TECHNOLOGY DEVELOPMENT REMOVAL OF NON-METALLIC INCLUSIONS IN OUT-OF-FURNACE STEEL PROCESSING

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Abstract. Objective. The paper studies the process of metallic melt refining using out-of-furnace treatment in a ladle, which allows to produce castings with minimal rejection by casting defect. A plant model was designed and made for the process of removing non-metallic inclusions from liquid by blowing with inert gas through the bottom plug and the top lance. Particularly the influence of top lance on stirring intensity and blowing time on the amount of removed non-metallic inclusions was estimated.

Keywords: nonmetallic inclusions, blowing, lance, steel, holding time.

INTRODUCTION

The demands of consumers for steel properties are increasing year-by-year. It is known that the main determining properties of steel are the proportion of harmful elements, nevertheless, non-metallic compounds also have a great influence on quality. In fact, the composition, shape, size, as well as the variety and number of inclusions play a significant role in the metal destruction process [3].

According to the authors [4], compounds of metals with non-metals, for example, with oxygen, sulfur, nitrogen, phosphorus, hydrogen, etc. are accepted as non-metallic inclusions in alloys and their castings. In addition to special dispersed elements, all elements are stress concentrators in castings, which accelerate the nucleation, development of cracks and have a significant impact on the nature of destruction. Based on this, the sizes, types, composition, shapes, hardness, location, temperatures, melting stability and other characteristics of the included elements significantly affect the quality of castings.

OBJECTS AND METHODS OF RESEARCH

The method of steel refining in the ladle with bottom blowing, with a combined top injection of desulfurizing slag-forming powder materials in a stream of argon was chosen in the work.

Slag-forming powder materials blown into the melt are reagents, with a maximum rate of interaction with the metal and a high degree of use of blown mixtures. The advantage of the method is the introduction of the reagent and metal by a stream of gas carrier, which has a positive effect on the metal melt (Fig. 2).

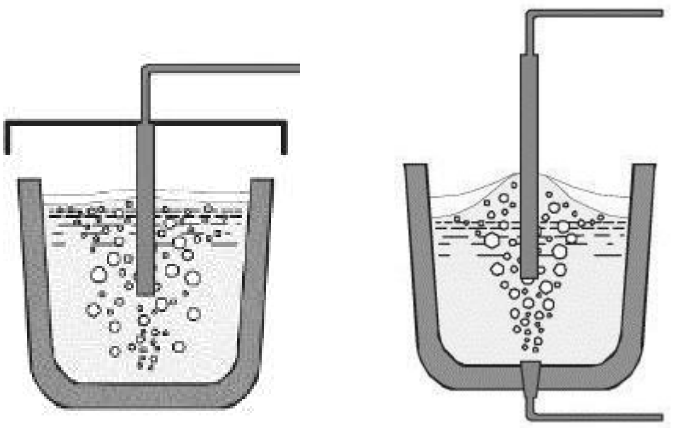

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Fig. 2 - Scheme of metal blowing in the ladle (a- upper blowing, b- combined blowing)

The model of installation for process of nonmetallic inclusions removal from liquid at gas blowing through bottom plug and top tuyeres was designed and made (fig. 2). In particular the influence of top lance on intensity of mixing, duration of blowing on quantity of removed nonmetallic inclusions was estimated.

PRACTICAL AND EXPERIMENTAL PART

The physical model of steel ladle with a capacity of 6 tons is modeled from a plastic container and made at a scale of 1:200. Water at 18 to 25°C was used as a working fluid simulating liquid steel, since the viscosity values of water and steel in the area of out-of-furnace processing and casting temperatures are close enough to each other (tab. 1). Sunflower oil was used as a slag. Air was used for stirring the melt. Fluxes movement was recorded with a video camera. Given the fact that when blowing gas in the liquid is very important processes occurring under the action of gravity, which determines the bubbles of gas and the forces of inertia, as well as the development of circulating flows in the liquid bath of the ladle. In the present work, Froude's criterion and homochronicity were adopted as the basic similarity criterion. Physical properties of water at 20°C and steel at 1600°C are shown in Table 1

Table 1

Characteristics	Water	Steel
Molecular viscosity, μ, kg/m·s	0,001	0,0064
Density , ρ, kg/m^3	1000	7800
Kinematic viscosity, υ=μ/ρ m^2/s	10^{-6}	$0{,}913 \cdot 10^{-6}$
Surface tension, σ, N/m	0,073	1,6

