UDC 669.162.262.3 DOI: http://dx.doi.org/10.17580/cisisr.2018.01.01

THE RESEARCH OF AUTOHESION PROPERTIES OF SINTERING BURDEN

K. K. Turgunova[1], N. R. Timirbaeva[1], Y. Kөbegen[1], G. I. Sultamurat[1], L. I. Kaplun[2]

[1] *Karaganda state technical university (Karaganda, Kazakhstan)*
[2] *Ural federal university (Ekaterinburg, Russia)*

E-mail: kamila.turgunova@mail.ru; nina_timir@mail.ru; erbolat_911@inbox.ru; sultamurat_gi@mail.ru

AUTHOR'S INFO

K. K. Turgunova, Mag. Tech., Quality control engineer,
N. R. Timirbayeva, Mag. Stud., "Nanotechnology and metallurgy" chair,
Y. Kөbegen, Post-graduate, "Nanotechnology and metallurgy" chair,
G. I. Sultamurat, Cand. Eng., Associate prof., "Nanotechnology and metallurgy" chair,
L. I. Kaplun, Dr. Eng., Prof., "Metallurgy of iron and alloys" chair.

Key words:

agglomeration, agglomeration productivity/efficiency, burden materials, evaluation criteria, binders, pelletization, granulation, gas permeability, particle/grains autohesion, autohesion index.

ABSTRACT

The usage of Lisakovsk ore mining and processing enterprise concentrates in sinter burden is accompanied by a decrease of the sinter machines specific productivity of ArcelorMittal Temirtau JSC. The specific productivity is less than 0.8 t/m^2·hour, whereas the sinter machines of world leading and Arcelor Mittal companies work with the specific productivity of 1.0 – 1.3 t/m^2·hour. The low specific productivity of sintering machines is defined with low burden permeability. The gravitational-magnetic concentrate of Lisakovsk consists of oolites in amount of 93–94%. Their dimensions are 0.2 ÷ 0.8 mm. The concentrate is keeping low autohesion properties and influence on low permeability and low productivity of burden.

This article shows the results of laboratory research of burden grain fineness optimization with adding of binders.

The aim of research is to demonstrate how scientifically justified technological solution is able to increase and keep the permeability of pellet agglomerative sinter during caking in the conditions of using a mixture with a low autohesion characteristic of dissimilar and dispersed bulk solids. Due to this process it is able to increase specific productivity of sinter machines.

For laboratory research bulk solids mixture was used which would correspond to the components and composition of averaged sinter production data of ArcelorMittal Temirtau JSC in 2016.

The burden of sinter production is represented by dispersed bulk solids which consist of gravitational-magnetic concentrate of Lisakovsk (GMCL), concentrate of the Sokolovsk-Sarbaisk ore mining and processing enterprise, Atasu ore burden fields, Atansor, Kentobe and other, combined flux and coke slack.

The properties of widely used binders are investigated within the laboratory research. They are bentonite, liquid glass, YPEEN, amino-acrylate, lime milk. The properties of binders are defined by pelletization of the sinter burden mixture components. These components are used as adding, as the establishment of their influence on the ability to pelletization and comparative analysis of the indicators for the purpose of selection and possible use in production conditions. To assess the autohesive properties, a basic experiment is performed without the additives. The amount of binder additives is determined within the limits while not affecting the cost of the technological process.

The results of investigations show that the usage of an aqueous solution of dispersed lime as a binder has a significant effect not only on the autohesion of a heterogeneous mixture of slug raw materials but also the stability of the optimal grain fineness of the pelletized burden during sintering. As a consequence, it provides high specific productivity of agglomeration.

Introduction. Iron/steel industry/metallurgy is the world polluter of the environment. The modern large enterprise of iron/steel industry /metallurgy represents a set of metal-energy-chemical manufacturing of environmentally harmful industries. The entire production cycle, starting from the extraction of metallurgical raw materials to the final product is associated with the release of gases, dust, the formation of slags and slimes. The amount of dust emissions depends on the technology used and equipment [1, 2]. The total consumption of raw material resources is up to 7 tons per 1 ton of finished mill products throughout the production cycle.

