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NEW METHODS OF BENEFICATION AND AGGLOMERATION OF IRON ORES AND CONCENTRATES FOR BLAST-FURNACE PROCESS: THEIR EFFICIENCY 1/

by

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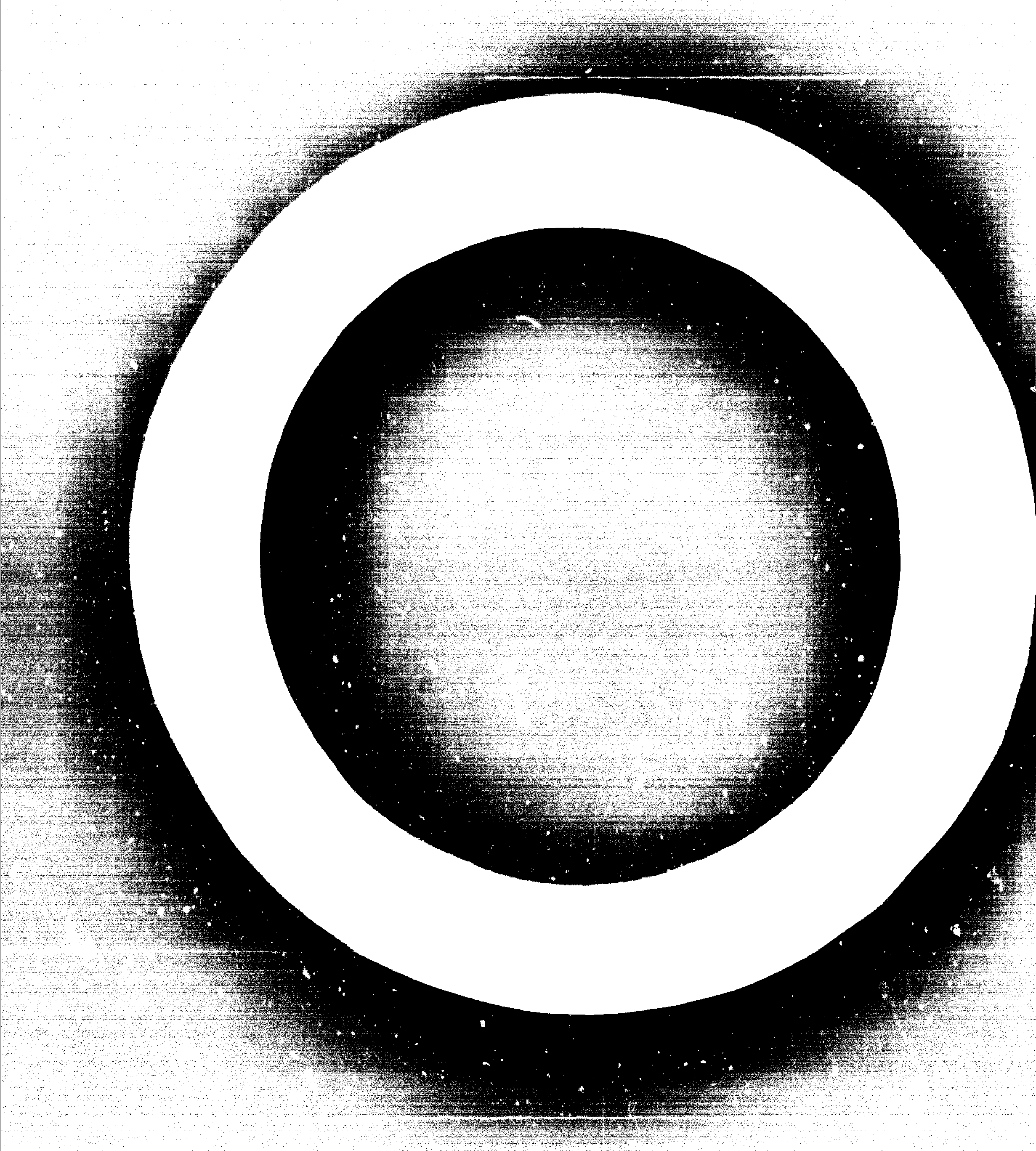

NEW METHODS OF BENEFICATION AND AGGLOMERATION OF IRON ORES AND CONCENTRATES FOR BLAST-FURNACE PROCESS; THEIR EFFICIENCY

NEW METHODS OF IRON ORE BENEFICATION

Present state of benefication technique

The present state of iron ore benefication technique is characterised by continuous growth of commercial ore production, particularly of concentrates, and by improving their quality.

The problem of large scale production of high grade concentrates in the USSR is a big economic task. The efforts of researchers are directed to looking for effective methods of iron ore benefication, providing for producing high-quality iron concentrates.

Improving the quality of iron concentrates and the degree of their benefication yields great advantages. On the one hand, the cost of iron and steel is much decreased and capital investments into iron and steel industry are reduced by 10-15 per cent, and on the other hand, the operating efficiency in different-shops is increased, the volume of slag decreases, the output of each production unit raises and automatic control of existing furnaces is faciliated.

The use of pre-reduced pellets opens great possibilities in iron and steel industry. So, the development of the iron ore mining industry of the USSR is now directed not only to increasing the production of commercial iron ores and concentrates but to the improvement of their grade and raising physical properties of agglomerated raw materials as well.

Magnetite quartzites can be easily dressed for producing high-quality iron ore concentrates. The efficiency of their benefication depends on their mineralogical composition, minerals particles size, which can widely differ even in the range of one deposit.

