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Laser ultrasound for in line and in situ measurements during casting and rolling.

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Laser ultrasound, a non-contact technique utilizing lasers for both excitation and detection of ultrasonic waves, offers an approach to assess structural and elastic properties in hot steel. This method employs an excitation laser emitting 7ns pulses at typically 10 to 100Hz repetition rate to generate ultrasonic waves through thermoelastic expansion and ablation. Detection is achieved via an interferometer, capturing reflected waves at the point of measurement. Both excitation- and detection- system are available for industrial use. For imaging, the lasers are scanned across the steel's surface, where preparatory treatment is only necessary where coarse scale has formed on the surface.

Our study introduces a laser ultrasonic system used in steel casting to determine the solid-fluid interface in strands at a surface temperature of 1150℃ and a core temperature of approximately 1500℃. Comparisons with solidification process models reveal a strong correlation in estimated shell thicknesses. Additionally, we applied this system to hot steel ingots during rolling, detecting non-metallic inclusions at around 1000℃ surface temperature.

Laser ultrasonic methods extend beyond interface reflections and obstacle detection, such as oxides or pores, they can also provide insights into elastic properties. This is achieved by correlating sound speeds with the metal's Young's modulus, shear modulus, mass density, and Poisson's ratio. In plate-like structures like rolled sheet steel, laser ultrasound can excite and analyze local resonances, offering valuable data on microstructural changes during thermal treatments. We present in situ measurement results on samples in a thermal simulator, showing recrystallization at different isothermal holding temperatures.

The application of Laser Ultrasound directly in line or in laboratory settings offers a high throughput advantage, a feature crucial to comply to high quality requirements at varying raw materials. This aspect becomes particularly significant during the transition to more sustainable steel production methods using increasing amounts of scrap. Alongside the demonstrations mentioned above, we will address the experimental and theoretical foundations of laser ultrasound. Our goal is to provide a foundation that not only explains current methods, but also stimulates interest in new studies and applications in this evolving field.

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