Preparation of High-Strength Details from Modified Steel Alloy 110G13L

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Keywords: High-Strength Steel, 110G13L Alloy, Ferromanganese Modification.

Abstract: In this article, in order to increase the friction of parts made of 110G13L modified steel (tank tracks (tracks), plows for tractors, railway relays, various parts that work under strong impact and friction), the Faculty of Mechanics of Tashkent State Technical University, "Casting Technologies Research work was carried out in the laboratory of the department. Ferromanganese-85 was added as a modifier to 110G13L steel in different amounts (0.1., 0.2., 0.3., 0.4., 0.5%) and melted in an induction melting furnace during the research. The chemical properties, hardness and structures of the molten samples were checked in the latest modern devices, and based on the results of the conducted research, it was found that the ductility of the steel parts increased.

1 INTRODUCTION

The scientists of the world conducted extensive research on the possibility of changing the structure of steel by heating and cooling the alloy, changing its internal structure, chemical, physical and mechanical properties, heating and cooling, and achieved results.

Today, machine-building is the main consumer of metals produced in our country. In the machine tool industry, in the automotive and aviation industry, in electronics and radio engineering, many machine and accessory parts are made from metals.

Metals used in technology are mainly divided into two groups - ferrous and non-ferrous metals. Ferrous metals include iron and its compounds (cast iron, steel, ferroalloys). The remaining metals and their alloys form the group of non-ferrous metals. Until now, iron and its alloys, considered the main machine-building material, are of particular importance among metals. Iron and its alloys make up 90% of metals produced worldwide. This is explained by the fact that ferrous metals have important physical and mechanical properties, as well as the fact that iron ores are widely distributed in nature, and the production of cast iron and steel is cheap and uncomplicated (Turakhodjayev et al., 2020a, b; Enloe et al. 2015).

The fact that metals have the ability to melt various elements allows the atoms of the substance surrounding the metal to diffuse into the metal at a high temperature, as a result of which the chemical composition of the surface layer of the metal changes. Diffusion of atoms into a metal is a chemical process, but temperature plays a major role in the course of this process, so the diffusion process cannot be considered a purely chemical process. Such processing, which changes the chemical composition of the surface layer of the alloy, is called chemical-thermal processing (Turakhodjayev et al., 2023). Types of chemical-thermal operation are described in detail when we study the literature of our country and foreign scientists. In recent years, the method of changing the structure of alloys while working under pressure is being used more and more widely (Umidjon et al. 2023; Ya Kozlov et al. 2003).). Such processing of alloys is called thermomechanical processing. When the alloy is deformed, not only its external appearance changes, but also a lump is formed in it, and this lumped alloy is thermally treated. Therefore, it is necessary to include thermomechanical performance in the process of studying literature specific to our various scientific research work of thermal performance. (Mirbabaev, 2004).

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Chorshanbiev, S., Atajanov, G., Abdullaev, F. and Nasirkhujaev, I.
Preparation of High-Strength Details from Modified Steel Alloy 110G13L.
DOI: 10.5220/0014262500004738

In *Proceedings of the 4th International Conference on Research of Agricultural and Food Technologies (I-CRAFT 2024)*, pages 287-293
ISBN: 978-989-758-773-3; ISSN: 3051-7710

In the scientific research centers of many developed countries, special attention is paid to the development of competitive techniques and technologies in order to increase the mechanical properties of modified steels of the 110G13L brand.

The leading scientists of the world, that is, Chinese scientist Li Huayun, Yuan Li conducted research on the topic "Effect of modifiers on the microstructure of high manganese steel". A modifier with potassium and sodium elements was selected for the experiment (Wang et al. 2019). As a result of the research, they found that it can reduce austenite grains and intercrystalline carbides, reduce the amount of pearlite in the microstructure of cast steel. British scientist Kuanshun Luo and Chinese scientist Jingshi Ju conducted research on the topic of "Crack resistance and crack mechanisms of high-manganese austenitic Gadfield steel by dry friction" (Turakhodjaev et al., 2020; Turakhodjaev et al., 2023
; Najafabadi, et al.2014). Vietnamese scientists Duvong Nam Nguyen and May Khan Pfamom and Japanese scientist Duvong-Nguyen Nguyen jointly conducted a study on the topic "Effect of rare earth metals on the structure and mechanical properties of high-manganese steel under impact loads" and reported that the mechanical properties were improved through the thermal treatment regime.

