# HD Scan Technology Implementation at U. S. Steel

United States Steel Corporation elected to implement HD Scan ultrasonic technology for the evaluation of as-cast samples in order to replace outdated and hazardous inspection methods and to achieve a more comprehensive and quantitative assessment of internal product quality. HD Scan provides objective, reproducible data on internal defects, segregation and solidification structure. This article describes the implementation of the HD Scan system at Fairfield Tubular Steel Operations and presents representative initial results for both round bloom and slab samples.

Authors

Rudolf Moravec (left), Process Engineer, U. S. Steel – Fairfield Tubular Steel Operations, Fairfield, Ala., USA
rrmoravec@uss.com

Tamara Gusarova (right), Senior Development Engineer, SMS group GmbH, Monchengladbach, Germany

Stephan Six, SMS group GmbH, Monchengladbach, Germany

## U. S. Steel – Fairfield Tubular Steel Operation

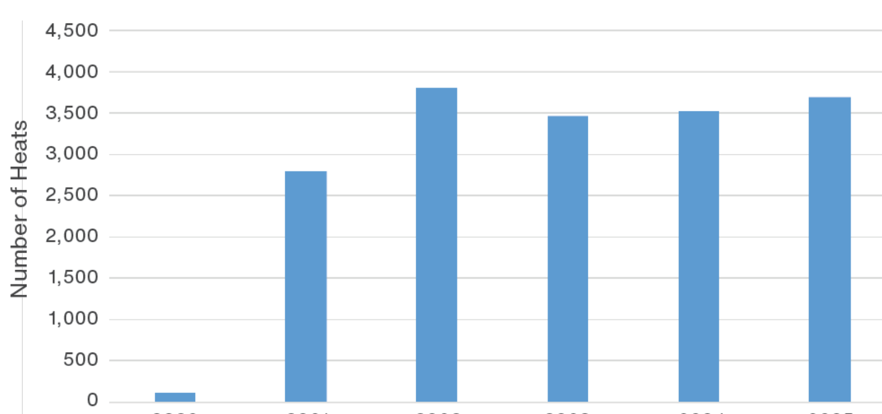
Fig. 1 shows bloom production at Fairfield Tubular Steel Operations (FTSO) over the last 5 years. Round blooms are produced primarily for seamless pipe products, particularly for oil and gas drilling applications, which require stringent internal and external quality standards. Over this period, significant improvements have been achieved across all areas of steelmaking and continuous casting, including maintenance practices, quality control and productivity.

Previously published papers[1,2] documented this improvement journey with a focus on the continuous casting process. Although bloom casting may appear simpler than slab casting, it demands even greater attention to detail to ensure stable and efficient operation. Modern slab casters are typically equipped with extensive sensor networks and monitoring tools that provide real-time feedback to operators. In contrast, bloom casters have limited on-line diagnostic capabilities. Therefore, any additional analytical tool that supports process evaluation and rapid corrective action can have a substantial impact on long-term operational stability.

Recognizing this need, U. S. Steel established a dedicated funding

Figure 1

Fairfield Tubular Steel Operations (FTSO) 2020–2025 production overview.



initiative focused on digitalization projects with a fast-track approval process. Under this program, FTSO pursued HD Scan technology not only to eliminate the legacy hot hydrochloric acid (HCl) etching process, but more importantly to gain deeper insight into bloom internal quality and its relationship to casting parameters. The long-term objective is to digitally link detailed sample imagery with casting process data to enable advanced process understanding and optimization.

## HD Scan Principles

Historically, FTSO relied on hot HCl macroetching to assess internal bloom quality. This method requires stringent safety precautions and careful sample handling. In addition to the inherent risks of working with hot acid, corrosive vapors cause significant damage to equipment within the etching room, including ventilation systems. The jib crane used for sample handling experiences one of the highest maintenance demands in the shop. Fig. 2 shows an overview of the etching room and acid tank.

The laboratory typically processes one or two sets of bloom samples per day, representing four to eight samples. Each bloom sample is cut using a band saw into a slice approximately 20 mm thick and then submerged into hot acid for approximately 3 hours. After etching, three characteristic zones can be identified: the chill zone, columnar zone and center equiaxed zone with dispersed segregation (Fig. 3). The center equiaxed zone is the most critical region for subsequent seamless pipe processing, as it strongly influences internal quality. Although samples are visually rated and photographed, the information obtained is qualitative and limited to human observations.

