INFLUENCE OF CHEMICAL REHEATING AT RH DEGASSER ON CLEANLINESS OF IF STEEL GRADES

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Abstract
Production practices of IF (interstitial free) steel grades intended for the most qualitatively demanding automotive applications calls for their continuous optimization. Precise control of steelmaking operation conditions leads to a minimization of clogging issues during their casting, but is also related to surface quality imperfections of finished material. With the aim to study the impact of RH degasser practices on cleanliness of the IF steel grades, the influence of heat chemical reheating was verified. While detailed analyses confirmed overall worse results and a higher presence of specific nonmetallic particles on steel samples collected from such treated heats, the limited reheating practice did not seem detrimental.

Key words: RH degasser, chemical reheating, IF steel, steel cleanliness

1 Introduction

In general, it can be said that to date, there have only been a few research papers published regarding the impact of chemical reheating on the cleanliness of heats processed at an RH (RH-OB) degasser. This technological operation represents one way of feeding the oxygen into the liquid steel. As well, depending on a number of other process parameters, it can strongly affect the degree of its cleanliness, casting conditions and consequently, the quality results of the final processed material. **Fig. 1** characterizes the typical temperature increase related to the amount of oxygen blown at the RH degassing station with steel grades deoxidized only by aluminum, or by a combination of aluminum and silicon. It is evident that the processed steel grades deoxidized only by aluminum have particularly at high volume of oxygen blown, higher efficiency of the chemical reheating process [1 - 4].

In this regard, the greatest attention should be paid to the conditions of formation and to the ways of minimizing the occurrence of mainly small alumina inclusions (under 10μm). Besides this, the area of concern is often focused also on other complex types of inclusions, in particular based on Titanium, whereas in view of its alloying, these steel grades exhibit the negative impact thereof on the conditions of removing inclusions from the molten steel and related issues during their casting [5 - 7]. **Fig. 2** indicates that the heat treatment of the processed heats in terms of the chemical reheating leads to a significant deterioration of steel cleanliness through the increase of concentration of Al_2O_3 inclusions in heat, mainly during the oxygen blowing for the reheating [8]. Although this finding is a common feature of most of the available research work on this topic, opinions and findings concerning the overall final level of steel cleanliness with a consequent impact on its castability and quality of the final processed material differ [9-13].

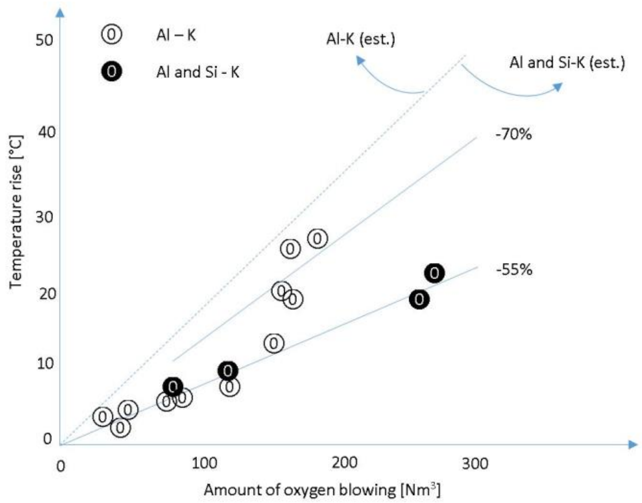

Fig. 1 Typical temperature increase during chemical heating at RH degassing station under different deoxidation practices

