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Laser Ultrasonic Inspection of Mash Seam Welds in a Steel Mill

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ABSTRACT

Weld breaks in mash seam welds in continuous sheet metal lines create significant downtime and are frequently caused by incomplete fusion and insufficient weld nugget size. A laser ultrasonic technology, which is a non-contact volumetric inspection method capable of measuring on moving targets at high temperatures, was evaluated for the in-line inspection of mash seam welds of a low-carbon steel base material in a blind test. Good correlations were found between the laser ultrasonic inspection results and the results from traditional inspection methods and destructive tests.

Keywords: coil joining, weld inspection, resistance seam welding, ultrasonic testing, steel making

1. INTRODUCTION

In 2021, the global production of both finished and semi-finished steel reached an estimated 1.82 billion tons, with approximately 436.3 million tons or about 25% being exported[1]. Of these exported products, around 42% were in the form of steel coils, which are crucial to the continuous processing that the industry relies on to stay competitive. In order to ensure that production runs smoothly without any interruption, it is essential that coils are welded seamlessly. Coil joining is often performed by a variation of resistance seam welding called mash seam welding, which is widely employed in modern continuous steel mills to join steel coils maintaining continuity[2, 3].

The welding process leads to rapid and significant metallurgical and thermal-mechanical changes in the base material, which is challenging to control as accurately as the steel making process. Moreover, the weld experiences numerous bending and compressive cycles at high line tension, high temperatures, and corrosive environments, making it the weakest point. Weld failures result in significant downtime, and if not resolved promptly, can lead to prolonged downtime. As such, it is crucial to produce high-quality, defect-free welds. Lack of fusion (LOF) is a common cause of weak welds, which occurs when the weld interface between two coils is inadequately fused, and can result in failures[2–5].

Two categories of methods exist to provide on-line monitoring of seam welds: surface or volumetric techniques. Surface techniques obtain thermal information from the coil surface using pyrometers or thermography, which is useful as the weld temperature is a critical parameter for weld quality[6, 7]. Although surface temperature is linked to internal temperature through heat transfer, it still provides indirect evidence of fusion. Thermal monitoring is prevalent in factories, yet weld breaks still occur, indicating that the picture remains incomplete.

Ultrasonic testing (UT) is a volumetric method that utilizes ultrasound travelling through the thickness of the part being inspected. Interior defects reflect ultrasound, which can be detected by either measuring the back-reflection on one side of the defect or the lack of ultrasound on the other. The most widely used generation and measurement method involves transducers in contact with the metal surface, with the aid of a coupling liquid, which inhibits their use when welds are hot. Although contact ultrasonic transducers have demonstrated significant promise for online seam weld inspection[8], a test system installed on a continuous galvanizing line test system had to be located downstream from the welder and added more than 30 seconds per cycle[9].