Gustav Tressi and Bianca Venturelli, scientists from the University of Sao Paulo, Brazil, conducted a study on "The effect of manganese content on the corrosion resistance and impact toughness of Gadfield steel." They modeled the process using Thermo-calc software to estimate the ranges of temperature phase changes and determine the casting parameters of the steel. All five steel variant castings were melted (1450-1500 °C) in induction furnaces with argon and several results were obtained (Yang et al., 2023; Nodir et. al. 2022).

2 METHODS

Induction melting of 110G13L modified steel alloy in laboratory conditions of Tashkent State Technical University, Faculty of Mechanics, "Foundry Technologies" department (INDUCTION MELTING MACHINE, Model: BF-TB2) was carried out in the furnace.

In the first stage of the research, 1 kg of 110G13L steel slag was loaded at 20^0C and liquefied at a temperature of $1250\text{-}1300^0$C. Then ferromanganese-85 in the amount of 0.2% was loaded into the liquid metal and the temperature in the induction furnace was raised to 1410^0C.

Figure 1: Induction Melting Furnace (Model: BF-TB2).

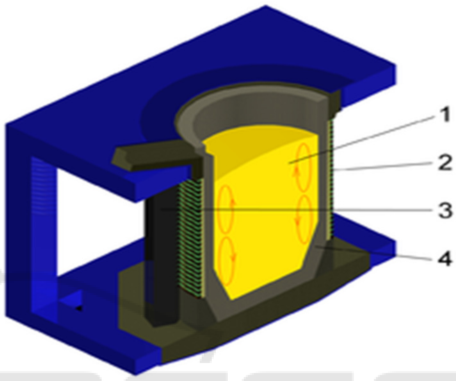

Figure 2: Induction Melting Furnace (Model: BF-TB2)

To determine the hardness of the obtained sample, the liquid alloy taken from the furnace was poured into a sand-clay mold at $1390\text{-}1410^0$C. The temperature of the liquid alloy was measured on a Kelvin PLTs 3000 device.

Figure 3: Kelvin PLTs 3000 equipment for measuring the temperature of a liquid alloy (Nodir et al., 2022).

3 RESULTS AND DISCUSSION

As a result of the research carried out in an induction furnace with the addition of 0.1% ferromanganese-85 as a modifier to 110G13L steel, the following indicators were obtained: the hardness of the surface parts of the sample according to HRB was 95.7 and 97.9, the hardness of the central part was 98.6, according to HRB average was 97.4, HB-217.8 according to Brinell.

Chemical properties were checked on the "Q4 TASMAN Bruker" device in the center of "INNO" Innovative Educational and Production Technopark on the territory of Tashkent State Technical University.

Figure 4: Kelvin PLTs 3000 equipment for measuring the temperature of a liquid alloy (Nodir et al., 2022).

Table 1: Chemical composition of steel, weight – %

Name of material	C	Si	Mr	P
FeMn - 85	1.15	0.50	11.55	0.056
Name of material	S	Cr	Ni	Mo
FeMn - 85	0.018	0.41	0.057	0.35

The hardness of the samples prepared in the mechanical workshop was determined by the TR-5018 PAS Tochline lathe, using a metallographic microscope at the MISIS branch of the Russian State "National Research and Technology University".

Received of results conclusion from that for comparison, in unmodified eutectic steel, primary molybdenum and chromium crystals up to 10 µm wide and 70 µm long have the dimensions shown in the above images. The mechanical properties and heat resistance of the alloy are partially improved.

The second stage of the study was carried out in an induction furnace with the addition of 0.2% ferromanganese-85 as a modifier to 110G13L steel.

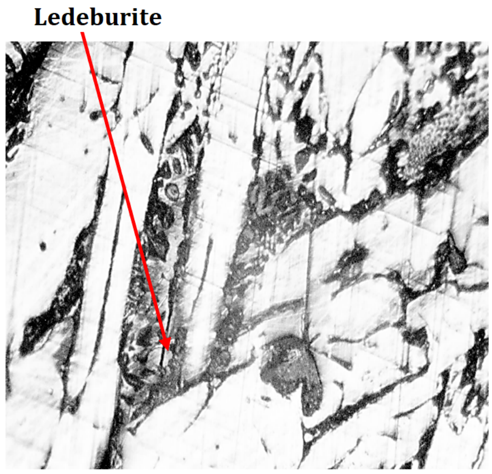

Figure 5: The results of structures obtained when adding 0.1% ferromanganese as a modifier to 110G13L steel, 1 x100 view.

