THE REGULATION OF VENTILATION BY CHANGING THE OPERATION OF THE MAIN FAN AND ITS IMPACT ON THE FACE WORKED UNDER THE MAIN HAULAGE LEVEL

REGULACE VĚTRÁNÍ ZMĚNOU PROVOZU HLAVNÍHO VENTILÁTORU A JEJÍ DOPAD NA PODPATROVĚ DOBÝVANÝ PORUB

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Abstract

The regulation of mine ventilation by changing the operation of the main fan (HV) has both positive and negative aspects. One of the positive aspects is that this regulation can be made directly on the mine surface without lowering into the mine, namely by turning the fan blades from the minimum to maximum position. This regulation can be performed either from the control room or directly at the fan.

The utilization of this control method in the mine ventilation (the reducing or increasing of the depression of main fans) brings with also certain disadvantages. By the overall regulation of the depression of main fans we influence the overall mine ventilation network. The HV regulation can without further interventions cause problems in other part of the mine. Therefore, to eliminate the negative effects we have to do partial steps in the regulation of ventilation in the ventilation network to achieve the desired effect in a specific part of the mining field and prevent the unwanted effect in other parts of the ventilation network. In this article we deal with the negative effects on a face worked under the main haulage level.

Abstrakt

Regulovat větrání dolu změnou provozu hlavního ventilátoru (HV) má jistá pozitiva, i negativa. Jedním pozitivem je to, že lze tuto regulaci provést přímo na povrchu dolu bez nutnosti fárání do dolu, a to natáčením lopatek ventilátoru z minimální polohy do maximální. Tuto regulaci můžeme provést buď z dispečinku, nebo přímo u ventilátoru.

Použití tohoto způsobu regulace při větrání dolu (snižování, popř. zvyšování deprese hlavních ventilátorů) s sebou ale přináší i jistá negativa. Celkovou regulací deprese hlavních ventilátorů ovlivňujeme celou větrní síť dolu. Regulací HV může dojít k tomu, že bez dalších zásahů nastanou problémy v jiné části dolu. V daném případě pro eliminaci negativních projevů musíme udělat dílčí kroky v regulaci větrání ve větrní síti tak, abychom dospěli k požadovanému účinku v konkrétní části důlního pole a zamezili nežádoucímu dopadu v ostatních částech větrní sítě. V tomto článku se zabýváme negativními účinky na podpatrově dobývaný porub.

Key words: Regulation of ventilation, main fan, face worked under main haulage level, aerodynamic resistance.

1 INTRODUCTION

Within the active regulation of mine ventilation, the depression control of the main fan (HV) can be applied by setting the angle of the impeller blades, the impeller replacement, or by changing the speed achieved by replacing the electric motor, or the regulation of the output power by a semiconductor inverter, as is operated e.g. at the Karvina Mine, Lazy Plant.

In this regulation mode of the ventilation network it is however necessary to evaluate the effect of the HV regulation induced by needs in other parts of the mine on the fire area, or the fire area being made accessible and propose the measures to eliminate the potential negative effects and the procedure how to proceed during the HV regulation.

For a model example, the real mine ventilation network of the Karvina Mine, CSA Plant has been used, which was measured in June 2008, and which resulted in preparing a mathematical model of the ventilation network.

2 MODEL EXAMPLE DESCRIPTION

The model example is based on the following assumptions:

- Spontaneous combustion is in progress in the coalface No. 14066 being mined under the main haulage level, herewith that by the negative regulation at the end of SAC (separate air compartment) in the mine workings No. 24041A and No. 14000A optimal conditions are achieved in the ventilation in relation to the ongoing spontaneous combustion, which at this stage do not require further interventions.
- In the mined coalfaces No. 74058 and No. 74056, having with the coalface No. 14066 common return airways from the ends of SAC of all coalfaces, a need has occurred to increase the air volume flow from the original 12.3 $m^3 \cdot s^{-1}$ in the face No. 74058 to about 15.0 $m^3 \cdot s^{-1}$ and in the face No. 74056 from 19.2 $m^3 \cdot s^{-1}$ to approximately 22.5 $m^3 \cdot s^{-1}$, herewith that the regulation possibilities inside the ventilation network have already been exhausted and it is necessary to proceed to regulate the HV operation.

In the mathematical model of the ventilation network, the specific values of depressions induced by the cooperation of individual main fans with natural depressions (TD) at the pits ČSA3, Doubrava III and Eleonora measured in June 2008, have been replaced with the curves of characteristics of the cooperation of individual HVs with single TDs approximated by 3-degree polynomials, see Figs 1 to 3.

The specific values of single coefficients of the polynomials in the form

$$\Delta p_v = A_0 + A_1 \cdot Q_v + A_2 \cdot Q_v^2 + A_3 \cdot Q_v^3$$

are listed in Table 1, including the coefficients of the polynomial, by means of which the working characteristics of HV at the pit Doubrava III has been modelled in further solution for the displacement of the blades of the regulating mechanism to +30 °; here TD is not taken into account.