The existing methods of benefication allow for producing concentrates with 64-66 pct Fe.

The development of highly efficient methods of low-quality iron ore benefication for producing high-quality concentrates is most promissing in view of both high efficiency of improving iron ore raw materials for iron- and steelmaking and progress of powder metallurgy and processes of direct reduction of iron.

Magnetic and flotation method for producing high-quality concentrates.

The practice of the Soviet industry shows that the improvement of iron ore raw materials and producing concentrates containing 64-71 pct of iron is accomplished by the use of multi--staged and combined flow sheets with ore and pebble grinding of magnetite quartsites. Data on the results of the improvement by floatation of magnetit quartsites from the Krivoi Rog deposits are as follows:

	Concentrate	
	NKMBC[2)] S M B C[3)]	N M B C[4)]
Per cent of iron content[1)]	65,0/71,0	63,2/68,0
Per cent of limestone content	7,0/1,1	8,5/3,6
Per cent of iron recovery to the up-graded concentrate	95,8	96,2
Per cent of iron-content in tailings of up-grading process	22,0	24,0

A lower iron content in the raw and the improved concentrates(concentrate II)may be due to a more fine penetration of non-metallic minerals into magnetite,and a relatively high content of iron silicates.

The floatation up-grading flowsheets include three stages of concentrate cleaning and one control operation.

The reagents used are: tall soap (250-300 gr per ton); sulfite cellulose liquor (2.0--2.5 kg per ton); soda-lime solution (3 kg per ton); pH= 11,6 - 12.

The quality of up-graded concentrates from magnetite quartzites produced at Krivoi Rog benefication plants meet the specifications stated for the processes of direct reduction of iron.

In 1967 the "Mekhanobrchermet" Institute developed a magnetic-floatation flow sheet for producing high -grade concentrates, this flow sheet differing from previous ones in the possibility of additional magnetic beneficiation of floatation tailings, that is magnetic concentrates, containing up to 30 pct Fe.

The magnetic separation concentrate with an iron content of 64-65 pct is treated by a "reverse" anionic floatation, the tailings of which are regrinded with subsequent repeated magnetic separation. As a result the iron content in dump tailings remains the same as in magnetic separation ones. The intermediate product of magnetic separation is returned to floatation. During floatation the following reagents are used: the collector being the raw tall oil soap (60 per cent into the primary floatation and 40 per cent into the check one); the depressor being the sulfit cellulose alkali, vinasse of sulfit alkali, containing lignin, which is the refuse of paper and pulp industry; the adjuster of media being the caustic soda alone or mixed with lime in ratio of 1:1.9 (pH of media being 11.5 - 11.0). The reagents are used in following ammounts 2 kg per ton of sulfit-cellulose alkali; 3 kg per ton of caustic soda mixed with lime; 0,3 kg per ton of tall oil soap.

When working to this flow sheet it is possible to produce concentrates containing 71.5 pct Fe; with the 81.2 pct recovery and 41.9 pct yield; the iron content in tailings is 11.5 - 12.0 pct . The mineralogical analysis of the concentrate shows that practically there is no free non-metallic grains in it and it fully consists of iron minerals.

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1) The numerator corresponds to the raw concentrate; the denominator to the up-graded concentrate.
2) Novo-Krivoroshski Mining and Benefication Combine
3) Southern Mining and Benefication Combine
4) Northern Mining and Benefication Combine.

Combined flow sheets benefication of oxidized ferriferrous quartsites.

In the USSR oxidised ferriferrous quartsites are used only to a certain extent . At the Central Mining and Benefication Combine (Krivoi Rog) 9,000,000 tons of oxidised quartsites ore processed by roasting magnetic flow sheet,and at Olenegorsk Combine a small amount of side recovery are is processed by gravity-magnetic flow sheet.

The benefication of oxidized quartzites by roasting-magnetic method was started at the Central Mining and Benefication Combine in 1962. The magnetizing roast is carried out in 36 x 50 m rotating kilns with the output of 1000 tons per day each. They are fired with natural gas, and for iron ore reduction a combined reducing agent (natural gas + lignits) is used.

During the work of the roasting plant different flow sheets of roasted ores benefication have been tried. The best results were received when using the flow sheet including three stages of grinding and four stages of magnetic separation:a concentrate with an iron content of 61.5 - 62.0 pct is produced using iron ore containing 23.5 pct of magnetic iron with the recovery rate of crude ore 62 - 63 pct.

The development and introduction of vortex chambers and fluidized bed furnaces are quite promissing for the advance of the magnetizing-roast process.

The techno - economic calculations show that dressing of oxidized ores with the use of fluidised bed furnaces and vortex chambers will allow for decreasing specific capital investments by 3 times and the cost of conversion by 1.5 times.

When dressing ore in a furnace with fluidized bed one can produce concentrates containing 62 pct Fe and tailings containing 7-12 pct Fe with 90 pct recovery of crude ore, even using two-stage grinding.

As a result of research work of the "Mekhanobrohermet" Institute, "Mekhanobr" Institute and Central Scientific and Research Institute for Ferrous Metallurgy other flow sheets for the benefication of oxidised quartsites have been developed for the use at country's largest iron ore deposits. The fundamental process for oxidised quartsites benefication is floatation combined with gravity and magnetic methods of dressing (separation in a high intensive electric field).