A new paradigm for the development of industrial technologies determines indissoluble current requirements: an increase of the scientific and technical progress rates with a sharp reduction in resource consumption and a fundamental increase in the importance of environmental tasks. This means that the technical progress of recent decades with the huge scale of production has determined new conditions for the use of natural resources, the inevitability of moving to the search for new ways to reduce production costs. It is impossible to provide sustainable economic growth while productivity of natural complex is being destroyed. It is impossible to solve social problems successfully if the environment is degraded. Utilization of waste from iron/steel industry / metallurgy is becoming a priority task for most enterprises, not only because of stricter legislation in the field of environmental protection, but also due to the high cost of "primary raw materials" [3].

The specific productivity and product quality is the main task of any production ever and existing. In given conditions, increased requirements are subject to the processes of preliminary preparation of raw materials for blast furnace treatment. Modern technology of raw materials agglomeration before melting complicated the agglomeration conditions with the involvement of finely ground concentrates, industrial waste, solid fuel substitutes enriched in the charge, as well as the use of various intensifiers and reinforcing additives. There are many works which aimed study and improvement of burden preparation processes in various raw materials conditions, which makes it possible to generalize the specific features of pelletization of sinter burdens also in various aggregates — the pelletizers. Therefore, the key issues of burden preparation processes are becoming increasingly important, because they determine the total volume of production [4]. There are also numerous proposals for improvement of methods and devices for burden mixing and pelletizing [5].

Sinter burden in modern production is a mixture of various substances, both in size and density, chemical composition, physical and chemical as well as physical and mechanical properties. From the theory and practice of technology, it is known that materials of the same density (if various substances of the nature are mixed) and the same grain size due to their moisture and shape are mixed in a best way.

Therefore, the homogenization of the mixture and the pellet formation will significantly depend on the degree of homogeneity of the granulometric and chemical compositions of the charge components. At the sinter plants of the former Soviet Union territory, the composition of sinter burdens varies in a very wide range. The content of the concentrate in the iron ore portion of the burden (and accordingly iron ore) is ranged from 0 to 100%.

Large deviations in the composition of sinter burdens are also observed in foreign sinter plants. This circumstance, as well as the difference in the productivity of aggregates, causes a great variety in the constructive while regime characteristics of the mixing and pelletizing equipment are used in domestic and foreign factories. In this research, we consider the possibility of increasing specific productivity in the conditions of consumption of metallurgical raw materials being heterogeneous in mineralogical, granulometric, physical and chemical analysis and the use of obsolete equipment, which is typical for most of the metallurgical enterprises of the post-Soviet Union territory. This can be achieved by increasing the gas permeability of the agglomerates burden in obtaining the optimum fraction composition that preserves the strength of the pelletized burden grain during sintering.

Literature Review

The analysis of technical solutions as for the use of effective binders and the role of binders in the mechanisms of pelletization

Increasing of the efficiency of the sinter process in the conditions of modern requirements for the development of industrial technologies.

The relatively high efficiency of pelletization of sinter pellets is determined by the predominant fraction of finely ground one-two-type iron concentrates that carry the mineral. Raw materials of ArcelorMittal Temirtau JSC sinter are represented by a heterogeneous mixture of loose materials, differing not only in mineralogical, granulometric, chemical compositions, but also in the shape and size of their particles. It should be noted that the physics of the processes of dynamic behavior and structure formation of dissimilar bulk materials mixtures has been studied just a little. On the other hand, tests performed in production conditions, based on an estimation of the autohesion of burden materials components showed that grains of the pelletized burden are destroyed during discharges. It becomes obvious that sinter burden containing oolitic gravitational-magnetic concentrate of Lisakovsk (GMCL) requires additional hardening of grains while one of the solutions is the introduction of binders into the burden.

The effective binders are used in the practice of sinter of iron-ore materials, so the technology of briquetting and pellet production provides these additives for imparting strength to briquettes and pellets. The range of binders is very wide. It is determined by the composition and requirements as for the quality of briquettes and pellets. Binders should provide high strength of briquettes; they should not disintegrate during storage, transportation and discharges. Binders should provide a high rate of hardening; have sufficient prevalence and low cost; should be environmentally friendly.

Some of the binders can be interesting for sinter production. The use of binders for sinter burden can be performed in different ways:

– supply of iron ore materials to the stockpile;

– batching binder into the burden in the batching area of the sinter plant;

– supply into the drum mixer directly before mixing;

– supply into the pelleting drum directly into the pelletizing process.

