Improvement of the Melting Technology of 35ХГСЛ Brand Steel Alloy in An Electric ARC Furnace

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Abstract. In this article, technologies for liquefaction of cast products from low alloyed steel alloys in an energy and resource – efficient way have been developed. In addition, the useful efficiency of the electric arc furnace has been increased based on the dynamics of loading the solid materials into the furnace. Also, before loading the solid materials into the furnace, the solid is summarized and the liquefaction technologies in the electric arc furnace have been improved.

Key words: low alloyed, ferrite, pearlite, plate – like, non – metallic inclusions, gas pores.

INTRODUCTION

There are four main factors that significantly affect the wear – resistance of steel alloys: a) heat treatment, b) alloying and modifying elements, c) the effect of carbon content, d) the effect of primary and secondary carbides. Factors affecting plastic deformation, for example, grain size of cast, recrystallization temperature, hardness, deformation rate affect the wear – resistance of steels. It is recommended that steel have a fine grain structure for good wear – resistance.

Studies have shown that low alloyed steels are recommended for use as wear – resistant materials. Microstructures such as martensite, ferrite and pearlite present in low alloyed steels provide good wear – resistance. Some research results show that martensite and ferrite two – phase steel have good wear – resistance based on microstructure and test conditions. Corrosion resistance increases with increasing volume fraction of martensite.

MATERIALS AND METHODS

Improvement of the technology of liquefaction of low alloyed steel alloy in an electric arc furnace. A new chemical composition of the alloy and liquefaction technologies have been developed for shaft parts made of low alloyed steels by casting method. At the same time, on the basis of ensuring energy and resource efficiency, the casting technology of the sand – clay mold was developed based on the modification of the construction of the mold. As a result, the alloy was liquefied in an electric – arc furnace based on the technologies presented in the "Casting – mechanics" workshop of "Uzmetkombinat" JSC in order to obtain low – cost and quality cast products.

First, a new composition was developed to change the chemical composition of low alloyed steel.

Table 1
Chemical composition of the proposed low alloyed steel

Brand	Elements, %										
	C	Si	Mn	Cr	Mo	W	Al	Ni	Ti	S	P
Samle 1	0.32 – 0.40	0.6 – 0.9	0.9 – 1.2	0.6 – 1.4	0.1 – 0.2	0.2	0.3 – 0.5	0.04	0.3 – 0.5	0.020 – 0.025	0.020 – 0.025

The procedure for loading charge materials into the furnace. It should be noted that large charge materials should be located near the electrodes, and easily liquefiable components were loaded on the near walls, away from the electrodes. The main reason for this is the temperature of up to 3500^0 C in front of the electrodes. If small charge materials are loaded near the electrodes, the amount of charge burns will increase. Therefore, large charge materials were loaded near the electrodes, thereby reducing the percentage of charge burning to 6 – 8 %. In addition to the chemical composition, the weight of the secondary metals and its location in the furnace are of great importance for the correct flow of the charge liquefaction process. Loading procedure: 20 – 30% of light and small – sized charge materials are loaded into the bottom of the furnace bath, one of the important aspects of which is to protect the lower refractory wall parts of the furnace from mechanical damage. 40% of large size and high weight charge materials were loaded into the electrode part of the furnace, between the small and heavy charge materials, charge – forming materials were loaded.

30 – 40% medium – sized aggregates were placed along the side walls of the furnace. This arrangement of charge materials ensured their good compact arrangement and sufficiently stable burning of electric arcs during the liquidation period.
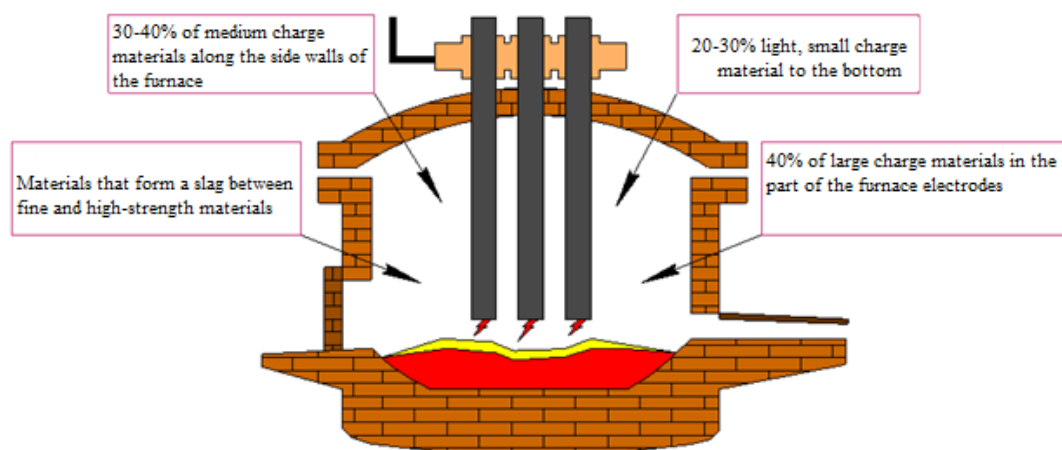
1 – figure. Technology of liquefaction of low alloyed steel alloy in an electric arc furnace
Liquefaction technology. Depending on the power of the supply transformer, the total time of the frost liquefaction period was 100 – 120 minutes. In the process of liquefaction of secondary metal scraps in an electric arc furnace, liquefaction of each part of the charge in the furnace bath included the following stages [1-5].