SMS group developed HD Scan technology[3] as a safe, nondestructive ultrasonic inspection system specifically designed for as-cast steel products. The system consists of an automated ultrasonic scanning unit combined with advanced evaluation software. In addition to ultrasonic analysis, the software can also objectively evaluate macroetch images for comparative purposes.

Sample preparation for HD Scan is similar to that used for macroetching, except that no surface treatment is required beyond standard cutting. Samples are placed in a water bath and scanned automatically. Ultrasonic sensors move above the sample surface without physical contact, eliminating sensor wear. Only standard tap water is used, without chemical additives, making the process nonhazardous and eliminating chemical handling and disposal costs. HD Scan can quantitatively evaluate segregation, internal flaws, cracks, geometry and solidification structure. Fig. 4 illustrates the ultrasonic principles implemented in the HD Scan system.

Figure 2

**Etch room with the acid tank.**

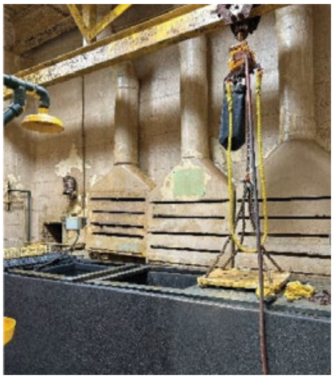
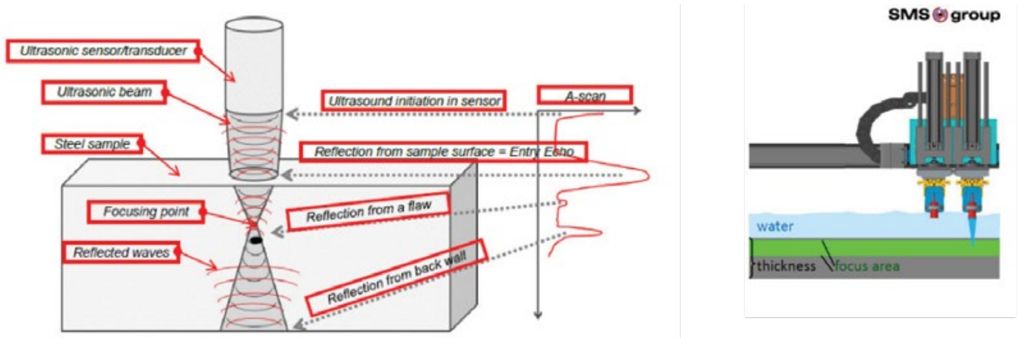


Figure 3

**Hot HCl sample example.**

Figure 4

**HD Scan ultrasonic principles illustration.**



## Installation and Commissioning

The HD Scan project for FTSO was approved in September 2024, with the purchase order issued shortly thereafter. Commissioning was scheduled for September 2025. A MINI-sized HD Scan unit was selected based on expected sample dimensions requirements.

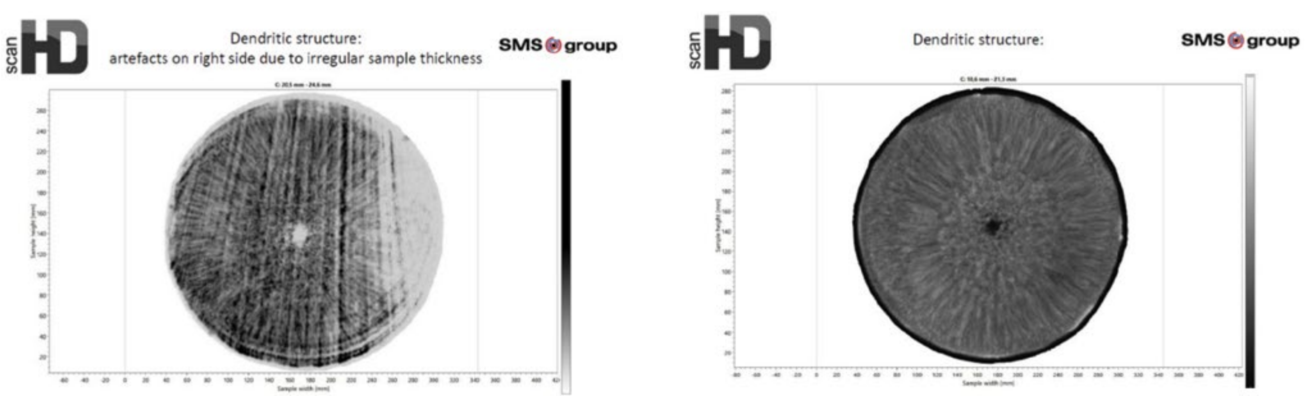
While the unit was being assembled at the SMS manufacturing facility, the FTSO team prepared the existing laboratory for the new equipment, focusing on improved ergonomics and sample handling. Bloom samples were sent to the SMS HD Scan laboratory to evaluate detection capability and to determine optimal surface preparation. Testing demonstrated that samples with uniform thickness of approximately 21 mm and a milled surface provided the most reliable results. Although saw-cut surfaces were acceptable, consistent sample thickness was identified as a critical requirement. Fig. 5 compares saw-cut and milled samples results.

