

# INNOVATIVE APPROACHES WHEN CREATING MODERN ENVIRONMENTALLY SAFE AND ENERGY EFFICIENT FERROALLOY PRODUCTIONS

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Ukrainian research and scientific center “Energostal” started its history as the legal successor of the two largest in CIS scientific/research and design institutes “Giprostal” and “UkrNiimet” in 1928.

Today, the SE “UkrRTC “Energostal” is one of the largest scientific and research, technology, engineering and manufacturing centers in the CIS countries that executes complex project works aimed at establishing production plants with complete technological cycles for mining and metallurgical complexes. These works include:

- basic and detailed engineering;
- selection, manufacture and delivery of standard and non-standard equipment;
- construction and installation works, installation supervision, start-up and test runs, commissioning of facilities with designers supervision and follow-up to achieve designed capacity.

Along with implementation of these works, the Center provides design and support activities during the construction of enterprises, workshops and individual productions for the ferroalloy sub-sector.

Innovative approaches applied by the Center during design and establishment of modern ferroalloy industries and likewise during reconstruction of existing productions are fully consistent with the basic dimensional route of modernizing machinery and technologies at ferroalloy production enterprises worldwide. These approaches take into account requirements of international standards to environmental protection, reduction of industrial emissions during ore preparation (agglomeration), ferroalloy raw-material handling and smelting of ferroalloys, efficient use of energy resources and recycling of production wastes (dust, sludge, slag, smaller fractions of ferroalloy formed during crushing).

In areas of design, creation and introduction of new technologies and equipment for ferroalloy productions, SE “UkrRTC “Energostal” effectively cooperates with leading scientific and research organizations in the CIS countries – TSNIICHERMET n. a Bardin (Moscow, Russia), NPF “Ferroalloy” (Dnipropetrovsk, Ukraine), USSI (Zaporizhzhia, Ukraine), NMetAU (Dnipropetrovsk, Ukraine), CMI n.a. Abisheva (Karaganda, Kazakhstan) and others, as well as with leading Russian manufacturers of main technological equipment – JSC “Sibelektroterm” (Novosibirsk, Russia), JSC NPO “Electroterm” (Novosibirsk, Russia), “KOMTERM” (Moscow, Russia) and manufacturers in foreign countries – SMS Siemag AG (Germany), INTECO (Austria), Sinosteel JEMECO (China), TENOVA pyromet (PTV) LTD (South Africa) and others.

It is worth mentioning that in the former USSR, the creation of ferroalloy subsector of mining and metallurgical works and construction of the following ferroalloy plants was particularly resulted from the development of the Center:

- In Ukraine – Zaporizhzhia, Stakhanov, Nikopol;
- In Russia – Kuznetsk, Kluchevsk, Serov;
- In Kazakhstan – Aktobe and Aksu (former Yermakovskiy).

Executed in 1950 – 1998 according to the project design of the Center was a complete revamp and creation of five new workshops for ferroalloy production at Chelyabinsk metallurgical works (Russian Federation), which was initially designed and built by the German “Demag” company in 1928 – 1931.

Designed and built in NPO “Tulachermet” (Russian Federation) is a workshop for the production of vanadium and electrolytically refined chromium of high purity.

The re-scheduling project of carbide electric furnaces with capacity of 60MVA used for the smelting of manganese containing ferroalloys was implemented and completed in 1998–1999 for CJSC “Alash” (Termitau, Kazakhstan).

A workshop with three DC electric furnaces DSPT-12 for smelting high-carbon ferrochrome and special steels was commissioned in CJSC "Ferrot trading" (Zaporizhzhia, Ukraine).

Implemented in 2008 was the launch of a new plant for producing high-carbon ferrochrome in Tikhvin (Russian Federation).

In foreign countries – China, North Korea, Egypt, Bulgaria, India, Slovakia – constructed according to the Center's designs and put into operation were nine workshops and specialized plants for the production of various ferroalloys (containing manganese, ferrotungsten, ferromolybdenum, vanadium pentoxides and ferrovanadium, ferrosilicocalcium, ferrosilicon, ferrosilicochrome, low-carbon ferrochrome). Project development works in ferroalloy productions were also implemented for companies in Germany, Iraq, Brazil and Vietnam.

Industries and ferroalloy plants of the former USSR built according to the designs of the Center, were producing approximately 5.6 mln. ton/year of various ferroalloys and the output of enterprises in foreign countries is about 400 thousand ton/year.