The main function of binders in sinter is to provide the autohesion of burden materials components. They are intensifiers of the pelletization process and provide its effectiveness. A significant increase in autohesion can also be achieved by changing the specific surface area of the particles by the use of a finely dispersed material or a crushed separate component of the burden. For the last process, the burden is activated, and activation increases due to the growth of surface energy.

The role of water as a binder of bulk materials during pelleting. Water is the latest thing in a multicomponent disperse system of burden that provides the binding of bulk material particles, giving certain pelletizing properties to pellets. As a result, grains of different strength can be formed depending on the component, chemical, mineralogical, particle compositions and pelletizing mode of sinter burden. In the theory of pelletization of iron ore materials, a number of indicators characterizing the pelletizing ability of loose mixtures have been developed. V. I. Korotich connects the appearance of grains speed with the strength of the particles adhesion. Thus, he recommends to characterize the pelletizing ability of materials with one parameter. It is the mutual strength of the particles adhesion in humid material. The basis of the rate of pellet formation speed by hypothesize of V. I. Korotich is the mass of rolled material at the centers of pelletization to be proportional to the size of the surface of particles as for given fractions [6].

The humidity of the burden determines the productivity of the sinter machine while the optimum humidity is selected experimentally for each burden. The article [7] presents the results of optimizing the rotational speed of the pellet drum operation, installed in Azovstal Iron and Steel Plant JSC taking into account the change in humidity content of the burden. Optimum parameters of the pellet drum operation, under the conditions of pelletization, ensure maximum porosity and gas permeability of burden.

The authors [8] found out that at the same humidity the size of the pelletized charge is determined by the speed of rotation of the drum and its productivity. At the same time, the parameters of the pelletizing regime are interrelated: the humidity level predetermines the pellet formation time and the speed of rotation of the granulator, and vice versa, the parameters of the pelletizer and its operating mode affect the optimum humidity level. The value of the optimum humidity content depends not only on the component composition of the burden, it can be different even for the same ore of different sizes [9–11].

The role of the humidity process is very significant. Therefore, in the production conditions the actual humidity content of the burden on the line must be continuously determined and corrected by automatically operating devices [4].

Numerous studies [5, 12–14] of wetting process influence on sinter were carried out with the aim to improve the grain fineness of the pelletized charge and increase the productivity of sinter machines with the lowest costs within the existing production conditions (dimensions of the pelletizer, sinter composition, etc.). To solve this problem, the water supply system was changed, so pulsed wetting of the burden [12] was tested in the sinter plant of the Kommunarsky Works [12], a method for impulse delivery of the humidifier was proposed [5] to the zone of pelletization of the burden with intervals between pulses equal to the pulse duration. In the conditions of Yuzhny Mining and Processing Plant (YuGOK, Ukraine), it is advisable to humid finely dispersed burden by zones. In this case, the length of the humidity zone should be determined by the conditions for the creation in the system of burden-water of germinal centers having the maximum plastic strength [13]. At the sinter plant of "Tulachermet" Scientific and Production Association for charge humidifying in pelleting drums with dimensions of 2.8 × 6 m, the construction of a pneumomechanical injector with the use of compressed air with a pressure of 0.07÷0.15 MPa with a low head of water (0.07 ÷ 0.15 MPa) is developed and tested. The water consumption varied from 1.5 to 2 m^3/h, air consumption — from 20 to 50 m^3/h. To prevent clogging the diameter of the outlet was increased from 12 to 20 mm. The opening angle of the torch of the moisturizing liquid was 75° [14].

It is possible to consider as binders: additives of surface active substances (surfactants) put in water, supplied for moistening of sinter burden, intensifiers of the pelletizing process. Surfactants, which reduce the surface tension of water, decrease the thickness of water films that bind the particles of the burden, thereby increasing the forces of molecular adhesion, strength and size of the grains formed.

Industrial tests [15] which were conducted in June 2014 on the technological line of sinter machine No. 3 of Ural Steel JSC showed the effectiveness of the surfactants usage. At the surfactant consumption in water up to 1.6 l/h (0.4 ml/l) the average productivity of sinter machine increased from 1.047 to 1.15÷1.20 t/(m^2h); the results of laboratory and semi-industrial tests [16] of Thermoplast SV binders use in amount of 500 g to 2 kg per 1 ton of iron ore sinter showed an increase in the degree of pelletization of the burden by 23.6÷31.3%, specific productivity of sinter machines up to 26.5%.

