Analysis of the technology of bucket processing of K-56 type steel pipe grades and development of recommendations to improve the quality of the finished metal.

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INTRODUCTION

Currently, steel pipes are in great demand in various industries. Modern pipe products (Fig.1) must meet many stringent requirements imposed on them, and have properties such as corrosion resistance, acid resistance, have high operational and mechanical properties, resistance to low and high temperatures. One of the key problems in the production of various grades of steels is the presence of non-metallic inclusions (NMI) in them, which have an adverse effect on the quality of the metal.

Fig. 1. Pipe products.

RESEARCH METHODS

In this work, the analysis of melting passports was carried out and metal samples were selected for the entire technological scheme of production of pipe grades of steel. The selected metal samples were analyzed using the fractional gas analysis (FGA) method and the main types of HB formed in the metal during smelting and out-of-furnace processing of steel were identified. The technology of pipe steel production consists of the following stages:

- smelting of a semi-product in an arc steelmaking furnace (EAF);
- processing of the intermediate product at the ladle furnace (LF) installation (deoxidation, chemical refinement, refining, alloying and heating of the metal to a predetermined temperature);
- processing of a semi-product on a vacuum cleaner (degassing, aluminum deoxidation, metal alloying);
-casting at the CSCM.

The study analyzes the existing technology of smelting and out-of-furnace processing of pipe grades of steel in an electric steelmaking shop. To do this, metal samples were taken along the entire technological scheme of production (EAF→ LF → VD→ CSCM→ Slab (Fig. 2).

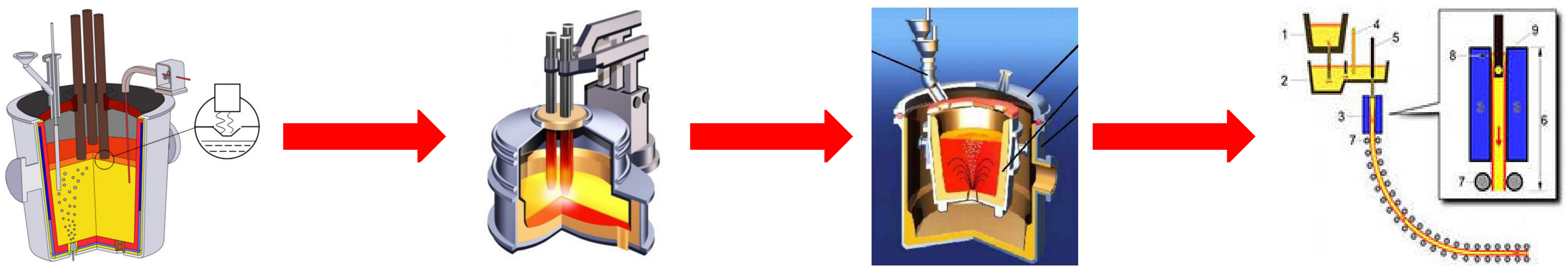
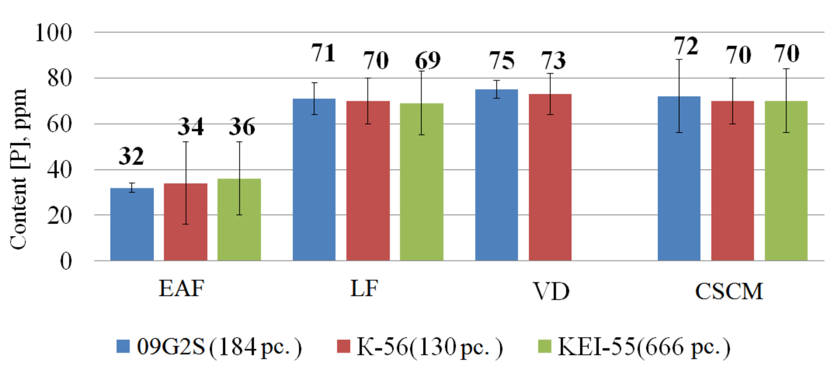
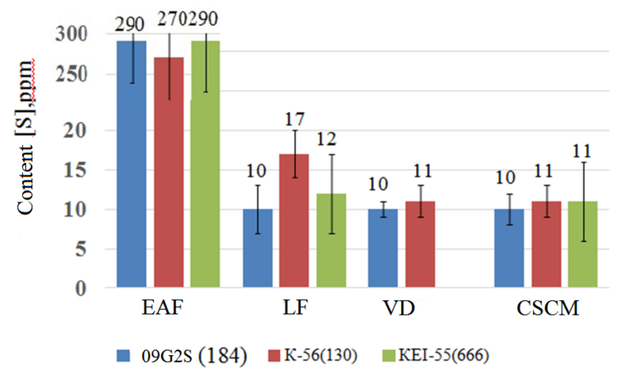


Fig. 2. Technological scheme of pipe steel production.

