# Dry Coal Cleaning Technology

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*Summary*

*The Instiute of Mechanised Construction and Rock Mininig - Warsaw, Poland - bought in China a concentracting table for dry cleaning of the type FGX-1. The unit has been tested mechanically since mid – November 2012. Preliminary research of coal dry cleaning has been conducted. These tests were designed to measure the impact of technical and technological parameters on the accuracy of the separation process of the coal from waste rock grains.*

*This paper describes the principles of enrichment, the construction of air concentrating tables, and some of the parameters affecting the accuracy of separation of grains with different densities. It presents the results of dry coal cleaning experiments. The summary indicates the potential of air concentrating tables and highlights their strengths and weaknesses.*

*Keywords: dry coal cleaning, air concentrating tables*

**Introduction**

The air enrichment is a method of separation of grains of different densities in the rising or pulsing stream of air. The dry coal cleaning is generally applied to the raw materials of low density and easily enriched, as well as where there is a lack of water or in the severe climate where there is a threat of freezing of the wet products. These method is in principle used for enrichment of hard coals – in particular these which contains easily sodden coal or refuse fractions – and some types of (hard) lignite.

The method of air enrichment is able to separate the components of coal output using air concentrating tables or air jigs, so called pneumatic separation plants. This article describes the air concentrating tables.

These units have been known for decades. The first table was constructed in USA in 1919. In the interwar period the air concentrating tables were implemented in England (1925) and then in Germany, Poland and Belgium (1928).

Air concentrating tables, due to their low accuracy of separation, were replaced by the wet methods of enrichment (jigs, heavy mediums). The air concentrating tables of new design worked and still are working in the regions where there is a lack of water. Their accuracy of separation is also relatively small (large losses of coal in the refuses and middlings products).

In the last decade the new construction of the air concentrating tables were developed in China. These tables are becoming more widely used in the coal enrichment processes. They are applied in the processes of so-called deshaling (dry coal separation). In case of the easily enriched coal removing the part of barren rock (in practice its amount can be reduced by 50-70%) helps to achieve the concentrates that can already be used in this form for combustion in the power plants. This applies to the power plants that are equipped with boilers dedicated for combusting the coals of the high ash content. For the purchasers that require very clean coal concentrates, products that are obtained on the air concentrating tables must undergo a secondary enrichment process – usually in the jigs.

The advantages of the dry coal separation method are: a considerable simplification of the technological scheme (in particular the possibility of reducing water and slime management), the possibility of obtaining the dry products and very clean refuse products, as well as low energy consumption and low enrichment process costs.

The disadvantages are: the quality of the final coal products in comparison with those obtained thanks to the wet method of separation, the necessity of extending the preliminary classification, the necessity of drying too wet feed material. However, very clean refuse products are obtained.

The dry separation units cannot replace the enrichment of coke coals, both in the heavy medium and in jigs, due to the required by the purchasers low ash content of concentrate and due to the lack of the barren rock in the coke coal.

The worldwide experiences (currently about 1800 FGX units is in operation) show that this method is appropriate for removing the contaminations from the feed, for reducing the ash content, for desulphurization of coals containing pyrite, for dedusting the enriched products, for increasing the calorific value of commercial coal.

The dry deshaling method can also be used for recovery of coal from the refuses that are in the heaps.

The Instiute of Mechanised Construction and Rock Mininig bought for its Non-resident Division – the Centre of the Waste and Environmental Management an air concentrating table with capacity up to 10 Mg/h. The unit of FGX-1 type was located in the territory of the Coal Company "Sobieski" that is a part of TAURON Wydobycie SA.

The tests on the coal output from the polish hard coal mines are conducted on the air concentrating table since 2012. Some of the results can be found in this paper.

**Construction and principle of separation of the grains of different densities**

The FGX units consist of a perforated separation deck, a vibrating device, an air chamber, a drive and a mechanism allowing to change the inclination angles of the table. The feed of raw coal is supplied through the vibrating feeder to the separation deck that is inclined at different angles in the transverse and longitudinal axis and driven to vibrate by a vibration generator.

Under the separation deck a several air chambers supplied by a centrifugal fan are located. Air goes through the perforation in the deck forming a rising air current. A fine material in the feed, together with air, is an autogenous center (medium), meaning it forms with air an "air-solid" suspension called fluidized bed. In result, the conditions for the restricted falling of the grains inside the fluidized bed depending on their size and density are created. The bed of raw coal floats and differentiates depending on the density of material –the lighter material is on the surface of the suspension bed and the fractions of higher density – in its lower part.

