PLAN FOR MECHANIZING AND AUTOMATING PRODUCTION AT ZAPOROZH'YE REFRACTORY PLANT

As part of the check up on implementation of the plan for mechanization and automation at the Zaporozh'ye Refractory Plant, which among other ferrous metallurgy establishments is to be equipped with modern machinery during the next few years, the All-Union Refractory Section of the Central Board of the Scientific-Engineering Society for Ferrous Metallurgy, in collaboration with representatives from the Society's branches at a number of refractory plants and institutes, heard reports and communications in December, 1961, by representatives of the All-Union Refractory Institute, which is the major planning and subcontracting organization of the design office (TsPKB) of the Glavproyektmontazhavtomatika Organization.

According to the program drafted by the All-Union Institute of Refractories and approved by the Council of Ministers of the Ukrainian SSR, apart from reconstruction of the shops presently working, the following new shops will be constructed at the Zaporozh'ye Refractory Plant; chamotte shop No. 2, an ingot-electric heater shop, an electro-fused refractory shop, and a shop for the production of mortars, mixtures and refractory concrete components.

The annual output of the plant will be considerably stepped up.

The total level of mechanization and automation of labor for the basic shops will be 73%, and of the plant as a whole, 53.4%. Labor productivity will be stepped up by a factor of 2.2, compared with 1958.

The draft plan provides for complex mechanization and automation of production processes of both the presently operating and future shops:

a) mechanization and centralized control of all receiving, unloading and storing operations for basic types of refractories reaching the plant;

b) automation of the production of initial charge components in all the production shops, drying raw materials, crushing, screening and charging materials, preparing green ware, batching, drying and firing;

c) mechanization of loading and conveying operations at finished-product stores;

d) automation of technical inspection of production.

Centralized control of production by means of computers and computing devices is being introduced.

Both the TsPKB and other design organizations took part in drafting the program.

It was noted in the reports that the preparation of working documents for the program was delayed through indecisions with regard to certain types of new equipment, means of mechanization, automation, and computing machinery; in certain cases workers have still not been appointed to jobs.

Taking into account the importance of mechanizing and automating production at the Zaporozh'ye Refractory Plant in the quickest possible time, and knowing that the experience gained should be widely applied in other refractory establishments, the All-Union Refractory Section adopted the decision to request the Gosplan of the USSR, the State Committee of the Council of Ministers of the USSR on automation and machine building and the Glav NII attached to the Gosekonomsovet of the USSR to see that production plans for machine building plants in 1962 included first samples of machines and instruments for mechanizing and automating production at the Zaporozh'ye Refractory Plant as submitted by the leading planning organization - The All-Union Refractory Institute; to include work which had not yet been assigned in the plans for research and design organizations; to take the necessary steps to speed up the issue of technical documents by the All-Union Refractory Institute and the TsPKB.

The All-Union Refractory Section decided to request the Council of Ministers of the UkSSR to consider reconstruction of the Zaporozh'ye Refractory Plant and to place orders for designed equipment and instruments with the plants in the plants in the Ukraine, to strengthen the TsIA of the Zaporozh'ye Plant and to ensure that the automation and mechanization office at the Kharkov Coke-Chemical Plant completes its program for new types of batching machines, conveyers and other means of mechanization and automation by 1962.

To avoid duplication in planning reconstruction and building other refractory plants and shops, it is essential for the All-Union Refractory Institute to supply information to the refractory industry in good time on new equipment, new types of dryers, furnaces and instruments, etc., scheduled for installation at the Zaporozh'ye Refractory Plant.

For this very important work to be carried out successfully and efficiently, it is essential to make an every day check on the implementation of it and render active assistance to the public organizations at the Zaporozh'ye Refractory Plant, the Society's Councils at the plants, the Zaporozh'ye Regional Board of the Society and the Central Board of the Society.

PRODUCTION

EXPERIENCE IN MANUFACTURING TAR-DOLOMITE BRICK AND TESTING IT IN SERVICE

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An experimental batch of non-fired dolomite brick with a tar binder was manufactured and tested in the walls of a 30-ton electric steel-smelting furnace in the refractory shop at the Kuznets Metal Works.

The manufacture of the experimental batch was preceded by laboratory research to select the grain composition of the mixture, the optimum amount of tar and to determine the time the brick could be stored.

To make the experimental tar-dolomite brick, use was made of dolomite fired in a rotary kiln possessing the following chemical composition: 4.2% SiO_2, 2.3% Al_2O_3, 2.1% Fe_2O_3, 52.8% CaO, 33.5% MgO and 4% other impurities. The alkali content was not determined.

