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Review paper

VENTILATION PLANNING AND DESIGN OF THE OMERLER B MINE

Lilić Nikola[1], Čokorilo Vojin[1], Cvjetić Aleksandar[1], Milisavljević Vladimir[1]

Abstract: This paper describes a case study for the ventilation planning at TKI Company's Omerler B Mine in Tuncbilek coal basin which is located in Kutahya region in central Turkey The Omerler B mine will comprise of two mechanized longwall coal mining operations and single manual longwall for annual production of approx. 1.6 mtpa of coal. Future ventilation system for the mine operations was determined by establishing ventilation model developed from data collected during a site visit. The paper discusses the challenge to coordinate necessary ventilation requirements with long-term demands. A diagonal mine ventilation system configuration was recommended based on the results of the network modeling exercise of the various options. The scope of the configuration changes, and the improvement resulting from these changes is discussed.

Key words: mine ventilation, underground longwall coal mining

1. INTRODUCTION

The methodology of mine ventilation planning and design in contemporary mining theory and practice differs substantially from the traditional approach. Novel approaches take full advantage of the possibilities offered by computer hardware and software that are at the disposition of mine engineers. Software packages for mine ventilation simulation are now playing a key role in the process of mine ventilation planning and design (McPherson 1993; Hartman 1997; Lilić et al. 1997, 2002).

The first phase of the outlined approach is data acquisition. In contemporary mining practice extensive and exhaustive investigations of ore deposits have been undertaken in order to collect as much information as possible for the planning and design of technological systems for deposit exploitation.

System planning is an introductory activity for the design process. In the planning phase, the key relations that have to be taken into account during the design phase are identified. The first activity in the mine ventilation planning and design process is the establishment of a basic or initial ventilation network and an appropriate database containing all necessary data related to this network. The design process is followed by the implementation of the mine ventilation system as well as its maintenance, aimed at securing the highest possible level of system effectiveness.

The final phase in the outlined approach is mine state evaluation and possible modification. All parameters of mine ventilation obtained through monitoring must be

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[1] University of Belgrade, Faculty of Minig and Geology, Đušina 7, 11000 Belgrade, Serbia,
e-mail: lilic@rgf.bg.ac.rs; cokorilo@rgf.bg.ac.rs; alex@rgf.bg.ac.rs; milisavljevic@rgf.bg.ac.rs

compared with designed parameters and when differences are identified, specific changes have to be made in the planning process.

Section 2 of this paper outlines the general description of the Omerler B mine design. The proposed mine ventilation concept of Omerler B mine is described in Section 3. Section 4 presents the results of performed calculations on required amount of air for mine ventilation. The analyses of Omerler B mine ventilation design scenarios is discussed in Section 5, followed by a conclusion in the last section.

2. GENERAL DESCRIPTION OF THE MINE DESIGN

Team of the experts from the University of Belgrade, Faculty of Mining and Geology, have developed conceptual design of the underground coal exploitation in Omerler B deposit from Tuncbilek coal basin which is in Kutahya region in central Turkey.