Tab. 1 The coefficients of polynomials of working characteristics of the HV-TD cooperation used in the modelling

HV	char.	A0	A1	A2	A3
CSA 3	HV+TD VI/08	1262, 02	17, 113	-2.03E-02	-7.86E-05
Eleonora	HV+TD VI/08	1203, 14	37, 208	-1.86E-01	-4.13E-05
Doubrava III	HV+TD VI/08	-2314, 37	93, 779	-4.03E-01	-3.05E-04
	30°	-4404, 59	60, 303	-1.12E-01	3.13E-05

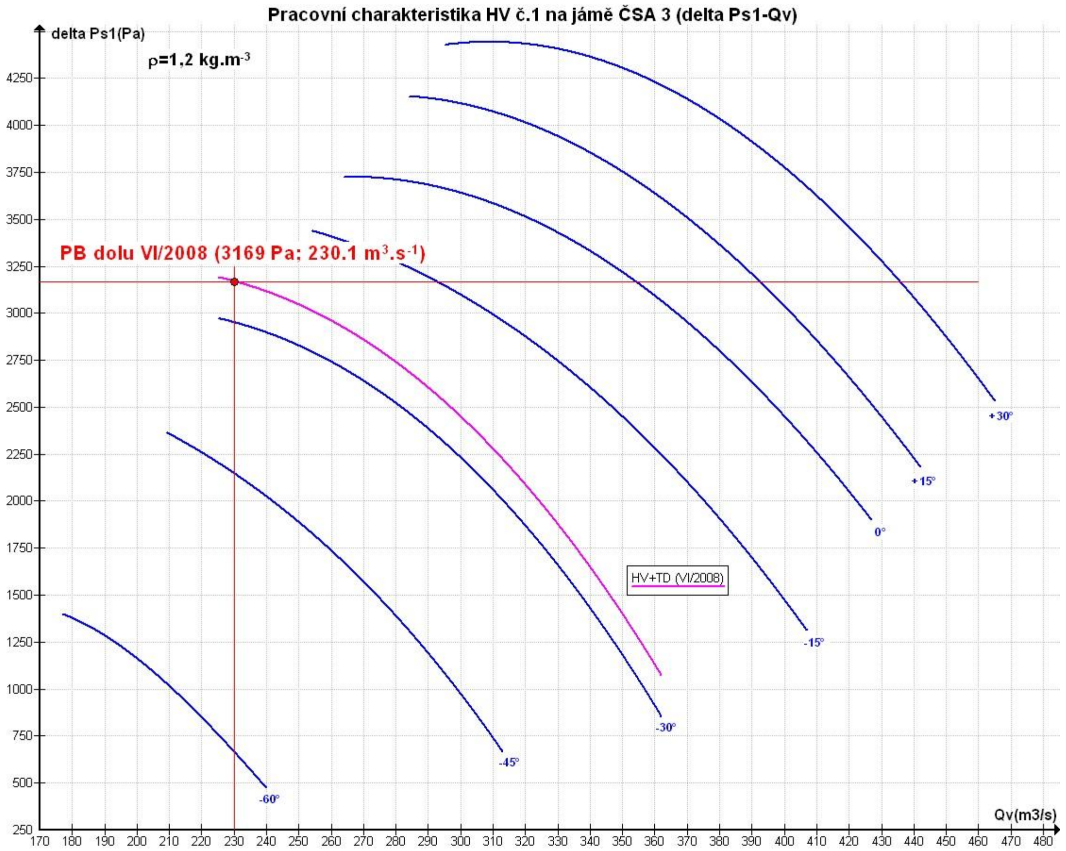

Fig. 1 Characteristics of HV at the pit CSA 3

