Study of regularities of the experimental dual-stage technological route for iron-bearing ore desulphurization

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This research presents the experimental results of the dual-stage technological route for removal of sulphuric impurities from refractory iron-bearing ore. Such ore contains various fractions and is subjected to processing in the conditions of solid phase and liquid phase sintering, via standard temperature procedures and with active use of catalytic impurities having different chemical composition. The study was carried out using high-temperature derivatography, which allows to analyze dependence between dissociation speed of minerals and temperature. The developed procedure for kinetic measurements of dissociation of sulphates opens new possibilities for examination of the thermal properties during chemical and metallurgical processes, within the wide range of iron-bearing ores. The results of dependence between desulphurization of iron-bearing ore and the size of ore fraction as well as addition of catalytic impurities are obtained. It was established that presence of pre pieces with size larger than 5-6 mm in charge, which are hardly absorbed by a sintering melt, leads both to decrease of sinter mechganical strength and to increase of sulphur content in this sinter. Additionally, it was revealed that removal of impurities from usual and refractory ore, in its small and large fractions, occurs at different temperature procudures. Essential difference in the decomposition mechanism for sulphates at the temperatures of solid phase and liquid phase sintering were found out. Usual (not refratory) ore needs high oxidation degree of a slag phase to provide liquid phase sulhur removal from large fractions, while replacement of an air atmosphere by neutral medium leads to decrease of decomposition temperature of sulphates. It was established for refractory ore that fluxing during low-temperature sintering has a negative effect on desulphurization, while during high-temperature sintering this effect is positive. Thus, analysis of the experimental data copnfirms necessity of using the dual-stage technological route in desulphurization nof iron-bearing ore, in order to obtain high-quality sinter.

Key words: sulphuric iron-bearing ore, sintering, desulphurization kineticsm temperature, derivatogram, heat exchange, ore smelting, exothermal effects.
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Introduction

Manufacture of castings with the highest quality, exceeding the existing requirements of international standards, is one of the priority directions of the development of modern metallurgical industry. Up-to-date metal products are the most important material component of such industries as machine-building, machine tool industry, construction industry, military industrial complex etc.

Removal of barite sulphur and other impurities, which deteriorate the quality of finished products, is considered as an important issue in metallurgy [1]. Part of these elements transit in oxidized metal during processing, what makes desulphurization process more complicated and, respectively, does not allow to achieve thje required result [2, 3]. Additionally, there are many deposits in Russia, which are developing for a long time, e.g. Bakalskiy iron ore region and Kusinskaya group. Ore from these deposits is not competitive at present time, but the leadership of such companies as Bakalskoe ore administration and Magnitogorsk iron and steel works ntry to organize scientific-research and technologiocal events, which are directed on quality improvement of manufactured products. Based on the data from these companies during recent 15 years, decrease of iron content in developed ore by 4–11 % and increase of silica and sulphur content by 4–6 % is noted [4]. Thus, examination of desulphurization mechanism and kinetics, as well as development of technological techniques for sinter manufacture with decreased sulphur content, will allow to regain mining operations for iron-bearing ore at many deposits within the considering region. It will provide, in its turn, increase of working places and growth of the regional economic parameters [5]. Similar problems are observed also for the atasuy group of deposits, in fact for karazhalskaya and kentobskaya iron-bearing ores: they are characterized by decrease of iron content by 1.55–6.82 % and increase of silica and sulphur content by 3–8 % during recent years [6]. Involvement of lisakovsky concentrates, having hardly removed harmful impurities, in metallurgical production is also noted [7]. In this connection, in order to intensify sintering process and to improve sinter quality, only those ways were chosen that can simultaneously lead to decrease of sulphur content in sinter [8, 9]. The most advanced researches in this field were carried out by such domestic scientists as Kopyrin I. A., Borts Yu. M., Greur I. F., Romankov P. G., Vegman E. F., Kototich V. A., Frolov Yu. A., Puzanov V. P., Kobelev V. A., Korshikov G. V. as well as foreign scientists Richardson E., Lellep O., Fincam S. and Vinius A. [10, 11]. However, most of them considered mainly a solid phase stage of sulphur removal, only several scientists examined liquid phase stage, and none of them studied the joint removal route for impurities [12, 13].

