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INTENSIFICATION OF STEEL PRODUCTION IN ARC FURNACES

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INTENSIFICATION OF STEEL PRODUCTION IN ARC FURNACES*

(Following is the translation of an article by F. P. Yedneral in Stal', Vol 1960, No 11, Moscow, November 1960, pages 1004-1007.)
(*(Note:) Brief report on the respective conference held in Moscow on 24-27 May, 1960.)

The conference on the intensification of steel production in arc furnaces organized by the Commission on the Physico-Chemical Bases of Steel Production (under the Institute of Metallurgy imeni A. A. Baykova of the Academy of Sciences, (AS) USSR) was opened with an introductory statement by Prof F. P. Yedneral, who noted the considerable amount of research work performed during the last 5-6 years by the plants and educational and scientific-research institutes for the purpose of speeding up the process of the electric smelting of steel.

The conference subjected to a revision the technology prevailing for decades, which has prohibited the combination of smelting with oxidation and has goverend the manganese rate and the low carbon burn-out speeds in the oxidizing period, the slow diffusion deoxidation of the metal, its long delay in the reduction period, and the alloying of the deoxidized metal.

The use of oxygen in smelting many steels in turn requires a correction of the technology. Plant engineers, in cooperation with scientific workers, have tested under production conditions a new technology permitting a 15-20% increase in electric furnace production with a simultaneous improvement in the quality of the metal.

The conference had the task of discussing the fundamental propositions of the new technology and working out technological recommendations for smelting the principal groups of steels for the compilation of new plant technological instructions.

Participating in the conference were 97 representatives of metallurgical plants, branch scientific-research institutes, higher educational institutions, scientific-research organizations of the union and republic academies, sovnarkhozes, projecting and other organizations.

The conference heard and discussed 18 papers and communications on questions relating to the intensification of steel production.

A. Brief Survey of the Questions Discussed

Corresponding member of the AS, USSR, A. M. Samarin, in a paper on "Main Tasks in the Field of Intensification of of Electro-Steel Production," noted the possibility of speeding up the smelting of the metallic charge in bucket feeding, if its components are prepared so as to do the charging in one operation; required are powerful transformers, a high secondary voltage, fast-acting reliable automatic apparatus, pre-heating of the scrap (with natural gas or low-value fuel in the charging baskets or in the furnace).

To shorten the oxidizing period of the smelting operation it is advisable to combine the oxidation and dephosphorization partially with the smelting and to conduct the carbon oxidation with gaseous oxygen.

To shorten the reduction period it is advisable to change the method of deoxidation and transfer the desulfurization to the beginning of the period, and to use a electromagnetic mixing and treat the metal with slag in the ladle.

In order to increase the electric-furnace production, it is necessary above all to shorten the idle time of the furnaces (using high-grade repair materials and refractory linings, dismountable and exchangeable furnace casings), and also to increase theoutput of acceptable steel (by treating the steel in a vacuum in the ladles, pouring in an atmosphere of inert gas, filling out the molds with a layer of slag, using thermite caps, tec.).

A radical improvement of the technico-economic indices of electro-smelting production can be attained by transferring the operating of the furnaces to the liquid semiproduct, i.e., by introducing the duplex process; design organizations are slow in organizing operating by this method in our plants.

As reported by Engr V. K. Vorob'yev in his paper on "Intensification of the Smelting of Fast-cutting, Stainless and Other Steels by the Use of Oxygen," the "Electrostal" plant smelts almost all stainless and acid-resistant steels with oxygen. Oxygen is blow into the metal to speed up fusion within an hour after the current is turned on. Ferrochromium is added immediately after the blowing is ended. With a 160-180 minute duration of fusion under current, the specific expenditure of electric power is 444 kw-hr/t and th expenditure of oxygen for smelting about 700 m^3.

The use of oxygen to speed up the melting of the charge and decarbonize it in the smelting of chromium-nickel structural steels permits an 8-10% reduction in the duration of smelting and a 3-4% reduction in the specific expenditure of electric power.

For five years the "Elektrostral" plant has used oxygen to smelt a charge of fast-cutting steels; after blowing, the slag is deoxidized and drained off; the smelting time has been reduced by 20-30%, and the power expenditure by 27-30%.