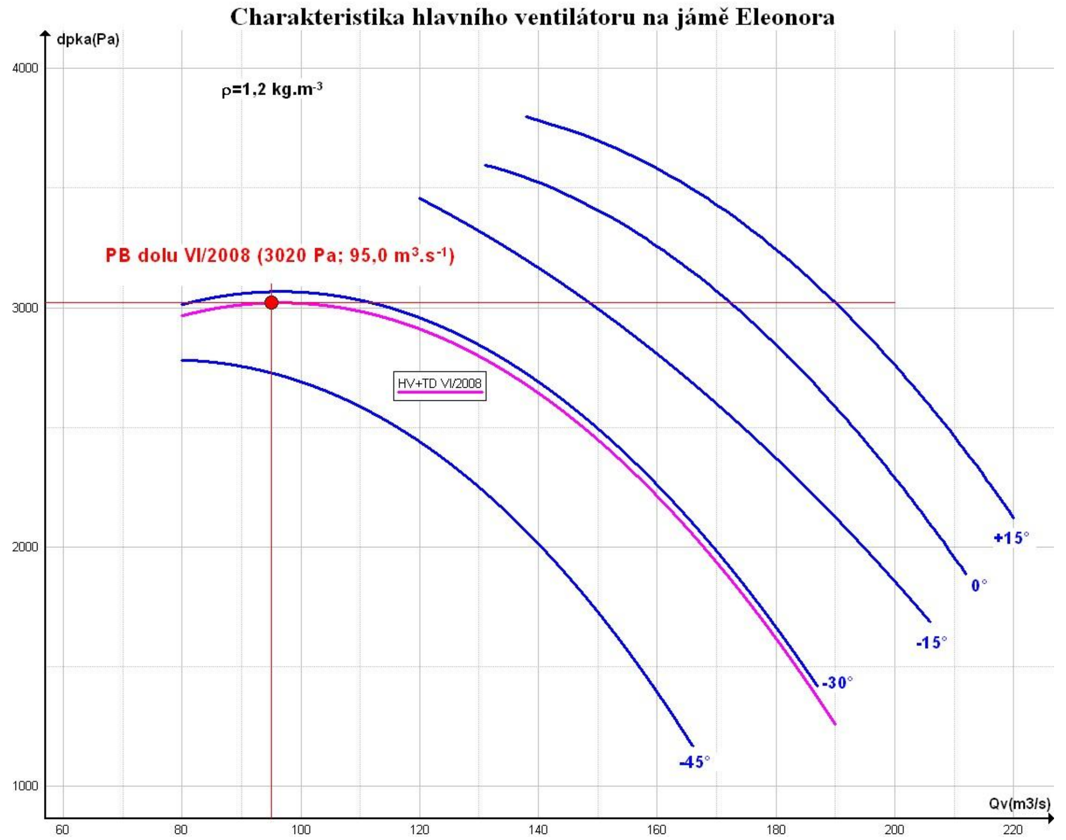

Fig. 2 Characteristics of HV at the pit Eleonora

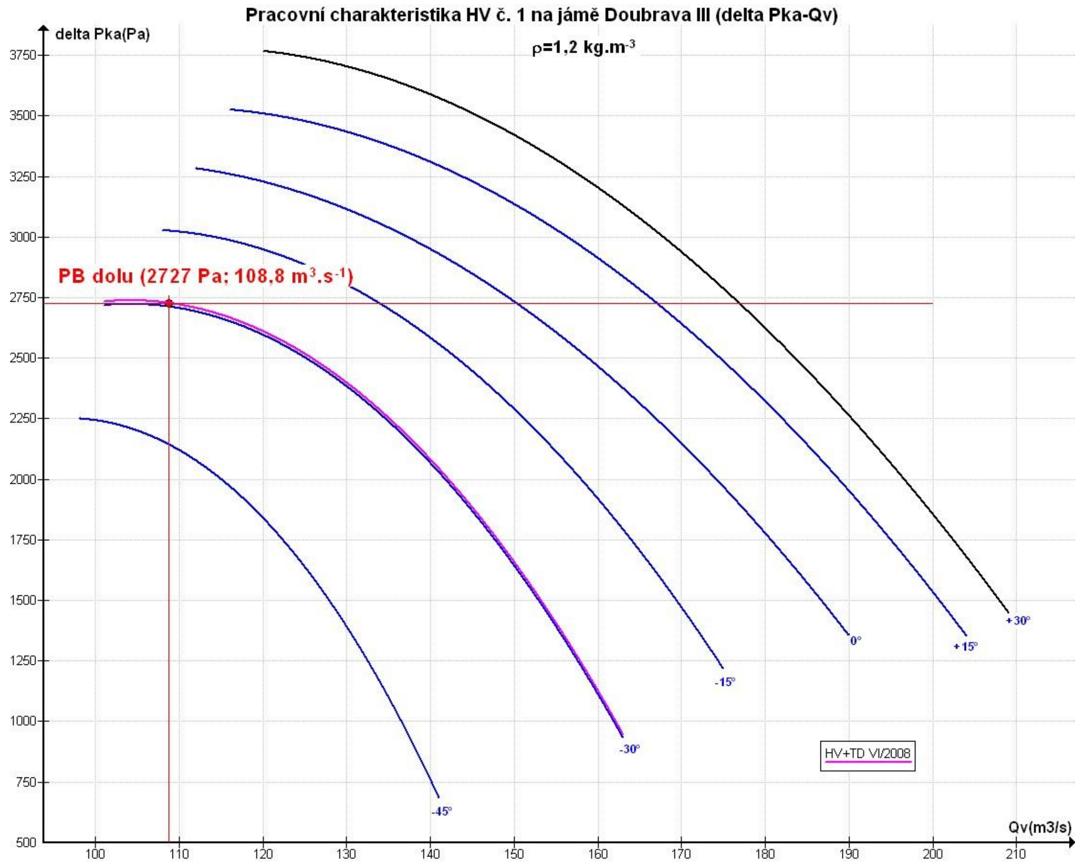

Fig. 3 Characteristics of HV at the pit Doubrava III

3 INITIAL STATE

Under this condition of the ventilation network model the calculation was performed and the initial state obtained. The ventilation situation around the coalface No. 14066 in this initial state is shown in Annex 1.

