Original Article

Implementation of the new continuous temperature measurement in continuous casting tundish

Rodrigo Seara Martins [1]*
Diego Camargos Bar Martinez [1]
Ricardo Ribeiro Soares [1]
João Fábio Teofilo [2]
Thais Carvalho Sá [2]
Octavio Alves Junior [3]

Abstract

Continuous temperature monitoring during steel solidification is one of the most effective methods for the continuous casting process and operational safety. It enables real-time temperature measurement during both the tundish preheating and casting stages. To enable this monitoring, a type B platinum thermocouple was installed near the internal valve and stopper of the tundish shells of Usiminas Steelmaking Plant #1. This setup allows for accurate steel temperature measurements, reducing casting sequence interruptions due to low temperature and improving operation by removing the need for operators to manually measure temperatures which is the main focus of this study.

Keywords: Continuous temperature measurement; Tundish; Operational safety; Process stability.

1 Introduction

The continuous casting process is responsible for solidifying the liquid steel originating from the secondary refining stage in the steelmaking plants. The steel is transferred to the tundish through a valve connected to the ladle, and from there it is directed to the mold via a submerged entry nozzle (SEN). Steel solidification begins in the mold, occurring through heat extraction from the liquid steel. Casting temperature has a crucial influence on the continuous casting process [1], particularly regarding the risk of breakout, as shown in Figure 1.

An inadequate temperature can lead to the formation of a weak or irregular solid surface, increasing the likelihood of breakout during the process and/or clogging of the submerged entry nozzle [2]. Usiminas employs two methods for measuring tundish temperature: spot measurement using a type S thermocouple, performed manually by the operator, and continuous measurement using an optical sensor, as shown in Figure 2. There are several methods available for measuring steel temperature in the tundish [2]. The main measurement methods are presented in Figure 2. Although manual measurement is low-cost, it is limited to a single moment in time and does not detect temperature fluctuations during casting. It captures a snapshot of the moment, while conditions inside the tundish can change abruptly, posing operational risks.

Continuous measurement using an optical sensor allows for better process control but requires frequent spot checks for calibration and extensive maintenance, making it labor-intensive and costly due to high argon gas consumption for lens cooling and cleaning, as well as presenting operational safety risks. The automatic measurement [4], installed on the tundish shell, performs temperature measurements near the tundish's inner valve and stopper rod in a continuous form, enabling steel temperature control throughout the entire casting process. Installation is carried out with the tundish at ambient temperature, increasing operational safety and allowing for precise control of the steel temperature during casting. Through precise steel temperature measurements, it is possible to reduce heat sequence interruptions due to low temperatures and enhance operational safety by eliminating manual temperature measurements, which is the focus of this study.

[1]*Usiminas, Ipatinga, MG, Brasil.*
[2]*Heraeus Electro-Nite, Ipatinga, MG, Brasil.*
[3]*Heraeus Electro-Nite, São Paulo, SP, Brasil.*

**Corresponding author: rodrigo.martins@usiminas.com*
E-mails: diego.martinez@usiminas.com; ricardo.ribeiro@usiminas.com; joao.teofilo@heraeus.com; thais.sa@heraeus.com; octavio.alves@heraeus.com

