which uses both direct current flow and coil magnetization.

1. Introduction

With the ever-increasing industrial demands for stronger, bigger, and more complex steel components and constructions, the requirements for MT-testing and demagnetization have been correlatively increasing over the past decades. Materials and material connections have to withstand more stress to achieve more efficient material utilization, be it for better competitiveness or even for plain feasibility of projects with challenging demands. Welding and MT-testing tasks have therefore also increased significantly in volume and complexity.

Welding technology accordingly has seen major progress and development and achieved technological advancements and completely new methods. MT-testing and demagnetization, however, remained conventional. HPT Hirsch Prueftechnik GmbH in Zweibruecken has set itself the task to significantly improve progress and development on the field of MT-testing and demagnetization. The goal is to achieve faster, more reliable, and cost-effective MT-testing and demagnetization solutions.

HPT Hirsch Prueftechnik GmbH develops, produces, and supplies small, weight- and energy efficient, mobile and stationary AC/DC pulse MT-testing devices with DC power peaks from 8,0000 A up to 30,000 A single current and 3 x 30,000 A multiple current peaks for surface crack detection and demagnetization of steel components.

2. MT-Testing

2.1 General functional principle

Like all other MT-testing methods, MT-testing with AC/DC Pulse Technology is based on the effect that, at the location of surface cracks, magnetic stray fields are escaping from magnetized parts. Once test liquid mixed with iron or iron oxide particles has been sprayed on the surface of the parts, the magnetic stray fields accumulate the particles at the cracks. The accumulated particles show the crack position by either the use of an UV-LED-lamp, which illuminates the surface and provides greenish crack indications where the fluorescent test particles accumulate, or by black test particles on white background for good contrast. The measuring device for current, magnetic- and residual field strength can be used to ensure that the magnetic field strength is sufficient and therefore MT-testing is carried out properly.

2.2 AC/DC pulse magnetization

Conventional MT-testing devices are based on continuous current technology, whereas the MT-testing devices of HPT Hirsch Prueftechnik GmbH utilize AC/DC pulse magnetization. This leads to major differences in the feasibility of MT-testing methods and applications, which shall be described in detail later on.

When AC/DC pulse magnetization is utilized, the test particles are pulled with each pulse towards the crack locations, thus creating clear and sharp crack indications. Due to the short pulse length (cf. Figure 1), the thermal stress on the MT-device is significantly reduced, so that they can be built much smaller and lighter despite their even higher power output.

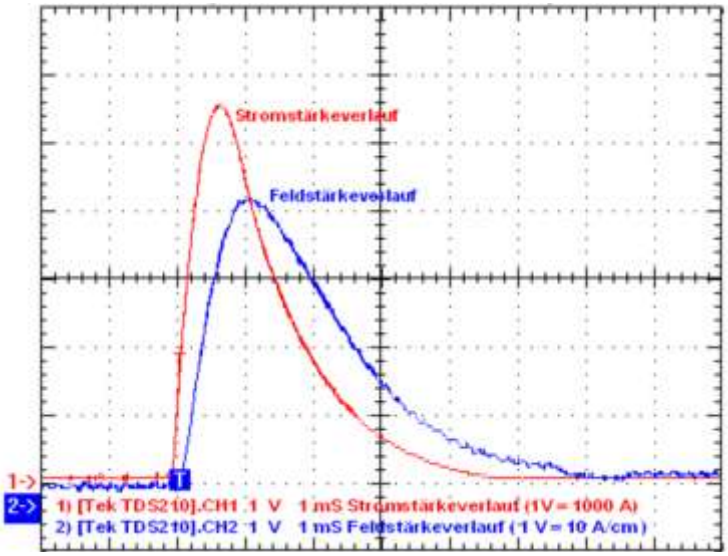

Figure 1: DC current flow (red) and magnetic field strength (blue) of the Multipuls-1003-C Hirsch device (6,000 A)

Compacting all the energy into short, fierce pulses also makes it possible for much stronger peak current generation, making significantly increased test area sizes feasible (cf. Figure 2). This allows for mobile, cost- and time effective MT-testing even on very large objects such as blades for hydroelectric plants (W= 4.5 m; H= 3.0 m).

