

Increasing the Operational Stability of Railway Core by Modifying

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Abstract. At the present time in conditions of high intensity use of the railways of great importance paid to longer service life the railroad tracks, elements turnout in particular crosspieces. The main element of the railway track turnouts are carrying out a change of direction of movement of trains. Many translations have exhausted their time and are obsolete. From is technical condition turnout's largely dependent reliability of rail transport.

Turnouts are the most complicated structure in the railway. Individual elements of the railway line – the spider who perceives high impact loads. Crossings should have sufficient strength and wear resistance because undergo complex dynamic loads. High dynamic impact and wear areas are also experiencing the antennae, which are located near the cores.

The basic technological aspects to improve the characteristics steel by modifying. The technology of producing high-manganese steel modified special modifier to improve the structural strength of receiving the item. As a result of a series of experimental heats received the samples that were subjected to mechanical testing. Structural studies have shown improvements steel microstructure as well as its mechanical properties.

Introduction

Successful decision facing rail problems in a timely manner and quality needs of the national economy and population in traffic due to the intensification of the transportation process based on advanced technologies and improve the reliability of hardware.

The introduction of the railway rolling stock of a new generation, characterized by an increase in consumer – performance and environmental qualities, is impossible without solving to improve the maintenance of track, including rails, fasteners, rail base, ballast, turnouts.

A special place in the road economy occupy crossing railway tracks, are quite complex in construction, operating in more difficult conditions than the main path, and which are responsible and expensive elements of the permanent way.

Turnouts are time-tested technical devices. Simultaneously, due to the increase in load due to increased train speed and weight, they become a weak point in the operational activities and limit the capacity of railways.

Currently is West-Siberian railway in operation for about 11% of defective turnouts. In the main ways is a 9.8% defective frog. Defects switch ties more than 11%. On the road, not enough attention is



paid to conduct work to extend the life of turnouts and their elements. Complexity of conducting of traveling facilities in Siberia caused by the harsh climate, high traffic volumes in and axial loads.

All this determined special urgency and urgency of improving the operational reliability of switches, their components and elements, an improved system of management of the switch.

And increase the requirements for automation and remote control devices in rail transport, track superstructure, which should provide a high degree of safety of trains. Link automation devices and track superstructure are track circuits, which have made it possible to ensure the safety, maximum throughput and the carrying capacity of the land and plants. Unfortunately, in the current track circuits on the railway network situation is far from satisfactory. Over 40% of device failures falls on the automation track circuits. In this case, statistics show that 50% of the track circuit failure occurs due to a malfunction of the insulating joints. Therefore, as a responsible member of the system, ensuring the safety of trains, track circuit failures on the number of standing in one of the first places.

In this regard, great importance attaches to measures aimed at improving the reliability of existing track circuits, in particular, an increase in the probability of failure-free operation of the insulating joints by improving their quality and to determine their optimal reserve to rebuild failed and preventive replacements.

One of the most widely used wear-resistant materials for the manufacture of switches is manganese austenitic steel serving for the manufacture of parts, wear is accompanied by strikes and heavy loads.

Improving the structure and properties of high-manganese steel wear, which wear resistance, resistance to high static and dynamic loads are much superior to most known materials used for the manufacture of switches, and at the same time the material is highly sensitive to the melting conditions, a slight change in the content of C, Si, S, carbide and other alloying elements by conventional means - is a complex production problems.

Traditional ways of improving the properties of materials due to their composition is almost exhausted. In general, the properties of materials depend on the structural construction material at the micro level. In metallurgy it is known that steel and alloys with fine-grained structure has several advantages structural and technological properties to steels and alloys with a coarse texture. One of the promising areas produce alloys with fine-grained structure is a modification of insoluble ultrafine powders.

These studies are of interest both from the practical and theoretical points of view, systematization of knowledge in the production of casting alloys with given technological and structural properties and structure.

Results and Discussion

Effect of modification depends not only on the amount of administered modifier, but also on the conditions of subsequent cooling rate and heat treatment of the alloy. Inoculation efficiency is dependent on the activity of the additives, oxidation, gas saturation, metal contamination, its physico-chemical properties, the melt temperature, the duration of its exposure to the ladle, etc. Therefore, the development of steels and alloys, new grades should undertake a systematic study to the accumulation of reliable data to determine the optimal concentration of processing aids. The chemical composition of different brands of modifiers is presented in Table 1.