The nomenclature of products manufactured in all plants designed by SE "UkrRTC "Energostal", totals more than 200 items – these are obtained by electric furnace, metallothermal, converter, vacuumization, nitrification, electrolysis, hydrometallurgical, smelting, mixing of molten alloys, powdered ferroalloy, electrically melted fluxes, complex modifiers and ligature methods. Total capacity of 260 electric furnaces (airtight, closed, semi-closed and open), installed in these enterprises amounts to ~ 470 MVA, including electric furnaces of 63 MVA – 14 units, 75 MVA – 6 units, 33 MVA – 20 units.

Two ferroalloy plants – Nikopol (with designed capacity of 1.2 mln. ton of ferroalloys a year) and Aksu (with designed capacity of 1.0 mln. ton of ferroalloys a year) are currently the largest ferroalloy production plants in the world.

Presently, the SE "UkrRTC "Energostal" remains the general designer of a number of ferroalloy plants in the CIS and is actively involved in reconstruction works at ferroalloy enterprises of Ukraine, Russia and Kazakhstan. In addition, discussions are going on with a number of companies in India, Egypt, Turkey and Poland for designing and building ferroalloy plants.

The project's working design implemented by the Centre for CJSC "Tikhvin Ferroalloy Plant" (Russian Federation) provides for reconstruction of the unfinished plant for special mode of casting on the industrial site of JSC "Transmash Plant" (Tikhvin). Work on the project was launched back in 1995, but was carried out with considerable interruptions. In 2005–2008, the Center made modifications to the technical part of project's working documents in parallel with construction works, and in 2008 the plant was commissioned with four electric furnaces for smelting high-carbon ferrochrome with a capacity of 140 thousand ton a year.

The design provides for the installation of four open electric furnaces of type RKO-16,5FKh-M with a capacity of 16.5 MVA each in the smelt shop and predetermined space planning decisions (spans and elevation points) for the existing shop building. The design of these electric furnaces was well fulfilled to ensure their safe operation.

Choice of electric furnace type (open, close or airtight) is conditioned by technological or economical expediencies:

– firstly, when implementing open electric furnaces, the raw material quality demands by their fractional compositions substantially lowers, which plays an important role in situations whereby steady supply of high grade lump chromic ore is not foreseen;

– secondly, due to increased requirements on atmospheric air protection and the establishment of very low maximum permissible concentration of chrome containing substances in the atmospheric air of populated settlements required for cleaning flue gases from the umbrellas of closed electric furnaces (and likewise for open electric furnaces) is the use of highly efficient gas cleaning installations. Availability, with a closed electric furnace, of two air cleaning systems (wet – for ferroalloy gas from the furnace's roof and dry with fabric filters – for flue gases from the furnace's umbrella and notches) leads to unjustifiably high capital and operational expenditures.

For airtight furnaces, gas cleaning from the umbrella above the furnace roof may not be implemented. The strict granulometric composition requirement to charge materials and the considerable cost of wet cleaning of ferroalloy gas with separate reverse recycling system for the polluted water and sludge treatment make its implementation under the site conditions of Tikhvin inexpedient.

Distinguishing features of CJSC "Tikhvin ferroalloy plant" as compared to similar plants with traditional layout include the availability of a general use furnace bay and individual casting bay for each electric furnace equipped with overhead electric cranes with lifting capacity of 20/5 t, and also the absence of unified finished product warehouses. Implemented in the casting bay is casting of alloys, crushing, sorting and dispatch of finished products.

Provided for cleaning dust-filled gas-air mixture, withdrawn from technological units, are the following gas treatment installations:

- gas cleaning unit № 1 – to clean the air-gas mixture withdrawn from the umbrellas and notches of electric furnaces № 3 and 4;
- gas cleaning unit № 2 – to clean the air-gas mixture withdrawn from the umbrellas and notches of electric furnaces № 1 and 2 and aspiration emissions from the smelting block;
- gas cleaning of storage compartments for charge materials and chromic carbon briquettes;
- aspiration unit for the coke preparation area in the charge material store.

Used in the project is an existing gas cleaning unit No. 1, which was provided for cleaning gases from six steel melting furnaces of DS-6N1 type. Used in all gas cleaning units are high efficiency bag filters with pulse regeneration (BFPR type) built according to the designs of SE “UkrRTC “Energostal”. Residual dust content after cleaning does not exceed 20mg/m<sup>3</sup>.

In 2009, the Center together with a number of leading Russian design and research organizations developed investment substantiation report for the construction of Enisei Ferroalloy Plant (EFP) with an output capacity of 620 thousand tons of manganese-containing ferroalloys a year. On achievement of maximum production capacity of this plant, the demands of all Russian mining and metallurgical complexes for manganese-containing ferroalloys shall be practically completely met.