In recent years two trends of iron ore benefication by floatation have been marked: direct floatation of iron oxides and reverse floatation of waste rook .

At the full scale production section of the Central Mining and Benefication Combine a concentrate with an iron content of 62,8 pct was produced by method of direct floatation of initial iron ore with the use synthetic oil substitutes mixed with diesel fuel, the recovery being up to 66.1 pct Fe. The following reagents are used for direct floatation: the collector being the mixture of fatty acid collectors with the addition of solar oil (0,75 kg per ton); sulfuric acid (0,7 kg per ton); liquid glass with aluminium sulfate (1.3 kg per ton).

In laboratory and pilot plant conditions,systems and flow sheets of reverse anionic floatation without de-sliming of material have been developed and tested, allowing to increase iron recovery to the concentrate to 84,3 pct.

The reverse anionic floatation has a number of advantages as compared with the direct one: it is successfully conducted in diluted slurries and hard water, containing acids of hardness about 67,5^{0}, besides it does not require desliming before floatation and non-toxic reagents can be used.

In 1966 combined gravity-floatation and gravity magnetic - floatation methods for benefication of oxidized quartsites were developed by the "Mekhanobrohermet" and

"Mekhanobr" Institutes. Gravity benefication was accomplished in spiral separators and magnetic separation, in multi gradient ones.

The studies fulfilled, showed the possibility of stage quartzite benefication with introducing up to 25-30 pct of dump tailings at the first stage of grinding (see fig. 1,2).

Multi-stage flow sheets can be used for the benefication of oxidized quartzites, whereupon at the first stage of crushing dump tailings are separated from the 0,3-0 mm material, at the second stage grain concentrate is reground to the size of 50-60 pct - 0,074 mm and produce gravity concentrate; at the third stage intermediate product of 92-96 pct -0,074mm is dressed by reverse floatation or magnetic separation and floatation.

The data characterizing the oxidized quartzites benefication by combined methods is shown below (both flow sheets have three stages of benefication):

	Gravity-magnetic floatation flow sheet	Gravity-floatation flow sheet
Yield, per cent:		
Dump tailings at the first stage	24,6	-
Gravity concentrate at the second stage	25,5	25,5
Product sent to the third stage of grinding and to the floatation	47,3	74,5
Iron content in summary concentrate taking into account ignition loss, per cent	62,3-63,5	62,3-63,7
Iron recovery in summary concentrate, per cent	83,0	83,6

The calculations indicate economic prerequisites for the possibility of wide utilisation of oxidized quartzites. It is most expedient to combine their processing along with mining of magnetite quartzites. The cost of product received from oxidized quartzites is practically equal to the production cost of concentrates produced from magnetite ore.

The use of combined methods with floatation makes it possible to produce concentrates of higher grade from oxidized quartzites.

The characteristics of up-grading by floatation of grain gravity concentrates and ones, produced by magnetic separation in a magnetic field of high intensity are as follows (in per cent):

Products and characteristics of benefication		Initial product	
		gravity concentrate	magnetic concentrate
Concentrate:	yield	87.5	66.2
	iron content	66.5	65.6
Concentrate (taking into account ignition losses)		67.8	67.7
	silica content	2.2	2.9
	iron recovery	97.0	89.6
Tailings:	yield	12.5	33.8
	iron content	14.4	15.0
	iron recovery	3.0	10.4
Initial product:	yield	30.0	70.0
	iron content	60.0	48.5
	silica recovery	11.5	27.1

