Ferroalloy Industry of Ukraine: Current Status, Development Trends and Future Prospects

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ABSTRACT:

The activity of Ukrainian ferroalloy industry in 2003-2014 in conjunction with production indicators of mining and smelting complex of Ukraine has been analyzed. The data on status of raw material base, in particular, of manganese-ore raw materials have been presented; the drivers of increased import of high-quality manganese ore in Ukraine over the last years and associated changes in the deployed ferroalloy melting technologies have been analyzed.

The production dynamics of main types of ferroalloys (manganese, silicon, nickel, titanium alloys and others) at the largest companies of ferroalloy industry, such as Nikopol, Zaporozhye, Stakhanov Ferroalloy Plants and Pobuzhsky Ferronickel Plant has been shown.

It is reported about the key trends of ferroalloy production technique and technology improvement, such as technical upgrading, equipment modernization; introduction of new energy-efficient and low-waste technologies in order to improve the quality and competitiveness of Ukrainian ferroalloys. Mining and smelting complex in general and ferroalloy industry as its integral part play an important role in the national economy of Ukraine. Ukraine is among the leading countries of the world in terms of production of and foreign trade in ferroalloys, and the most notably manganese alloys.

As is known, global steel production according to WSA in 2014 reached its historical peak and amounted to 1.637 billion tons, that by 1.1% exceeds the level of 2013. At the same time, in the counties of EU steel production decreased by 1.8%; in the USA it increased by 1.7% (furthermore, import of metal products in the USA increased by 35%); in South Korea steel production increased by 7.5%; the same indicator increased by 2.3% in India. In other countries included in the top ten world leaders, steel production indicators remained in general at the level of last year. Steel production in China in 2014 amounted to 820 million tons (+ 0.9% to 2013, that is below expected figures) – this corresponds to 50% of global production (Fig. 1).

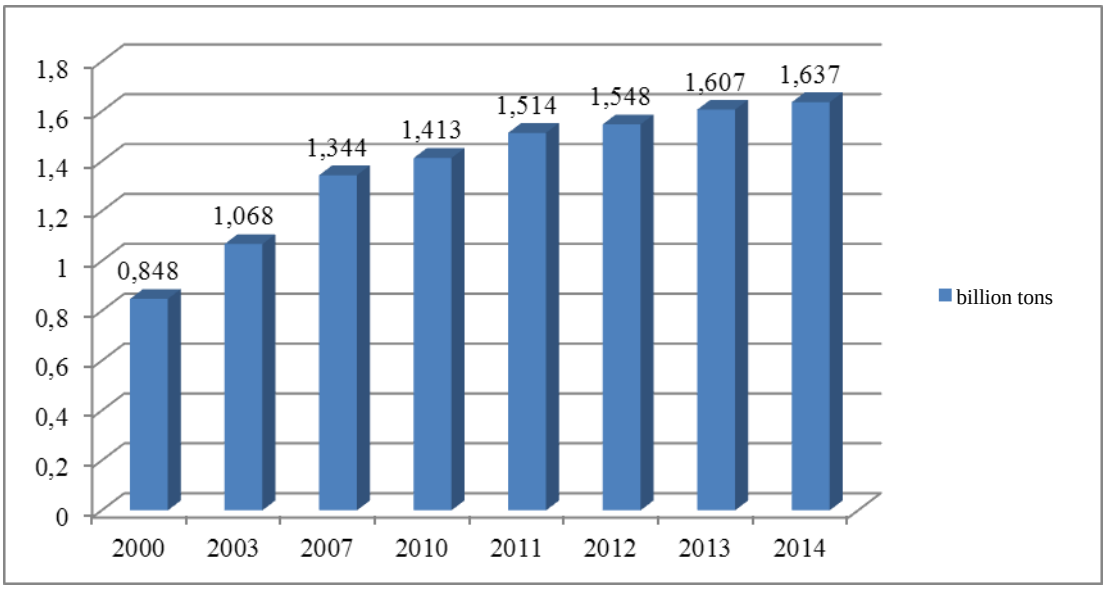

Fig. 1. Dynamics of global steel production in 2000-2014

According to long-term forecasts from experts, global steel production may reach 1.814 billion tons by 2020, and, taking into account higher-than-anticipated growth of high-alloy steel production it is evident that the need for ferroalloys will rise significantly.

Last year, steel production in Ukraine reached 27.2 million tons that is 17.1% lower compared to the indicator of 2013 (Fig. 2). However, this figure was enough for Ukraine to keep the 10th place among the global steel producers by the results of 2014.

