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The effect of continuous casting conditions on the mechanical properties of low-carbon steel wire rods

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Solidification plays a fundamental role in metallurgical processes, such as continuous casting of steel billets, as it greatly influences the final microstructure, in terms of grains morphology and size and chemical segregation. Segregation of solute elements occurs because of their partitioning between the liquid and the growing solid. The liquid interdendritic regions are enriched of solute elements rejected by the growing dendrites. Such segregation cannot be fully mitigated through subsequent hot rolling processes. Common evidence of this undesirable phenomenon is the banded microstructure observed in hot-rolled products, characterized by alternating longitudinal bands of ferrite and pearlite. Normalization can reduce the banded microstructure, but micro-segregation remains difficult to completely homogenize. Therefore, hot-rolled wire rods produced from steel billets solidified under different conditions exhibit varying mechanical properties.
In this context, the study presents a comparative analysis of two low-carbon steel billets with similar chemical composition but produced under different casting conditions. One billet was produced by using a continuous casting machine equipped with a strand electromagnetic stirrer (S-EMS), while the other billet was produced on another machine without S-EMS. The analysis investigated the differences in macro and micro-structure of the two billets also by measuring the secondary dendrite arm spacing (SDAS) and the segregation index. Additionally, the mechanical properties of wire rods derived from these billets were assessed by tensile tests and micro-hardness Vickers measurements, and the final microstructure was analyzed by optical and scanning electron microscopy (SEM). The lower SDAS measured at the core of the billet produced with S-EMS, after hot rolling, resulted in a finer and more homogenous microstructure, also leading to enhanced mechanical properties of the final wire rods.

Primary author: BALDUSSI, Federico (Università degli studi di Brescia - Italy)

Co-authors: Mrs CHUGAEVA, Angelina (Acciaierie di Calvisano S.p.a. Feralpi Group - Italy); Mr MILAN, Alessandro (Acciaierie di Calvisano S.p.a. Feralpi Group - Italy); Mr PARIMBELLI, Andrea (Acciaierie di Calvisano S.p.a. Feralpi Group - Italy); Mr GUERRA, Francesco (Acciaierie di Calvisano S.p.a. Feralpi Group - Italy); Mr ANGELINI, Lorenzo (Acciaierie di Calvisano S.p.a. Feralpi Group - Italy); Prof. GELFI, Marcello (Università degli studi di Brescia - Italy); Prof. POLA, Annalisa (Università degli studi di Brescia - Italy)

Presenter: BALDUSSI, Federico (Università degli studi di Brescia - Italy)

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