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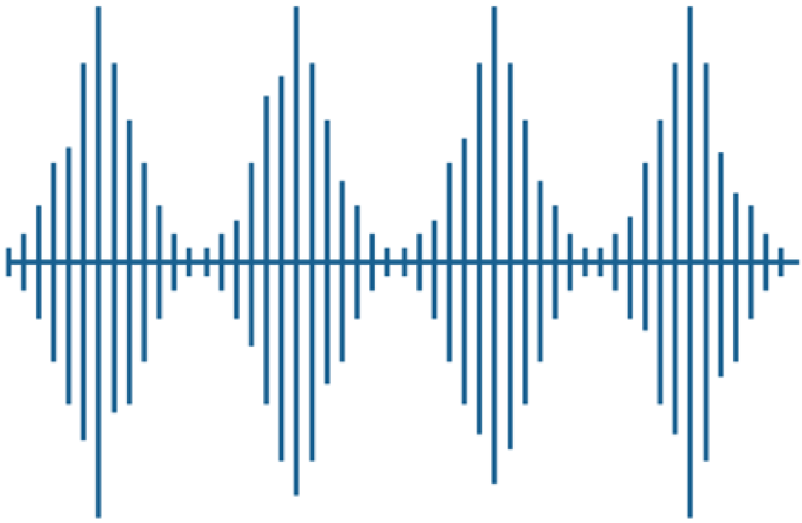


STRESSTECH BULLETIN 2

The Properties of Barkhausen Noise

In Stresstech bulletin 1, the phenomenon of Barkhausen noise (BN) was explained. Bulletin 2 explains the properties of Barkhausen noise.

Text: Murat Deveci, Figures: Stresstech

Barkhausen noise gives information from the surface and very close area beneath the surface. Barkhausen noise signal has a wide power spectrum starting from the adjusted magnetizing frequency and ending above 2 MHz in most of the ferromagnetic materials. The effective depth of signal penetration is between 0.01 mm and 1 mm. To have more information from beneath the surface (to increase the penetration depth), one possible way is to lower the magnetization and analysing frequencies. However, the penetration of the Barkhausen noise signal is damped due to skin effect which is caused by the opposing eddy currents induced by the changing magnetic field.

An estimation of the penetration depth of the BN signal can be calculated using the following formula:

$$\delta = {}^{1}\!\Big/\!\sqrt{\pi\mu\sigma f}$$

where δ denotes the penetration depth, μ represents the magnetic permeability, σ means the electrical conductivity and ƒ denotes the frequency of the alternating magnetic field.

Damping of a noise-like signal as Barkhausen noise, containing a spectral distribution of frequencies between f1 and f2 can be described by a function of D(x):

$$D(x) = \frac{\int_{f_1}^{f_2} g(f) exp\left[-Ax_n\sqrt{f}\,\right] df}{\int_{f_1}^{f_2} g(f)\, df}$$

where

$A = \sqrt{\pi\mu\sigma}$

μ = magnetic permeability

σ = electrical conductivity

x = distance from surface

For a low-alloyed hardened and tempered steel component, if we use a magnetizing voltage frequency of 125 Hz, the penetration depth of the applied magnetic field is around 2 mm. For industrial applications, such as grinding burn detection, heat treatment defect detection, analysing frequency range is 70 – 200 kHz. For the same steel component, this range will give an analysing depth around 0,1 mm.

	Material	
	Mild Steel (Annealed)	300M (Hardened and Tempered)
Conductivity	$5*10^6$ Ω·m	10^6 Ω·m (estimated)
Relative Permeability	2000	200
Frequency Range	**Analysing Depth**	
3 – 15 kHz	0.07 mm	0.40 mm
20 – 70 kHz	0.035 mm	0.18 mm
70 – 200 kHz	0.015 mm	0.10 mm

The actual values of analysing depth of measurement may be somewhat (approx. 30%) higher than given in the above table, due to the actual variations in g(f).

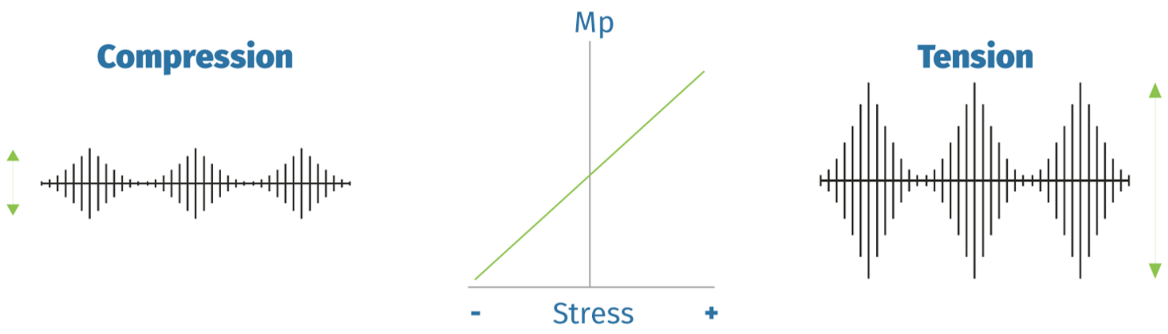
The lower the permeability and conductivity, the deeper the analysing depth of measurement. Decreasing the frequency range of the Barkhausen noise has the same effect on the analysing depth of measurement.