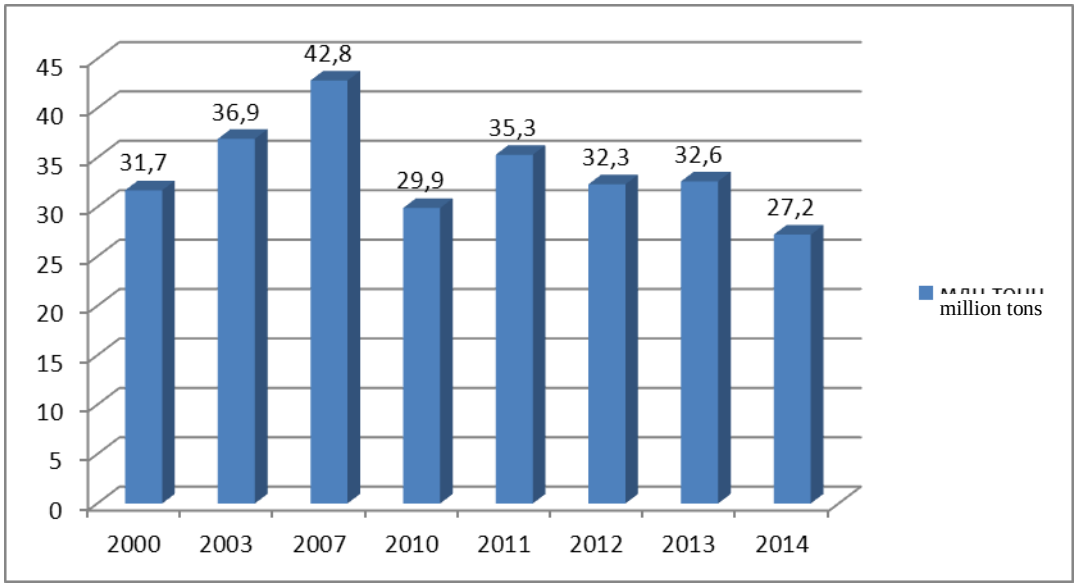

Fig. 2. Dynamics of steel production in Ukraine in 2000-2014

It seems there is no need to explain that the reason for this decrease in metallurgical production underlies in the military operation in the Eastern part of Ukraine where nearly 1/2 of Ukrainian steel mills. The situation has been exacerbated since July 2014, and at the moment production at a number of steel mills in Donbass region has been stopped or reduced by several times.

The remarkable thing is that ferroalloy production in Ukraine decreased continuously over the last years (by 13.8% in 2012 and by 12.4% in 2013); however, ferroalloy production increased by 20.9% in 2014 compared to 2013, and amounted to 1.188 million tons.

The distinctive feature of Ukrainian ferroalloys industry is its focus on manganese alloys production that is connected with large manganese ore reserves in the country.

It is known that manganese takes the fourth place in global consumption among other metals yielding just to iron, aluminium and copper. In 2012, over 30 million tons of manganese ore were mined globally and this figure can reach 58.8 million tons by 2020. According to IMnI (International Manganese Institute) experts, the global market of raw materials and manganese ferroalloys has been relatively balanced over the last few years.

At the same time it is obvious that quite significant changes has taken place in global ferroalloy industry over the past decade. Rapid economic growth in China that created powerful production facilities at the end of 90's (more than 10 million tons of Mn alloys and 6 million tones of Cr alloys) and turned into the biggest manufacturer and exporter of manganese ferroalloys resulted in liquidation of a number of ferroalloy facilities in the USA and many European countries. Western countries became highly dependent on ferroalloy import especially on Chinese production. At the same time, Chinese manufacturers, in their turn, are highly dependent on manganese and chromite ore import.

To date, manganese ore deposits have been discovered in 56 countries and general global manganese reserves (as of 01/01/05) amount to 8.6 billion tons, proven reserves amount to 3.5 million tons.

The biggest manganese reserves are concentrated in the Republic of South Africa (52% of general reserves and 29.9% of proven reserves). Ukraine, that ranks second in the world by its manganese reserves, possess 650 million tons of general reserves and 630 million tons of explored manganese reserves that amounts to 7.5% of general and 18% of explored global reserves. The following places in global statistics by discovered manganese ore reserves are taken by Kazakhstan, Gabon and Brazil (Fig. 3).

