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Efficiency of Brown Coals Heat Treatment and Enrichment.

[1]Valery A. Moiseev*, [2]Vladimir G. Andrienko, [3]Vladimir G. Piletskii, [4]Valery E. Gorlov, [5]Valery A. Donchenko, [6]Nikolay A. Makotrenko, and [7]Andrey V. Chentsov.

[1]Doctor of Engineering Science, Professor CEO, Closed Joint Stock Company "COMPOMASH-TEK" CJSC "COMPOMASH-TEK"
[2]Ph.D in Engineering Science, Deputy CEO, Closed Joint Stock Company "COMPOMASH-TEK" CJSC "COMPOMASH-TEK"
[3]Ph.D in Engineering Science, Deputy CEO, Closed Joint Stock Company "COMPOMASH-TEK" CJSC "COMPOMASH-TEK"
[4]Doctor of Engineering Science, Professor Adviser to CEO Closed Joint Stock Company "COMPOMASH-TEK"CJSC "COMPOMASH-TEK"
[5]Chief Project Engineer, Closed Joint Stock Company "COMPOMASH-TEK" CJSC "COMPOMASH-TEK"
[6]Deputy Head of Directorate of Research and Development and Implementation, Closed Joint Stock Company "COMPOMASH-TEK" CJSC "COMPOMASH-TEK"
[7]Chief Structural Engineer, Closed Joint Stock Company "COMPOMASH-TEK" CJSC "COMPOMASH-TEK"

ABSTRACT

The article concerns the efficiency of brown coals heat treatment and enrichment using a facility for rapid heat treatment and a corona-electrostatic separator. The versions of process flow diagrams for the efficient heat treatment and enrichment have been considered. The versions of brown coal regrinding after the hammer mill and before heat treatment, as well as re-grinding of the heat-treated brown coal before enrichment, have been set forth. The economic efficiency of the two versions of the process flow diagrams for heat treatment and enrichment has been evaluated.
Keywords: Facility, parabolic vibro-pulse grinder, heat-treated brown coal, regrinding, heat treatment, enrichment, carbon containing materials, economic efficiency.

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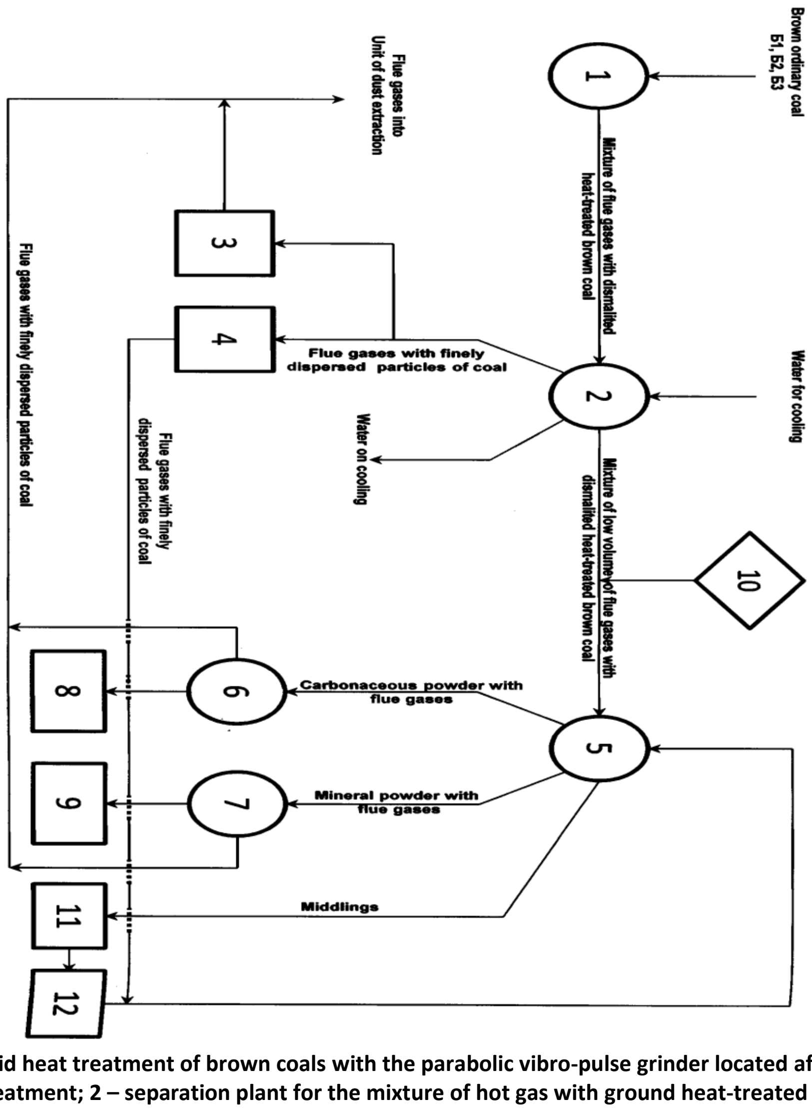
Corresponding author