As mentioned above, the assumption for the modelling is that in the caving space of the face, being worked under the main haulage level, the spontaneous combustion is in progress, but the situation is stabilized.

4 INCREASE IN THE VOLUME FLOW RATE IN THE SEVENTH BLOCK BY INCREASING THE HV OUTPUT POWER AT THE PIT DOUBRAVA III.

In the mathematical model of the initial state, the increase in the HV output power at the pit Doubrava III was simulated by changing the angle of the blades of the control mechanism to +30 °, again by entering the characteristic by the 3-degree polynomial with the coefficients listed in Table 1 above.

After this increase a growth in the volume air flow rate in the area of the 7th block of the 40th seam, thus at the faces No. 74056 and No. 74058; at the same time, however, an increase in the volumetric air flow rate in the whole air area has occurred and thus even at the face No. 14066. The depression gradients across the air area increased as well.

In the next step it is advisable to follow the methodology proposed in [1].

4.1 Measurements of the mine depression image

The depression image of the mine was measured in June 2008. The state we would like to solve, thus the state after the increase in the HV output power, cannot be measured in practice, for the measures we would like to suggest, should be implemented before raising the HV output power to allow to eliminate any negative impacts on time. Therefore, the determining of the measures should be based on the mathematical modelling of the ventilation network.

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4.2 The analysis of the massif, distribution of pressure gradients of the assessed area, identification of possible ventilation communications

In the area of the coalface No. 14066, coalfaces at the 40th seam to the west of this coalface are worked up. To the east of this coalface, the coalface No. 14068 is being prepared; the possible communications are therefore the caving areas of the coalface No. 14066 and also the coalfaces No. 14064, No. 14062 and No. 14060. The partial distribution of the pressure gradients and the situation of this coalface is illustrated in Figure 4.

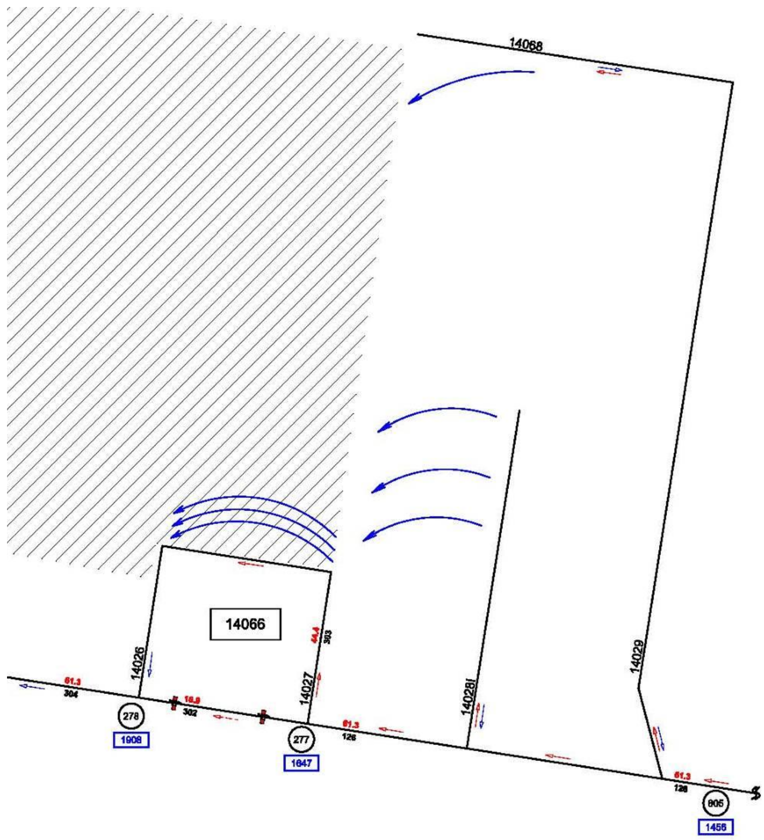

Fig. 4 The situation of the coalface No. 14066 before the modelling

Analyzing the situation in the coalface No. 14066, we can easily come to the conclusion that by changing the HV operation at the pit Doubrava III the pressure gradient between the initial and return airway of the coalface, thus between the 277 and 278 points of the ventilation network, will increase from the original 198 Pa to 261 Pa, and the increase in the air volumetric flow rate through the face from 38.7 $m^3 \cdot s^{-1}$ to 44.4 $m^3 \cdot s^{-1}$ will occur. Both of these changes can affect in a negative way the drafts of the mine air through the caving areas of the coalface No. 14066 and subsidize the ongoing spontaneous combustion with oxygen. A considerable fact in the configuration of the coalface of interest is that an increase in the pressure gradient between the driven crosscut No. 14068 and the coalface No. 14066, thus between the points 805 and 277 of the ventilation network, will occur from initial 145 Pa to 191 Pa, resulting in the increase of the risk of drafts of the mine air through the caving area from the driven crosscut towards the coalface No. 14066.