Furnace steel processing modifiers performed in order to improve its quality indicators and the following tasks:

- increasing fluidity;
- crushing of cast structure;
- reducing nonmetallic inclusions in steel;
- decrease in the propensity to crack,
- improving cold resistance, corrosion resistance and other service characteristics.

Table 1 – Chemical composition of the different brands of standard modifiers

Brand modifier	The content of the basic chemical elements, mass. %								
	Si	Ca	Ba	Al	Mg	Ti	Mn	Zr	Fe
SIBAR [®] 12	60.0-70.0	<2.0	11.0-14.0	<2.0	–	–	–		rest
SIBAR [®] 22	45.0-60.0	<3.0	20.0-30.0	≤3.0	–	–	–		rest
INSTEEL [®] 1.2	40.0-50.0	12.0-15.0	12.0-15.0	≤2.0	1.0-1.5	–	–		rest
INSTEEL [®] 4.1	40.0-50.0	8.0-10.0	7.0-10.0	1.0-3.0	1.0-1.5	8.0-12.0	–	–	rest
INSTEEL [®] 6	30.0-50.0	8.0-16.0	7.0-12.0	7.0-12.0	–	–	–	–	rest
Z-GRAPH [®]	60.0-70.0	–	2.5-3.0	–	–	–	6.0-7.0	6.0-7.0	rest
ZIRCALLOY [®]	70.0-75.0	1.5-2.5	–	<2.5	–	–	–	1.0-2.0	rest

The use of modifiers causes binding of sulfur, phosphorus, harmful gases and non-ferrous metal impurities, size reduction, spheroid zing and reduction in the remaining amount of metal inclusions, grain boundaries purification crystallizing the melt. Non-metallic inclusions become favorable morphology.

We use the modifier is different from the standard modifiers. Modifier used consists of ultra- and nanopowders zirconium, titanium, niobium, hafnium, vanadium, tantalum, copper, and aluminum; used as a reductant Na_3AlF_6 .

In this paper we investigated a series of samples cores of manganese steels produced by conventional manufacturing technology JSC "Novosibirsk Switch Plant" and with the use of a modifier based on ultrafine particles of metal oxides and cryolite. Modification of high-manganese steel production was carried out in conditions of "Novosibirsk Switch Plant" in the bucket with the addition of a modifier in the amount of 4 kg per ton of melt.

The purpose was to study the effect of the modifier on the basis of ultrafine metal oxide and cryolite on the chemical and phase composition, microstructure and mechanical properties of high-manganese steel cores.

In this paper, we obtain samples of the modified special steel modifier investigated its physical and mechanical properties that affect the structural strength of the material. Chemical composition of the investigated steel is given in Table 2.

Table 2 – Chemical composition of the investigated cores

Sample	Mass fraction of elements, %				
	C	Mn	Si	P	S
				no more	
normal core	1.00 – 1.30	11.50 – 16.50	0.30 – 0.90	0.09	0.02
not modified core	1.20	14.70	0.52	0.03	0.001
modified core	1.20	14.10	0.47	0.03	0.001

X-ray diffraction studies were performed on the X-ray diffract meter Shimadzu XRD 6000 ("Nano-Center" TPU, Tomsk) at a voltage of 40 kV and anode current of 30 mA, using $\text{CuK}\alpha$ -radiation ($\lambda = 1.5418 \text{ \AA}$), in increments of $2^\circ/\text{min}$. Used to decrypt the database catalogs JCPDS.

Found that the test samples are matrix austenite having dissolved therein carbon – phase (Fe, C) (№ cards 31-0619, Fig. 1). Changing the relative peaks in samples is due to preferred orientation of the grains.

