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DESHALING TECHNOLOGY – A PERSPECTIVE METHOD OF ENRICHMENT OF COAL IN POLAND

1. Introduction

The technologies of the dry coal separation have been applied in Poland from the twenties of the last century. In the several processing plants the air jigs (pneumatic separation plants) and the air concentrating tables were operating. These units were characterized by small accuracy of the separation of the coal fractions from the grains of barren rock. The concentrates contaminated with rock were obtained. There were also big losses of the carbonaceous substance in the refuse. Due to that the unit stopped to be used. The dry deshaling was replaced by the wet cleaning methods – enrichment in the jigs.

The processes of wet coal cleaning are very expensive and for many years after the World War II the grain fractions smaller than 20 (30) mm were not enriched. They were transferred directly to the power plant in the raw state, in which the ash content exceeded 25-35%. The units (boilers) in the power plants were adjusted to this ash content. The environmental protection requirements, however, forced (already in the eighties) in many Polish hard coal mines the necessity of construction of complicated wet enrichment systems. The concentrates obtained in this processes, due to the significant processing costs, are however very expensive. In the recent years it has resulted in losing the competitiveness in comparison with the imported coals.

For the last several years in Poland the solutions of technological nature aimed at reducing costs of production of commercial assortments of hard coal have been looking for. One of the method of costs reduction may be replacing wet cleaning processes with the process of dry deshaling the coal output.

The reported news, as well as the publications presented at the International Coal Preparation Congress (ICPC) by the Chinese scientists [1,2,3] and practitioners drew attention of the Polish engineers to the new constructions of air concentrating tables of the FGX type.

The Institute of Mechanised Construction & Rock Mining (IMBiGS) – Centre of Waste and Environment Management – Branch in Katowice after in-depth analyzes of quality of the Polish coal and quality requirements of power generators, made the decision of bringing from China an air concentrating table of the FGX-1 type.

Before the purchase of the FGX-1 a 2-tons sample of coal from one of the Polish company was sent to the Tangshan Schenzou Machinery Ltd. Company. The ob-

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tained positive results of deshaling process conducted on this coal resulted in decision of buying the FGX-1 unit. Purchasing and bringing to Poland the air concentrating table was entrusted to the WARKOP Sp. z o. o. company. In 2012 the unit was delivered to Poland. It was installed in the territory of one of the coal mines belonging to the TAURON Wydobycie SA Company.

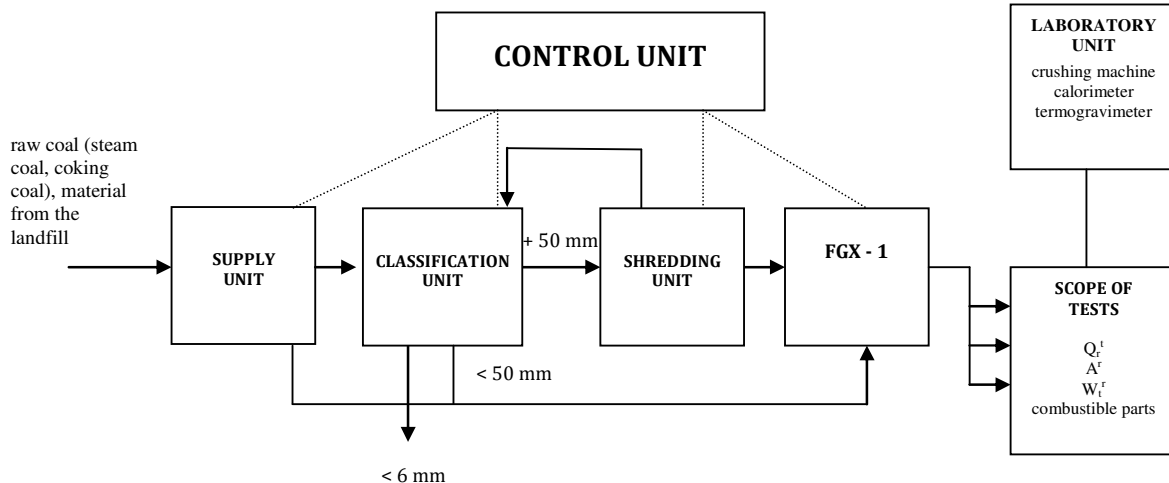
The purchased FGX-1 unit is the first of this type installation in Poland, as well as in the European Union.

2. Application of the FGX unit

The Tangsan Shenzou Machinery Co. Ltd. produces series of ten models of the air concentrating tables of the FGX type. Out of these models the IMBiGS chose the FGX-1 model with the lowest capacity (up to 10 Mg/h). The choice of this model was determined by the assumption that it will be a unit designed for the research purposes. The capacity of the FGX-1 allows to use it to the quarter- and semi-industrial tests.

The air concentrating table of the FGX-1 type was complemented with the Polish auxiliary units. The power supply module, scales, systems for raw coal transport and for discharging the obtained separation products were constructed. A screen extracting the grains exceeding, determined at a given stage of tests, size (+50, +25, +6) was installed. A crushing machine grinding the feed of raw coal to the required grain class was also built-up.

