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CURRENT INDUCTED BARKHAUSEN NOISE TECHNIQUE

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MOTIVATON

- Barkhausen Noise (BN) measurement is an efficient non-destructive technique for material characterization
- BN is highly sensitive to materials stresses and can be used for quantitative determination of residual stresses and external mechanical loads.
- Typical applications are quantification of plastic deformation, hardness, tensile strength, field strength and hardness depth.
- Ordinary magnetic BN-Sensors have a relatively large measuring spot, which makes measuring in corners rarely possible - with a current-induced sensor, this measuring spot could be significantly reduced.

IDEA

Barkhausen Noise by electric current magnetization

Innovative techniques of exciting BN by electric current magnetization (Eddy field technique) opens new areas of applications for Electromagnetic Non Destructive Evaluation. When an alternating electric current is used to flow through the sample, a magnetic field is induced normal to the electric current which excites the Barkhausen Effect (Fig. 1). This so called Eddy-Field BN is sensitive to re-magnetization processes. The sensitivity of the effect to residual and applied stresses can be used to develop it into a stress detection technique [1]. The principle of coupling in an electrical current can be applied by using electrodes. The surface of the sample is directly contacted with one or two small tips that couples in an alternating electrical current. At the surface of the sample, the highest current density is generated. The electrical current excites a magnetic field on the surface of the sample, which excites the BN. The Barkhausen Noise is detected with a coaxial pick up coil in case of a single electrode (Fig. 2, left). Using two electrodes the detection is realized with an intermediate coil (Fig. 2, right).

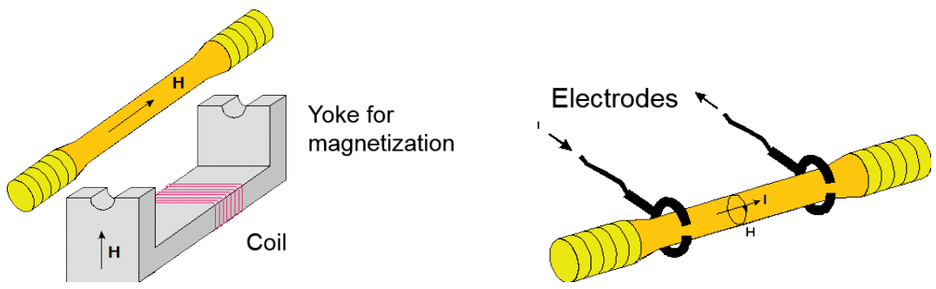


Figure 1: Comparison of an excitation setup on a circular tensile specimen by means of magnetic (left) and current induced excitation (right).

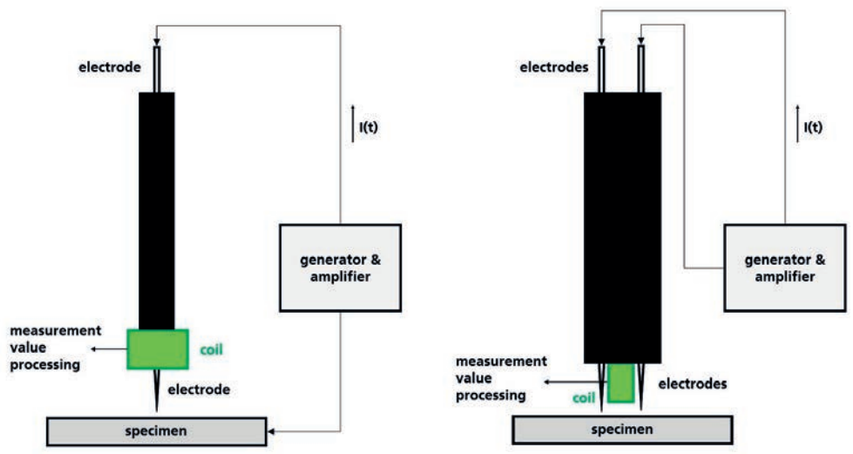


Figure 2: Schematic of the two different prototype systems for Barkhausen Noise measurements using alternating electrical current through a single thin tip with a coaxial pick up coil (left) and two tips with an intermediate coil (right).

PROTOTYPES

Present BN sensors are very large, not optimally adapted for each application and must be specifically designed for each kind of different component geometry. The Eddy field BN sensors are more compact than conventional sensors and can work in complex small sample geometries. The two different Eddy field BN sensor prototypes are show in Figure 3 and 4. In each case, the electrical contact is realized via pointed tungsten electrodes.

Figure 3: Single-Tip Sensor

Figure 4: Double-Tip Sensor

CONCLUSION

The application possibilities of Eddy field excitation BN sensors are based on the detection of the residual stress / fatigue states and the material properties on complex geometries of ferromagnetic alloys. For this purpose, sensor prototypes have been successfully tested.

MEASUREMENT SYSTEM

As part of the SAB project "EnBaStro", the project partners "SURAGUS GmbH", "dresden elektronik ingenieurstechnik gmbh", "Fraunhofer IKTS" and "IMA Materialforschung und Anwendungstechnik GmbH" developed the "Barkhausen Noise Analyzer" (Fig. 5). Among other things, this portable measuring system provides power electronics for current-induced Barkhausen noise measurements and works with the Double-Tip BN Sensor. At the same time, the device can also be used for magnetic BN sensors and post-processing. The software includes among other tools the envelope calculation, butterfly curve, fractal dimension.

