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Coal mining and coal preparation in Vietnam

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Abstract: Vietnam is rich in mineral resources, from which coal is one of the most important minerals of Vietnam due to its abundance and its role in the national economy. Quang Ninh Coal Basin is the most important resource of coal as most of the coal exploitation and preparatory works are being run in this area. Red River Delta Coal Basin is the second large coal basin, which is still under development stage. VINACOMIN Group is the biggest coal producer in the country which is 100% dependent on state policy.

The article deals with issues related to the hard coal mining sector and coal processing in Vietnam. The final part of the article will discuss a simple preliminary coal enrichment system at mining plants and coal processing plants with schemes in Vietnam. The summary will be the description of future plans for the coal mining industry and enrichment systems.

Keywords: Coal preparation, coal resources, coal basin, coal industry, coal processing, coal preparation flowsheet, Vietnam coal industry

1. Introduction

Vietnam is one of the most important anthracite producers in the world. VINACOMIN is the leading company in Vietnam coal market. Coal industry plays an important role in the fast growing economy of Vietnam, particularly in the energy sector. By the mid of the 1990s, total annual coal production was about 6–7 Mt/y, two thirds of produced coal were mined by surface mining while the rest by underground method and most of the coal were not washed, however, the picture is now turned in reverse due to the harder government pressure on environmental protection. Current annual coal production is kept at a level of 45 Mt/y and about 30% of coal is washed at large coal preparation plants utilizing both jigging and dense medium separation.

2. Coal resources and coal basins in vietnam

Currently, available data shows that coal reserves in Vietnam area about 49.8 billion tons. Coal resources are classified into a few categories: measured & indicated reserves (categories A+B+C_1) are 33%, inferred (C_2) is 39%, and

prognostic resources (P) are 28%. In Vietnam appeared all types of coal: anthracite (67% and already mined), bituminous coal (insignificant), sub-bituminous coal (26%), lignite coals (2%, rarely mined), and peat (5%).

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, and Mekong River Delta (Fig. 1). Vietnam has one of the biggest resources of the world anthracite. Quang Ninh coal basin plays the key role as most of the coal mines and coal preparation plants are operated in this area. Quality parameters of raw coal in Vietnam from a few coal mines are described in Table 1.

Table 1: Parameters of coal from opencast mines in Vietnam (Buiand Drebenstedt, 2004)

Quality factor	Coc Sau	Cao Son	Deo Nai	Ha Tu	Nui Beo
Ash (%)	2.24–40.0	8.08–11.27	2.49–39.28	2.64–28.33	2.52–30.6
Inherent moisture (%)	1.42–4.92	0.35–3.5	0.99–3.56	1.88–13.83	1.82–14.2
Volatile matter (%)	2.82–9.86	7.0	4.2–24.51	4.48–13.83	4.52–13.96
Sulfur (natural) (%)	0.1–1.64	0.01–2.72	0.07–0.6	0.24–0.33	0.23–0.35
Heat content (kJ/kg)	25.79–36.26	28.45–35.56	31.17–39.31	29.31–35.77	29.1–34.9
Density (t/m^3)	1.39–1.46	1.38–1.46	1.39–1.44	1.38–1.45	1.37–1.5

Quang Ninh basin, located in the northeast part of the country, occupies the area of about 5900 km^2 of which 2800 km^2 is forestland and 510 km^2 is agricultural. Coalfields in this area are located very close to the coast to form good conditions for mining and trading. Quang Ninh coalfield got 8.7 billion tons of coal resources (anthracite). Most important coal deposits in Quang Ninh basin: Mao Khe, Trang Bach, Nam Mao, Vang Danh, Uong Thuong, Dong Vong, Nga Hai, Khe Tam, Giap Khau, Nui Bao, etc. The main coal areas of Quang Ninh Basin are Uong Bi, Hon Gai, and Cam Pha. The coal has been mined since 1839 and the mining is being expanded continuously.

Red River Delta coal basin was discovered in 1960 during the search for oil and gas. More than 39.4 billion tons of sub-bituminous coals lie beneath Red River Delta over the area of 2000 km^2. The coal seams are located at 300–2500 m. VINACOMIN attempted to develop here projects for few coal mines like Binh Minh, Khoai Chau I, Khoai Chau II, however, the projects are delayed due to the dense population and the main rice field of Vietnam (Chuan, 2011a, b; Binh, 2015; Strzałkowska and Strzałkowski, 2011; Hoa, 2010; Paul, 2010; Bui and Drebenstedt, 2004) (Table 2).

