Mining and preparation of hard coal in Poland and Vietnam

Górnictwo oraz przeróbka węgla kamiennego w Polsce i Wietnamie

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Abstract: This paper describes issues related to the hard coal mining sector and coal processing in Poland and Vietnam. In Poland, there are three important coal regions: Lublin Coal Basin (LZW), Upper Silesian Coal Basin (GZW) and Lower Silesian Coal Basin (DZW). In Vietnam, the main coal basins are Quang Ninh and Red River Delta. The Polish coal industry is currently in the phase of transformations and restructuring. In 2017, the restructuring program was constantly implemented. This program included a number of changes in the ownership structure and structure of existing and newly established companies. Vietnam has one large company, VINACOMIN, which is 100% state-controlled. The final part of the paper describes a simple preliminary coal enrichment system in mining plants in Vietnam, as well as coal processing schemes in Poland and Vietnam. The summary is a description of future plans for both coal enrichment systems discussed in his paper.

Treść: Artykuł porusza kwestie związane z sektorem wydobywczym węgla kamiennego oraz jego przeróbki w Polsce oraz Wietnamie.. Polska posiada trzy ważne zagłębia węgla kamiennego: Lubelskie Zagłębie Węglowe (LZW), Górnośląskie Zagłębie Węglowe (GZW) i Dolnośląskie Zagłębie Węglowe (DZW). W Wietnamie głównymi zagłębiami węgla są Quang Ninh i Red River Delta etc.. Polski przemysł węglowy aktualnie znajduje się w fazie przeobrażeń i procesu restrukturyzacji. W 2017 program restrukturyzacyjny był ciągle wdrażany w życie. Program ten zawierał szereg zmian w strukturze właścicielskiej oraz strukturze pracy istniejących spółek oraz nowo powstałych. Wietnam posiada jedną wielką spółkę, jaką jest firma VINACOMIN, która w 100% zależna jest od polityki państwa. W końcowej części artykułu zostanie omówiony prosty, wstępny system wzbogacania węgla w Wietnamie przy zakładach górniczych, a także schematy przeróbki węgla w Polsce i Wietnamie. Podsumowaniem będzie opisanie planów na przyszłość dla obu omówionych systemów wzbogacania węgla.

Słowa kluczowe:

coal processing, coal resources, coal basins, coal industry, coal preparation flowsheet

Keywords:

przeróbka węgla, zasoby węgla, zagłębia węglowe, przemysł węglowy, schematy przeróbki węgla

1. Introduction

In Europe, Poland is the biggest hard coal producer, Vietnam is one of the most important producers of anthracite. After 1990, the position of coal industry and coal in economy in these countries changed. Throughout the European Union the role of renewable resources is strengthening and Polish coal industry is changing. Coal production and consumption should be in accordance with the environmental requirements. Vietnam also starts paying more attention to environmental protection but another thing is the increasing production efficiency in processing plants, building new underground mines and closing open-pit mines. Large coal resources in this countries can give some opportunities in the future.

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2. Coal resources and coal basins

2.1. Poland

In the end of 2016, the total documented balanced coal resources in Poland amounted to 56 578 mln tons. Steam coal was 71.56%, coking coal - 27.09% and the remaining types of coal - 1.35% of all coal resources.

The share of deposits currently in use come up to 37.93% of balanced coal resources (22 222 mln tons).

Hard coal deposits in Poland occur in 3 coal basins (Zdanowski, Żakowa 1995):

– Upper Silesian Coal Basin (GZW) – located in the south area of Poland. In this basin almost all coal mines are opened. The area of GZW is 5 600 km^2 and with 80.23% of all documented balanced coal resources. The seam thickness of coal deposits in GZW basin fluctuates between 1.0 and 1.5 m (sometimes from few to dozen meters).

– Lublin Coal Basin (LZW) – located in the east of Poland. In this basin only "Bogdanka" coal mine operates. The area of perspective deposits is 9100 km^2 and the area of documented deposits is 1200 km^2. Only 0.9% of this basin is currently being developed. Seam thickness of a coal deposit in this basin fluctuates between 0.8 and 3.0 m.
– Lower Silesian Coal Basin (DZW) – exploitation was finished in 2000.

The exploitation was stopped mainly due to hard geological conditions. Actual balanced resources in this coal basin amount to 423.98 mln tons (Bilans… 2013, Bilans… 2017).