Figure 5: Barkhausen Noise Analyzer with the Double-Tip Sensor.

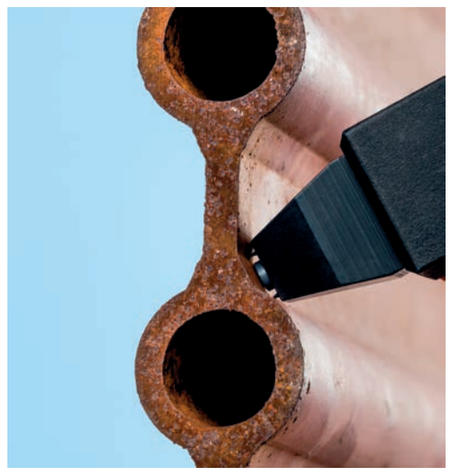


Figure 6: Double-Tip Sensor on a welding seam.

TESTING

As with BN sensors with magnetic excitation, with the Double-Tip sensor it is possible to determine the stress preferred direction of materials. Figure 7 show the double-tip sensor in a vertical orientation during a tensile test on a C45 sample. Figure 8 shows the Double-Tip Sensor on a bogie during a fatigue process.

Figure 7: Double-Tip Sensor on a tensile sample.

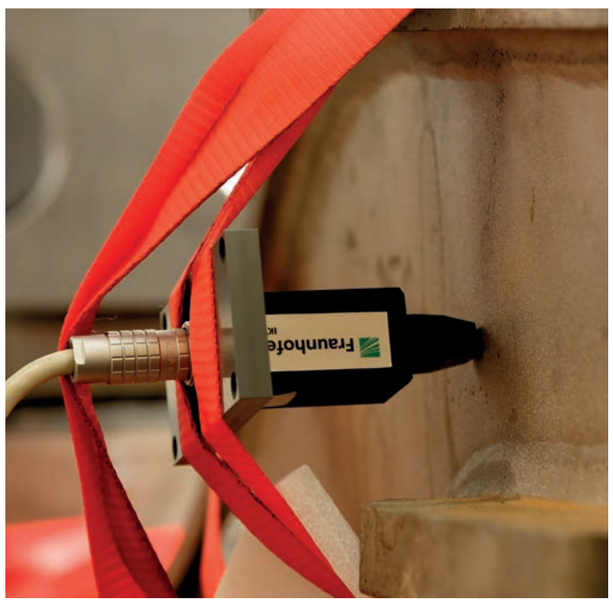
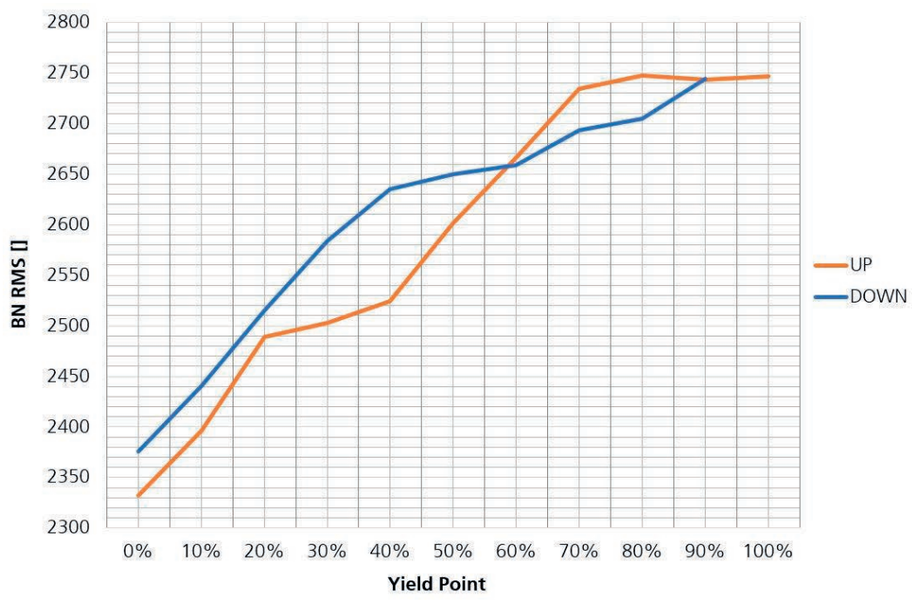


Figure 8: Double-Tip Sensor on a bogie during a fatigue process.

Diagram 1: BN RMS trend during a tensile test with a C45 sample



The result of one tensile experiment is shown in Diagram 1. If the sensor is aligned horizontally (the two tungsten tips are perpendicular to the preferred stress direction during stretching), the increase in stress is visible evident as the stretch increases (see diagram 1, graph 1). This confirms that the magnetic field propagates perpendicularly to the current flow and that direction-dependent measurements can be carried out with the sensor.

REFERENCES

[1] S. Hillmann, N. Meyendorf, A New Barkhausen Noise Technique for Applications at Miniaturized Geometries, AIP Conference Proceedings 1581, 1293, 2014, doi: 10.1063/1.4864970, QNDE Conference, Baltimore, Maryland, July (2013).

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