The laboratory layout was redesigned to include a dedicated room for the HD Scan unit, located adjacent to the sawing machines to minimize sample handling. Fig. 6 shows the installed equipment and a round bloom sample positioned in the water tank during scanning.

The HD Scan unit was shipped fully assembled from Germany and installed in the new room. After electrical connection and functional verification, commissioning was carried out on-site with support from SMS experts. The process was conducted in several stages to ensure thorough understanding of system operation and data interpretation. Start-up was completed successfully, with only minor electrical issues that were quickly resolved without schedule impact.

Figure 5

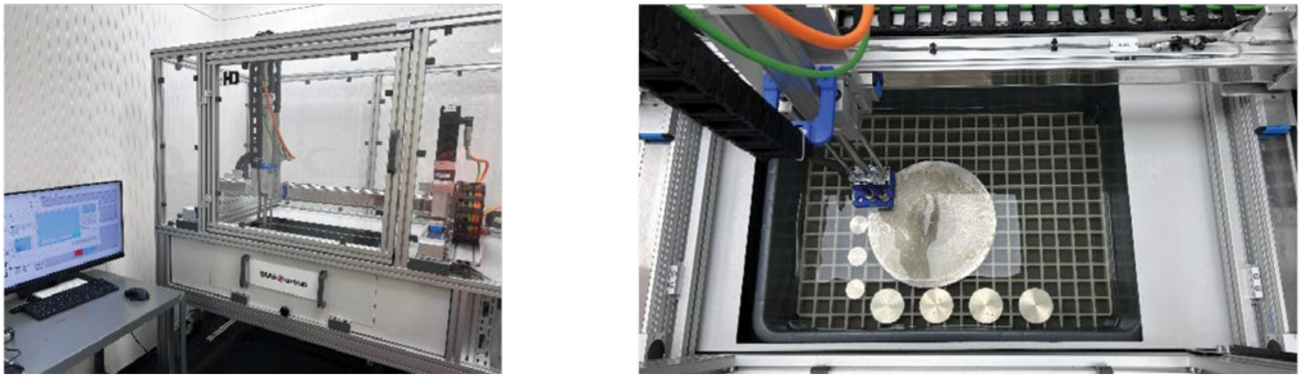
**Saw cut surface (a) and milled surface and even thickness (b).**




(a) (b)

Figure 6

**HD scan equipment (a) and sample inside the water tank during scanning (b).**



(a) (b)

## Round Sample Analysis

Accurate sample thickness and straightness are essential for reliable HD Scan analysis. During commissioning, saw-cut surface quality was found to be sufficient; however, sample geometry proved to be more critical. Historically, bloom samples were approximately 150 mm long and cut using an off-line torch. To ensure uniform thickness during sawing, full engagement of the clamping jaws is required, which necessitated increasing sample length to approximately 300 mm. Standard bloom quality evaluation practice at FTSO involves collecting one set of four samples per tundish.

The HD Scan system includes a dedicated desktop computer used to define scanning parameters and optimize scanning time based on sample size. Typical scan time for one round bloom sample is approximately 50 minutes. The MINI unit supports a maximum scanning area of 350 × 350 mm, which is well suited for the 311-mm-diameter blooms commonly cast at FTSO.

Fig. 7 shows a typical screen view during scanning. In this example, improper cutting resulted in missing regions within the sample (indicated by blue area). When such conditions are detected, scanning is stopped and a new sample is prepared. The HD Scan software provides detailed visualization tools for individual sample analysis, as shown in Fig. 8. For higher sample volumes, the batch analyzer function is used. This tool allows predefined report templates to be applied automatically to large data sets and includes a monitoring function that initiates analysis as soon as new scan data are available. Selected analysis outputs are shown in Fig. 9, and quantitative data are also exported to spreadsheet format for further evaluation.