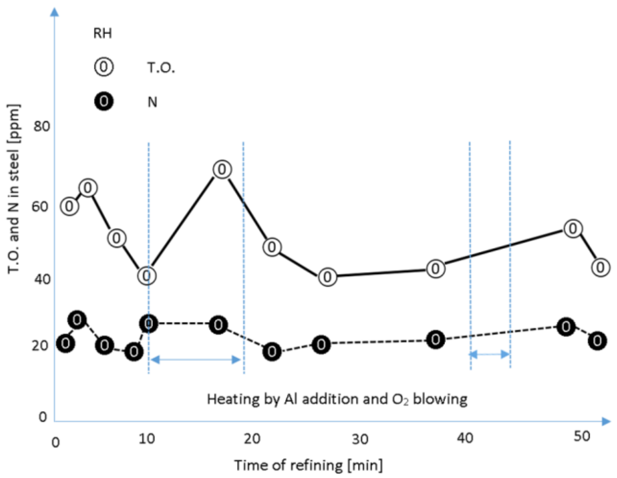

Fig. 2 Characteristic trend of steel cleanliness (T.O. – Total Oxygen) during chemical reheating practice

2 Materials and experimental methods

Understanding the origin of inclusions and developing practices to control their composition and content in liquid steel are key points for optimization of production processes and parameters [14, 15]. To study the inclusions in the steelmaking process and final products, techniques are being developed to rapidly identify inclusions in steel [16]. The inclusion analysis technique used in this work was based on a computer-controlled scanning electron microscope known as the Automated Steel Cleanliness Assessment Tool (ASCAT). Using image analysis of the backscattered electron image, inclusions are systematically located, sized and analyzed for

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composition using EDS. The process of analysis and identification of each inclusion on ASCAT is depicted in **Fig. 3**. The process consists of four steps: (1) inclusion is detected and sized, (2) spectrum is analyzed and the percentage of each element is determined, (3) spectrum data is processed through special modules and rules, (4) inclusion classification is assigned. Further description of the ASCAT may be found elsewhere [17, 18].

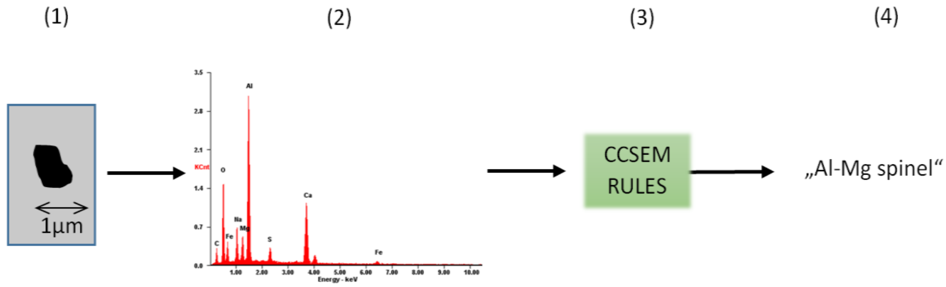
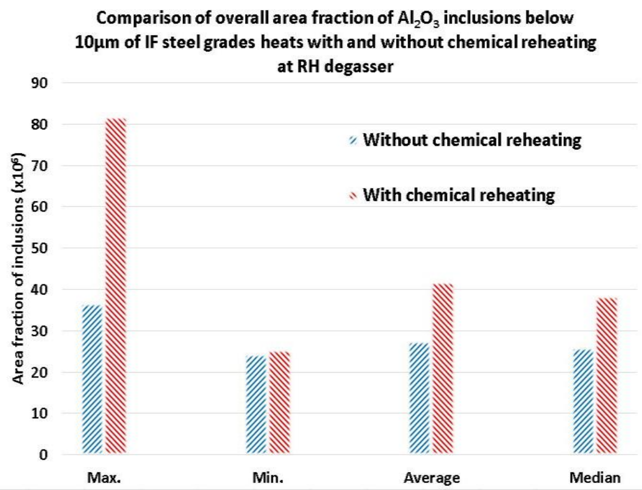


Fig. 3 Process of inclusion analysis and identification on ASCAT

To verify the overall influence of chemical reheating at the RH degassing station on cleanliness of selected IF steel grade heats, the process liquid steel samples were taken and contents of the most important categories of nonmetallic inclusions were evaluated. Within this context, the cleanliness results of twenty heats of IF steel grades that were chemically reheated by blowing the oxygen in volume of 50 to 210 m^3 were compared with regularly produced heats without temperature adjustment. In both cases, the area fraction of investigated inclusions was used as the main steel cleanliness evaluation criteria.