EFP is a strategic facility of construction for the Russian Federation whose industries presently entirely depend on importation of manganese-containing ferroalloys, whereas this plant was planned to utilize ores from own raw material base. The purpose of its construction, planned to be fulfilled by CJSC “CHEK-SU. VK”, is the organization of an integrated technological process cycle of mining, enrichment and processing of manganese ores from the largest in Russian Federation Usinsk deposit, located in the Mezhdurechinsky district of Kemerov region.

Developed and approved by the main governing expert body of Russia in 2011 is the design documentation for the 1<sup>st</sup> phase of construction of EFP with production output up to 250 thousand ton a year of manganese ferroalloy. It envisages the construction of a ferroalloy producing plant does ahead the completion of the mining and processing plant. Initially, the plant will use imported manganese ores and later, after the commissioning of mining and processing plant, will use oxide and carbonate manganese concentrates from Usinsk deposit.

According to the technical specifications of SE “UkrRTC “Energostal”, TSNIICHERMET n. a Bardin together with the Center developed a new technological production process for manganese ferroalloys from Usinsk concentrates under the conditions of the construction site at LLC “Krastyazhmash” which were laid as the basis for all design solutions for constructing EFP.

The Center, at all stages of plant development, designed the engineering part of main facilities for production purpose, including ferroalloy workshops № 1 and 2, gas cleaning, aspiration installations, slag processing unit and repairs bay with a section for fabricating electrodes shells, and likewise the APCS, instrumentation and automation project of the entire plant.

The ferroalloy plant is planned to be built on the industrial territory of former Krasnoyarsk Heavy Machines Plant that was acquired by CJSC “CHEK-SU. VK”. Construction shall be carried out in two phases:

- I – shop № 1 with all the necessary infrastructures;
- II – shop № 2 with the later development of infrastructures.

Ferroalloy shop № 1 for producing high-carbon ferromanganese and ferrosilicomanganese was designed to include five open electric furnaces of RKO type with low umbrellas and of capacity of 33 MVA each. Shop № 2 will be designed to include four open electric furnaces of RKO type with low umbrellas and of capacity 63 MVA each. In addition to each furnace, the installation of gas cleaning unit with bag filters is envisaged to ensure the concentration of dust in emitted air into the atmosphere does not exceed 12 mg/m<sup>3</sup>.

Installation of open electric furnaces with low umbrellas (i.e. semi-closed) significantly reduces the amount of gas-air mixture flowing into the gas cleaning unit and exclude ejection of gases into the workshop. To minimize the volume of emissions into the atmosphere, thermo-crushing of liquid slag by water is carried out in the slag processing section. Provisions are made for suction of dusty air from process equipment followed by its purification from dusts in the aspiration installations, and complete utilization of production wastes – ferrosilicomanganese worked slag, slag-filled metals, associated phosphorus-containing metals, screens of coke and dusts, captured by gas cleaning units and aspiration installations.

The water requirement for technological needs is provided from the plant’s water recycling cycle, which completely eliminates the discharge of sewerages to outside water bodies.

The designed Enisei ferroalloy plant will take its rightful place among the best ferroalloy production plants of Europe and Russia thanks to the applied innovative approaches in developing the technology, choosing the main process equipment with modern automated technological control and energy monitoring systems, as well as the project design solutions, which comply with all international standard requirements for environmental protection.

The SE “UkrRTC “Energostal”, being the lead organization on environmental protection issues for the mining and metallurgical industries of Ukraine, promptly solves problems of cleaning waste gases from ferroalloy productions.

Open thermal ore furnaces in ferroalloy production plants are powerful sources of dust emissions into the atmosphere. Employed for the dry treatment of ferroalloy furnace gases, over a long period of time in the CIS and foreign countries are bag filters with reverse air blowing, basically under pressure. Several years of operational experiences have revealed a number of operational and design inadequacies of these filters.

An alternative solution for cleaning open ferroalloy furnace gases is the use of high efficiency suction bag filters with pulse regeneration of fabric.

For the first time in the CIS, the SE “UkrRTC “Energostal” developed and mastered the production of modern high efficiency bag filters (of BFPR type) with pulse regeneration and APC systems, which match the technical levels of bag filters from known foreign companies.

