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# INDUSTRIAL OPTIMIZATION OF BOF STEELMAKING: INCREASING SCRAP RATIO THROUGH HOT METAL PARAMETAR CONTROL

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**Abstract**

*This paper presents the results of an industrial process improvement in BOF converters aimed at increasing the consumption of steel scrap by stabilizing the input parameters of hot metal, primarily its temperature and silicon content. By implementing control points and making technical and technological adjustments to the blast furnace operating regime and hot metal transport, consistency of the input raw material was achieved. This directly enabled a higher and more secure scrap charge in the converter process.*

*Through systematic process monitoring and statistical analysis of results from October 2023 to December 2024, an increase in average steel scrap consumption of 2.36% was recorded, representing a significant improvement compared to the previous reference period. At the same time, energy savings were achieved, oxygen consumption was reduced, and converter yield was improved. The planned targets were exceeded, with the achieved result being 1.62% above the initially defined goals.*

*The obtained results confirm that stabilizing the quality of hot metal in terms of temperature and chemical composition represents a key factor for the successful and sustainable integration of increased amounts of steel scrap in the BOF process. This study provides a foundation for further digital optimization of the converter charging process and greater flexibility in raw material management under modern steel plant operating conditions.*

**Keywords:** *BOF converter, steel scrap, hot metal, input stability, process optimization*

## 1. INTRODUCTION

In modern basic oxygen furnace (BOF) steelmaking, increasing the share of steel scrap in the charge is one of the main process optimization objectives, as it directly contributes to cost reduction, lower energy consumption and $CO_2$ emissions, and greater flexibility in the use of available raw materials. However, achieving this goal under industrial conditions requires high stability and predictability of the hot metal input parameters, primarily its temperature and chemical composition.

One of the key challenges in this process is controlling the energy balance in the converter, since excessive temperature losses during hot metal transport from the blast furnace to the steel shop limit the potential for increasing scrap rates. At the same time, the chemical composition—particularly silicon content—has a direct impact on the thermal balance of the reaction and the efficiency of decarburization. By increasing the silicon content and reducing temperature fluctuations, it is possible to provide more stable conditions for scrap melting, enabling a safe and consistent increase in its share in the charge.

This paper presents the results of an industrial process improvement implemented from October 2023 to December 2024, during which targeted technical and technological measures were applied

to the blast furnace operation and hot metal transport. The collected data show that the average scrap consumption increased by 2.36% compared to the reference period, exceeding the planned target by 1.62%. In addition, oxygen consumption was reduced, steel yield was improved, and the process energy balance was optimized.

## 2. EXPERIMENTAL

The chart 1 shows the monthly share of steel scrap in the total BOF converter charge mass for the period October 2023 – December 2024. The target value is 20.5%. In 2023, the share was 19.76%, while from October 2023 onwards, the values remained consistently above the target, ranging from 20.56% (November 2023) to 23.17% (August 2024). The data represent weighted monthly averages from production records, calculated based on all heats produced during the observed month.

