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Online and Real-Time Recrystallized Fraction Estimation in Steel Rolling Processes by Laser Ultrasound

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This study introduces an innovative method for estimating accumulated strain and recrystallized fraction in steel using the existing online laser ultrasonic (LUS) grain size gauge [1]. This method extends the capability of the grain size gauge by extracting more information from the same measurement. The method leverages the detection of shear wave splits, observed as small shear-wave echoes splitting into two distinct echoes, to estimate accumulated strain. By comparing this LUS-measured strain with the total rolling reduction, an implicit measure of the recrystallized fraction (RX) was achieved. This approach is based on the principle that a fully recrystallized material exhibits near-zero accumulated strain, while a non-recrystallized material shows strain equal to the total engineering strain.

The method has been validated against cold rolled austenitic stainless steel with 0 to 80 % deformation. The observed shear wave splits, attributed to material texture changes due to the rolling reduction, were correlated with accumulated strain.

Previous suggestions for measuring the texture with LUS [2,3] required special optics to scan the material in different directions whereas this technique works with a single LUS measurement in the normal direction making the method much more robust. This technique therefore offer the ability to provide real-time feedback for process control without reducing the measurement frequency for the grain size gauge. The method's application in hot rolling processes demonstrates its potential to optimize material properties and improve process efficiency during hot rolling.

[1] M. Malmström et. al, Laser-Ultrasound-Based Grain Size Gauge for the Hot Strip Mill, Appl. Sci. 12 (2022) 10048. https://doi.org/10.3390/app121910048.

[2] M. Malmström et. al, Application of Laser-Ultrasonics for Evaluating Textures and Anisotropy, Appl. Sci. 12 (2022) 10547. https://doi.org/10.3390/app122010547.

[3] M. Malmström, et. al, Comparative study of structures in cold rolled 316 stainless steel using laser ultrasonics and electron backscatter diffraction measurements, in: ESTAD 2021.

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