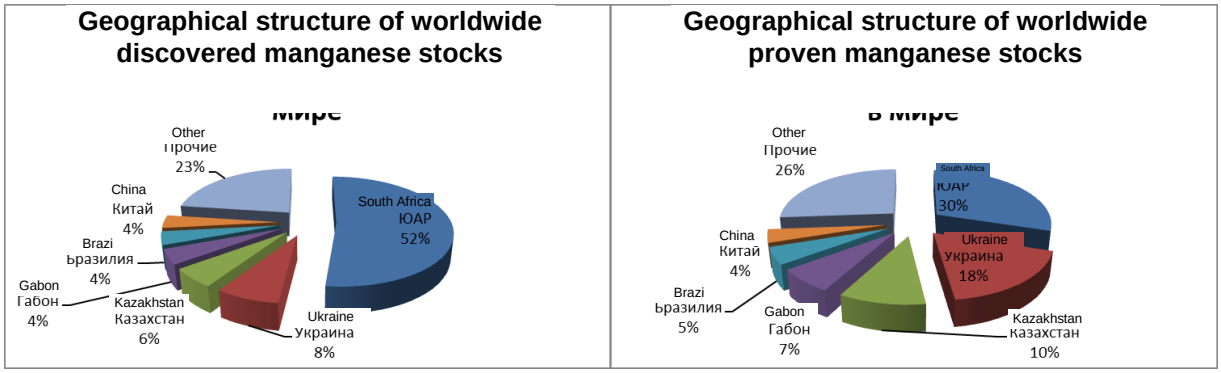

Fig. 3. Geographical structure of explored and proven manganese reserves

It is the powerful ore base that was one of the factors which led to creation of ferroalloy industry in Ukraine. The other factor was the location of large metallurgical enterprises in the Donetsk and Pridneprovie region that are the consumers of ferroalloys.

Manganese ore stocks in Ukraine are concentrated in one manganese ore basin that includes Nikopol (33% of explored stocks) and Big Tokmakskiy (67%) deposits.

Mining at Nikopol deposit by existing Marganetsk and Ordzhonikidze Mining and Processing Plants is mostly carried out on sites that were developed in Soviet period and now are virtually considerably exhausted. Development of new sites with mineral reserves is restricted to a certain volume, primarily due to complications with allocation of land lots for enterprises by local authorities within mining allotments. Pilot mine of Tavricheskiy Ore-dressing and Processing Plant at Big Tokmakskiy deposit is currently suspended.

Annual production of manganese concentrates by existing Ordzhonikidze and Marganetsk Ore-dressing and Processing Plants, as shown in Fig. 4, amounts to 1.1-1.6 million tons per year over the last few years (2011-2014). Thus, in 2014 the output of manganese concentrate and sinter by ore-dressing and processing plants amounted to 1529 thousand tons and increased by 19% in comparison with the previous year (the growth was mainly achieved owing to Marganetsk Ore-dressing and Processing Plant from 441 thousand tons of concentrate in 2013 to 648 thousand tons in 2014). It should be noted, however, that production facilities of ore-dressing and processing plants summarily amount to 5 million tons; in other words, these ore-dressing and processing plants use only one-third of total production facilities. The provision of these ore-dressing and processing plants with resrves considering current manganese ore production rate amounts to 25-30 years.