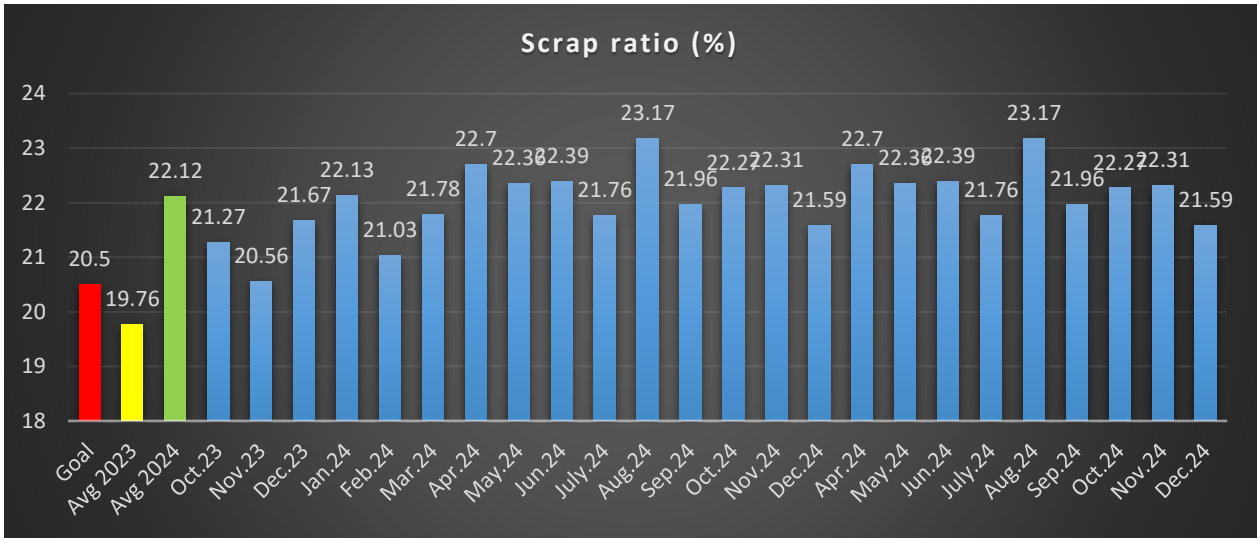


*Chart 1. Scrap ratio*

The chart 2 depicts the monthly average temperature of hot metal (HM) charged into the BOF converters, measured using disposable thermocouple probes during each delivery from the blast furnace and before charged in convertors from mixer or transport ladles. In 2023, the average temperature was 1294°C, while from October 2023 to December 2024, values ranged between 1304°C and 1333°C and average temperature was 1321°C in 2024.

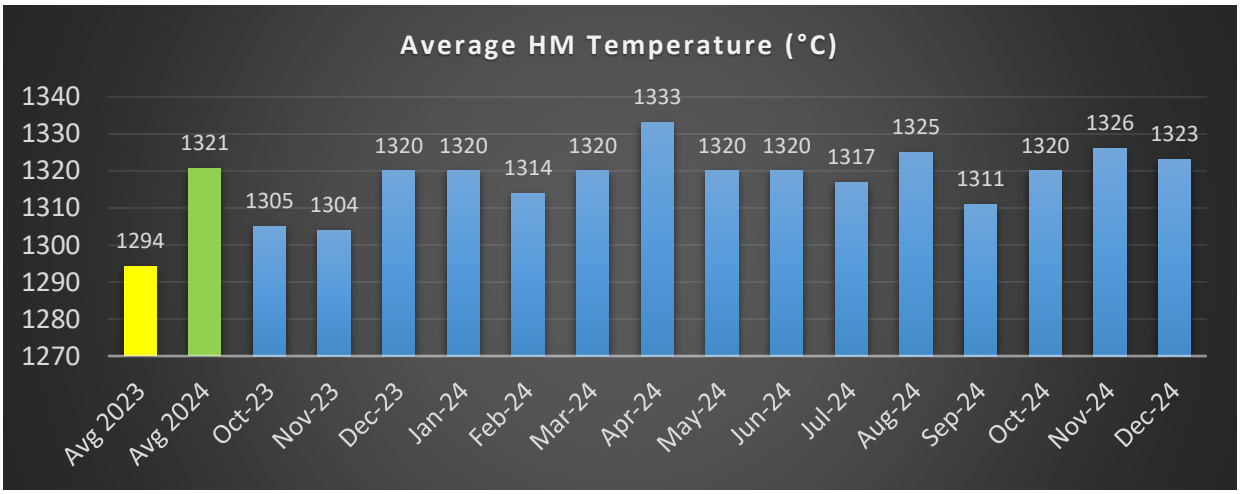


*Chart 2. Average HM temperature charged in convertors*

The chart 3 depicts the monthly average silica content in HM charged into the BOF converters, determined by chemical analysis of samples taken from the transport ladles using a spectrometer.

In 2023, the average content was 0.749%, and from October 2023 onwards, values ranged between 0.693% and 0.811%. The average value for the observed 2023 period was 0.761%, while in 2024 it was 0.720%. To improve control of hot metal Si contains in blast furnace (BF) process the following was undertaken. Screens of ore materials were reconstructed, new equipment for sampling raw material and sample preparation was purchased and installed.