3 Results and discussion

Fig. 4 presents the results of cleanliness in terms of pure alumina inclusions (Al_2O_3) in both size categories that were compared (below and above 10µm), which are related to the nature of the reaction of chemical reheating itself. In addition, **Fig. 5** subsequently presents the results of complex inclusions based on Al_2O_3 x TiO_x, and Al_2O_3 x MgO (spinels) in the size category below 10µm.



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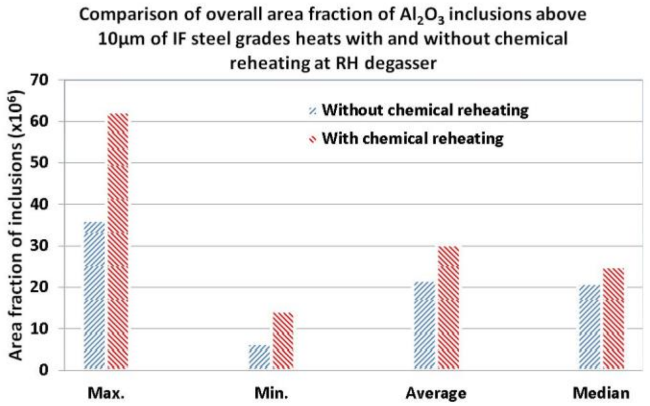

Fig. 4 Cleanliness results of the compared heats - pure Al_2O_3 below and above 10 µm

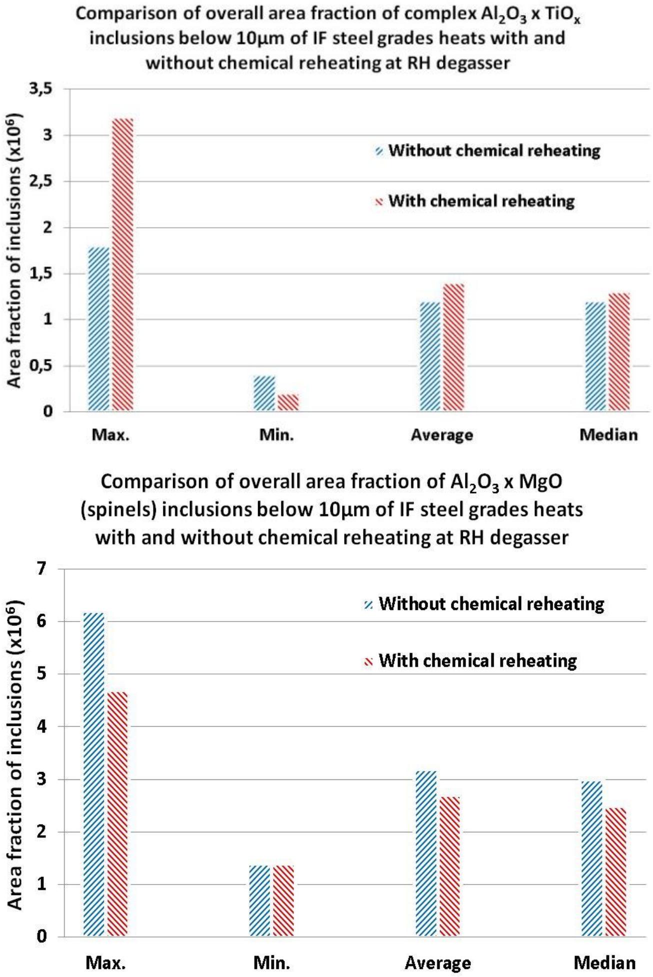

Fig. 5 Cleanliness results of the compared heats – complex Al_2O_3 x TiO_x and Al_2O_3 x MgO

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Based on this comparison it can be concluded, that the heats with temperature adjustment (reheating) at the RH degassing station have generally higher area fraction of pure alumina inclusions in both compared size categories.