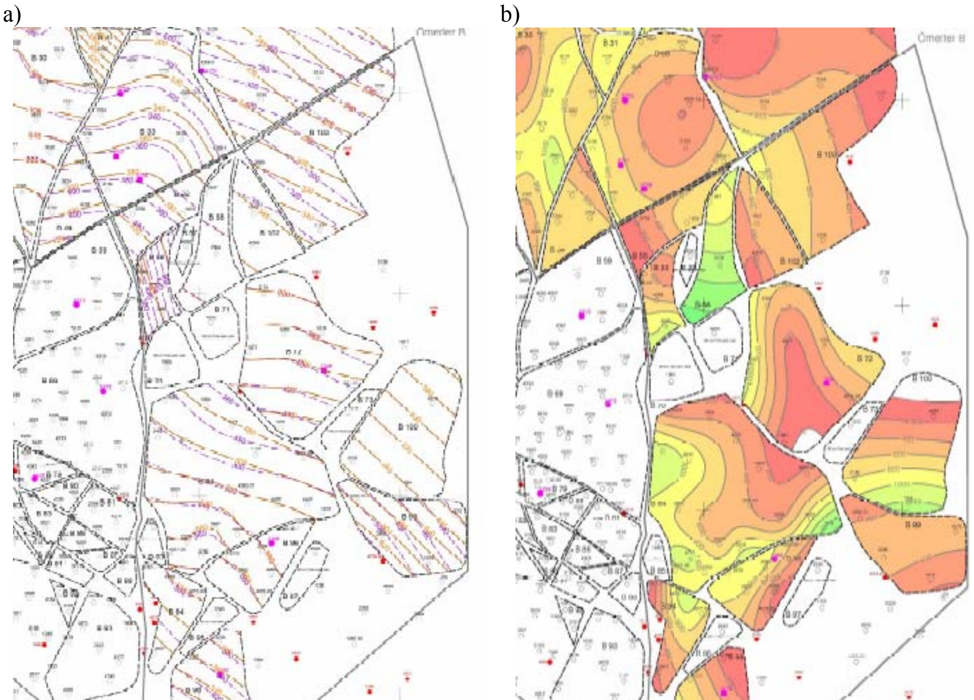

Figure 1 - Blocks in Omerler B deposit
a) geological and workable seam floor, b) thickness of workable coal

Coal exploitation is designed for retreat longwall mining. The biggest amount of reserves, 18.86 million tons from 19.64, will be mined by fully mechanized longwall method of work with top coal caving (TCC). The rest of the reserves will be mined by semi-mechanized longwall method using drilling and blasting and individual friction props. Combined longwall mining is recommended because of small reserves in Omerler B deposit and requirement for maximal utilisation of coal. Also the deposit is heavily faulted what means that mechanized mining is not possible in small blocks: B70, B71, B73, B94 and B102 (Figure 1).

Above mentioned restricted design in such manner to optimize complete mining process as well as costs for mine opening and exploitation having in mind relatively short life of the mine of 12 years. Special attention in this paper is given to ventilation concept and design of Omerler B mine in consideration of described restrictions.

3. MINE VENTILATION CONCEPT

According to the suggested concept of mine and longwalls development for Ömerler B exploitation field, ventilation of coal production will be organized as presented on Figure 2. Ventilation of mining activities during coal exploitation shall be organized by combined ventilation circuit and auxiliary ventilation of underground roadways.

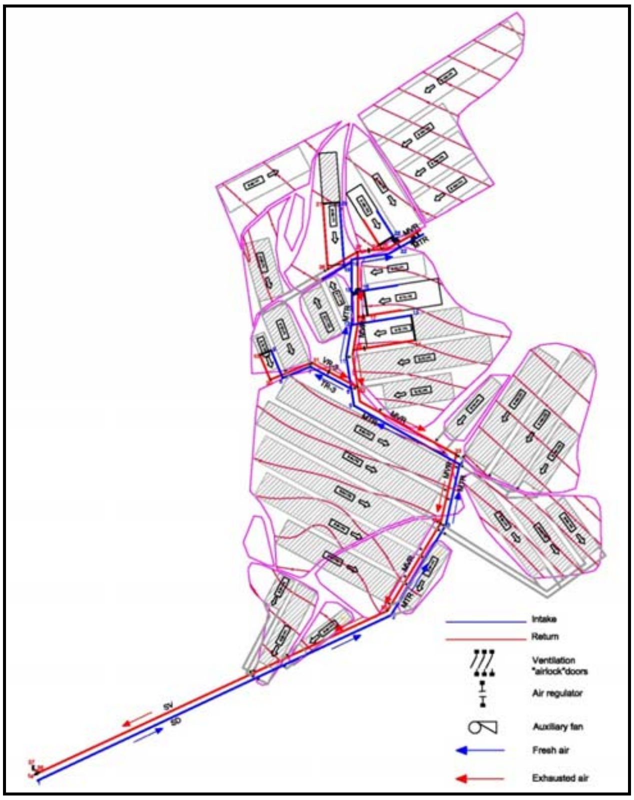

Figure 2 - Ventilation concept for Ömerler B mining field

Concept of mine ventilation is designed according to standards for gassy mines. Stream of airflow intakes and airflow returns are given on Figure 2. Also, it can be seen that concept is based on exhaust ventilation; therefore, return air will ascend to the surface. Proposed solution is central ventilation system, which is having some advantages, such as fast establishment of main ventilation airflow and reduced investment works.

