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IMPROVING THE QUALITY OF STEEL USED FOR THE MANUFACTURE OF CAST PARTS OF ROLLING STOCK THROUGH THE USE OF MODIFIERS

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Abstract
The growth of requirements for the properties of steel, as a rule, outstrips the development of technological techniques aimed at improving the purity of the metal. As a result, it is necessary to further search for effective ways of refining, alloying and modifying steel. In this regard, the development of new technological methods of smelting and out-of-furnace processing, allowing to effectively refine and modify steel, is an urgent task.
This work is devoted to the development of new technological methods of smelting and out-of-furnace processing, in particular, improving the processes of refining and modifying steel in a steel ladle using PW.
The initial 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 released into the bucket.

Keywords: steel production, steel grade 20GL, powder wire, solid slag mixtures, dendritic structure, crucible furnace, desulfurization, casting properties, fluidity, mechanical properties.

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1. Introduction

Currently, in the steel production, powder wire (PW) is widely used, having a high affinity for oxygen, sulfur, nitrogen, non-ferrous metals and other impurities. The most effective use of PW in conjunction with solid slag mixtures (SSM). At the same time, in each specific case, it is necessary to pay attention to both the selection of SSM and the level of metal oxidation before the introduction of PW. The influence of PW is manifested both in reducing the content of the above-mentioned impurities in steel, and in transferring them from active forms to passive ones, which helps to clean the grain boundaries and ensures the formation of a finely dispersed dendritic structure. By cleaning steel from harmful impurities, PW improves its casting properties, fluidity, mold casting conditions and crack resistance of castings, as well as reduces the anisotropy of the mechanical characteristics of steel. The high efficiency of the PW effect 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, reducing its physical and chemical heterogeneity, providing increased density and dispersion of the crystal structure in all areas of the cast workpiece, including small cross-section.

2. Methods

The initial 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 released into the bucket.
In order to increase operational reliability and improve mechanical properties, the steel in the bucket was treated with aluminum Al, silicocalcium SC and PW in four different variants, with argon purging without exposing the metal for 5 minutes. The chemical composition of 20GL steel, adopted for research and thermodynamic calculations, is shown in Table 1.

Table 1 - Chemical composition of steel grade 20GL

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

The results of melting using PW are presented in Table 2. The initial sulfur content in the metal before processing PW was 0.015%.

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Table 2 - Main results of melting when using PW for desulfurization of 20GL steel

Variants	Q_R, mass.%	τ_{exc}, min	$[S]_{con}$,%	$[O]_{\Sigma}$, %	$[Al]_{con}$, %	$[V]_{con}$,%
1	Al - 0,1	5	0,015	0,0095	0,026	-
2	Al – 0,1; СК 30 – 0,1	5	0,014	0,0089	0,030	-
3	Al – 0,1; PW– 0,1	5	0,011	0,0075	0,044	0,025
4	Al–0,1; СК30 –0,1; PW – 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 treatment mode, the sulfur content in the metal decreased from the initial values ($[S]_{ini}$) 0.015% to 0.011 ...0.008%. The total oxygen content 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 20GL steel after normalization are shown in the table in Table 3.

Table 3 - Mechanical properties of steel grade 20GL

Processing option	Property category				
	Yield strength σ_t, MPa	Temporary resistance σ_v, MPa	Elongation δ, %	Relative contraction ψ, %	Impact strength, kJ/m2 (at -60 ℃)
	at least				
GOST	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

3. Results and Discussion

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

This is primarily due to a decrease in the number of non-metallic inclusions in steel and their more uniform distribution in the volume of metal.

Smelts treated with PW are characterized by higher deoxidation and a degree of desulfurization. This leads, first of all, to a decrease in the number of oxide, sulfide and complex composition of non-metallic inclusions in steel, as well as to their uniform distribution in the volume of metal, which coagulate into macrosclusters and then are partially removed from liquid steel by surfacing.

4. Conclusion

Thus, the research results by the quality of 20GL steel processed according to various variants in the bucket allow us to draw the following conclusions:

- a new concept of metal modification technology has been proposed, which makes it possible to improve the quality of finished products, improve the macro- and microstructure of metal and increase the yield of suitable parts of railway trolleys;
- The introduction of PW made it possible to obtain a metal with a significantly lower sulfur content (up to 0.008%), total oxygen (up to 0.0016%);
- The technology of the process of modifying steel in a steel ladle with a capacity of 6 tons, allowed the improvement of mechanical properties, especially the impact strength value is 2.57 times greater than with traditional technology;
- Quantitative dependences of the technological parameters of metal modification were obtained, which are the basis of the new technological instructions for the production of 20GL steel;
- On the basis of complex semi-industrial research, a rational technology for modifying 20GL steel with the use of powder wire has been developed and mastered, which provided a unique combination of service properties of railway trolley parts.

The results are introduced into industrial production DP "Foundry and Mechanical plant" JSC "Uzbekistan railways".

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