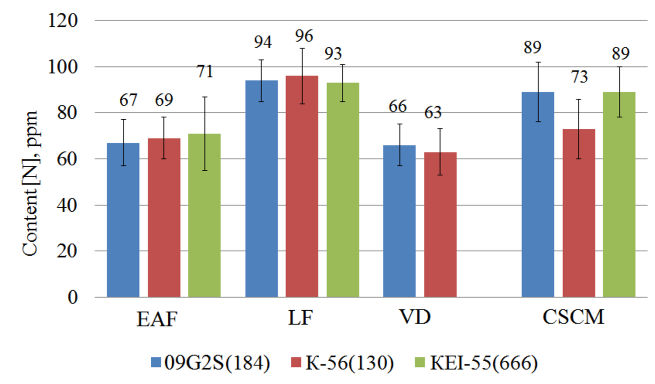
One of the most common methods for determining HB in a metal is metallographic analysis of the plume on an optical microscope. This method makes it possible to determine the quantity, type, linear dimensions, volume fraction of NMI. However, this type of analysis does not provide complete information about the shape and distribution of NMI, since the cross section of the metal sample is examined directly, and not its volume as a whole .Further, all the selected metal samples were examined by the FGA method. FGA was performed on a LECO TC600 gas analyzer with specially preset heating parameters. 3 samples weighing 1.2-1.6 g were cut from each sample in order to conduct parallel analyses. FGA allows you to determine the total oxygen content in the metal, the amount of oxygen contained in various groups of NMI and the volume fraction of various types of oxide NMI. The analysis of melting passports for the content of impurities in steel was carried out throughout the technological scheme of production, the result of which is shown in the figures 3-5.



THE PHOSPHORUS CONTENT IN THE METAL ALONG THE ENTIRE PROCESS CHAIN



THE SULFUR CONTENT IN THE METAL ALONG THE ENTIRE PROCESS CHAIN



THE NITROGEN CONTENT IN THE METAL ALONG THE ENTIRE PROCESS CHAIN

RESULTS AND DISCUSSIONS

Samples of these steel grades were analyzed by the FGA method, during which curves of oxygen release of oxide inclusions were obtained. After processing the oxygen release curves using the OxSeP Pro program, the main types of inclusions were determined and graphs (Figures 6-8) of the distribution of HB in these groups were compiled during the entire production stage of pipe steel grades from Table 1. In addition to determining the number and main types of inclusions, the FGA method allows determining the total oxygen and nitrogen in the metal. The obtained data on total oxygen and nitrogen are shown in the graphs in Figures 6-8. The graphs also show the impact of the main additives that affect the formation of non-metallic inclusions.

Name	Melting 1	Melting 2	Melting 3
Steel grade	K-56	K-56	K-56

Table 1. Analyzed samples by steel grades.

