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Obtainment of Carbon Containing Powders for Foundry from Enriched Heat-Treated Brown Coals.

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ABSTRACT

The article presents the requirements set to the quality of manufactured carbon containing powders (materials) used in steel-melting and blast furnaces as a carbonizer, carburizer or for slag foaming. The processes of brown coal heat treatment and enrichment with the obtainment of new carbon-containing materials possessing characteristics appropriate for foundry have been described. The equipment located at the production site of "Itatugol" LLC (Kemerovo region) and undergoing the installation completion stage has been shown.

Keywords: Carbon containing materials, brown coals, high-speed treatment, thermal shock, corona-electrostatic separation, moisture and volatiles removal, sulfur content reduction, calorific value enhancement.

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Today's steel industry development process is characterized by material changes in both quality and high-quality steel manufacture, and its share in overall production and methods of production.

Higher requirements set to steel quality in present-day steel industry have led to the development of a great number of new technologies, which has significantly changed the state of affairs in the steelmaking industry. This, in its turn, predetermined the creation of higher-quality carbon containing materials of higher modification degree required for the intensification of steelmaking processes of present-day steel industry.

New carbon containing materials shall be manufactured of high-quality low-ash, low-sulfur anthracites and brown, hard coals mined at the mines of the Russian Federation with the application of high temperature treatment, crushing and enrichment. The products shall be manufactured with the use of state-of-the-art high-technology equipment, including drying of raw materials, heat treatment, and suction cleaning during the whole process.

At the same time, the injection (blowing in) of powder-like carbon containing materials into the ladle, electric furnace, converter, open-heath furnace, shaft furnaces (cupola furnaces, blast furnaces), etc., for the purpose of carbonization, desulphurization, dephosphorization, deoxidation, reduction, acceleration of slag formation and slag foaming, and disposing of solid hydrocarbon wastes is performed by injection plants. The injection method makes it possible to significantly enhance the key performance indicators for manufacturing steel, iron, etc. The objects subject to powder injection can include molten steel and iron.

When performing metal injection with carbon-containing powders, the maximum contact of the injected solid agents with molten steel, maximum speed of their interaction and a higher degree of the injected materials usage are ensured.

In order to ensure slag foaming under carbon deficiency, the balance of decarburization reaction shall provide for the injection of high quality powder-like carbon, since lumpy coke additives are characterized by low efficiency (small specific surface of contact), and the use of iron is not always economically feasible (the use of 30% of iron in EAF (Electric Arc Furnace) charge results in 1.5% increase of power consumption by electric steelmaking).

High carbon material is currently supplied as non-cohesive material with 0.5-2 mm particle size.

The described carburizer is made to be used for the intended purpose. The process of its manufacture comprises extensive cleaning and enrichment of the highest quality materials of natural and artificial origin, which have undergone high temperature treatment, as well as particle-size and chemical composition classification, in order to obtain a set of physical and chemical parameters of the product in full compliance with the technical specification agreed upon with the customers, inter alia, in accordance with the characteristics summarized in Table 1.

Table 1 – Physical and chemical characteristics of high carbon materials consumed by steel-making plants