During pelletizing of finely divided concentrates, coagulation cohesion forces have great importance.

The ability of substances in an aqueous environ to change the dispersion state under the influence of various factors, such as the pH of the aqueous medium, the salt composition, the temperature, the intensity of mixing, etc., are used to control the coagulation processes in the aqueous environ of the burden [7, 8, 17–19]. Therefore, laboratory experiments of experts of the Japanese works Nippon Steel Corp. [8] for pelletizing iron ores (7 types of 3 kg each) with an aqueous solution of an anionic polymeric dispersant (which was used to accelerate the dispersion of ore micro-particles in samples of 10 grams) in a pelleting mixer during 1 to 4 minutes, shown that the use of a dispersed solution allows the mashing of a lower humidity content, while the strength of the grains after drying becomes higher. After drying, solid bridges of micro-particles are formed between the ore particles. They prevent further disintegration of the grains and improve the gas permeability of the sintered layer.

The role of lime used as a binder for sinter burden. A practically accessible regulator of the environ is lime. It disperses during the quenching, forming an aqueous alkaline solution that binds into strong grains of the burden particles during pelletization. The efficiency of use and the optimum consumption of lime put into the sinter burden are determined by the mass fraction quenched and past the dispersing stage and assimilated as the binder burden.

Lime supply method. In the technology of sinter it is possible to use different methods of lime supply: in a stack of iron ore materials; in the burden section of the sinter plant, dosing the amount of lime in the charge directly before mixing. There are methods known for putting lime in the form of lime milk into a drum-mixer, floured lime into a drum-pelletizer for rolling on the surface of burden grains, liming and granulating the concentrate followed by curing the mixture in an averaging warehouse, etc. Industrial tests conducted at the "Tulachermet" Scientific and Production Association [20] showed that the introduction of lime hydrated with recycled slurry into the burden increased the productivity of sinter machines by 1.3% and reduced the yield of the fraction –5 mm in the skip sinter by 0.7% (abs.).

The authors [21] described a new method of introducing lime into agglomerate. A mixture of coke dust with freshly burned lime is moistened to 15÷20%, after holding for 2÷3 hours is dosed into the burden. Under the conditions of Cherepovets Metallurgical Works (Severstal), with a lime consumption in amount of 10 kg per ton of sinter, the productivity of sinter grows by 10%, which is 2÷3 times higher than the effect of putting lime into the burden by preliminary liming of iron ore concentrate or directly into the burden without exposure. In addition, the consumption of coke dust is reduced to 0.5%.

A method of lime suspension preparing in a ball mill where it is ground and mixed with water is proposed in the research [22]. Slaked lime is put together with water into a mixer to produce a lime suspension that enters the mixing drum through the tubes, where the suspension is sprayed through the nozzles along the length of the drum.

Materials and methods

Laboratory studies performing technique for determination of binders effectiveness in the process of pelletization.

The objective of the laboratory studies was the selection and justification. The selection used included the most effective binder components of the sinter burden of widely

Table 1. **Quantitative composition of the mixture for pelletization**

The material	Composition of fraction, mm	Composition of % by weight	Average weight of particle diameter, mm/g
Gravitational-magnetic concentrate of Lisakovsk	0 ÷ 3	29	0,67
Sokolovsk-Sarbaisk mining and processing plant iron ore concentrate	0 ÷ 0,75	14	0,16
Mixture of ores	0 ÷ 12	36	3,50
Combined flux	0 ÷ 4	16	2,29
Coke fines	0 ÷ 3	5	1,95

used binders. They are bentonite [23], liquid glass [24], YPEEN [25], amino-acrylate, lime [26]. In the investigation, an indicator was used to estimate the influence of the binder type on autohesion between the particles of the cloddy materials of the charge, which represents the ratio of the mass of the characteristic fractions of the pelletized burden to those in the original dry burden (base burden). Autohesion of particles is a connection between contiguous particles, which prevents their separation. To disturb this connection, an external influence is necessary. The term "autohesion" encompasses all types and forms of this phenomenon, regardless of the number and properties of the particles, the forces of the nature responsible for this interaction, the causes and conditions under which it occurs [27].