In order to develop versions of process flow diagrams for efficient heat treatment and enrichment with the use of the experimental models of the mineral processing equipment designed by CJSC “COMPOMASH-TEK”, two basic process flow diagrams of practical application, involving the use of the designed experimental models of the mineral processing equipment, have been taken [1].

Figure 1 shows the first version of the process flow diagram for the efficient enrichment of re-ground heat-treated brown coal supplied from the facility for rapid heat treatment, with the parabolic vibro-pulse grinder located after the hammer mill (see Figure 2) for coal regrinding before heat treatment.

A mixture of flue gases containing re-ground heat-treated brown coal comes from the facility 1 to the hot gas mixture separation plant 2, where, with the help of the exhauster 9, a part of flue gases is collected and directed to the dust extraction unit, and further to the atmosphere.



1 – facility for rapid heat treatment of brown coals with the parabolic vibro-pulse grinder located after the hammer mill, before heat treatment; 2 – separation plant for the mixture of hot gas with ground heat-treated brown coal; 3, 4 – exhausters; 5 – corona-electrostatic separator; 6 – dynamic filter No. 1 for recovering flue gases from mineral powder; 8 – container for carbonaceous powder receipt and accumulation; 9 – container for mineral powder receipt and accumulation; 10 – electromagnetic pulse device; 11 – special container for middlings receipt and accumulation; 12 – exhauster for redirecting middlings to the corona-electrostatic separator.

Figure 1 – First version of the processing flow diagram for the efficient enrichment of the re-ground heat-treated brown coal with a parabolic vibro-pulse grinder located at the facility, after the hammer mill, before the heat-treatment process.

The other part of flue gases, together with re-ground heat-treated brown coal, which has passed through the field of electromagnetic pulse device 10, is fed to the corona-electrostatic separator 5, where solid particles are separated into three streams [2].

Figure 2 – Picture of a parabolic vibro-pulse grinder used for regrinding before brown coals heat treatment with the heat-treated coals further activation before separation. The equipment is undergoing the assembling and adjustment stage.

The first stream includes the recovered carbonaceous powder in the flue gas atmosphere, which moves through the dynamic filter 6 and is precipitated. The purified flue gases are emitted to the atmosphere. The carbonaceous powder precipitated in the dynamic filter gets to container 8 for being received and accumulated, and further applied in steelmaking, power engineering and housing services, and utilities.

The second stream includes the recovered mineral powder in flue gas atmosphere and moves through the dynamic filter 7 and is precipitated, while the purified flue gases are emitted to the atmosphere. The precipitated mineral powder is collected in container 9 for being received and accumulated, and further used in construction industry.

The third stream includes middlings which are accumulated in a dedicated container 11, and, with the help of the exhauster 12, redirected to the corona-electrostatic separator 5 for repeated separation.

