

Article

Optimization of the Continuous Casting Process of Hypoeutectoid Steel Grades Using Multiple Linear Regression and Genetic Programming—An Industrial Study

Miran Brezocnik and Uroš Župert *

Faculty of Mechanical Engineering, University of Maribor, 2000 Maribor, Slovenia; miran.brezocnik@um.si

* Correspondence: uros.zupert@um.si

Abstract: Štore Steel Ltd. is one of the major flat spring steel producers in Europe. Until 2016 the company used a three-strand continuous casting machine with 6 m radius, when it was replaced by a completely new two-strand continuous caster with 9 m radius. For the comparison of the tensile strength of 41 hypoeutectoid steel grades, we conducted 1847 tensile strength tests during the first period of testing using the old continuous caster, and 713 tensile strength tests during the second period of testing using the new continuous caster. It was found that for 11 steel grades the tensile strength of the rolled material was statistically significantly lower (*F*-test method) in the period of using the new continuous caster, whereas all other steel grades remained the same. To improve the new continuous casting process, we decided to study the process in more detail using the Multiple Linear Regression method and the Genetic Programming approach based on 713 items of empirical data obtained on the new continuous casting machine. Based on the obtained models of the new continuous casting process, we determined the most influential parameters on the tensile strength of a product. According to the model's analysis, the secondary cooling at the new continuous caster was improved with the installation of a self-cleaning filter in 2019. After implementing this modification, we performed an additional 794 tensile tests during the third period of testing. It was found out that, after installation of the self-cleaning filter, in 6 steel grades out of 19, the tensile strength in rolled condition improved statistically significantly, whereas all the other steel grades remained the same.

Keywords: continuous casting; hypoeutectoid steel; tensile strength; modeling; optimization; multiple linear regression; genetic programming; self-cleaning filter

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1. Introduction

Tensile strength, as a genuine material property, is defined as the maximal stress achieved during stretching of a material before breaking [1–3]. For determination of the tensile strength of steel and steel products representative test pieces are needed. Accordingly, orientation (relative to the principle direction of working), location (related to segregations originating from the solidification process) and preparation (cutting, machining and heat treatment) of these test pieces are essential. On the other hand, the basis for typical steel tensile strength prediction is its chemical composition [4–7], but contemporary models also involve solidification influences, including grain size and morphology [8–10], microstructure [8–17], macrostructure [8,10,12,15,18,19], chemical non-homogeneities/segregations [6,7,19–23] and casting defects [24,25]. The tensile strength researches are related mostly with individual steel grades, but also more general prediction models were developed [5,14,26]. Below, few studies are presented where, besides the chemical composition, the influence of solidification on the mechanical properties of steel was also elaborated, including continuous casting.

Optimization Of Continuous Casting Process In Steel

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