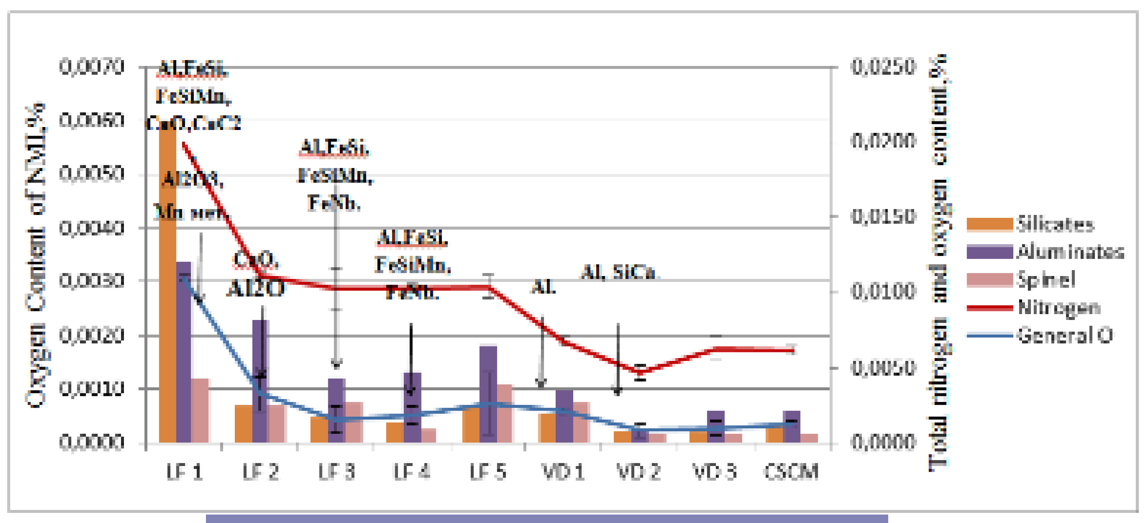


FIGURE 6. RESULTS OF FGA METAL MELTING 1.

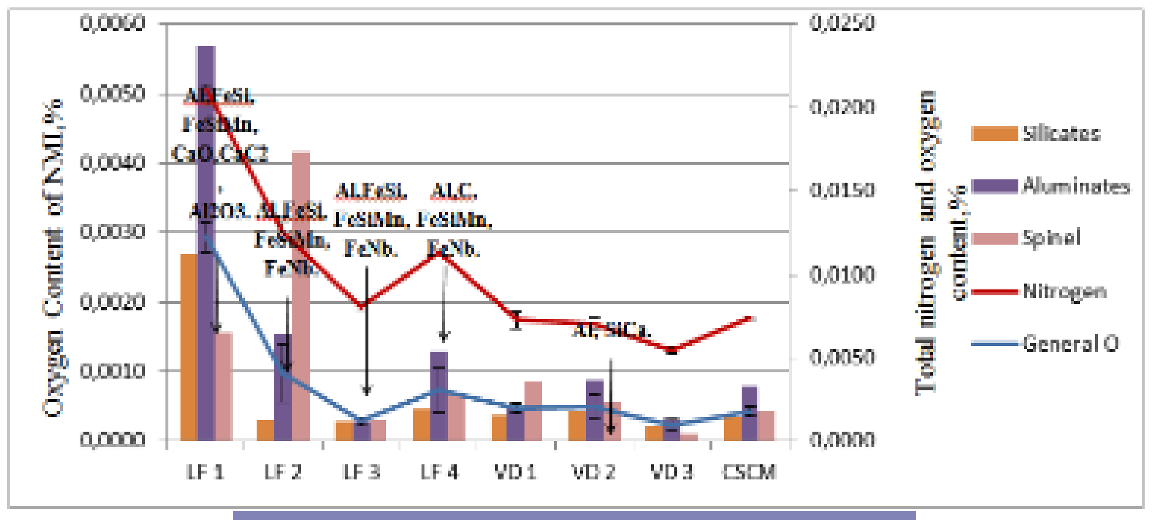


FIGURE 7. RESULTS OF FGA METAL MELTING 2.