2.2. Vietnam

Available data presented by Vietnam shows that the coal reserves amount to ca. 49.8 billion tons. The share of measured and indicated reserves (categories A+B+C1) is 33%, inferred (C2) - 39% and prognostic resources (P) - 28%. The most important coal basins are located in Quang Ninh, Red River Delta, Thai Nguyen, Backan, North Path, Da River, Ca River, Na Duong, Nong Song, Ba River, Mekong River Delta. Vietnam provides large resources of anthracite.

Two of the abovementioned hard coal basins can be described wider:

– Quang Ninh basin is located in the northeast part of the country. In this basin exploitation begins at 1839. Quang Ninh coalfield covers 8.7 billion tons of coal resources (anthracite). The most important coal deposits in Quang Ninh basin are: Mao Khe, Trang Bach, Nam Mao, Vang Danh, Uong Thuong, Dong Vong, Nga Hai, Khe Tam, Giap Khau, Nui Bao etc.
– Red River Delta basin was discovered in 1960 during the search for oil and gas. The 39.4 billion tons coalfield lies beneath the Red River coal basin (sub-bituminous coal) with the area of 2000 km^2. The coal deposits are located at the depta of 2500 m. The seam thickness of coal deposits in the Red River Delta fluctuates between 1.0 and 10.0 m (Bilans… 2013, Le Minh Chuan 2011, Le Minh Chuan 2012, Nguyen Binh 2015, Strzałkowska, Strzałkowski 2011, Tran Xuan Hoa 2010).

3. Coal mining industry

3.1. Poland

Poland is still changing during the restructuring program for coal companies implemented after the crisis which occurred due to the decrease in coal prices on international markets.

Before the restructuring program, the coal industry in Poland presented itself as follows (before 2016):

– Kompania Węglowa (Towarzystwo Finansowe Silesia Sp. z o.o.) coal mines: KWK "Jankowice", KWK "Chwałowice", KWK "Rydułtowy-Anna", KWK "Marcel", KWK "Bolesław Śmiały", KWK "Piast", KWK "Halemba-Wirek", KWK "Bielszowice", KWK "Ziemowit", KWK "Pokój", KWK "Sośnica",
– Węglokoks Kraj Sp. z o.o. coal mines: KWK "Bobrek", KWK "Piekary",
– Katowicki Holding Węglowy S.A. coal mines: KWK "Mysłowice-Wesoła", KWK "Murcki-Staszic", KWK "Wieczorek", KWK "Wujek",
– Jastrzębska Spółka Węglowa S.A. coal mines: KWK "Borynia-Zofiówka-Jastrzębie", KWK "Budryk", KWK "Krupiński", KWK "Pniówek", KWK "Knurów-Szczygłowice",
– Tauron Wydobycie S.A. coal mines: "Sobieski", "Janina", "Brzeszcze",
– LW "Bogdanka" S.A,
– Zakład Górniczy Siltech Sp. z o.o. – private mine,
– Eko-Plus Sp. z o.o. – private mine,
– Przedsiębiorstwo Górnicze "Silesia" – property of a Czech coal company,
– Spółka Restrukturyzacji Kopalń S.A. – preliminarily aimed for liquidation as unprofitable coal mines.

After the restructuring programme was created, the biggest coal company in Europe Polska Grupa Górnicza Sp. z o.o., PGG consisted of two big companies: Kompania Węglowa (Towarzystwo Finansowe Silesia Sp. z o.o.) and Katowicki Holding Węglowy S.A.

– PGG Sp. z o.o. coal mines: KWK ROW (complex mines KWK "Marcel", KWK "Rydułtowy", KWK "Jankowice", KWK "Chwałowice"), KWK Ruda (complex mines KWK "Halemba", KWK "Pokój", KWK "Bielszowice"), KWK "Piast-Ziemowit", KWK "Bolesław Śmiały", KWK "Sośnica", KWK "Murcki-Staszic", KWK "Mysłowice-Wesoła", KWK "Wieczorek", KWK "Wujek",
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3.2. Vietnam

The VINACOMIN Holding Corporation Ltd. with its 54 coal mines constitutes the biggest coal mining company in Vietnam. The beginning of VINACOMIN is dated on 2005. VINACOMIN hold 5 big opencast mines, 15 open pits, some smaller coal mining sites and 30 underground coal mines. This is a 100% state-owned economic Corporation. 95% of coal production in Vietnam comes from VINACOMIN Company. The most important plants are:

– Hon Gai (2 million tons/year),
– Cua Ong (10 million tons/year),
– Vang Danh (3 million tons/year).