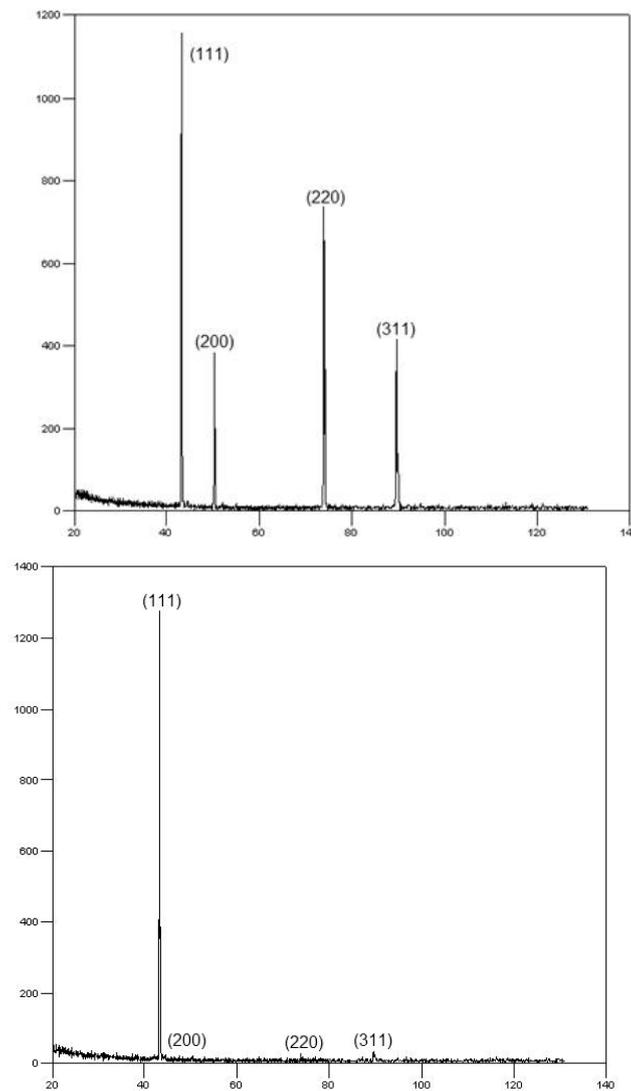


Figure 1. Core sample, № cards 31-0619

At cross-sectional samples are observed blowholes. The microstructure of the samples studied is an austenite inclusion along the boundaries and within the grains.

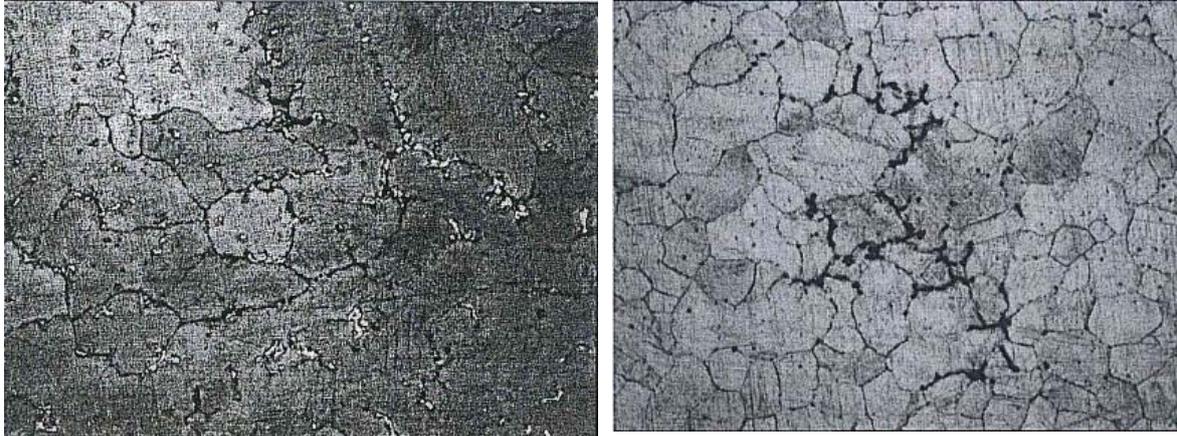
Impact modifier quality and structural characteristics of the samples were evaluated cores austenite grain size, number, shape and distribution of nonmetallic inclusions in the grain boundaries and inside the grains, the presence of the carbides.