Necessity of such researches is determined by insufficient information about desulphurization processes during sintering of sulphate ores as wellm as mixtures of sul[hate and sulphide ores (1) and by lack of the developed recommendations for sinter quality improvement (including decrease of sulphur content) and increase of its production volume (2). Desulphurization kinetics for barite and sulphate-containing ores as well as laboratorial sintering of charges with various relationships of the a.m. ores were conducted during this work. A row of technological methods for the dual stage increase of charge desulphurization degree were tested. Thje conducted researches will allow to provide the growth of competitiveness of domestic metallurgical industry.

The aim of this research is analysis of technological efficiency for the developed dual-stage desulphurization route of usual and refractory iron-bearing ores with various fractions. This analysis was carried out for the temperature procedures of solid and liquid smelting phases with use of chemical and technological impurities providing intensification of the examined processes. It was also planned to establish potential possibilities of improvement of the developed production and technological system.

Research methods

Experimental research and technological analysis of the dual-stage desulphurization process for high-sulphuric iron bearing ores with various fractions were conducted. They are characterized by the temperature procedures of impurities removal both in solid and liquid sintering phases, with use of chemical catalysts for nprocess improvement.

Experimental research of efficiency of the dual-stage desulphurization route for usual iron-bearing ore

Examination of kinetics of impurities removal from usual and refractory ores were conducted during laboratorial sintering experiments with various iron-bearing charges; these experiments used several technological methods of the dual-stage route for desulphurization degree increase and sinter quality improvement. The researches were carried out in a tubular furnace. Each pilot unit used 0.05 kg of charge, which was placed in a corundum crucible with diameter 50 mm and height 65 mm. The crucible is fixed in a basket made of stainless wire and is located inside the furnace, thus providing possibility of exact temperature control using an platinum/platinum-rhodium thermocouple, with its junction just above charge material. Another tungsten-rhenium thermocouple for temperature mearurement directly in cake was mounted inside charge. Temperature regulation in the furnace was implemented with use of a platinum/platinum-rhodium thermocouple, which is protected by abn insulating shell. Its heating element was located in the bottom part of the furnace area where the temparature was kept permanent. Charge heating was conducted via crucible lowering with definite speed towards the isothermal area. In order to adjust oxygen contenty in a gas mixture (in %), helium was used, which played the role of an inert component. Slag viscosity and smelting temperature could be corrected via partial or complete replacement of usual limestone by its fluoritized substitute. Chemical and mineral charge composition was determined via spectral analysis using MCA S,P spectrometer. Both usual and fluoritized limestones were used for charge smelting. Coke fines were applied as fuel, detailed chemical analysis of such fines is presented in the **Table 1**.

Table 1. Chemical composition of fluxing additions and fuel

Elements and oxides	Materials		
	Limestone	Fluoritized limestone	Coke fines
CaO	53.96	40.65	4.15
SiO_2	1.5	10.8	47.16
MgO	0.42	—	1.62
Fe (total)	1.23	—	14.61
FeO	1.28	—	—
S (total)	0.05	0.25	0.10
CaF_2	—	16.16	—

To determine the temperature boundaries and decomposition speed of minerals (including volatile substances, such as sulphur-containing ones), high-temperature derivatography was used. The studies were carried out with the derivatograph OD-102, which registered temperature, its variation and speed of heat extraction as well as mass of samples in automatic mode.

The small fraction component (with size 0–0.5 mm) was subjected during the experiment to briquetting with flux or without it. The temprature in briquettes was measured via derivatograph thermocouple, which was located in the special hole drilled in the sample edge.

Derivatographic expriments with the functions corresponding to the ranges 3–5 and 8–10 mm were conducted in corundum crucibles. The method of addition of wet ore fragments to limestone was used in fluxing. The left limestone was additionally charged in the crucible.

Composition of the gas atmosphere was varied during derivatographic experiments via introduction of previously prepared gas mixture in the furnace. When taking a sample from the furnace, the oxygen level in this gasixture was measured manually using a gas analyzer.