A comparative analysis of binders influence on the quality of the pelletized burden was carried out with the indices of the experiment performed during pelleting by means of water. The criterion for estimate the quality of the influence of the binder was the fractional composition, the average diameter of the pelletized bulk material and the strength of the large grains at discharge is about 10 mm.

Laboratory studies were carried out on a mixture of bulk materials, which corresponded to the averaged sinter data of ArcelorMittal Temirtau JSC for 2016 according to the composition of the main agglomerate components (**tab. 1**).

The number of binding additives is taken on the basis of literary and patent sources within the limits used in the sinter practice. The process of pelletization was carried out on a laboratory unit; it was a drum-pelletizer.

If the binders were in the free-flowing state, a mixture of burden materials with binder additives was loaded into a rotating drum where it was mixed to averaging in composition for 2 minutes. The operation of the drum automatically switched to the charging of the burden by supplying an optimum amount of water or an aqueous solution of the burden (if the water is in a liquid aggregate state). Pellets were pelletized for 9, 12 and 15 minutes.

Determination of the grains strength of the pelletized burden was carried out in accordance with the technique which was developed by the Central Plant Laboratory of ArcelorMittal Temirtau JSC by dropping them from a height of 30 cm onto the steel plate before breaking the sample, forming cracks or chipping the pieces. For the resistance to impact or strength, an average number of drops was accepted [28]. The test was subjected to five pelletized samples and five samples after standing for 24 hours (**tab. 2**).

The effect of the most effective binder on the parameters of the sinter process was carried out by control tests in laboratory conditions.

The dry burden (table 1) was mixed in the granulator in a waterfall mode for two minutes without water supply, and then for five minutes it was pelletized by feeding an aqueous solution of the dispersed calculated lime amount (in the volume of 1% of the weight of the dry charge). After mixing and pelleting, the burden was discharged from the pelletizer and analyzed for moisture content and grain fineness. As a base variant, the grain fineness of the dry and water-charged burden was taken.

Sinter burden with a layer height of 450 mm with a depression under the grate 900 mm of water was carried out on a laboratory sinter unit with a bowl diameter of 250 mm. The main indicator as a criterion for evaluating the efficiency of the process was the specific productivity of the sinter installation.

Results

The influence of various types of binders on the process of sinter components pelletization is given in **tab. 3**.

The results of laboratory experiments showed that the largest volume amounting in 42.75% of 2.5÷0 mm contained pelletized mixture with the addition of 0.6% of bentonite as a binder and 9 minutes of pelletization time. During the basic experiment, while pelletizing sinter burden without the addition of binders, the best results achieved were 17 to 29%. With the increase in the amount of the additive to the bentonite charge up to 1.1—1.5% and the pelletizing time to 12—15 minutes, the level of the indicator of the base variant was reached.

After adding amino-acrylate to the charge, the achieved degree of pelletization would not exceed the parameters of the basic variant.

The results presented on **fig. 1** show that the ratio between the content of small, medium and large fractions in the pelletizing of bulk materials depends on the type of binder and is different from the initial dry burden. Analysis of fractions distribution and the change in the average content of fractions 2.5÷0; 5÷2.5 and 10÷5 mm of the initial dry burden before pelletization and grain fineness after pelletization clearly demonstrate the influence of binders on the wet burden components autohesion.

As you can see (fig. 1), the maximum content of fine fractions corresponds to the initial mixture of components (76% of the total mass). At pelletizing this indicator significantly decreases, which indicates the autohesion being in process.

Table 2. **Grain fineness of the mixture for pelletization**

Fraction content,%											
>10	10 ÷ 7	7 ÷ 5	5 ÷4.5	4.5 ÷ 3	3 ÷ 1	1 ÷ 0.5	0.5 ÷ 0.25	0.25 ÷ 0.125	0.125 ÷ 0.063	0.063 ÷ 0.045	<0.045
3.86	3.97	4.27	1.79	7.94	12.08	25.28	14.52	7.39	11.59	4.21	3.10

Table 3. **Influence of bonding additives type, pelletizing period on physical and mechanical properties of pelletized burden**