• the first stage is the period from the beginning of the liquidation of the initial phase to the liquidation of the fragments in the metal bath;

• the second stage lasted from the liquidation of most of the metal fragments to the level of the liquid metal bath, including the opening of the combustion arc;

- the third stage included the period of liquefaction of charge materials located near the edges of the furnace bath;

- the final stage is the liquefaction of the pieces of charge remaining near the walls of the metal bath and the raising of the metal bath to a sufficient temperature.

On the basis of the given proposal, based on the chemical composition, charge was calculated and liquefied in an electric arc furnace. Charge composition and calculation: initially secondary metal, 22 kg of ferromanganese (FeMn90), 11 kg of ferrosilicon (FeSi75), 14 kg of ferrochromium (FeCr100) ferroalloys and 0.4 kg of Ni, 120 kg of oxide (FeO), 50 kg of quartz sand, 6 kg of coke, based on the weight of 10 kg of limestone ($CaCO_3$) liquid metal, 5 kg of Al to be added as a modifier and 5 kg of FeTi70C1 to the slurry were extracted. In order to speed up the process of arc formation, 1 kg of coke was loaded into the electric arc furnace. The system of automatic control of the location of the electrodes was activated, depending on the size of the furnace through the copper cables of the transformer, a voltage of 170 W, a current of 50 – 75 A was supplied, and an electric arc was formed between the electrodes and the metal of the slab. As a result of the increase in the temperature of the electric arc, the frost began to heat up and melt. Then 40 kg of FeO was added and the furnace was turned on at a voltage of 216 W and a current of 75 – 100 A. An additional 30 kg of FeO was added to the furnace, after 6 minutes the furnace was turned off and the electrodes were lifted. Voltage 170 W, current 50 – 75 A, the oven has been restarted. An additional 40 kg of FeO was added to the furnace. After 10 minutes, the furnace was turned off and the liquid metal temperature was determined to be 1621^0 C using a Heraeus digitemp – e thermocouple. A sample of the liquid metal was taken and sent to the rapid laboratory of the "Casting – Mechanics" workshop to determine the amount of carbon in the alloy. When the chemical composition of the samples was checked, it was found that the amount of C was 0.43%. To moderate the amount of carbon in the liquid metal, an additional 10 kg of FeO was added and the furnace was started. After 6 minutes, the furnace was turned off and the liquid metal temperature was determined to be 1640^0 C using a Heraeus digitemp – e thermocouple. After that, high melting point ferroalloys ferrochromium (FeCr100), ferrosilicon (FeSi75) and ferromanganese (FeMn90), all ferroalloys that reduce Fe from FeO, and a specified amount of Ni were introduced into the furnace. 4 kg of limestone ($CaCO_3$) was introduced into the furnace as a flux material in order to make the liquefaction process go well and to separate the slag and clean the liquid alloy content.

When the metal in the furnace bath turned into a liquid state, oxidation of the metal and its components and separation of slag began. The slag was formed from the products of oxidation reactions of additives, non – metallic additives (added to the furnace in the slag), limestone, and the decomposition of the refractory layer [6-11].

Samples were poured into special molds prepared to determine the chemical composition of liquid metal. In the central laboratory of Ozmetkombinat JSC, the following chemical composition of the samples was obtained using the Spectrolab LAV M12 device (table 2).

Table 2

**Chemical composition of the examined samples**

Brand	Elements, %										
	C	Si	Mn	Cr	Mo	W	Al	Ni	Ti	P	S
Sample 1	0.42	0.80	1.05	0.83	0.015	0.003	0.365	0.08	0.074	0.034	0.026

Microstructural analyzes of cast samples. Low alloyed steels usually form a two – phase microstructure during hardening and cooling. The two phases identified in this structure are ferrite

and martensite. The ferrite phase usually precipitates at the grain boundaries and is called granular ferrite.
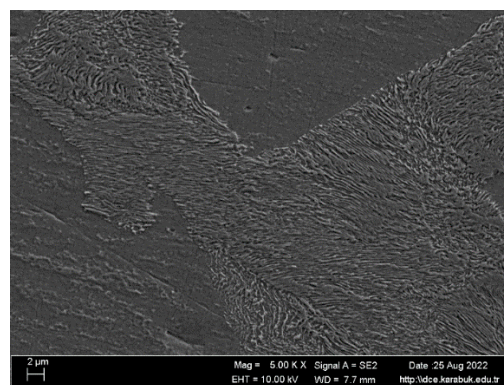
a)   x2000   b) x5000

2 – figure. Microstructure images of a low alloyed steel alloy taken with a Zeiss Ultra Plus Field Emission SEM scanning electron microscope at x2000 and x5000 magnification

The microstructure of pearlite is shown at higher magnification in Figures 2 – a – b, it can be seen that the (parallel – plate) microstructures consist of ferrite, pearlite and less cementite. Accordingly, when the carbon content of these samples was increased from 0.08 to 0.35%, the excess carbon appeared in two different structures, cementite particles and cementite carbide phase in pearlite. Here, both structures help to increase the hardness and strength of the steel [12, 13].

CONCLUSION

As a result of the technology of liquefaction of low alloyed steel alloy in an electric arc furnace in an optimal way, the cast product was liquefied based on energy and resource efficiency.

Purification of the liquid alloy using an inert gas resulted in a quality cast product free of non – metallic inclusions and gases. As a result of the introduction of the developed technology, the amount of gas pores in the cast products obtained from steel alloy has decreased..

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