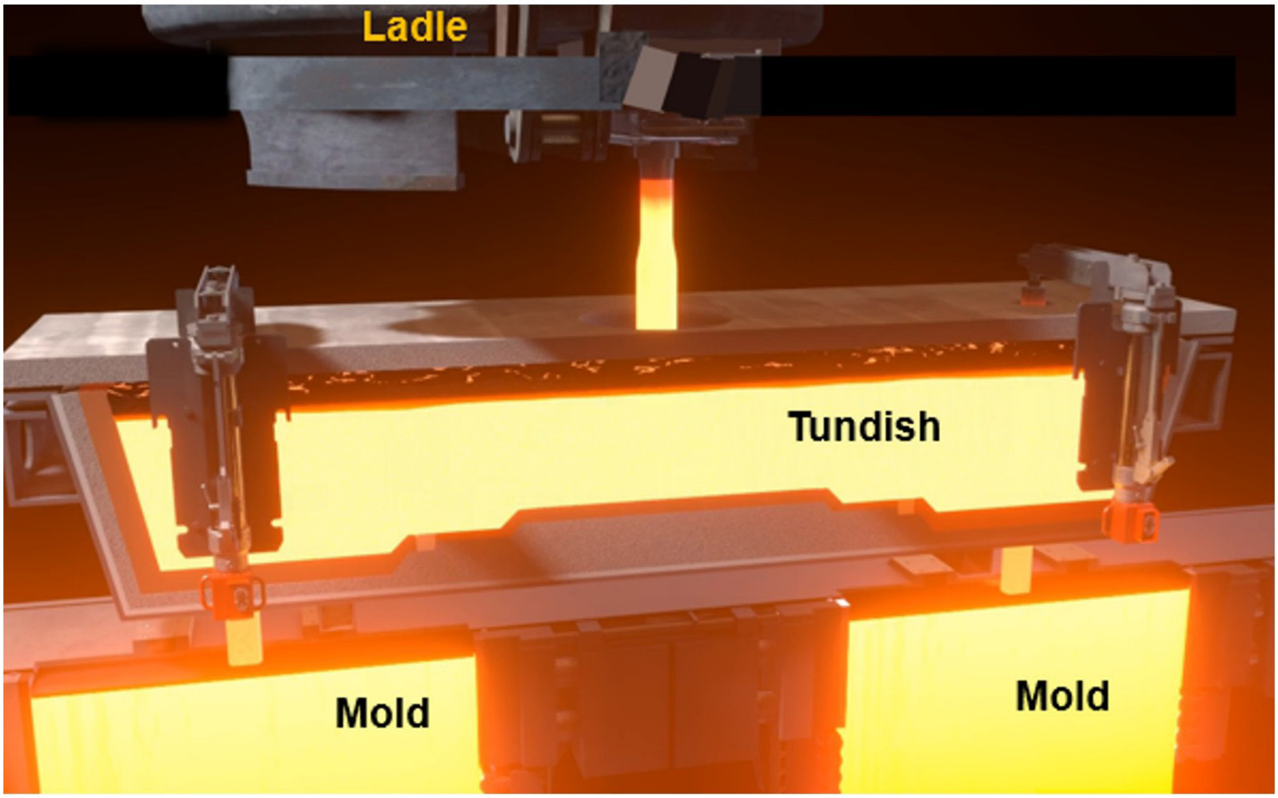

Figure 1. Schematic drawing of the tundish in a continuous casting machine [1].