The block diagram of the test stand is shown in the picture.



The block diagram of the test stand for preliminary dry hard coal deshaling

The unit equipped with the air concentrating table of the FGX-1 type enables to conduct the comprehensive studies on coal from the different coal mines in order to determine its susceptibility to the dry cleaning process.

3. The ways of conducting tests

As known from the Chinese experience, in case of the air concentrating table of

the FGX type, the most effective is separation of the grains of the limit size 80-6 mm. The grain class 80-0 mm may also be a subject to enrichment process under the assumption that the share of the grain class 6-0 mm in total feed directed to the process does not exceed 10(15)%.

On the test unit, equipped with the air concentrating table of the FGX-1 type, that belongs to the IMBiGS the operating parameters are set separately for each type of tested coal. For this purpose, from the point of view of a given research objective, the optimal values of the following parameters are determined experimentally:

- angles of inclination of the separation deck,
- amount of air supplied to the separation zones,
- frequency of vibration of the separation deck,
- height of the baffle plate in the discharge zone of the rock, middling's and coal.

The researches on coal deshaling that lasted almost a year (we do not conduct the tests during the winter period, as well as during the days of heavy rain) enabled to gain a rich experience in conducting separation processes and to develop a research methodology for obtaining optimal separation for the particular fractions of raw coal output from the Polish coal mines.

So far, the studies were conducted on samples from the several coal mines. Some of the results are presented below.

4. The tests aiming at obtaining clean refuse

According to information received from the manufacturer the air concentrating tables of FGX type enables to the separate from the coal output the clean refuse products that can be substitutes for the natural aggregates used in engineering and construction works. As a part of the works conducted by the IMBiGS the possibilities of obtaining such products were analyzed. The exemplary results of the tests are summarized in the table 1. The criterion of the process effectiveness was the ash content in the refuse products at a level exceeding 80%. During the series of tests the quality parameters of the other separation products were a secondary (resulting) problem.

Table 1

Tests results for the raw steam coal of granulation of 25-8 mm

Raw steam coal 25-8 mm					
No.	Name of parameter	Feed	Coal	Middling	Rock
1.	Ash content [%]	39,5	25,0	69,8	84,1
2.	Total moisture content [%]	8,7	6,9	3,8	2,3
3.	Sulphur content [%]	0,52	0,70	0,33	0,39
4.	Calorific value [kJ/kg]	16 291	20 914	5 494	948
5.	Yield [%]	100	84,4	1,6	14,0

5. Tests aiming at obtaining the possible cleanest coal products

The experience gained by the IMBiGS has shown that there is a possibility of producing clean coal concentrates that can be treated like an ecological fuel. The results of this type of research are summarized in the table 2. As a result of the air separation proc-

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ess the very clean concentrates with low ash content (ap. 20%), as well as middling's that contained big amount of coal grains were obtained. These products, depending on the ash content, can become a tradable product that is sold to the power industry, they can be enriched on the simultaneously operating air concentrating table or they can also be directed to the wet enrichment processes. In Poland very clean concentrates are sought in order to heat the houses that are equipped with the appropriate boilers.

Table 2

Tests results for the raw steam coal of granulation of 20-0 mm					
Raw steam coal 20-0 mm					
No.	Name of parameter	Feed	Coal	Middling	Rock
1.	Ash content [%]	37,8	21,2	29,5	74,5
2.	Total moisture content [%]	9,6	9,0	8,4	5,3
3.	Sulphur content [%]	0,56	0,62	0,68	0,43
4.	Calorific value [kJ/kg]	15 412	21 558	18 885	3 498
5.	Yield [%]	100	79	3	18

6. Tests aiming at obtaining products of high calorific value

A part of raw hard coal in the grain class 20-0 mm extracted in Poland has relatively low calorific value. It varies in the range of 16-19 MJ/kg. Currently, the Polish power sector is searching for coal with a calorific value of 22 MJ/kg. The tests conducted by the IMBiGS on the FGX unit have shown that the removal of even small amount of rock allows to increase the calorific value to the level required by the power plants and thermal power plants. The exemplary results of tests on increasing the calorific value of the raw coal in the grain class of 20-0 mm are shown in the table 3.

Table 3

Tests results for the raw steam coal of granulation of 20-0 mm					
Raw steam coal 20-0 mm					
No.	Name of parameter	Feed	Coal	Middling	Rock
1.	Ash content [%]	31,7	24,8	38,6	83,7
2.	Total moisture content [%]	10,3	5,0	4,4	2,2
3.	Sulphur content [%]	0,65	0,62	0,61	1,58
4.	Calorific value [kJ/kg]	17 596	22 383	17 459	1 307
5.	Yield [%]	100	78,40	15,3	6,30

1. Analyzing the possibilities of removing sulphur from the coal output

Hard coal deposits located in the eastern part of the Upper Silesian Coal Basin are characterized by high sulphur content. In Poland high sulphur content is considered to be the level **exceeding 1,2%**. There are also coal deposits in Poland that sulphur content exceeds 4%. There is even one coal seam in which the sulphur content is higher than 12%. Obviously such seams are not extracted. Sulphur in this kind of coal seam is mainly in the form of pyrite. Pyrite of a density higher than density of coal is possible to remove by using gravity methods. The IMBiGS conducted the research on possibility of removal pyrite by using the owned unit equipped with the air concentrating table of the FGX-1 type. For this purpose, the operation parameters were se-

lected in a way enabling to remove pyrite in a maximum extent. The quality parameters of the other products of the separation process were a secondary (resulting) problem. The results of tests on reducing sulphur content in raw coal from one of the Polish coal mine in which extracted coal has a sulphur content above 1,8% are summarized in the table 4.

