The Marketing of Barkhausen Noise Analysis

by Michel Cardon

Twenty years ago, I read about a group of Finnish scientists who concentrated on an obscure phenomenon—Barkhausen Noise.

This phenomenon was unknown at that time, at least by those who could usefully apply it to their quality control problems. I was one of them, researching how shot peened parts could be controlled in production.

Between 1919, when Prof. Heinrich Barkhausen published his first work in a scientific magazine, and 1977, when Dr. Seppo Tiitto published results of his study relative to spectral damping of Barkhausen Noise, almost nothing happened related to this phenomenon.

Seppo Tiitto was lucky. He met a lovely blonde, Kirsti Mielityinen, at the Oulu University. They both worked on magnetic phenomenon. Happily enough for them, they appeared being of opposite polarities, so they got together, married and produced, beside a family, the first industrial quality testing system utilizing their knowledge of Barkhausen Noise.

While the main use of this instrument now is for the testing of grinding quality improvement, the initial instrument was made to test for tensile stresses appearing beyond the surface of cold rolling cylinders. When cylinders have been used for a long time, the effect of pressure in the mill, together with fatigue due to cycles of loading/unloading, can cause roll surface failures. This is extremely dangerous as large pieces from the cylinders' surface can detach and fly through the workshop.

The instrument developed by the Tiittos could detect variation in the stress condition of mill rolls without dismantling them and allow operators to stop and recondition the rolls before they became a real danger. Developed to scan a roll, they named their instrument Rollscan and it was marketed by Stresstech in Finland.

My experiences in introducing a new quality testing instrument

When I started to introduce these Barkhausen Noise Analysis (BNA) instruments, I found it was not always easy.

Most manufacturers believe their quality is very good. Introducing a new system to test for invisible or potential defects is sometimes received as a vexing proposal. As a production manager of a large automotive manufacturer put it, "Testing for quality would mean that we are not confident in our manufacturing procedure." However, this manufacturer became a regular BNA user in several of their production units.

As most Non-Destructive Testing methods (NDT), Barkhausen noise testing requires a calibration procedure. NDT is most often a relative, not absolute measurement method. Comparison with other NDTs or destructive testing calls for a comprehensive understanding of both methods and their limitations. A long, practical, daily industrial experience is a prime advantage to serve lab or production users.

Is this landing gear safe?

Selling this line of instruments sometimes called for nerves. As an example: A landing gears manufacturer asked for help. They used our Stresstech BNA instruments in production. They had an emergency: An Airbus was just back from Africa and

Barkhausen Noise Analysis

Barkhausen Noise Analysis (BNA) method, also referred to as the Magnetoelastic or the Micromagnetic method, is based on a concept of inductive measurement of a noise-like signal, generated when magnetic field is applied to a ferromagnetic sample. After a German scientist Professor Heinrich Barkhausen who explained the nature of this phenomenon already in 1919, this signal is called Barkhausen noise.

Barkhausen Noise - the Phenomenon

Ferromagnetic materials consist of small magnetic regions resembling individual bar magnets called domains. Each domain is magnetized along a certain crystallographic easy direction of magnetization. Domains are separated from one another by boundaries known as domain walls. AC magnetic fields will cause domain walls to move back and forth. In order for a domain wall to move, the domain on one side of the wall has to increase in size while the domain on the opposite side of the wall shrinks. The result is a change in the overall magnetization of the sample.

If a coil of conducting wire is placed near the sample while the domain wall moves, the resulting change in magnetization will induce an electrical pulse in the coil. The first electrical observations of domain wall motion were made by professor Heinrich Barkhausen in 1919. He proved that the magnetization process, which is characterized by the hysteresis curve, in fact is not continuous, but is made up of small, abrupt steps caused when the magnetic domains move under an applied magnetic field. When the electrical pulses produced by all domain movements are added together, a noise-like signal called Barkhausen noise is generated.

Barkhausen noise has a power spectrum starting from the magnetizing frequency and extending beyond 2 MHz in most materials. It is exponentially damped as a function of distance it has traveled inside the material. This is primarily due to the eddy current damping experienced by the propagating electromagnetic fields that Domain wall movements create. The extent of damping determines the depth from which information can be obtained (measurement depth). The main factors affecting this depth are

i) frequency range of the Barkhausen noise signal analyzed, and

ii) conductivity and permeability of the test material.

Measurement depths for practical applications vary between 0.01 and 1.5 mm.