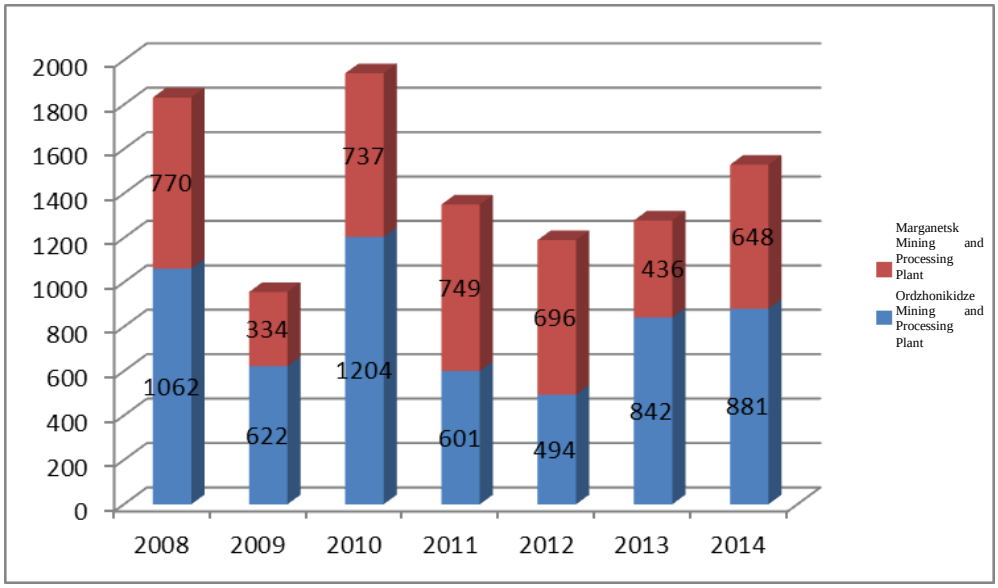

Fig. 4. Production dynamics of manganese raw materials in Ukraine in 2008-2014, thousand tons

At the same time, Ukraine has been a large importer of manganese raw materials for the past decades. The main reason for manganese raw material production decrease in Ukraine and its wide-scale import is unsatisfactory technological quality of concentrate produced from Ukrainian ore (low content of manganese and high content of phosphorus). To solve the 'phosphorus problem' a two-phase technology of manganese ferroalloy production with preliminary pyrometallurgical dephosphorization of the raw materials and production of the so called saturated low-phosphorous slag was implemented at a certain time at a range of enterprises. However, with electric power price manyfold increase using this energy-consuming technology is economically unjustified that necessitates using high-quality import manganese ore mixed with Nikopol concentrates.

For siliceous ferroalloys production the quartzites of Ukrainian Ovruchskiy, Banichskiy, Tolkachevskiy, Vasilkovskiy deposits etc. are utilized as raw material. Quartzite reserves here amount to: general - 179.7 million tons, proven - 173.1 million tons, including those being developed - 164.5 million tons. Ovruchckiy deposit is the main raw material base for siliceous ferroalloys production at Nikopol, Zaporiozhye and Stakhanov Ferroalloy Plants. Annual quartzite output in Ovruch amounts to 2.3-2.5 million tons, including 1.5-1.8 million tons intended for ferroalloy production.

Ukraine possesses limited reserves of chromite raw material suitable for chromite ferroalloy production. Explored reserves and resources of chromite ore are between 50 and 170 million tons (deposits of Middle Pobuzhia region). In 2000-2004, on a trial basis, Pobuzhia FNP mined batches of chromite ore on Kapitanovsk area and organized

their beneficiation on concentrating tables receiving concentrate that contains 45-46% Cr2O3. Obtained concentrates were used for trial smelting of high-carbon ferrochrome in one of ore smelting furnaces of the plant with acceptable technical and economic performance.

For a long time raw material base of Pobuzhie Ferronickel Plant was represented by the reserves of poor (average nickel content - 0.75%) silicate nickel ore of Middle Pobuzhie deposits (residue of 1.2 million tons of ore or 8000 tons in terms of pure nickel). However, in the last few years this enterprise has stopped mining of poor ore and shifted to high-quality import ore processing (with average nickel content more than 2%) from New Caledonia and other nickel-mining countries.

The raw material for producing ferrotitanum is ilmenite concentrate. It should be noted that Ukraine is one of the largest titanium provinces in the world. Its mineral and raw materials potential is estimated at 900 million tons of ilmenite and rutile, which is equivalent of 30% of explored global stocks. Titanium raw material base in Ukraine includes more than 40 deposits, including a unique one, 13 large and 10 average. 11 deposits are explored in details and passed to industry. Annual production of ilmenite concentrate by exciting enterprises amounts to about 600 thousand tons.

The production dynamics of main type of ferroalloys (silicon manganese, ferromanganese, ferrosilicon and ferronickel) by the enterprises in Ukraine in 2007-2014 is shown in Fig. 5.