Table 4

Tests results for the raw steam coal of granulation of 25-6 mm					
Raw steam coal 25-6 mm					
No.	Name of parameter	Feed	Coal	Middling	Rock
1.	Ash content [%]	10,2	5,5	8,0	23,5
2.	Total moisture content [%]	17,9	18,2	17,8	14,2
3.	External (or called surface) moisture content [%]	11,4	10,2	10,6	9,1
4.	Sulphur content [%]	1,91	0,86	1,20	2,88
5.	Calorific value [kJ/kg]	21 488	23 074	22 424	18 038
6.	Yield [%]	100	22,6	67,7	9,7

2. Tests of deshaling coking coal

The coking coal users require that the ash content of trading product should not exceed 7-7,5%. It is connected with the necessity of obtaining coke of high quality. It is worth-mentioning here that Poland is currently the biggest exporter of coke. Therefore, it has to fulfil the highest quality standards.

It is obvious that by using dry coal separation method it is impossible to obtain the concentrates of an ash content lower than 7,5% without very big coal losses in the middling's. Therefore, this method will not replace the wet methods of coking coal enrichment in the heavy medium, jigs and flotation machines. These processes are, however, very expensive. In order to reduce the total costs of coking coal production the IMBiGS conducted the tests aiming at examining the possibilities of removing a part of refuse grains from coking coal. Their removal will enable to reduce the load of jigs and flotation machines and at the same time it will increase the efficiency of these processes. The tests results of coking coal deshaling are summarized in the table 5. The obtained results have shown the possibilities of applying the air separation process as a bypass element in the system of a wet enrichment.

Table 5

Tests results for the raw coking coal of granulation of 50-25 mm					
Raw coking coal 50-25 mm					
No.	Name of parameter	Feed	Coal	Middling	Rock
1.	Ash content [%]	38,4	19,9	33,3	65,0
2.	Total moisture content [%]	4,0	1,7	2,6	2,0
3.	Sulphur content [%]	0,53	0,62	0,62	0,38
4.	Calorific value [kJ/kg]	19 260	26 076	21 336	9 251
5.	Yield [%]	100	49,4	13,5	37,1

Table 6

Tests results for the raw coking coal of granulation of 25-6 mm

Raw coking coal 25-6 mm					
No.	Name of parameter	Feed	Coal	Middling	Rock
1.	Ash content [%]	28,15	19,8	56,6	82,2
2.	Total moisture content [%]	5,8	4,8	2,2	1,6
3.	Sulphur content [%]	0,64	0,63	0,50	0,87
4.	Calorific value [kJ/kg]	22 761	25 847	12 052	3 004
5.	Yield [%]	100	83,2	8,4	8,4

Table 7

Tests results for the raw coking coal of granulation of 25-0 mm

Raw coking coal 25-0 mm					
No.	Name of parameter	Feed	Coal	Middling	Rock
1.	Ash content [%]	18,4	12,2	27,0	75,6
2.	Total moisture content [%]	7,8	7,0	3,3	2,2
3.	Sulphur content [%]	0,68	0,66	0,63	0,57
4.	Calorific value [kJ/kg]	25 538	27 991	23 668	4 921
5.	Yield [%]	100	77,4	16,8	5,8

9. Summary

The researches analyzing application of the air concentrating table for the processing of hard coal in Poland, that have been lasting for almost a year and a half, have shown the possibilities and benefits of using this technology. The obtained tests results were published by the employees of the IMBiGS in the Polish scientific journals and they were also presented at the conferences in Slovakia and Czech Republic [4-13].

The method of dry deshaling applying the air concentrating tables aroused great interest of the coal industry in Poland. As a result of the tests on coals from the concerned coal mines the possibilities of purchasing the commercial air concentrating tables of the FGX type are currently taken under consideration. As a consequence of this great interest in the Chinese technology a study tour to China was organized in April 2014. The representatives of eight Polish coal companies took part in it. The visit to the Tangsan Shenzou Machinery Co. Ltd. Company, as well as to several coal mines using FGX unit has expanded knowledge of the Polish engineers on the air dry cleaning of coal output. At this point we would like to express our sincere gratitude to the Tangsan Shenzou Machinery Co. Ltd. Company and the coal mines using FGX unit for giving us an opportunity of going on this study tour. As a result of this visit i.e. more orders from the Polish coal industry is directed to the IMBiGS. The tests that are currently conducted by the IMBiGS on the different assortments of coal are intended to confirm the desirability of purchasing the commercial versions of the air concentrating tables of the FGX type.

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