According to the Center’s design, introduced and successfully being operated are gas cleaning units with bag filters of BFPR type at JSC “Serov ferroalloy plant”, PJSC “Zaporozhe ferroalloy plant”, OJSC “Chelyabinsk electric metallurgical plant”, PJSC “Stakhanov ferroalloy plant”, OJSC “Aktobe ferroalloy plant (a subsidiary of JSC “TNK “Kazprom”), CJSC “Tikhvin ferroalloy plant”, CJSC “Ferrotrading”, PJSC “Nikopol ferroalloy plant” and other ferroalloy production plants.

Built and successfully being operated according to the Center’s design are dry gas cleaning units with bag filters BFPR-7000 behind the two open ferroalloy furnaces of capacity 27.6 MVA for smelting manganese containing ferroalloys at LLP “Taraz Metallurgical Plant” (Republic of Kazakhstan). The residual dust in emitted gas after the filter is between 8 and 11 mg/m<sup>3</sup>.

Reconstruction of the sinter plant’s aspiration system was carried out at PJSC “Nikopol Ferroalloy Plant” with the implementation of bag filters BFPR-7000, and also enlargement of the hot metal workshop warehouse facility in the ferroalloy smelting shop with the installation of filters of BFPR-2000x2 design type which were manufactured and supplied by SE “UkrRTC “Energostal”.

Before the reconstruction, cleaning of aspiration gases from B-3 and B-5 systems at the unloading zone and the linear coolers of sinter machines № 3 & 4 were done in wet dust extractors with residual dust content above 150mg/m<sup>3</sup>, which exceeds today’s normative requirements for manganese dust emissions by 15 times.

Reconstructed gas cleaning systems B-3 and B-5 are currently being operated in PJSC “NFP” for over two years, and steadily provides residual dust content in emitted gases of 3-5 mg/m<sup>3</sup> against the designed value of 10 mg/m<sup>3</sup>.

It is worth noting that the project for cleaning aspiration gases from sinter machines in bag filters with pulse regeneration of fabrics was implemented in the CIS for the first time.

In 2014, installation and commissioning of two bag filters BFPR-8500 in the workshop No. 4 at PJSC “Zaporizhzhia Ferroalloy plant” was conducted.

Many years of experience in the industrial exploitation of bag filters (the design by SE “UkrRTC “Energostal”) with pulse regeneration behind ferroalloy smelting furnaces has demonstrated their high efficiency, dependability and a number of significant advantages when compared to filters of other designs.

To date, the Center has produced more than 150 bag filters with capacities ranging from 1 thousand to 1.2 mln. m<sup>3</sup>/h. They were installed at enterprises of metallurgical, machine building and other industrial sectors and are working effectively.

Innovative solution of the Center is also the development of a centralized aspiration system for dust generating equipment used for steel, ferroalloy and sinter productions with the application of BFPR-type bag filters which ensures the residual dust content of emissions at a level not exceeding 10mg/m<sup>3</sup>. Complex work packages that are carried out by SE “UkrRTC “Energostal” aimed at implementing gas cleaning in industries include designing, engineering, manufacture and delivery of equipment, designer’s supervision, installation, commissioning and warranty maintenance services.

The Center has experience in general design of combined cycle gas turbine power plant that operates on secondary fuel gases (blast furnace, converter and coke gas) which was built for the first time in Ukraine at PJSC “Alchevsk Metallurgical Plant”. In view of this experience, the Center developed technical and commercial proposals for constructing cogeneration power plants that will operate on ferroalloy gas at PJSC “Nikopol Ferroalloy Plant” and PJSC “Stakhanov Ferroalloy Plant”.

Operation of such power plants is connected with the necessity to meet high reliability and safety demands of main and auxiliary equipment. One of its major requirements is uninterrupted and steady supply of ferroalloy gas to the plant in the required quantity and quality (by temperature, pressure, calorific value and dust content level), which is especially important in a situation of changing ferroalloy gas production regime by the furnaces and the fluctuations in heat and technical parameters with time. Implementation of these requirements is ensured by the Center’s optimal innovative design decisions.

Based on years of experience, gathered knowledge, statistical data and calculations performed, SE “UkrRTC “Energostal” develops and introduces into industries modern innovative technologies for water supply, sewage disposal and water purification at enterprises of metallurgical and ferroalloy productions which are at par or in most cases surpass foreign analogues by their technical, economical and environmental characteristics. Schemes and equipment de-

veloped by the Center were implemented and are successfully being operated at the leading enterprises of Ukraine and Russia.

In conclusion, it is worthy to mention that SE “UkrRTC “Energostal” having qualified staff and basing designs of modern ferroalloy plants on innovative approaches is capable of developing and implementing projects for any ferroalloy plant.