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ASSESSMENT OF ACTUAL TEMPERATURE REGIME IN CHAMBERS FOR INSTALLATION OF FANS

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Abstract. The article considers an assessment of the safe temperature regime in mine chambers used for the isolated suction of methane from the mined-out space after coal mining.

The isolated removal of methane from the produced space outside the mining area through a pipeline with the help of gas-suction fans is used in the Donbas mines. Gas suction units are placed in specially prepared chambers that are ventilated with fresh air. In accordance with the regulatory requirements, ventilation units should be evaluated for air temperature at permanent workplaces in underground workings of coal mines, depending on humidity, air movement speed, and individual categories of work.

An analytical comparison of actual temperature regime in the chambers for ventilation gas suction units with permissible norms according to sanitary and hygienic standards was performed. The rational parameters of temperature regime in the chambers for ventilation gas suction units were determined, which can be considered “conditionally” acceptable for the mining and geological conditions in mines of the “Pokrovs’ke” Mine Administration.

The substantiation is given to physical parameters of air inflowing into the chambers for ventilation gas suction units needed for their ventilation and in order to maintain sanitary and hygienic standards by temperature. The dependence of the flow rate of air inflowing into the chambers for ventilation gas suction units on its maximum permissible value according to sanitary and hygienic standards is established.

It is established that in order to ensure a standard temperature regime in the chambers for ventilation gas suction units in the mining and geological conditions of mines of the “Pokrovs’ke” Mine Administration; it is recommended not to use cooling plants due to their economical impracticability. This will reduce economic costs of ensuring the standard temperature regime.

It is necessary to reduce the cost savings on ensuring the standard temperature regime in these chambers and to ensure safe operation associated with the isolated removal of methane from the mined-out space after coal mining

Keywords: recommendations, methane, goaf, temperature, ventilation.

1. Introduction

The isolated removal of methane from the goaf through the pipeline to outside the extraction area with the help of gas suction fans has been used in the mines of Donbas for more than fifty years and has proven to be a reliable and effective way to control gas. According to the requirements of the "Safety Rules in Coal Mines" (hereinafter SR) [4], gas suction units should be installed in specially prepared chambers, which are ventilated with fresh air.

Under the conditions of mines of the “Pokrovs’ke” Mine Administration (hereinafter the Pokrovs’ke mines), the coal seam d_4 is developed by the pillar mining system. The main part of the extraction areas is ventilated according to the reverse scheme of 1-M type with removing of the outgoing stream of air to the coal massif, if the airway behind the face is not serviced and controlled.

The main drawback of the ventilation scheme of 1-M type is that all methane is taken away from the goaf by the air leaked to the connection of the face with the airway. Therefore, even with a slow methane flow rate (0.5–2.0 m^3/min), its local accumulations with an unacceptable rate of concentration can be formed. This is explained by insufficient turbulization occurred when air flows from the goaf and the face join.

The danger of occurrence of local accumulations of methane with an unacceptable rate of concentration depends on the absolute amount of methane released from the goaf after degassing, its average concentration in air leaked through the goaf within the extraction area, and the speed of the methane-air mixture moved from the goaf to the connection of the face with the airway [1–4]. When methane releases from the goaf, the degree of danger increases at a small absolute amount of air leaked through the goaf within the extraction area, when the coefficient, which takes into account the air leaks, is $k_{l.a.}$=1.2–1.4, and decreases with an increase of this coefficient to $k_{l.a.}$=1.6 or more.

According to the scheme for extraction area ventilation with removing of outgoing air stream to the coal massif and with induced caving of the airway behind the face (1-M scheme type), the probability of occurrence of methane local accumulations at the connection (in the case of dead-end induced caving) with a concentration higher than the norm according to the "Guidelines..." [5] (formula 6.1) is excluded if:

$$k_0 = \frac{1434 \cdot \bar{I}^*_{m.g.} \cdot \sqrt{S_{v.w.}}}{Q^{1,5}_{l.a.} \cdot \left(\frac{k_{l.a.} - 1}{k_{l.a.}} \right)^{1,5}} \le 1 \quad \text{or} \quad k_0 = \frac{1434 \cdot \bar{I}^*_{m.g.} \cdot \sqrt{S_{v.w.}}}{Q^{1,5}_{l.a.} \cdot} \le 1 \qquad (1)$$