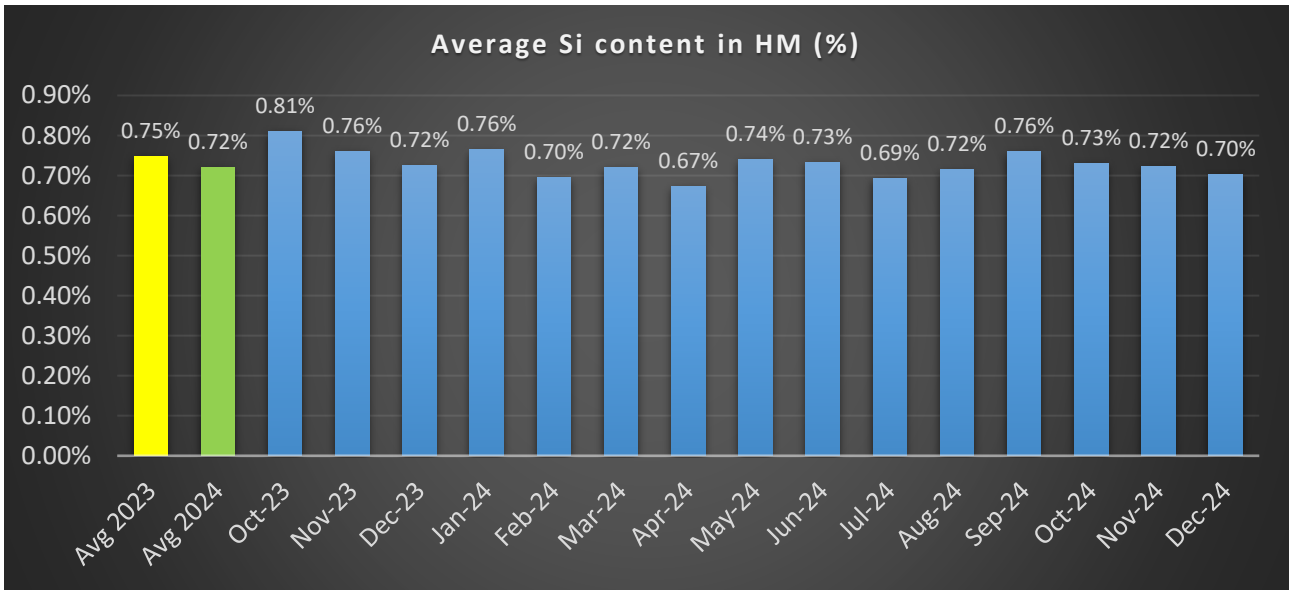


*Chart 3. Average silica content in hot metal*

Transport of hot metal from BF to the desulphurization station (DS) is carried out by ladles with a capacity of 80 tons of liquid metal. In order to reduce the heat loss of the hot metal, the following measures were taken. After filling the ladle with liquid metal, rice ash was sprinkled over the surface to reduce heat loss by radiation. An analysis was performed and the optimal number of ladles in circulation was determined in order to reduce the cooling of the refractory lining of the ladle before filling.

Graph 4 shows the average temperature drop of HM during transport from BF to the desulfurization station, where in 2024 the result was better by 7 °C compared to 2023.

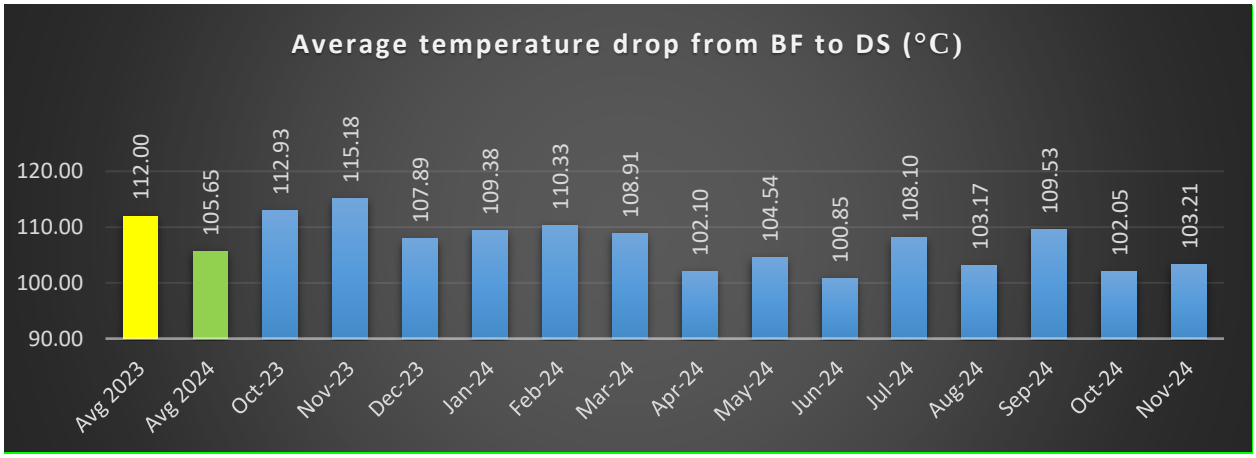


*Chart 4. Average temperature drop*

Also, there are prescribed instructions for handling the transport ladles during filling and for maintaining of the ladles. On graphic 5, you can see a reduction in the number of ladles that waited more than 8 hours to be filled. A key role in reducing HM temperature drops from the BF to the