However, disadvantages of central ventilation systems are:

- long ventilation routes;
- large differences in ventilation pressures (heads) by phases during mining near the boundaries of the deposit or during mining in proximity of opening roadways;
- higher possibility for air losses and more complex tasks in prevention of air losses;
- higher ventilation pressures (heads);
- larger operational costs associated to ventilation.

It is suggested to consider possibility to develop main vent decline from South-East direction (Figure 3) during the coal production in blocks B84 and B99. Positioning of main fan in this vent would enable establishment of diagonal system of ventilation.

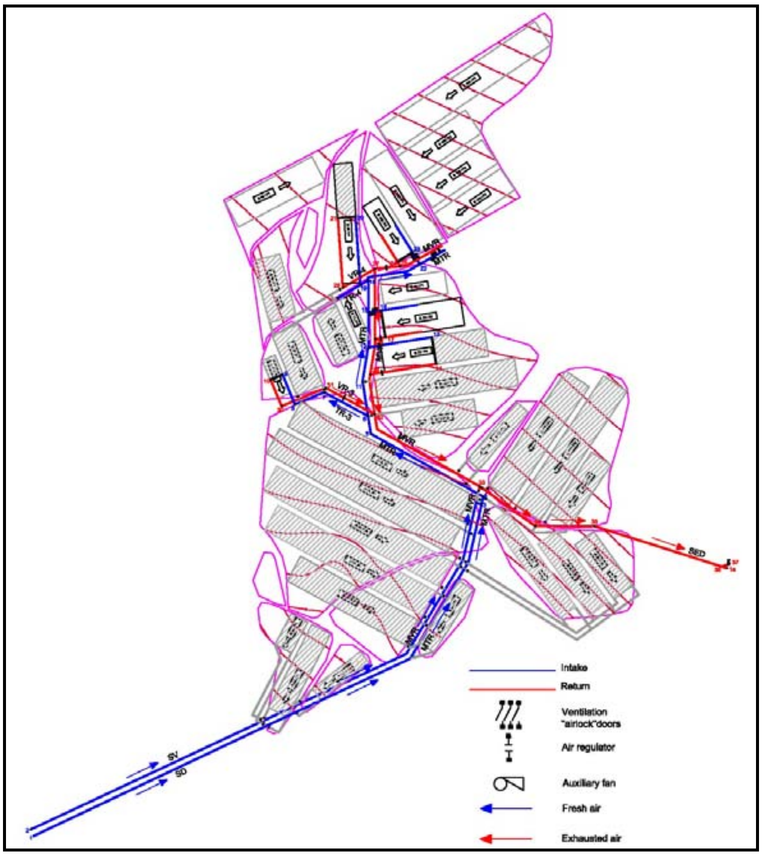

Figure 3 - Ventilation concept with South-East ventilation decline

Advantages of this approach are:

- proportional constant ventilation pressure differences during longer periods of operation or with smaller oscillations. This would have big importance regarding safety and economics;
- smaller absolute values of required ventilation pressure (head);
- significantly reduced possibility of air losses;
- easier management of air distribution and fewer required flow regulators;
- easier isolation of parts of the mine, when necessary;
- reduced operational costs associated to ventilation.

These remarks are gaining importance since this mine will operate as gassy mine including the fact that existing experience in Ömerler A mine is showing that coal is liable to spontaneous combustion.

4. REQUIRED AMOUNT OF AIR FOR MINE VENTILATION

Required amount of air for a single mechanized longwall is calculated according to following criteria (MSHA 2011): intensity of dust emission at the longwall face and minimal allowed air velocity, required for taking out gasses and dust.

Required amount of the air according to the significant criterion of dust emission can be determined:

$$Q_{LW} = \frac{I}{n_{risk} - n_o} \cdot k_v \tag{1}$$

where:

Q_{LW} - required air quantity for longwall ventilation [m^3/min],

I - intensity of dust emission [mg/min],

n_{risk} - concentration of dust by level of risk [mg/m^3] (Ediz et al. 2001, 2006),

Dust risk grading	Respirable dust concentration [mg/m^3]
I	0 - 2.5
II	2.6 - 6
III	6.1 - 10
IV	> 10

n_o - dust concentration in the inlet [mg/m^3],

k_v - coefficient of dust emission variation, (k_v = 1.1 - 1.3).