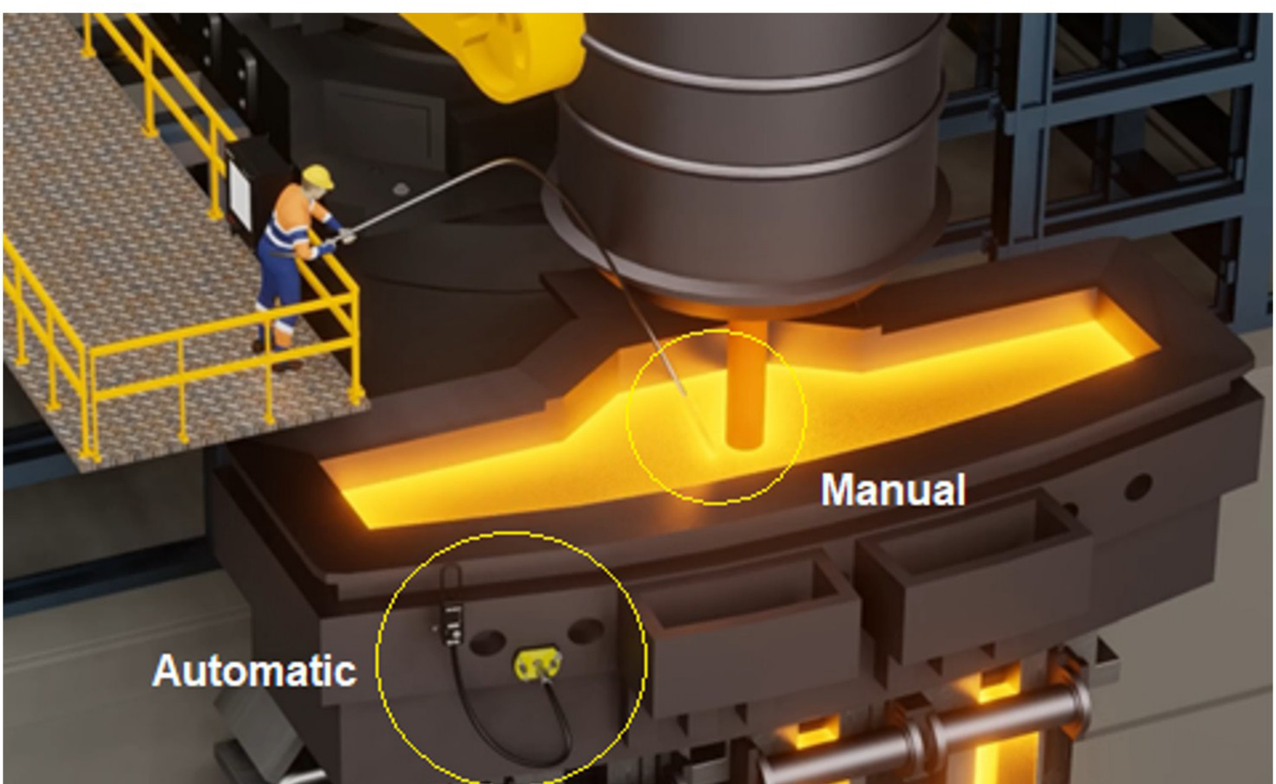

Figure 2. Types of liquid steel temperature measurements in the tundish [3].

2 Development

2.1 Materials and methods

2.1.1 Materials

The automatic measurement consists of a type B thermocouple installed on the tundish shell, near the inner valve and stopper rod, as shown in Figure 3.

The components of the automatic measurement include:

- type B thermocouple sensor;
- wireless equipment;
- alumina refractory seating brick;
- high-alumina mortar for fixation;
- flange, pins, and wedges;
- flange cover.

To use the automatic measurement, the tundish must be prepared by installing the flange on the shell and the seating brick in the refractory lining. The flange and seating brick are used during the sensor test installation, as shown in Figure 4.

During the tests, the tundish preheating was monitored using the system installed on the tundish preheater.

Monitoring is essential to predict the starting temperature of the tundish operation cycle. With this information, it is possible to request adjustments from the refining process, increasing or decreasing temperatures according to the values observed during tundish preheating.

2.1.2 Methods

This study was developed on 15 tundishes in the continuous casting process of Continuous Casting Machine 4 at Usiminas Steelmaking Plant #1. The performance of the automatic measurement was evaluated against the manual temperature measurement method, which is performed through spot measurements during the casting sequence: 5 minutes after ladle tapping, at half of the ladle steel volume during casting, and 5 minutes before finishing the ladle steel.

2.1.2.1 Measurement system

For the tests, a wireless instrument was used that enables fast reading of the continuous measurements performed by the temperature measurement system sensor, without the need for cables spread across the operational platform. Data transmission is wireless, using the QUBE device connected to the sensor [3], which transmits the temperature measurements to the wireless instrument, as shown in Figure 5.