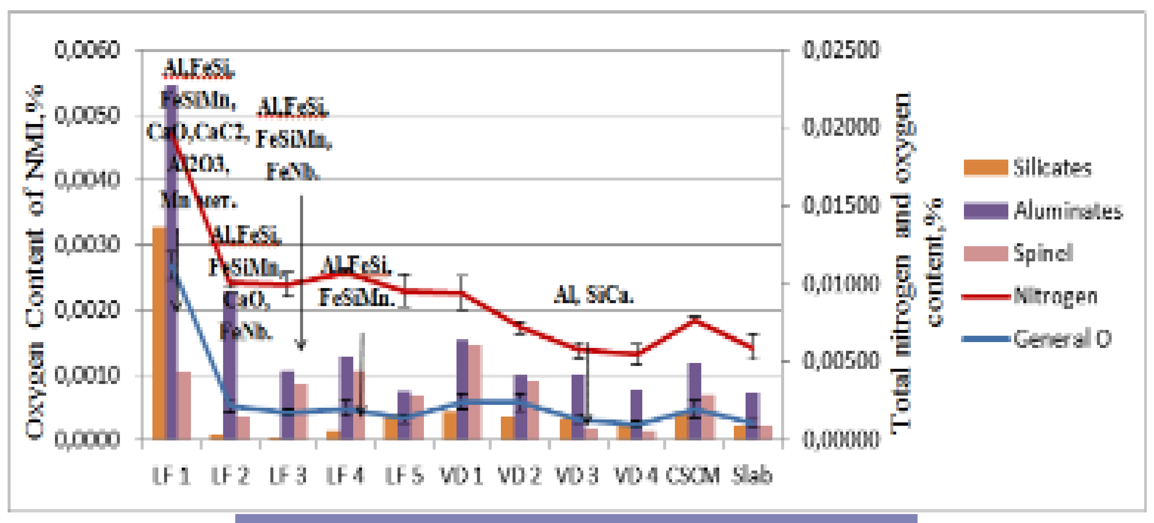


FIGURE 8. RESULTS OF FGA METAL MELTING 3.

In the first sample (LF 1), a large number of inclusions of silicates, aluminates and spinels were found on the bucket furnace for melting steel grade K-562 after the processes of deoxidation and alloying of metal with aluminum, ferrosilicon, ferrosilicon manganese. The metal oxidation at EAF for K-56 grade steel was 1244 ppm. The increased oxygen content in the intermediate for grades K-56 explains the higher concentrations of oxide inclusions in the LF 1 sample for these melts.

For all three melts, a decrease in the content of non-metallic inclusions in steel is observed in metal samples from LF 2 and further in metal samples on the bucket-furnace unit. The increase in the number of spindles in metal samples is associated with the release of deoxidizers, which leads to intensive destruction of the lining. Increased argon consumption can contribute to the mixing of slag particles into the metal. There is a decrease in the content of NMI on the vacuum cleaner, which is associated with the return of SiCa, the metal is modified with calcium, which favorably affects the removal of NMI. Further, from VD to CSCM, an increase in the total oxygen content is observed, which indicates secondary oxidation of the metal.