As a result of the good mixing of the metal with oxygen, the composition of the bath as to tungsten is evened out more quickly; as a result of the reduction of tungsten losses with a somewhat increased waste of chromium and vanadium, the cost of a ton of P9 steel ingots was lowered by 135 rubles and P18 steel ingots by 466 rubles.

A paper by V. S. Kudryavtsev on "Intensification of Electro-Steel Smelting through Pre-dephosphorization and Combination of Boiling with Smelting by Means of Oxygen," discussed the improvement of technology at the "Sibelektrostal'" plant: The addition of cinder or iron ore and lime to the charge, undercutting of the charge with oxygen and draining of the slag by gravity, which makes it possible, at the end of the smelting operation, to bring the phosphorus content down from the 0.055-0.070% in the charge to 0.015-0.025%. During smelting, 0.20-0.30% C burns out, and 0.30-0.20% C in the oxidation period.

Shortening the reduction period to 60 minutes through simultaneous deoxidation with carbon and silicon results in an average diminution of the smelting time by 60 minutes or 23%. The quality of the metal (45G2, 45 and 18KhNVA steels) evaluated by its contents of gases and non-metallic inclusions and by its mechanical properties, remained practically unchanged.

Doctor of Technical Sciences F. P. Yedneral, in a paper on "The Use of Oxygen and Complex Deoxidizers to Intensify the Electric Smelting of Structural Steels," set forth the results of the author's respective work at the Zlatoust and "Dneprospetsstal'" plants.

The dephosphorization of the bath to a 0.020% P content is accomplished as a result of addding 3% lime to the charge and briefly blowing oxygen through the metal for 10-15 minutes before smelting is ended, with spontaneous runoff of the smelting slag, aided by tapping; subsequent blasting with oxygen to decarbonize, keeping the slag basicity within the limits of 2.5-3.0, is accompanied by further dephosphorization.

A study was made of the loss of chromium, manganese and tungsten in smelting with oxygen on a charge of alloyed wastes.

A shortening of the reduction period in smelting structural steels 45KhNMFA, 12KhN3A and 18KhNVA, amounting to 70-80 minutes, resulted from introducing complex deoxidizers (silico-manganese, Mn-Si-Al or Mn-Si-Ca alloy) with 0.12-

0.15% Si immediately after draining off the oxidation slag. Early sedimentation deoxidation with strong deoxidizers and subsequent deoxidation with ground coke and silico-calcium speeded up desulfurization 2-3 times and furnished highly deoxidized slag. About 20% of additional sulfur was removed by mixing the metal with slag upon tapping. Alloying was speeded up by adding ferrochromium simultaneously with the complex deoxidizers.

As shown by all-around tests of the metal smelted by the altered technique, it is not inferior in quality, and in a number of indices is even better than that obtained by the prevailing technique with a two hour reduction period.

The productivity of the electric ovens is increased by 18-20%, while the specific expenditure of power is lowered by 15%.

Doctor of Technical Sciences P. Ya. Ageyev, in a paper on "The Factors Determining the Rate and 'Depth' of Deoxidation," evaluated theoretically the conditions for the flotation of deoxidation products and the possibility of controlling the rate of their removal, and also reported on the results of the laboratory test of the propositions advanced. Study of the process of blasting the metal with argon after introducing lump deoxidizers, of deoxidizing with ferrosilicon powder, also introduced with the argon jet, and of the effect of blasting the liquid metal with mixtures of powdered oxidizer and fluxes on the processes of the removal of dissolved and bound oxygen showed that the deoxidation of the metal and the removal of the products of deoxidation can be considerably speeded up.

At the Izhevsk plant, according to Engr K. K. Prokhorenko (paper on "Improvement of the Technology of Smelting Steel in Electric Furnaces"), regarding the work done under the direction of Academician N. N. Dobrokhotov, AS, Ukrainian SSR, they succeeded in raising the purity of steel ShKh15 from oxygen inclusions by oxidizing with aluminum in the amount of 1 kg/t; the increase of the expenditure of aluminum to 1.5 ig/t in deoxiding structural steel 30KhN2MFA resulted in diminishing its liability to seams. By mixing the metal in the ladle with well deoxidized basic slag, an efficient removal of sulfur is attained (the need for such mixing was noted by many readers of papers).