According to the Master Plan of coal industry development in Vietnam by 2020 - with the perspective to 2030 - the total coal output will reach 55 million tons in 2015, 60 million tons (in 2020), 65-70 million tons (in 2025) and 65-75 million tons (in 2030) (Baic, Blaschke 2017, Bieńko 2004, Blaschke 2001, Blaschke i in. 2006, Blaschke i in. 2016, Kowalczyk, Strzelec 2004, Kurczabiński, Łój 2004, Le Ba Viet Bach, Gheewala 2008, Le Minh Chuan 2011, Le Minh Chuan 2012, Nguyen Binh 2015, Nycz 2000, Nycz, Zieleźny 2004, Tran Xuan Hoa 2010).

4. Coal processing plant technology

4.1. Poland

The process of washing +20 mm of coal is conducted in dense medium separators. Magnetite is used as a thickener. A typical flowsheet of washing +20 mm of steam coal is presented in Fig. 1.

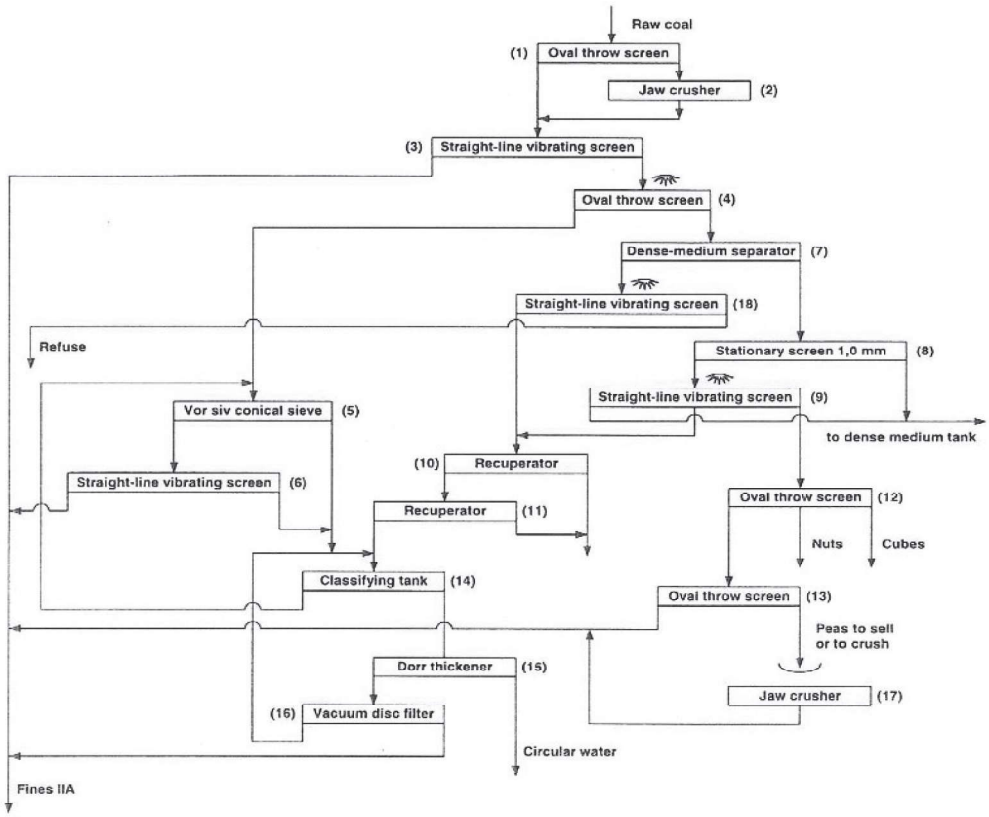

Fig. 1. Steam coal preparation process flowsheet (Baic, Blaschke 2017)
Rys. 1. Schemat przeróbki węgla energetycznego (Baic, Blaschke 2017)