Experiment number	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Bonding agent	Water			YPEEN			Amino-acrylate			Bentonite			Liquid glass			Lime milk		
Bonding agent quantity,% from mass	-	-	-	0.6	1.1	1.5	1.8	2.6	3.5	0.6	1.1	1.5	5	6	7	2	1.3	1.1
Pelletizing period, min	9	12	15	9	12	15	9	12	15	9	12	15	9	12	15	9	12	15
Screen size,%																		
>10	25.21	24.41	43.18	24.07	23.92	34.59	12.23	15.14	8.82	11.43	28.24	22.47	46.45	28.08	41.13	40.79	34.21	41.11
10÷7	32.12	22.37	16.63	16.4	18.16	22.2	17.16	20.41	23.33	16.47	12.94	13.57	19.18	22.45	26.39	26.09	30.13	29.85
7÷5	17.32	13.51	0.83	16.46	15.61	13.27	18.29	14.77	24.41	11	11.38	12.45	10.16	15.97	10.89	15.28	15.98	12.62
5÷3.5	5.2	4.96	4.65	13.46	10.91	6.82	10.81	6.03	12.25	7.52	7.03	9.82	4.7	7.15	3.75	5.13	6.5	5.31
3.5÷2.5	3.54	5.28	10.48	11.83	11.3	6.93	10.91	7.03	8.71	10.83	12.53	17.68	6.63	7.13	5.09	4.33	4.69	5.42
2.5÷1.6	11.56	13.65	14.65	11.48	12	11.42	11.08	8.76	7.38	13.34	18.44	19.51	9.4	12.33	8.47	6.64	5.13	4.26
1.6÷1.0	1.0	6.18	3.23	4.42	6.32	2.97	5.61	7.87	4.61	10.74	7.42	2.93	2.55	4.99	3.08	1.38	2.03	1.04
1÷0	4.05	9.64	6.36	1.87	1.78	1.81	13.92	19.99	10.49	18.67	2.02	1.57	0.92	1.9	1.19	0.37	1.33	0.39
Autohesion capacity,%	27.89	21.93	12.96	23.24	23.12	21.91	23.72	21.76	29.61	19.48	18.10	19.96	17.93	23.8	21.42	23.45	26.19	23.9
Weighted average diameter, mm/g	7.39	6.41	7.53	6.5	6.49	7.61	5.18	5.28	5.55	4.58	6.33	5.99	8.44	7.08	8.37	8.53	8.18	8.72
Averagediameter, mm	3.89	2.47	3.06	3.78	3.7	4.32	1.93	1.57	2.32	1.55	3.28	3.46	5.11	3.94	5.05	5.99	5.33	6.35
Pellet strength (raw), hit/pellet	2.4	2.6	2.4	2	1.8	1.4	2.4	4	3.2	2.8	3.6	3	7.2	6.2	5.8	3.6	3.4	4.6
Strength (after maturing), hit/pellet	1	1	1.2	1.2	1.2	1.2	1.4	2.6	2.2	2.2	3.2	2	2.2	3.8	2.6	2.6	2.4	2.2
Humidity,%	8.78	9.34	10.62	6.19	7.74	15.4	7.4	5.2	4	4.2	11.67	8.62	4.59	7.21	7.2	10.4	12.06	5.16

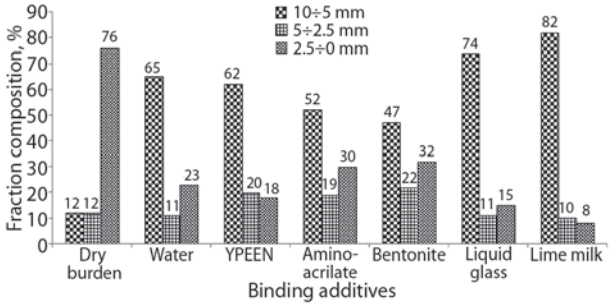

Fig. 1. Composition change as for large (>5 mm), average size (5÷2.5 mm) and small (<2.5 mm) screening sizes of initial dry, pelletized with water and having additives of burden bonding agents

The best indicators of pelletization in laboratory studies were achieved by pelleting the burden with lime milk and liquid glass binders as additives. The content of fine fractions was in ranging between 8–15% of the total mass of pelletized raw materials. The conclusion about the best effect on autohesion and chemical ability is proved by the maximum value of 82 and 74% of the content of the largest fractions >10÷5 mm.

By adding of YPEEN as a binder, the burden components pelletization achieved as for content of fine fractions <2.5 mm is 18% and fractions >10÷5 mm — 62% in the pelletized sinter mixture. In comparison with the indicators of burden pelletized without addition of binders, given indicators show the advantage.

