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# REDUCTION OF GAS PORES AND NONMETALLIC IMPLEMENTS IN CASTINGS FROM 35ХГСЛ AND 110Г13Л STEEL

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**Abstract**
A technology has been developed for producing high – quality foundry products with high physical and mechanical properties without non – metallic and gaseous pores by treating steel grades 35ХГСЛ and 110Г13Л with oxidizing elements in and outside the furnace.

**Keywords**: electric arc furnace, lining, alloy, flux, low – alloy steel, limestone, quartz sand, ferroalloy, ferromanganese, ferrosilicon, oxidation, reduction.

## Introduction

Today, it is important to develop methods for the production of iron and its alloys and obtaining high – quality ingots from them. In particular, the production of stainless types of steel increased rapidly [1, 2]. Methods of obtaining steel in quantities of industrial importance are called steel metallurgy. An alloy of iron deformed by carbon and other elements is called steel [3]. The composition of steel includes carbon, manganese, silicon, sulfur, phosphorus. Alloying additives are added to the metal to obtain special properties: chromium, nickel, molybdenum, tungsten, copper, neobium, vanadium, etc., and a large amount of manganese and silicon. Obtaining iron in its pure form is a difficult and expensive process. For this reason, the technology of melting low – alloyed steels has been developed at the production enterprise [4 – 8].

## RESEARCH METHODS

Nowadays electric arc and induction furnaces are widely used for melting products made from high – quality steel alloys in bulk. One of the most important priorities for melting in an electric arc furnace is to obtain quality castings.





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**Figure 1. Melting process of 35ХГСЛ steel alloy in a 500 kg electric arc furnace in the foundry mechanics workshop of "UzMetkombinat" JSC [9].**

Therefore, in order to melt high – quality cast products from 35 ХГСЛ and 110Г13Л steel alloys, an electric arc furnace consisting of a 500 kg base liner was selected in the foundry workshop of the "UzMetkombinat JSC" enterprise [9 – 12]. Furnace linings are divided into acidic and basic types. Basic furnaces are widespread, the walls are made of magnesite bricks, and the bottom is covered with magnesite powder. As a flux, limestone is used for basic furnaces, and quartz sand is used for acid furnaces [13, 14 – 18].

First of all, the chemical composition of low – alloy steel alloy brands 35ХГСЛ and 110Г13Л was developed by the production enterprise. The developed chemical composition can be seen in Table 1.

**Table 1 The chemical composition of the alloy developed by the enterprise**

| Brand | C | Si | Mn | Cr | Mo | W | Ni | S | P |
|---|---|---|---|---|---|---|---|---|---|
| **35ХГСЛ** | 0.32–0.40 | 0.6 – 0.9 | 0.9 – 1.2 | 0.7 – 1.0 | 0.1 – 0.2 | 0.2 – 0,3 | 0,03 – 0.04 | 0,015– 0.025 | 0,015 – 0.025 |

Based on the developed chemical composition, it was found that the shafts have glassy inclusions and gas pores after pouring into a sand – clay mold. Defects of shafts cast from factory – cast 35ХГСЛ low – alloy steel alloy are shown in Fig. 2 [19 – 24].

**Figure 2. Defects of cast shafts are shown**





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The causes of the above problems and the appearance of mirror inclusions were studied and several methods were analyzed [25 – 28].

**In the first way:** non – metallic inclusions include modifiers and non – metallic inclusions with ferroalloys. In addition, due to the oxygen contained in the air, the alloy is oxidized and metal oxide is formed.

**In the second way:** non – metallic inclusions occur as a result of mold sand being added to the metal composition, furnace lining (lining) being added to the metal composition in the process of melting the alloy.

Researchers have developed a technological route to prevent these defects. The chemical composition of the alloy in the developed technological route is shown in Table 2 [29 – 35].

**Table 2 Developed chemical composition**

| Brand | C | Si | Mn | Cr | Mo | Ni | Al | P | S |
|---|---|---|---|---|---|---|---|---|---|
| **35ХГСЛ** | 0.32–0.40 | 0.6 – 0.9 | 0.9 – 1.2 | 0.7 – 1.0 | 0.1 – 0.2 | 0,03 – 0.04 | 0.3 – 0.5 | 0,015–0.025 | 0,015–0.025 |

СПЦ – 1 and СПЦ – 2 (Ст3 – Ст5) samples, ferrosilicon FeSi75, ferromanganese FMn88, FMn90, ferrochrome FX100, and coke pieces were used as solid materials for melting 35ХГСЛ brand steel.

For the purpose of reoxidation, the following were used.

– cast aluminum Al – 1 and Al – 2;

– pieces of coke ГОСТ 3340 – 88.

The following alloying elements were used as alloying elements.

– ferrosilicon ГОСТ 1415 – 93;

– ferromanganese ГОСТ 4755 – 91;

– ferrochrome ФХ100 ГОСТ 4757 – 91

The following were used as slag formers and as coating agents on the surface of liquid metal [16]:

– TSh 64 – 14869486 – 01:2007 “Limestone of the Kuterminsky mine.

All charge materials: metal part, slag forming agents and reoxidizers were used [36 – 40].