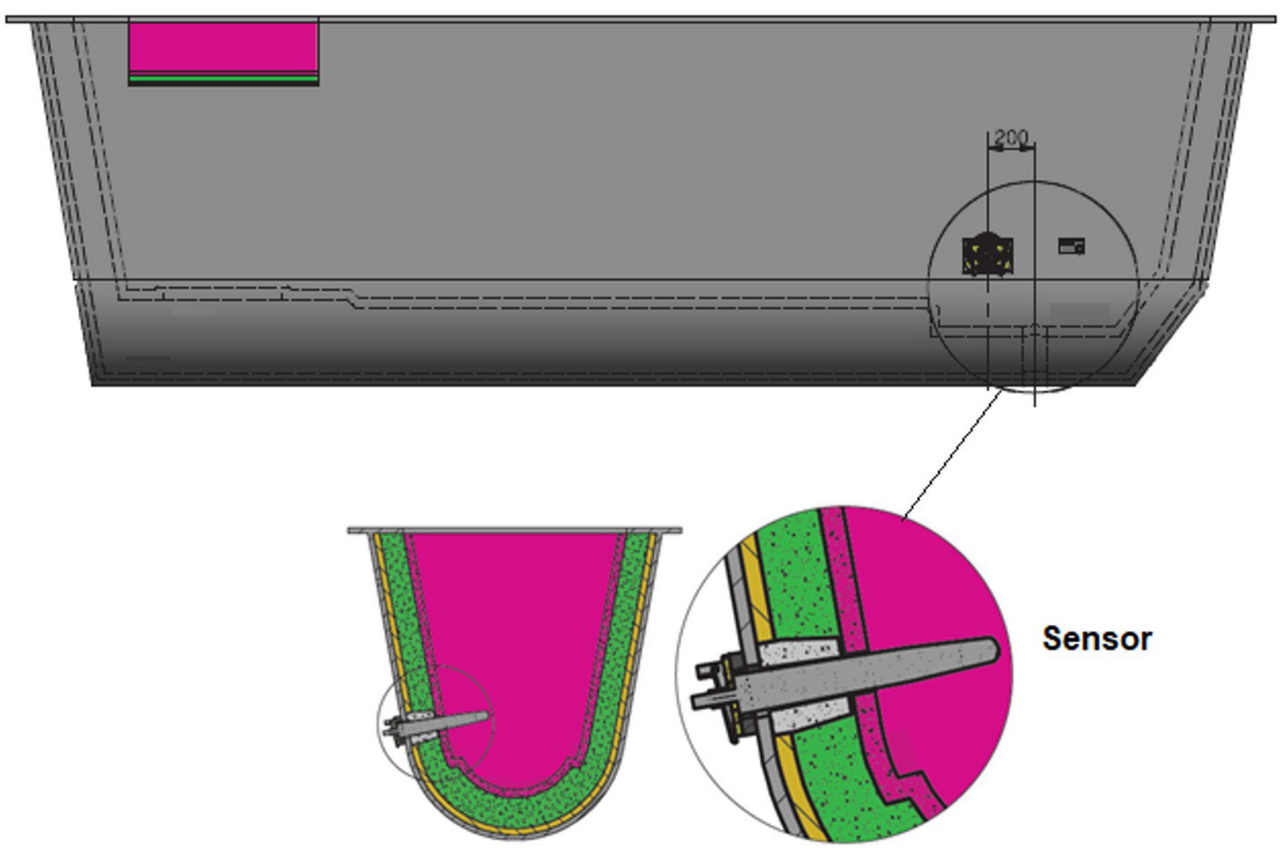

Figure 3. Position of the thermocouple installed on the tundish shell at Usiminas.