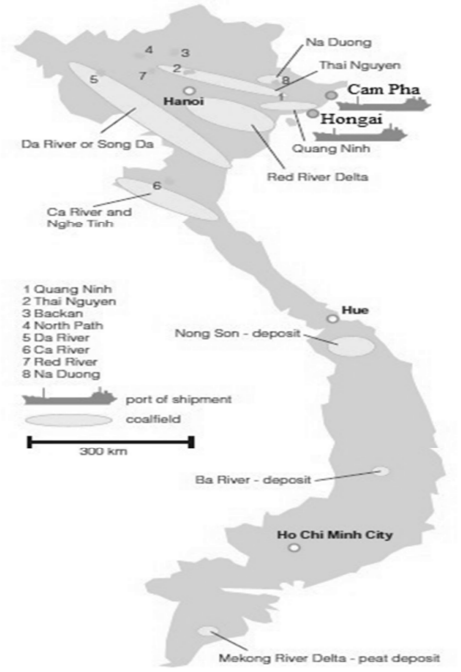

Figure 1: Map of Vietnam coal resources (Paul, 2010)

Table 2: Total coal resources in Vietnam (Mt) (Buiand Le 2011)

Mine areas	Total resources ($A+B+C_1+C_2+P$)	Measured resources ($A+B$)	Indicated resources (C_1)	Inferred resources (C_2)	Prognostic resources (P)
Total	49.777	285	2.220	2.928	44.344
1. North-East basin	9.904	236	1.468	2.234	5.966
+ VINACOMIN	3.826	234	1.325	1.663	604
+ Government	6.078	2	143	571	5.362
2. Other investor basins	191	49	99	24	19
3. Peat basins	332		129	107	96
4. Red River Delta Basin	39.352		525	564	38.263
+ Khoai Chau area (80 km^2)	1.581		525	564	492
+ Phu Cu-Tien Hai area 2000 km^2	37.771				37.771

3. Vietnam coal industry policy

The Ministry of Industry and Trade (MOIT) is responsible for the state management of all energy industries as it is not only to determine first-line policy but also has supervisory responsibilities for state owned companies VINACOMIN and Electricite de Vietnam (EVN). The Ministry is also responsible for master plans for electricity, coal, oil and natural gas exploitation and supply.

The coal industry has a strategic position in the Vietnam economy. Government still accepts new plans for new coal-fired power projects. It will need more coal supply from coal mines. These decisions will change the policy of Vietnam and maybe even stop the export of anthracite coal. Government now focuses on developing and increasing coal industry practice and productivity. VINACOMIN has been merged from Vinacoal and Vietnam Mineral Corp in 2005. VINACOMIN Holding Corporation Ltd. with 54 coal mines, it is the biggest coal mining company in Vietnam. It operates five big open pit mines, 15 smaller pits, and 30 underground coalmines. This is an economic corporation with 100% owned by the state. Ninety-five percent of coal production in Vietnam is from VINACOMIN Company. It also runs the most important washing plants such as Hon Gai (2 Mt/year), Cua Ong (10 Mt/year), and Vang Danh (3 Mt/year).

According to the master plan of coal industry development in Vietnam by 2020, with perspective to 2030, the total coal output will reach 60 million tons (in 2020), 65–70 million tons (in 2025), and 65–75 million tons (in 2030).

The master plan is also presented for the coal mining industry in Table 3 (Viet, 1994; Chuan, 2011a, b; Binh, 2015; Hoa, 2010; Paul, 2010; Giang, 2014; Dung, 2014).

Table 3: Master plan for development of Vietnam coal industry (Mt) (Bui and Drebenstedt, 2004)

Coal area	2020	2025	2030
Total run-off-mine coal	92,430	119,250	120,732
I. North-East basin	72,330	85,050	83,282
1.1. VINACOMIN	64,530	67,150	59,782
In which: banned area & coal bearer	6200	7400	7300
1.1.1. Uong Bi coal field	19,280	20,550	20,950
1.1.2. Hon Gai coal field	9,350	9,800	8,800
1.1.3. Cam Pha coal field	35,900	36,800	30,032
1.2. New coal mines	7,800	17,900	23,500
II. Other interior basins	3,050	2,650	2,700
III. Out of VINACOMIN	3,550	6,550	9,750
IV. Red River Delta basin	13,500	25,000	25,000

Vietmindo is the only joint venture with a foreign country (Indonesia). It is operating in Vang Danh-Uong Bi area of Quang Ninh province. The concession is for 30 years and can be renewed for another period if the company

still needs more time to achieve longer-term production goals (Chuan, 2011a, b; Binh, 2015; Hoa, 2010; Paul, 2010; Giang, 2014; Dung, 2014).

