Automatization of Barkhausen noise measurements for high resolution evaluation of stress distribution in welded steel components.

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The system presented in this paper allows for high-resolution measurement and imaging of 2D stress distribution on the surface of electron welded sample. Barkhausen noise equipment used for non-destructive testing of ferromagnetic materials is paired with a robotic arm to enable taking measurements with high precision and repeatability. This pairing allows to scan a mesh of points with minimum distance between them being 0.1 mm. The data is then used to evaluate stress and/or microstructural changes in the welded sample.

Keywords: Barkhausen noise; automatization; high resolution measurement; non-destructive evaluation.

1. Introduction

Understanding the stress distribution on the surface of a welded sample is crucial for evaluating the structural integrity of the product and ensuring the safe operation of industrial components. Measuring stress in such material can be done by utilizing Barkhausen effect phenomenon. During sample magnetization, movement of magnetic domain walls (DW) causes generation of Barkhausen noise (BN) signal during pinning and unpinning of DWs on material imperfections. External and residual stresses cause modification of domain wall structure, modifying the BN signal which allows for correlation between signal and stress distribution. [1]

2. Results and discussion

In this work, BN measurement set equipment with 100Hz magnetizing unit generating sinusoidal waveform was used. Wedge shaped probe with detecting coil wound on a 1 mm diameter core, was used to test surface of welded sample. Multiparameter BN analysis software, which was created in LabVIEW environment, provided 16 descriptors that were derived from different signal features.

This equipment was then paired with Universal Robots UR3e cobot. This high precision robotic arm allows for movements with 0.1 mm accuracy. Pairing this manipulator with Barkhausen noise equipment allows for high-resolution testing and imaging of samples. Programming a mesh of points with resolution of 0.5mm over 20x18mm rectangle provides 1440 unique data points. This area covers 3 electron welds and heat-affected zone (HAZ). Fig. 1 shows sample with measured area marked by black lines and welds marked with red lines

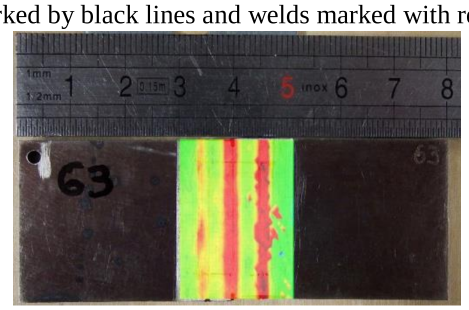

Figure 1: Electron welded sample with overlaid descriptor values

Different descriptors can be used to evaluate state of measured sample surface. In this paper descriptor being an integral of Barkhausen noise envelope was chosen. This parameter can be effectively used to evaluate residual stress present on the surface of sample after electron welding. Fig. 2 shows values of this descriptor versus measurement location, and also photograph of the sample with descriptor values overlaid on top of it.

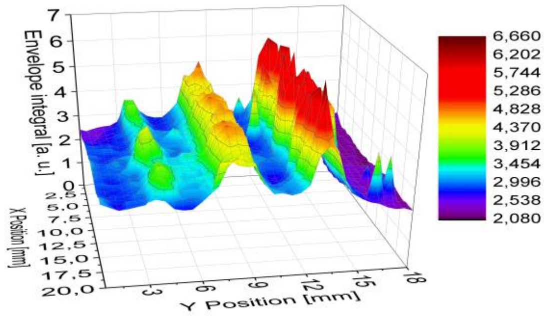

Figure 2. Distribution of the chosen descriptor on sample surface.

As seen in figure 2, chosen descriptor peak values corelate with location of three electron welds present in the sample. Values over different welds vary, which can be explained by weld fabrication process. Subsequently placed welds cause relaxation process to occur where the first weld is relaxed by next welds and the second weld relaxed by the third. Analysing obtained values, we can also see that HAZ generated in process of electron welding is extremely small compared to traditional welding methods. This combined with small weld surface necessitates usage of high-resolution measurement techniques.

Barkhausen noise equipment paired with high precision robotic arm allows for near instant evaluation of ferromagnetic samples thus combining non-destructive evaluation with rapid diagnostics not available with other testing apparatuses. This method is undoubtedly well suited for monitoring and/or optimizing welding processes.

References

[1] Lu, J. (ed.): Handbook of Measurement of Residual Stresses, The Fairmont Press, Liburn (1996)

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