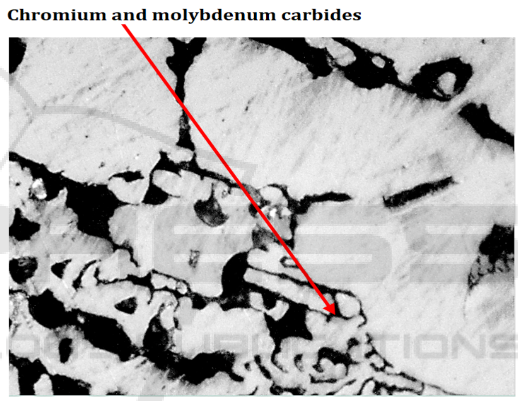

Figure 6: The results of structures obtained when adding 0.1% ferromanganese as a modifier to 110G13L steel, 2 x400 view.

The following indicators were obtained: hardness of the surface parts of the sample according to HRB was 96 and 97.7, hardness in the central part was 100.9, HRB The average was 98.2, according to Brinell HB-228.

When studying its structure and chemical properties, the following results were obtained.

Received of results conclusion from that is that small dispersion carbides of chromium and molybdenum can be seen in ledeburite layers. It reduces the size of molybdenum and chromium grains to 3-4 microns in width and 40-45 microns in length (Karimov et al., 2021; Mardonov et al. 2023).

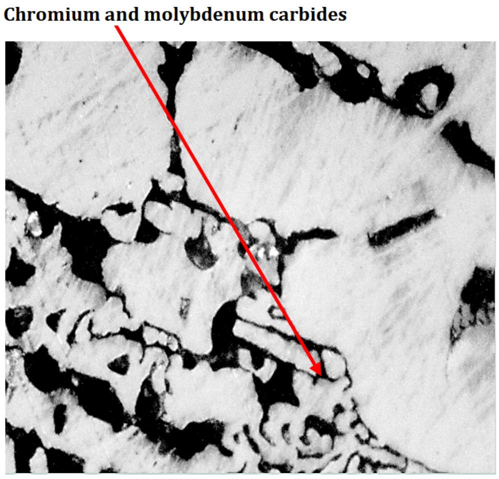

Figure 7: The results of structures obtained when adding 0.2% ferromanganese as a modifier to 110G13L steel, 1 x100 view.

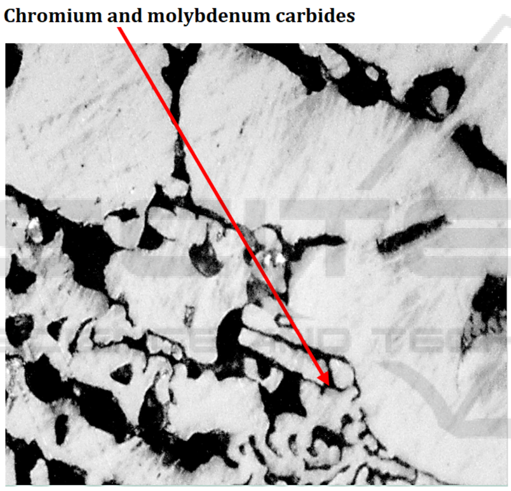

Figure 8: The results of structures obtained when adding 0.2% ferromanganese as a modifier to 110G13L steel, 2 x400 view.

Based on the results presented above, the following conclusions can be drawn: when 0.1% - 0.2% ferromanganese was added as a modifier to the composition of 110G13L steel , the hardness of the surface and central parts of the alloy was found as follows, i.e., when 0.1% ferromanganese was added, the hardness was HB -217.8 and adding 0.2% made HB-228. This explains the small amount of ferromanganese added as a modifier and the chemical reactions formed in the alloy did not take place at the same rate.

Table 2: Results of chemical properties obtained when adding 0.2% ferromanganese as a modifier to 110G13L steel are in %.

Name of material	C	Si	Mr	P
FeMn - 85	1.15	0.50	11.55	0.056
Name of material	S	Cr	Ni	Mo
FeMn - 85	0.018	0.41	0.057	0.35

Table 3: Results of chemical properties obtained when adding 0.3% ferromanganese as a modifier to 110G13L steel are in %.

Name of material	C	Si	Mr	P
FeMn - 85	1.15	0.50	11.55	0.056
Name of material	S	Cr	Ni	Mo
FeMn - 85	0.018	0.41	0.057	0.35

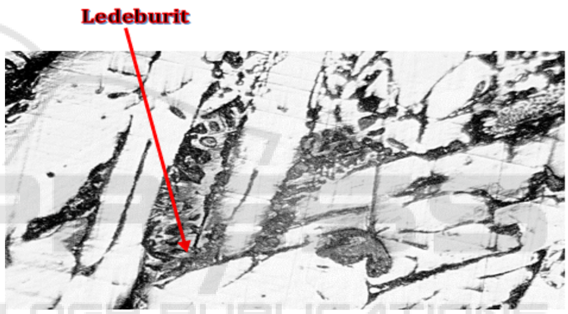

Figure 9: The results of structures obtained when adding 0.3% ferromanganese as a modifier to 110G13L steel, 1 x100 view.