Structure of unmodified and modified samples cores is austenite with non-metallic inclusions on the boundaries and within grains (Fig. 2). Studies have shown that after the introduction of the modifier changed austenite grain size and changed the character of the distribution of non-metallic inclusions (Fig. 2). The grain size in the unmodified sample is 85 μm . After modifying the grain size decreased to 15 μm .

In the unmodified samples in the horizontal cross-sectional at a distance of 10-15 mm from the bottom plane of the tide in all samples are observed globular carbides along the boundaries and within

grains. Also in the modified sample non-metallic inclusions are observed along the boundaries and within the grains.

Study of microstructure and local chemical composition was performed with an electron microscope Vega II LMU integrated with the X-ray energy dispersive microanalysis Oxford INCA Energy 350 (Regional Center for collective use of scientific equipment, Tomsk).



a) without the addition of modifier

b) after adding the modifier

Figure 2. Optical metallographic increase $\times 70$

Research samples without modifier showed that their microstructure is austenite with non-metallic inclusions on grain boundaries and inside (Fig. 3). In the not modified sample contains excessive carbides which reduce the strength and toughness of the steel.

Morphological characteristics and chemical composition of inclusions was investigated using scanning electron microscopy. Figure 3 shows that the non-metallic inclusions have a size of ~ 55 microns, and along the grain boundaries, they are placed in a thin layer between the grains.

Figure 4 shows the microstructure of the modified samples cores. The structure of the cores as well as in the unmodified sample is austenite with nonmetallic inclusions along the grain boundaries. It is seen that after modification significantly reduced the number of nonmetallic inclusions. In composition it is clear that non-metallic inclusions are mainly carbides, whose number has dropped significantly.

In the modified samples no carbides, blowholes, a decrease in the number and size of nonmetallic inclusions on the boundaries and within the grains, and visually observed to decrease grain size.

Modification of molten steel significantly improved homogeneity of the structure of steel, which in turn contributes to its density and it leads to improved isotropy, i.e. promotes uniform distribution of stress under load, reduces cracking, chipping and pore formation.