When carrying out the experiments with specimens of bakalshaya, kusinskaya and karazhakskaya ores, which don't require high-temperature procedures for processing, it was revealed that sulphur can be removed during sintering process either before ore smelting, or after melt forming. Indeed, desulphurization degree achieves 70–80 % (mass.) in the experiments without fuel, despite the temperature in a level did not exceed 1150 °C, for ore fractions with size 3–5 and 8–10 mm werer not molten. In the case of melt forming in the experiments with fuel, desulphurization degree was 90–97 % (mass.). The typical features of blocking solid ore particles were found out for the observed melt with use

Table 2. Chemical composition of extracted ore fractions

Elements and oxides	Content in fractions, % (mass.)	
	–0.5 mm	3–5 mm
CaO	2.87	1.89
BaO	1.83	1.46
SiO_2	10.2	11.7
MgO	1.69	1.38
Fe	56.7	58.7
FeO	22.8	24.0
S	3.91	0.87

Table 3. Mineral composition of extracted ore fractions

Mineral	Coarseness, mm	
	–0.5 mm	3–5 mm
Magnetite	63.9	67.2
Hematite	7.0	11.3
Pyrite	4.5	1.1
Calcite	1.4	0.4
Quartzite	4.1	4.8
Silicate minerals	10.0	11.6
Other minerals	9.1	3.6

of X-ray micro-probe analyzer "Camebax", as well as lack of possibility for gas products of reaction to be removed. Moreover, sulphur transferred in the melt also can't be removed due to low speed of ion exchange in viscous liquid. These factors hamper desulphurization of non-fluxed briquettes within the temperature interval 1150–1200 °C. Practical absence of melt is noted during sintering of large fractions (3–5) and (8–10) mm, and solid phase sulphur removal becomes possible, ensuring desulphurization degree 75–90 % (mass.) at 1150 °C. Introduction of calcium oxide and calcium fluoride decreases melt viscosity by several times and provides sulphur removal from small fraction by 85–90 % (mass.) at 1150 °C.

As soon as the temperature in the layer increases, viscosity decreases and non-fluxed briquettes from small fraction demontrate better desulphurization. Viscosity of calcium slags decreaseswith temperature rise not so intensively as this of silicon slags, thereby smaller elevation of desulphurization degree with temperatur rise is observed [14, 15].

Principally another temperature relationship was found out during examination of desulphurization degree in the large ore fraction. Solid phase sulphur removal, providing desulphurization degree 80–85 % (mass.) at 1150 °C occurs when melt is absent, independently of charge composition. Forming of viscous slags starts within the temperature range 1200–1250 °C, mainly on the base of acidic gangue ore mineral. They block ore pieces, thus hampering gas emission. Desulphurization from melt was impossible owing to high viscosity. Temperature rise to 1300 °C finalizes in forming of free-running slag. In this case most ore part is dissolved and active desilphurization from the melt to degree 90–95 % (mass.) is achieved.

So, the suggested desulphurization route during sintering of bakalshaya, kusinskaya and karazhakskaya iron-bearing ores includes solid phase sulphur removal from large fractions (3–10 mm) within the temperature range 1100–1200 °C and liquid phase sulphur removal at the temperature > 1250 °C. To provide liquid phase sulphur removal from large fractions, high oxidation degree of slag phase is required, while iron monoxide content in sinter should not exceed 12–15 % (mass.). In this case it is necessary to avoid sintering at the temperature 1200–1250 °C, because viscous slags are forming within this range, and they hamper both solid phase and liquid phase desulphurization.

The fractions (–0,5 mm) and (3–5 mm) were extracted for further examination of the dual-stage experimental procedure with initial ore batch. Chemical and mineral compositions of these fractions are presented in the **Table 2** and **Table 3**.

It can be seen from these data that ore part of both small and large fractions mainly consists of magnetite; hematite strips also can be observed. Sulphur in ore is presented mainly by pyrite, which is located in the small fraction with 60–70 % (mass.). Sulphate sulphur is practically absent, non-ore minerals are presented by quartzite, mica and soda feldspar.

The derivatogram of ore heating with (–0.5) mm coarseness in the air was obtained using the derivatograph OD-102 (see **Fig. 1**).