Figure 2: MT-testing of a blade for a hydroelectric power plant (W= 4.5 m; H= 3.0 m), Hirsch Multipuls-1003-E2-1 device using direct current flow with up to 30,000 A

With conventional MT-testing technology, it took two men 40 hours to test the whole surface, whereas with the utilization of the Hirsch Multipuls-1003-E2-1 device, the whole blade is MT-tested and demagnetized within four hours by one man.

MT-testing with AC/DC Pulse Technology can be applied in many industries like submarine ship yards, machine building, foundries, forging shops, mobile cranes, offshore equipment, hydroelectric- and wind power plants, armoured vehicles, tanks, casted GGG40-blades, turbines for the aircraft industry, etc.

3. MT-testing and demagnetization Methods

According to DIN EN ISO 9934, magnetization directions for a test piece have to differ by at least 30° to ensure sufficient magnetization for visualization of all crack directions.

Following these guidelines, there are three methods of magnetization for application:

- direct current flow
- double coil
- combined method

3.1 Direct current flow

The direct current flow method utilizes the test piece itself as a conductor which is flooded with direct current pulses. Following the physical law that every current carrying conductor generates a magnetic field, the test piece therefore generates via current flow the magnetic field necessary for MT-testing, granted the current strength is sufficient. The test piece can be checked for all crack directions given the current paths and thus the magnetic field directions differ by at least 30° (cf. DIN EN ISO 9934).

When conventional technology is used, usually the direct current method cannot be applied to finished machined component surfaces or can only be applied with very limited test distances to avoid electric sparks and surface burning.

However, when AC/DC pulse magnetization is utilized for direct current flow, ready machined test areas up to several square meters, as for example presented in Figure 2, can be MT-tested and demagnetized in one step only, without any electric sparks or surface burning.

3.2 Double coil (non-contact MT-testing and demagnetization)

The double coil method utilizes two differently oriented coils to generate the magnetic fields required for MT-testing. The coils are usually oriented in a 90° angle to each other and may vary greatly in size and shape, depending on the test parts, to allow for optimal magnetization.

Figure 3: Non-contact MT-testing and demagnetization of a gearwheel carrier with an approx. 3 m diameter using two coils and the Hirsch Unit, type Multipuls-1003-E2-1 (30,000 A)

One of the big advantages of this method is that the entire MT-testing and demagnetization process can be carried out contact free. Large parts like gearwheels with diameters up to 10 m are MT-tested and demagnetized with Hirsch equipment within minutes, whereas conventional technology requires more time only for adjusting the test bench to the test parts' diameter and clamping it into/onto the test equipment.

The MT-testing and demagnetization setup shown in Figure 4 has been set up for planet wheel carriers with diameters up to 1.7 m. Multidirectional crack indications which had been found in one of the tested components are shown in Figure 5.

Figure 4: Non-contact MT-testing and demagnetization of a planet-wheel carrier with two coils and the Hirsch Multipuls-1003-E2-1 (30,000 A) device