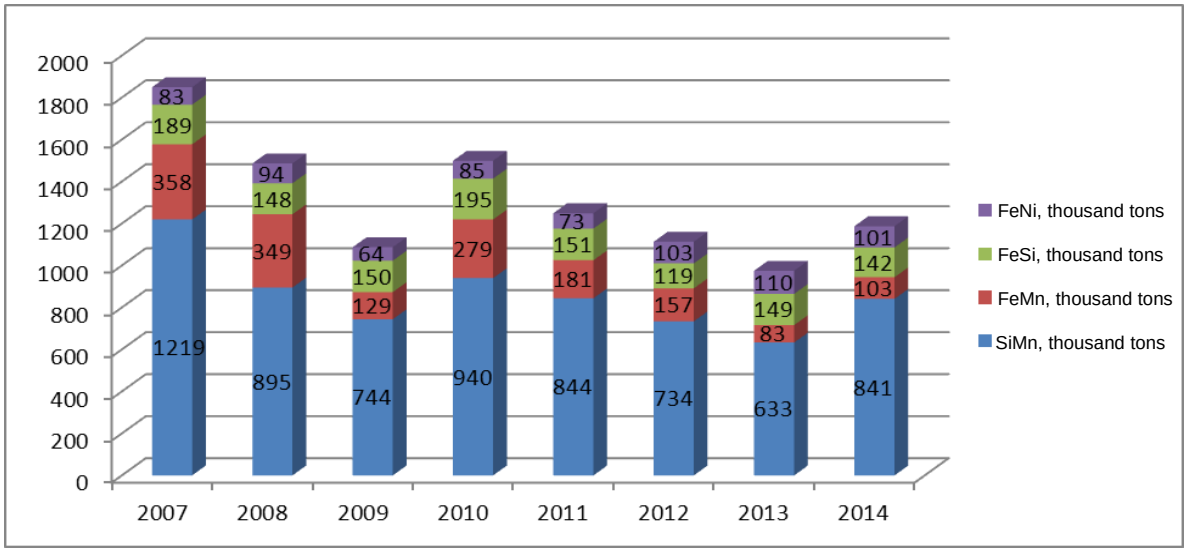

Fig. 5. Production dynamics of the main types of ferroalloys in Ukraine in 2007-2014, thousand tons

As shown in Fig. 5 and noted above, in 2014 ferroalloy production in Ukraine increased by 20.9% compared to the previous year and amounted to 1188 thousand tones at 4 plants (Nikopol, Zaporozhie, Stakhanov and Pobuzhie). Growth of production volumes in Ukrainian ferroalloy industry takes place despite the fact that Stakhanov Ferroalloy Plant located in Luhansk region has been almost shut-down in the second half of year.

We would recall that similar to the whole metallurgical industry of Ukraine, ferroalloys industry has substantially reduced production in 2008-2009 that resulted in the production rate in 2010 which almost reached pre-crisis level. But starting with 2011 production of ferroalloys in Ukraine reduced again while annual ferroalloys production rate increased by 3% in the world (corresponding to global steel production growth). In 2014, for the first time since the pre-crisis period, as noted above, Nikopol and Zaporozhie Ferroalloy Plants increased their production volumes. Due to the difficulties encountered in nickel ore supply, Pobuzhie FNP had to reduce ferronickel smelting by 8%. In 2014, Stakhanov Ferroalloy Plant located in the Eastern part of Ukraine reduced production by 41% to 91 thousand tons compared to 153 thousand tons in 2013.

It's worth mentioning that as opposed to pre-crisis period of 2003-2007 ferroalloy production growth, as well as overall situation in mining and smelting complex of Ukraine after crisis is not in general accompanied with economic and financial performance improvement. The main reason was that the price for ferroalloys did not reach pre-crisis level while cost of production exceeded pre-crisis level due to the increase in raw material, power, logistics and other costs.

For ferroalloys industry that is high power-consuming, power rates are of significant focus. In 2010 power rates increased by 30.9% (power cost was revised 4 times), in 2011 by 21.4% (price has been revised 8 times), in 2012 by 10.8 % (again revised 4 times), starting with January 1st 2013 power rates for industrial consumers increased by 1%, and starting with March 1st by 3.8%; by the end of 2013 power rates grew by 9.3% more. It's obvious that high prices and high power rates have negative influence on the competitiveness of Ukrainian ferroalloys in domestic as well as foreign markets.

Wrong power pricing policy resulted in creating artificial unprofitability of ferroalloys production that led to substantial decrease in production volumes at Zaporiozhie and Stakhanov Ferroalloy Plants to almost complete sus-

pesion at the end of 2012. Only signing specially developed Memoranda for power supply with the Government allowed resuming production of ferroalloys at these plants started from March 2013.

Nikopol Ferroalloy Plant faced the same situation in 2013. Only after Nikopol Ferroalloy Plan was included into Memorandum for power supply, unavoidable suspension of the largest ferroalloys producer in Ukraine was averted. Production of Mn ferroalloys at NFP, however, decreased dramatically in 2013, as shown above. Conversely, in 2014 the situation for NFP improved substantially: silicon manganese smelting increased by 33% and ferromanganese – by 46% compared to 2013.

