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Status and prospects of underground coal mining technology in Vietnam

Tien Dung LE[1,*] and Xuan Nam BUI[1]

[1] HUMG Hanoi University of Mining and Geology, Faculty of Mining, Hanoi, Vietnam

Abstract. Underground coal mining in Vietnam plays an important role to not only the sustainable coal industry but also the energy and social security in this country. Although the Vietnam coal industry has produced 35–45 million tonnes of raw coal per annum in past ten years, a great volume of coal resources remains distributed in complex geo-mining conditions and mostly unmined. This paper presents a brief review of the current and potential technologies for cutting coal and controlling roof in Vietnam underground coal mines. From the review, it is concluded that there is an urgent demand on improvement of current technologies as well as on investigation for effective application of more advanced mining methods into the industry, especially for deep mining at Red River Delta—the largest coal basin in Vietnam.

1 Reserves and coal production in Vietnam

Vietnam has been ranked to have a remarkable potential of coal extraction. In this country, there are four major coal types with the corresponding distributions: anthracite coal in North-East basin mainly at Quang Ninh province; bituminous coal in other domestic basins at Thai Nguyen, Lang Son and Hoa Binh provinces; sub-bituminous coal in Red River Delta basin; and peat coal mainly in peat basin at Mekong River Delta. The total coal resources estimated by March 2016 is approximately 48.8 billion tonnes (Table 1) [1].

Coal industry in Vietnam is mostly operated by Vietnam National Coal–Mineral Industries Holding Corporation Limit (VINACOMIN) through surface and underground mining methods. According to [2], VINACOMIN has operated five large surface coal mines with annual production greater than 2 million tonnes (Cao Son, Coc Sau, Deo Nai, Ha Tu and Nui Beo mines), 15 surface coal mines with production from 0.1 to 0.7 million tonnes per year, and some mines with production lower than 0.1 million tonnes per year. Regarding underground mining, VINACOMIN has operated 30 coal mines with nine mines producing greater than 1 million tonnes per year (Mao Khe, Nam Mau, Vang Danh, Ha Lam, Quang Hanh, Khe Cham, Duong Huy, Thong Nhat and Mong Duong mines). Other underground coal mines have small reserves, narrow coal field and are not favourable for mechanised mining technologies. The coal production in the period of 2007–2015 is summarised in Table 2 [3]. In 2017, VINACOMIN produced approximately 33.5 million tonnes and in 2018 the planned production was 36 million tonnes. To 2020, the coal production is forecasted around 42 million tonnes per annum.

* Corresponding author: t.d.le@humg.edu.vn

Table 1. Total estimated coal resources in Vietnam by March 2016, million tonnes [1].

Coal basin	Reserves	Firm resources	Trust resources	Estimated resources	Forecast resources	Total
Total	2,260	161	1,137	2,687	42,632	48,878
North-East basin	2,219	109	395	1,585	1,979	6,287
Red River Delta basin			525	955	40,531	42,011
Domestic basin	41	52	74	32	6	206
Local coal mines			10	8	19	37
Peat coal			133	107	96	336

Table 2. Coal production in period of 2007–2015, million tonnes [3].

	2007	2008	2009	2010	2011	2012	2013	2014	2015 (est.)
Raw coal	45	45	46	47	48	44	43	37	41
Surface	27	25	26	27	26	22	21	17	18
Underground	16	18	18	20	21	21	22	20	22
Others	2.39	1.84	2.02	0.50	0.71	0.51	0.65	0.50	1.00

The technical solutions to the urgently required sustainable mining in Vietnam are to decrease surface mining operation, increase underground mining operation, focus on deep large mines and apply advanced technologies. VINACOMIN has planned to close 19 surface mines by the year 2030 and will operate 19 new coal mines which are mostly underground in the period of 2015–2025 [4]. At the North-East basin, many underground coal mines are operated at 200–250 m below surface and going deeper. At the Red River Delta basin, coal gasification extraction has been investigated for application due to complex geo-mining conditions and social security at the site. It can be seen that these solutions are largely relevant to the mining technology. As a result, the authors hope that an introduction of status and prospect of the underground coal mining technologies in Vietnam in this paper would be an interest to the participants of the 5th Pol-Viet conference.

