Ferroalloy production: state and development trends in the world and Russia

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Abstract. The indicators of ferroalloys production and consumption in the Russian Federation, as well as the main producers of ferroalloys are presented. The changes in the structure of ferroalloy production in the world and Russia from 2009 to 2018 are shown. The main priority tasks of the domestic ferroalloy industry are listed, the solution of which will help to increase its competitiveness.

1. Introduction
Prospects for the development of the global ferroalloy industry are determined primarily by the corresponding trends in the “large” metallurgy, especially in the production of high-quality (special) steels, which consumes the bulk of the ferroalloys produced. By 2020, global steel production will increase to 1.814 billion tonnes in the Russian Federation, steel production will be about 78 million tonnes [1-3]. The growth in steel production, including steel of special high-alloy grades, entails the need to increase the production of ferroalloys – chromium, manganese, silicon, nickel.

A growing trend in recent years in the development of steel production such as complex alloying and microalloying of not only special, but also low-alloy steels of HSLA group – high-strength low-alloy steels should be noted. New steel grades are becoming more widespread, where up to 0.5% Ni, 0.5% Mo, 0.3% Nb and 0.3% V are also included along with traditional elements (Mn, Si and Cr). The expansion of the assortment of ferroalloy production with regard to meeting the needs of the steel industry with such steel grades is primarily associated with the smelting of ferroalloys of the small tonnage group – alloys of nickel, titanium, niobium, molybdenum, vanadium and ferrovanadium, ferro-tungsten, etc.

2. Mineral resources base
By 2020, the world production of manganese ore is forecast at 58.8 million tonnes, which is caused by an increase in the consumption of manganese ferroalloys in connection with the projected increase in steel production. In South Africa, by 2020, it is planned to increase the production of manganese ore to 16 million tonnes, which corresponds to an increase of 27% compared with the existing level. In Australia, manganese production will exceed 20% of the world level. In addition to these countries, manganese ore is mined in China, Brazil, the CIS countries, Gabon, India, Ghana, Malaysia.

To ensure the resource independence of Russian metallurgy in providing manganese ferroalloys, it is necessary to carry out work to create a domestic manganese ore base.
Russia has significant balance reserves of manganese ores (more than 290 million tonnes), forecast resources are more than 1 billion tonnes [4], but manganese ores of most domestic deposits are of low quality: with a low manganese content (18 – 33%) and high specific phosphorus content (P/Mn ratio > 0.006) they have a high content of iron and silica and are difficult to reach. At the same time, about 90% of the balance reserves fall on carbonate raw materials. In Russia, manganese ores are mainly represented by three types: carbonate, oxide and oxidized. The structure of confirmed reserves is dominated (90.2%) by poor carbonate ores (19.8% Mn) with a high phosphorus content (0.2 – 0.3% or more). The reserves of oxide ores containing 23 – 26% Mn are 6% [5]. The deposits are located in Kemerovo Region (Usinskoe), in Krasnoyarsk Territory (Porozhinskoe), in the Urals (Severouralskoye), in the Komi Republic (Parnokskoye), in Irkutsk Region (Novo-Nikolaevskoye), etc.

The largest manganese ore deposit in the country, Usinskoye, accounts for 55% of the country’s balance reserves. The manganese content in the ores of the deposit is 18 – 22%, the predominant type of ores is carbonate. The Usinsky ore cluster and the promising Kaygadat ore occurrence (Kemerovo region) together make up one third of the Russian forecast resources of manganese ores.

The ores of these deposits are characterized by low manganese and high phosphorus. Currently, scientific and practical research is being carried out with the aim of involving domestic manganese ores in the production and smelting of ferroalloys from them. At the same time, mining of manganese ores in Russia on a scale industrially significant for the ferroalloy industry is not currently conducted [5].

Chromium ore reserves are identified in 47 countries of the world, the largest deposits are concentrated in South Africa – 76% (1st place in the world). In the Republic of Kazakhstan, reserves are over 350 million tonnes – 9% (2nd place in the world). Next in the world in terms of reserves is Zimbabwe (with 6%) and Russia, deposits of which are concentrated in the Urals: Saranovskoye, Rais-Iz, Verblyuzhegorskoye (according to various estimates, from 0.5 to 2%). Significant reserves are also held by the USA, Greenland, Finland, India, the Philippines and Turkey – 6% in total [6].

Mining of chrome ore in Russia is at the level of 530 – 550 thousand tonnes per year with a Cr₂O₃ content of 37–39% in concentrate. New deposits are not commissioned, and the balance reserves amount to 51.2 million tonnes, forecasted – more than 540 million tonnes.

The world tungsten production volume is 85-87 thousand tonnes. The distribution of tungsten reserves in the world is shown in figure 1 [7]. About 2.6 thousand tonnes of tungsten are mined in Russia per year. In terms of tungsten production, Russia ranks third in the world.

3. Dynamics of ferroalloy production
Dynamics of world production of ferroalloys for the period 2008 – 2018 is shown in figure 2 [6, 8-10]. The world structure of production of ferroalloys has not undergone significant changes in recent years and corresponds to their world consumption. In the world, manganese alloys are in first place in terms of production volumes (figure 2). In Russia (figure 3), manganese alloys also occupy the first place in production growth: in 2015, 10.8%, and in 2018, 25.8%, with more than 2 times growth (figure 3). Among the ferroalloys on the Russian market in 2018, one can distinguish ferrosilicon with a share in the production volume of 49.39% and ferrochrome – 13.92%.

