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Comparative study of structures in cold rolled 316 stainless steel using laser ultrasonics and electron backscatter diffraction measurements

5.3 Industry 4.0 within Rolling and Forging

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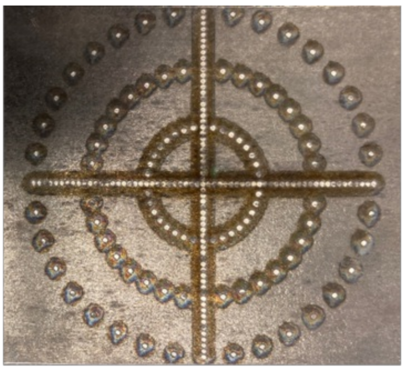
Text

This work aims to develop an online texture sensor for the steelworks environment in order to estimate the recrystallized fraction [1]. The material investigated was AISI 316 stainless steel of which 4 samples had been cold rolled with either 70% or 50% reduction to a final thickness of ~12 mm. Prior to the rolling two of samples were annealed at 1200 °C for 1.5 hours resulting in a grain size growth from ~25 to ~60 µm. All measurements were made at room temperature. The influence of texture on the anisotropy of wave velocities were measured for various polar- and azimuthal-angles, ρ and θ respectively. Additionally, the grain sizes were measured by LUS using the b-parameter analysis of attenuation data. Thus, both grain size and texture were measured on the specimen. In addition, the microstructures and the textures were determined using electron back-scattering diffraction (EBSD) at the through thickness center of the 4 samples after which the stiffness matrix was calculated using the Hill approximation with tabulated single crystal stiffness coefficients and sample density. The phase velocity was then calculated using the MTEX toolbox [2] for the same angles as the LUS measurements. The resulting velocity for the TD scan of the high temperature annealed sample with 50 % reduction is plotted in Fig. 1 below. There is a significant difference between the EBSD and LUS data especially for large angles mostly due to the in-house lab rolling which introduced several bends in the RD direction and had a ~2 % thickness variation over the TD direction. The LUS measurements were performed in a position with the least curvature but the geometrical effects are not compensated for in the velocity calculation. Nevertheless, in a future industrial application such compensation will not be necessary since the product uniformity is expected to be very high.

Selected references

[1] Lena Mauritzson, Bevis Hutchinson, Pete Bate, Peter Lundin, Mikael Malmström, and Eva Lindh-Ulmgren, "Texture studies using laser ultrasonics (LUS) in metal processing," presented at the In-line Measurement and Control for Metals Processing, Warwick, 2017, [Online]. Available: http://www.fems.org/event/line-measurement-and-control-metals-processing.

[2] D. Mainprice, R. Hielscher, and H. Schaeben, "Calculating anisotropic physical properties from texture data using the MTEX open-source package," *Geological Society, London, Special Publications*, vol. 360, no. 1, pp. 175–192, 2011, doi: 10.1144/SP360.10.



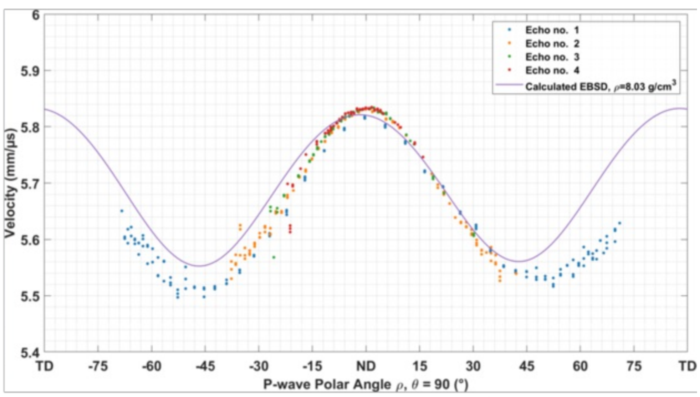


Fig. 1. (left) Image of a sample surface after the LUS measurement showing the ablation marks of the generation laser. (right) Measured ultrasonic group velocities by LUS (colored dots), as well as the calculated phase velocity from the EBSD data (solid line) as a function of polar angle for the TD direction i.e., azimuthal angle θ = 90° .