2 Technologies for underground coal mining in Vietnam

Although Vietnam has more than 100 years of coal extraction, its coal industry officially started in the 1990s in the North-East coal field. Before the 1990s, the mining technology was simple and mostly manual. Coal was broken by blasting and roof was supported by

wooden/steel/hydraulic prop and cage (Fig. 1). This mining technology unsurprisingly resulted in low mine safety and production. Since the 1990s to the early 2000s, coal was still cut and broken by blasting while roof pressure was mainly controlled by hydraulic prop and semi-mechanised support (Fig. 2). The semi-mechanised support has greatly improved the safety at working area, saving the time for roof control and consequently significantly increasing the productivity (up to three times) compared to manual technology. The extraction with semi-mechanised support has been innovated and adapted for unfavourable mining conditions in the North-East coal basin. For example, since 2015 VINACOMIN has applied the soft support namely ZRY (Fig. 2) for medium-thick and steeply inclined seams at Hong Thai coal mine with high production and low coal loss rate.

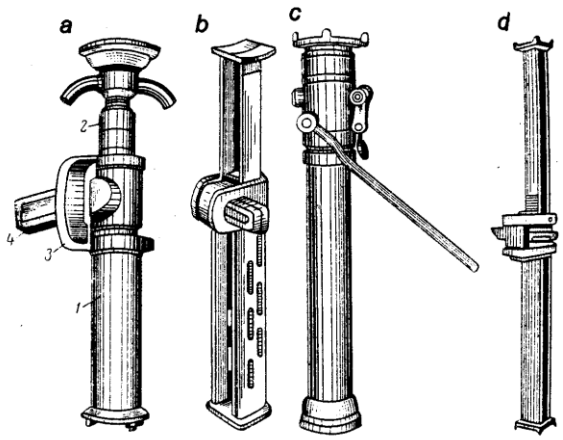

Fig. 1. Steel (a, b, d) and hydraulic (c) props [5].

Fig. 2. (a) Semi-mechanised support ZH-1600 at surface and in underground [5].

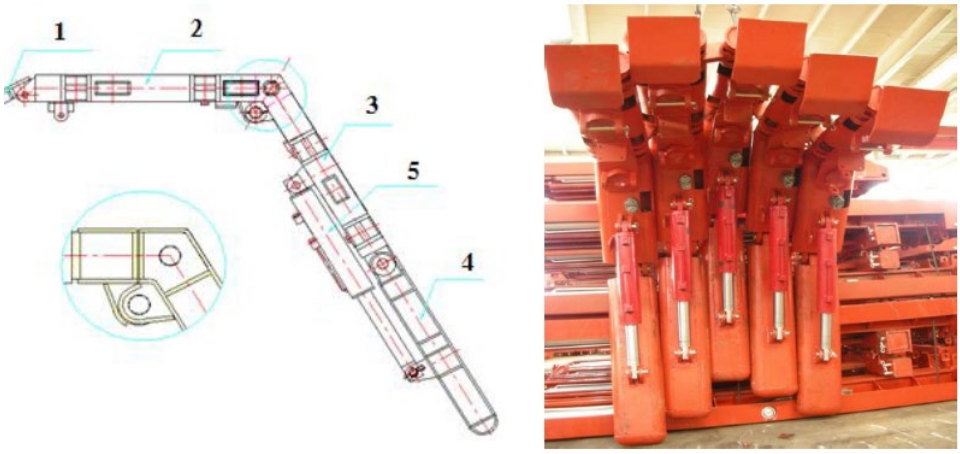

Fig. 2. (b) Soft support ZRY 20/30L at Hong Thai coal mine with 1-oriented bar, 2- roof bar, 3- rear bar, 4- tail bar, 5- piston [6].

In June 2005, the first fully mechanised coal mining technology was trialled at Khe Cham coal mine (now Khe Cham I) [7]. Coal was cut by shearer and roof was controlled by mechanised supports (shield). The production was reported at 1.5–2.5 times as much as that of previous technologies applied at the mine. This technology, however, did not allow to extract the top coal section in the thick seams at Khe Cham I. Since then, the fully mechanised technology has been increasingly applied at VINACOMIN coal mines (Vang Danh, Nam Mau, Ha Lam, Duong Huy and Khe Cham III mines). The technology is now capable of mining thick coal seam and referred to as High Reach Single Pass Longwall and Longwall Top Coal Caving (LTCC) methods. The LTCC face support and shearer operated at some mines are illustrated in Figs. 3–6. It is noted that at Khe Cham III, the equipment was selected to deal with the soft coal and surrounding rock, groundwater issue and inconsistent seam angles at the site.

Fig. 3. Support VINAALTA 2.0/3.15 and shearer MB 12-2V2P/R-450E applied at Vang Danh coal mine in period of 2008–2012.