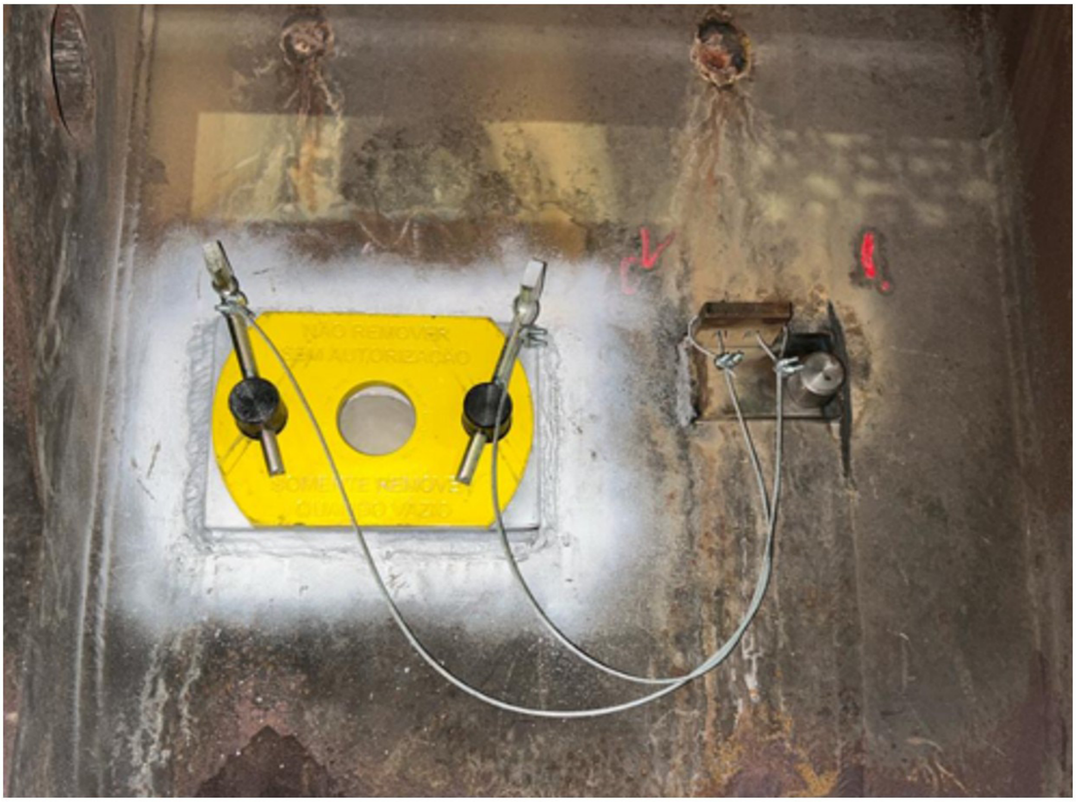

Figure 4. Position of the flange installed on the tundish shell at Usiminas.

Figure 5. (a) Wireless equipment; (b) Position of the sensor on the tundish shell.

The system offers several advantages, such as:

- fast response: the actual temperature stabilizes in less than five minutes after the first ladle tapping;
- high reliability: the measured temperature is highly reliable, especially during ladle changes with low tundish steel volume;
- continuous monitoring: enables casting at the appropriate speed throughout the entire process;
- safety: reduces the operator's time on the ladle platform, enhancing operational safety;
- productivity: improves casting control by preventing temperature-related clogging and increases casting availability.

The sensor installation is simple and performed during the tundish preparation process at ambient temperature, reducing the risk of contact with hot metal during installation. This ambient temperature assembly is a significant advantage compared to other measurement methods, such as the installation of the sleeve/tube for optical sensor measurement, as shown in Figure 6. The installation process of the automatic measurement consists of:

- removal of wedges and flange cover;
- removal of the used thermocouple;
- cleaning of residual mortar from the seating brick channel;
- application of mortar to set the sensor;
- insertion of the sensor into the seating brick;
- positioning of the flange cover and placement of wedges;
- application of mortar around the thermocouple inside the tundish;
- projection of the working lining.

2.1.2.2 Pairing of the QUBE with the wireless system

The QUBE is a wireless device that transmits the temperature signal measured by the sensor to the automatic temperature measurement instrument.

It is responsible for capturing, processing, and wirelessly transmitting tundish steel temperature data to the automatic measurement. After installation of the automatic measurement device on the tundish and prior to the start of casting, the QUBE must be paired with the wireless system [3]. This procedure is performed by the casting operator to ensure correct device identification and operational safety. The operator verifies the QUBE identification number and confirms its correct pairing with the corresponding wireless instrument. This step prevents incorrect device association and measurement errors, thereby ensuring the accuracy and reliability of the temperature data [5], as shown in Figure 7.

2.2 Results and discussion

The automatic temperature measurement system was evaluated in 15 tundishes over 348 casting sequences and demonstrated stable operation. The temperatures measured were consistent with manual measurements, with no significant deviations observed. No casting sequence interruptions due to low temperature occurred during the test period (Figure 8).

2.2.1 Temperature difference between steel grades for continuous and manual measurement

A total of 106 sequences were performed with low-carbon (LC) steel and 242 with medium-carbon (MC) steel. The average temperature differences between automatic measurement and manual measurements were −0.44 °C for LC steel and 0.61 °C for MC steel, indicating minimal deviation regardless of steel grade (Figure 9).

