Linking magnetic steel structure and Barkhausen noise – effect of carbides in industrial bearing steels

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Non-destructive testing (NDT) methods are commonly utilized for product quality control during different industrial manufacturing processes. One NDT method, magnetic Barkhausen noise (BN), is used commonly in grinding quality control. The basis of the BN method is the interaction of materials structural details and magnetic domain walls (DWs) in ferromagnetic materials. The BN signal is very sensitive to microstructure and stresses of the sample and therefore changes in the signal level point out the altered material areas. However, many details linking microstructure to BN signal remain to be understood. In this study TEM, Lorentz microscopy, STEM-EDS, SEM-TKD, and XRD were used for characterization of the industrially relevant steel structures and the results were linked to the BN signal. Two different roll-bearing steels, case-carburised (CC) steel and 100Cr6 bearing steel, with different carbide structures were studied as-received and after grinding experiments.

Carbide size and density influenced on formation of the magnetic domain structure in the steels. The size of the carbides in 100Cr6 steel was larger compared to the CC steel whereas density of the small carbides was higher in CC steel. Due to the carbides, the domain structure was noticeable different in steels: the domain size in the 100Cr6 samples was larger compared to the CC steel. Carbides and areas with high dislocation density seemed to be nucleation sites for domain walls. Smaller domain size of the CC steel influences on BN signals; there are more domain walls which might produce the BN signal but also has effect on the mean free path of moving domain walls. During the grinding trials, for 100Cr6 steel, the carbide structure alteration was smaller whereas for CC steel, both carbide refinement and coarsening was detected as a result of the temperature increase. In the industrial point-of-view, this study showed that the different materials have their unique BN response to the increased temperature in the grinding burn occurrence. Same BN rejection threshold values of the quality control cannot be used for different ground materials and detailed characterization should be done before dictating the threshold values.