The above concerned bulk ferroalloys production of Mn and Si alloys at Pobuzhie Ferronickel Plant. About 5 thousand tons of FeNi has been totally produced by different plants as a result of re-melting of Ni-containing waste. Last year in Ukraine about 20 thousand tons in terms of nickel metal of different grades has been produced including "poor" and "rich" grades of FeNi.

In 2014, Ukraine produced 2.5 thousand tons of "rich" FeTi with 70% Ti content by re-melting different types of Ti-containing waste. For the first time over the last few years, FeTi with 35% of Ti content has been started to be produced by aluminothermic method using ilmenite concentrate of Ukrainian origin using new production facilities. FeMo production has also been established at the electrical and metallurgical plant Dneprospetsstal in Zaporozhie.

Smelting of FeMo, FeV, FeNb and other alloys of "small group" took place in limited quantities (from time to time, basing on demand and raw material supply), mainly at Donetsk Chemical and Metallurgical Mill that is a part of Illich Iron and Steel Works of Mariupol (small town of Donskoye, Volnovakha district, Donetsk region).

Practically all enterprises of ferroalloy sector of Ukraine conduct the policy of technical upgrading and modernization aiming at providing sufficient competitiveness of production and expanding range of products with improving energy efficiency, introduction of the latest environmentally friendly methods, processing and utilization of previously accumulated production wastes.

To increase energy efficiency the works to optimize the design of ore-smelting furnaces were carried out. At Pobuzhie FNP the furnace design and geometry of RTP-1 furnace have been changed with the transition to a rectangular bath with spring-actuated walls and back-arched hearth.

The so-called high voltage "deep input" directly to furnace transformers was applied during the reconstruction of furnaces, modern electrocompensation installations have been constructed, "multizonal rates" system is used which allows minimizing energy costs within a day, etc. The works on transfer of ferroalloy furnaces to the direct current supply, including furnaces for re-melting of waste of ferroalloy production, are being carried out (Zaporozhie Ferroalloy Plant). These actions have contributed to reduction in energy consumption by 8-10% in the recent years.

Secondary energy resources with the use of waste gases heat of the closed and semi-closed ore-smelting furnaces were also applied. At Pobuzhskiy FNP, for instance, preliminary air heating up to 280-300°C is used; this air is supplied for fuel combustion in tubular rotary kilns. Natural gas supplied to the furnaces is being partially replaced by injecting of pulverized-coal fuel as a cheaper source of energy.

At all ferroalloy plants certain methods of processing waste slag of ferroalloy production are implemented with obtaining additional (secondary) products. At Nikopol Ferroalloy Plant, for instance, the method of recovery of various metal concentrate fractions from slag by means of lumpy sorting module (LSM) is deployed. This method is focused on lumpy material (slag size of 10-20 mm, 20-40 mm and 40-70 mm) sorting with the use of electronic sensor technology. Special sensors analyze slag lumps in the flow, and the pieces enriched with metallic beads are extracted from the general flow by air separation. Installation productivity depending on the size of the processed slag ranges from 12 to 40 t/h by the initial supply, in this case 3-4% of slag-mix can be separated from slag (it's exactly the slag and metal mixture) which contains approximately 50% of the metallic phase (manganese content in this slag and metal mixture is defined by specifying the parameter in the LSM module). The use of slag and metal mixture along with production wastes improves melting performance, promotes an increase in Cr recovery and reduction of primary ore consumption.

After extraction of metal component from slag, slag processing products are used as fillers in concrete production; dust and sludge from ferroalloy production are used as binding materials in cement production; slag crushed stone is used in road construction.

The majority of ferroalloy furnaces with the installation of state-of-the-art equipment for gas cleaning and dust removal is reconstructed; most of BF top dust and sludge is used for agglomeration (sintering, pelleting or briquetting) for re-melting.

Various agglomeration methods for agglomeration of ferroalloys fines obtained during crushing and screening by briquetting or re-melting with specialized electric furnaces (arc or induction) are applied.

CONCLUSIONS

Ferroalloy industry of Ukraine is being developed mainly on the basis of its own raw material base, solving the issues of ferroalloys supply to the enterprises of Ukrainian metallurgical industry and exporting the part of manufactured products to the global markets. Introducing the programs of technical upgrading and modernization, improvement of energy efficiency and resource saving developed by the enterprises, as well as developing the international commu-

nication and partnership Ukrainian ferroalloy production will continue keeping the one of the leading positions in the global ferroalloy community.