The raw coal is directed for pre-classification at 200 mm vibrating screens PWK-1 (1) with a rotary movement. Particles greater than 200 mm are directed for crushing at jaw crushers KWK-200U (2). Then the coal moves on to PZ 2675 (3) screen equipped with slotted sieves with the slot width of 20 mm. The coal class +20 mm to -200 mm moves on for de-sliming at the rotary motion screen WK-1 (4) and then for treatment in classifiers DISA-2S-300 (7). The adjustment and control of dense medium thickness is done automatically. The product is dewatered and the heavy medium/magnetite is separated on table screens (8) and screens with water sprays (9). The filtrate is directed to magnetic recuperator MR-9/204 (10, 11) where the magnetite is recovered. The dewatered concentrate is sent for final classification (12, 13) into size grades: cobbles, nuts, peas. In case there is a lack of demand for coarse or middle size grades, coal can be crushed (17) and sent to raw coal bins. The rejects which were dewatered and stripped of magnetic are sent to waste bins and transported onto waste dumps.

The plant operates with a closed water circulation circuit. The filtrate from the de-sliming screen (4) is sent to a sieve (5). The filtrate from the sieve (5) together with the non-magnetic product from the separator (11) is directed to a classification sump (14) from which the overflow is sent back to the sieve (5) is then dewatered on vibrating screens with linear motion (6). The dewatered product is directed to the fine coal bin. The overflow from the classification sump is sent for thickening and filtration. The thickening process is done in radial thickeners and filtration at disc vacuum filters (16). Filtration cake is directed to raw coal bin. The control of commercial productions is carried out using a continuous system of coal quality measurement "AIFA-03".

Technological circuits for treatment of coal with particle size +20 mm are practically identical in all coal washing plants. Particular plants differ one from another in technical equipment. They have for instance different types of DISA separators, screens or filters installed. The quality of commercial products in coarse and medium particle sizes is very good. The average ash content is 6%, sulfur below 0.64% and calorific value ca. 28 MJ/kg (Blaschke 2010, Blaschke 2001).

Beneficiation process for coking coal is led in full range of grain sizes. Coal grains with size >20 mm are treated in DISA separators or grain jigs. Fine coal > 0.5 and < 20 mm is separated in jigs. During the gravity separation process three products are separated: concentrate, middlings and rejects. Middlings are used as steam coal. Another option is crushing the middlings and send them once again for beneficiation process.

Slimes < 0.5 mm, (sometimes 0.3 mm) are washed by foam flotation methods in flotation cells of the Polish manufacture (PA-38, PA-6X, IŻ-5, IŻ-12, FLOKOB-12, FLOKOB-24, FLOKOB-40) or in the imported ones (Denver, Allmineral). Flotation concentrates are dewatered in vacuum filters. At prezent, the imported centrifuges are replacing the vacuum filters in several plants. Modernization of the dewatering process is intended, targeted at the elimination of the coal drying process. Flotation tailings are thickened in Dorr radial thickeners. The sediment is dewatered in filter presses or at belt filter presses manufactured in Poland. A typical technological flow sheet of coking coal washing is presented in Fig. 2.

4.2. Vietnam

Coal mining industry in Vietnam lead coal preparation into two stages. First stage is to implement the ROM coal pre-treatment system by handpicking, screening, grinding or blending. The second one is typical coal preparation in coal preparation plants. The management system in Vietnam coal preparation industry is showed in Fig. 3.