The pouring of highly alloyed chromium-nickel steels under a layer of liquid slag (of fluorspar, refractory clay and lime), poured into the mold after discharge of the metal (in siphon pouring), eliminated the oxidation of aluminum, titanium and chromium and the formation of oxidized scums.

A theoretical explanation was proposed for the deoxidation of steel by aluminum (with the formation of a solid interaction product).

V. I. Simonov's report on "Testing the Smelting of Ball-Bearing and Structural Steel with Previous Deep-Reaching Deoxidation and Abbreviated Refining," gave the following results of experimental smelting at the "Electrostal'" plant: Steel ShKh15 was smelted by blasting with oxygen, having been deoxidized with refined manganese pig-iron before drawing off the oxidation slag, and lump silico-chromium, aluminum and ferrochromium were added at the beginning of the reduction period (duration of the period 60-80minutes). Evaluation of the non-metallic inclusions by the TsNIIChM scale and by GOST 801-47 showed no increase in impurities.

The smelting time was shortened by 40 minutes, the specific expenditure of electric power was diminished by 50-60 kw-hr/t. Work has been begun on intensifying the smelting of structural steel.

Candidate of Technical Sciences, A. I. Kholodov, in a paper on "Intensification of the Reduction Period of Electric Smelting in Arc Furnaces," gave a survey of the work performed by him and other researchers in the substitution of deep-reaching for diffusional deoxidation by means of complex deoxidizers; he recommended that a fourfold alloy (Mn-Si-Ca-Al) be added at the beginning of the reduction period for full deoxidation of the metal and that the use of aluminum be excluded for final deoxidation. The amount of complex deoxidizer to be added and its calcium content should conform with the initial concentration of oxygen in the metal.

According to the report by A. I. Kondrat'yev ("Deoxidation and Desulfurization of Steel in Arc Furnaces"), previous deoxidation of the metal at the beginning of the reduction period and production of slag with a low iron-oxide content speed up the desulfurization process and shorten the reduction period (the work was performed in an MIS induction furnace and the results were confirmed by smelting batches of transformer steel in 30-t arch furnaces).

Doctor of Technical Sciences YU. A. Shul'te, in a paper on "The Influence of the Intensification of the Electric-Smelting Process on the Nature and Character of Non-Metallic Inclusions in Steel," gave the results of investigations made with 20-t arc furnaces in smelting chromium-nickel, chromium-nickel-tungsten and ball-bearing steels, with final deoxidation by various means: Aluminum, silico-aluminum, ferrotitanium, ferrosilicon and silicocalcium. The author came to the conclusion that the quality of the electric steel is mainly determined by the nature and character of the non-metallic inclusions and that final deoxidation is a very important stage of the process. Preparation of the batch for this stage can be reduced to a minimum without impairing the quality of the steel by the employment of progressive metallurgic factors (oxygen, complex deoxidizers, synthetic slags); it is also necessary to make a rational selection of the final deoxidizers.

On the basis of the work done at the Kuznetsk Combine, Candidate of Technical Sciences, A. M. Levin, in a paper on "Experiments in the Intensification of Electric Smelting of Structural Steel," proposed the following technique variant: Dephosphorization during smelting, combination of the end of smelting with the beginning of oxidizing blasting of the metal with oxygen, and additional (after fusion) oxidation with 0.20% C make it possible to shorten the smelting and the oxidizing period by 35 minutes; employment of predeoxidation with silicomanganese and aluminum, addition of ferrochromium at the beginning of the reduction period, deoxidation of the slag with ferrosilicon and coke powders permit shortening of the smelting by one hour (i.e., by 15%) without impairing the quality of the steel.

When the reduction period lasts 70-80 minutes, the correction of the composition already delays the output; it is necessary to speed up the making of analyses.

The results of similar work at the Zlatoust plant on the smelting of steels 30KhGSA, 60Kh2N1.5, S65A and S65GA were set forth by Engr L. F. Kosoy (paper on "The Question of Improving the Technique of Smelting Structural Steel"); here too dephosphorization is combined with the melting of the charge; in the boiling period, they oxidize 0.2-0.3% C; the metal is deoxidized beforehand (with open-hearth pig before drawing off the slag), with the oxidation period lasting altogether about an hour; after drawing off the slag, the metal is deoxidized with electrode shavings, lump aluminum, then ferrosilicon and ferromanganese; the slag is deoxidized first with ground coke, then with ferrosilicon; they employ an additional two-stage deoxidation of the metal with aluminum (total duration of the reduction period: 70-90 minutes).