During routine operation, HD Scan reports are reviewed immediately after scanning to identify defects or dimensional anomalies. At the time of writing, hot HCl etching is still performed in parallel for all samples to establish correlation between the two methods. It should be noted that HD Scan evaluates internal volume information, whereas macroetching provides surface-based observations.

Figure 7

HD Scan program screen for controlling the scanning process.

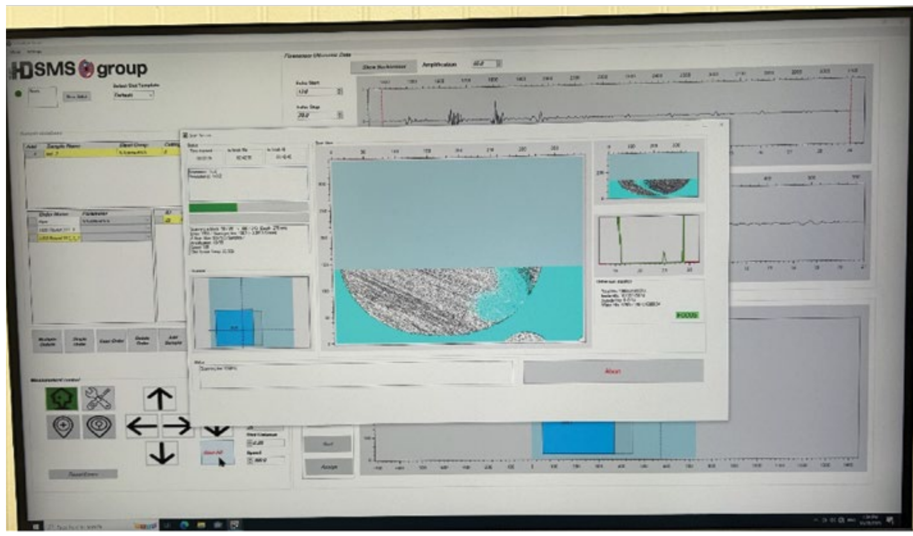



Figure 8

HD Scan software main screen for detailed sample analysis.