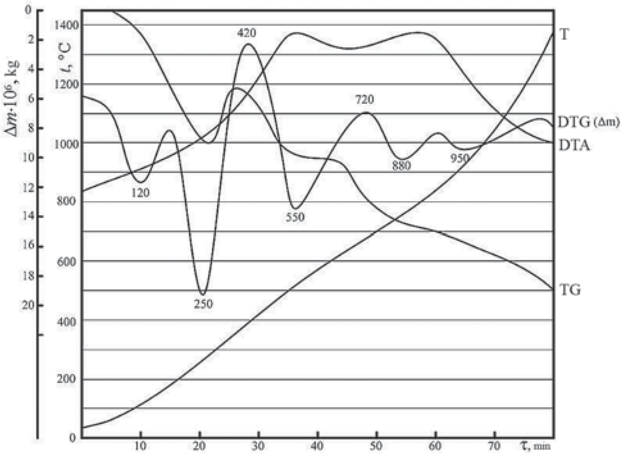

Fig. 1. Derivatogram of ore heating with coarseness (–0.5) mm in the air. DTG – differential thermogravimetric curve; DTA – differential thermographic curve; T – thermographic; TG – thermogravimetric

Analysis of this derivatogram displayed that water is removed during hydromica decomposition at low temperatures 120 and 250 °C. Intensive heat extraction within the temperature range 400–500 °C, which is accompanied by mass enlargement, testifies on magnetite oxidation (the peak at 720 °C on the differential thermogravimetric (DTG) curve). Consequent mass decrease (the peaks at 600 °C on the (DTG curve) is connected with decomposition of gangue rock minerals of hydromica and chlorite. Hydromica loses ceolite moisture at the temperature 950° C. No evident exothermal effect due to burning od sulphides at the temperature 600–650 °C was revealed, because this reaction passes together with magnetite oxidation, while sulphuric gas is partly absorbed by calcium and barium oxides (they are extracted during decomposition of gangue rock minerals). However, pyrite is identified via mass loss at the temperature 600–700 °C. Calcium carbonate is subjected to decomposition at the temperature 880 °C, and the temperature 1180 °C

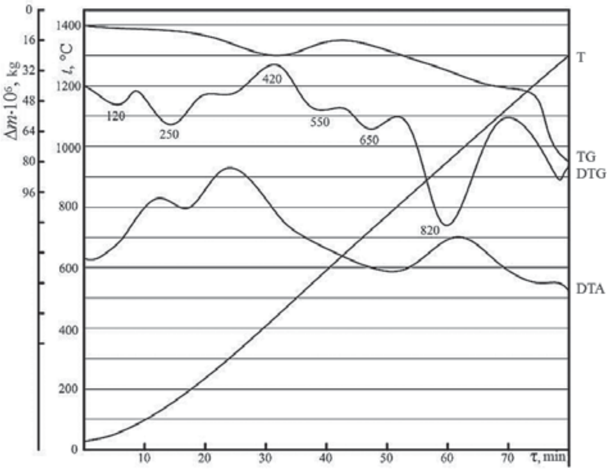

Fig. 2. Derivatogram of ore heating with coarseness (–0.5) mm with limestone additive. DTG – differential thermogravimetric curve; DTA – differential thermographic curve; T – thermographic; TG – thermogravimetric

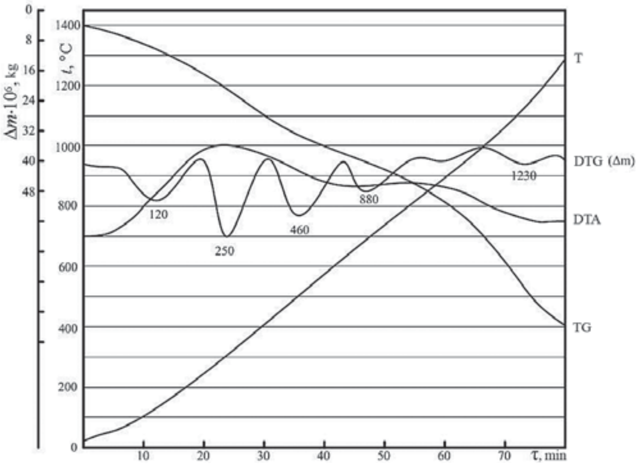

Fig. 3. Derivatogram of ore heating with coarseness (–0.5) mm in helium. DTG – differential thermogravimetric curve; DTA – differential thermographic curve; T – thermographic; TG – thermogravimetric

we observed removal of sulphates, which were presented in a specimen or were formed owing to sulphatization of gangue rock oxides.

Limestone additive to ore with coarseness (–0.5) mm (**Fig. 2**) does not change the heating derivatogram principally. The effects at the temperatures 120, 250, 550, 650 and 420 °C are saved, they are typical for hydromica dehydratation as well as for magnetite and chlorite oxidation.