The grain composition of dolomite was 60% 15 - 1.5 mm and 40% finer than 1.5 mm. The dolomite from both fractions was mixed for 10 minutes in roller mills with extra-light rollers with preheating by means of coke oven gas. The brick was pressed in metal holders on a 500-ton hydraulic press at a pressure of about 915 kg/cm^2. The size of the brick was 430 × 150 × 75/85 mm and the type was ES-625.

When 10% tar was added and the temperature of the mixture before pressing was 90 - 110°, it did not mold properly (the mixture "poured out" of the holder). The addition of tar was then reduced to 7.5 - 8.0% and the preheating temperature lowered to 55 - 75°. In all 11 tons of bricks were pressed.

The properties of the tar-dolomite bricks are shown in Table 1.

It was not possible to test the brick immediately after manufacture. Hence 10 days later the brick was coated with tar and kept for another 15 days in the store, after which it was used to line the walls of the steel-smelting furnace.

As a result of being kept for 24 days, some of the brick which had been laid less tightly began crumbling at the edges and swelling.

The walls of this furnace are usually made of non-fired magnesite-chrome brick of two kinds: the two bottom rows and the back wall opposite the loading window are made of ES-625 brick, while the remaining part of the walls is laid with ES-626 brick, 300 × 130 × 75/85 mm in size.

The tar-dolomite brick was laid in two areas: on the left and right-hand sides of the charging windows, beginning at the second row (Fig. 1). The rest of the wall was lined, as usual, with non-fired brick.

During the first period after the furnace was started up, the seams between the rows stood out more clearly in the experimental areas than in the normal brickwork. During the ensuing period the tar-dolomite brick on the right-hand side protruded slightly beyond the magnesite-chrome brick. During service the brick became slagged and spalled. The lining lasted 122 melts, after which the furnace was stopped for normally scheduled repairs. The mean strength of the lining made of magnesite-chrome brick was 108 melts.

The residual length of the tar-dolomite brick ranged from 210 to 350 mm, and in the magnesite-chrome brick from 110 to 320 mm. The mean wear per melt was 1.32 and 1.43 mm, respectively.

During service the tar-dolomite brick acquired a zonal structure, with different colored zones running along it, as a result of interaction with the melt dust (Fig. 2).

Spectrographic and physical-chemical study of the spent brick was made on two bricks.

The cold or unaltered zone, 230 and 118 mm thick, retained its black color and coarse bumpy structure of unused brick.

TABLE 1

PROPERTIES OF EXPERIMENTAL BATCH OF TAR-DOLOMITE BRICK*

No. of experiment	Amount of time kept, hours	Porosity, %	Bulk density, g/cm^3	Compressive strength, kg/cm^2
1	48	2,3	3,00	7,0
2	48	3,3	2,98	8,5
3	72	Not determined		8,0
4	72	"	"	7,0

* All commas are equivalent to a decimal point.

The transition zone, 40 - 50 mm thick, was gray and had a somewhat densified structure.

The sintered zone, 50 and 35 mm thick, was greenish in color and had a homogeneous, monolithic structure.

The working or hot zone, 10 - 15 and 5 - 7 mm thick, was black and had a fused, bumpy surface. Spalling cracks were seen 30 mm from the working surface.

The mineralogical and chemical composition (Table 2) of the cold zone is the same as for the spent brick; i.e., it is composed of fine, thin, rounded grains of periclase and lime (Fig. 3), cemented here and there with a black fringe

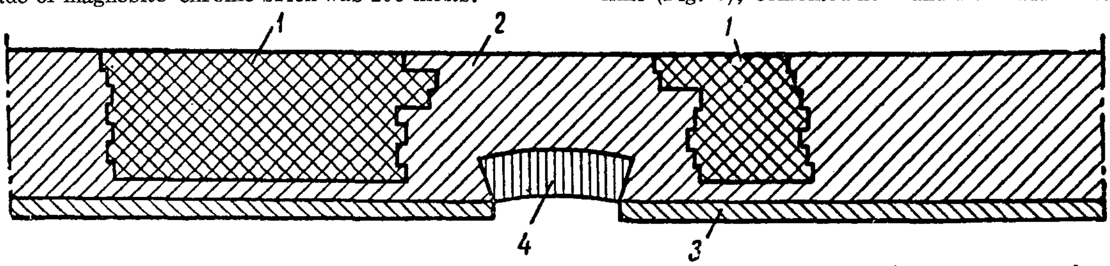

Fig. 1. Lining of electric steel smelting furnace (unfolded): 1) tar-dolomite brick; 2) non-fired magnesite-chrome brick; 3) magnesite; 4) chrome-magnesite