In order to maintain risk within boundaries of second risk level, value for specific dust emission must be less than 2 g/t. This corresponds with recommended value in references and practice. This approach is accepted since there is no available data on dust emission (I) for different conditions and rocks in Ömerler B mine. Intensity of dust emission will be 4.7 g/min at longwall production faces.

Required amount of air, with this data, for ventilation of longwall will be:

$$Q_{LW} = \frac{4700}{4.3 - 0.2} \cdot 1.1 = 1260.9\,\mathrm{m}^3/\mathrm{min} = 21\,\mathrm{m}^3/\mathrm{s}$$

Required amount of air for a single manual longwall is calculated according to following criteria: intensity of dust emission at the longwall face, minimal allowed air velocity, required for taking out gasses and dust, maximal amount of explosives in one blast.

Criterion on minimal air velocity includes minimal velocity necessary to achieve turbulent flow of air in order to prevent bedding of gasses and creation of unventilated zones. Accepted air velocity is recommended values of 1.5 m/s - velocity required for scuffing respiratory particles (1 - 2 m/s, NIOSH IC 9465, 2003), since this mine has non-methane conditions.

Regarding criteria on minimal air velocity necessary amount of air for single manual longwall face would be:

$$Q_{LW} = A \cdot w_{\min} = 6.0 \cdot 1.5 = 9\,\mathrm{m}^3/\mathrm{s}$$

Total amount of air required for mine ventilation the Omerler B mine will comprise two mechanized longwalls, single manual longwall, 4 longwall development roadways and 2 mine development roadways, or:

Mechanized longwalls	$2 \cdot 21\ \mathrm{m^3/s} = 42\ \mathrm{m^3/s}$
Manual longwall	$9\ \mathrm{m^3/s}$
Longwall development roadways	$(4.5\ \mathrm{m^3/s} \cdot 1.3) \cdot 4 = 23.4\ \mathrm{m^3/s}$
Mine development roadways	$(4.5\ \mathrm{m^3/s} \cdot 1.3) \cdot 2 = 11.7\ \mathrm{m^3/s}$
Air losses on entrance	(3% of total air quantity) $2.5\ \mathrm{m^3/s}$
TOTAL	$Q_{tot} = 88.6\ \mathrm{m^3/s}$

5. DESIGN SCENARIOS ANALYSES

First considered scenario for definition of ventilation parameters of Ömerler B was coal mining at mechanized longwall panels B72/P3 and B58/P1, together with mining at manual longwall B70/P2, with active development faces in panels B72/P2, B102/P2 and roadway development at elevation 347 m (Figure 2).

Results of performed calculations on branch aerodynamics resistances are shown on Figure 4 canonical ventilation scheme of the analyzed mine ventilation - scenario 1. Aerodynamics resistances of roadways are calculated after following expressions:

$$R = k \cdot \left(L \cdot U / A^3 \right) \tag{2}$$

where:

R - aerodynamics resistances [$\mathrm{Ns^2/m^8}$];

k - aerodynamics friction coefficient [$\mathrm{kg/m^3}$], (Hartman 1997, McPherson 1993);

L - length of the roadway [m];

U - perimeter of roadway [m];

A - cross-section area of the roadway [$\mathrm{m^2}$].

Pressures of roadways are calculated after following expressions:

$$h = R \cdot Q^2 \tag{3}$$

where:

h - pressures of roadways [Pa];

Q - air flow volume through the roadway [$\mathrm{m^3/s}$].

Distribution of node pressure in ventilation network is shown on Figure 4.

