



DEVELOPMENT OF THE TECHNOLOGY OF STEEL MODIFICATION FOR THE MANUFACTURE OF LARGE, PARTICULARLY RESPONSIBLE CAST PARTS

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Abstract

A study was carried out on the refining and modification of steel in a steel-pouring ladle using flux-cored wire grade PP-TM14-FeVAlCa. Steel grade 20GL was used as the test metal. The results of various variants of refining, both traditional and steel processing by combining the operations of deoxidation and desulfurization with flux-





cored wire, are presented. The paper presents the results of a study of the mechanical properties of steel grade 20GL for various processing options.

Keywords: metal refining, steel modification, flux-cored wire, steel desulfurization, impact strength.

Introduction

The growth of requirements for the properties of steel, as a rule, outstrips the development of technological methods aimed at increasing the purity of the metal. As a result, further search for effective methods of refining, alloying and modification of steel is necessary. In this regard, the development of new technological methods of smelting and out-of-furnace processing, which make it possible to effectively refine and modify steel, is an urgent task.

At present, in the production of steel, flux-cored wire (FC) is widely used, which has a high affinity for oxygen, sulfur, nitrogen, non-ferrous metals and other impurities. The most efficient use of FC is in combination with solid slag mixtures (SSM). In this case, in each specific case, it is necessary to pay attention to both the selection of TSS and the level of metal oxidation before the introduction of FC. The influence of FC is manifested both in a decrease in the content of the above impurities in steel, and in their transfer from active forms to passive ones, which helps to clean the grain boundaries and ensures the formation of a finely dispersed dendritic structure. Purifying steel from harmful impurities, FC improve its casting properties, fluidity, conditions for pouring molds and crack resistance of castings, and also reduce the anisotropy of the mechanical characteristics of steel. The high efficiency of the effect of FC on the properties of steel is due to their favorable effect on the composition, type, shape, quantity and uniformity of the distribution of the resulting non-metallic inclusions, a significant improvement in the macro and microstructure of the workpiece, a decrease in its physical and chemical heterogeneity, providing increased density and dispersion of the crystal structure in all zones of a cast billet, including small sections.

This work is devoted to the development of new technological methods of smelting and out-of-furnace processing, in particular, the improvement of the processes of refining and modification of steel in a steel-pouring ladle using FC.

The starting metal was prepared in an induction crucible furnace with a capacity of 6 tons. After carrying out the desulfurization process in an induction crucible furnace, the reducing slag was partially removed and the metal was tapped into a ladle.

In order to increase operational reliability and improve mechanical properties, the





steel in the ladle was treated with aluminum Al, silicocalcium (SC) and FC according to four different options, with argon purge without exposing the metal for 5 minutes. The chemical composition of steel 20GL, adopted for the study, is shown in table 1.

Table 1 - Chemical composition of steel grade 20GL

C	Mn	Si	S	P	Cr	Cu	Ni	Al
Content of elements by weight, %								
0,206	1,296	0,427	0,015	0,019	0,162	0,177	0,121	0,026

The results of melts using FC are presented in Table 2. The initial sulfur content in the metal before treatment was 0.015%.

Table 2 - The main results of melting when using FC for desulfurization of steel 20GL

Option processing	Q _R , masses%	τ _{выд} , min	[S] _{finite} , %	[O] _Σ , %	[Al] _{finite} , %	[V] _{finite} , %
1	Al - 0,1	5	0,015	0,0095	0,026	-
2	1- additive: Al - 0,1 2- additive: SC 30 - 0,1	5	0,014	0,0089	0,030	-
3	1- additive: Al - 0,1 2- additive: FC - 0,1	5	0,011	0,0075	0,044	0,025
4	1- additive: Al - 0,1 2- additive: SC 30 - 0,1 3- additive: FC - 0,1	5	0,008	0,0016	0,056	0,045

As can be seen from the data given in Table 2, depending on the melt processing mode, the sulfur content in the metal decreased from the initial values ([S]_{finite}) 0.015% to 0.011 ... 0.008%. The content of total oxygen in the metal treated according to option 4 is 5.9 times less than when using the technology according to option 1 (traditional for this enterprise).

The results of the study of the mechanical properties of steel 20GL after normalization are shown in the table in table 3.



Table 3 - Mechanical properties of steel grade 20GL

Option processing	Property Category				
	Yield strength σ_T , MPa	Temporary resistance σ_B , MPa	Relative extension δ , %	Relative contraction ψ , %	Impact strength, $\kappa J/m^2$ (at -60 °C)
	He мeнee				
ГОСТ	343	510	18,0	30,0	200
1	387	534	21,0	37,3	210
2	355	527	24,2	35,2	234
3	402	537	24,0	37,9	417
4	404	534	24,2	38,1	540

As can be seen from the data shown in Table 3, the highest values for mechanical properties were obtained when processing metal according to option 4, especially the value of impact strength, 2.57 times higher than with the technology according to the base option (BO).

This is due, first of all, to a decrease in the number of non-metallic inclusions in steel and their more uniform distribution in the bulk of the metal.

Melts treated with FC are characterized by a higher degree of deoxidation and desulfurization. This lead, first of all, to a decrease in the amount of oxide, sulfide and complex composition of non-metallic inclusions in the steel, as well as to their uniform distribution in the volume of the metal, which coagulate into macro clusters and then are partially removed from the liquid steel by floating.

Conclusions

Thus, the results of the study of the quality of steel 20GL, processed according to various options in the ladle, allow us to draw the following conclusions:

- A new concept of metal modification technology has been proposed, which allows improving the quality of finished products and increasing the yield of good parts of railway bogies;
- The introduction of PP made it possible to obtain a metal with a significantly lower content of sulfur (up to 0.008%), total oxygen (up to 0.0016%);
- The technology of the process of modifying steel in a steel-pouring ladle with a capacity of 6 tons, made it possible to improve mechanical properties, especially the value of impact strength is 2.57 times higher than with traditional technology;



- Quantitative dependences of the technological parameters of metal modification were obtained, which form the basis of the new technological instruction for the production of steel 20GL;
- On the basis of complex semi-industrial research, a rational technology was developed and mastered for modifying 20GL steel using flux-cored wire, which provided a unique combination of service properties of railway bogie parts.

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