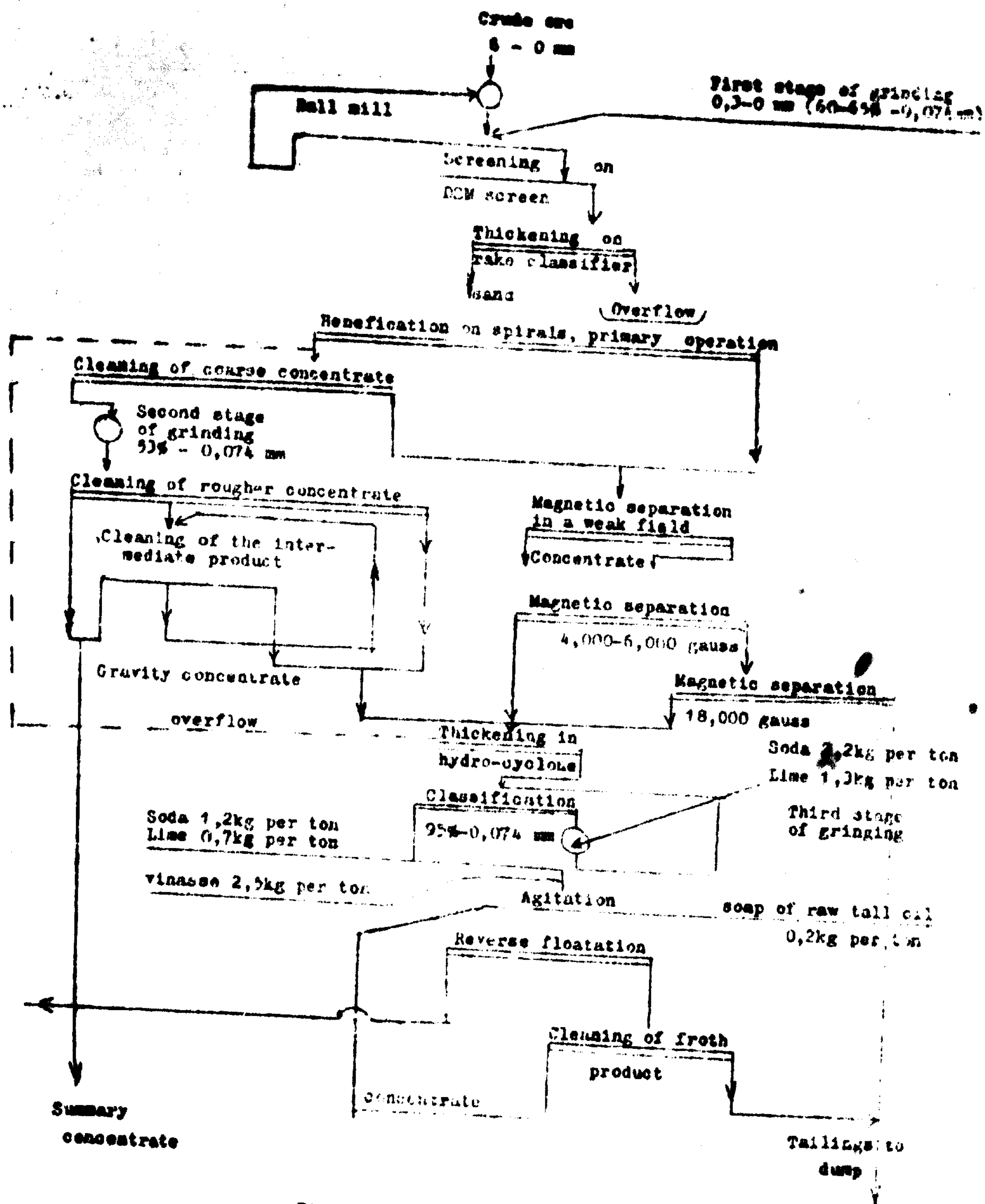

Fig. 1. The flowsheet for gravity magnetic floatation benefication of oxidized quartzites

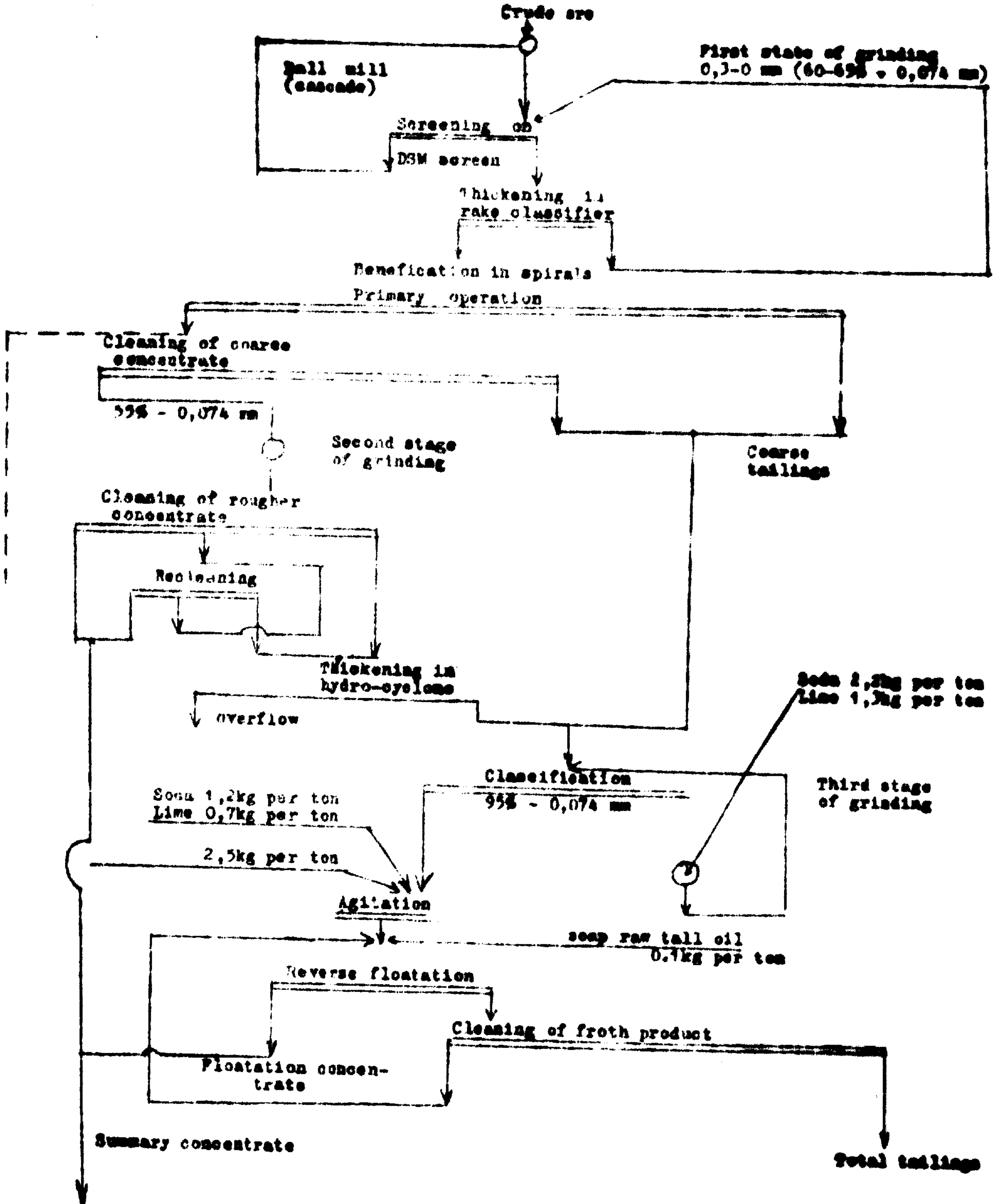

Fig. 2 The flowsheet for gravity flotation benefication of fine-disseminated oxidized quartzites.