In order to reduce the above risks, it is necessary to proceed to the local regulation of ventilation in the area of the coalface No. 14066.

4.3 The measures proposed to reduce the drafts of air after making the fire area accessibel and their verifying on the mathematical model

The aim of the ventilation network adjustments is to perform the most time and economic advantageous adjustments in the ventilation network, in order the coalface ventilation parameters to approach the state before the HV regulation. Each proposed measure will be verified by mathematical modelling and subsequently the optimal solution will be selected.

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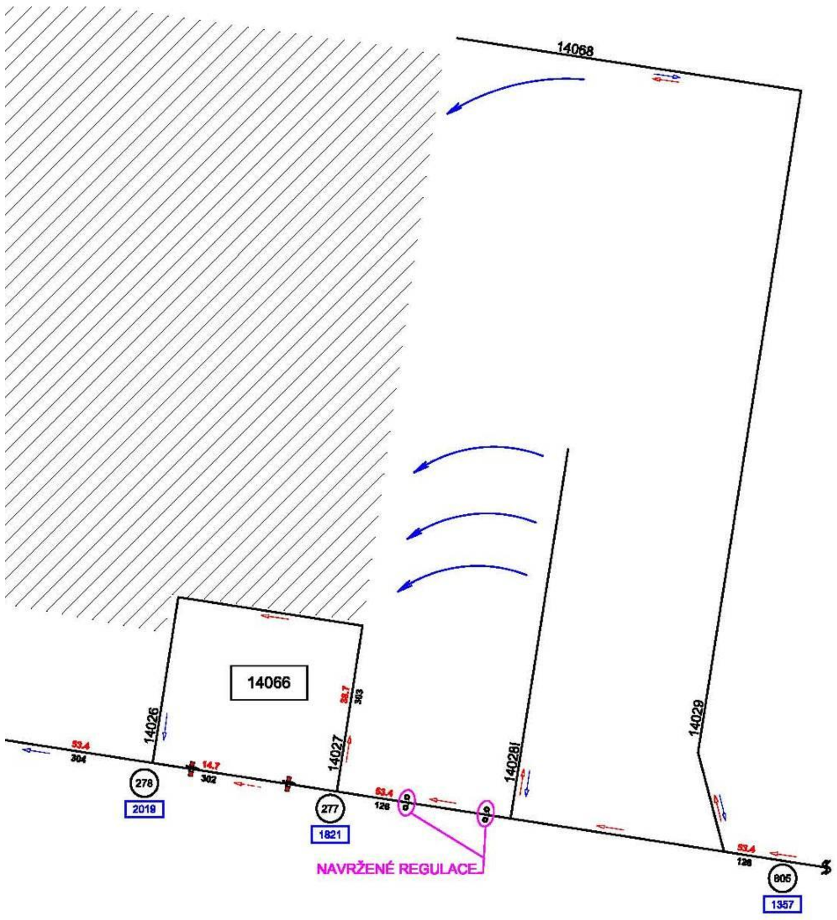
The regulation on the home side before the coalface

The mine working No. 14000 between the initial airway No. 14027 and the driving No. 14028I can be considered as a suitable location for the regulation of the volumetric air flow rate being led into the coalface. The suitability of this location is justified particularly by the speed of construction, for the transport to the area of the coalface No. 14066 is realized from the initial side of SAC and in addition, the door regulator built in this place could help to reduce dustiness penetrating from the driven mine workings No. 14028I and 14068.

In the mathematical model of the ventilation network, this proposed measure has been implemented by increasing the resistance of the branch No. 126 between the points 805 and 277 from the value of 0.05085 $\mathrm{kg \cdot m^{-7}}$ to the value of 0.16278 $\mathrm{kg \cdot m^{-7}}$.

Using this regulation the volumetric air flow rate through the face and the pressure gradient between the home and return airway have been reduced to the initial value, as shown in Figure 5.

However, from the subsequent analysis it is clear that the risk of drafts of the mine air from both driven mine workings, especially then from the crosscut No. 14068 through the caving space towards the coalface No. 14066 will significantly increase. The pressure gradient between the points 805 and 277 will increase from the value of 191 Pa to 464 Pa. This regulation method is not suitable; therefore it is necessary to proceed to the next option.