For the experimental smeltings they used lime containing not more than 0.05% moisture; the average sulfur content in the finished metal did not exceed 0.008%. Internal seams were almost entirely lacking when it was rounded off gradually.

The average rating for oxide inclusions in S65GA steel was 1.50, for sulfide inclusions 1.71 (in smeltings by the prevailing technique, 1.80 and 2.09, respectively. The furnace productivity was increased 15%.

Doctor of Technical Sciences, V. M. Zamoruyev (report on "Intensification of the Steel Smelting Process in an Acid Arc Furnace"), gave the following data: The duration of smelting in a 5-t furnace was brought down to 1 hour 50 minutes with a specific electric-power expenditure of 565 kw-hr/t; the charge in the bucket is heated beforehand to

600^o on a mazuth furnace, which permits a shortening of the smelting time by 25 minutes and the power expenditure for smelting from 625 to 485 kw-hr/t; the walls are primed by the Uralvagon Plant method; after smelting the reduction of the silicon is organized by means of reaction with the carbon from the charge.

The liberation of carbon monoxide contributes to the elimination of hydrogen as well (from 3.5-4.00 to 2.5 cm^3/100 g). Ferromanganese is added in the ladle upon tapping.

The "Dneprospetsstal'" plant jointly with the Dnepropetrovsk Metallurgical Institute has introduced an altered technique of smelting ball-bearing steel characterized, according to the paper by V. B. Rutkovskiy ("Technology of the Electric Smelting of Ball-Bearing and Structrual Steel with Treatment of the Metal With Electric-Furnace Slag in the Ladle"), by the following data: Blasting of the metal with oxygen is employed in the oxidizing period of smelting, with 0.3-0.5% C being burned out at an average oxidation rate of about 0.45% C/hr.; ferrochromium is added at the beginning of the reduction period, which is conducted under lime and refractory-brick slag with a low calcium-fluoride content; the slag is deoxidized with ground coke and ferrosilicon; the final deoxidation is done with aluminum in the ladle.

The duration of the reduction period and of the entire smelting operation has been shortened by 20-40 minutes and the electric-power expenditure by 40-50 kw-hr/t; a CaF_2 content of less than 2% in the slag is recommended before tapping.

In smelting structural steels, the metal is previously deoxidized with ferromanganese and ferrosilicon or with silicomanganese at the rate of 0.4-0.5% Mn and 0.1% Si. The shortening of the reduction period did not affect the quality of the steel.

Candidate of Technical Sciences, A. G. Shalimov ("Refining of Alloyed Steel with Synthetic Slgas") reported on the results of the respective TsNIIChM work at the Zlatoust Metallurgical Plant: Slags of CaO and Al_2O_3 were smelted in an arc furnace and poured into the ladle, into which ball-bearing and structural steel was then tapped -- after alloying and partial oxidation; the final deoxidizing was done with aluminum in the ladle after treating the metal with synthetic slag.

Electric-furnace productivity is here increased by about 15%, the sulfur content of the metal is lowered to 0.005-0.007%, the ratings for both oxides and sulfides are diminished by 0.5, and the mechanical properties of the structural steels are improved (particularly the toughness and the relative contraction of the transverse specimens).

In V. A. Chernikov's experiments (paper on "Experiments in Desulfurization in the Process of Vacuum Treatment of Liquid Steel") carbon steel with 0.25-0.30% Si was kept in a low vacuum 40 kg furnace for 10 minutes at a pressure of 17-35 mm merc. with treatment with a slag mixture of 80% lime and 20% fluorspar; with 2-4% slag, as much as 80% of the sulfur was removed from the steel.

In treating steel under these same conditions with liquid slag of lime and alumina (1:1), the sulfur content was lowered only to 45% of the initial amount.