In the unit an effect of so-called liquidation is used. It is formed in result of the interaction between the density of the fine grains forming a suspension and the density of more coarse grains what leads to the improvement of the separation process of coarse-grained fractions.

The enrichment process is similar to the process of the heavy medium enrichment process, however in this case medium, in which the separation process is ongoing, is a fluidized bed. Due to the fact that the separation deck is inclined at the transverse direction, material of low density, that is on the fluidized bed surface, has tendency to move on the surface and falling in a continuous manner under the force of gravity through a baffle that is situated on the edge of the table (dumping of enriched coal). The material of higher density concentrates in the lower part of the fluidized bed and, moving in the direction of the outlet of rock, is discharged by the baffle plate that directs it to the discharge chute of rock. Depending on the feed type and the way of setting the unit many products can be obtained (fractions of: rock, intergrowths of the hard coal with barren rock, shales, coal of high ash content, coal of low ash content) that can be adjusted to the purchasers' requirements. Usually three products are obtained, however the baffle plates can be set in the way that allows to get five, or even nine, products. Taking into account the protection of the environment against dustiness – the concentrating table is covered with a roof and equipped with built-in dust collector where the negative pressure is maintained.

It is worth-highlighting that 75% of the dusted air circulates in the circuit, meaning thanks to the fan it goes through the cyclone separator and is used once again. However, 25% of air after dedusting by the bag dust collector with efficiency of 99,5%, is released into the atmosphere. Thanks to that the unit meets the strict environmental requirements.

In the pictures 1a and 1b the principle of operation of dry concentrating table is shown on the basis of the paper presented during ICPC in Istanbul in 2013.

**The factors influencing the effectiveness of the deshaling process**

The separation process of the enriched material on the air concentrating tables of the FGX type depends on many factors. The most important ones include:

- preliminary preparation of the feed taking into account the phenomenon of equaly fall of grains
- grains size,
- grains density,
- amount of the supplied air,
- height of the baffles,
- angle of inclination (longitudinal and transverse) of the separation deck,
- number of oscillations of the separation deck,
- load (capacity) of the separator.

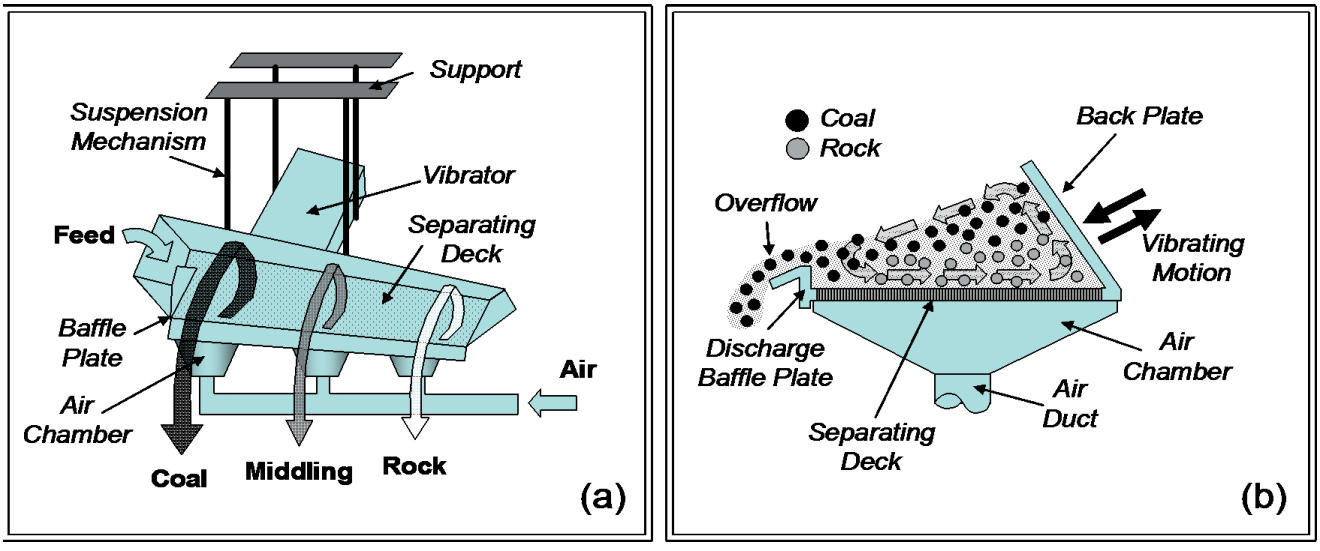


Fig. 1a, 1b.Principle of operation of the FGX type air concentrating table

Rys. 1a, 1b Zasada działania powietrznego stołu koncentracyjnego typu FGX.