An additional endothermal effect appears at the temperature 820° C, it is connected with decomposition of flux limestone. It is natural that limestone in charge dissociates within the same temperature range and is not characterized by ant separate effect. Decomposition of sulphates occurs at the temperatures above 1200 °C.

The effects connected with dehydratation of hydromica and chlorites at the temperatures 120, 250, and 550 °C are saved in neutral medium (see **Fig. 3**). Exothermal effects at the temperatures 420 and 650 °C are connected with oxidation of sulphides and magnetite and are absent in oxygen-free medium. Exothermal effect appears at the temperature 460 °C , which was concealed by the peak at the temperature 420 °C (this peak was connected with magnetite oxidation). Most probably it is connected with decomposition of small amounts of iron carbonates.

Mass loss at bthe temperature 1230 °C, which is typical for sulphates, testifies on presense of primary sulphates in ore, because secondary sulphates are not formed in oxygen-free medium.

Ore with more coarse fraction is characterized by small mass losses during heating, it is connected with smaller gangue rock amount. In this connection, decomposition of hydromica, chlorites and oxidation of pyrite is finished earlier, and the temperatures of corresponding effects on the DTG cirve are lower than that for small fraction by 20–30 °C. Calcium carbonates and sulphates of calcium and barium dissociates at the temperatures 880 amd 1230 °C.

As soon as these recent processes are extremely intersting for studying ore desulphurization kinetics, the influence of gas phase composition and flux kind on parameters of decomposition of sulphates were examined.

The experiments were carried out with ore fractions (–0.5 mm) and (3–5 mm). Air and helium were used as gas medium. Helium was introduced at the room temperature during the first experimental series, thus preventing oxidation of magnetite, burning of sulphides and forming of sulphates. In the second series, helium was introduced after bpreliminary holding in the air at the temperature 900 °C, when the above-mentioned processes finished and the sample mass stabilized. Relative variation of the speed constant for decomposition process was assessed via the temperature of reaching maximal speed. The results of experiments are presented in the **Table 4**.

Sulphates start to decompose in non-fluxed sinter (with coarseness (–0.5 mm)) in helium at the temperature 1170 °C, while maximal speed is achieved at 1230 °C. Amount of these sulphates is small. Recalculation of weight losses for calcium and barium sulphates content displays 0.8 and 1.5 % (mass.) respectively. Thus, sulphate sulphur amount does not exceed 0.4 % (mass.) absolutely or 7.0 % (mass.) respectively regarding to its total content in ore. It was revealed that mass losses and temperature ranges don't depend on fluxing during testing in helium (see Table 4, positions 2, 4 and 6). As soon as secondary sulphates don't form in an oxygen-free medium, the total observed amount of sulphates is located in an initial sample. Such data confirm the results of mineralogical studies on mainly sulphidic sulphur form in usual ore.

Mass losses during decomposition of sulphates in the air is rather larger than in helium, and they increase when adding limestone (see Table 4, positions 1, 2, 3 and 5). With its content 13–15 % (mass.), the part of sulphidic sulphur increases up to 40 % (mass.). Consequently, only 60 % (mass.) of sulphidic sulphur is removed, while its another part interacts with calcium compounds and remains in a sample as sulphates.

Replacement of the air atmosphere by a neutral one after preliminary oxidation, as previously that for sulphates of iron-bearing ore, leads to lowering of the temperature

Table 4. Influence of low-oxidizing medium and flux content in charge on decomposition temperature for sulphides of karazhakskaya ore

No.	Charge composition, % (mass.)			Ore coarseness, mm	Atmosphere	Decomposition temperature, °C		Weight losses during desulphurization, % (mass.)
	Ore	Limestone	Fluoritized limestone			Start	Maximal speed	
1	100	—	—	–0.5	air	1050	1180	1.02
2	100	—	—	–0.5	helium	1170	1230	0.56
3	85	15	—	–0.5	air	1140	1280	2.72
4	85	15	—	–0.5	helium	1170	1240	0.78
5	87	—	13	–0.5	air	990	1190	2.28
6	87	—	13	–0.5	helium	1160	1240	0.88
7	100	—	—	–0.5	helium at $t > 900$ °C	1120	1180	0.66
8	85	15	—	–0.5	—	1110	1220	3.36
9	87	—	13	–0.5	—	920	1160	3.32
10	100	—	—	3–5	air	1140	1220	0.08
11	100	—	—	3–5	helium	1020	1160	0.18
12	82	18	—	3–5	air	1180	1240	0.18

of starting their decomposition drom 1140 to 1110 °C. In this case the maximal speed temperature decreases by 60 °C (please compare positions 3 and 8). Use of fluoritized limestone instead of usual one both in the air (positions 3, 5) and in helium (positions 8 and 9) lightens low temperature dissociation of sulphates.