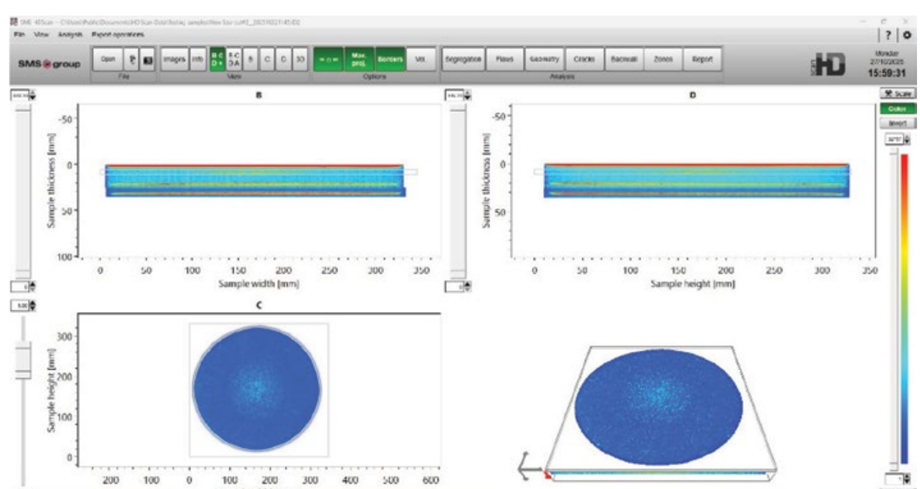


Figure 9

**HD Scan report analysis from left to right: segregation, flaws, cracks, backwall (structure) and dimensions.**

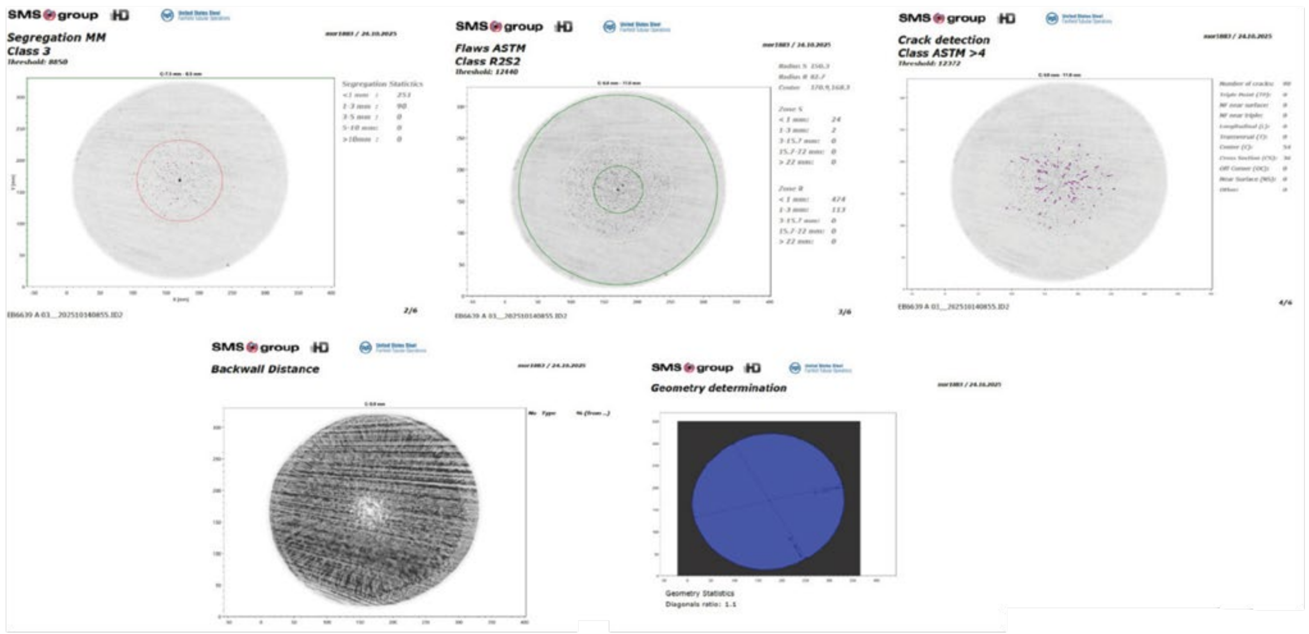



Figure 10

**Etched sample comparison with HD Scan data.**

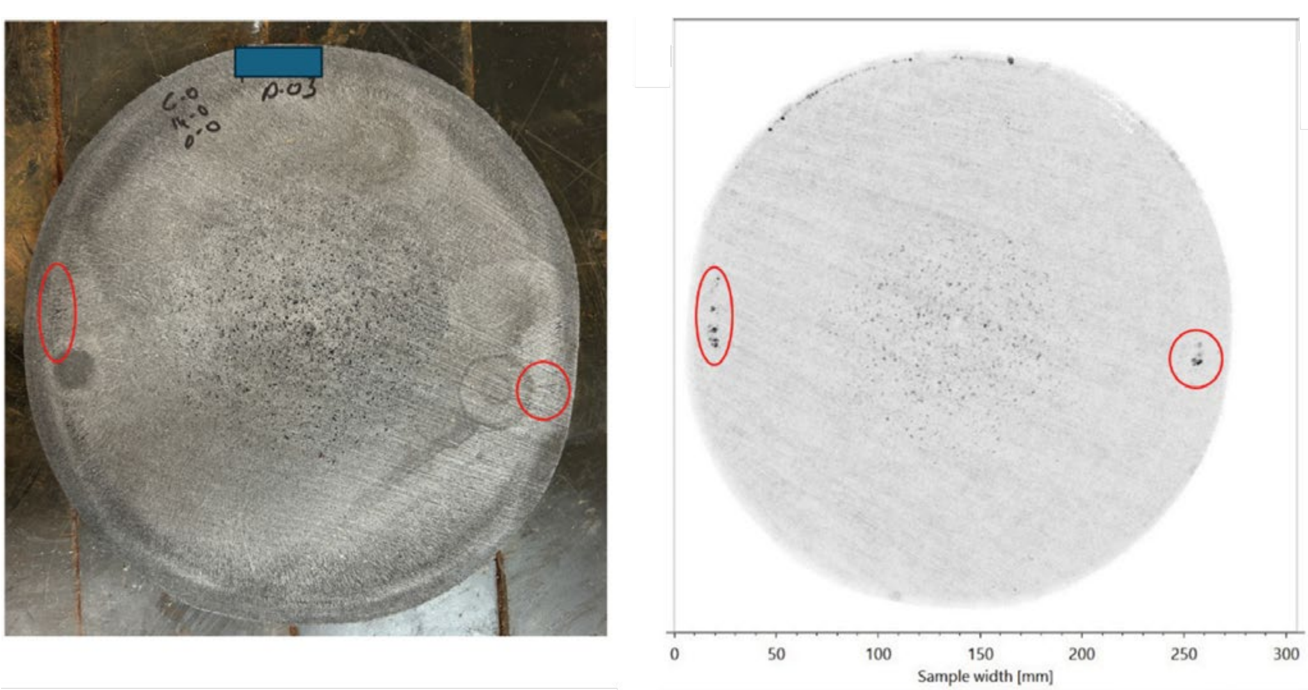


Figure 11

**Etch (top) and HD Scan (bottom) samples with mold electromagnetic stirring (MEMS) on (left) and with MEMS turned off (right).**