BOF converters, particularly after the desulfurization process, is played by the mixer, which—through proper temperature maintenance and controlled HM charging, significantly minimizes temperature losses.

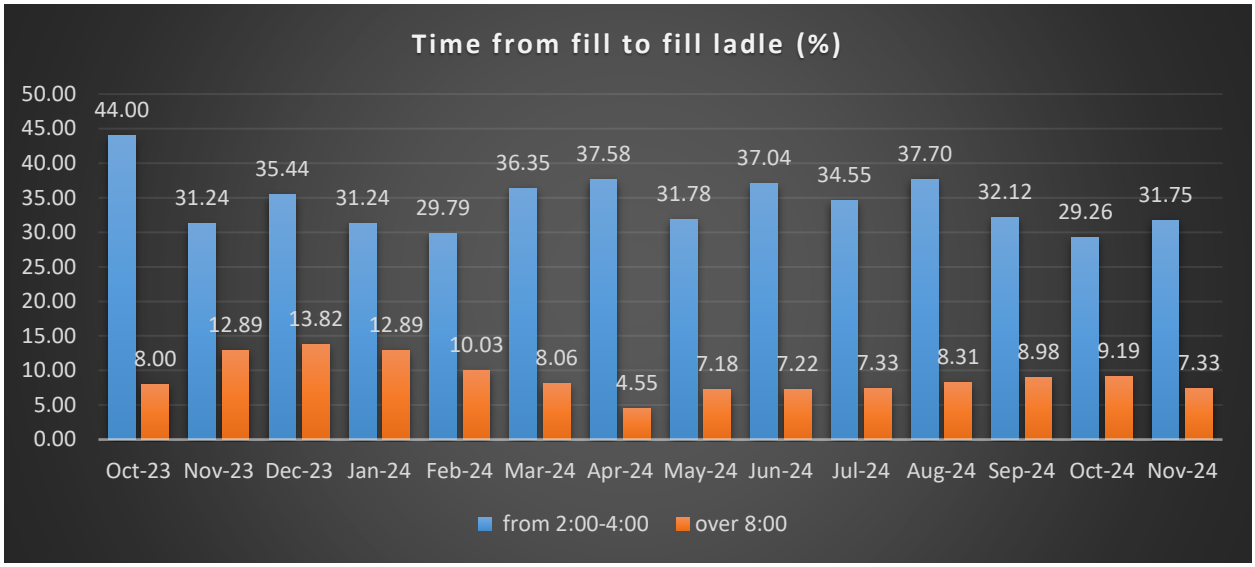


*Chart 5. Ladles waiting for filing*

## 3. CONCLUSION

The stabilization of hot metal temperature and silicon content had a significant and measurable impact on increasing steel scrap consumption in BOF converters. During 2023, both temperature and silicon levels exhibited noticeable fluctuations, which contributed to process variability and required frequent corrective interventions. From October 2023 onward, hot metal temperatures stabilized in the range of 1304–1333°C, while the silicon content narrowed to 0.69–0.81%. This consistent control of input parameters improved the predictability of converter reactions, reduced unexpected deviations, and allowed for a more precise adjustment of process conditions.

As a result, the steel scrap ratio consistently exceeded the target of 20.5%, with most months of 2024 reaching values above 22%. The observed improvements in temperature and chemical composition not only facilitated higher scrap utilization but also contributed to enhanced thermal efficiency and energy balance of the process. These findings highlight the critical role of monitoring and controlling key hot metal parameters to optimize converter operation, minimize process variability, and support sustainable steel production practices. The combination of higher and more stable temperatures with a uniform and slightly lower silicon content created optimal conditions for reliable and efficient steelmaking, demonstrating a clear link between input material stabilization and improved process outcomes.