PROPOSED REGULATION

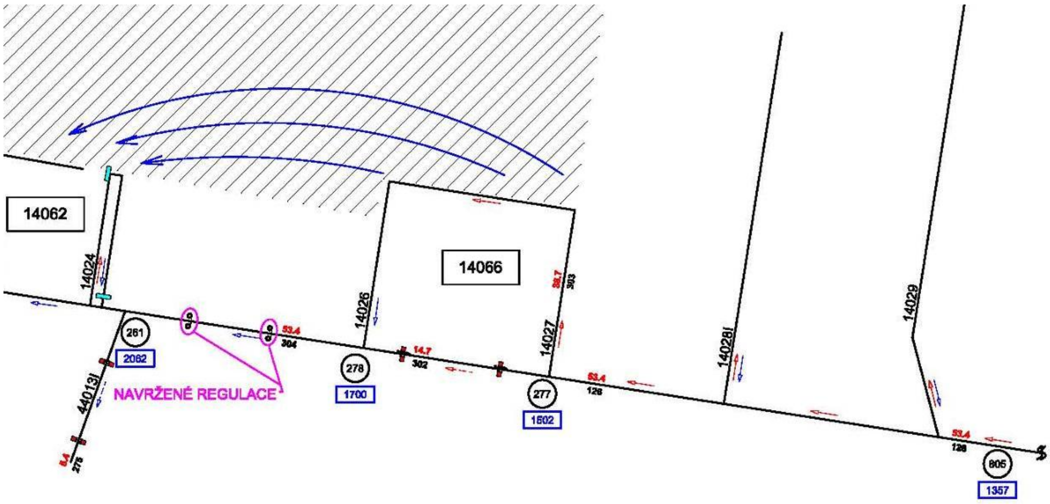
Fig. 5 Location of the regulation between the home airway No. 14027 and the driving No. 14028I

The regulation on the return side behind the coalface

As another possible location for the regulation of the volumetric air flow rate led from the coalface we can use the mine working No. 14000 between the mine workings No. 14026 and No. 44013I, as it will affect the overall volumetric air flow rate leaving the face No. 14066 and also its short-circuit.

In the mathematical model of the ventilation network this proposed measure has been implemented by increasing the resistance of the branch No. 304 between the points 805 and 261 from the value of 0.01508 $\mathrm{kg \cdot m^{-7}}$ to the value of 0.12701 $\mathrm{kg \cdot m^{-7}}$.

From Figure 6 it is clear that this regulation has reduced the volumetric air flow rate through the face and the pressure gradient between the home and return airways to the original values. Compared to the regulation performed on the home side, this solution has the advantage consisting in the decrease of the values of absolute depressions in individual points of the coalface.



PROPOSED REGULATION

Fig. 6 Location of the regulation between the mine workings No. 14026 and No. 44013I

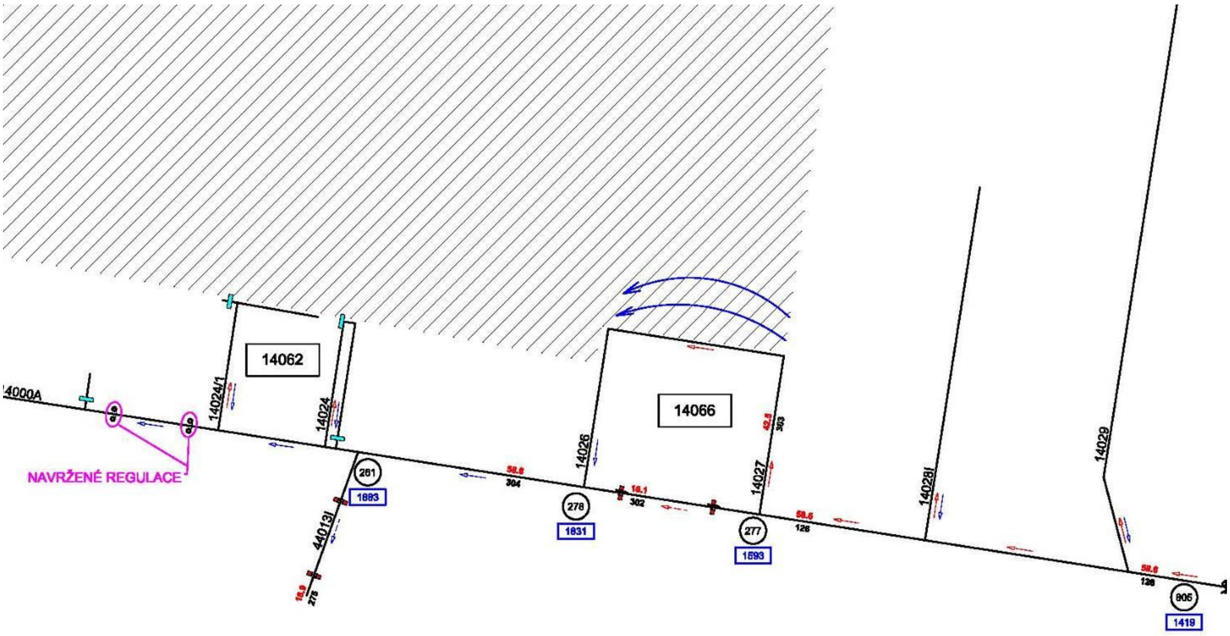
Upon a closer analysis, however, we encounter a problem that can result in the increase in the pressure difference between the face No. 14066, being operated, and the face No. 14062, being disposed. The pressure gradient between the points 805 and 261 will increase from the initial value of 56 Pa to 362 Pa. This greatly increases the risk of drafts of the mine air in this direction, the risk of subsidizing the spontaneous heating in the caving space of the face and the risk of its further spread towards the coalface No. 14062. This method of regulation is not appropriate as well.

