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EFFECT OF ROTARY DRUM DRYING ON THE MOISTURE CONTENT AND GRANULOMETRIC COMPOSITION OF SPECIAL COKE OBTAINED FROM SHUBARKOL COAL

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Abstract. The present study investigates the moisture content and granulometric composition of special coke produced from Shubarkol coal before and after rotary drum drying under industrial conditions. The initial moisture content was determined from samples collected on the conveyor belt prior to entering the rotary drum dryer and after drying, taking into account the return of aspiration dust. It was established that the initial moisture content of special coke ranges from 13.3 to 13.7%, indicating stable material quality. After rotary drum drying, the moisture content decreases to 4.1–5.5%, corresponding to an approximately threefold reduction. Dry sieve analysis showed that the drying process is accompanied by significant redistribution of the particle size distribution and an increase in the proportion of fine and dust fractions due to mechanical impacts inside the drum. The content of particles smaller than 1 mm increases to 17–20%, while the dust fraction (–0.5 mm) reaches 8–12%. Additionally, aspiration dust was found to have low moisture content (~1%), and its return to the dried material stream does not significantly affect the overall moisture level. The obtained results can be used to optimize rotary drum drying regimes and reduce dust formation in metallurgical processes.

Key words: special coke, rotary drum drying, moisture content, granulometric composition, dust.

Introduction

In electrothermal ferroalloy production, carbonaceous reducing agents determine the thermodynamic and kinetic parameters of reduction processes, as well as the stability of thermal and electrical furnace operation [1, 5-12]. In contrast to blast furnace production, materials used in electrothermal processes are subject to more stringent requirements regarding chemical composition, reactivity, and specific electrical resistivity [1, 5-12, 3, 4]. Coke quality directly affects energy consumption, completeness of reactions, and overall productivity of metallurgical units.

The expansion of the raw material base of Kazakhstan's ferroalloy industry is associated with the utilization of coal from the Shubarkol deposit. The geochemical characteristics of these coals and their suitability for special coke production have been described in a number of studies [5–7]. It has been shown that with proper selection of coking regimes, it is possible to obtain material suitable for ferroalloy production [6, 7].

Moisture content is one of the key parameters of carbon-based reducing agents. Elevated moisture increases thermal energy consumption required for evaporation, reduces the efficiency of reduction processes, and may negatively affect the electrical properties of the material [2, 8, 9]. Therefore, the drying stage becomes critically important in preparing coke for use in electrothermal units.

Rotary drum dryers are the most widely used units for processing bulk carbonaceous materials due to their high capacity and operational reliability [10–13]. Drying efficiency depends on the intensity of heat and mass transfer, as well as on the hydrodynamic conditions of particle movement inside the drum [12–14]. Mechanical action during material cascading may lead to changes in granulometric composition and redistribution of particle size fractions [13–15].

Changes in granulometric composition can influence the electrical and structural characteristics of coke, including its specific electrical resistivity, which is crucial for stable electrothermal operation [3, 8, 9, 16]. Therefore, investigation of moisture and granulometric composition changes in Shubarkol special coke during rotary drum drying necessitates experimental research.

The aim of this study is to investigate changes in moisture content and granulometric composition of special coke during rotary drum drying under industrial conditions.

Materials and methods of research

The object of the study was Shubarkol special coke of 0–20 mm fraction used in metallurgical technological processes. The investigations were conducted under operating industrial conditions.

Sampling of special coke was carried out at various points of the technological scheme. To assess moisture distribution within the stored material, samples were taken from the stockpile cone of charge materials (MB02) at different levels and zones: from the surface layer at the base of the cone (Sample No. 1), from the surface layer at a height of approximately 2.5 m (Sample No. 2), and from the upper part of the cone with sampling from deeper layers (Sample No. 3). The sampling scheme is shown in Figure 1.