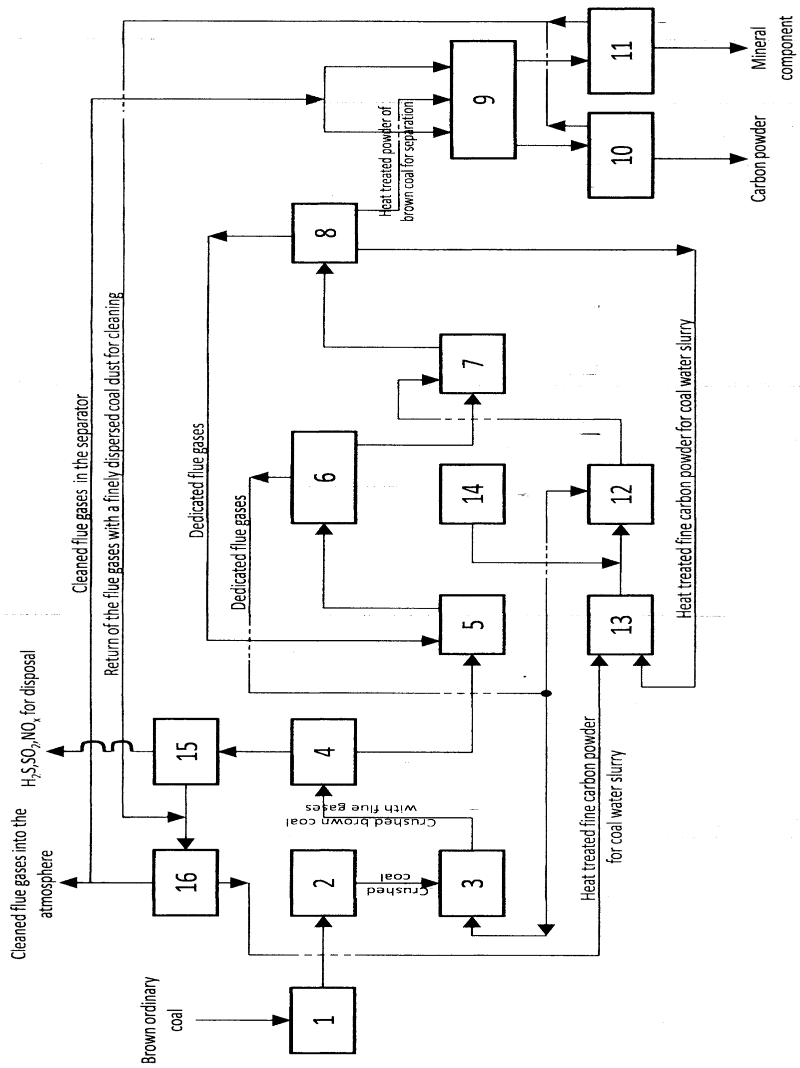
Size, mm	Carbon, %	Humidity, %	Sulfur, %	Volatiles, %	Ash content, %
as required by the customer	not less than 95%	less than 1%	less than 0.25%	less than 2%	less than 5%

Present-day production practice proves that the application of powder-type carbon injection can lead to the reduction of specific electric power consumption by 7-10%, the reduction of energized furnace operation time by 10-15%, the reduction of specific electrode consumption – by 4-5% and the gain of electric arc furnace refractory life by 1.6-2.5%.

Therefore, based on steel makers' requirements set to high carbon powder materials, CJSC "COMPOMASH-TEK" has developed and manufactured equipment for heat treatment and efficient enrichment of brown coals.

The flow-chart for brown coal heat treatment and enrichment with the obtainment of carbon containing powders is shown in Figure 1.

Run-of-mine coal will be charged into a charging hopper, where from the coal will be transferred by a belt feeder to a hammer crusher 2. From the hammer crusher, the brown coal in size of 10-20 mm is fed by a scraper feeder to a hammer mill 3, where, alongside with crushing, the coal is dried by hot flue gases, blown by a fan of the first stage cyclone 6. Besides, the classification of crushed coal to size 0-3 mm is ensured. The milled and dried brown coal in size of 0-3 mm is fed to the cyclone with a feeding silo 4, where flue gases are emitted from the gas-coal mixture. The flue gases are further transferred for cleaning and then emitted to the atmosphere. Precipitated in the feeding silo 4, the dried milled brown coal is fed by a conveying screw into the swirl chamber of the first stage 5, from where the dried gas-coal mixture is transferred to the first stage cyclone 6 with hot flue gases, blown by the fan.



1 – charging hopper; 2 – hammer crusher; 3 – hammer mill; 4 – cyclone with a feeding silo; 5 – swirl chamber of the first stage; 6 – first stage cyclone; 7 – swirl chamber of the second stage; 8 – second stage cyclone with a service bunker; 9 – corona-electrostatic separator; 10 – dynamic filter with a hopper; 11 – dynamic filter with a hopper; 12 – combustion chamber for coal-water slurry; 13 – line for coal-water slurry preparation and conveyance to the combustion chamber; 14 – tank with diesel fuel and a supply pump for combustion chamber heating; 15 – gradient separator; 16 – dynamic filter.

Figure 1 – Flow-chart for brown coals heat-treatment and enrichment with the obtainment of carbon containing powder materials.

In the first stage cyclone 6, the incoming mixture of flue gases and milled brown coal is separated into milled coal and purified flue gases, which are blown by the fan to the combustion chamber 12 for further cooling of flue gasses formed there as a result of combusting coal-water slurry. The cooled flue gases, exiting the combustion chamber 12 and having the temperature of 650-720 °C, move to the second stage swirl chamber 7. The flue gases of the specified temperature pick up the hot dried milled coal, fed from the first stage cyclone 6 by a conveying screw, form a gas-coal mixture, which, while moving through the swirl chamber of the second stage 7, is subject to thermal shock in the vortex and is accompanied by the process of milled brown coal heat treatment, which enhances its calorific value.