where k_o is a coefficient, which takes into account the danger of methane local accumulations at the connection of the face with the airway; $\bar{I}^*_{m.g.}$ is an average expected release of methane from the goaf after its degassing, m^3/min; $S_{v.w.}$ is design cross-sectional area of the airway in the light, m^2; $k_{l.a.}$ is a coefficient which takes into account air leaks through the goaf within the extraction area; $Q_{l.a.}$ is the air leaks through the goaf within the extraction area, m^3/min.

According to the requirements of the "Safety Rules in Coal Mines" (hereinafter SR) [4], gas suction units are installed in specially prepared chambers which are ventilated with fresh air. In Pokrovs'ke mines, at least three gas suction units are installed when mining highly loaded extraction areas. As a rule, two or more gas suction fans are in work simultaneously. They require high energy consumption and, therefore, emit a sufficient amount of heat, which is used to heat the air. Therefore, in some cases, the temperature regime required by the RS is not maintained in the chambers.

According to the existing regulatory requirements [5], all ventilation units must, among other things, be rated for air temperature at the places with permanent works in underground workings of coal mines depending on humidity, air flow rate and certain categories of works.

Thus, when considering temperature regime in chambers for installation of fans, it should be noted that in accordance with existing regulatory requirements [4], all ventilation units, both newly installed and those which are put into operation after reconstruction or overhaul, should be tested for efficiency. Based on the results of the tests and adjustments, a chart is made for each ventilation system. Air temperature at places with permanent works in underground workings of coal mines should correspond

to the values given in [6] depending on humidity, air flow rate and certain categories of works. At the same time, in deep mines characterized by a significant excessive heat, an increase of the upper limit of the air temperature by 3 degrees C is allowed, but not higher than +26°C.

At the same time, the regulations stipulate that any surfaces of stationary workings, machines, mechanisms and other equipment, which have a temperature of more than +33ºC, must be covered with heat-insulating material to protect workers from thermal radiation. If the microclimate parameters deviate from the values given in [5], the system, which prevents the miners from overheating or hypothermia, should be used in the workings. Air leakage through the goaf and from other areas of the massif should also be taken into account. Measurement of temperature regimes was carried out by mine equipment by the methods in accordance with the requirements of the safety rules [4].

The purpose of this article is to assess the actual temperature regime in the chambers for ventilation gas suction units in the mining and geological conditions of mines of the “Pokrovs’ke” Mine Administration.

2. Methods

To achieve the purpose set in the article, the methodology involves completing of the following tasks.

1. To analyze the results of monitoring of actual temperature regime in the chambers for ventilation gas suction units in the mining and geological conditions of the Pokrovs’ke mines.
2. To substantiate the physical parameters of the air supplied to the chambers for gas suction units for their ventilation, which are necessary to ensure sanitary and hygienic standards in terms of temperature, and to calculate the temperature of air, which ventilates the chamber for gas suction units according to the standard methodology [4, 5].

3. Results

It goes without saying that workings, where air temperature exceeds the permissible value, should be equipped with air shower installations (for the places with permanent work), devices for providing first aid and cabins for restoring the thermal state of miners in case of their acute overheating.

It should also be mentioned that in accordance with the requirements of clause 6.1.4.1 of the "Guidelines..." [5], the isolated removal of methane from the goaf through the pipelines to outside the extraction area by using the gas suction fans should be used when methane content in the goaf after degassing is $\bar{I}^{*}_{m.g.}$ = 4.0 m^3/min and more. The isolated removal of methane must be carried out according to the project approved by a technical manager of mine and coordinated with the industry institute and territorial body of the State Labor Service. The project is an integral part of the extraction area chart. The explanatory note of the project should include the calculation of the air flow rate required for ventilating the chamber for ventilation gas suction units according to formula 8.11 of the "Guidelines..." [5]:

$$Q_к = \frac{16{,}7\sum_{i=1}^{n_e} N_{em}(1-k_e)\cdot k_{je} + 0{,}8\sum_{i=1}^{n_m} N_t}{26 - t_w} \quad (2)$$

where N_{em} is the power of electric motor, kW; k_e is the efficiency factor of the electrical installation; k_{je} is a coefficient that takes into account the duration of operation of the electrical installation during the day, k_{je} =1 if duration of continuous operation is more than 1 hour; N_t is the power of the transformer installed in the chamber, kW; n_e is the number of simultaneously operating electrical installations; n_m is the number of simultaneously operating transformers t_w - is the temperature in the working in the warmest month of the year (°C).

According to the requirements of p. 22, chapter 1, section IV of the RS [4], air temperature in active mining workings must meet the requirements of the 3.3.1.095-2002 "The State Sanitary Rules and Norms of the Enterprises of the Coal Industry" (hereinafter, the SSR) [6]. At places with permanent works where workers stay during the shift, the maximum air temperature should not exceed +26ºC. Therefore, the denominator in the formula (2) of the "Guidelines..." [5] has the form 26.

If the air temperature at the entrance to the chamber exceeds the sanitary standards, then, according to the requirements of p. 8.2.2 of the "Guidelines..." [5], the measures for cooling the air at the entrance to the chamber should be taken.

According to the requirements of p. 6.3.3 of the "Guidelines..." [5] of the RS [4], concentration of methane in the chambers for ventilation gas suction units must be monitored by a stationary automatic device, which turns off electrical equipment in the chamber if methane concentration is 1%; air flow rate and temperature in the chambers must be the measured not less than once a month.

For conducting the research, four active and two mined-out extraction areas in the conditions Pokrovs'ke mines were selected for analyzing actual temperature regime in the chambers for ventilation gas suction units and the parameters of the air supplied for their ventilation. Information on the number of gas suction units in the chambers and the design flow rate of air required for their ventilation specified in the projects on isolated methane removal, which are to be agreed with the IGTM of the NAS of Ukraine, is presented in Table 1.

The records of monitoring the actual temperature regime in the chambers for ventilation gas suction units and the flow rate of air supplied for their ventilation provided by the safety and ventilation service of the mine are presented in Table 2.

The permissible by the RS [4] and SSR [6] air temperature was exceeded by 2ºC in the chambers for ventilation gas suction units with ВМЦГ-7 fans in extraction areas of the northern face 1 of central panel 11 and of southern face 1 of panel 1 and by 4ºC in the chambers for ventilation gas suction units in extraction areas of the northern face 2 of southern panel 10 and of the northern face 7 of panel 10 (see Table 2). In the chamber for ventilation gas suction unit in extraction area of face 4 of southern panel 10, the ingoing air temperature was 6ºC, and the outgoing air temperature was 12ºC higher than it is allowed by the RS [4] and SSR [6] (see Table 2).

Table 1 – Information on the number of gas suction units in the chambers and the design flow rate of air required for their ventilation

№	Name of face	Number and type of fans in the chamber		Design ingoing air flow rate Q_K, m³/min
		УВЦГ-9	ВМЦГ-7М	
1	Face 2 of southern panel 10	3 (2)	5 (4)♦	725
2	Face 4 of southern panel 10	3 (2)	5 (4)♦	725
3	Northern face 1 of central panel 1	-	5 (4)	535
4	Southern face 4 of northern panel 7	-	4 (2)	352
5	Northern face 7 of northern panel 10	-	4 (2)	352
6	Southern face 1 of northern panel 1	-	4 (2)	621♦♦
The maximum number of simultaneously operating fans is indicated in brackets ♦ - backup fans ♦♦ - design air flow rate taking into account the operation of two ВВН»-50 vacuum pumps				

Table 2 – Records of monitoring the actual temperature regime in the chambers for ventilation gas suction units and the air flow rate supplied for their ventilation

№	Name of face	Temperature, °C		Ingoing air flow rate, Q_K, m³/min
		of ingoing air - t_e	of outgoing air - t_o	
1	Face 2 of southern panel 10	25	30	700
2	Face 4 of southern panel 10	32	38	1010
3	Northern face 1 of central panel 1	25	28	450
4	Southern face 4 of panel 7	23	26	380
5	Northern face 7 of panel 10	25	30	400
6	Southern face 1 of panel 1	24	28	810

Thus, out of the six chambers under the study, only in the chamber for ventilation gas suction units in the extraction area of face 4 of panel 10, the temperature regime does not meet the requirements of the RS [4] and SSR [6].