MAGNETIC AND MAGNETIC-FLOATATION METHODS FOR OXIDIZED IRON ORE BENEFICATION

In the iron and steel industry of the USSR they use a great amount of hematite-martite iron ores without preliminary benefication. These are mined by underground methods in the Krivoi Rog iron ore- deposits and by open pit technique at the Kursk Magnet Anomaly. The iron content of these ores avarages 55-56 pct and that of silica 16-17 per cent.

The use of such raw materials does not provide for high efficiency of conversion.

In recent years efficient technological flow sheets for the benefication of these ores have been developed by Mekhanobrchermet Institute and NIIKMA. In particular, for the ores of "the Krivbass" a laboratory and pilot plant technique has been developed with the use of magnetic separation in multi-gradient separators, which allows high rates of benefication to be reached.

For lump (blast furnace) ores a three-stage flow sheet for magnetic separation with two stages of grinding is developed (see fig. 3). The first stage of grinding and the primary operation of magnetic separation were mastered at the pilot benefication plant of the Institute.

The magnetic separation of the classifier overflow was carried out in a drum electro-magnetic multi-gradient separator having the size of 600 x 1200 mm which was designed by the "Mekhanobrchermet" Institute. The operating zone of the separator is filled with balls 7mm. in diameter, the magnetic density of the ball bed being 4000-4500 gauss.

The most favourable size of grinding at the first stage is 0,85-0mm (70-75 pct lower than - 0,074 mm). When grinding up to 71.9 pct lower than - 0,074 mm at the first stage of benefication 50 pct of final products (concentrate and tails) is received.

The cleaning of magnetic fraction received by the main operation was carried out in a magnetic field with the magnetic density in the operation zone about 4000 gauss, the cleaning of non-magnetic fraction - in a field with magnetic density of 11000 gauss.

The third stage is characterized by returning intermediate products of cleaning operations to the thickener just before the primary magnetic operation of the third stage. It is also possible to return intermediate products of the second stage of benefication to the thickener just before the second stage of grinding.

According to the same flow sheet 61.5 pct of concentrate containing 62.2 pct Fe and 8,0 pct SiO_2 was received from hematite iron ore, containing 46.3 pct Fe; the rate of recovery being 82.7 %. The iron content in total tailings is 20,9 pct.

Along with magnetic benefication flow sheet, magnetic - floatation and floatation flow sheets were tested in the laboratory. Two alternatives of magnetic floatation flow sheet were tested (see the table following):

Engineering data of oxidized ore benefication according to different flow sheets (in per cent):

Flow sheet	Product	Yield	Iron content	Iron recovery
Magnetic	Concentrate	61,5	82,2	82.7
	Tails	38.5	20.9	17.3
	Crude ore	100.0	46.3	100.0
Magnetic-floatation (floatation of the intermediate product of the first stage of magnetic separation	Magnetic separation concentrate	28.8	62.4	38.8
	Floatation concentrate	33.5	62.0	45.0

	Summary concentrate	62.3	62.2	83.8
	Magnetic separation tailings	21.2	19.6	8.9
	Floatation tailings	11.7	11.0	2.8
	De-sliming overflow	4.8	43.0	4.5
	Total tailings	37.7	19.9	16.2
	Crude ore	100.0	46.3	100.0
Magnetic floatation(floatation of primary magnetic operation and cleaning of first stage tailings fractions)	Floatation concentrate	63.7	62.7	86.3
	Magnetic separation tailings	21.2	19.6	8.9
	Floatation tailings	15.1	14,5	4.8
	Total tailings	36.3	17.4	13.7
	Crude ore	100.0	46.3	100.0
Floatation	Concentrate	64.0	62.0	85.6
	Tailings	36.0	18.5	14.4
	Crude ore	100.0	46.3	100.0

Floatation of regrinded total intermediate product after separation of concentrate and tailings at the first stage of magnetic separation and floatation of magnetic fraction of primary operation of magnetic separation (58.4 pct Fe) and cleaning of the tailings of this operation (46.3 pct Fe) are shown. In the last case during the first stage of benefication only dump tailings, containing 19.6 pct Fe are separated.

The reverse floatation flow sheet in hard water(15,75^{0}) included primary and control operations and two cleanings of froth product. The consumption of reagents is as follows: 0.8-1.0 kg per ton of sodium hydrate; 2.2kg per ton of sulfite alkali vinasse; 0.3 kg per ton of tall oil soap.

The highest engineering data were obtained when using floatation and magnetic-floatation flow sheets with separation of tailings at the first stage of magnetic separation. In this case the iron content in the concentrate is 62.0-62.7 pct, the recovery being 85.6--86.3 pct. The magnetic separation flow sheet permitting the 82.7 pct recovery of iron into concentrate is quite promising.