Influence of bentonite, amino-acrylate bonding agents addition on autohesion ability of sinter burden components as for small screening size <2.5 composition is at the same level 32÷30% and has lower rate in amount of 23% as for pelletized burden without addition of bonding agents.

Fig. 2 shows average rates of pellets strength as for pelletized burden. The analysis of strength features showed that the highest values correspond to grains pelletized with the addition of 5% liquid glass as a binder. The strength was 7.2 hits per pellet, which decreases with further increase in the amount of binder additive (at 6% to 6.2 hit/pel, at 7% to 5.8 hit/pel). Relatively high strength indicators are characteristic for burden grains pelletized with lime milk (3.9 hit/pel).

Indicators of grains strength obtained by burden pelleting with lime milk and with additives of bentonite are close to limits in amounts. For wet grains pelletized with lime milk,

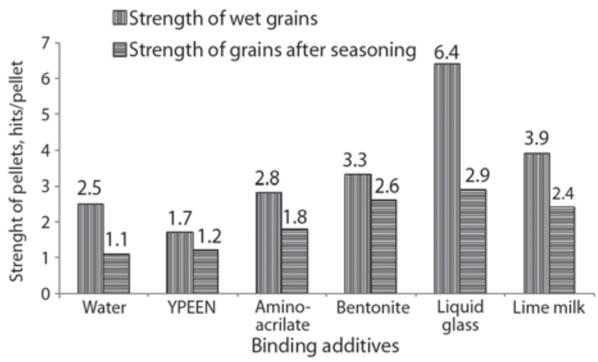

Fig. 2. Average values of pelletized burden grains strength depending on the type of binder additives

strength averaged 3.87 hits per pellet, and for grains obtained with additives of bentonite — 3.30 hits per pellet. For pellets after laying, these figures are 2.40 and 2.60 hits per pellet. These values are higher than those obtained in the basic version by 30÷60%.

However, the high impact strength of pellets in combination with the poor quality of pelletization, in the content of fine fractions in the pelletized burden, makes unacceptable the use of bentonite as a binder in production. According to the results of the research work done, it can be concluded that, according to physical and mechanical indicators, the best variant is to use liquid glass as a binder. However, the use of liquid glass has a number of significant drawbacks:

– the content of silicon diaxide and alkalines in pelletized burden adversely affects further sintering;

– preparation of binding agents, poor mixing properties with bulk material complicates the process of pelletization and makes it more labor-consuming;

– relatively high price as for pelletizing, in real production, with given type of binder is required most of its consumption, in comparison with other binders and additives.

Laboratory studies have shown that the Lysakovsk gravitational-magnetic concentrate is subject to pelletization. The main reason for the low relative productivity of sinter machines is the low strength of pelletized burden grains, which begin to break down during the transportation of the burden. This is confirmed in the pelletizing experiments themselves, when an increase in the duration of the pelletization process leads to a change in the autohesion rate, which deteriorates from 7.17 (9 min) to 6.63 (15 min). Strength of wet grains (2.5 hits per pellet) after seasoning is 1.1 hits per pellet, which means destruction of almost all pellets. It means that the considerable destruction of the pellets of pelletized with water burden happens during agglomeration process, forming a compacted layer in the zone of waterlogging and drying. From this point of view, the most effective binding additive is lime milk, injected directly into the pelletizer. The strength of wet grains as 3.9 hit/pellet after the seasoning remains at a relatively high level in comparison with others. During agglomeration, the hydrated lime transforms again into calcium carbonate, thereby maintaining the strength of the pelletized burden during sintering.

Thus, the evaluation of binder's effectiveness calculated according to the strength indicators, average diameter and the number of fine fractions of pelletized raw material compared with the baseline experiment showed:

– the best indicators of granulated pellets strength are achieved while using liquid glass as a binder;

– high strength indicators are also possessed by granules bound with amino-acrylate;

– the use of liquid glass as a binder bring to the deterioration of the pelletized raw materials quality by chemical composition and increases the cost of production;

– the best binder is lime milk, additives in the amount of 1.1% of burden weight, improves the autohesive properties of the agglomerated components, makes the composition of the fractions more uniform with a significant increase in the strength of pelletized burden pellets.