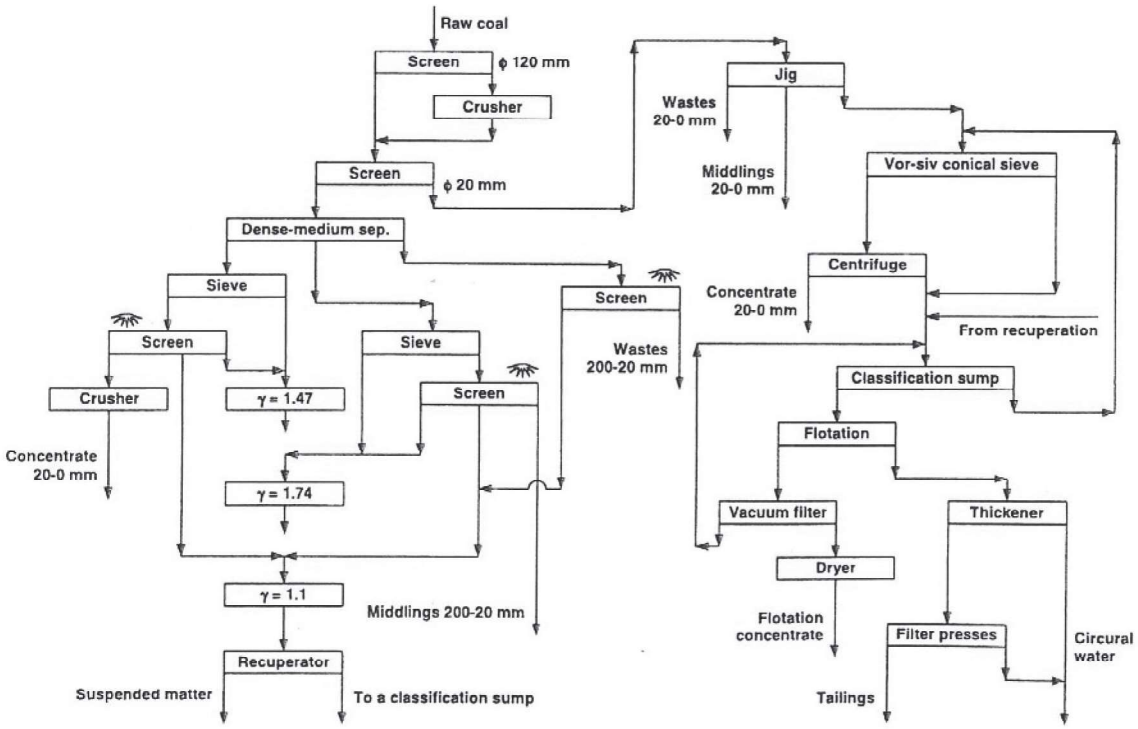

Fig. 2. Coking coal preparation process flowsheet (Baic, Blaschke 2017)
Rys. 2. Schemat przeróbki węgla koksującego (Baic, Blaschke 2017)

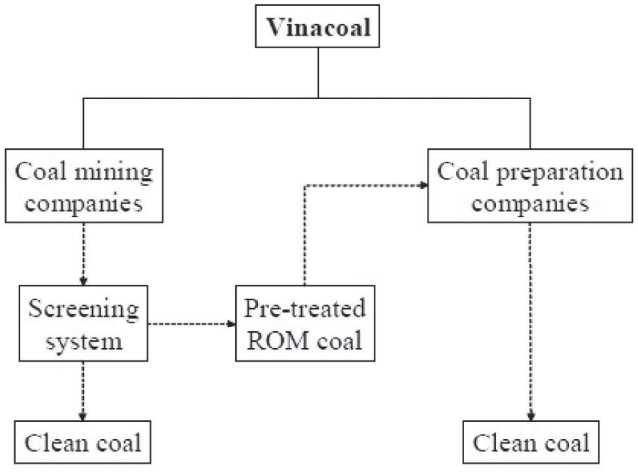

Fig. 3. Management system of the coal preparation industry in Vietnam (Le Ba Viet Bach, Gheewala 2008)
Rys. 3. Schemat zarządzania sektorem przeróbki węgla kamiennego w Wietnamie (Le Ba Viet Bach, Gheewala 2008)

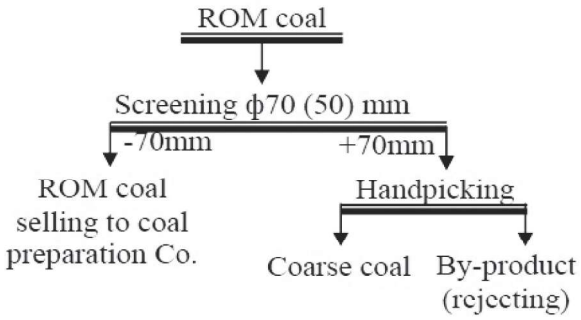

Fig. 4. Simple pre-treatment system for ROM coal (Le Ba Viet Bach, Gheewala 2008)
Rys. 4. Schemat prostego procesu wzbogacania wstępnego w wietnamskich zakładach górniczych (Le Ba Viet Bach, Gheewala 2008)

Pre-treatment of ROM coal can be prepared on a very simple technological line. The system uses screens with mesh size of 100 mm, 70 mm or 50 mm to classify coarse coal. A product with size < 70 mm is sold to coal preparation companies. A product with size >70 mm is first grinded into fine coal, blended with good fine coal and then it can be sold to domestic holders. A simple pre-treatment system has been presented in Fig. 4.