The use of magnetic separation in multi-graded separators allows to realise a stage-by-stage benefication flow sheet for oxidized ores, to give up the use of reagents and to improve the conditions of fine-grained concentrate filtration. It is quite obvious that a flow sheet for oxidized iron ores benefication can be finally chosen only after techno-economical comparison of them, bearing in mind the results of pilot plant tests and design studies.

NEW METHODS OF IRON ORE AND CONCENTRATE AGGLOMERATION

In the USSR the fundamental method of agglomerating fine ores and concentrates is sintering. The capacity of existing equipment allows to produce more than 120.000.000 tons of sinter per year. The main trends in developing methods of sintering are the intensification of the process and the improvement of sinter quality. The process of briquetting did not find a commercial spreading in the USSR. In connection with the uti-

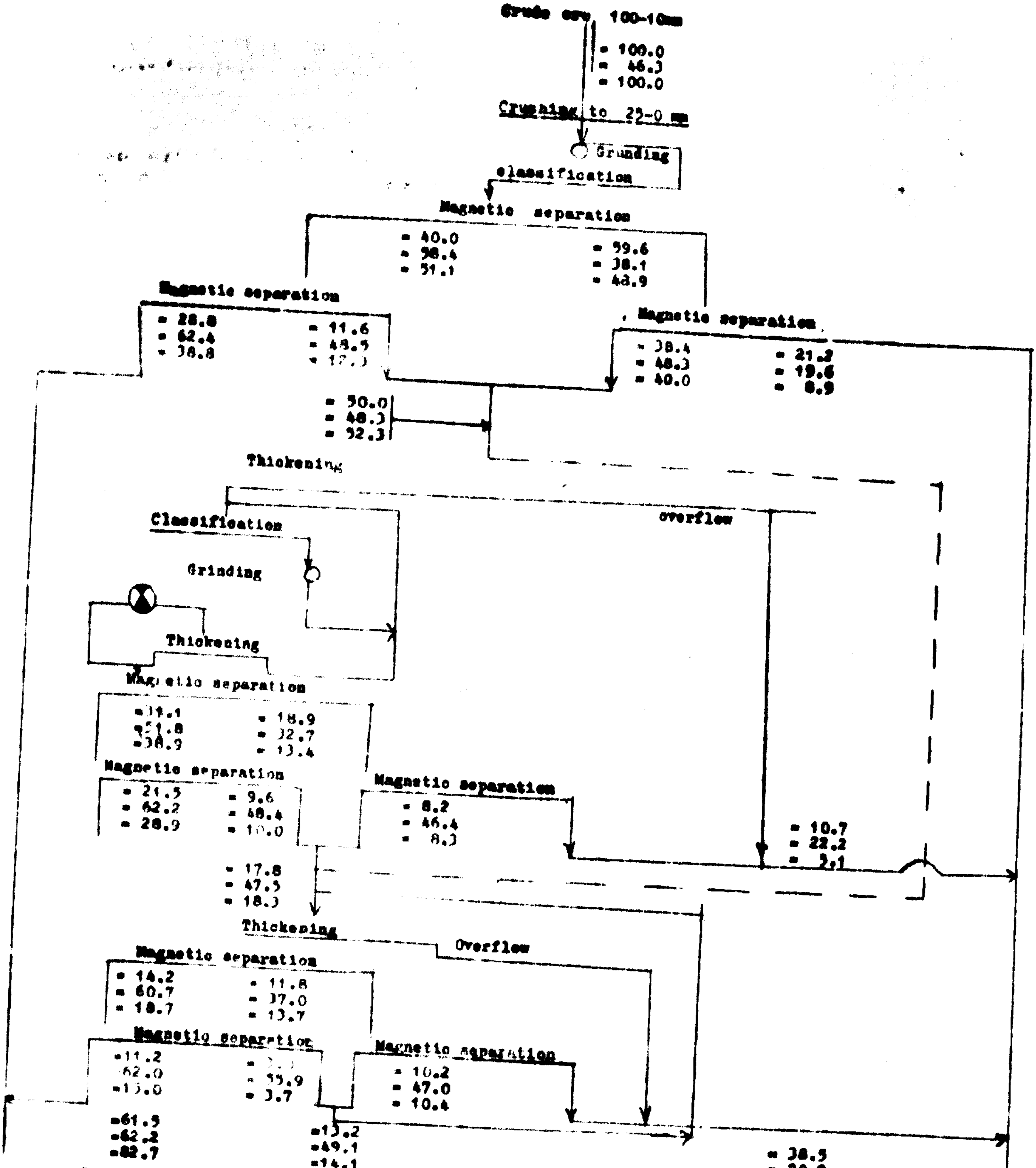

Fig. 3 Magnetic scheme of benefication of hematite-martite ores indergreund mined.

lisation of magnetit finely-disseminated ores and with a significant growth of finely-disseminated concentrate production, the process of palletizing has been widely developed in recent years.

THE PRODUCTION OF SELF-FLUXING PELLETS

Pelletizing fine-grained concentrates is an efficient method for agglomerating this raw material of new type. This is due to the uniform grain-size composition, high degree of reduction and pellets strength as well as the possibility of transportation of indurated pellets to great distances between mines and iron and steel plants without decreasing their strength and generating fines. The efficiency of pellets use in blast furnace practice is explained not only by their high properties but sometimes is also due to a higher iron content in the initial concentrate of which pellets are made, as compared to crude iron ore used in the blast-furnace burden or the iron ore component of the sinter.