The regulation on the return side in a greater distance behind the coalface

Another alternative of the measures is to strengthen the negative regulation at the end of SAC in the mine working No. 14000 behind the face No. 14062, see Figure 7.

In the mathematical model of the ventilation network, this proposed measure has been implemented by increasing the resistance of the branch No. 277 between the points 261 and 254 from the value of 0.13974 $\mathrm{kg \cdot m^{-7}}$ to the value of 0.30942 $\mathrm{kg \cdot m^{-7}}$.

Implementing this regulation method, the volumetric air flow rate through the face and the pressure gradient between the home and return airways have been reduced, however to the values that are still higher than in the initial state (Figure 7). The reason why there was no decline to the initial values is that the return air flows from the coalface No. 14066 are partially led out by the short-circuit connection No. 44013I.



PROPOSED REGULATION

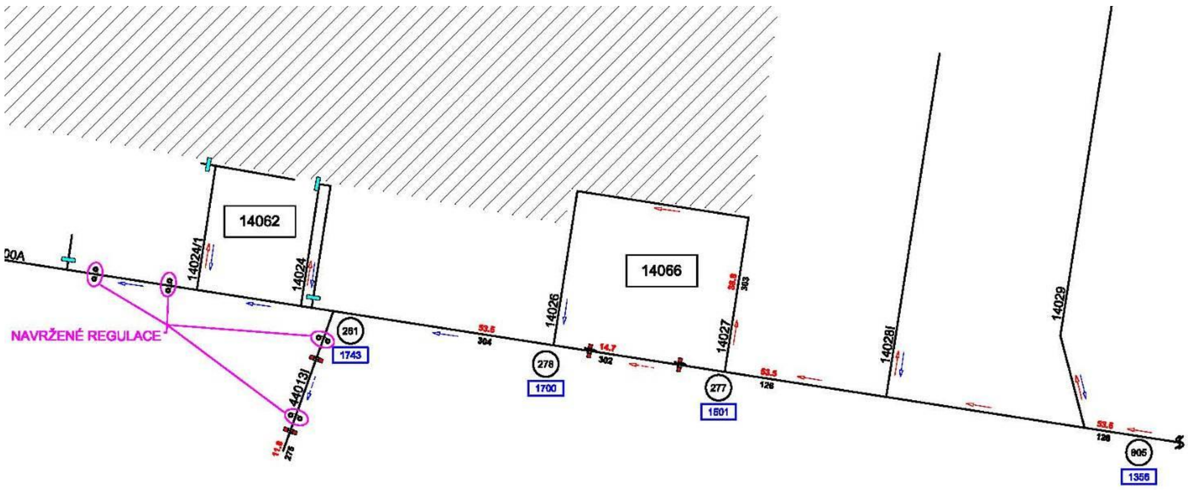
Fig. 7 Reinforcement of negative regulation at the end of SAC at tyhe work No. 14000A

Implementing the negative regulation in the short-circuit connection

In the mathematical model of the ventilation network, this proposed measure has been implemented by increasing the resistance of the branch No. 275 between the points 261 and 260 (thus a short-circuit connection No. 44013I) from the value of 0.36526 $\mathrm{kg \cdot m^{-7}}$ to the value of 2.11601 $\mathrm{kg \cdot m^{-7}}$.

Figure 8 illustrates that this regulation has reduced the volume air flow rate through the face and the pressure gradient between the home and return airways to the original values and the pressure gradient between the possible indicated communications of the drafts of mine air do not increase as well.

This regulation version is suitable for the implementation in the mine.



PROPOSED REGULATION

Fig. 8 Strengthening the negative regulation at the end of SAC in the mine working No. 14000A and simultaneous strengthening the regulation in the short-circuit connection No. 44013I

4.4 The final proposal of the ventilation regulation

After the analysis made this way we come to the measures that can be implemented at the mine:

- before increasing the HV output power at Doubrava III, to prepare negative regulations in the mine working No. 14000A to the west of the disposed face No. 14062 and in the mine working No. 44013I and secure them in the open position; to prepare the material for the possible sealing-up of the built regulations;
- after increasing the HV output power at Doubrava III, to put into operation the prepared negative regulations and modify their aerodynamic resistance by the sealing-up based on the measurements of the volume air flow rate in the area of the coalface No. 14066.

4.5 The implementation of the measures at the mine and verifying their accuracy by measurements

This phase cannot be done for practical reasons with regard to the inaccessibility of the workplace.

5 CONCLUSION

Based on the modelling of the above example in the real mine ventilation network, we can conclude that the increase in the HV output power induced by needs in other parts of the mine may adversely affect the ventilation parameters of the fire area, or the fire area being made accessible, in that the increase in depression gradients between the points of the ventilation network and also the increase in the volumetric air flow rate throughout the ventilation network will occur.

It is therefore necessary in such cases prior to change the HV operation to analyze its impact on the fire area and to propose measures to eliminate the potential negative effects and the procedure how to proceed in regulating HV, whereas the procedure given in [1] can be successfully applied.