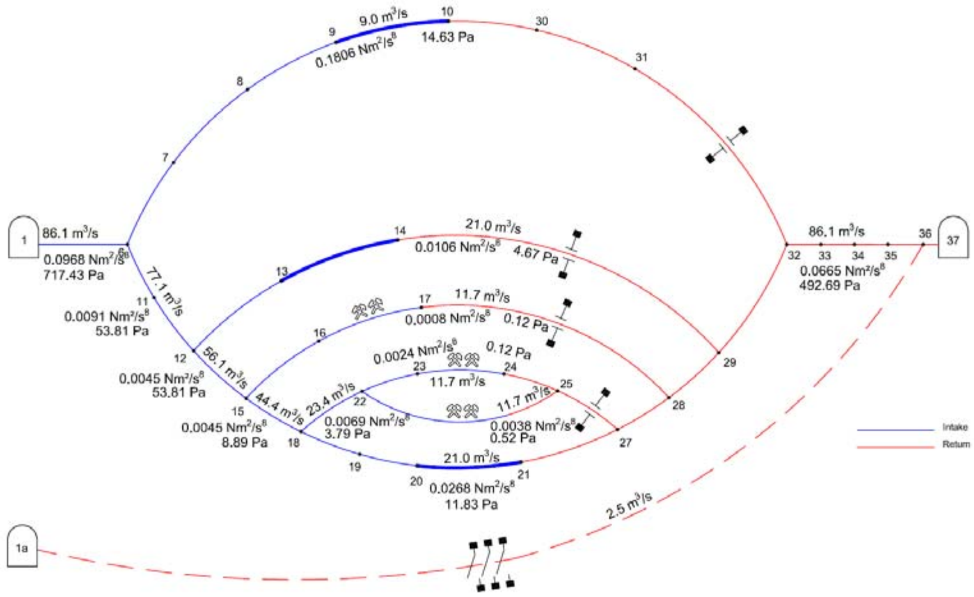

Figure 4 - Canonical ventilation scheme - scenario 1

Due to the requirement for establishment of controlled air distribution in ventilation network shown on Figure 2, it is necessary to install air flow regulators in branches 25 - 27, 17 - 28, 14 - 29 and 31 - 32 (Figure 4). Air flow regulators resistance, pressure drop and opening are given in Table 1. Air flow regulator in branch 24 - 25 is not necessary because of low impact on air distribution and sufficient air reserve major branch.

Table 1 - Parameters of mine ventilation regulators

Scenario 1

Branch	R_r [Ns^2/m^8]	h_r [Pa]	A_r [m^2]
24 - 25	0.0040	0.55	11.96
25 - 27	0.0352	19.30	5.32
17 - 28	0.1410	19.30	2.89
14 - 29	0.0438	19.30	4.85
31 - 32	1.6098	130.39	0.91

As already suggested, installation of main fan in South-East Decline would provide diagonal ventilation system. Next analyzed case is coal mining at mechanized longwall panels B72/P3 and B58/P1, with mining at manual longwall B70/P2, and development faces in panels B72/P2, B102/P2 and roadway development at elevation 224 m, with main fan positioned in South-East Decline (Figure 3).

Canonical ventilation scheme of the analyzed mine ventilation - scenario 2 is shown on Figure 5. Calculation of ventilation network was performed according to presented methodology. Results are shown on Figure 5.

