Ultrasonic Imaging: A Tool to Evaluate Quality of Continuously Cast High Carbon Billets

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Abstract

In recent years, there has been a tremendous increase in the demand of clean steel. With over 90\% of the World steel production through the continuous casting route it is important to improve product quality with respect to overall cleanliness level, reliability and surface quality.

The continuously cast billet has a heterogeneous structure, dependent on the cooling conditions. A chilled zone forms in the region in contact with the mould followed by a columnar and then an equiaxed zone (EAZ) at the core. Carbon segregation at the core may lead to cementite formation at localized regions, thereby increasing the hardness and ultimately causing breakage during wire drawing operation. A large EAZ is desirable, so that segregation per unit area is reduced. By electromagnetic stirring (EMS), a well-established high efficiency technique, it is possible to achieve an effective and reliable stirring of the molten steel in the continuous casting process, which can meet the metallurgical objective of improving the quality of cast products.

In this study attempt has been made to arrive at the optimum casting parameters at Tata Steel’s billet caster by varying the EMS current, the steel superheat and the casting speed to achieve acceptable high carbon billet quality with minimum 16\% EAZ area, segregation index < 1.12 and central porosity <3mm. Trials have been conducted with different superheats and casting speeds at EMS currents across the entire available range (0 to 380 Amps). For each trial, the samples were scanned using the ultrasonic immersion technique to evaluate the equiaxed area and the central porosity. The results of ultrasonic imaging have been validated with commonly used macro-etching technique. Additionally an image processing protocol has been developed for faster determination of EAZ area from the macrostructure of the billets as imaged using ultrasonic c-scan.

This study has established a minimum threshold for the EMS current above which the billet quality is acceptable at all superheats and casting speeds (within the tested range). It has also been seen that even at high superheat (>42\degree C) acceptable equiaxed area could be obtained without any EMS when the casting speed is restricted to 2.9 m/min.