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Technology for the Production of Raw Pellets with Solid Fuel Rolled Inside

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Abstract

Reagents for increasing hydrophilicity of solid fuel particles surface are selected and tested. The optimum consumption and duration of reagents' influence on the surface of solid fuel particles to ensure complete rolling of all fuel inside the raw pellets were determined. The technological parameters of the pelletizing process have been worked out, which make it possible to obtain raw pellets with rolled solid fuel of the required granulometric composition with the required strength characteristics.

Keywords: *Raw pellets; Solid fuel; Hydrophilicity of the surface; Anthracite; Strength of raw pellets.*

1. Introduction

The main cost item in the production cost of cast iron smelting in blast furnaces is specific coke consumption [1-3]. Metallurgical production requires the use of carbon and hydrogen-containing reducing agents such as coke, coal and natural gas. The quality of coke is one of the main parameters that determine the progress and results of blast furnace smelting. Given that coke is the most expensive component of the cast iron charge, the task of reducing its consumption is always relevant. It can be solved by replacing coke with less expensive energy sources [4]. Such technologies include: introduction of lump anthracite into the charge of blast furnace smelting, blowing of pulverized coal fuel, natural and coke gases, as well as fuel oil into the tuyere of the blast furnace [5].

Technologies for obtaining pelletized iron ore materials (sinter and pellets) containing residual carbon from the introduced solid fuel, which was not completely burned in them in the process of thermal hardening, have also been developed. Experimental smelting with the use of these materials in blast furnace charge was carried out, which showed the effectiveness of the use of such material [6-8].

The agglomeration of metal ores and concentrates involves pelletizing them by clinkering, which is done by burning fuel in the pre-pelletized material, the clinker charge. Coke fines, which account for 3-5% of the total weight of the clinker charge, can be partially or completely replaced by biomass fuel (wood of various species in the form of pellets and briquettes, or agricultural waste, such as sunflower, straw, walnut, corn, rice and buckwheat husks, tree leaves, sunflower husks) [9-11]. The addition of pyrolyzed biofuels to the sinter charge improves the gas permeability of the agglomerated layer. The particles of biomaterials are distributed among the charge granules quite evenly and increase the porosity of the layer. Also, when using pyrolyzed biomass, a higher vertical clinkering rate is observed than when using coke fines alone. However, biofuels are characterized by a higher reactivity than coke fines, which can reduce the yield and negatively affect the quality of the sinter. According to [12], the use of coarse-grained or molded biofuels reduces the contact area, complicates O_2 diffusion, and, as a result, improves clinkering quality.

Each of the above-mentioned technologies has its own advantages and disadvantages both in preparation of fuel for input into the blast furnace and in its influence on technical and economic indicators of blast furnace melting. It should be noted once again that the introduction of less expensive and scarce solid fuel into the blast furnace as a part of the pelletized iron ore material can be very promising provided that the metallurgical characteristics of this material are preserved or improved. The undoubted advantage of such material is that in the process of its thermal strengthening it is partially restored from inside due to gasification of solid fuel carbon rolled inside, and then during melting it is restored simultaneously from the surface by reducing gases of the blast furnace and from the center of the piece due to gasification of residual carbon, which accelerates the speed of restoration of the whole piece and, accordingly, the productivity of the blast furnace. Besides, the influence of destruction of coal pieces during their thermal heating on gas permeability of charge materials column in the blast furnace is excluded, as the coal is inside the sinter or pellet.

High-temperature technology of obtaining pelletized iron ore material (sinter or pellets) with the maximum amount of residual carbon inside it can be realized under the indispensable observance of two main technological conditions: effective rolling of small components of the charge on pieces of solid fuel, which are nuclei, with ensuring the necessary strength of the obtained raw lumps (pellets) and minimum carbon burnout of this solid fuel in the process of thermal hardening and cooling of the pelletized material. In addition, the burnout rate of solid fuel inside the pelletized iron ore material depends on its reactivity. Minimal reactivity among coals has anthracite, which is recommended for rolling inside the iron ore material [13]. Optimality of observance of the specified technological parameters of production of pelletized material with residual carbon is dictated by both possible simplicity and manufacturability of parameters of its realization, and economic feasibility of the process.

As noted above, an indispensable initial condition for obtaining high quality pelletized material with residual carbon is effective rolling and adhesion of small components of the charge, both between themselves and with the surface of solid fuel pieces of 1.5-10 mm in size, which act as germs for the formation of strong lumps (raw pellets). This can be realized due to molecular and capillary forces of adhesion developed in a three-phase medium (solid, liquid and gaseous phases) only between hydrophilic materials. All components of charge (iron ore concentrate, fluxes and binding additives) in pellet production are hydrophilic materials. Solid fuel (anthracite) is a hydrophobic material and hydrophilic components of the charge are not practically rolled on it. Researchers tested variants of preliminary coating of anthracite pieces of 3-7 mm in size with a binder, bitumen or fuel oil with a mixture of certain oxides (ferromanganese production slag) to form a hydrophilic surface on them [7,14-15]. However, these measures significantly complicate the technology of production of pelletized material, and some of them introduce waste rock into its composition, reducing the iron content. In the literature are known reagents that allow to strengthen or change the hydrophobicity or hydrophilicity of the surface of minerals [16].

