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Technology for Cleaning Non-Metallic Inclusions and Gaseous Pores in the Process of Liquefaction of Steels in an Electric Arc Furnace

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Abstract: In this article, the technology of liquefaction of high-grade steels and increase of resource efficiency is developed. Non-metallic inclusions are foreign particles trapped in steel during the manufacturing process. The inclusions have different chemical compositions and affect the mechanical properties of steel in different ways: ductility, hardness, mach inability and corrosion resistance. As a rule, the less non-metallic inclusions are contained in the steel, the higher its quality. Therefore, the analysis and documentation of non-metallic inclusions is an important step in quality control.

Keywords: Non-metallic inclusions, inclusion, ductility, hardness, electric arc furnace (EAF), ferroalloy, slag, coke, flux, electrode, liquefaction, melting.

INTRODUCTION

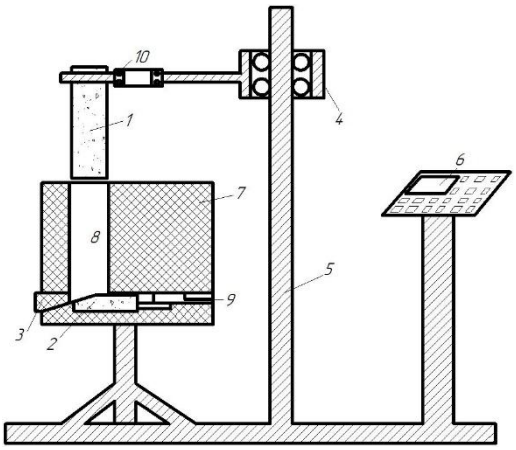
In the Americas, ASTM E45 is the primary quality standard for the analysis of non-metallic inclusions in steel. Quality control laboratories make extensive use of the Reference Scale Comparison Method (ASTM) for the analysis of inclusions. The operator visually assesses the type and severity of the inclusions by comparing the optical image in the microscope with a reference micrograph placed next to the microscope. Non-metallic inclusions in steel and alloys are mainly chemical compounds of metals with oxygen, sulfur, nitrogen, and other inevitable non-metallic impurities, present in the form of a separate phase; Non-metallic inclusions worsen the quality of the metal, since during its operation they can serve as centers of destruction. Chemical composition distinguishes oxygen, sulfide, nitride, phosphate, and other nonmetallic inclusions. are found in the form of simple oxides (FeO, Al_2O_3, SiO_2, etc.), complex oxides such as spinels ($FeO \times Cr_2O_3$, $MgO \times Al_2O_3$, etc.) and aluminates, silicates and silicate glasses ($2FeO \times SiO_2$, $3Al_2O_3 \times 2SiO_2$, etc.). Sulfide Non-metallic inclusions are most often present in steel in the form of manganese and iron sulfides, which form a continuous series of FeS - MnS solid solutions. There are also sulfides CaS, TiS, ZrS, etc. Nitride Non-metallic inclusions are found in significant quantities in steels and alloys alloyed with nitride-forming elements; the most common are TiN, ZrN, AlN, NbN, VN. By origin, endogenous, exogenous and exoendogenous non-metallic inclusions are distinguished Endogenous non-metallic inclusions are formed by the reaction of steel components with oxygen, sulfur and nitrogen dissolved in it. Exogenous non-metallic inclusions are refractory erosion products, slag particles, inclusions from ferroalloys, ores, etc., which did not have time to float to the

surface of liquid metal or dissolve. Exoendogenous nonmetallic inclusions are exogenous nonmetallic inclusions that have changed their composition due to reactions occurring at their interface with the metal. Dimensions of non-metallic inclusions range from a few mm to fractions of a micron. A distinction is made between macro-inclusions (> 1 mm) and micro-inclusions (1 mm or less). When the metal is deformed, some non-metallic inclusions or their accumulations are crushed, stretched and form defects called hairs [1-9].