4. Discussion

The analysis of the results of monitoring of the actual temperature regime in the chambers for ventilation gas suction units and the flow rate of air supplied for their ventilation showed the following.

All chambers for ventilation gas suction units are provided with the design air flow rate (see tables 1, 2). Of the six chambers under the study, only in the chamber for ventilation gas suction units with ВМЦГ-7М fans in the extraction area of the southern face 4 of panel 7 the actual temperature regime fully meets requirements of the SR [4] and SSR [6]. The air temperature allowed by the SR [4] and SSR [6] was exceeded by 2ºC in chambers for ventilation gas suction units with ВМЦГ-7М fans in the excavation areas of the northern face 1 of central panel 11 and of the southern face 1 of panel 1 and by 4ºC in the chambers for ventilation gas suction units in the extraction areas of the northern face 2 of southern panel 10 and of the southern face 7 of panel 10 (see Table 2).

In the chamber for ventilation gas suction units in the extraction area of the face 4 of southern panel 10, the ingoing air temperature was 6ºC and the outgoing air temperature was 12ºC higher than it is allowed by the SR [4] and SSR [6] (see Table 2). The difference between the temperature of the ingoing air and the outgoing air of the chamber was from 3ºC to 6ºC (see Table 2). In all chambers, where the outgoing air temperature exceeded the permissible temperature, the ingoing air temperature exceeded the calculated one (20ºC) by 4–5ºC, and in the chamber in the extraction area of the face 4 of the southern panel 10 - by 12 ºC.

At the same time, it should be noted that since the operator of the gas suction units spends the most part of his working time in the section of the chamber into which a fresh stream of air is supplied, therefore, if in the chambers for ventilation gas suction units the ingoing air temperature is less than 26ºC and the outgoing air temperature does not exceed 30 ºC, the temperature regime can be considered "conditionally acceptable", since, according to the requirements of p. 8.2.2 of the "Guidelines..." [5], measures to cool the air at the entrance to the chamber should be undertaken if temperature of the air at the entrance to the chamber exceeds sanitary standards, that is, is more than 26 ºC.

Thus, out of the six chambers under the study, only in the chamber for ventilation gas suction units in the extraction area of the face 4 of southern panel 10 the temperature regime does not meet the requirements of the SR [4] and SSR [6].

To ensure the standard temperature regime in the chambers for ventilation gas suction units, it is economically impractical to use cooling plants. Because, in fact, there are no effective mine cooling plants in Ukraine. Instead, in order to ensure a normal temperature regime for operator of the ventilation unit, it is recommended to use individual protection means against heat and to spend the most part of the working time on the side of the fresh air supply to the chamber.

5. Conclusions

1. The Institute of Geotechnical Mechanics of the National Academy of Sciences of Ukraine developed recommendations for assessing the actual temperature regime in the chambers for ventilation gas suction units in the mining and geological conditions of mines of the “Pokrovs’ke” Mine Administration, from which it follows that it is economically impractical to use cooling plants in such chambers. At the same time, in order to ensure normal temperature regime, it is recommended for the operator of the fan unit to use individual protection means against heat and to spend most of the working time on the side of the fresh air supply to the chamber.

2. It can be considered that in the chambers for ventilation gas suction units with an ingoing air temperature less than 26 ºC, and outgoing air temperature not exceeding 30 ºC, this temperature regime is "conditionally acceptable", since, according to the requirements of p. 8.2.2 of the "Guidelines..." [5], measures to cool the air at the entrance to the chamber should be undertaken if temperature of the air at the entrance to the chamber exceeds sanitary standards, that is, is more than 26 ºC.