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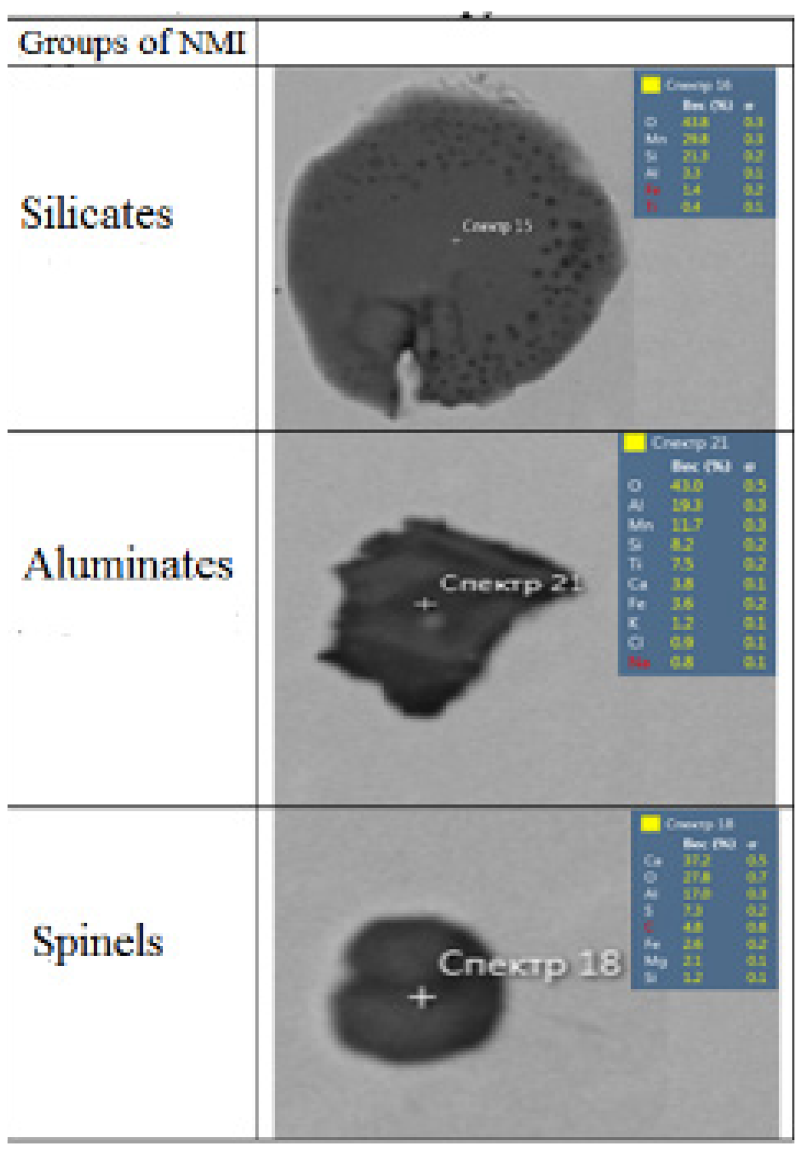
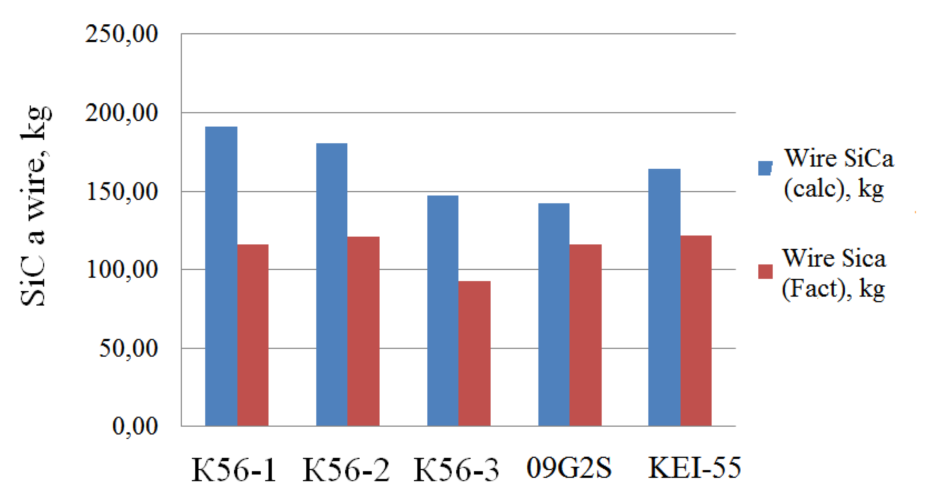


FIGURE 9. RESULTS OF STUDIES OF METAL SAMPLES ON AN ELECTRON MICROSCOPE.

Metallographic analysis revealed the main NMI, their chemical composition and linear dimensions (Figure 9). Based on the results obtained, it was found that the oxides of aluminates and silicates are the main types of NMI. Metallographic analysis confirmed the results of the FGA for the main groups of NMI contained in the finished metal.

COMPARISON OF CALCULATED AND ACTUAL DATA FROM THIS SICA FOR METAL MODIFICATION

Figure 10 shows a comparison of the actual return of the SiCa wire with the calculated data. From Figure 10, it can be concluded that the return of SiCa at the enterprise is somewhat lower than the calculated data.



CONCLUSIONS

The calculation of deoxidation of metal by aluminum was made. The final dissolved oxygen content is 1.5 ppm according to the calculated data, and the actual content is 2 ppm. But when metal is deoxidized, 66.3 kg of aluminum is given at the enterprise, and according to the calculated data, 48 kg must be given, in the future, excessively given aluminum forms unfavorable NMI during secondary oxidation of the metal. To prevent the formation of NMI, it is necessary to reduce the return of Al, and also protect the metal from secondary oxidation.According to the results of studies of metal samples by microrentgenospectral analysis and FGA, three main types of non-metallic inclusions were identified: aluminates, silicates and spinels. The high content of aluminates can be explained by the introduction of Al as a deoxidizer.An increase in the content of total nitrogen and oxygen, as well as the amount of NMI in the metal, is observed at the CSCM, this is explained by the secondary oxidation of the metal during the casting of steel.