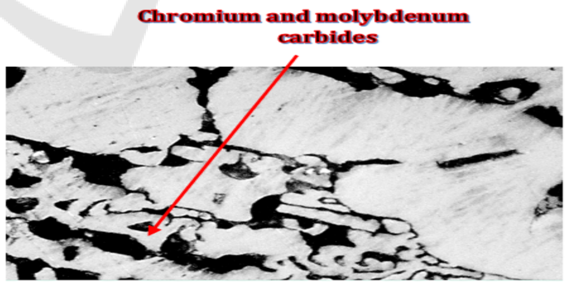

Figure 10: The results of structures obtained when adding 0.3% ferromanganese as a modifier to 110G13L steel, 2 x400 view.

The third stage of the study was carried out in an induction furnace with the addition of 0.3% of ferromanganese-85 as a modifier to 110G13L steel. The following indicators were obtained: the surface hardness of the sample was 103.9 and 104.1, and the hardness in the central part was 105.3 , averaged

104.4 on HRB , HB-269 on Brinell.When studying its chemical properties and structure, the following results were obtained.
The microstructure of the sample shows that the columnar crystals are located on the upper ledeburite base, and the rounded crystals are chromium and molybdenum carbides among the ledeburite crystals. The effect of molybdenum (Fig. 7) was not noticeable, the heat resistance of the alloy may have increased.

The fourth stage of the research was carried out in an induction furnace with the addition of 0.4% ferromanganese-85 as a modifier to 110G13L steel. The following indicators were obtained: the surface hardness of the sample was 108.8 and 109.7, and the hardness in the central part was 113.4, averaged 110.6 on HRB, HB-311 on Brinell.

When studying its chemical properties and structure, the following results were obtained.

Table 4: Results of chemical properties obtained when adding 0.4% ferromanganese as a modifier to 110G13L steel are in %.

Name of material	C	Si	Mr	P
FeMn - 85	1.15	0.50	11.55	0.056
Name of material	S	Cr	Ni	Mo
FeMn - 85	0.018	0.41	0.057	0.35

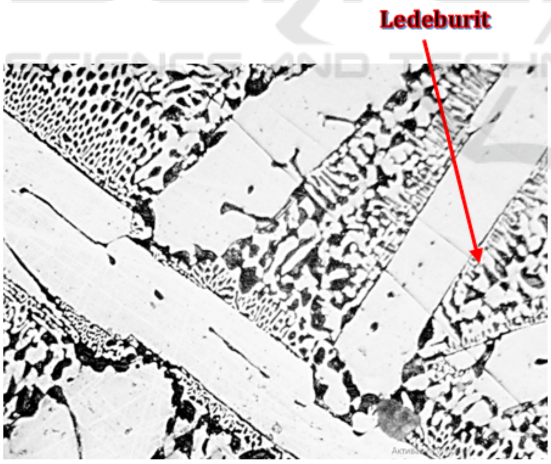

Figure 11: The results of structures obtained when adding 0.4% ferromanganese as a modifier to 110G13L steel, 1 x100 view.

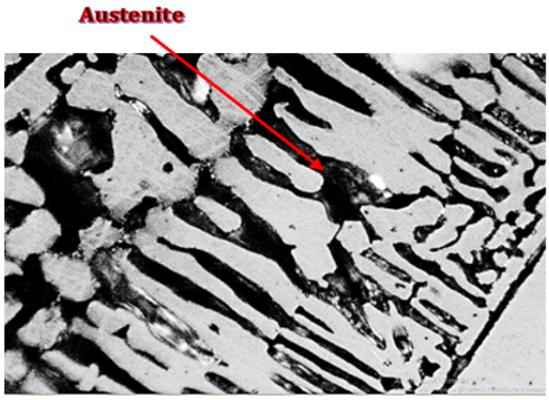

Figure 12: The results of structures obtained when adding 0.4% ferromanganese as a modifier to 110G13L steel, 2 x400 view.

Don't look at it microstructure high in ledeburit main of austenite big columnar are crystals . The size of the crystals is 37 micrometers wide and 30 micrometers long. Figure 8 shows the quasi-dendritic structure of ledeburite grains (Valuev et al., 2012).

Table 5: Results of chemical properties obtained when adding 0.5% ferromanganese as a modifier to 110G13L steel.