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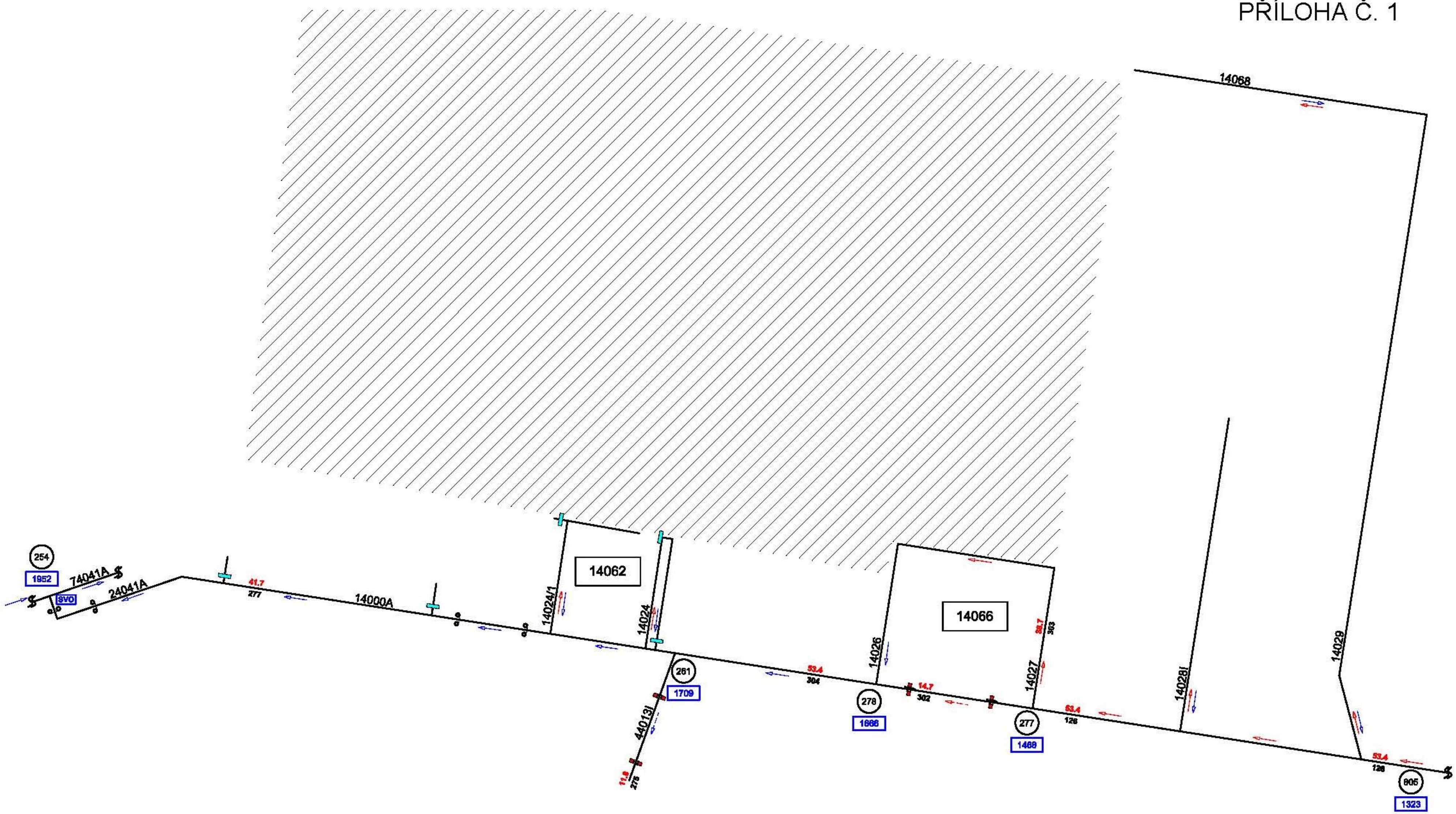
RESUMÉ

Při regulaci větrní sítě pomocí HV je vždy nutné zhodnotit vliv regulace HV vyvolané potřebami v jiných částech dolu na požářiště, popř. zpřístupňované požářiště a navrhnout opatření na eliminaci případných negativních vlivů a postup, jak při regulaci HV postupovat.

V tomto článku jsou ukázány čtyři varianty, jak lze eliminovat negativní dopady ve větrní síti vyvolané potřebami regulace hlavního ventilátoru. Vždy je důležité dodržet navržený postup řešení, zhodnotit možné další dopady na větrní síť a pak navržená opatření eliminující negativní dopady před samotnou regulací HV realizovat v dole.

Tento způsob regulace větrání je výhodné použít při nutnosti zdolávání požáru v nepřístupných podmínkách, když už nezbývá jiná možnost zdolávání požáru, což by mohlo například být zdolávání požáru ve svislém důlním díle (úvodní nebo výdušná jáma).

PŘÍLOHA Č. 1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