4. Coal mining and coal preparation status

Surface mining currently is dominated by truck and shovel methods. Some of the major equipment includes Russian EKG hydraulic shovels, dump trucks of 30–80 ton payload from BalAZ, Komatsu, and Caterpillar 769C.

Typical surface mine is showed in Fig. 2 (Coc Sau mine). Large surface mines with production more than 2 million tons/year are Cao Son, Coc Sau, Deo Nai, Ha Tu, and Nui Beo, from which Ha Tu and Nui Beo are converted into underground mines. There are a number of average and small-scale surface coal mines with a total year capacity between 0.5 and 2 million tons/year.

Rocks in surface coal mines are mainly conglomerates of sandstone or mudstone leading to the use of drilling and blasting. Surface mining major problem is environmental protection (such as how to locate waste dumps, ways of dumping, the stability of waste dumps, wastewater draining, and the processing of water before it flows into rivers and seas). Surface coal mines are now facing huge pressures from the local governments and communities due to the destruction of the landscape, deforestation, and pollutions. There is a trend to close surface coal mines and convert existing surface mines into the underground.

Figure 2: General view of opencast coal mine Coc Sau
(Strzałkowska and Strzałkowski, 2011)

Currently, the depth of underground mining in Vietnam is on 300 m. Under VINACOMIN control, there are 30 underground coal mines, nine of

which have capacity of more than 1 million tonnes/year (Mao Khe 1.6 Mt, Nam Mau 1.5 Mt, Vang Danh 3.1 Mt, Ha Lam 1.8 Mt, Duong Huy 2.0 Mt, Thong Nhat 1.6 Mt, Mong Duong 1.5 Mt, etc.). Rest of coal mines have an annual capacity of less than 1 million tonnes.

Coal seams of Quang Ninh Coal Basin have complex geological structures with many faults and folds and most of the coal seams need to be mined by selective mining technologies to ensure the required factors of loss and dilution. Complicated geological structures of coal seams decrease the efficiency of longwall mining, decrease the mining face production, while the high cost of coal makes underground production less competitive and there are many safety issues related to complex geology, mine pressure, gas, and ventilation.

Coal preparation in Vietnam is carried out in two alternatives. The first is to implement the run-of-mine (ROM) coal pre-treatment system by handpicking, screening, grinding or blending. All coal mining companies have their pre-treatment systems. The second alternative is typical coal washing by jigs and dense medium separation (DMS) at central coal preparation plants. About 30% of ROM coal can be cleaned by coal preparation plants. Management system in Vietnam coal preparation industry is showe in Fig. 3.

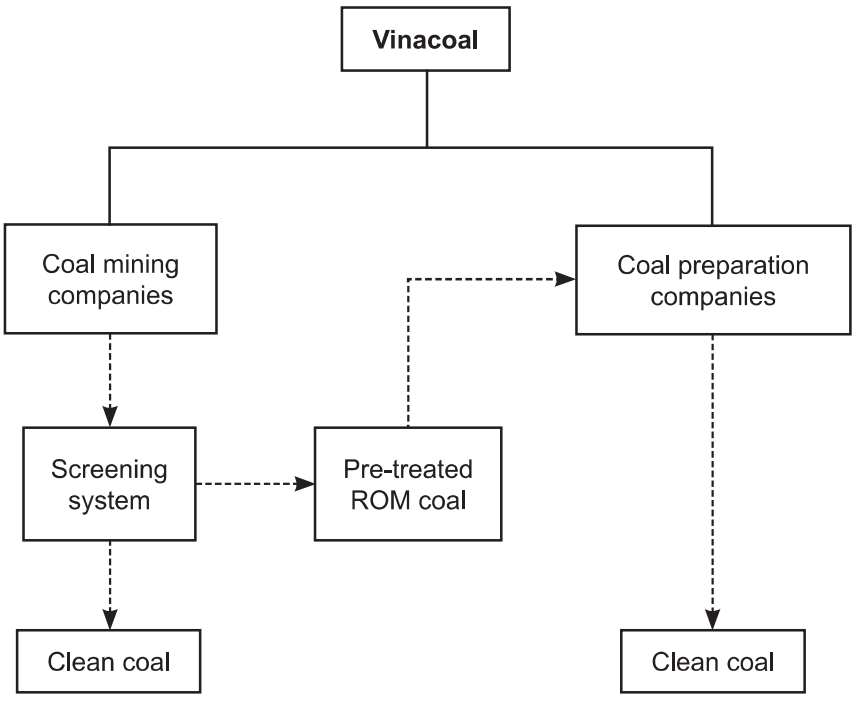

Figure 3: Coal preparation management in Vietnam (Viet Bach and Gheewala, 2008)

ROM coal is prepared at coal mines by simple technologies as described by Fig. 4.