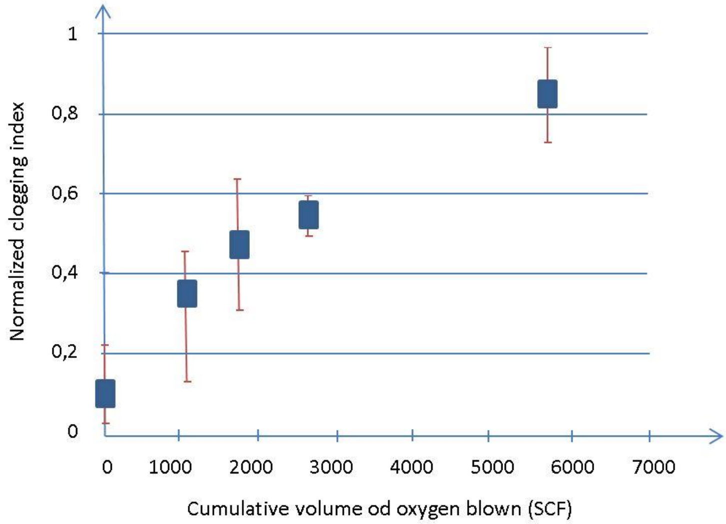

Fig. 6 Relation of chemical reheating at RH degasser and castability of IF steel grades

Vice versa, presented findings indicate that this technological operation has no effect on the steel cleanliness in the case of assessing other types of complex Titanium-based and MgO-based spinel inclusions represented in these IF steel grades that could have significant influence on their castability [10, 19, 20]. Direct relation of chemical reheating and overall stability of the casting process is also evident from **Fig. 6**, which characterizes the effect of the volume of oxygen blown for chemical reheating at the RH degassing station on IF steel grades castability [21 - 26].

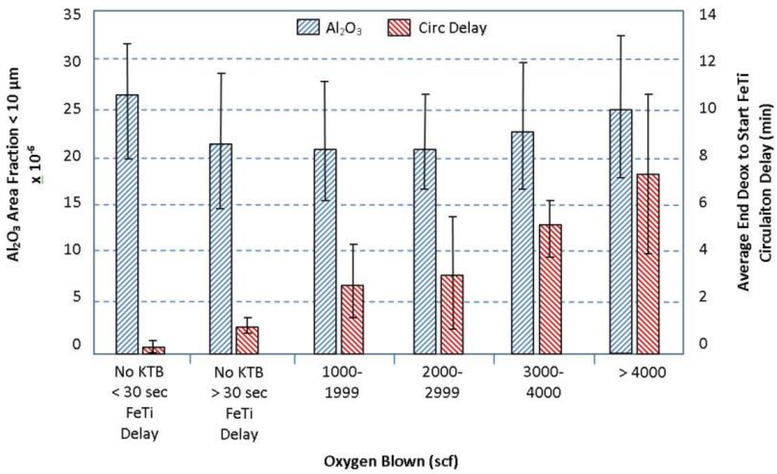

Fig. 7 Influence of volume of oxygen blown for chemical reheating at the RH degasser on cleanliness of IF steel grades

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However, according to results of the latest conducted wider research presented in **Fig. 7**, it appears that in the case of heats with the chemical reheating and oxygen blowing at 1,000 to 3,000 SCF (about 30 to 85 m^3), the impact on the cleanliness of such processed heats is less significant [27].

Conclusions

This research study focused on investigating the influence of the chemical reheating practice at the RH degasser on cleanliness of selected IF steel grades. According to presented steel cleanliness results it was confirmed that heats with temperature adjustment (reheating) have generally higher area fraction of pure alumina inclusions in both compared size categories (below and above 10µm), but this technological operation has no negative effect in the case of assessing other types of complex Titanium and MgO-based spinel inclusions.

Even if the chemical reheating at the RH degasser generally deteriorates the overall steel cleanliness, the stability of the casting process and the final quality of processed material, its application in the case of oxygen blowing at 1,000 to 3,000 SCF (about 30 to 85m^3) appears to be less significant.

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