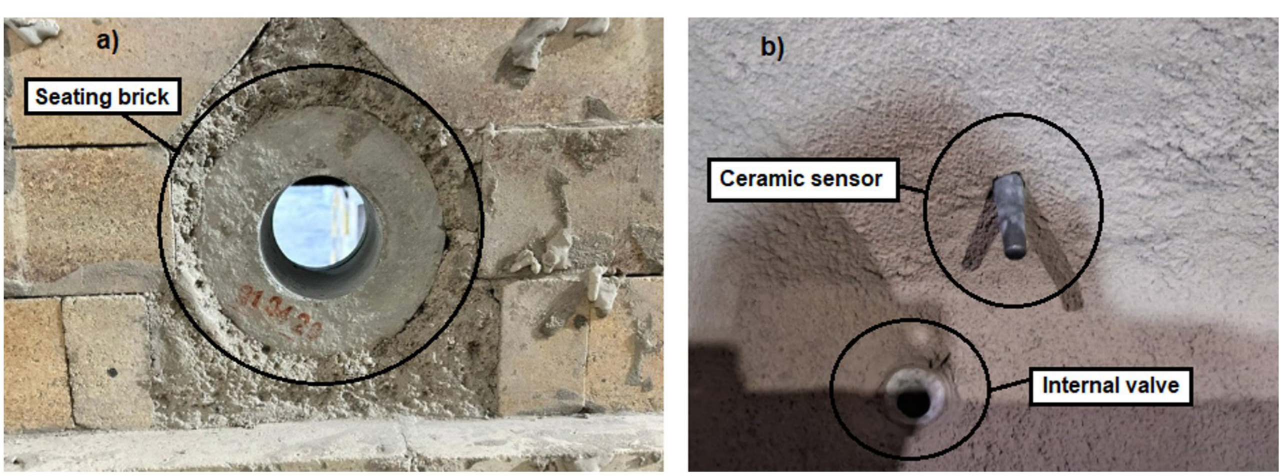

Figure 6. (a) Seating brick inserted in the region of the tundish permanent brick; (b) Ceramic sensor installed in the internal position of the tundish.

Figure 7. QUBE device with Wireless system.

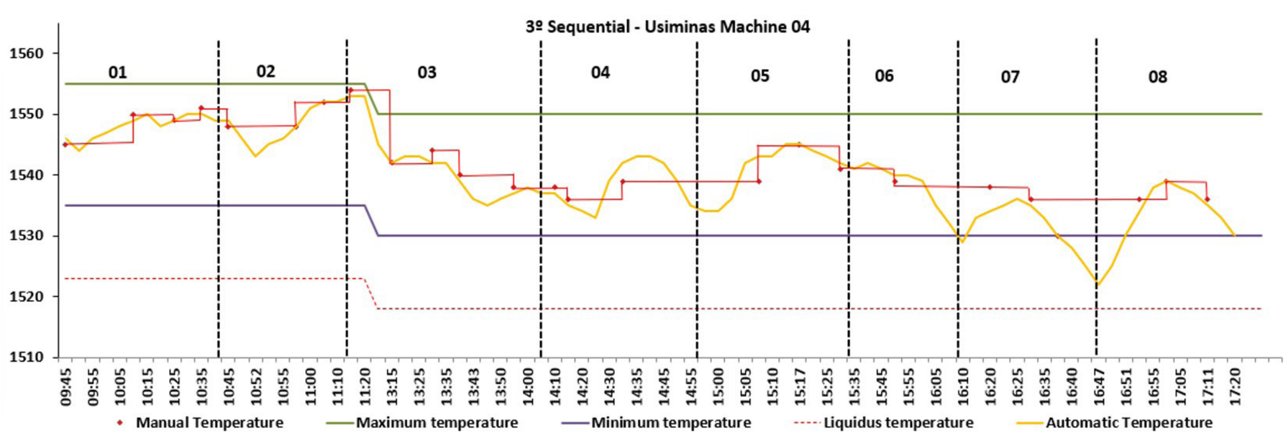

Figure 8. Example of a test with the automatic measurement and manual system.

2.2.2 Temperature difference between automatic measurement and manual measurement.

The average temperatures measured were 1543.75 °C for the automatic measurement and 1544.34 °C for the manual system. The associated standard deviations were 7.93 °C and 6.99 °C, respectively, demonstrating equivalent measurement accuracy (Figure 10).

2.2.3 Interruptions in the sequence due to low temperatures

Between 2022 and 2024, 23 casting interruptions caused by submerged entry nozzle blockage due to low tundish temperature were recorded, resulting in an estimated production loss of 5,500 tons. During the test period with automatic measurement, no interruptions occurred, as continuous temperature monitoring enabled timely operational decisions and eliminated gaps between measurements.