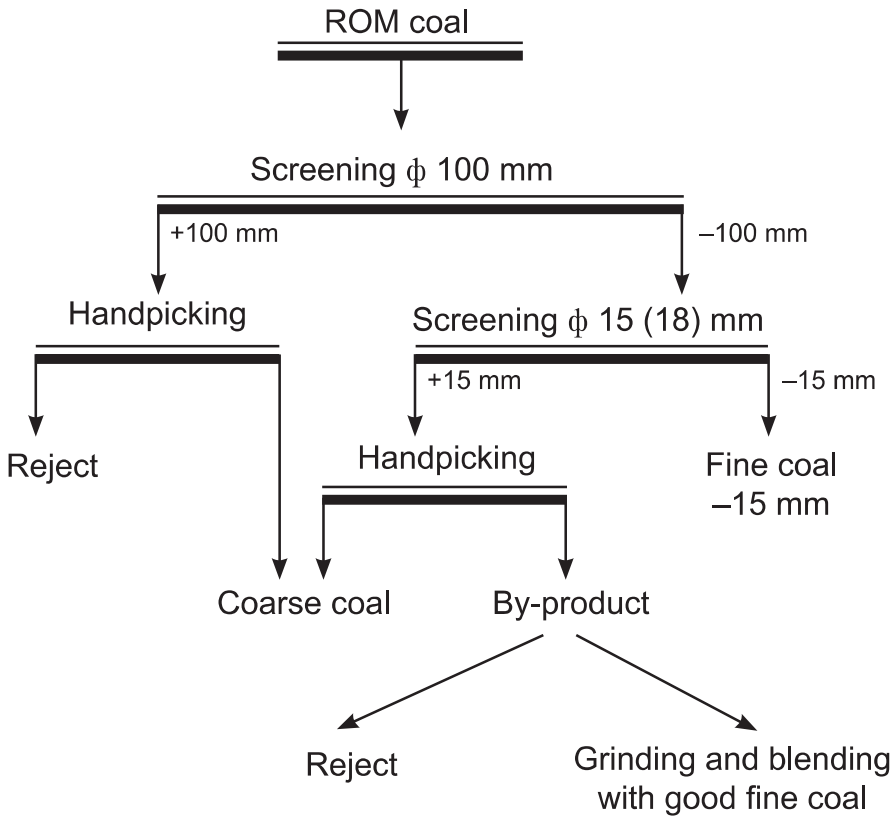

Figure 4: Simple treatment system for ROM coal at coal mines (Viet Bach and Gheewala, 2008)

Coal preparation plants use different cleaning methods including jigging, DMS, spiral separation, cyclones, and flotation. Typical coal preparation flowsheet and technology can be described from the examples of Cua Ong Coal Preparation Company and Vang Danh Coal Mining Co.

The Cua Ong plant No. 2 flowsheet is shown in Fig. 5. First coal preparation plant Cua Ong CPP II was designed and built by Polish engineers in the 1970s. Production was started in 1980. First using capacity was 3.2 Mt/y and used equipment was dense medium separators DISA. In the 1990s the Cua Ong Coal Preparation Plant No. 2 was remodified by Australian Technology and the used DISA was replaced by a line of jigs and DMS cyclones.

Vang Danh Coal Preparation Plant No. 1 was first designed by Russian in 1972 with designed capacity of 0.6 Mt/y. Then the plant modified to adopt the capacity of 2.7 Mt/y. Current flowsheet is shown in Fig. 6.