According to the results of experiments conducted by professors and researchers of the Department of "Casting Technologies" in the "Casting-mechanics" plant of JSC "Uzmetkombinat", currently working in abrasive operating conditions in a number of enterprises of mining, metallurgy, chemical engineering and others. many parts are being cast from alloy steels. Alloy steels are mainly made of parts that work under operating conditions with high aggressive environments and abrasive corrosion. Therefore, there is great interest in these steels in the production and processing of our country. Alloy steels have high performance properties, from which it is important to obtain quality castings. This is because the alloying properties of steel with various alloying elements, especially chromium, improve depending on the amount of chromium. In addition, the ductility of alloy steels is very sensitive to the formation of its microstructure, that is, when obtaining alloy steels, it is necessary to ensure not only the quality of the casting, but also the formation of a microstructure that ensures the abrasion resistance of steel.

MAIN PART

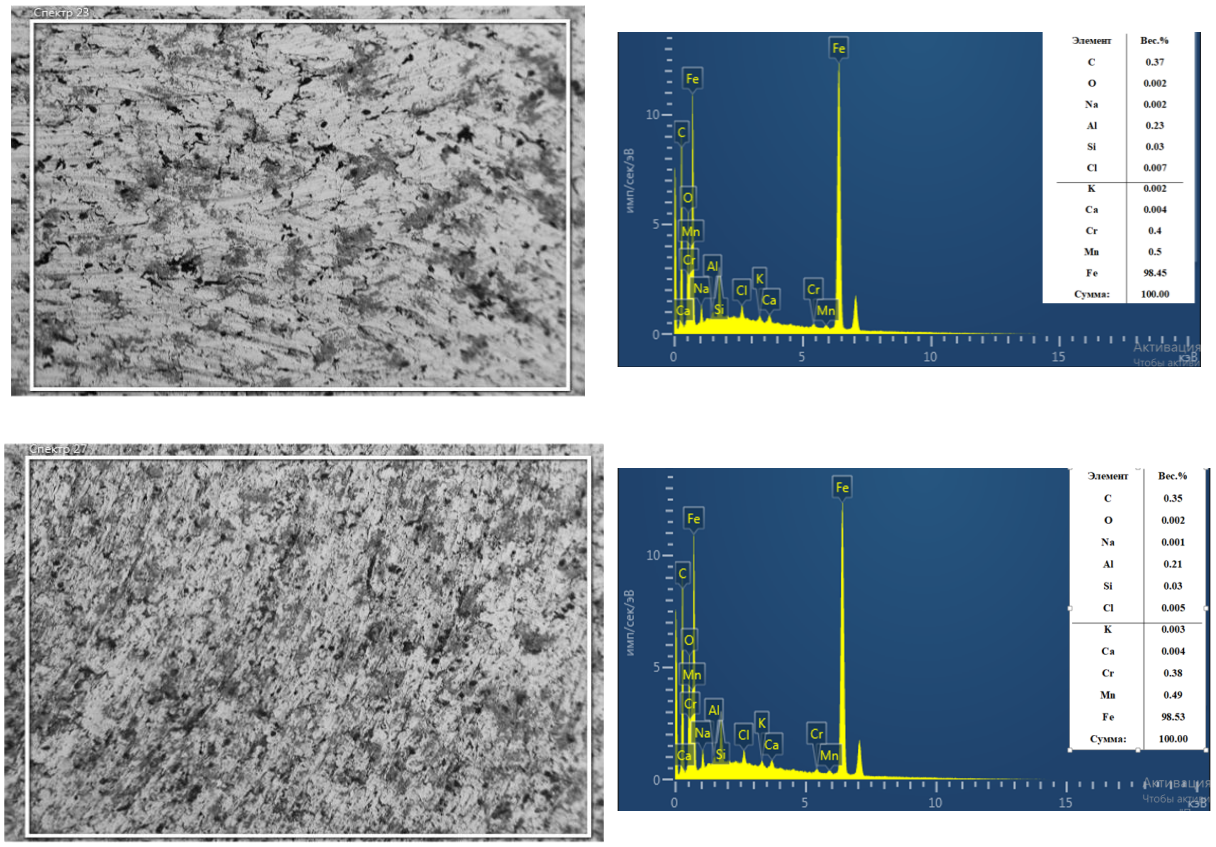
Professor teachers and researchers of the Department of "Casting technologies" of Tashkent State Technical University studied the problems of production of the plant "Casting mechanics" of JSC "UzMetkombinat". During the casting of 110Г13Л, 35ХГСЛ and 65Г steels, which are cast in sand-clay molds in this plant, there are problems with non metallic inclusions, gaseous pores and cracks. The castings are manufactured with high surface roughness, the presence of non-metallic alloys and pores, the large size of the cast parts for machining, due to the lack of modern casting technology. many parts have problems with casting during casting. In the laboratory of the Department of "Casting Technologies" in the process of liquefaction of steel alloys in an electric arc furnace was carried out research work on the removal of non-metallic inclusions and gaseous pores in steel [10-14].



