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The Use of Clay as A Binder in Briquetting Finely Dispersed Dust of Ferrosilicon Production

[1]***ERZHAN Aidana,** *Doctoral Student, Teacher, aidana_kartu@mail.ru,*
[1]**KVON Svetlana,** *Cand. of Tech. Sci., Professor, svetlana.1311@mail.ru,*
[2]**OKISHEV Konstantin,** *Dr. of Phys. and Math. Sci., Professor, k.okishev@inbox.ru,*
[1]**ISAGULOVA Diana,** *PhD, Acting Associate Professor, isagulovada@mail.ru,*
[1]**KOVALEVA Tatiana,** *Doctoral Student, Teacher, Sagilit@mail.ru,*
[1]NPJSC «Abylkas Saginov Karaganda Technical University», N. Nazarbayev Avenue, 56, Karaganda, Kazakhstan,
[2]Ural Federal University named after the First President of Russia B.N. Yeltsin, Mira Street, 19, Yekaterinburg, Russia,
**corresponding author.*

Abstract. *The paper presents the results of studying the use of bentonite clay as part of a complex binder for briquetting finely dispersed dust generated during the production of ferrosilicon. Samples obtained with various compositions and compaction pressures were studied. As a result of the study, it was determined that the use of bentonite clay as part of a complex binder made it possible to obtain briquettes of increased strength. The most optimal for briquetting is the following composition of the charge: finely dispersed dust of ferrosilicon production – 85%, water – 5%, binder – 10%, of which liquid glass – 3-7%, bentonite clay the rest. Briquette production modes were as follows: the drying temperature 40°C within 60 minutes, compaction pressure 50 kN. This method of producing briquettes makes it possible to provide briquettes with the silicon content comparable to the content in the main products and to obtain the technologically necessary strength of the briquette (about 38-40 MPa).*

Keywords: *finely dispersed dust of ferroalloy production, liquid glass, bentonite clay, strength, compaction pressure.*

Introduction. At present, there is generated a lot of substandard waste of ferroalloy production. Dust-like waste obtained from crushing largely loses its production and material value, in contrast to the final product. Recycling of industrial waste generated during production of ferroalloys is becoming increasingly important. One of the tasks at such enterprises of the Karaganda region as the Asia FerroAlloys LLP and the YDD Corporation LLP is to produce briquettes made of finely dispersed dust of ferrosilicon production. For briquettes, one of the main quality indicators is strength. In turn, one of the important factors ensuring strength, alongside with technological modes of pressing and sintering, is the binder.

Liquid glass is usually used as a binder, however, there are a number of studies that deal with the use of various components as a binder.

For example, work [1] presents studying the technological properties of carbon-containing materials as an assessment of their feasibility when used as an alternative binding additive in the process of granulating dusty waste of ferroalloy production.

The issue of using carbon-containing materials as a binder during briquetting is also discussed in work [2]. It examines the pros and cons of using carbon-containing binders to briquet ferrosilicon dust for reuse. Comparing the characteristics of the technological indicators of various coal materials is shown, including the issue of the fire hazard of such materials.

Invention [3] deals with the issue of increasing the strength of briquettes that can be used in briquetting silicon-containing materials. This method involves dosing and mixing together the components of the charge that includes ferrosilicon, finely dispersed dust of ferroalloy furnace gas purification, strengthening additives and briquetting the charge.

To reduce the amount of fine dust generated during production of ferrosilicon, method [4] of its briquetting for the purpose of reuse was proposed. Under production conditions, the possibility and feasibility of pressing the dust that is formed when smelting ferrosilicon with the use of the electroslag remelting method was studied, and the technological modes of briquetting were determined. A pilot batch of briquettes was produced of the dust fraction waste. There were used the charge materials of smelting ferrosilicon in DC furnaces using various binding additives.

Another method of briquetting dusty waste of ferrosilicon production [5] involves the following sequence of operations: ferrosilicon is dosed, mixed with an alkaline binder consisting of silica and an aqueous solution of the alkali element sodium or potassium hydroxide; the resulting mixture is pressed into briquettes, the briquettes are dried and strengthened. Before mixing begins, an inorganic material such as bentonite, or an organic material such as polystyrene, is introduced as a plasticizer. Before drying, the briquettes were pre-strengthened by neutralizing the alkali element hydroxide in the binder material of the mixture by treating the compacted briquettes with carbon dioxide. This method makes it possible to reduce the degree of silicon oxidation in briquettes and to improve their solubility in melts.

The purpose of this study is to test the possibility of using clay as a binder in the process of briquetting finely dispersed dust of ferroalloy production.

Research methods. The object of study was finely dispersed dust generated in the production of ferrosilicon grade FS70 at the YDD Corporation LLP plant (Karaganda). The chemical composition of the conditioned FS ferrosilicon grade is given in Table 1.