Two main material characteristics will directly affect the intensity of the Barkhausen noise signal.

One is the presence and distribution of elastic stresses which will influence the way domains choose and lock into their easy direction of magnetization. This phenomenon of elastic properties interacting with domain structure and magnetic properties of material is called a “magnetoelastic interaction”. As a result of magnetoelastic interaction, in materials with positive magnetic anisotropy (iron, most steels and cobalt), compressive stresses will decrease the intensity of Barkhausen noise while tensile stresses increase it.

This fact can be exploited so that by measuring the intensity of Barkhausen noise the amount of residual stress can be determined. The measurement also defines the direction of principal stresses.

Processes as cold rolling and shot peening which are used to create complex compressive residual stress distributions at the surface layer can be characterized by Barkhausen noise.

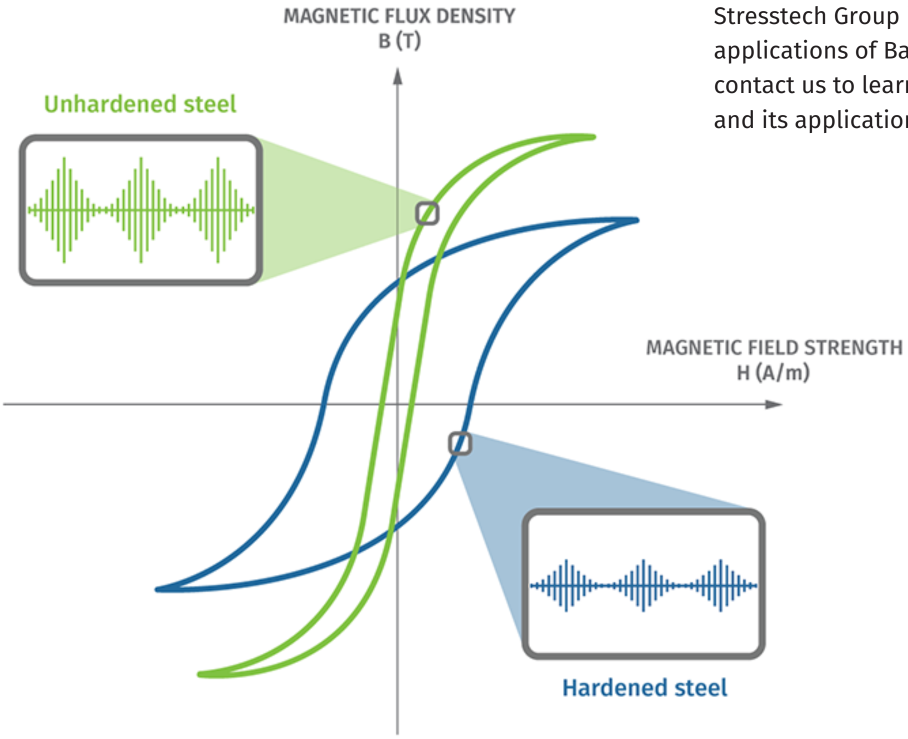


The other important material characteristic affecting Barkhausen noise is the microstructure of the sample. This effect can be broadly described in terms of hardness: the noise intensity continuously decreases in microstructures characterized by increasing hardness. In this way, Barkhausen noise measurements provide information on the microstructural condition of the material. Microstructure of the sample directly affects the shape of the signal output as well. As an example, hard magnetic materials have wider and soft magnetic materials have narrower BN signal envelope shape.

As the Barkhausen noise is an inductive method, there are number of factors which influence the BN signal. Here are some of them:

Residual Magnetism

Excessive residual magnetism (remanence) will prevent the correct formation of Barkhausen pulses with the result that the displayed test signal will be lower. The maximum permissible residual magnetism in test workpieces is 4A/cm, measured at the surface to be tested. In special cases a residual magnetism value of up to 8A/cm may be permissible, but in these cases the effectiveness of testing must be verified. The BN signal will be lower because large amount of the domains are locked in one direction caused by the residual magnetism.



Retained Austenite Content

The retained austenite content should not exceed 40% by volume. As the retained austenite content rises, the Barkhausen value falls. This is because the austenite is paramagnetic.

Electromagnetic Fields and Grounding

Strong electromagnetic fields for example from a PC monitor or a transformer can be a source of faults in signal. In this kind of case, care must be taken by maintaining an appropriate distance between the sensor and interference source to ensure that the test signal is not affected. Not having a proper grounding could be another source of signal problems.

In grounding related cases, the test workpiece should be connected to the same potential as the testing device.

Dirt on the test workpiece or sensor

Dirt or other particles will prevent the correct and repeatable making of a contact between the sensor and test workpiece. A particle-free and clean film of oil not only benefits the test signal but also helps the sensor to slide and reduces wear on this. Especially magnetic particles like chips or grinding dust may cause problems with the Barkhausen noise signal.

Barkhausen noise analysis (BNA) is effective to detect the hidden metallurgical defects such as grinding burns in hardened and ground components. It has been demonstrated that (BNA) is a cost effective and capable non-destructive testing method of identifying defects.

Stresstech Group is specialized in the industrial applications of Barkhausen noise analysis. Feel free to contact us to learn more about the Barkhausen noise and its applications.

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