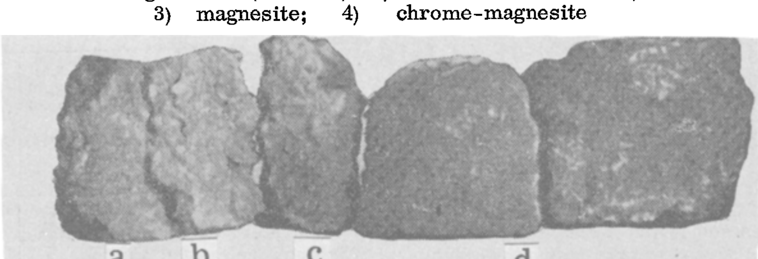

Fig. 2. Thermal structure of bricks: a) working zone; b) sintered zone; c) transition zone; d) unaltered zone.

TABLE 2

CHEMICAL COMPOSITION OF BRICK AFTER SERVICE, % *

No. of samples	Zone	SiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	CaO	MgO	Other impurities	C	Total
				Tar-dolomite brick						
8156	Unaltered	3,44	3,24	—	2,32	53,62	34,76	2,11	0,74	100,12
8157	Transition	4,40	3,69	—	2,41	54,08	31,19	2,56	0,20	98,52
8158	Sintered	4,50	4,35	—	2,32	55,12	29,74	2,50	0,14	98,67
8159	Working	5,42	7,38	—	10,62	51,96	28,93	0,00	0,14	99,45
				Tar-dolomite brick						
8299	Unaltered	3,80	3,47	—	3,51	53,01	32,56	1,09	1,92	99,36
8300	Transition	4,40	3,50	—	3,13	51,67	33,57	2,31	0,19	98,77
8301	Sintered	4,64	6,13	—	3,05	53,74	31,08	0,55	0,20	33,39
8302	Working	5,88	3,54	—	13,92	50,63	26,00	0,03	0,23	100,23
				Non-fired magnesite-chrome brick						
8160	Unaltered	5,24	4,73	10,52	7,63	2,08	69,31	—	—	99,51
8161	Transition	5,52	4,15	10,11	7,20	2,46	69,09	—	—	98,53
8162	Sintered	10,72	5,24	9,68	7,64	9,86	55,66	—	—	98,80
8163	Working	8,28	5,83	9,47	12,72	10,24	53,06	—	—	99,70

* All commas are equivalent to a decimal point.

of tar and, very occasionally, braunmillerite $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$. Occasionally to be seen were grains of tricalcium silicate (Fig. 4) and coarse-grain periclase. The periclase showed normal refraction $\eta = 1.734$.

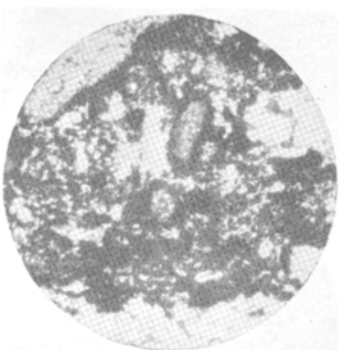

Fig. 3. Microstructure of unaltered zone in tar-dolomite brick. × 80. Without analyzer. The segregations of light-colored rounded grains are periclase and lime; the black edges and grains are tar

The transition zone was marked by absence of tar (it had burned up) and a high content of tricalcium silicate (Fig. 5).

In the sintered zone there was sharp densification of the structure and the fine grain aggregates of periclase and lime merged into solid fields of rounded grains (Fig. 6), in some areas interspersed with elongated crystals of tricalcium silicate. In chemical composition the sintered zone differed from the transition zone by having a higher content of aluminum oxide and calcium oxide and a correspondingly reduced amount of magnesium oxide.

The working zone (Fig. 7) - the most altered and densified - was saturated with iron oxides (10.61 - 13.92%), in terms of Fe_2O_3, alumina (7.38%) and silica (5.42 - 5.88%) with the formation of numerous segregations of braunmillerite, tricalcium silicate and solid solutions of iron oxides in periclase. As a result, the periclase acquires a dark yellow or brown coloring had a higher refractive index $\eta = 1.764$.