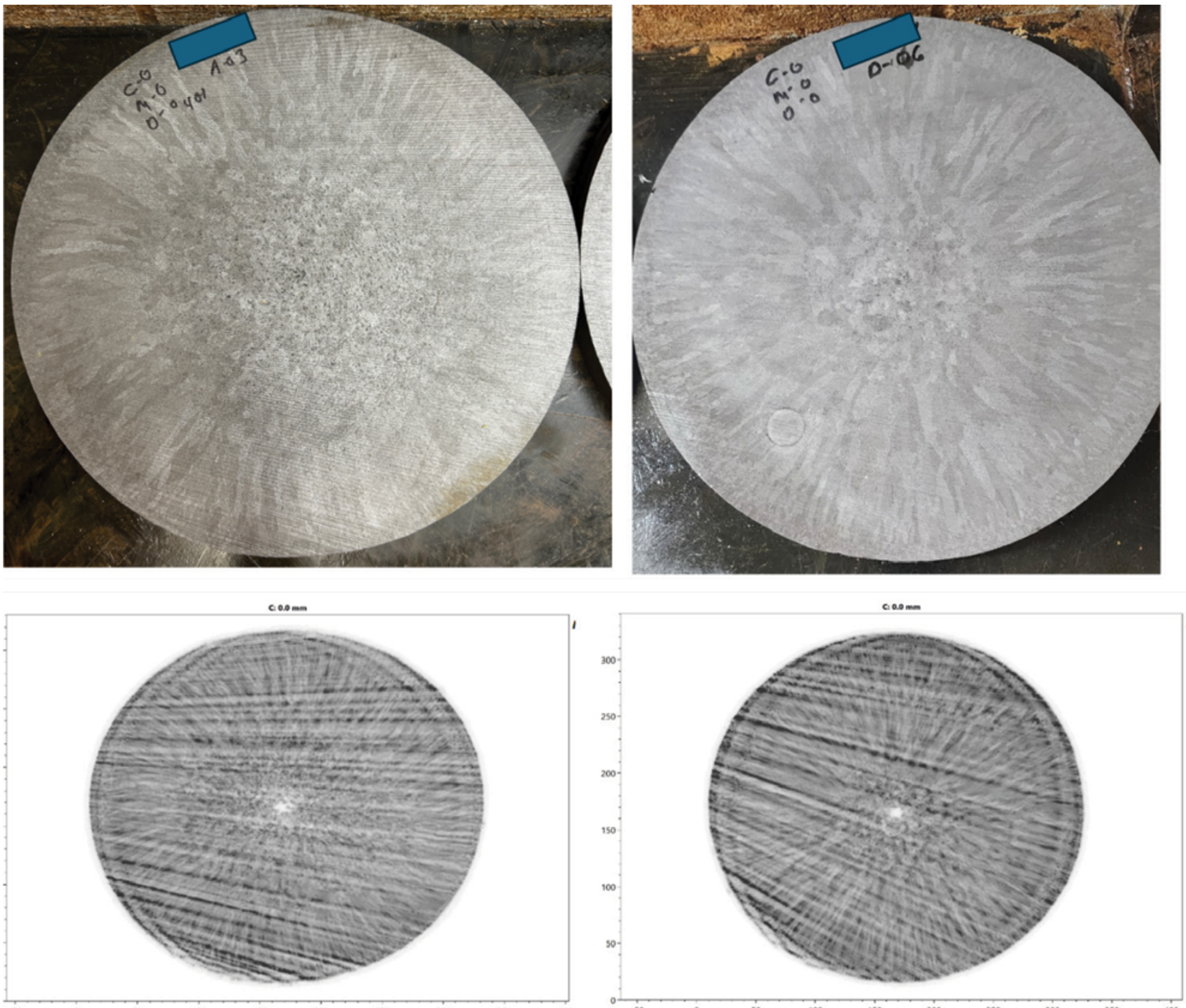



Fig. 10 presents an example of crack detection using both methods, with defects observed at the same location. The crack position suggests a potential issue below the mold, possibly related to foot roll alignment. This type of feedback is valuable for targeted caster maintenance and quality improvement.