A coal preparation plant can be described by the coal preparation plant Cua Ong No. 2. Flowsheet of this coal preparation plant has been presented in Fig. 5.

In the Cua Ong No. 2 coal is passed into the screen with sieve mesh of 100 mm (1). Coal grains bigger than 100 mm are directed for crushing (2). After the crushing process coal grains are sent to jigs (3), products from jigging process are sent to the stable screen (4) where grains -1.0 mm are directed to the classified cyclone (9) and +1.0 mm are sent to classified screening (5). After the classified screening 6 to 35 mm grains go to the DM cyclone (6), products are dewatered in screens (7) and after that the clean coal is classified in screens with sieve mesh of 6 mm (8) into coal grains 15-35 mm and 6-15 mm.

Small coal grains from classified cyclone (9) are directed to thickener cyclone (10) and after it to centrifugal machine (11). Sludge from the centrifugal machine (11) is directed to thickener tank (12). Sludge from thickener tank is then sent to pool (13). Water from thickener tank and pool goes back to closed water circulation circuit.

Technological lines in another coal preparation plants in Vietnam are different.

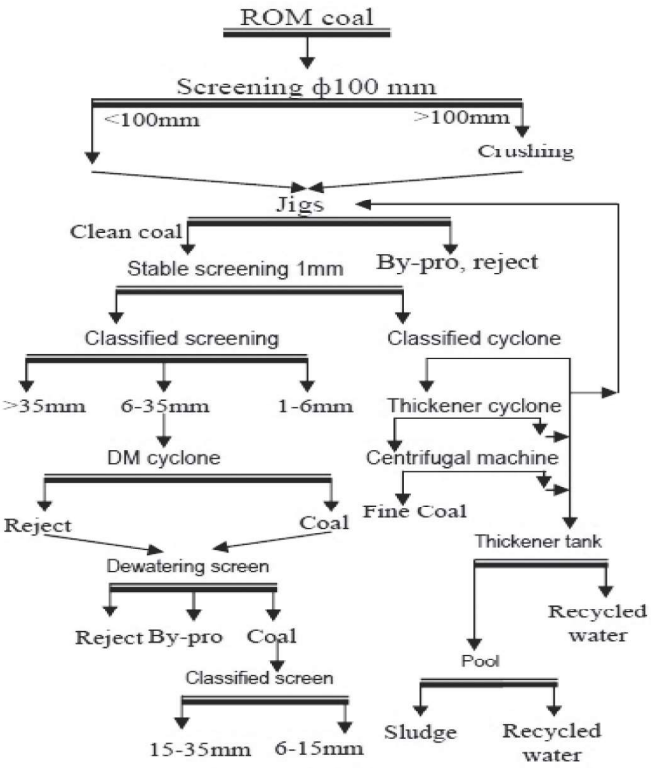

Fig. 5. Coal preparation plant Cua Ong No. 2 (Le Ba Viet Bach, Gheewala 2008)

Rys. 5. Schemat zakładu przeróbczego Qua Ong nr 2 (Le Ba Viet Bach, Gheewala 2008)

It depends on the location of plant, coal properties in deposit. Most techniques and technology level applied in the plants are similar (Baic, Blaschke 2017, Blaschke 2001, Blaschke i in. 2006, Blaschke i in. 2016, Le Ba Viet Bach, Gheewala 2008, Nguyen Binh 2015, Tran Xuan Hoa 2010).