Name of material	C	Si	Mr	P
FeMn - 85	1.15	0.50	11.55	0.056
Name of material	S	Cr	Ni	Mo
FeMn - 85	0.018	0.41	0.057	0.35

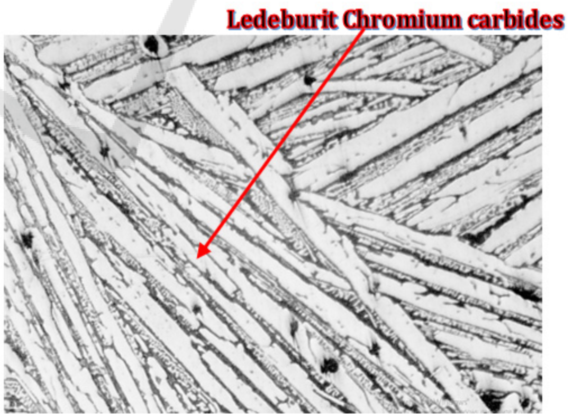

Figure 13: The results of structures obtained when adding 0.5% ferromanganese as a modifier to 110G13L steel, 1 x100 view.

The fifth stage of the research was carried out in an induction furnace with the addition of 0.5% ferromanganese-85 as a modifier to 110G13L steel. The following indicators were obtained: the surface hardness of the sample was 111.1 and 112.5, and the hardness in the central part was 113.8 , averaged 112.4 on HRB , HB-339 on Brinell.

When studying its chemical properties and structure, the following results were obtained.

The microstructure of the sample - in the form of primary crystals of high ledeburite. Crystals are 2-3 micrometers wide and 35-40 micrometers long.

The effect of chromium was manifested in changing the sizes of ledeburite grains, they became thinner and longer. A small amount of chromium carbides is present in the ledeburite mass.

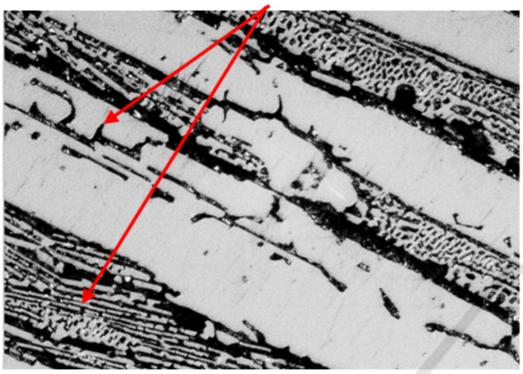

Figure 14: The results of structures obtained when adding 0.5% ferromanganese as a modifier to 110G13L steel 2 x400 view.

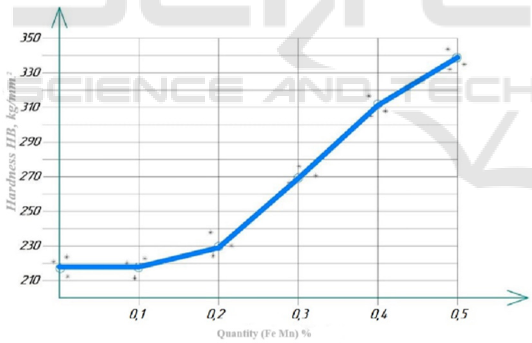

Figure 15: The highest hardness of 110G13L steel according to GOST is HB-217-229. 217.8 HB when 0.1% ferromanganese is added to the composition; 228 HB at 0.2%; 269 HB at 0.3% ; 311 HB at 0.4%; 339 HB at 0.5%.

Table 6: Hardness results.

Name of material	C	Si	Mr	P
FeMn - 85	1.15	0.50	11.55	0.056
Name of material	S	Cr	Ni	Mo
FeMn - 85	0.018	0.41	0.057	0.35

4 CONCLUSIONS

As a result of theoretical and practical research on the development of high-strength parts from modified 110G13L steel alloy, the following recommendations were developed:

1. Load ori musta h shortage to the composition have the details get for It is recommended to add ferromanganese in the amount of 0.4-0.5% as a modifier to 110G13L steel .
2. ferromanganese was added as a modifier to 110G13L steel in the amount of 0.4%, HRB-110.6 and NV-311 were measured according to Brinell .
3. ferromanganese was added as a modifier to 110G13L steel in the amount of 0.5%, HRB-112.4 and NV-339 were measured according to Brinell .
4. ferromanganese was added as a modifier to 110G13L steel in the amount of 0.4%, it was increased by 26.4%.
5. When 0.5% ferromanganese was added as a modifier to 110G13L steel, it was increased by 32.4 %.

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