Figure 3 shows the second version of the processing flow diagram for the efficient enrichment of the ground heat-treated brown coal coming from the facility for rapid brown coal heat treatment [1], with no regrinding, to the separation plant for hot gas mixture 2, where the mixture is cooled and a part of flue gases is extracted. This part is directed to the dust extraction unit. The second part of flue gases containing ground heat-treated brown coal comes to the air-cooled parabolic vibro-pulse grinder 3 for solid particles regrinding within a narrow size interval (0.5-1.2 mm) with no dust formation (see. Figure 2). The re-ground heat-treated brown coal from the grinder 3 is processed by the electromagnetic pulse device 13 and gets to the corona-electrostatic separator 4, at the outlet of which three streams are formed.

The first stream includes the recovered carbonaceous powder in the flue gas atmosphere, which moves through the dynamic filter 5 and is precipitated there. The recovered purified flue gases are emitted to the atmosphere. The carbonaceous powder precipitated in the dynamic filter gets to container 8 for being

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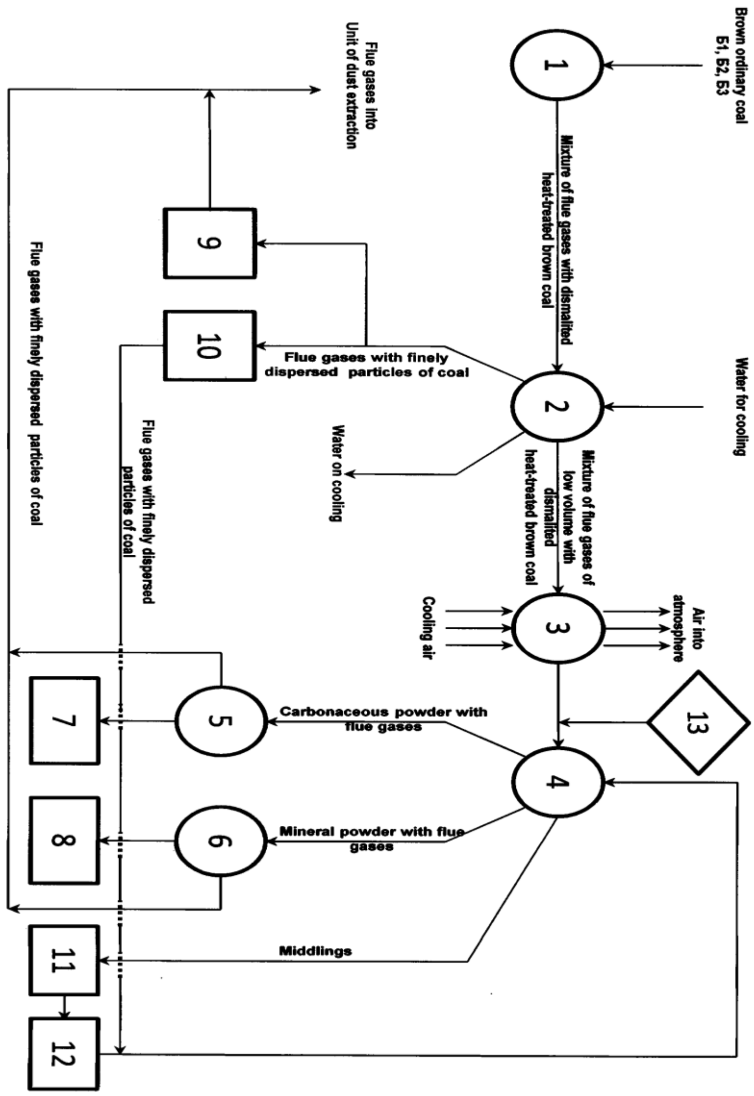
received and accumulated, and further applied in steelmaking, power engineering and housing services, and utilities.