So, the previously revealed regularities of low temperarure decomposition of sulphates in usual ore were completely confirmed and don't require any additional clarification.

Study of desulphurization regularities for refractory iron-bearing ore using the presented dual-stage technological route

Testing of the dual-stage technological route for refractory iron-bearing ore was carried out via the same scheme as the above-described one for usual ore, which does not require processing procedures with higher temperature.

In the first series, fuel was not added in charge and the temperature above the layer was kept 1300 °C. As soon as this ore is characterized by high-melting point, the temperature in the layer increased to the level 1200–1250 °C. The small fraction was briquetted as before, while the large fraction (3–5 mm) was filled in a crucible. Oxidation and wear oxidation blowing contained 8 % (vol.) and 1.0–1.5 % (vol.) of oxygen.

In the second series, the small fraction (–0.5 mm) was briquetted with 5 % (mass.) of coke having the same coarseness. The experiments were conducted only with air blowing. The gas emitting out of a layer contained 10–12 % (vol.) of CO_2 and 4–5 % (vol.) of O_2. Temperature in the layer increased up to 1300–1325 °C owing to coke burning. Usual and fluoritized limestone was used as flux in both series.

The average value of desulphurization degree is rather high for ore briquettes (–0.5 mm) and makes 90–95 % (mass.), what corresponds to sufficient sulphur content 0.08–0.18 % (mass.). For ore with coarseness (3–5 mm), desulphurization degree is lower and constitutes 65–90 % (mass.), but residual content is close to small fraction owing to smaller sulphur amount in the initial ore fraction (3–5 mm).

As for experiments in oxidation medium without fuel, when temperature in the layer does not exceed 1200–1250 °C, and ore was not subjected to smelting, additives of usual limestone led to essential deterioration of desulphurization.

Residual sulphur content in fluxed charge increased more than by 2 times. It is explained by quick burning of mainly pyrite sulphur located in refractory ore, in oxidizing medium without limestone. Presence of calcium oxides during solid phase sulphur removal leads to sulphuric gas catching and sulphate forming. Decomposition speed for sulphates is significantly lower than their burning speed, and residual sulphur content in cake increases.

This situation changes principally for the experiments with fuel, when the temperature is holding at the level sufficient for smelting of the main mass of small charge fraction. In this case, desulphurization degree of non-fluxed briquettes made appr. 80 % (mass.) and fluxed briquettes – appr. 98.9 % (mass.). Residual silphur content drops to 0.03 % (mass.). Evidently, quick temperature rise and early forming of viscous silicate slags in non-fluxed briquettes lead to retarding of magnetite oxidation and fuel burning. It causes high content of iron monoxide (43.1 % (mass.)). It was revealed that sulphur is hardly removing from such melts. Fluxing provides porosity increase for briquettes and rise of smelting temperature for ferrite mictures by 30–50 °C in comparison with iron-silicate mixtures. Such granules display stronger oxidation, bteer burning of fuel and active desilphurization of low-viscous calcium-containing melts.

Consequently, low-temperature sintering within the temperature range 1200–1250 °C stipulates negative effect of fluxing on desulphurization, while high-temperature sintering within the temperature range 1300–1320 °C displays positive effect. It should be noted that the temperature range of positive basicity influence for usual low-melting ore is lower by 100–120 °C.

Replacement of the oxidizing medium by low oxidizing one led to deteroration of desulphurization for a snall fraction both in fluxed and non-fluxed briquettes. It is probably caused by quick heating, when sulphur enters the high-temperature area mainly as pyrite. Lack of oxygen prevents its burning and retards desulphurization. Slow SO_2 removal from a sample creates the conditions for forming of secondary sulphates. Thermodynamic conditions of decomposition of sulphates within the temperature range 1200–1250 °C are favourable both in oxidizing and low oxidizing medium, thereby the process speed will be determined by the conditions of extraction of reaction gas products. The low oxidizing medium contains more FeO, so there is more melt providing sintering and, consequently, desulphurization retarding.