In contrast to the USA and Canada the process of pelletizing began to be developed in the USSR after the production of self-fluxing sinter had been mastered; the use of this sinter considerably contributed to the improvement of blast-furnace practice. The use of pellets under such conditions is more expedient than that of self-fluxing sinter, and this permits to compensate the high cost of pelletising.

As the waste rock of concentrates is acid by nature, as a rule, the use of self-fluxing pellets is most efficient. Therefore in the USSR the main attention was paid to the production of this kind of pellets, the designs of first pelletising plants providing for the introduction of limestone into the pellets composition.

Presently two commercial pelletizing plants producing self-fluxed pellets are working in the USSR.

At the Sokolovsk-Sarbaisk Mining and Benefication Combine peletising plant (Rudnyi, Kustanai region), designed in 1962, they use magnetite concentrate containing 65-67 pct Fe, 4.? pct SiO_2, 1.5 pct Al_2O_3 and about 2.0 pct CaO + MgO. The rated capacity of the plant is 8.400.000 tons of pellets with the basicity of 1.15. When reaching the full capacity, 12 indurating machines will work having useful firing area about 108 sq. m. each. Two machines were put into operation at the end of 1965; at present nine machines are operating.

The concentrate proceedes to pelletising through a sheltered storehouse.

Satisfactory pellets are produced from a concentrate consisting of 92-95 pct-0.074 mm with humidity up to 9.5 pct.

Limestone and bentonite are grinded up to 0.1 mm and simultaneously dried in ball mills with ventilation. Green pellets are conveyed to each machine from three technological lines including hoppers with proportioning devices for concentrate and grinded limestone and bentonite, a pug mill and a balling drum with a single deck vibrating screen. The output of the 2.8x11.0 m balling drum is 40 tons per hour, its angle of inclination being 7°. The pellets having 20-12 mm diameter are hardened and after that they are grouped into three classes: final product having 20-12 mm diameter, bed product 12-6 mm and return product 6-0mm, the latter being sent to sintering plants.

Natural gas is used for pellet firing. Pellets with the highest strength and the highest degree of desulfurization are produced with the firing temperature about 1300-1350°C which is the temperature corresponding to the beginning of their softening. The pellets fired at such a temperature have a zonal structure. The surface oxidized zone up to 7 mm thick (1-7mm) consists mainly of hematite and calcium ferrites acting as a hardening binder for hematite grains. The nucleus of a pellet having 3-10mm in diameter (depending on the place of pellets in the layer, that is, on temperature and duration of a high-temperature firing) consists mainly of magnetite and slag binder.

When firing pellets at the temperature below 1300°C their drum index is unsatisfactory, despite a rather high crushing strength (up to 225 kg per pellet); this is confirmed by generating 10-20 pct of 1-0 mm class material when testing in the drum. Much dust appears during the transportation of such pellets, their strength in the process of reduction being low too.

Quality characteristics of pellets produced in 1967 are following:

Composition (in per cent):

Fe = 62-63; FeO = 3 - 5; S = ,06-,12

Basicity (CaO: SiO_2): 1.11 - 1.16

Fine material content (5-0 mm when shipping): 5-8 pct

Compession strength: 200-240 kg. per pellet

Drum sample (yield of 5-0 mm particles when tested in the Rubin drum): 4-6 pct.

The output of one firing machine is 80-85 tons of pellets per hour.

The rated capacity of the pelletizing plant of the Central Mining and Benefication Combine (Krivoi Rog) designed for self-fluxing pellets production is 6.800.000 tons per year. At this plant eight indurating machines with useful firing area of 108 sq. m each will be installed.

The first machine is commissioned the middle of 1967; the completion of plant building is planned in 1968. At this plant, pellets are produced with the use of concentrate received as a result of magnetit quartzites benefication containing 66 pct Fe. After putting into operation all indurating machines the quantity of this concentrate will be insufficient, therefore it is supposed to use concentrate received by magnetic roasting of low-grade oxidised ores.

The problem of full scale production of hard self-fluxing pellets of uniform quality is not yet satisfactorily solved. When firing at travelling grates it is practically impossible to receive pellets of uniform quality at all levels of the layer. A narrow range of firing temperatures interferes with attaining minimum necessary temperatures at the bottom and almost inevitably is accompanied with the sintering of a certain part of pellets with the formation of druses and conglomerates. For the same reason there is a hazard of circular skuls formation when firing in rotating kilns. To avoid the desintergation of pellets during storage it is essential to provide full assimilation of flux when firing self-fluxing pellets.

For eliminating a possibility of appearing free lime inside the self- fluxing pellets it was proposed to introduce into the mix for pelletizing an iron-flux instead of raw limestone[x].

An experimental 10 days melting of self-fluxing pellets in a blast furnace of 1000 cu m useful volume showed the advantages of their use as compared to sinter: the furnace output was increased by 7.5 pct, and the coke rate decreased by 6.8 pct. The pellets used were produced in 1961 by the above method at the pilot plant of the Southern Mining and Benefication Combine at Krivoi Rog.

However the use of this method does not eliminate the main disadvantage of the self--fluxing pellets firing process, which is the narrow range of permissible temperature gradient; besides, its use is connected with two high cost processes of conversion: producing

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x) L.P. Migutski and G.N. Pudovski. Patent N145600 (USSR) with the priority since Dec. 26,1960. - Bulletin of Inventions and Trademarks, 1962, N6.

self-fluxing sin. : (iron-flux) and its fine grinding.