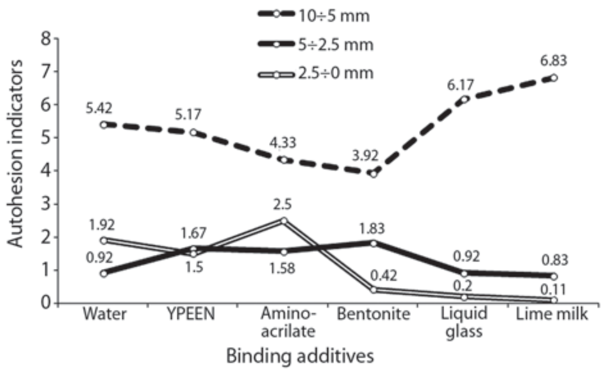

Fig. 3. The index of autohesion in different fractional ranges of the pelletized sinter burden

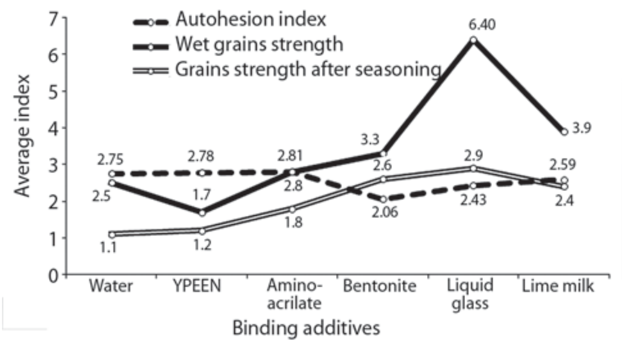

Fig. 4. The average index of autohesion in comparison with the measurement of granules strength after pelletization and after seasoning

Fig. 3 shows the autohesion of the pelletized burden by fractions. The autohesion index of dry charge is taken as one. The diagram curves show that the growth of the indicator is directly proportional to the mass of the pelletized burden of the corresponding fraction. The index of autohesion of fine fractions (2.5÷0 mm) of the pelletized burden practically does not depend on the type of binder used. A significant index of autohesion increased in the fraction 10.0÷5.0 mm.

Fig. 4 presents a comparative analysis of the average autohesion indicators of sinter burden particles with the strength characteristics of the wet after pelletization and after the granulation of the burden.

Comparative characteristics of laboratory sintering results for burdens containing in the iron ore portion of 0, 30 and 45% LGMC showed that pelletization with 1% water solution of dispersed lime increased the specific productivity of the agglomeration up to 1.37 t/m^2·hour (**fig. 5**).

For complete performance of lime intensifying properties as for agglomeration process, it is necessary to provide lime for sinter plant, to develop and implement measures aiming to ensure complete dispersion of lime within the existing technology of agglomerate preparation for sintering.

Conclusions

Thus, the main role of the binder in the mechanisms of the pelletization process is devoted to water, which ensures

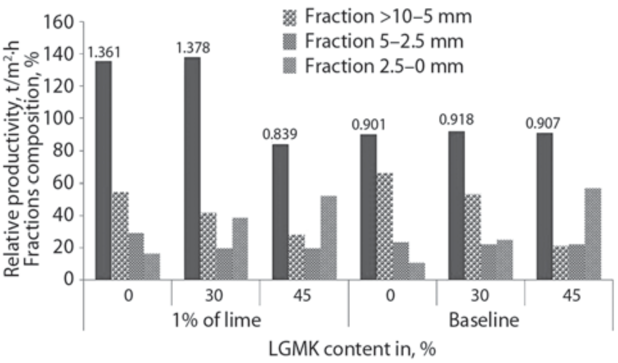

Fig. 5. Comparative characteristics of laboratory sintering results

the autohesion of the bulk material particles, giving certain mechanical properties to grains formed during granulation.

The use of additives in water, like surface active substances which lower the surface tension of water, increases the forces of molecular adhesion, strength and size of the grains formed.

The binding properties of water can vary depending on the influence of various factors: the pH of the aqueous medium, the salt composition, the temperature, the intensity of mixing, etc., into the components of the burden-water components that generate the physical processes in the system.

Autohesion determines the behavior of sinter burden components, the possibility of their better pelletization with the combined influence of other external factors such as the use of binding additives. Their main role is to keep strength of pelletized grains during all stages of loose materials agglomeration process.

The critical significance for sinter process productivity is the gas permeability of the sintered burden layer, which is determined by the preservation of a stable optimal grain fineness during sintering.

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