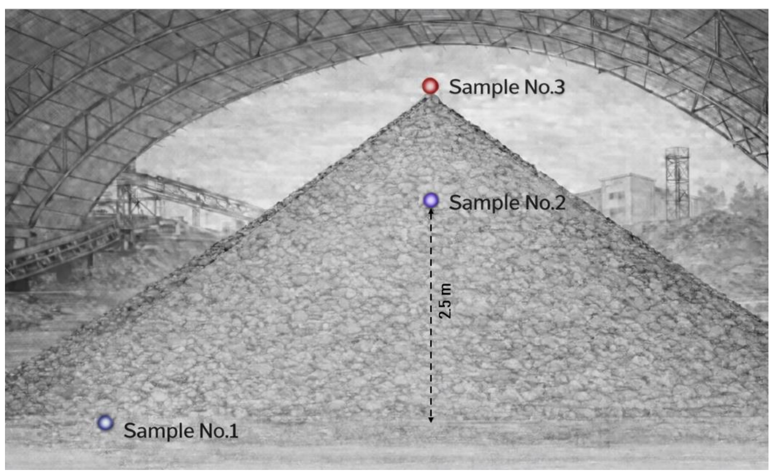

Figure 1 – Sampling scheme of special coke from the stockpile cone

In addition, special coke samples were collected from the conveyor belt before entering the rotary drum dryer (MB04) and after passing through the dryer, taking into account the return of aspiration dust (MB05). At each sampling point, five samples were collected at 15-minute intervals.

The moisture content of special coke was determined by the gravimetric method through drying the samples in a laboratory drying oven at a temperature of 140–150 °C until constant mass was achieved.

The granulometric composition of special coke was determined by dry sieve analysis using a standard set of sieves with mesh sizes of 20, 10, 5, 1, and 0.5 mm.

Additionally, the moisture content of aspiration dust collected from the rotary drum dryer aspiration system was investigated. The dust moisture was determined using the same gravimetric method.

Results and its discussion

Moisture Content of Special Coke

The results of moisture determination before and after rotary drum drying are presented in Table 1.

Analysis of the obtained data shows that the moisture content of special coke sampled from the conveyor belt before entering the rotary drum dryer (MB04) ranges from 13.3 to 13.7%. The slight variation between individual samples indicates stable quality of the initial material and uniform moisture distribution.

Table 1 – Moisture content of special coke before and after rotary drum drying

Sampling Location	Sample	Moisture, %
Before rotary drum drying (MB04)	Sample 1	13.74
	Sample 2	13.55
	Sample 3	13.35
	Sample 4	13.44
	Sample 5	13.65
After rotary drum drying (MB05)	Sample 1	5.46
	Sample 2	4.29
	Sample 3	4.36
	Sample 4	4.08
	Sample 5	4.61

After passing through the rotary drum dryer (MB05), the moisture content of special coke decreases significantly and ranges from 4.1 to 5.5%. Thus, rotary drum drying ensures an approximately threefold reduction in moisture content. The obtained results confirm the high efficiency of the applied drying regime and comply with the moisture requirements for special coke used in metallurgical technological processes.

It should be noted that the residual moisture content of special coke after drying remains at a stable level, indicating steady operation of the drying unit and the absence of significant fluctuations in technological parameters.

Changes in Granulometric Composition of Special Coke

The results of sieve analysis of the granulometric composition of special coke before and after rotary drum drying are presented in Figure 2. The values were obtained based on the analysis of five samples.

In the initial state, the material is characterized by the predominance of the +10 mm lump fraction, the share of which exceeds 70%. The content of fine and dust fractions is relatively low, which is favorable from the standpoint of transportation and use of coke in the charge mixture.