The second stream includes the recovered mineral powder in flue gas atmosphere, which moves through the dynamic filter 6 and is precipitated there, while the purified flue gases are emitted to the atmosphere. The precipitated mineral powder is collected in container 8 for being received and accumulated, and further used in construction industry.

The third stream includes middlings which are accumulated in a dedicated container 11, and, with the help of the exhauster 12, redirected to the corona-electrostatic separator 5 for repeated separation.



1 – facility for rapid heat treatment of brown coals; 2 – separation plant for the mixture of hot gases with ground heat-treated brown coal; 3 – parabolic vibro-pulse grinder for re-grinding of heat-treated brown coal within a narrow size range (0.5-1.2 mm); 4 – corona-electrostatic separator; 5 – dynamic filter No. 1 for recovering flue gases from carbonaceous powder; 6 – dynamic filter No. 2 for recovering flue gases from mineral powder; 7 – container for carbonaceous powder receipt and accumulation; 8 – container for mineral powder receipt and accumulation; 9, 10 – exhausters; 11 – dedicated container for middlings receipt and accumulation; 12 – exhauster for redirecting middlings to the corona-electrostatic separator; 13 – electromagnetic pulse device.

Figure 3 – Second version of the processing flow diagram for the efficient enrichment of the ground heat-treated brown coal, coming from the facility for rapid brown coal heat treatment, with a parabolic vibro-pulse grinder located before the corona-electrostatic separator, for re-grinding of the heat-treated ground brown coal within a narrow size range before enrichment, with no dust formation.

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Based on the requirements set by steel makers to the used high carbon materials, out of many considered versions of processing flow diagrams for the efficient heat treatment and enrichment of brown coals with the use of experimental models of mineral processing equipment, CJSC "KOMPOMASH-TEK" has carried out a comparative analysis of the economic feasibility for the two versions of diagrams shown in Figures 1 and 3.

The evaluation of economic feasibility of the first version of the processing flow diagram shown in Figure 1.

The version of the second processing flow diagram shows the facility for rapid heat treatment of ground brown coal, quite close to which the area for heat-treated re-ground brown coal electrostatic enrichment is located. The operation of slightly dried brown coal re-grinding prior to its heat treatment is performed by the parabolic vibro-pulse grinder, located after the hammer mill of the facility (see Figure 2).

In order to calculate economic performances it has been assumed that the facility for rapid heat treatment of re-ground brown coal with the area of electrostatic enrichment will produce high-carbon material for the steel-making industry. The material produced will possess the physical and chemical characteristics as specified in Table 1.

Table 1. 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%

Currently, "Uglerodpromsnab" supplies steelmaking plants with high-carbon materials at the price of 12,700 RUR per ton. CJSC "KOMPOMASH-TEK" is planning to supply steelmaking plants with high-carbon materials of enhanced characteristics for the manufacture of high quality steel at the price which will be 10-12% lower than that for the material supplied by "Uglerodsnab", i.e. approximately 11,000 RUR per ton.

The capital expenditures for the construction of the facility for rapid heat treatment of re-ground brown coal with the area for electrostatic enrichment will come to:

138,450,000* + (10,250,000 + 10,250,000 x 0.2)**= 138,450,000 - 12,300,000 = 150.7 mln. roubles (Table 2).

*' – approximate expenditures for the construction of the facility for rapid heat treatment of brown coals and approximate operating costs.

** – cost of parabolic vibro-pulse grinder, including installation and adjustment, with approximate operating costs.

In the event of three-shift operation of the facility with the enrichment area, the below indications are expected to be achieved within 8,000 hours:

- initial brown coal of 2B grade supplied from Berezovsky deposit of Kansk-Achinsk Basin with the following characteristics:

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- after heat treatment and enrichment of the specified coal: the volume of obtained high-carbon materials with enhanced characteristics, due to the application of heat treatment and enrichment modes, can come to 7.16 t x 8,000 h = 572,800 t/year;

- annual revenues from the sales of high-carbon material with enhanced characteristics can come to 57,280 t x 11,000 roubles = 630.9 mln. roubles;

- the profit that can be used to cover costs related to the designed facility will come to approximately 315.0 mln. roubles.