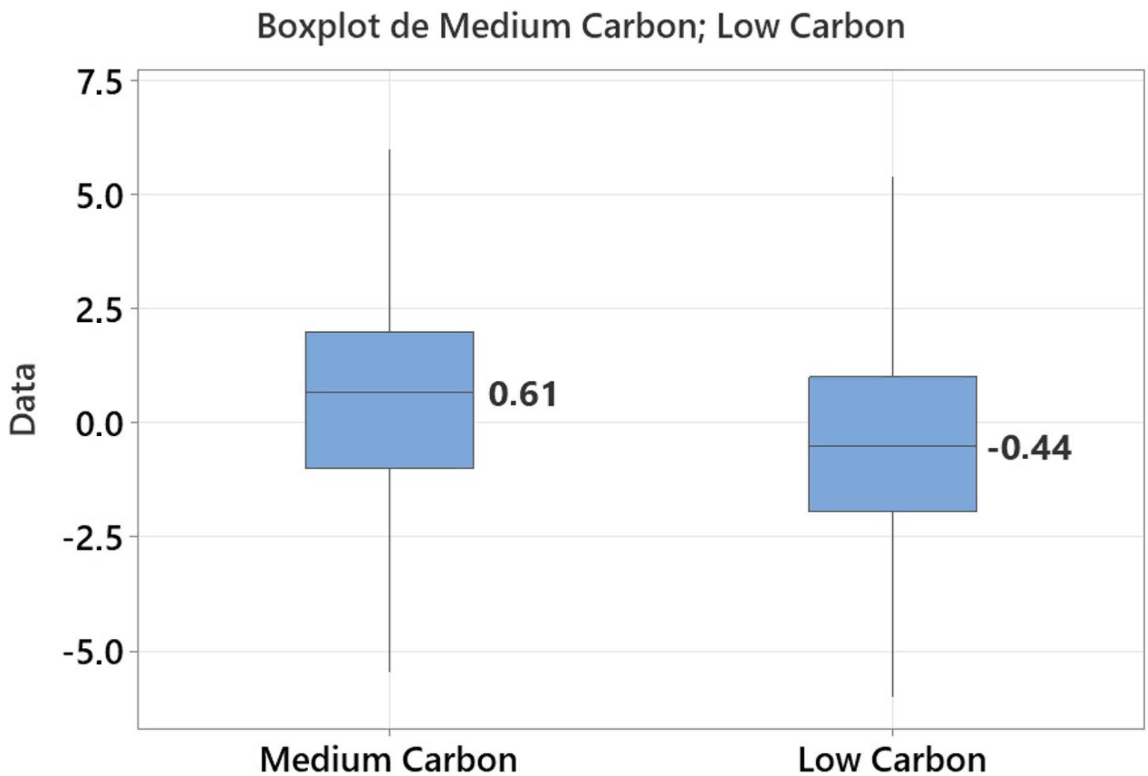

Figure 9. Temperature difference for steel grades between automatic measurement and manual measurement.