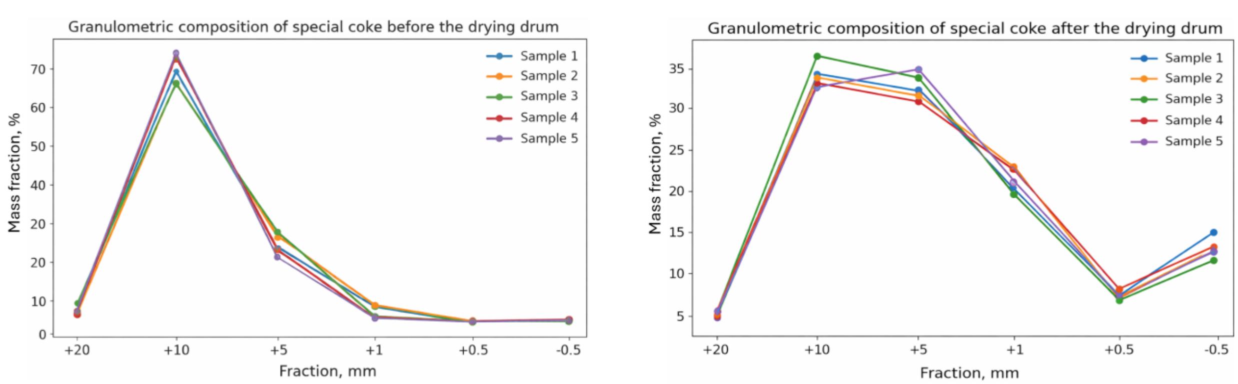

Figure 2. Granulometric composition of special coke: (a) before rotary drum drying; (b) after rotary drum drying.

After rotary drum drying, pronounced redistribution of the granulometric composition is observed. The share of the +10 mm fraction decreases by more than two times, while the proportion of the +5 mm fraction and particles smaller than 1 mm increases simultaneously. The content of the dust fraction (–0.5 mm) after drying reaches 8–12%.

The increase in fine and dust fractions is attributed to intensive mechanical impacts of the material inside the drum, accompanied by partial fragmentation of lump special coke. This effect should be taken into account when selecting technological drying regimes, since an increase in fine particles may reduce the gas permeability of the charge and increase the load on aspiration systems.

Moisture Content of Aspiration Dust

The results of moisture determination of aspiration dust and special coke after dust return are presented in Table 2. It was established that the moisture content of aspiration dust is approximately 1%, indicating nearly complete moisture removal during the drying process.

Table 2 – Moisture content of aspiration dust and special coke after rotary drum drying

Material	Sample No.	Moisture, %
Aspiration dust of special coke	Sample 1	0.98
Special coke after rotary drum drying	Sample 2	4.28

The moisture content of special coke after rotary drum drying, taking into account dust return, remains at approximately 4.3%, which is comparable to the values obtained for samples without dust return. This indicates that the return of aspiration dust does not significantly affect the overall moisture content of the dried special coke. At the same time, dust return may contribute to an additional increase in the proportion of fine fractions, which should be considered when analyzing the granulometric composition of the final product.

The results of the study demonstrate that rotary drum drying is an effective method for reducing the moisture content of special coke. However, along with moisture reduction, the process is accompanied by changes in granulometric composition and an increase in the proportion of fine and dust fractions. These factors must be taken into account when selecting drying regimes and operating aspiration systems.

Analysis of the operational parameters of the rotary drum dryer showed that the actual drying capacity of special coke is lower than the design capacity. Although the design throughput is 45 t/h, the required final moisture content is achieved only at reduced loading of the unit. One of the main reasons is the insufficient filling degree of the drum, which limits the contact between the material and the heat carrier and reduces the intensity of heat and mass transfer.

At low filling levels, the lifting flights are not fully loaded, and the material cascades prematurely, forming a free gas channel inside the drum. This results in decreased heat and mass transfer efficiency and reduced moisture removal capacity of the drum. Increasing the filling degree of the drum is therefore considered a promising approach for intensifying the drying process.

The obtained results may be used in selecting operating regimes for rotary drum dryers used in special coke processing, as well as in modernization of drying units aimed at reducing dust formation and improving overall drying efficiency.

Conclusion

The conducted research established that the initial moisture content of Shubarkol special coke sampled before entering the rotary drum dryer ranges from 13.3 to 13.7% and is characterized by high stability. Rotary drum drying effectively reduces the moisture content to 4.1–5.5%, corresponding to an approximately threefold decrease, confirming the feasibility of this drying method under industrial conditions.

It was shown that rotary drum drying is accompanied by significant changes in the granulometric composition of coke, expressed in a reduction of the lump fraction and an increase in fine and dust fractions. The proportion of particles smaller than 1 mm increases to 17–20%, while the dust fraction reaches 8–12%, which must be considered when optimizing drying regimes and operating aspiration systems.

