The soundness of continuously cast slabs that were accelerated-cooled prior to completion of the gamma to alpha transformation has been evaluated in a project at the University of Pittsburgh. To achieve this objective, an ultrasonic NDT technique was selected to assess the level of anomalies or defects in the slabs. The results from the analysis were evaluated with the aid of software developed to identify the type of defects and their location in the slabs. These results were complemented with a systematic microstructural analysis.

Ultrasonic testing

The ultrasonic NDT image can be processed and analyzed to give qualitative characterization of the defects in a continuously cast steel slab. The ultrasonic sensor and its compatible software can provide information regarding the distribution, location, and density of the defects. The specific objectives of this work were to:

- Assess the level of anomalies or defects in the steel slabs via ultrasonic testing.
- Identify the types of defects and locations in the slabs by ultrasonic testing and specially developed software.
- Verify the result via direct microstructural analysis.

In this project, ultrasonic NDT and direct microstructural analysis were conducted on 24 samples of the three grades of steel 1010, 1091, and 1319. The samples were cut from four different locations from the as-received steel slabs. The slabs having thicknesses of 175 to 230 mm were grouped in two sets based on the cooling conditions provided by the steel company supporting this work. The slab samples were either air cooled or cooled in a cooling chamber to room temperature. The temperature at which the slabs were introduced into the chamber was between 550 and 570°C (1020 and 1060°F).

Based on this information, it appears that the slabs enter the cooling chamber after austenite has largely decomposed to either high- or low-temperature products. That is, the slabs enter the cooling chamber at subcritical temperatures.

In ultrasonic NDT testing, ultrasonic signal waves are emitted from a sensor made up of a piezoelectric transducer and a receiver. A schematic view of the ultrasonic mechanism can be seen in Fig 1(a). Parts of the emitted waves are reflected by anomalies to the transducer or other electronic receivers, and other portions of waves are scattered and damped into the texture. The magnitude of initial input pulls and captured reflected signals can be compared by an oscilloscope, or by a collecting and compiling signal software. Sonics is a DOS software package used for this purpose in these tests.

The ultrasonic tests were carried out in a bath filled with 160 liters of water, to minimize the undesirable sound waves from environments and equipment that may have changed the image of the results.

An image of the ultrasonic machine is shown in
Figure 1 (b). Scatter in the energy of the waves traveling through the sample because of obstacles, gives information about the anomalies. The sensor moves with a constant speed and scans the surface of the sample. An overlapping of scanning is considered to remove the uncertainty of the signals received from the edges of the scanning beam band. Accuracy of the images and speed of scanning depend on the sensitivity of the sensor.

The economical advantage of NDT tests over destructive testing is obvious, but the disadvantages are the level of accuracy and the strength or detail of the information. This work used NDT analysis to locate the presence of a defect and microstructural analysis to assess the type and size of the defect.

The method of image processing of ultrasonic time-of-flight maps introduced in this work using the Microsoft Excel macro offers a promising processing and analysis tool to specify the type and location of anomalies observed in the continuously cast slabs cooled from different thermal path conditions. This method can be used to test the internal soundness of slabs that have been accelerated-cooled to room temperature.

This summary has outlined the procedures detailed in Using NDT Image Processing Analysis to Study the Soundness and Cleanliness of Accelerated Cooled Continuously Cast Steel Slabs. For the complete presentation, please contact the authors.

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