Large fractions don't demonstrate deteroration of desulphurization for decrease of oxygen content, because porosity of bulks does not change after appearance of small melt amount. Thus, blowing enrichment by oxygen will support desulphurization of pyrite-bearing ore both in solid phase and liquid phase sintering.

When comparing the experiments with usual and fluoritized limestone in oxidizing conditions within the temperature range 1200–1250 °C, without total melt forming, we can confirm its positive role in desulphurization. Especially significant effect takes plac for the fraction (3–5 mm), where residual sulphur content dropped more than by 2 times. It is caused by the fact that fluorite promotes more complete contact between sulphates and oxides of silicon and iron (withoy melt filling the pores) for the case with small liquid slag amount in refractory ore. However, increase of melt amount in the small fraction, with low oxygen content in vlowing, leads to excessive amount of early liquid after fluorite adding. Filling nof pores retards desulphurization essentially and finalizes in rise of residual sulphur content up to 0.48 % (mass).

Similar situation occurs at the high temperature, during the experiments with fuel. Despite low viscosity of fluoric melts, desulfurization is retarding owing to high content of iton monoxide (51.3 % (mass.)) in th melt, while this monoxide was obtained due to slow fuel burning.

Conclusion

The conducted experimental studies demonstrated necessity of using the dual-stage technological route for removal of impurities from iton-bearing ore in order to provide higher quality of foundry products in the metallurgical industry. Use of the developed desulphurization procedure allowed to testify that more narrow contact between limestone or barite and iron oxides, decrease of oxygen in the gas phase and replacement of usual limestone by fluoritized one allows decreasing the beginning temperature of decomposition of sulphates and lowering possibility of calcium oxide sulphatization. When sintering fluxed iron-bearing ore, it was established that coarseness decrease slightly improves desulphurization within the temperature range 1150–1250 °C and has small effect on desulphurization during active slag forming within the temperature range 1250–1350 °C. Sintering of the small fraction of iron-bearing ore occurs in presence of a liquid phase within the total examined temperature range 1150–1350 °C. Lowering of iron monoxide content support desulphurization process. Temperature rise and introduction of calcium compounds promote decrease of viscosity of melts and improves desulphurization of th small ore fraction.

Sintering of th large fraction takes place without essential forming of liquid phases within the temperature range 1150–1200 °C. Desulphurization degree in this case is achieved as large as 80–85 % (mass.). Viscous melts, hampering both solid phase and liquid phase sulphur removal, are forming within the temperature range 1200–1250 °C. At the temperature t > 1250 °C desulphurization takes place mainly from liquid phase and its degree reches 90–95 % (mass.).

For iron-bearing ore with Fe content 0.02–0.04 % (mass.), which is processed via the standard procedure, the lowest sulphur content in a cake is achieved within the temperature range in ther layer 1300–1320 °C, on the condition that iron monoxide content does not exceed 15 % (mass.). Such ore is characterized by improvement of desulphurization by 10–15 % after replacement of usual limestone by fluoritized one at the low sintering te,peratures 1150–1200 °C. Presence of fluoritized limestone deteriorates the conditions of fuel burning, and the temperature in the layer was lower in several experiments in comparison with furnace space. However, in the case of normal burning, desilphurization speed is rather high and residual sulphur content does not exceed 0.03 % (mass.).

Use of low oxidizing medium in the conditions close to sinter agglomeration didn't reveal its positive effect on desulphurization of refractory ores. When sintering fluxed charge from refractory ores, part of sulphur is removing during pyrite burning, and other part – during decomposition of calcium sulphates. Rise of oxygen content in blowing supports acceleration of both processes: first of them due to intensification of oxidation and second – due to lowering of iron monoxide content in melt.

Replacement of usual limestone by fluoritized one, wuth provision of stable fuel burning, allows decreasing od sulphur content in a cake of the large fraction of refractory sintewring ore.

In general, the new scientific data on the mechanism and kinetics of charge desulphurization during sintering were obtained as a result of the conducted scientific and research work aimed on use of the dual-stage for removal of impurities. It allows to provide the scientifically substantiated approach to the problem of obtaining low-sulphuric sinter.

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