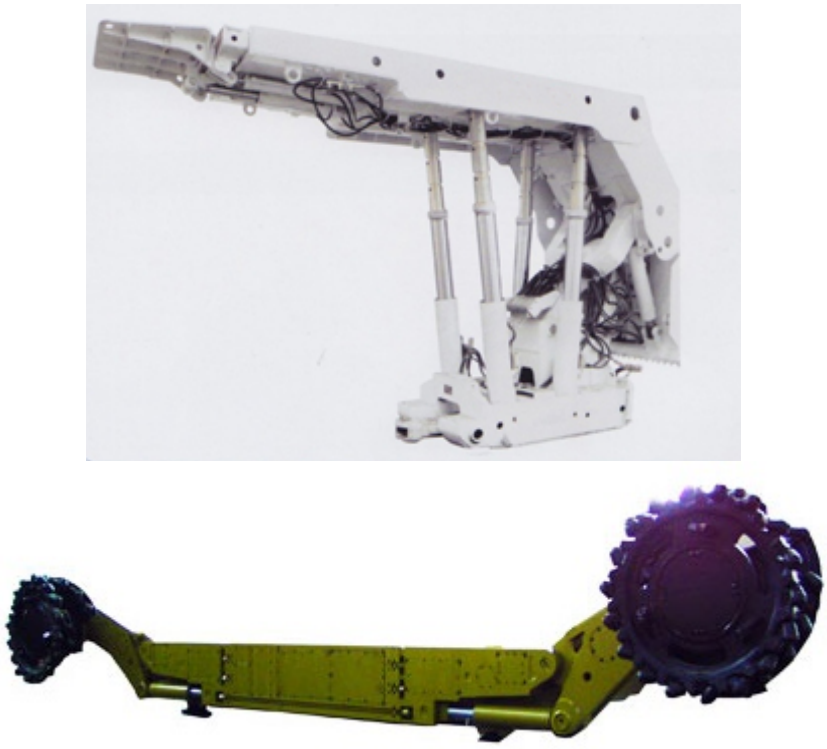

Fig. 4. Support ZF4400/17/28 and shearer MG 170/410-WD applied at Vang Danh since 2017.

Fig. 5. Support ZF4400/16/28 and shearer MG 150/375-W applied at Ha Lam coal mine.

Fig. 6. Supports ZFY5000/16/28, ZFG6200/17/30 and shearer MG150/375-WD applied at Khe Cham III coal mine since 2016.

3 Potential technology for mining Red River Delta coal basin

According to [8], Red River Delta coal basin plays an important role in the energy security of Vietnam because of (1) large reserves of 30–60 billion tonnes and (2) good coal quality for producing electricity, gasification and metallurgy. Unfortunately, the geological conditions here are extremely complex (e.g., weak surrounding strata and closely-located aquifers) while the surface is crowded area with agricultural activities. The governmental coal plan [9] has identified traditional underground mining and Underground Coal Gasification (UCG) (Fig. 7) as applicable technologies for the basin. However, since a reliable geological exploration has not been implemented at the area, the above technologies are considered as potential at present and must be well tested prior to real operation. This also means that there is certainly room for far more technical investigations and development to socially and economically efficient extract Red River Delta coal basin.

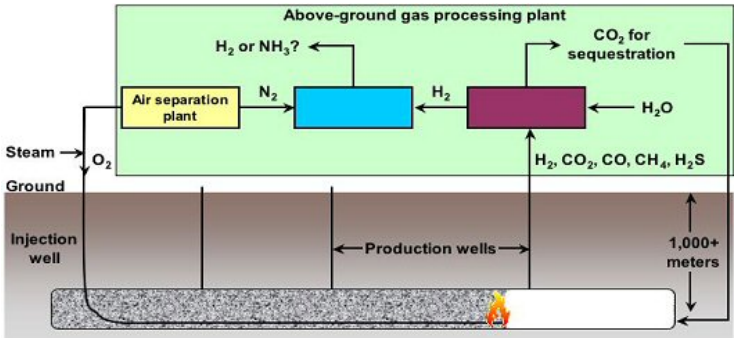

Fig. 7. Principle of Underground Coal Gasification [10].

4 Conclusions

Underground coal mining is becoming more important to the sustainable coal industry in Vietnam. The cutting and roof controlling technologies for underground coal extraction has been significantly improved since the 1990s, contributing to safer mining operation with higher and more efficient coal production. Since a great volume of coal resources is distributed in complex geo-mining conditions in this country (e.g., weak coal and surrounding rocks, thickness and angle of seams varying along strike and dip, hard rock band, deep mining, etc.), there is an urgent demand to improve the mentioned technologies, taking into consideration the advanced techniques in the world for extracting coal in more unfavourable conditions. For the mining at the largest coal basin Red River Delta, the information regarding both geological assessment and potential mining method is insufficient at present that requires more reliable investigations in future.

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