**RESULTS**

**Figure 3. 35ХГСЛ low – alloy steel melt – cast shaft detail without defects**





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In Figure 3, the shaft detail is placed in the 35ХГСЛ sand – clay mold, the samples are removed from the sand – clay mold, and the surface of the samples is cleaned with SiC. Then it was determined on the spectral analysis device of the "SPEKTROLAB – 10 M" model and is listed in Table 3 [41, 42].

**Table 3 Chemical composition of melted 35ХГСЛ brand**

| Brand | C | Si | Mn | Cr | Mo | Ni | Al | P | S |
|---|---|---|---|---|---|---|---|---|---|
| **35ХГСЛ** | 0.35 | 0.7 | 1.1 | 0.8 | 0.1 | 0,03 | 0.4 | 0,020 | 0,018 |

The samples were metallographically examined in laboratory conditions at a magnification of x500 to x1500 in an optical microscope, and the obtained result is shown in Figure 4.

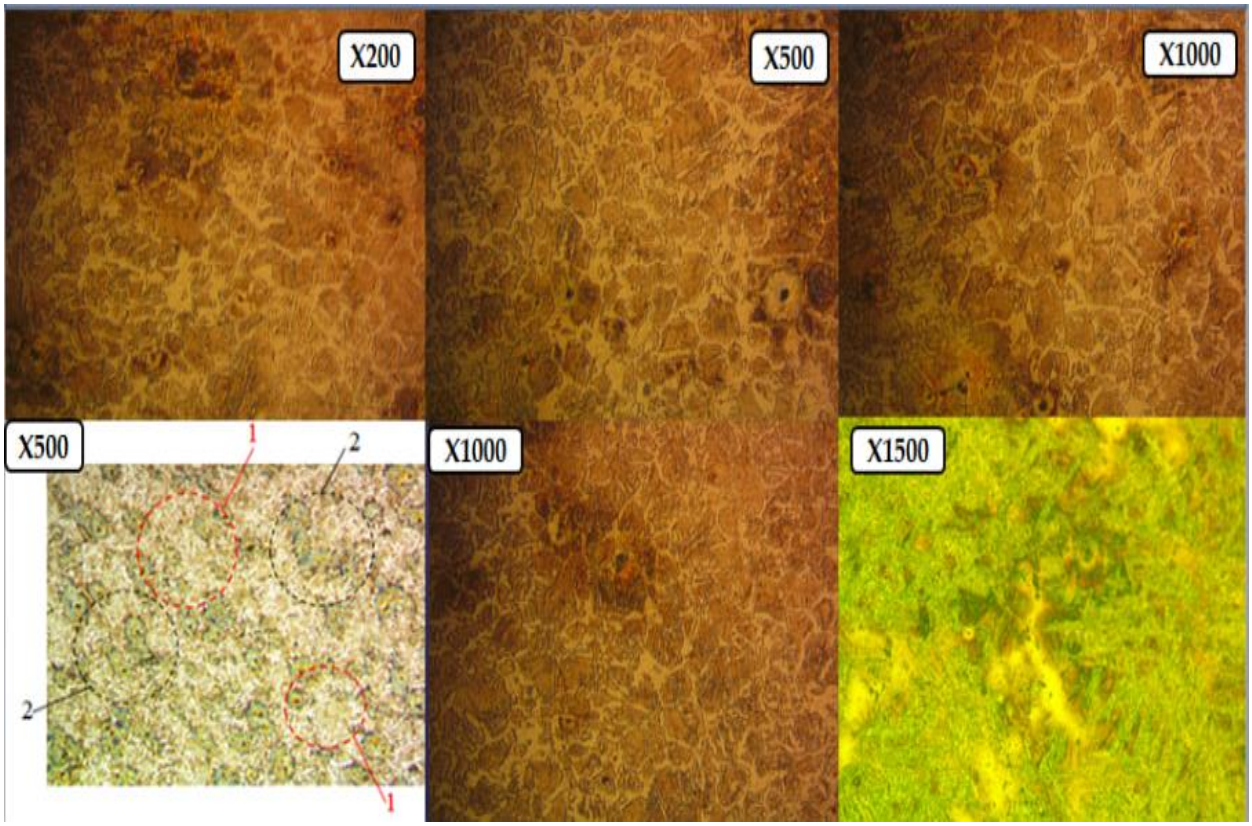


**Figure 4. Microstructures of the samples obtained under an optical microscope**

As can be seen in Figure 4, a ferrite – pearlite and less austenite structure was observed when the samples were magnified from x500 to x1500 times in an optical microscope. It was observed that the hardness of the sample after heating to 880 $^{o}$C is 47 – 51 HRC according to Rockwell, and the structure after tempering is martensite and residual austenite [43 – 45].

## CONCLUSION

The technology of obtaining high – quality cast products with high physical and mechanical properties, free of non – metals and gas pores, was developed by treating liquid metal with additives of 35ХГСЛ and 110Г13Л steel alloys in the furnace and outside the furnace.

The technology of melting 35ХГСЛ and 110Г13Л alloys in an optimal way and pouring them into sand – clay molds has been developed.





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