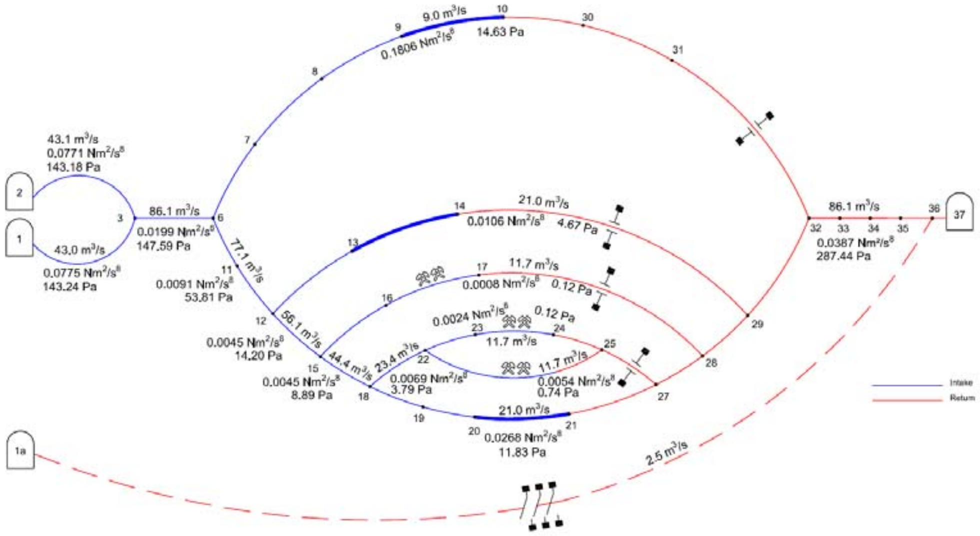

Figure 5 - Canonical ventilation scheme- scenario 2

Distribution of node pressure in ventilation network is shown on Figure 5.

Due to the requirement for establishment of controlled air distribution in ventilation network shown on figure 5, it is necessary to install air flow regulators in branches 25 - 27, 17 - 28, 14 - 29 and 31 - 32 (Figure 5). Air flow regulators resistance, pressure drop and opening are given in Table 2. Flow regulator in branch 24 - 25 is not necessary because of low impact on air distribution and sufficient air reserve major branch.

Table 2 - Parameters of mine ventilation regulators

Scenario 2

Branch	R_r [Ns^2/m^8]	h_r [Pa]	A_r [m^2]
24 - 25	0.0056	0.77	10.72
25 - 27	0.0349	19.09	5.34
17 - 28	0.1394	19.09	2.91
14 - 29	0.0433	19.09	4.88
31 - 32	5.1584	417.83	0.52

Based on the aerodynamics resistances and ventilation pressures of roadways, it can be concluded that static ventilation pressure of mine, with given scheme and designed amount of air at level of 88.6 m^3/s, is $h_{st} = 1359.01$ Pa in the case of mine ventilation scenario 1 and $h_{st} = 727.16$ Pa in the case of mine ventilation scenario 2.

In this case, equivalent opening of exploratory declines would be:

$$A_1 = 1.19 \cdot \frac{Q_{tot}}{\sqrt{h_{st}}} = 1.19 \cdot \frac{88.6}{\sqrt{1359.01}} = 2.9\mathrm{m}^2$$

$$A_2 = 1.19 \cdot \frac{Q_{tot}}{\sqrt{h_{st}}} = 1.19 \cdot \frac{88.6}{\sqrt{727.16}} = 3.9\mathrm{m}^2$$

According to equivalent opening of underground operations, it can be said that these are very favorable for ventilation.

Concept described in this paper has following ventilation network parameters (Table 3).

Table 3 - Ventilation network parameters

Ventilation network parameters	Unit	Scenario 1	Scenario 2
Total amount of air	m^3/s	88.6	88.6
Total resistance of the mine ventilation network	Ns^2/m^8	0.0926	0.0926
Static ventilation pressure	Pa	1359.01	727.16
Equivalent opening of the mine	m^2	2.9	3.9
Dynamic ventilation pressure	Pa	477.7	477.70
Total ventilation pressure	Pa	1836.7	1204.87
Main fan power	kW	150.6	98.8 ~ 100

According to presented ventilation concepts (scenario 1 and scenario 2) suggested solution is South-East Decline as main roadway for exhaust-return air, with main fan installed at entry. This solution has advantage regarding safety because it has lower total static pressure in ventilation network, which is more favorable in case of coal self-combustion risk. Also, this solution has two roadways for fresh air, providing better quality of air for ventilation of faces (main coal transport is in one roadway, while the other one is free).

6. CONCLUSION

In this paper we presented a case study for the mine ventilation planning and analysis of Omerler B coal Mine. The Omerler B mine will comprise of two mechanized longwall coal mining operations and single manual longwall for annual production of approx. 1.6 mtpa of coal. The paper discusses the challenge to coordinate necessary ventilation requirements with long-term demands.

A diagonal mine ventilation system configuration was recommended based on the results of the network modeling exercise of the analyzed options. Suggested solution with South-East Decline as main roadway for exhaust-return air and main fan installed at entry has advantage regarding safety because it has lower total static pressure in ventilation network, which is more favorable in case of coal self-combustion risk. Also, this solution has two roadways for fresh air, providing better quality of air for ventilation of faces (main coal transport is in one roadway, while the other one is free).

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