PAUT Testing System
for Large, Seamlessly Rolled Rings

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1 Abstract

The company Rothe Erde (Dortmund, Germany) manufactures seamlessly rolled rings for complex industrial applications. The rings' dimensions and technical specifications require a customized testing system for automatic inspections in order to meet the customer's testing requirements: With the ECHOGRAPH PKFR PAUT system, the test piece is positioned in three concentrically adjustable roller blocks that set the ring in rotation. The vertically and horizontally aligned probes of the system scan the ring's volume from the front side and the bottom side. For surface-near defects, two multi-transducer TR probes are operated with conventional testing electronics. Two phased array probes are used to inspect the testing volume in the range of 50 to 750 mm. Gimbal mounting ensures constant contact between the probes and the test surface. The system permits the consistent detection of natural defects with a reference defect size of FBH 1.0 mm and a reproducibility of ±2 dB for all flaw positions and depths.

Keywords: PAUT, volume testing, multi-transducer TR, gimbal mount, steel industry

2 Introduction

The seamlessly rolled rings manufactured at Rothe Erde are unique in their shape and size and require a customized testing system. The ECHOGRAPH PKFR PAUT system by KARL DEUTSCH enables volume testing and the detection of small material defects, as required for the test pieces' applications. It utilizes a special mount for the TR and PA probes as well as adjustable roller blocks for clamping and rotating the test pieces.

3 Customer Requirements

Rothe Erde manufactures seamlessly rolled rings as functional components in complex industrial applications. With a diameter of up to 6.5 metres and a weight of up to 30 tons, the test pieces are unique in their shape and size. The tangential fibre orientation of these forging slugs ensures isotropic material characteristics across the entire ring's circumference and contributes significantly to the structural integrity of these components that are used in roller bearings for wind turbines and highly stressed components of tunnel drilling machines. Reliable detection of natural defects with a reference defect size of FBH 1.0 mm and a reproducibility of ±2 dB for all flaw positions and depths was required by the customer. Furthermore, compliance with the standards EN 10228-3 and ASTM A388 was mandatory.

4 System Setup

4.1 General Construction

The rings are moved in and out of the testing system with an indoor crane (see Fig. 1).

Fig. 1. Loading of the rings into the testing system

The test pieces are placed into three roller blocks (see Fig. 2, A) that can be moved concentrically to account for different ring sizes. The test equipment is mounted to a carriage itself (see Fig. 2, B) which can be adjusted in height: The probes arranged on the side move vertically along the front sides of the ring. At the same time, horizontally adapted probes scan the underside of the ring in a radial test direction from the outside inwards, thus ensuring that all potential material inhomogeneities are detected. An additional manual traversing operation allows rotation in both directions and at varying speeds.