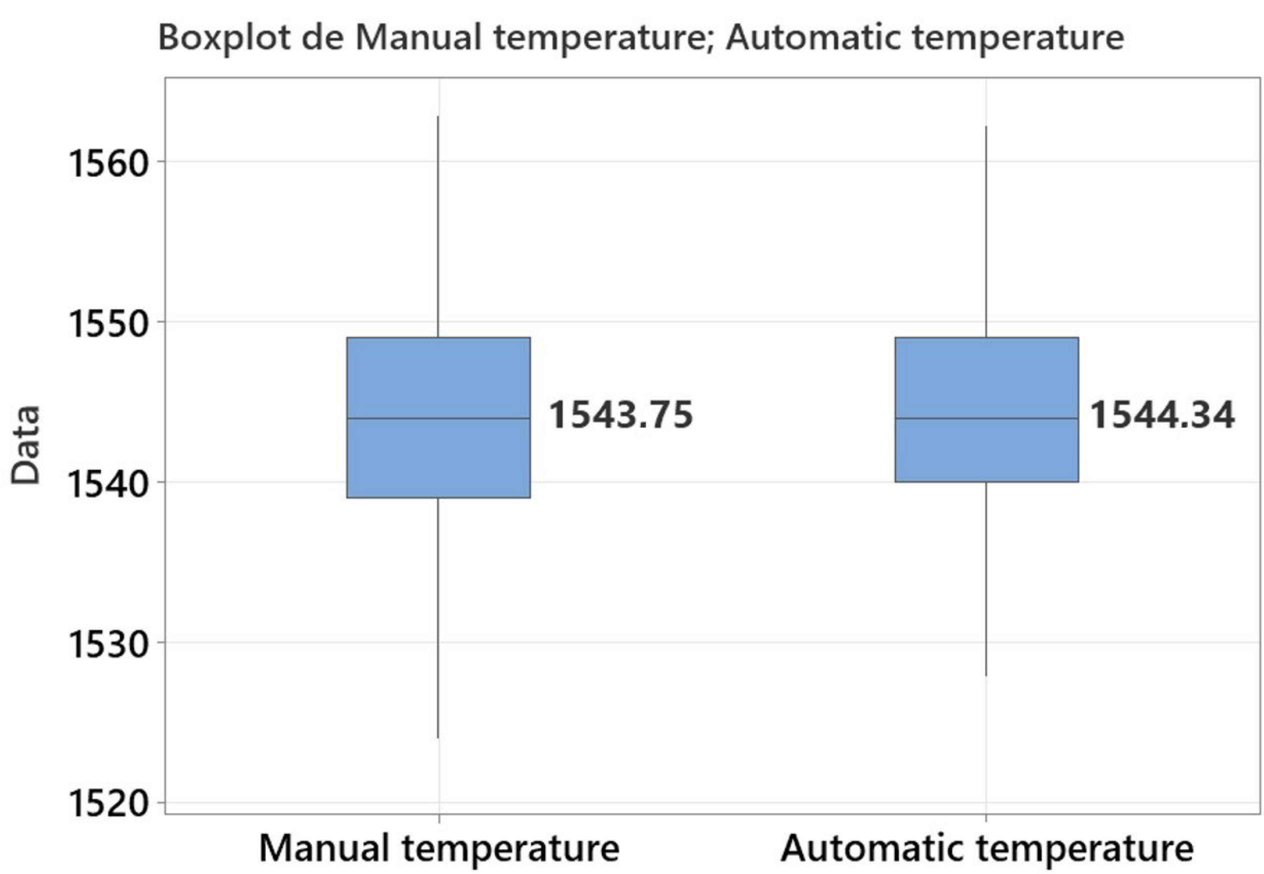

Figure 10. Comparison between manual and continuous temperature measurement.

3 Conclusion

The automatic measurement system demonstrated good performance in the continuous casting process, showing greater accuracy than the manual temperature measurement system. It enabled the detection of temperature variations throughout the casting sequence, allowing improved operational stability, such as maintaining a consistent casting speed. No sequence interruptions due to low temperature occurred in the tested tundishes during the evaluated period. In contrast, between 2022 and 2024, 23 such occurrences were recorded. Continuous temperature data are essential for operational decision-making. Regarding operational safety, the automatic system eliminates the need for operator exposure to molten steel, which is required during manual temperature measurement. This high-risk task has therefore been eliminated, significantly reducing the potential for accidents.

Acknowledgements

The authors would like to thank the instrumentation team at Steelmaking for their contribution to the development of this work, represented by the following individuals: Weverton Neubaner Ponciano da Cruz, Fabiano Correa Martins and Gladistone Lincon Soares.

References

1 Cardoso P. Installation and commission of a manipulator robot in the continuous casting at steelmaking plant Ternium Brazil [slide 4]. São Paulo: ABM Week; 2023.

2 Glistscher W, Berndt M, Pagden S. A system comparison of continuous temperature systems in concast operations. La Metallurgia Italiana. 2008;(setembro):27-32.

3 Heraus Electro-nite. CasTemp: automatic measurement liquid steel [internet]. [cited 2025 May 15]. Available at: https://clicktime.symantec.com/15x8NNgw1ASLb77Mex3eD?h=LFM8S8haKLdM9zor56RujdA0xd4mUxqRdFeyFK2MSUA=&u=https://www.heraeuselectronite.com/en/products/CasTemp/

4 Berndt M, Alves O Jr, Corsi AC, Oncken MHM. A novel approach to continuous tundish temperature measurement. In: Technical Contribution to the 43rd Steelmaking Seminar; 2012; Belo Horizonte, Brazil. São Paulo: ABM; 2012.

5 Electro-Nite H. Positherm® and Positherm® Non-Splash: Fast, accurate, and reliable liquid metal temperature readings [internet]. Houthalen-Helchteren: Heraeus Electro-Nite;2024 [cited 2025 May 15]. Available at: https://clicktime.symantec.com/15x8HYVeYYkkBAHS7PeVb?h=hYx9la6WcN1RyXcafnDuxbZJFOvKGiXltFU8PGWODok=&u=https://www.heraeus-electro-nite.com

Received: 16 Out. 2025
Accepted: 9 Jun. 2026

Editor-in-charge:
André Luiz Vasconcellos da Costa e Silva