The possibility of increasing the use of chromium (from wastes and ferroalloys) to 96-97% instead of 83% was reported on by Engr Ye. I. Kadinov (paper on "Lowering Chromium Losses with Slag in Smelting 1Kh18N9T Steel with the Use of the Complex Deoxidizer AMS," in connection with the work done by the DMI at the "Kneprospetsstal':): With an approximately 0.4% Si content in the charge, lime is added to it (about 2.5% of the weight of the charge), and oxygen (not more than 5-6 nm^3/t is used at the end of the smelting. After smelting, the slag is not drained off, but is deoxidized with ground ferrosilicon and coke, then the metal is blasted with oxygen to decarbonize it (about 1 nm^3/t per minute), the sedimentation deoxidation is done with AMS alloy or SiMN-30 and aluminum in the proportions 0.15% Al, 0.40% Si and 1% Mn, and ferrochromium is added, after which the slag is deoxidized for 20 minutes by means of silicochromium (15kg/t) with lime (10kg/t) and by means of a powder of 75% ferrosilicon (2-3 kg/t) with aluminum (1-2kg/t).

Doctor of Technical Sciences, N. V. Okorokov, in a paper on "Electromagnetic Mixing of Steel in Arc Furnaces" reported on the indices of the operation of mixing devices on two 25-t electric furnaces: Acceleration of the deoxidation and desulfurization permitted the shortening of the reduction period by 30-45 minutes, the contamination of ball-bearing steel with non-metallic inclusions (particularly globular ones) was reduced, and the drawing of the slag was facilitated.

The reader of the paper recommended that the introduction of electromagnetic mixing be speeded up, that the capacity and frequency of stators for furnaces of different capacities be precisely defined, that work be continued on the search for the most rational configuration for the stators, and that optimal technological and electric regimes be established for smelting various kinds of steel in furnaces with electromagnetic mixing.

The conference resolved to address a request to the directing organs to examine the questions of the most rapid organization in the USSR of the production of electric steel by the duplex process (oxygen converter-electric furnace).

The conference recognized the desirability of holding yearly conferences of electrometallurgists by turns in the various economic regions of the country with well-developed electric metallurgy.

B. Technological Recommendations

The conference drew up technological recommendations regarding the smelting of structural steels on a carbon charge and on a charge of alloyed wastes, and regarding the smelting of chromium-nickel-tungsten, ball-bearing and stainless steels, the main propositions of which are given below.

1. Smelting of Structural Steels on a Carbon Charge With the Use of Oxygen.

A. The excess of carbon in the charge is taken as 0.4-0.6% higher than the lower limit fixed by the brand (large amount for furnaces with less than 25 t capacity); not less than 0.3% C of this amount is burned out in the oxidizing period.

B. In the smelting period 2-3% lime and 1% cinder or iron ore is fed into the furnace for dephosphorization; at the end of the smelting operation the metal is briefly blasted with oxygen; the phosphorus content in the first sample of metal should not exceed 0.020% (temperature of the metal at this moment 1480-1520°).

C. After the first sample is taken, the smelting slag is drawn off (not less than 70%), 1% lime is added and the metal is blasted with oxygen for 10-20 minutes to degas it. In smelting low-carbon steels, the carbon content at the end of the oxidizing period should not drop below 0.08-0.09%. The manganese rate is not regulated. The duration of the oxidizing period is from 30 to 50 minutes, the temperature of the metal at the end of the period 1600-1640°, depending upon the composition of the steel.

D. The reduction period is begun by sedimentation deoxidation with complex lump deoxidizers containing aluminum, silicon, manganese and calcium in the form of double, triple or quadruple alloys, to be added to the exposed bath so as to obtain 0.10-0.15% Si in the liquid metal. Ferrochromium is fed in at the beginning of the period. Slag formers (3-4%), deoxidizers and ferrochromium are fed in with a charging machine.

During the period, the iron-oxide content in the slag is brought to 0.5% by means of mixtures of powdered coke, silicocalcium, 75% ferrosilicon and aluminum (basicity of the slag about 2.5 with a 50-60% CaO content).

The final deoxidation is conducted with the minimum amount of aluminum sufficient to obtain a grain of the prescribed size, and 0.5-0.7 kg/t of silicocalcium (aluminum is added in the oven, silicocalcium during tapping). For further desulfurization, the metal is tapped into the ladle simultaneously with the slag.

The total duration of the period os from 40-90 minutes depending on the capacity of the furnace and the degree of alloying of the steel smelted.

E. Instead of greasing the molds, the use of wooden frames and protective media (paraffin, bitumen, liquid slags, argon), is recommended.