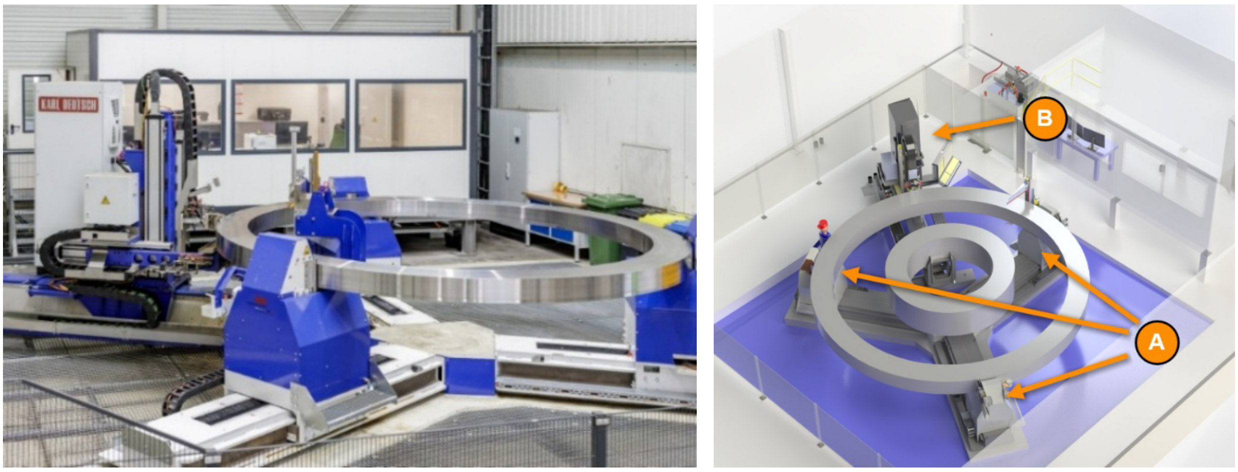

Fig. 2. The testing system contains three roller blocks (A) and the carriage with the mounted probes (B)

4.2 Ultrasonic Testing Configuration

For the detection of defects in the surface-near areas of the ring, which cover depths of 2 to 60 mm, two multi-transducer TR probes (see Fig. 3, right) are used per inspection system, operated with conventional testing electronics for the vertical and horizontal inspection direction. For greater wall thicknesses in the range of 50 to 750 mm, two phased array probes are used per inspection system (see Fig. 3, left).

The probes are equipped with fully parallel testing electronics that allow simultaneous control of multiple test channels. This makes it possible to perform a comprehensive volume test with high depth resolution, which means that defects deep within the material can reliably be detected. Depending on the material and the dimensions of the ring, even smaller defect sizes than the one specified in the requirements can be detected. The combination of the axial and radial inspection systems ensures full-surface inspection and precise quality assurance across the entire wall thickness of the ring.

Fig. 3. Probes used in the system. Left: Phased array probe, right: Multi-transducer TR probe.

The test track has a scanning range of about 50 mm per TR and PA probe and is integrated into each testing system in overlapping arrangements for a resulting test track of about 100 mm.

4.3 Probe Mounting and Coupling

The probe holders are gimbal-mounted to compensate for surface unevenness and apply the probes to both the front and underside of the ring (see Fig. 4). For rings with a height of over 500 mm, the probe holder can be turned 180° manually to also test the top side. Due to the pre-set pneumatic pressure, the probe holders are placed on the ring elastically, thus compensating for any unevenness. The coupling of the probes is done via a water gap, the inflow of which is controlled via PLC.

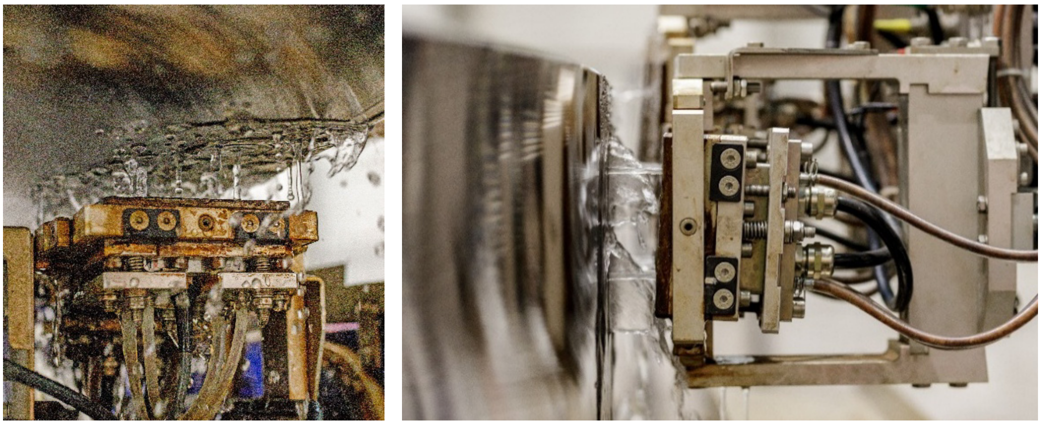

Fig. 4. Gimbal-mounted probe holder during the coupling process. Left: bottom, right: front.