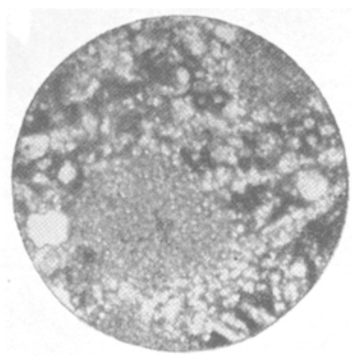

Fig. 4. Microstructure of unaltered zone in tar-dolomite brick. × 80. Without analyzer. The elongated light-colored grains are tricalcium silicate; the rounded grains are periclase, the black grains are tar

Thus, the phase composition of the working zone in the tar-dolomite brick is represented mainly by the same high-refractory minerals as the brick prior to service, except that there is coarsening of all the crystal phases and a change in the ratio of them: the content of braunmillerite is increased, the amount of tricalcium silicate is slightly increased,and the periclase and lime are decreased accordingly.

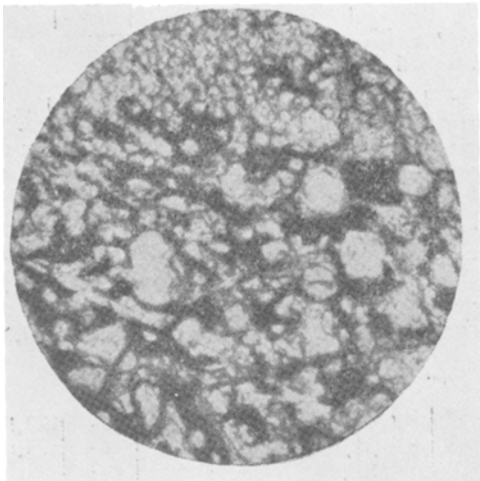

Fig. 5. Microstructure of transition zone in tar-dolomite brick. × 80. Without analyzer. The light-colored fine grain aggregates are periclase and lime; the large rounded grains are periclase; the elongated grains are dicalcium silicate, the black grains are ferrites

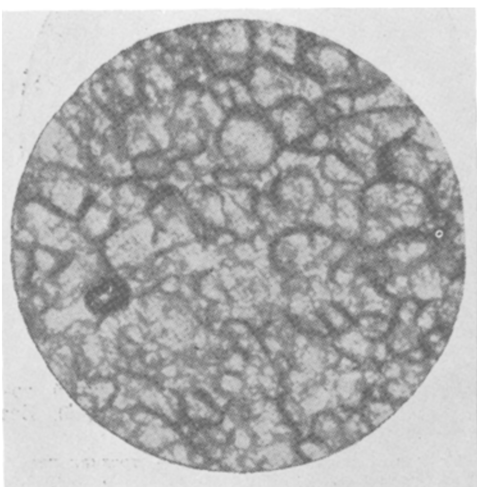

Fig. 6. Microstructure of sintered zone in tar-dolomite brick. × 80. Without analyzer. The gray aggregates of rounded grains are periclase and lime

Fig. 7. Microstructure of working zone in tar-dolomite brick. × 80. Without analyzer. The large white grains are tricalcium silicate; the black areas are periclase and braunmillerite

Chemical and microscopic study shows that the magnesite-chrome non-fired brick, as distinct from the tar-dolomite brick, is saturated to a high degree in the working and sintered zones with silica and calcium oxide with the formation of a considerable amount of low-melting merwinite and monticellite. The low-melting silicate melts in the magnesite-chrome brick penetrate to a depth of 50 - 55 mm and in the tar-dolomite brick to 15 - 17 mm.

The penetration of the oxides to this depth and the formation of low-melting silicates promote more rapid wear, whereas in the working zone of the tar-dolomite brick, the content of high refractory tricalcium silicate is increased, which alongside the other refractory phases should reduce the wear and tear.

CONCLUSIONS

The results of petrographic and chemical analysis show that tar-dolomite brick can be used satisfactorily for the lining of electric steel-smelting furnaces.

It is advisable to test the dolomite brick made by the above-described production process in the lining of converters using oxygen.

MECHANIZATION AND AUTOMATION OF PRODUCTION PACKAGE METHOD OF HANDLING REFRACTORY PARTS

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The cost of delivering refractory parts to consumers at the present time is high. This is mainly due to the large amount of reloading which the parts have to undergo during transportation, and also to the fact that most reloading operations are done by hand and accompanied by breakage and damage to the parts. Investigation has shown that refractory plants as well as the organizations using refractory parts practice an almost identical system of loading-unloading and handling operations.

The mechanization of loading-unloading operations, the protection of refractory parts from damage as well as a cut in the cost of delivery are all possible by using the package method of transportation.