Table 1 – Chemical composition of ferrosilicon grade FS70

Element	Fe	Si	Al	C	Mn
Content	26.7	71.2	1.8	0.1	0.2

The analysis of the fractional composition of ferroalloy dust using an analytical sieving machine from the Retsch (Germany) shows that the bulk of particles (≈ 70%) are the 0-0.6 mm fraction. The fraction 0.7-1.0 mm was ≈ 25%. The content of particles > 1 mm was less than 5%.

To determine the feasibility of producing briquettes of finely dispersed dust of ferrosilicon production in industrial conditions, identical laboratory studies of the FS70 grade were carried out; briquettes with different binder compositions were studied. The criterion for the condition of a briquette was its strength and silicon content.

Mixing the components (Table 2) was carried out in laboratory roller-type runners. A complex composition of liquid glass and bentonite clay is proposed as a binder. Various ratios of these additives were studied.

Pressing was carried out into molds with a diameter of 50 mm using a laboratory press with a pressure of up to 500 kN. The briquettes were sintered in a Snol-67/350 drying oven.

The briquette production was carried out in two modes with the same temperature (drying temperature 40°C, drying time 60 minutes) and different pressure values (Table 3). As comparison samples, there were used samples of series 0 obtained by briquetting dust, water and liquid glass in the same ratio.

Research results. The strength characteristics of the briquettes (Figure) are presented in Table 4. The compressive strength was determined on a floor-standing machine for determining tensile and compressive strength Instron 5982. The chemical composition was controlled on a SPAS-05 emission spectrometer.

It can be seen from the data in Table 4 that the use of a complex binder (bentonite clay 3-7%, liquid glass the rest) leads to increasing the compressive strength of the briquette by 27-33%.

However, the total binder content should not exceed 10% by weight. Further increasing the amount of binder does not lead to a noticeable increase in the strength of the briquette.

A probable strengthening mechanism is the enveloping (cladding) of dispersed dust particles with clay and their good adhesive bond in the liquid glass environment. The most optimal

Table 2 – Compositions of briquette samples

Component	Component content in the sample						
	No. 0	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Finely dispersed duct	80	80	80	80	85	85	85
Water	5	5	5	5	5	5	5
Liquid glass	15	10	8	6	7	5	3
Bentonite clay	-	5	7	9	3	5	7

Table 3 – Modes of manufacturing briquettes of finely dispersed dust produced by FeSi

Type of the binding additive	Mode	Compaction pressure, kN
Sample No. 1	A	40
	B	50
	C	60
Sample No. 2	A	40
	B	50
	C	60
Sample No. 3	A	40
	B	50
	C	60
Sample No. 4	A	40
	B	50
	C	60
Sample No. 5	A	40
	B	50
	C	60
Sample No. 6	A	40
	B	50
	C	60

Table 4 – Results of studying the samples

Sample	Compressive strength, MPa	Silicon content, including silicon oxide, %
No. 0 A	23	68.5
No. 0 B	23	69.7
No. 0 C	26	69.7
No. 1 A	21	64.2
No. 1 B	23	64.8
No. 1 C	24	64.9
No. 2 A	25	66.3
No. 2 B	24	66.1
No. 2 C	25	66.7
No. 3 A	23	67.5
No. 3 B	26	67.3
No. 3 C	28	67.3
No. 4 A	34	69.5
No. 4 B	36	69.6
No. 4 C	37	69.8
No. 5 A	36	70.1
No. 5 B	38	70.4
No. 5 C	40	70.3
No. 6 A	35	70.9
No. 6 B	38	71.2
No. 6 C	42	71.1

A briquette sample

total binder content is about 10% but exceeding it is not advisable, since this results in the formation of a thicker layer between the particles, which can be subject to brittle fracture as a result of loads.

In addition, increasing the binder content negatively affects the silicon content in the briquette.

It was established that the optimal compaction pressure for briquettes with a complex binder composition was 50 kN. Further increasing pressure is not advisable, since it has virtually no effect on increasing the briquette strength.

Conclusion. As a result of the studies, it was determined that the use of bentonite clay as part of a complex binder made it possible to obtain briquettes of increased strength. The most optimal for briquetting is the following composition of the charge: finely dispersed dust from ferrosilicon production – 85%, water – 5%, binder – 10%, of which liquid glass – 3-7%, bentonite clay the rest. Briquette production modes were as follows: the drying temperature 40°C within 60 minutes, compaction pressure 50 kN.

This method of producing briquettes makes it possible to provide briquettes with the a silicon content comparable to the content in the main products and to obtain the technologically necessary strength of the briquette (about 38-40 MPa).