HD Scan can also generate images of the solidification structure, which can be analyzed automatically. Fig. 11 compares two samples cast under different conditions. The left sample was cast with mold electromagnetic stirring (MEMS), while the right sample was cast without MEMS. Both etching and HD Scan results clearly show a significantly reduced equiaxed zone in the nonstirred condition.

## Slab Samples Analysis

In addition to bloom evaluation, HD Scan implementation at FTSO was intended to support other U. S. Steel plants, particularly those producing slabs. Understanding internal slab quality through HD Scan analysis can support process optimization for quality-sensitive products.

Fig. 12 shows a 74-inch-wide slab evaluated using electrolytic etching (bottom images) and HD Scan results. The grayscale and color images represent the same HD Scan data with different visualization techniques to emphasize specific features. Ongoing collaboration with SMS specialists is helping to interpret these indications and improve understanding of slab solidification behavior.

Figure 12

**Full-width sample analysis.**

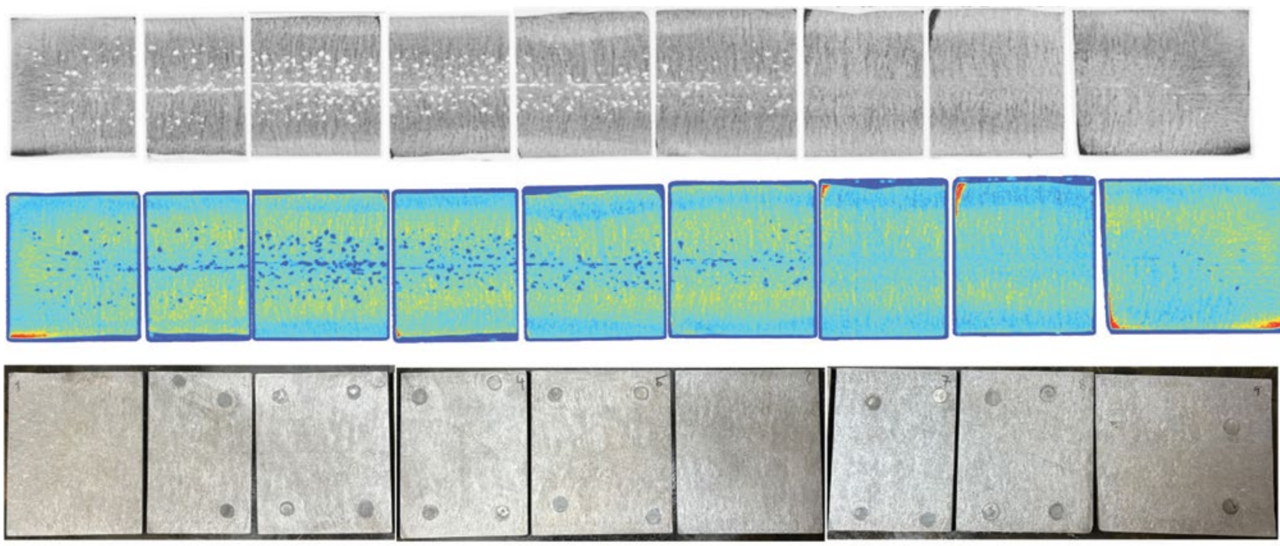


Figure 13

**Longitudinal slab sample analysis.**

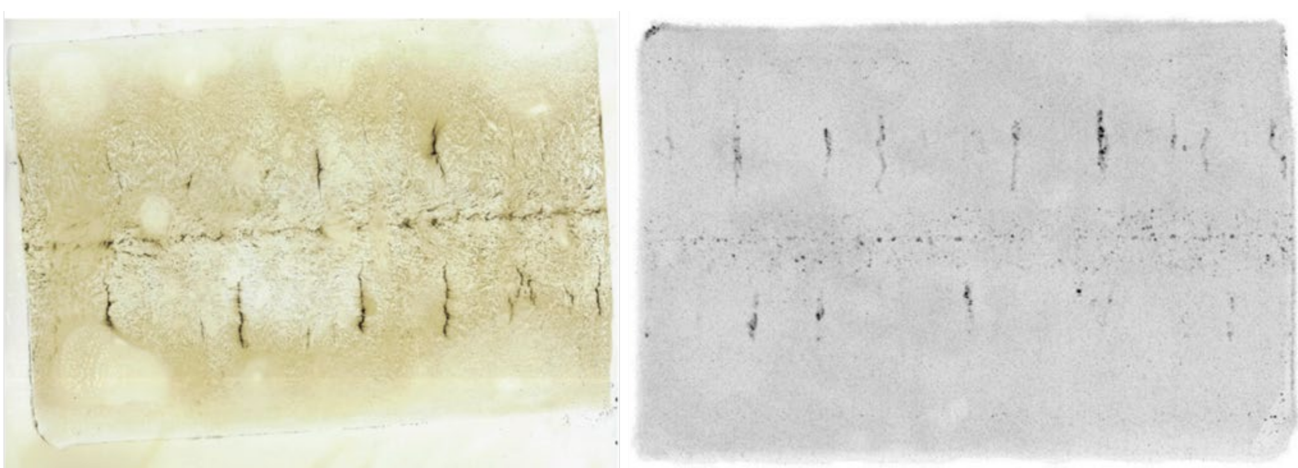


Fig. 13 compares sulfur print results (left) with HD Scan analysis (right), clearly showing internal cracking. These results demonstrate the value of HD Scan as an analytical tool not only for assessing as-cast quality, but also for identifying the origins of defects and process inconsistencies.

## Next Steps

Further integration of HD Scan technology into FTSO process improvement activities is ongoing. A new sawing machine will enhance sample handling ergonomics and improve repeatability of sample thickness. A centralized data storage solution is being implemented to provide easy access to reports and raw scanned data. Each sample generates approximately 5 GB of data, requiring sufficient storage capacity to retain at least 2 years of records.

Most importantly, future efforts will focus on linking HD Scan results with casting process data from the time of production. This integration is expected to support improved decision-making for new product development and optimization of casting conditions to achieve the desired internal quality.

## Conclusions

HD Scan ultrasonic technology has been successfully implemented at Fairfield Tubular Steel Operations as part of standard bloom quality evaluation practices. SMS group provided critical support during commissioning, training and subsequent interpretation of results. At the time of paper submission, more than 450 round bloom samples and approximately 50 slab samples from multiple U. S. Steel casters had been evaluated.