2. Results and discussions

In order to simplify and improve the production technology and reduce the amount of burning carbon inside the pellets, tests were carried out, which showed the possibility of obtaining fired pellets meeting the requirements of blast furnace smelting with minimal complication of the accepted industrial use of the technology of obtaining and thermal hardening of raw pellets, as well as maximum preservation of residual carbon of solid fuel in the pellet after its thermal hardening and cooling.

For use in pellets anthracite of 0-10 mm size was allocated, which shortens the technology (there is no need to allocate three narrow fractions as in [7,14-5]: 0-3 mm, 3-7 mm and +7 mm) of fuel preparation by size and allows to use all fuel less than 10 mm without removing the fractions 0-3 mm and +7 mm. In this case, particles of 1.5-10 mm size will act as germs, and finer particles will be rolled on them together with the charge. The separated fuel oil was treated with an aqueous solution of reagent-plasticizer sodium or ammonium lignosulfonate, which is a waste product of the pulp and paper industry. The role of this reagent is to increase

the hydrophilicity of the surface of coal particles while creating around them a hydrate shell no thicker than (15-20)10-6 mm, which promotes rolling on them hydrophilic particles of the fluxed charge due to molecular and capillary forces of adhesion, with the formation of raw pellets of the required size and strength. It is provided by specific consumption of lignosulfonate equal to 2,4-15,1 kg/t of dry coal. This technological operation to increase the hydrophilicity of the surface of anthracite particles in laboratory conditions was carried out in one of two possible variants as follows.

In the first variant, the required mass of coal and dry reagent was loaded into the tank from the calculation of its specific consumption specified above. Then water was poured into the tank, covering the coal at 30-50 mm, and the mixture was continuously stirred for 0.5-5.0 minutes. In the second variant the reagent solution was made in advance, the concentration of which was calculated on the basis of the required volume of the solution and specific consumption of the reagent per 1 ton of anthracite. Then the solution was poured into the tank with anthracite in it according to the parameters specified in the first variant and continuously mixed with it. After that the rest of the reagent solution was released from the tank, and the obtained anthracite with hydrophilic surface was dosed in the specified ratio with the components (iron ore concentrate, flux and binder) of the charge and mixed in the mixer. The charge mixed with anthracite was dosed into the pelletizer in a continuous mode where raw pellets were obtained, in which coal pieces were nuclei on which finely ground charge was rolled up to obtain raw pellets of the required diameter, and the smallest particles of coal (0-1,5 mm), which could not be nuclei, were rolled together with the charge on the nuclei and in the process of thermal hardening of the pellets were gasified to CO and CO_2, protecting in the oxidizing atmosphere the carbon of the nuclei from burning out.

Table 1. Parameters for obtaining raw pellets with solid fuel rolled inside.

Indicators pelletizing	By technology [15]	Technology development options							
		1	2	3	4	5	6	7	8
Pelletizer capacity, t/h	–	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Anthracite size, mm	3-7	0	0-10	0-10	0-10	0-10	0-10	0-10	0-10
Used reagent	bitumen	sodium lignosulfonate							
Specific reagent consumption, kg/t anthracite	25-40	0	0	1.3	2.4	8.6	12.4	15.1	18.3
Duration of anthracite exposure with reagent, min	–	0	0	6.4	3.6	5.1	0.5	1.4	4.3
Carbon content in charge, %	–	0	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Mass fraction of moisture in raw pellets, %	–	9,1	8.6	8.7	8.5	8.8	8.6	8.5	8.4
Amount of merchantable grade (8-20 mm) in raw pellets, %	–	92.4	74.7	83.1	92.3	93.5	92.8	94.1	93.7
Quantity of anthracite pieces rolled into pellets, %	100	0	32.8	68.6	99.4	99.8	100	100	100
Compressive strength of raw pellets, kg/ok	–	1.2	0.8	1.0	1.1	1.2	1.3	1.2	1.2
Impact strength of raw pellets, times	–	5.8	4.1	5.2	5.5	5.7	5.6	5.7	5.8

The conducted tests have shown that after anthracite treatment with the reagent solution (sodium lignosulfonate) at its optimum specific consumption, in the process of obtaining raw pellets in the bowl pelletizer, at the same productivity and at practically the same moisture content of obtained raw pellets, the amount of suitable fraction (8-20 mm) in raw pellets with rolled anthracite amounted to 92,3-94,1 %, and their strength characteristics were practically similar to raw pellets without solid fuel oil (Tables 1 experiments 1 and 6-8). At the same time, practically all solid fuel was rolled inside the pellets. When anthracite, not treated with lignosulfonate, was used in the charge, only 32.8 % of anthracite pieces were rolled into the pellets, and their strength characteristics were lower (Table 1, experiment 2) [17]. Based on the test results, the optimum values of specific consumption of the reagent for anthracite

treatment, allowing to change its hydrophobic surface to hydrophilic and rolling the charge on all its pieces to obtain raw pellets suitable for subsequent heat-strengthening were determined.

3. Conclusions

Thus, the technological parameters for changing the hydrophobic surface of anthracite to hydrophilic and modes of obtaining raw pellets of the required particle size distribution and strength characteristics for their subsequent heat-strengthening have been worked out.

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