Additionally, it was established that aspiration dust of special coke has low moisture content (approximately 1%), and its return to the dried material stream does not lead to a noticeable increase in overall moisture content. The obtained results may be used to optimize technological regimes of rotary drum drying and to reduce dust formation in metallurgical processes.

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ШҰБАРКӨЛ КӨМІРІНЕН АЛЫНҒАН АРНАЙЫ КОКСТЫҢ ЫЛҒАЛДЫЛЫҒЫ МЕН ГРАНУЛОМЕТРИЯЛЫҚ ҚҰРАМЫНА БАРАБАНДЫ КЕПТІРУДІҢ ӘСЕРІ

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Аңдатпа. Жұмыста өндірістік жағдайда барабанды кептіруге дейін және кейін Шұбаркөл арнайы коксының ылғалдылығы мен гранулометриялық құрамын зерттеу нәтижелері ұсынылған. Кокстың бастапқы ылғалдылығы кептіру барабанына кірер алдында таспалы конвейерден алынған сынамалар бойынша, сондай-ақ аспирациялық шаңды қайтаруды ескере отырып, барабаннан шыққаннан кейін анықталды. Бастапқы арнайы кокстың ылғалдылығы 13,3–13,7 % құрайтыны және мәндерінің аз ғана ауытқумен сипатталатыны анықталды, бұл материал сапасының тұрақтылығын көрсетеді. Барабанды кептіруден кейін кокстың ылғалдылығы 4,1–5,5 %-ға дейін төмендейді, бұл ылғал мөлшерінің шамамен үш есе азаюына сәйкес келеді. Құрғақ електік талдау әдісімен гранулометриялық құрамға талдау жүргізіліп, кептіру процесі кептіру барабанындағы механикалық әсердің нәтижесінде ұсақ және шаңтәрізді фракциялар үлесінің артуымен және гранулометриялық құрамның елеулі қайта бөлінуімен қатар жүретіні көрсетілді. Сонымен қатар арнайы кокстың аспирациялық шаңының ылғалдылығы төмен (шамамен 1 %) екені анықталды және оның кептірілген материал ағынына қайта қосылуы жалпы ылғалдылықтың айтарлықтай артуына әкелмейтіні белгіленді. Алынған нәтижелер барабанды кептіру режимдерін оңтайландыруға және металлургиялық технологиялық процестерде шаң түзілуін азайту шараларын әзірлеуге пайдаланылуы мүмкін.

Түйін сөздер: арнайы кокс, барабанды кептіру, ылғалдылық, гранулометриялық құрам, шаң.

ВЛИЯНИЕ БАРАБАННОЙ СУШКИ НА ВЛАЖНОСТЬ И ГРАНУЛОМЕТРИЧЕСКИЙ СОСТАВ СПЕЦКОКСА ПОЛУЧЕННОГО ИЗ ШУБАРКОЛЬСКОГО УГЛЯ

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Аннотация. В работе представлены результаты исследования влажности и гранулометрического состава спецкокса Шубарколь до и после барабанной сушки в промышленных условиях. Исходную влажность кокса определяли по пробам, отобранным с ленточного конвейера перед входом в сушильный барабан, а также после его прохождения с учётом возврата аспирационной пыли. Установлено, что влажность исходного спецкокса составляет 13,3-13,7 % и характеризуется незначительным разбросом значений, что свидетельствует о стабильности качества материала. После барабанной сушки влажность кокса снижается до 4,1-5,5 %, что соответствует уменьшению влагосодержания примерно в три раза. Проведён анализ гранулометрического состава методом сухого ситового рассева, показавший, что процесс сушки сопровождается существенным перераспределением гранулометрического состава и увеличением доли мелких и пылевидных фракций вследствие механического воздействия в сушильном барабане. Дополнительно установлено, что аспирационная пыль спецкокса обладает низкой влажностью (порядка 1 %), а её возврат в поток высушенного материала не приводит к заметному увеличению общего влагосодержания. Полученные результаты могут быть использованы для оптимизации режимов барабанной сушки и разработки мероприятий по снижению пылеобразования в металлургических технологических процессах.

Ключевые слова: спецкокс, барабанная сушка, влажность, гранулометрический состав, пыль.