The mixture consisting of hot flue gases and heat-treated milled brown coal of higher calorific value, exiting the swirl chamber of the second stage 7, moves to the second stage cyclone with a service bunker 8.

In cyclone 8, flue gases are recovered from the gas-coal mixture and are blown by the fan to the first stage swirl chamber 5, and the rest of the hot heat-treated milled brown carbon powder is accumulated in the service bunker, where it is cooled to 150 °C by a dedicated cooling device. The carbon powder of the above temperature is fed to the corona-electrostatic separator 9 for the enrichment and the obtainment of carbon-containing materials.

Hot flue gases, coming from cyclone 8 to the swirl chamber of the first stage 5, pick up the milled brown coal fed from the cyclone with a feeding silo 4 and subject it to vortex swirling under the thermal exposure of 350-400 °C, which removes the residual moisture. At the same time, the dried milled brown coal is fed to the first stage cyclone where the flue gases are recovered from the gas-coal mixture. The flue gases are then separated into two streams. One stream moves to the milled coal preliminary drying in the hammer mill, and then the gas-coal mixture gets to the cyclone with a feeding silo 4, where the flue gases are recovered from the gas-coal mixture and get to the gradient separator 15. Due to vortex gas separation in the gradient separator 15, harmful gas components H_2S, SO_2, NO_x are separated and disposed of, while the purified flue gases containing residual coal dust get to the dynamic filter 16, where the residual coal dust is recovered and the purified flue gases are emitted to the atmosphere. The recovered residual coal dust is collected in the dynamic filter hopper 15 and if fed therefrom to the CWS (coal water slurry) preparation line. Then the CWS is supplied by the pump through the injectors to the combustion chamber to be combusted and for the formation of flue gases, participating in moisture removal and milled brown coal heat treatment. In order to prepare CWS, a part of the prepared heat-treated milled brown coal (to 5% of the prepared amount), which is extracted from the service bunker of the second stage cyclone 8, is used. With the aim to ensure explosion safety of the heat-treated milled brown coal enrichment, a part of purified flue gases exiting the dynamic filter 16 is used. The extracted purified flue gases are fed to the inlet to the corona-electrostatic separator. These gases act as inert gases and, at the same time blow off the adhering particles of the incoming milled brown coal, supplied for enrichment, from the drum and the electrodes. The particles of the heat-treated milled brown coal together with flue gases move through the separator 9, where they are separated into mineral and organic constituents. The organic constituent, containing flue gases, gets to the dynamic filter 10, where the carbon containing powder is precipitated and accumulated in the hopper. The recovered flue gases are supplied to the dynamic filter 16 for clearance and are afterwards emitted to the atmosphere. The mineral constituent, together with flue gases, gets to the dynamic filter 11, where the ash part is precipitated in the dynamic filter hopper, and the flue gases are supplied to the dynamic filter 16 for clearance, and are afterwards emitted to the atmosphere.

Figure 2 presents a picture of the heat treatment and enrichment equipment (testing bench) undergoing the installation process and located at the site of “Itatugol” LLC (Kemerovo region), intended for the obtainment of carbon containing powder materials used in foundry. The physical and chemical characteristics of the obtained carbon containing powders shall be controlled as per the customers’ requirements.

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Figure 2. The picture of the equipment for milled brown coal heat-treatment and enrichment (testing bench) intended for the obtainment of carbon containing powders used in foundry. The equipment is undergoing the installation phase at the site of "Itatugol" LLC (Kemerovo region).

The below physical and chemical characteristics of high-carbon materials are expected to be obtained. Table 2 also shows the physical and chemical characteristics of the materials supplied by "Uglerodpromsnab" today.

Table 2. Physical and chemical characteristics of high-carbon materials.

Supplying Company	Size	Carbon	Humidity	Sulfur	Volatiles	Ash content
"Uglerodpromsnab"	0.5-2 mm	not less than 95%	less than 1%	not less than 0.25%	less than 2%	less than 5%
CJSC "COMPOMASH-TEK"	0.5-1.2 mm	99.8%	less than 1%	traces	less than 2%	less than 0,5%

The high calorific value of the carbon-containing powders obtained from brown coals will be ensured due to thermal shock, during which coal particle will be subject to break-down with the predominant formation of low-molecular oxygen containing compounds (H_2O, CO_2, CO, etc.). At the same time complete removal of moisture and a part of ballast oxygen takes place. The powder combustion heat will be 1.5-1.87 times increased [2].

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