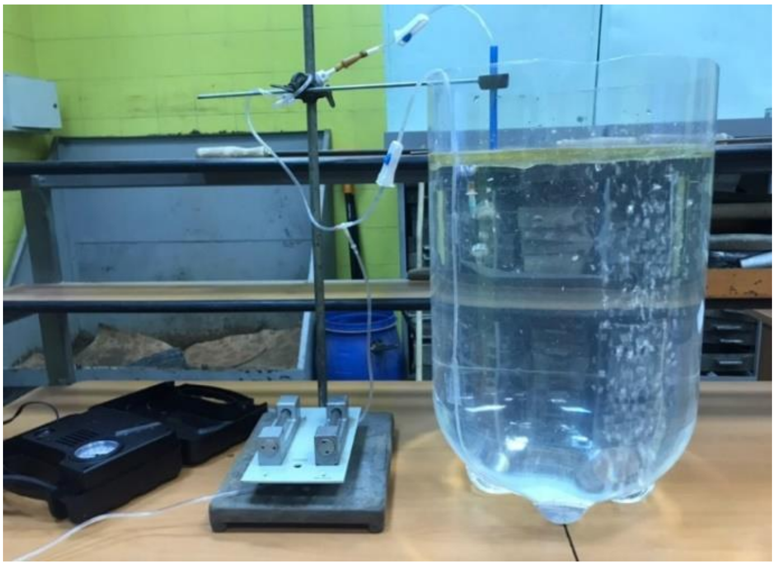

Fig. 3 - Experimental setup

EXPERIMENTAL RESULTS

A series of experiments on studying the processes of removing inclusions from liquid at blowing through the bottom plug (1) and together with the top tuyeres (2), with different duration of blowing were carried out on the experimental setup. Graphical results are shown on fig. 4.

The results, presented in Fig. 4, show that the intensity of removal of nonmetallic inclusions at the beginning of blowing is maximal, and then rapidly slows down. After blowing duration of 180 seconds the degree of removal of inclusions is very insignificant, i.e., ineffective, the weak influence of blowing intensity is evident. Besides, connection of the top tuyeres significantly accelerates the process of nonmetallic inclusions removal. Similar results are observed on real ladles with metal.

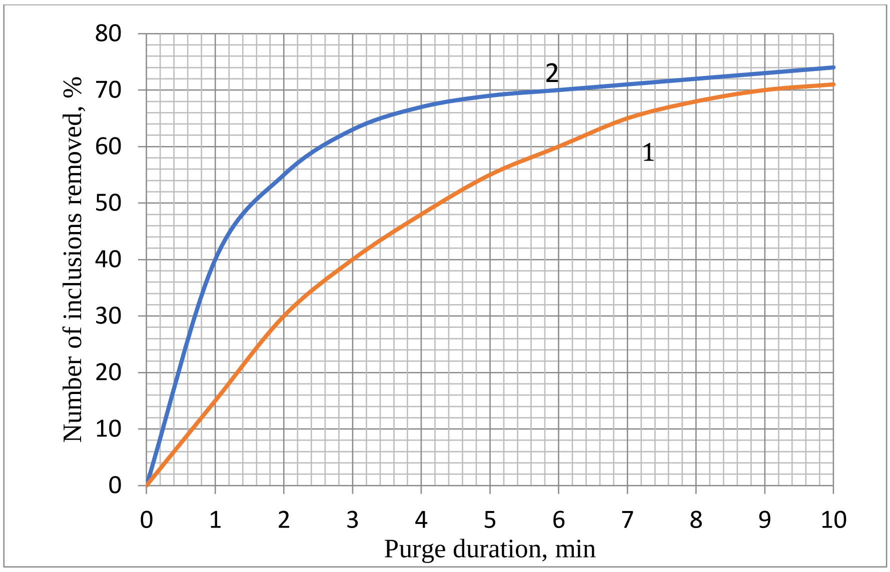

Fig. 4 Dependence of number of removed inclusions on blowing duration. 1- at blowing through the bottom plug; 2- combined with the top tuyeres

GENERAL CONCLUSIONS

Physical modeling reflects the real processes in the steel ladle. Studies have allowed to present the hydrodynamics of the bath when blowing the liquid metal in the steel ladle. We studied the peculiarities of blowing influence on the degree of inclusions removal at the expense of the top lance and the duration in the system "ladle-metal-slag-nonmetallic inclusions". The presence of threshold values of blowing intensity and duration is established, after reaching which further processing becomes ineffective.

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