5. Development plans & challenges to overcome

5.1. Poland

Development plans in the Polish coal preparation industry can be divided into 2 categories:

a) Steam coal:
- Modernization of preparation plants with beneficiation technology for grains > Φ 0.1 mm to preparation plants with full range of grains size separation,
- Location of the de-shaling positions under mine surface,
- Fully automatic technological sections and complete beneficiation processes,
- Modernization of technological sections and methods to the highest level and standards in Polish and foreign processing plants,
- Modernization of equipment, technological processes to increase the safety standards (decrease noise, vibrations, dust emission etc.),

b) Coking coal:
- Location of the de-shaling positions under mine surface,
- Fully automatic processes of beneficiation,
- Increase of control and monitoring by systems in technological sections as well as dispatcher system of controlling and monitoring the work system of preparation plant,
- Modernization of technological sections and methods to the highest level and standards in Polish and foreign processing plants,
- Modernization of equipment, technological processes to increase the safety standards (decrease noise, vibrations, dust emission etc.)
- Generally accepted development directions:
- Minimization of the consumption of water in water--sludge circulation process,
- Higher efficiency of water clarification, compaction and dewatering products,
- Shorter time of wet processes (minimized contact of coal grains with water),
- Implementation of dry separation processes for coarse coal,
- Increased level of separation grains < 0.063 mm to reduce the load of water-sludge circulation process,
- Elimination of thermal drying processes by more effective mechanical ones to dry beneficiation products after separation processes,
- Increase in production of ecological coals,
- Optimization of employment.

5.2. Vietnam

Beginning in 2011, in Wietnam 19 mines with total capacity of 11 million tons/year will be closed by 2030. There are 9 opencast coal mines with total capacity 8.2 million tons/year: Nui Beo (3.5 mln tons/year), Ha Tu (1.65 mln tons/year), South west Da Mai (1.0 mln tons/year), East Da Mai (0.4 mln tons/year), Bang Nau (0.55 mln tons/year), North west Khe Tam (0.03 mln tons/year), Khe Sim (1.05 mln tons/year), West Khe Sim (0.05 mln tons/year) and 10 smaller opencast mines (2.7 mln tons/year). The share of underground coal mines will increase from 45% in 2011 to 75% in 2020 and 80% in 2030 (Government plan for coal industry).

Between 2015 and 2030 coal mining industry will invest to open 19 new mines, 5 mines will be owned by VINACOMIN in North East basin (Quang Ninh), 9 new mines (North East basin) and 5 pilot mines (Hung Yen, Thai Binh in Red River Delta basin). Between 2016 and 2030 a few new preparation plants will be constructed. These are: Khe Than 2, Bao Dai, Dong Trieu-Pha Lai. In 2017 the test phase of coal preparation Khe Cham IV plant was started.

Other plans for coal preparation industry:
- Investing in modern preparation technologies and increasing efficiency of old equipment and technologies,
- Decreasing the level of water consumption in coal preparation plants. It is very important to find new fresh water sources and focus on recycling water from water-sludge circulation circuit (Quang Ninh province is located in mountains area and near sea),
- Decreasing the level of solid wastes and finding solutions to use it after coal preparation process,
- Enhancing technology to recover magnetite after dense medium separation,
- Enhancing technology and investing in equipment to separate coal from by-products,
- Strengthening coal economy. To find solutions VINACOMIN starts cooperation with foreign countries like Australia, Indonesia, Russia to find good market and import coal from foreign markets,
- Centralizing coal preparation plants with modern processing lines,
- Enhancing mechanization in underground coal mines,

– Constructing a terminal for coal import in the Southern part of the country (Baic, Blaschke 2017, Blaschke i in. 2016, Le Ba Viet Bach, Gheewala 2008, Le Minh Chuan 2011, Le Minh Chuan 2012, Nguyen Binh 2015, Tran Xuan Hoa 2010).

6. Conclusions

To compare this two industries it can be said that coal mining and preparation processes in Poland and Vietnam are still developing but they are in two different phases. Recently, production of coal in the Polish mining industry has decreased, but still Poland is the biggest coal producer in Europe. Vietnam developed coal production to the level which meets the domestic demand. The difference between Polish and Vietnamese coal resources is not so big. In Poland, there are 56.6 billion tons of coal while in Vietnam - 49.8 billion tons. When it comes to coal preparation the most important difference is that Vietnam has beneficiation system divided into two stages. The first one is a pre-treatment system before sending coal to processing plants and the second one is typical preparation in coal preparation plants. One the Rother hand, coal processing plants in Poland receive raw coal straight from underground mines. Both countries try to develop more automatic technological lines, decrease the level of water in processing plants etc. This way of development will help the Polish coal industry to be a leader in the European Union in coal production and Vietnam will increase its role in Asian coal market.

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