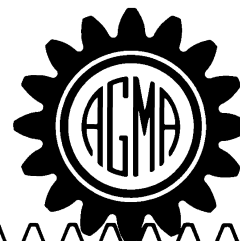


Using Barkhausen Noise Analysis for Process and Quality Control in the Production of Gears

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TECHNICAL PAPER

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

The use of magnetic Barkhausen Noise Analysis (BNA) has been proven to be an effective tool for the non-destructive detection of microstructural anomalies in ferrous materials. Used as an in-process tool for the detection of surface temper burn, heat treat defects and stresses, BNA is a quick comparative and quantitative alternative to traditional destructive methods.

Applications of BNA as a quality control tool in gear production have existed for nearly two decades. This paper presents examples that demonstrate how BNA is used to evaluate changes in microstructural properties. Quantitative results correlate BNA test values to X-Ray diffraction values for the detection of changes in surface residual stress. Other quantitative analysis correlates BNA test values to surface hardness values for the detection of re-tempering burn. Qualitative results correlate BNA test values to acid etch patterns/colors for the detection of re-tempering burn defects.

Robotically automated systems can test gear teeth and provide immediate feedback for process control and quality assurance.

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500 Montgomery Street, Suite 350
Alexandria, Virginia, 22314

October, 2007

ISBN: 978-1-55589-910-3

11/11/2007 10:11:11 AM

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Introduction

In the manufacturing process of grinding hardened gear teeth to final dimensions, there exists the possibility of thermal damage to the ground surface. This thermal damage results in a change of the surface microstructure and/or surface residual stresses, which, in turn, leads to poor performance and premature failure of the end product. In the extreme, grinding can produce rehardening tensile stresses and cracking. The practice of testing for this damage has been implemented in many destructive and non-destructive forms.

Barkhausen Noise Analysis (BNA) is a proven non-destructive method to accomplish this task. Unlike many other methods, BNA is a quick, efficient and safe way to provide feedback with regards to changes in microstructural properties of the ground gear surfaces. It is quick, in that real time data is given with little or no manual analysis required. It is efficient, in that it does not require any surface preparation. It is safe, in that it does not use hazardous chemicals.

With the proper initial setup and studies, BNA is a useful tool in monitoring the metallurgical effects of the grinding process and ensuring product quality.

Barkhausen noise

Barkhausen Noise is produced when a ferromagnetic material is influenced by an external magnetic field. As the ferromagnetic material becomes magnetized, magnetic domains grow or are consumed under the influence of the external field. The changing domain volumes emit electromagnetic signals that are inductively detected. The aggregate result of signals received is Barkhausen Noise.

The apparatus for creating and detecting Barkhausen Noise consists of a processing unit that sends an AC current to an electromagnet. An inductive pick-up collects the resultant electromagnetic pulses and sends them back to the processing unit

for filtering and amplification. The results reported herein are in terms of the RMS amplitude of the Barkhausen Noise or BNA value.

In the machined, hardened and properly ground gear, the microstructure remains hard and the surface stresses are compressive. With grinding induced heat at and above the original tempering temperature of the material, the resultant microstructure becomes softer and the favorable residual surface stresses are less compressive.

Initial setup and verification

Since Barkhausen Noise provides data relating to the magnetic and microstructural properties of the material, it is useful as a comparative tool. In relation to Barkhausen Noise, softer material is easier to magnetically influence by an external field and the BNA values are higher in comparison to a hard material. Once the baselines for known acceptable parts are established, deviations from the normal curves can be evaluated and deemed acceptable or rejected. There are no NIST traceable standards.

The traceability of the system (CPU and sensors) is dependent on master set-up parts. Periodically verifying that the values of the master parts have not changed over time ensures that the system is still in alignment.

Verification must also be made to correlate the BNA values to some other measure of material property or degree of retemper burn. For retemper burn, BNA values are frequently compared to nital etch results, which is the traditional method used to test for retemper burns. Other notable methods used for correlation are fatigue life, residual stress and hardness.

Instrumentation and technique

The Barkhausen data for the results presented in this paper were obtained using an AST RoboScan 600 (Figure 1). A robotically articulated arm holds and moves the BNA sensor, which improves repeat-