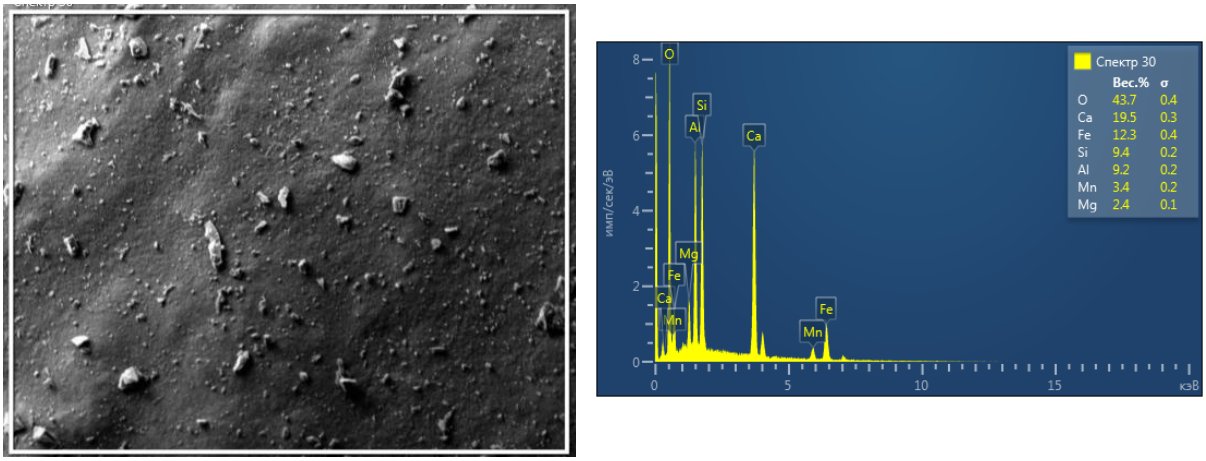
Pic 1. *Construction of special electric arc furnace in the laboratory of the Department of "Casting Technologies"*

1-high graphite electrode, 2-lower graphite electrode, 3-liquid metal outlet, 4-moving electrodes mechanism, 5-furnace stand, 6-electrodes remote control mechanism, 7-lining material, 8-charcoal loading place, 10,11- high voltage electricity.

