DOI 10.33313/380/250

Smart Ladle: AI-Based Tool for Optimizing Caster Temperature

Nicholas J. Walla[1], Zhankun Luo[1], Bin Chen[1], Yury Krotov[2], Chenn Q. Zhou[1]

[1]Center for Innovation Through Visualization and Simulation
Purdue University Northwest
2200 169th St, Hammond, IN 46323, USA
Phone: 1-219-989-2765
Email: civs@pnw.edu

[2]Steel Dynamics, Inc.
4500 Country Road 59, Butler, IN 46721, USA

ABSTRACT

From the BOF/EAF to the caster, the ability to quantify and respond to the variables that affect steel casting temperature is crucial for achieving consistent casting quality and maximizing productivity. Deviations from the optimum steel casting temperature can require adjustment to casting speed, which impacts productivity and can also harm product quality. This work will use a deep-learning network to develop quantifiable relationships between the casting temperature and various factors during the ladle refining process to enable predictions of casting temperature and precise adjustments to steel temperature prior to the ladle reaching the casting stage of the production process.

Keywords: Machine learning, Refining ladle, Ladle heat loss, Continuous casting, Smart manufacturing

INTRODUCTION

The development of the Smart Ladle focuses on taking data collected from the ladle process and creating history-based predictions for ladle heat loss and tundish temperature behavior, then providing these predictions to operators so that they can make process decisions with better information. There are varying approaches to solving this issue, including the approach of this work. Operators can only react on information they know; the LMF operator knows to expect additional heat loss in the first few heats of a ladle's campaign, but they may not know about the long wait at the tap car that allowed a well-used ladle to cool. Data collection and presentation gives the operator more knowledge to work with, but still there exist hidden correlations between the data.

A key part of modern-day manufacturing across all sectors is the increased implementation of data collection systems and software utilities that make use of the collected data. This is especially true for the steel industry, where the progress of *smart manufacturing* and *Steel 4.0* use modern technologies to reduce costs and improve product quality.[1] One such technology that is having impact on many industries is machine learning and more recently deep learning.[2][3]

Data usage may be as simple as "gather and display", giving operators and technicians access to data feeds that help inform operations and design. Collected data can be further used with control systems to improve automation and safety, using data feeds to augment process rates or initiate emergency procedures and alarms. Where these two concepts meet sits deep learning: the use of data history, real-time feeds, and "fuzzy-logic" algorithms to create correlations in the data feed that allow for process optimization and prediction.

Advancements such as these allow for greater consistency and higher production quality, ensuring that operators have the information they need to apply expertise while filling in knowledge gaps with algorithm-based decision making. In the continuous casting process, operator expertise plays a key role in balancing casting parameters using the knowledge of current process conditions. Cast too slowly with low temperatures and you risk clogging, cast too quickly or with high temperatures and a breakout may occur.