The evaluation of economic feasibility of the second version of the processing flow diagram is shown in Figure 3.

The second version of the specified processing flow diagram for the enrichment of heat-treated ground brown coal shows the facility for rapid heat treatment of ground brown coal, quite close to which the area for heat-treated re-ground brown coal electrostatic enrichment is located. In order to perform re-grinding of heat-treated ground brown coal, coming from the facility, a parabolic vibro-pulse grinder is located after the separation plant [3].

The second version of the processing flow chart differs from the first one by the location of the parabolic vibro-pulse grinder only, which influences the quality of produced high-carbon materials with enhanced characteristics.

According to the first version, the parabolic vibro-pulse grinder is located at the facility after the hammer mill and before the heat treatment process. Re-grinding of slightly dried brown coal, preliminarily ground by a hammer mill, at the vibro-pulse grinder will provide coal particles with a comminuted shape. When being heat-treated, the movement of coal particles within the flue gas atmosphere along the flue gas ducts, through vortex chambers of the first and second stage with thermal shock effects, changes the shape of coal particles from comminuted to pebbles, which reduces their surface area and lowers mechanical and chemical activity. In its turn, this deteriorates the quality of high-carbon materials and impairs the efficiency of steelmaking processes, increasing, at the same time, their cost by approximately 1.3-1.5 times.

According to the second version, the parabolic vibro-pulse grinder is located at the electrostatic enrichment area, after hot gas mixture separation plant, which preserves the obtained comminuted shape of the brown coal particles before being enriched in the corona-electrostatic separator. The comminuted shape of coal particles increases their surface area up to 30%, and boosts their mechanical and chemical activity in steelmaking processes, which contributes to higher intensification, high quality slag foaming, and active decarburization. This all lowers electric power consumption, furnace operation time, as well as the specific electrode consumption.

Capital expenditures for the construction of the facility for rapid heat treatment, including the area for ground brown coal electrostatic enrichment, for both versions, one and two, remain unchanged and are set forth in Table 2.

Table 2. Capital expenditures for the construction of the facility for rapid heat treatment, including the area for re-ground brown coal electrostatic enrichment, as per the second version of the processing flow diagram for enrichment.

Item No.	Capital expenditures	1st quarter, 2016	2nd quarter, 2016	3rd quarter, 2016	4th quarter, 2016	Altogether:
1	Tie-in design. Updating of the Working Construction Documentation, thousand roubles	2,500				2,500
2	Construction and installation works, supply of utilities, thousand roubles			21,715	5,125	26,840
3	Purchase of standard and manufacture of non-standard process equipment, including a parabolic vibro-pulse grinder, thousand		45,425	40,380	20,555	106,360

	roubles					
4	Supervised installation and commissioning, thousand roubles			6,500	8,500	15,000
	TOTAL, thousand roubles:	2,500	45,425	68,595	34,180	150,700

Based on the above, for the purpose of subsequent calculation of the economic efficiency of the second version, it is assumed, that:

The cost of a ton of high-carbon product of enhanced mechanical and chemical activity (with coal particles possessing a comminuted shape) is taken as by 5-8% lower than the cost of the products supplied by "Uglerodpromsnab", i.e. 12,000 roubles.

Then, the annual revenue will come to 57,280 t x 12,000 roubles = 687.4 mln. roubles.

The profit that can be used to cover costs related to the construction of the facility for rapid heat treatment of ground brown coal, including the area for electrostatic enrichment, can come to approximately 343.7 mln. roubles.

The second version appeared to be the most efficient.

Due to the higher quality of the manufactured high-carbon product, its price will rise by 5-8%, which ensures a short payback period for the project as per the second version as compared with the first version (6 months after commissioning).

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