These factors are determined on the basis of the tests on the raw coal output, taking into account also the required quality of the separated products. On this basis the technological regime of the enrichment process is set. It is worth-highlighting here that the strict compliance with the technological regime is a necessary condition of achieving the given quality parameters of the separated products. The producer of the air concentrating tables of the FGX type, based on its own research and industrial experience collected from the operating coal preparation plants, using the technology of dry coal separation, developed the general recommendations concerning conducting of the separation process. In these recommendations the producer draws attention to the possibility of adjusting of the following technical parameters of the air concentrating table:

- height of the baffle plate in the discharge zone of the light product (coal),
- height of the baffle plate in the discharge zone of the middlings,
- height of the baffle plate in the discharge zone of the heavy product (refuse)
- longitudinal angle of the separation deck in the scope from 0° to -2°,
- transverse angle of the separation deck in the scope from 0° to -10°,
- amount of the supplied air to the particular separation zones of the tested material,
- positioning of the dampers that regulate directing of the separated streams of materials to the defined separation products.

Setting the particular above-mentioned technical parameters have to take place during the trial (preliminary) tests in a way which helps to gain the most favorable separation effect of the feed between the particular products. The foreign experiences show that the effectiveness of the separation process depends also on the technological parameters of the feed that is to be enriched.

During the tests conducted in the IMBiGS it has been observed that the following parameters of the feed material influence the accuracy of the separation process:

- total moisture content,
- size of the separated experimental material,
- range of the grain class,
- share of the grain class 6-0 mm,
- ratio of the amount of rock to the amount of coal,
- ash content in the experimental material,
- content of the pyritic sulphur in the experimental material,
- the content of the middling (dirt band) in the feed.

**Exemplary results of the coal deshaling process**

Testing unit equipped with the air concentrating table of FGX-1 type on which the researches on the dry coal deshaling process were conducted is shown in the picture no 1.

In the IMBiGS the tests of the separation process have been conducted on the hard coal output of several grain classes.

**Summary**

The air concentrating tables are used for separation from the coal output the clean grains of rock. The air concentrating table parameters are determined in a way thanks to which it is possible to achieve the separation of the components at the theoretical density of medium equaled around 2,0 g/cm3. The grains of this density are practically the grains of the clean rock. Due to the fact the accuracy of


Pic. 1 Air concentrating table of FGX – 1 type

Zd. 1 Powietrzny stół koncentracyjny typu FGX - 1

Tab. 1 Tests results for the raw coal of granulation of 25-8 mm

Tab. 1 Wyniki badań dla węgla surowego o granulacji 25-8 mm

| Raw coal 25-8 [mm]<br>Węgiel surowy 25-8 mm | | | | | |
|---|---|---|---|---|---|
| No.<br>Nr. | Name of parameter<br>Nazwa parametru | Feed<br>Nadawa | Coal<br>Węgiel | Middling<br>Przerost | Rock<br>Odpad |
| 1. | Ash content [%]<br>Zwartość popiołu [%] | 35,9 | 28,0 | 65,8 | 86,1 |
| 2. | Total moisture content [%]<br>Zawartość wilgoci całkowitej [%] | 8,7 | 6,9 | 3,8 | 2,3 |
| 3. | Suphur content [%]<br>Zawartość siarki [%] | 0,55 | 0,6 | 0,33 | 0,39 |
| 4. | Calorific value [kJ/kg]<br>Wartość opałowa [kJ/kg] | 16 727 | 20 914 | 5 494 | 948 |
| 5. | Yield [%]<br>Wychód [%] | 100 | 81,4 | 1,6 | 14,0 |