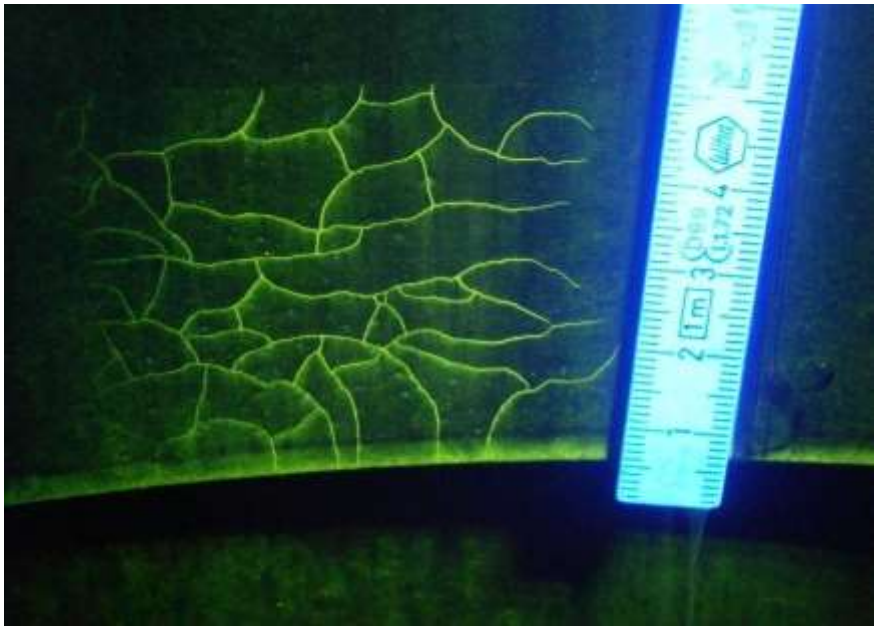

Figure 5: Clear multidirectional crack indications of non-contact MT-testing with two coils and the Hirsch Multipuls-1003-E2-1 (30,000 A) device

3.3 Combined Method

The combined method utilizes direct current flow as well as coil magnetization. Usually applied on elongated components, the direct current flow runs from one end of the component to the other, thus creating a circular field around the current path, which is used for detecting longitudinal cracks. The coil winding is usually oriented around the elongated component, thereby creating a magnetic field in direction of the longitudinal axes, which is used to detect transverse cracks. Especially large turbine or blade shafts are checked with this method.

4. Hirsch Multipuls-1003-E3 device with 3 x 30, 000 A

HPT Hirsch Prueftechnik GmbH developed the Hirsch Multipuls-1003-E3 device for the application of MT-testing and demagnetization of large metal parts with rough surfaces. Compared to the strongest single pulse device Multipuls-1003-E2-2 with 30,000 A, its energy output has tripled to 3 x 30,000 A. Not only has the energy output tripled, but also a new advanced pulse technology has been developed: the 3 DC Pulse Technology. It is used to evenly distribute the energy in a burst of three pulses.

This 3 DC Pulse Technology improves crack indication results on rough surfaces, which are usually found on large casted components as shown in Figure 6. With a DC peak of 3 x 30,000 A, it has more energy to produce a strong magnetic field, but still has convenient handling with long cables coupled with magnetic connectors.

Figure 6: Mt-testing of a casted component with direct current flow using 3 DC Pulse Technology and the Hirsch Multipuls-1003-E3 (3 x 30, 000 A) device

5. Conclusions

Following industry's demand for stronger, faster, and more efficient MT-testing and demagnetization devices, the application of DC-Pulse Technology for these purposes has been rising steadily.

Starting from its roots in the submarine MT-testing business, the product range of HPT Hirsch Prueftechnik GmbH has increased from small mobile handheld DC-Pulse devices with 6,000 A peak current to MT-testing devices with up to 30,000 A peak current which also have the ability to apply AC/DC-Pulses of the same power. The newest and also strongest Hirsch device even utilizes a 3-DC-Pulse-Technology with up to 3 x 30,000 A peak current, which is mainly used for the inspection of large components with very rough surfaces.

The increasing diversity of HPT Hirsch Prueftechnik's product range allows more and more companies to benefit from the advantages that DC-Pulse Technology has to offer.

Advantages of DC-Pulse Technology are:

- Clear, high-contrast crack indications within seconds
- No false indications, which allows for faster, easier and more reliable evaluation
- No burnt areas on contact points due to special magnetic connectors or through non-contact MT-testing and demagnetization methods
- Applicable for the smallest as well as for the biggest component dimensions
- In spite of its high-power output, the MT-testing devices are still small, compact, and easy to handle
- Time saving and ease of use by not having to clamp components into a fixed stationary test bench/device
- Permanent demagnetization down to the core of the component
- High-power output at low energy costs thanks to very energy efficient DC-Pulse-Technology
- Repair work of defects is possible with a minimal amount of grinding work
- MT-testing of large areas for all crack directions in one single step not only enables low operational costs due to elimination of excessive overlapping area and significant savings in MT-test ink expenditure, it also allows for easy, fast, and therefore economic photo documentation of the tested components
- Improvements of MT-testing performance up to 2000 %