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Ферросилиций өндірісінің жоғары дисперсті шаңын брикеттеу кезінде сазды байланыстырғыш ретінде пайдалану

[1]***ЕРЖАН Айдана,*** *докторант, оқытушы, aidana_kartu@mail.ru,*
[1]***КВОН Светлана Сергеевна,*** *т.ғ.к., профессор, svetlana.1311@mail.ru,*
[2]***ОКИШЕВ Константин Юрьевич,*** *ф.-м.ғ.д., профессор, k.okishev@inbox.ru,*
[1]***ИСАГУЛОВА Диана Аристотелевна,*** *PhD, доцент м.а., isagulovada@mail.ru,*
[1]***КОВАЛЕВА Татьяна Викторовна,*** *докторант, оқытушы, Sagilit@mail.ru,*
[1]*«Әбілқас Сағынов атындағы Қарағанды техникалық университеті» КеАҚ, Н. Назарбаев даңғылы, 56, Қарағанды, Қазақстан,*
[2]*Ресей Федерациясының бірінші президенті Б.Н. Ельцин атындағы Орал федералды университеті, Мира көшесі, 19, Екатеринбург, Ресей,*
**автор-корреспондент.*

Аңдатпа. *Жұмыста ферросилиций өндірісінде пайда болатын жоғары дисперсті шаңды брикеттеу кезінде кешенді байланыстырғыштың құрамында бентонит сазын қолдану бойынша зерттеулердің нәтижелері келтірілген. Әр түрлі композициялар мен престеу қысымынан алынған үлгілер зерттелді. Зерттеулер нәтижесінде бентонит сазын кешенді байланыстырғышта қолдану беріктігі жоғары брикеттерді алуға мүмкіндік беретіні анықталды. Брикеттеу үшін ең оңтайлы-шихтаның келесі құрамы: ферросилиций өндірісінің жоғары дисперсті шаңы – 85%, су – 5%, байланыстырғыш – 10%, оның ішінде сұйық шыны – 3-7%, қалғаны бентонит сазы. Брикеттерді дайындау режимдері: кептіру температурасы – 40°С 60 мин, престеу қысымы – 50 кН. Брикеттерді өндірудің бұл әдісі негізгі өнімдерегі мазмұнымен салыстырылатын бар брикеттерді беруге мүмкіндік береді, кремний құрамы және брикеттің технологиялық қажетті беріктігін алады (шамамен 38-40 МПа).*

Кілт сөздер: *ферроқорытпа өндірісінің жоғары дисперсті шаңы, сұйық шыны, бентонит сазы, беріктігі, басу қысымы.*

Использование глины в качестве связующего при брикетировании высокодисперсной пыли производства ферросилиция

[1]***ЕРЖАН Айдана,** *докторант, преподаватель, aidana_kartu@mail.ru,*
[1]**КВОН Светлана Сергеевна,** *к.т.н., профессор, svetlana.1311@mail.ru,*
[2]**ОКИШЕВ Константин Юрьевич,** *д.ф.-м.н., профессор, k.okishev@inbox.ru,*
[1]**ИСАГУЛОВА Диана Аристотелевна,** *PhD, и.о. доцента, isagulovada@mail.ru,*
[1]**КОВАЛЕВА Татьяна Викторовна,** *докторант, преподаватель, Sagilit@mail.ru,*
[1]НАО «Карагандинский технический университет имени Абылкаса Сагинова», пр. Н. Назарбаева, 56, Караганда, Казахстан,
[2]Уральский федеральный университет имени первого Президента России Б.Н. Ельцина, ул. Мира, 19, Екатеринбург, Россия,
**автор-корреспондент.*

Аннотация. *В работе представлены результаты исследований по использованию бентонитовой глины в составе комплексного связующего при брикетировании высокодисперсной пыли, образующейся при производстве ферросилиция. Исследовались образцы, полученные из различных составов и давлениях прессования. В результате исследований определено, что использование бентонитовой глины в составе комплексного связующего позволяет получить брикеты повышенной прочности. Наиболее оптимальным для брикетирования является следующий состав шихты: высокодисперсная пыль производства ферросилиция – 85%, вода – 5%, связующее – 10%, из них жидкое стекло – 3-7%, глина бентонитовая – остальное. Режимы изготовления брикетов: температура сушки – 40°С в течение 60 мин, давление прессования – 50 кН. Такой способ изготовления брикетов позволяет обеспечить брикеты с содержанием кремния, сопоставимым с содержанием в основной продукции, и получить технологически необходимую прочность брикета (порядка 38-40 МПа).*

Ключевые слова: *высокодисперсная пыль ферросплавного производства, жидкое стекло, бентонитовая глина, прочность, давление прессования.*

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