Tab. 2 Tests results for the raw coal of granulation of 20-0 mm

Tab. 2 Wyniki badań dla węgla surowego o granulacji 20-0 mm

| Raw coal 20-0 [mm]<br>Węgiel surowy 20-0 mm | | | | | |
|---|---|---|---|---|---|
| No.<br>Nr. | Name of parameter<br>Nazwa parametru | Feed<br>Nadawa | Coal<br>Węgiel | Middling<br>Przerost | Rock<br>Odpad |
| 1. | Ash content [%]<br>Zwartość popiołu [%] | 31,7 | 21,8 | 40,6 | 85,7 |
| 2. | Total moisture content [%]<br>Zawartość wilgoci całkowitej [%] | 10,3 | 5,0 | 4,4 | 2,2 |
| 3. | Suphur content [%]<br>Zawartość siarki [%] | 0,69 | 0,62 | 0,61 | 1,28 |
| 4. | Calorific value [kJ/kg]<br>Wartość opałowa [kJ/kg] | 19 244 | 24 383 | 14 459 | 1 307 |
| 5. | Yield [%]<br>Wychód [%] | 100 | 71 | 15 | 12 |

Tab. 3 Tests results for the raw coal of granulation of 20-0 mm

Tab. 3 Wyniki badań dla węgla surowego o granulacji 20-0 mm

| Raw coal 20-0 [mm]<br>Węgiel surowy 20-0 mm | | | | | |
|---|---|---|---|---|---|
| No.<br>Nr. | Name of parameter<br>Nazwa parametru | Feed<br>Nadawa | Coal<br>Węgiel | Middling<br>Przerost | Rock<br>Odpad |
| 1. | Ash content [%]<br>Zwartość popiołu [%] | 31,7 | 21,2 | 29,5 | 80,5 |
| 2. | Total moisture content [%]<br>Zawartość wilgoci całkowitej [%] | 9,6 | 9,0 | 8,4 | 5,3 |
| 3. | Suphur content [%]<br>Zawartość siarki [%] | 0,56 | 0,62 | 0,68 | 0,44 |
| 4. | Calorific value [kJ/kg]<br>Wartość opałowa [kJ/kg] | 17 151 | 21 558 | 18 885 | 1 860 |
| 5. | Yield [%]<br>Wychód [%] | 100 | 80 | | 18 |

the air concentrating tables is relatively small (the smaller medium density in which the separation process is ongoing, the smaller the accuracy of the separation process), apart from the rock, also the shale grains, less frequently – intergrowths of the hard coal with barren rock, are directed to the heavy products of the process. The foreign tests have shown that the accuracy of the separation process described by the écarte probable ep factor equals 2,0. This is the accuracy of not the best working jigs, therefore for the air enrichment process it is relatively high.

On the air concentrating tables it is possible to separate the grains of the limit size: the upper limit – 80 mm, the lower limit – 6 mm. In practice, due to the phenomenon of równoopadanie (big, lighter grains descend at the same speed as the smaller grains but of high density), it is advisable to direct the narrower grain classes to the separation process, i.e. 80-50 mm, 50-20 mm, 20-6 mm. For a such classified material the cleaner rock products (not contaminated with coal) are obtained.

The operation of the air concentrating table is regulated by the height of the baffle plates in the particular discharge zones: rock, middling and coal. Depending on the type of the feed the angles (longitudinal and transverse) of the separating deck are appropriately set. The amount of the air that is supplied to the particular separation zones is experimentally selected. The tests that have been conducted by the Centre of the Waste and Environmental Management (Non-resident Division of the IMBiGS in Katowice) many months allowed to gain experience in the field of separation process and to develop a research methodology of optimal recovery of rock fractions from the coal output.