![Figure 1. Worldwide distribution of tungsten reserves.](image-url)
Figure 2. Change in the structure of ferroalloy production in the world.

(a) 2015

(b) 2018

Figure 3. Change in the structure of ferroalloy production in the Russian Federation.

The distribution of ferroalloy production by federal districts is shown in figure 4.
4. Production of certain types of ferroalloys

4.1. Production of manganese alloys
Currently, China accounts for 67% of the global smelting of silicomanganese, 53% – refined manganese alloys, and 48% – high-carbon ferromanganese. China is a leader in the production of electrolytic metal manganese. Its production is 97% of the world level.

Russia’s need for manganese ferroalloys is about 600 – 650 thousand tonnes per year. Of the imported manganese ores, mainly ferromanganese is smelted carbonaceous (JSC “Satka Cast Iron Plant” and PJSC “Kosogorsk Metallurgical Plant”), silicomanganese (JSC “ChEMK” and LLC “ZSEMZ”). The dynamics of ferromanganese production in Russia since 2015 has a positive trend, in 2018 there was an increase in indicators by about 14% [4-6, 8-10].

4.2. Production of ferrosilicon
The increase in steel production determines the increase in demand for ferrosilicon. The growth of ferrosilicon consumption in the world will be determined by demand in the Asian region.

Asia continues to play a leading role in the production of ferrosilicon. Along with this, an increase in alloy production is also expected in the CIS countries, the European region and South America. China and Russia are world leaders in the production of ferrosilicon; in China, 66% of the global volume is produced.

The main producers of ferrosilicon in Russia are JSC “ChEMK”; JSC “SZF”; JSC “Kuznetsk Ferroalloys”; JSC “Bratsk Ferroalloys Plant”. In 2018, the production of silicon alloys in Russia reached more than 890 thousand tonnes, with the export volume of about 50%.

4.3. Production of chromium alloys
A significant amount of chromium alloys produced is primarily high-carbon ferrochrome. The world production capacities for its smelting are distributed as follows: China accounts for 39.4% of world production, South Africa – 30%, Kazakhstan and Russia – 11%, India – 9%.

Russia is one of the leading exporters of ferrochrome and one of the five world leaders. Ferrochrome production capacities account for 6% of the world, and export more than three quarters of the production volume (figure 5).

The largest producers of chromium in the Russian Federation are JSC “ChEMK”, JSC “SZF”, JSC “KZF” and JSC “Tikhvin Ferroalloy Plant”. The dynamics of the production of alloys of ferrochrome and silicochrome is shown in figure 6.
4.4. Production of small tonnage ferroalloys

The main producers of niobium alloys are Brazil (about 90% of world production) and Canada. In 2014, the production and consumption of ferroniobium was estimated at 83 thousand tonnes; in the past 5 years, the growth has been approximately 4.9% annually.

About 80 thousand tonnes of tungsten-containing products are sold on the world market (data from 2018), of which about 20% of the total ferro-tungsten is accounted for, i.e., about 16 thousand tonnes. The largest producers and exporters of ferro-tungsten are countries such as China (2.8 thousand tonnes), Vietnam (2.2 thousand tonnes), Sweden (0.5 thousand tonnes). The tungsten content is usually from 75 to 85%. According to the results of 2018, the total volume of imports of ferrotungsten in the Russian Federation amounted to 13.3 thousand tonnes, exports – about 880 tonnes [11].

The main producers of ferromolybdenum and ferro-tungsten in the Russian Federation are OJSC “KZF” and LLC “Ryazan Ferroalloys and Ligatures Plant”. According to the results of 2018, ferromolybdenum production in Russia amounted to about 6.4 thousand tonnes.

The need for nickel is satisfied mainly due to electrolytic nickel produced at non-ferrous metallurgy enterprises. One of the largest producers of ferronickel is Indonesia, where the total ferronickel smelting capacity in Indonesia exceeded 140 thousand tonnes per year.

Ferronickel production in Russia is carried out at PJSC “Yuzhuralnickel” and LLC “Buruktalsky Nickel Plant”.

The global production and consumption of vanadium in the form of ferrovanadium will increase to 140 thousand tonnes by 2020. The main producers of ferrovanadium: China – 49.7% of world
production, South Africa – 13.9%, Russia – 7.8%, Europe – 6.7%, North America – 4.5%. In the Russian Federation, the production of ferrovanadium was established at JSC “EVRAZ Vanadium Tula” and JSC “Chusovsky Metallurgical Plant” [11].

The dynamics of ferrovanadium production in Russia is shown in figure 7.

Figure 7. Dynamics of production in Russia.

5. Conclusion
In the context of the aggravation of the struggle for the domestic and world markets of ferroalloys and the strengthening of import substitution of products, the urgent task remains to increase the competitiveness of ferroalloy enterprises in Russia by reducing production costs and improving product quality. The projected increase in steel production by 2020, primarily high-alloyed and low-alloyed steel of the HSLA group, will require a corresponding increase in the output of ferroalloys and ferroalloy raw materials. To achieve these goals, it is necessary, first of all, to solve the issues of energy supply of ferroalloy enterprises and increase the energy efficiency of ferroalloy processing, as well as provision with qualified personnel, the requirements for which are constantly growing.

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