Influence of heat treatment state and damage level on detectability of grinding damages by Barkhausen noise analysis

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Barkhausen noise analysis is a micromagnetic method widely used for the non-destructive detection of thermo-mechanical surface damages from grinding, also known as grind burn. Compared to nital etching as conventional method, no environmental and health dangerous chemicals are needed and there is no influence on functional surfaces. Even if Barkhausen noise analysis is already employed in industry, there is no norm or standard for the investigations. Test procedures are company-intern and there is a lack of knowledge about parameters influencing the results, in particular concerning the influence of the heat treatment parameters.

In this study different influences on the Barkhausen noise on tooth flanks of carburized and profile ground gears from the steel 18CrNiMo7-6 were investigated. For this, systematic variations of heat treatment parameters to vary the initial hardness, case hardening depth and the amount of retained austenite were analysed for different steel melts. A complete procedure to produce and characterize the different damage levels was first established and then used to identifiy representative flanks for the main damage levels: B (light tempering), D (heavy tempering), E (rehardening) as well as a damage free reference (A). Through the use of statistical data analysis, single effects of the heat treatment state were evaluated on the Barkhausen noise levels of the different damage levels, and on their detectability. It could be shown, that small effects of the initial state are present, but after building a ratio between damaged regions and the damage-free reference, no significant influence could be observed. This allows a classification of the damage levels mostly independently from the heat treatment state. For very high damage levels (heavy tempering or rehardening), the results show that an unambiguous classification based on one micromagnetic parameter only is not possible, since the signal exhibits a non-monotonic evolution. To solve this issue, the combination of at least two micromagnetic parameters appeared indicated.

The reason for the observed drop of Barkhausen noise amplitude for heavy tempering and rehardening zones were then analysed by considering the residual stress state, the diffraction peak width (FWHM) as indicator for hardness level and the amount of retained austenite after grinding. The results showed that the Barkhausen noise level is mainly influenced by the residual stress state while it increases with decreasing FWHM (hardness). On the other hand, the amount of retained austenite has no significant impact on the Barkhausen noise signal in the investigated range.

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