**Literatura - References**


1. *Baic I., Blaschke W., Góralczyk S., Sobko W., Szafarczyk J.,2013 - Odkamienianie urobku węglowego metodą suchej separacji. Monografia Innowacyjne i przyjazne dla środowiska techniki i technologie przeróbki surowców mineralnych Wyd. ITG KOMAG, Gliwice, p. 99-108*
2. *Baic I., 2013 - Wykorzystanie powietrznych stołów koncentracyjnych do otrzymywania substytutów kruszyw oraz produktów węglowych; Materiały konferencyjne – Szkoła Górnictwa Odkrywkowego, Akademia Górniczo-Hutnicza im. S. Staszica w Krakowie*
3. *Blaschke W., 2013 - Nowa generacja powietrznych stołów koncentracyjnych. Zeszyty Naukowe IGSMiE PAN, Kraków, p. 67-74*
4. *Baic I., Blaschke W., 2013 - Analiza możliwości wykorzystania powietrznych stołów koncentracyjnych do otrzymywania węglowych paliw kwalifikowanych i substytutów kruszyw. Polityka Energetyczna, Tom 16 Zeszyt 3, p. 247-260*
5. *Blaschke W., Baic I., 2013 - Wykorzystanie powietrznych stołów koncentracyjnych do otrzymywania substytutów kruszyw metodą deshalingu. Kruszywa Nr 3, p. 48-50*
6. *Blaschke W., Baic I., 2013 - Otrzymywanie substytutów kruszyw z wykorzystaniem metody deshalingu. Proceeding International Conferences – The New Mineral Policy and Progressive Technologies in Mining, Geology and Environment. Demanowska Dolina, Słowacja, p. 121-125*
7. *Blaschke W., Baic I., Szafarczyk J., 2014 - Ograniczenie kosztów produkcji węgla kamiennego poprzez wdrożenie technologii suchej separacji; Materiały konferencyjne XXIII Szkoły Eksploatacji Podziemnej, SESJA – Nowe techniki i technologie w eksploatacji podziemnej złóż, Kraków*
8. *Baic I., Blaschke W., Sobko W., Szafarczyk J., Okarmus P., 2014 - Badania możliwości usuwania kamienia z urobku węgla koksowego na powietrznych stołach koncentracyjnych; Monografia – Innowacyjne i Przyjazne dla Środowiska Techniki i Technologie Przeróbki Surowców Mineralnych – Bezpieczeństwo - Jakość – Efektywność – ITG KOMAG, Gliwice, p. 65-79*
9. *Blaschke W., Okarmus P., Ziomber S., 2014 - Skuteczność suchego odkamieniania węgla koksowego metodą separacji na powietrznych stołach koncentracyjnych. Monografia – Innowacyjne i Przyjazne dla Środowiska Techniki i Technologie Przeróbki Surowców Mineralnych – Bezpieczeństwo - Jakość – Efektywność – ITG KOMAG, Gliwice, p. 81-91*

10. *Baic I., Blaschke W., Sobko W., 2014 - Ekologiczne oczyszczanie urobku węgla kamiennego za pomocą powietrznych stołów koncentracyjnych. Na mokro czy na sucho? Kwartalnik Ekologia Nr1/69, Wyd. Polska Izba Ekologii, p. 32-34*
11. *Ghost T., Patil D., Parekh B.K., Honaker R.Q., 2013 - Uprading low Rank Coal Using A Dry, Density – Based Separator Technology. Proceedings of the 17th International Coal Preparation Congress. Istambuł, p. 295 - 308*
12. *Honaker R.Q., Luttrell G.H., Bratton R., Patil D., 2006 - Dry deshaling technologics. CPSA Journal. The magazinc by the Coal Preparation Socicty of America, Vol. 5 No 2, p. 21-25*
13. *Honaker R.Q., Luttrell G., Mohanty M., 2010 - Coal preparation rcscarch in the USA. Procccdings of XVI International Coal Preparation Congress. Lcxington. USA, p. 864-874*
14. *Honaker R.Q., 2007 - Course dry cleaning. Workshop on Coal bcneficiation and utilization of rejects: Initiativcs, policies and practices. Ranchi. India*
15. *Li Gongamin, 2006 - Coal compound dry cleaning tcchniquc-study and practicc. Proceedings of XV International Coal Preparation Congress. Pekin. Chiny, Vol II, p. 439-447*
16. *Schen L., 2002 - The compound dry cleaning machine and its application. Procccdings of XIV International Coal Preparation Congress and Exhibition. Johannesburg-Sandton. RPA, p. 419-423*

## *Technologia suchego wzbogacania węgla*

*Intytut Mechanizacji Budownictwa i Górnictwa Skalnego - Warszawa, Polska - kupił w Chinach stół koncentracyjny do wzbogacania węgla na sucho, typu FGX-1. Urządzenie zostało przetestowane mechanicznie od połowy - listopada 2012. Wstępne badania suchego wzbogacania wegla zostały przeprowadzone w ZG Sobieski. Badania miały na celu zbadanie wpływu parametrów technicznych i technologicznych na dokładność procesu separacji węgla od ziarn odpadów.*

*W artykule opisano zasadę wzbogacania, budowę stołu koncentracyjnego powietrznego, okreslono parametry wpływających na dokładność rozdziału ziaren o różnych gęstościach. Przedstawiono wyniki wzbogacania na sucho węgla. W podsumowaniu wskazano potencjał powietrznej koncentracji wegla, okreslono mocne i słabe strony technologii.*

*Słowa kluczowe: suche wzbogacanie węgla, powietrzny stół koncentracyjny*