Continued education of technical personnel in HD Scan data interpretation is essential for maximizing the benefits of this technology and supporting its broader adoption for as-cast product analysis.

## Acknowledgment

The authors would like to express special appreciation to laboratory technician Scott Cain for his dedication and support during the implementation of HD Scan technology at FTSO. The authors also thank United States Steel Corporation for permission to publish this article.

## Disclaimer

The material in this article is intended for general information only. Any use of this material in relation to any specific application should be based on independent examination and verification of its unrestricted availability for such use and a determination of suitability for the application by professionally qualified personnel. No license under any patents or other proprietary interests is implied by the publication of this paper. Those making use of or relying upon the material assume all risks and liability arising from such use or reliance.

*This article is available online at AIST.org for 30 days following publication.*

### References

1. R. Moravec, W. Schlichting, J. Ruf and F. Mantooth, "Initial Experience With New Round Caster Operation and Improvements at U. S. Steel Fairfield," *AISTech 2023 Conference Proceedings,* 2023.
2. R. Moravec, W. Schlichting, J. Ruf and F. Mantooth, "Process and Quality Improvements at U. S. Steel Fairfield Tubular Steel Operations," *AISTech 2025 Conference Proceedings,* 2025.
3. J. Laughlin, J. Wans, T. Gusarova, M. Klein and O. Hofmann, "HD Scan – Ultrasonic Technology for Quantitative Evaluation of the Internal Quality of As-Cast Steel Products," *AISTech 2016 Conference Proceedings,* 2016.

AISTech This paper was presented at AISTech 2026 — The Iron & Steel Technology Conference and Exposition, Pittsburgh, Pa., USA, and published in the AISTech 2026 Conference Proceedings.

Did You Know?

### U.S.-Made Steel Supports Groundbreaking of Google's Steel River Energy Center

Google broke ground on the Steel River Energy Center, a solar and battery storage facility that will be built using 100% U.S.-made structural steel from United States Steel Corporation's Big River facility in Mississippi County, Ark., USA, reported Pulse 2.0.

Pulse 2.0 reported that Google will work with Cypress Creek Energy on the three-phase project, estimating upon completion it will offer 2.5 GW DC of solar generation and 2.9 GW-hours of battery storage to the grid in the region. Full operation is expected by 2029.

U. S. Steel will source the steel while PACO Steel's Arkansas plant will manufacture it, Pulse 2.0 reported.