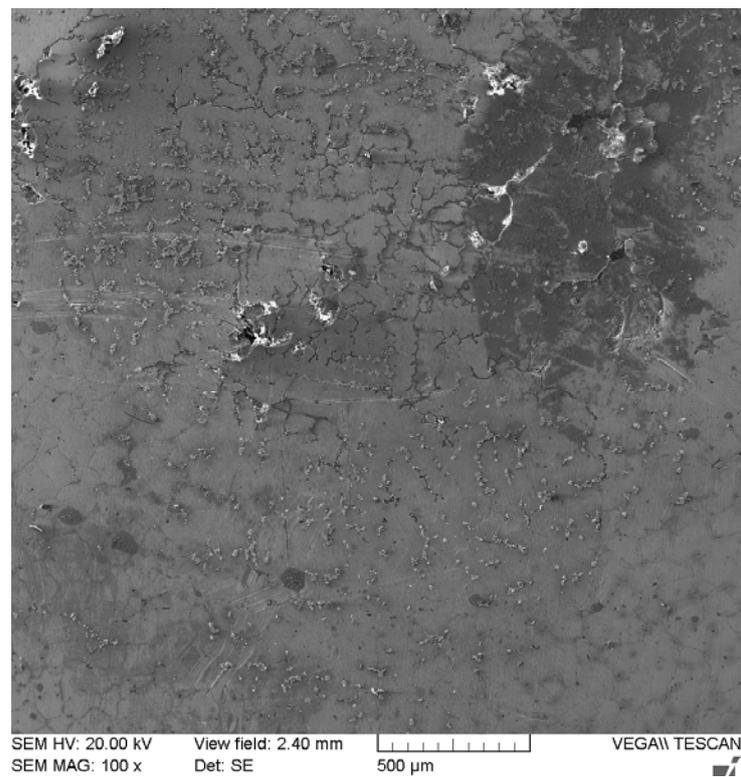


Figure 3. The microstructure of unmodified core

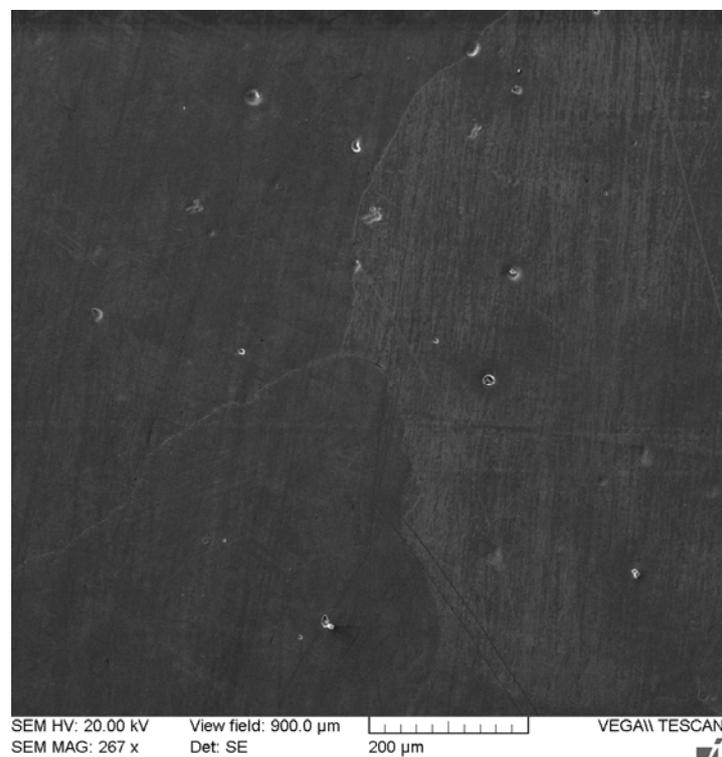


Figure 4. The microstructure of modified core

Calculating the size of nonmetallic inclusions showed that for samples without modifying the data sizes of inclusions are in the range from 18 microns to 145 microns, and the sample after introducing the modifier type inclusions sizes are in the range from 5 microns to 15 microns, i.e. observed a significant reduction in the size of non-metallic inclusions, which leads to a reduction in the range of sizes of inclusions and improves the density of the steel structure.

According to the results of mechanical testing of the modified and unmodified samples cores shown in Table 3, it is possible to judge small improvements in strength characteristics of steel.

Table 3 – Mechanical properties of cores

Sample	Tensile strength, kgf/mm ²	Tensile fluidity, kgf/mm ²	Specific elongation, %	Relative narrowing, %
not modified core	86,7	48	30,7	24,4
modified core	89,5	48	38,0	29,6

Conclusion

As a result, the modification does not change the basic chemical composition of the steel, but reduces the number and size of nonmetallic inclusions in the grain boundaries and also a decrease in grain size. Points to the improved quality obtained of metal. Introduction modifier significantly changes the mechanical properties of the samples, namely improving the service characteristics of the cores.

References

- [1] Cherepanov A N, Poluboyarov V A, Kalinin A P, Korotaeva Z A 2000 J. Materials **10** 45-53
- [2] Malushin N N, Valuev D V, Valueva A V, Serikbol A 2014 J. Applied Mechanics and Materials **682** 58-63
- [3] Turcan D A, Korzunin J K, Roschupkin V I 2010 J. Omsk Scientific Bulletin **2** 113-115
- [4] Davydov N G 1979 Manganese steels (Moscow)
- [5] Volynova T F 1988 Metallurgy (Moscow)
- [6] Fedoseev S N, Lychagin D V, Sharafutdinova A S 2014 J. Advanced Materials Research **1040** 236-240
- [7] Kalinin V T, Hrychikov V E, Krivosheev V A 2004 J. Metallurgical and Mining Industry **6** 38-42
- [8] Rodzevich A P, Gazenaur E G, Belokurov G M 2014 J. Applied Mechanics and Materials **682** 206-209.
- [9] Mulyavko N M 2001 J. Proceedings of the Chelyabinsk Scientific Center **4** 28-30.
- [10] Makarov S V, Sapozhkov S B 2014 J. World Applied Sciences Journal **29(6)** 720-723.