TWO - ZONE
SELF - FLUXING PELLETS

At the Moscow Institute of Steel and Alloys a new method for producing self-fluxing pellets has been developed[x], these pellets remaining hard both in storage and in transportation and having a high basicity. In the process of production of these pellets regular of dolomitic limestone is used.

This method provides for making the pellet nucleus from a mixture of an iron ore concentrate (40-60 pct) and a fine-grained flux (60-40 pct). With this ratio the basicity of the material in the pellet nucleus is 4-10, besides during firing easily melted ferrites are formed.

The external pellet layer usually consists only of concentrate, however a small addition of flux is possible, provided its self-fluxing degree does not exceed 0,5. The most favourable temperature for the firing of two - zone pellets is higher than that of sintering and beginning of softening of the nucleus material, which have high basicity, but it is lower than that of softening of non-fluxing pellet shell.

As the external pellet layer consists only of concentrate and contains a small amount of limestone, the temperature schedule for two zone pellets firing is almost equal to that for non-fluxing pellets. Owing to the higher permissible temperature of gas - the heat carrier - higher gradient of temperature between gas and material is possible and thus a higher heat transfer ratio is attained. As a result, a higher specific output is reached than it is possible when firing pellets having a uniform distribution of flux. A higher temperature of softening the shell material as compared to that of regular self-fluxing pellets allows to avoid pellets sintering and decreases the possibility of skull formation when firing at combined machines, called "grate - kiln".

The permissible range of temperature for firing two-zone pellets is 2 to 3 times higher (80-130°C), which facilitates the firing process control.

As the acceptable temperature for firing (1300-1350°C) is higher than that for sintering and even melting of fusible nucleus having high basicity (1200-1250°C), CaO in the process of firing is fully assimilated and forms an iron-calcium liquid phase which impregnates the material of an intermediate zone of the pellet (between the nucleus and shell). When firing temperature is high a cavity is often formed in the centre of a pellet. This method of producing self-fluxing pellets makes it possible to increase the degree of sulphur removal, therefore its use is most effective when firing self-fluxing pellets produced from concentrates with high sulphur content.

This method of producing two - zone pellets was tested at the pilot plant of Sokolov-Sarbaisk Mining and Benefication Combine. The pellets with 1.3-1.35 basicity were produced step-by-step: at first, in a 1.3 x 4.4 m drum and then in a flying saucer having 2.8m in diameter. The pellets were fired on a traveling grate machine with the useful area of 5.2 sq.m.

The results of the test showed the importance of high uniformity of mix before pelletizing so as to receive two-zone pellets of the high quality required. The yield of two-zone pellets was 92-95 pct.

Sintering of separate pellets during firing did not occur. The specific output of the travelling grate was 1.0 ton per sq.m per hour. The pellets were characterized by

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x) F.A. Yarkho, A.N. Pokhvistnev, A.N. Spektor. Patent N 668421 (Belgium) with the priority since Aug. 17, 1965.

high degree of reduction and by high strength (250-350 kg per pellet and 10-12 pct of 5-0 mm material in a drum sample). Sulphur content was decreased from 0.22 - 0.61 pct to 0.05 -0.07 pct.
The use of this method for pellet production is possible only with a low water content in the concentrate prior to pelletising, otherwise along with external shell formation non--fluxing pellets will be formed.

SINTERING

When constructing new sintering plants, cooling of sinter is provided on the extended part of the machine or on separate coolers (straight-line or pan). The practice showed the advantages of the straight line ones. After cooling sinter is secondary screened. The intensification of firing process is acheived by the addition of burn lime to the charge and its pre-heating. At some sintering plants a complex fuel is used.

Studies are carried out for increasing sinter strength and for intensification of the firing process. In different research institutes of the country ("Mekhanobrechermet" Institute, Baikov Institute for Metallurgy, Cheljabinsk Research Institute for Metals, Donetzk Research Institute for Ferrous Metallurgy) studies have been carried out concerning the increase of sinter strength by the use of a combined fuel.

A study on sintering under pressure (1.5 atm.) has been carried out at the TSNIY Tch. The duration of sintering decreased by 5 times, and air consumption by 2 times. The sinter received is uniformly porous.

BRIQUETTING

A process of producing briquets from fine ores and concentrates with the use of 10-20 pct of quick lime and with hardening by carbonization of CaO by CO_2 has been developed by the Ukranian Research Institute. For mastering this process a pilot plant with the output of 200.000 tons per year was built at the Kommunarsk iron and steel works. The briquets are produced in a roller press with the output of 30 tons per hour.

A full scale process of autoclave hardening of briquets prepared from a mix of powdered ores or concentrates with lime is developed by the Voronesh State University. The process is characterized by the following data: temperature 175 - 185°C; steam pressure, 8-12 atm.; soaking time at the autoclave, 4-8 hours. This process is similar to that for silicate producte manufacture. The briquets consisting of ore and lime are hardened as a result of formation of different hydrothermal compounds, such as hydro-silicate, calcium hydro-alumosilicate, etc.

In 1961-1964 several experimental heats in open-hearth furnaces were carried out with the use of self-fluxing briquets produced by the autoclave method at the pilot briquetting plant in Gubkin-town (KMA). The subsitution of the charge, usually used in open hearth furnaces, for non-fired self-fluxing briquets was found to be expedient. This method is also proposed for producing blast furnace burden (briquets, pellets). Studies to this end are being carried out.

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