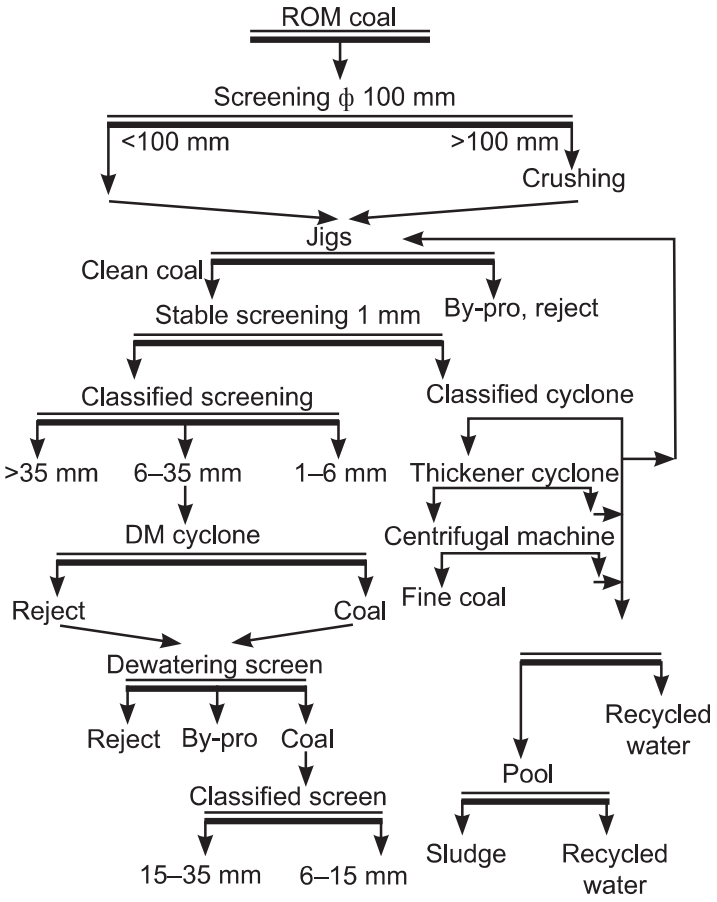

Figure 5: Coal preparation plant Cua Ong No. 2 (Viet Bach and Gheewala, 2008)

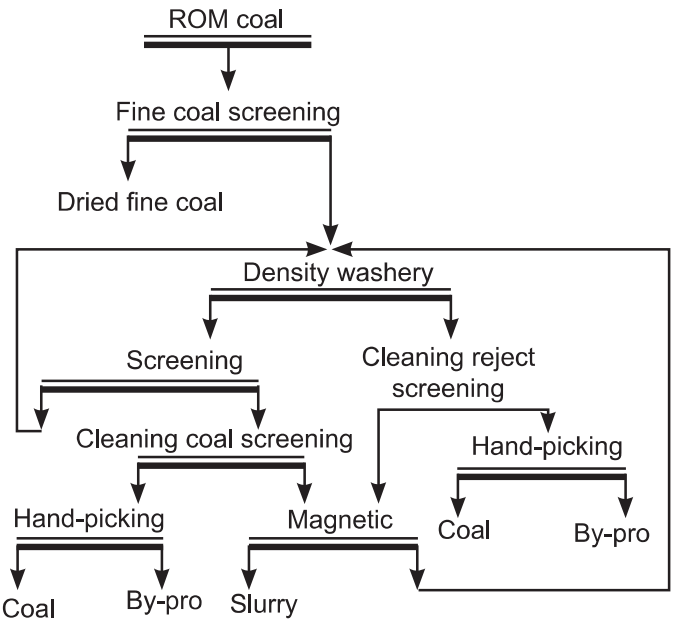

Figure 6: Flowsheet of Vang Danh coal processing plant (Viet Bach and Gheewala, 2008)

5. Conclusion

Coal industry of Vietnam plays an important role in the national economy as the country is rich in coal resources, particularly in anthracite. Vietnam is one of the key anthracite producers of the world. The industry produces approximately 45–50 Mt of ROM coal/annum, and one-third of this volume is cleaned in central coal preparation plants.

Environmental impacts are the major challenges for the coal industry. Many surface coal mines are to be closed or to be converted into underground mines due to the government's increasing pressure for environmental protection. Complicated geological structures of coal seams prevent the use of long wall mining and decrease the mining face production; high cost of coal makes the underground production uncompetitive; and many safety issues related to complex geology, mine pressure, gas and ventilation. Coals fed to the preparation plants are more unpredictable as more fines and slimes in the feed.

To overcome the difficulties and challenges, the coal mining industry of Vietnam should concentrate on the followings:

- To invest in modern mining and preparation technologies;
- To exclude ineffective old equipment and outdated technologies;
- To reuse more recycle water at preparation plants to reduce fresh water consumption (Zero-freshwater policy);
- To increase the percentage of coal cleaned by preparation plants to increase the coal value and its efficiency;
- VINACOMIN and coal miners should actively cooperate with foreign countries such as Russia, Poland, Australia, Indonesia, India, etc. for better coal market and technologies;
- Establish more effective environmental management systems.

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