4.4 Evaluation and Data Interface

Both PA and TR probes are calibrated once per shift with the back wall of the test piece currently at hand. Before starting the test procedure, the user enters the required sensitivity level. The necessary amplification is then calculated with the corresponding DGS curve and automatically assumed by the evaluation software. The primary evaluation of the material flaws is done via C-scan. Notably, the error list shows the found flaws live during testing in three dimensions with the equivalent reflector sizes.

The evaluation software (see Fig. 5) was expanded to allow for multiple types of error categorisation. A category “detection limit” was added for registrable flaws that need to be documented, but do not cause the tested ring to be dismissed (“acceptance limit”).

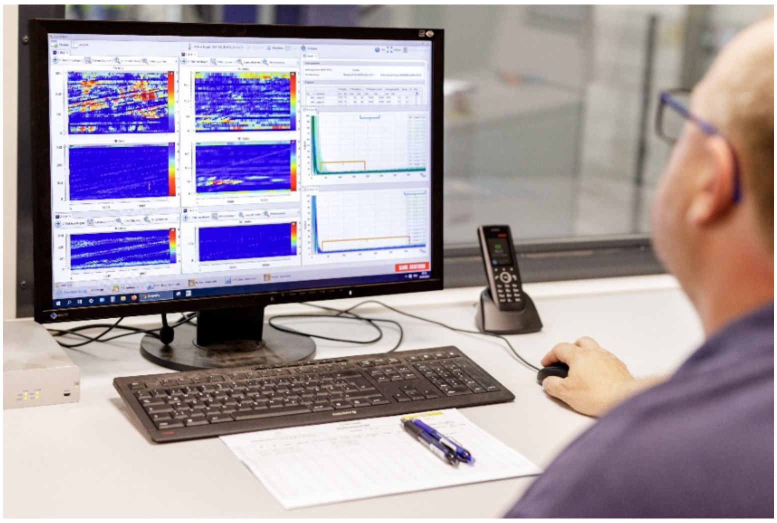

Fig. 5. Evaluation software ECHOVIEW

In addition, a special interface was developed as to allow data exchange with the ERP system “SAP”. This modification allows integration of the test procedure into the commercial and logistical workflow. Both aforementioned categories of evaluation are transmitted for additional documentation purposes.

As is common practice for many ultrasonic testing systems, the system features a flaw marking device that highlights detected defects with different colours (see Fig. 6). This facilitates finding the flaws on the specimen as is particularly necessary with the dimensions of the rings.

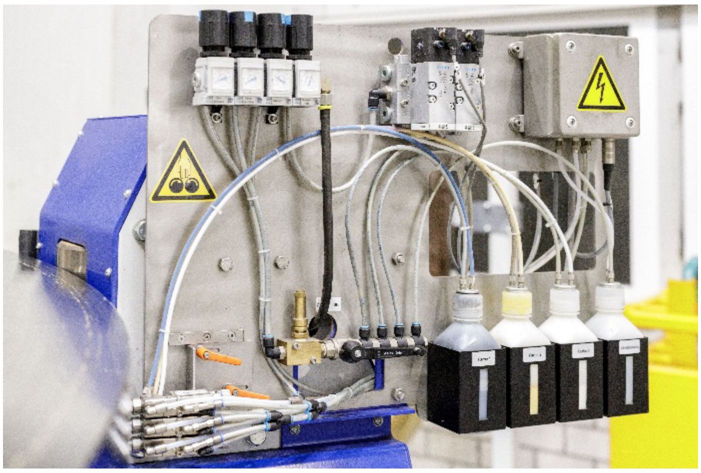

Fig. 6. Flaw marking device

5 Conclusion

The ECHOGRAPH PKRF PAUT system is a custom system for specific test pieces with unique dimensions and requirements for high flaw detection probability. Despite the high level of specialisation in its application, the system still had to maintain a notable degree of flexibility for test piece dimensions without compromising on quality of the results. The ability to flip the probe holder in conjunction with the custom probes allows for full volume inspection of larger test pieces without increasing the need for additional equipment or probes. A notable effort has been put into expanding the evaluation software to allow for integration into the existing framework for documentation, logistics and quality assurance.

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