2. Smelting of Structural Steels (Except Those Containing Tungsten) on a Charge of Alloyed Wastes

A. The chromium content in the charge is taken at the lower limit, the carbon content 0.15-0.20% above the lower limit; it is advisable to have in the charge 0.4% Si in the form of silicon wastes. Simultaneously with the charge, 2-2.5% limestone is fed into the furnace.

B. After fusion and selection of the first sample, the bath is blasted with oxygen at a metal temperature of 1480-1520° (at the beginning of the blasting) without removing the slag.

C. In feeding in the deoxidizers and alloy components, allowance is made for the residual content of the respective elements at the end of the oxidizing period (otherwise, the smelting is conducted in a manner similar to that on a fresh charge).

3. Smelting of Steel on Chromium-Nickel-Tungsten Wastes with Employment of Oxygen

The smelting is conducted on semi-acid slags with a basicity of not more than 0.6 to preserve the tungsten (no lime is added to the charge). After blasting with oxygen, the chromium is partially reduced by means of ground coke and ferrosilicon before drawing off the slag.

4. Smelting of Ball-Bearing Steel With Employment of Oxygen.

The oxygen content in the charge is taken 0.5-0.6% higher than the lower limit (higher indices for furnaces with not more than 25 t capacity).

B. The recommendations under "B" and "C" of Section 1 are also extended to ball-bearing steel, but the temperature at the end of the oxidation period is brought up to only 1570-1590°.

C. The reduction period is begun with sediment deoxidation: For ShKh15 steel, 45% ferrosilicon and 0.4 kg/t of aluminum are added; for ShKh15SG steel, silicomanganese and aluminum. Silicon alloys are added in such amounts as to obtain 0.12-0.15% Si in the metal.

Ferrochromium is fed in after the deoxidizers together with the slag mixture. Refining is done under white or weak carbide slag. A mixture of ground coke and ferrosilicon is used to treat the slag. In the final deoxidation, 0.5 kg/t of aluminum is added on the rod and 0.5 ig/t of aluminum on the slag.

The slag should contain about 0.4% FeO before tapping. The temperature of the metal in the ladle should be 1540-1570° (the smaller index relates to furnaces of larger capacity).

5. Smelting of Stainless Steel Using Oxygen

A. The rated chromium content in the charge is determined from the carbon content in the steel:

Carbon content in steel, % not greater than --------	0.06	0.10	0.12
Amount of chromium in charge, % not more than --	7	9-12	12-14

The rated carbon content in the charge is 0.15% higher than the upper limit, the silicon content 0.8-1.0%; the silicon is introduced in the form of silicochromium wastes or 45% ferrosilicon.

B. Blasting of the liquid metal with oxygen is begun when 20-30% of the charge has not yet been melted. It is advisable to begin oxidation blasting to burn out the carbon with the current turned on and to carry it on uninterruptedly, expending not less than 0.5 m^3 of oxygen a minute per ton of charge, until the carbon content has been diminished by 0.02-0.05% below the upper level. After blasting, silicomaganese and ferrochromium are added.

C. Deoxidation is conducted at first with lump deoxidizers (silicochromium, silicocalcium, 45% ferrosilicon, AMS), and then with powdered deoxidizers in the course of fusion. At the same time, the basicity of the slag is increased. The ferrotitanium is melted under limestone slag (the slag is drawn off once before adding ferrotitanium). The temperature of the metal in the ladle is 1570-1620°.

D. To increase the general use of chromium (to 95%) it is advisable to make extensive experiments to verify the following recommendation of the Dnepropetrovsk Metallurgical Institute:

Add lime to the charge (2.5% of the weight of the metal); do not introduce silicon wastes; deoxidize the slag formed in the process of smelting with powders of coke

(5-6 kg/t), silicochromium and ferrosilicon (in such amounts as to introduce 0.20-0.25% Si into the metal); have deoxidation coincide with the end of the smelting; after blasting with oxygen and before adding ferrochromium, introduce 0.15-0.2% Al, 0.3-0.4% Si and 0.8-1.0% Mn (as complex deoxidizers or separately); deoxidize the slag with silicon-containing powders in such amounts as to obtain 0.35-0.40% Si in the metal before adding ferrotitanium; bring the basicity of the slag to be drained off up to $(CaO + MgO)/SiO_2 = 1.4 - 1.6$ by adding lime in the process of deoxidizing and fusing the ferrochromium.

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