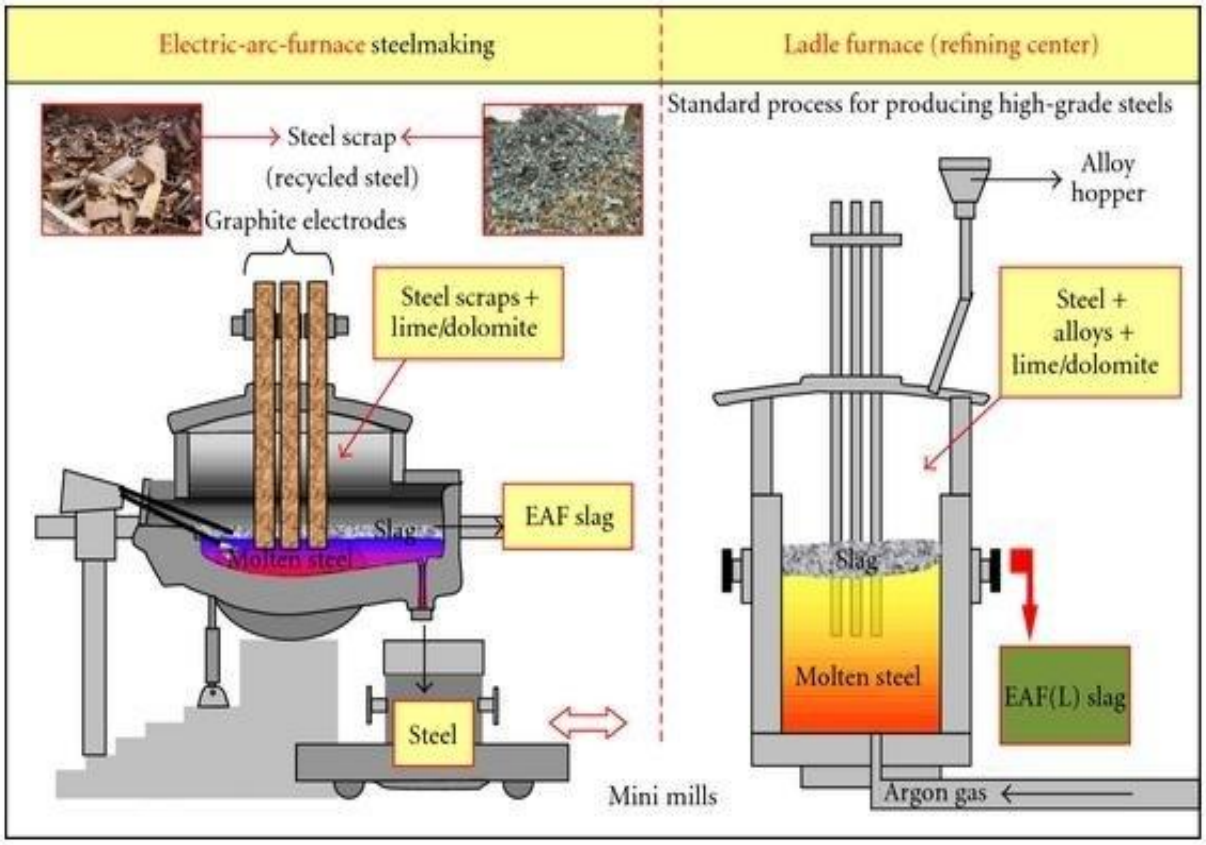
We clean these non-metallic inclusions using flux (chemically), until the metal is removed from the furnace to the bucket, 3-5% of the mass of the liquefied metal is added to the molten slag in the electric furnace. Then molten steel is poured into it. This increased the rate of reactions due to the rapid mixing of the steel with the slag and the increase of the contact surfaces, and the metal was purified to almost 65% from gaseous and non-metallic inclusions[14-22].



SEM micrographs of experimental stell specimens



SEM micrographs of experimental slag obtained from research results



Schematic representation of the electric-arc-furnace steelmaking and ladle refining process. (Source: Google image)

CONCLUSION

In the last few years, many efforts have been made by experimenting with alternative melting methods and by improving traditional methods. In the first research, the following amount of slag was introduced during the liquefaction of the secondary metal in the electric arc furnace, which mainly resulted in the liquefaction of high-quality steel with a change in the amount of ANF-6 flux in the furnace, as well as 7-9% slag.

In the electric arc furnace, a flux was introduced into the liquid metal in order to liquefy the secondary metal and produce quality castings. The main purpose of the introduction of flux is to obtain pure quality metal from slag and nonmetallic additives in the slag. To do this, after the furnace was started, secondary charcoal was loaded into the furnace, and ferroalloys FeSi75 and FeMn90 were added to the liquid metal in order to return Fe from FeO.

Extraction of non-metallic inclusions and gaseous pores by processing of steel alloys with inert gases by extraction of the furnace, as well as the technology of obtaining high-quality castings has been developed. The technology of cleaning steel alloys in an optimal way, cleaning them using synthetic slag and pouring them into sand-clay molds has been developed.

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