Barkhausen Noise - the Properties

Two important material characteristics will 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

Continued on page 20

Continued from page 18

because of very hard landing conditions, it was necessary to test for compressive residual stresses on gear main tubes. Compressive stresses, induced by shot peening, protect the high strength steel part against stress corrosion failure, but compressive strength can be relaxed by high temperature due to emergency braking or by excessive fatigue. The manufacturer needed to decide whether to let the Airbus leave with same landing gear, or change parts. The first option was faster and economical, but was it safe? The second option, to change parts, was safe, but long and costly.

With BNA, my crew found static electricity charges on the aircraft body. Their operator couldn't read stable measurement values. We grounded the BNA instrument and the landing tubes together with a piece of wire, and this eliminated the effect of static charges. When the instrument and gear tube where grounded together, measurements became stable. Gear was judged good for service, and customer's return-on-investment was excellent!

The case of the musical NDT instrument

Sometimes, BNA is quite surprising. In an aerospace hydraulic components factory, in the centre of France (Vierzon), we could hear faint music coming from our BNA instrument. The customer was not surprised…they were located a short distance from a powerful radio station, France Inter. They were used to hearing the radio station in every electrical component, from telephones to electric shavers!

Nomenclature can also have interesting consequences. People suffering from fatigue and stress would call us in response to our promotion of BNA— a product that tested for stress—in hopes we would have a remedy for them.

Sample testing mishaps

Suitability of a sample can also cause confusion. A ball bearing manufacturer had stress problems in rings. They wanted to compare analysis methods. So they merely cut a ring in two, and sent half to each supplier. Of course, after cutting the ring, its stress conditions had very little to do with original problem. Obviously, there is still a strong division between what is taught in scientific circles and the problems faced daily on the shop floor. Similar to the shot peening industry, continuous information from conferences, seminars, and dedicated magazines on NDT are surely excellent ways to fill this gap.

With the high demand for improved quality of mechanical components, fields of application for Barkhausen Noise and micromagnetic testing systems have grown to a highly used Non-Destructive Testing method for most steel part manufacturers worldwide.

Should you wish to learn more about BNA, may I suggest you look into ICBM conferences? For information on the upcoming International Conference on Barkhausen Noise and Micromagnetic Testing ICBM 6 in France, visit www.icbmconference.org.

Michel Cardon is retired from the vacu-blast industry and resides in Paris, France. During his career, he was the manager of the vacu-blast department of his family business, Satem. He formed Matrasur which was later purchased and became Wheelabrator. Some of his career highlights include being a guest of the U.S. Capitol in 1982 and a meeting with Jacques Chirac.

Barkhausen Noise Analysis con't.

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.

The other important material characteristic affecting Barkhausen noise is the micro-structure 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.

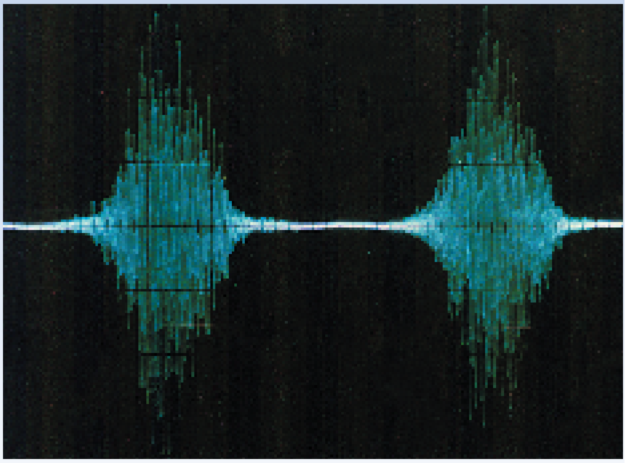
Barkhausen Noise Analysis - the Applications

Many common surface treatments such as grinding, shot peening, carburizing and induction hardening involve some modification of both stress and microstructure and can be readily detected using the method. Various dynamic processes such as creep and fatigue similarly involve changes in stress and microstructure and can also be monitored with Barkhausen noise.

Practical applications of the magnetoelastic Barkhausen noise method can be broadly divided into three categories:

- Evaluation of residual stresses; provided microstructural variables can be reasonably controlled.
- Evaluation of microstructural changes; provided level of stress can be reasonably controlled.
- Testing of the following surface defects, processes and surface treatments that may involve changes in both stresses and microstructure:
  - Detection of grinding defects and grinding process control
  - Detecting surface defects through Cr-coating
  - Evaluation of shot-peening effect in steel
  - Measurement of residual surface stresses in steel mill rolls and steel sheet

Source: www.stresstechgroup.com



Oscilloscope image of the Barkhausen Noise measured with Rollscan instrument. (Image courtesy of Stresstech Group)