REFERENCES

1. Zvyagil’sky, Ye.L., Boky, B.V. and Kasimov, O.I. (2013), *Upravleniye metanovydeleniyem na vyyemochnykh uchaskakh ugol’nykh shakht* [Management of methane emissions in the excavation areas of coal mines], Nowdligh, Donetsk, Ukraine.

2. Mineev, S.P., Rubinskiy, A.A., Vitushko, O.V. and Radchenko, A.V. (2010). *Gornye raboty v slozhnykh usloviyakh na vybrosoopasnykh plastakh* [Mining operations in difficult conditions in the outburst seams], Skhidny vidavnichiy Dim, Donetsk, Ukraine.

3. Bulat, A.F., Mineev, S.P., Belikov, S.N. and Belikov, I.B. (2021), *Pozhary v gornykh vyrabotkakh. Izolyatsiya avariynykh uchastkov* [Fires in mine workings. Isolation of emergency areas], V delye, Kharkov, Ukraine

4. Ukraine Ministry of Coal Industry (2010), 10.0-1.01-10. *Pravila bezopasnosti v ugolnykh shakhtakh, Normatyvnyy dokument Minvuhlepromu Ukrainy. Standart* [10.0-1.01-10. Safety Rules in Coal Mines. Regulatory Document of Coal Industry of Ukraine. Standard], Ukraine Ministry of Coal Industry, Kiev, Ukraine.

5. (1994), *Rukovodstvo po proyektirovaniyu ventilyatsii ugol'nykh shakht* [Guidelines for coal mine ventilation design], Osnova, Kiev, Ukraine.

6. Ministry of Health of Ukraine (2002), SSR 3.3.1.095-2002 *Gosudarstvennyye sanitarnyye pravila I normy «Predpriyaty ugol'noy promyshlennosti»* [SSR 3.3.1.095-2002 State sanitary rules and norms of «Enterprises of the coal industry». Standard], Kiev, Ukraine. https://zakon.rada.gov.ua/laws/show/z0498-03#top

7. Mineev, S.P., Novikov, L.A., Samopalenko, P.M. and Makarenko, R.V. (2022), Peculiarity of calculating air leaks through the produced space of coal mines. *Systemni tekhnologii*, 2 (139), pp.100–110. https://doi.org/10.34185/1562-9945-2-139-2022-10

8. Mineev S.P., Smolanov S.N., Belikov I.B. and Samopalenko, P.M. (2018), Methodology of temperature prediction in the field of fire. *Modern Scientific Researches,* 1(5), pp. 30–39.

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ОЦІНКА ФАКТИЧНОГО ТЕМПЕРАТУРНОГО РЕЖИМУ У КАМЕРАХ ДЛЯ РОЗМІЩЕННЯ ВЕНТИЛЯТОРІВ

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Анотація. У статті розглянуто оцінку безпечного температурного режиму у шахтних камерах, які використовуються для ізольованого відсмоктування метану з виробленого простору після виїмки вугілля.

Ізольоване відведення метану з виробленого простору за межі виїмкової ділянки трубопроводом за допомогою газо-відсмоктуючих вентиляторів застосовується на шахтах Донбасу. Газо-відсмоктуючі установки розміщуються у спеціально підготовлених камерах, які провітрюються свіжим струменем повітря. Відповідно до нормативних вимог вентиляційні установки повинні оцінюватися за температурою повітря на постійних робочих місцях у підземних виробках вугільних шахт залежно від вологості, швидкості руху повітря та окремих категорій робіт.

У статті розглянуто оцінка фактичного температурного режиму у камерах газо-відсмоктуючих установок у гірничо-геологічних умовах «ШУ «Покровське», проведено аналіз та узагальнення результатів спостережень за фактичним температурним режимом у камерах вентиляторів газо-відсмоктуючих установок у гірничо-геологічних умовах «ШУ «Покровське».

Проведено аналітичне зіставлення фактичного температурного режиму у камерах газо-відсмоктуючих установок з допустимим за санітарно-гігієнічними нормами. Визначені раціональні параметри температурного режиму, який можна вважати «умовно» припустимим у камерах газо-відсмоктуючих установок у гірничо-геологічних умовах «ШУ «Покровське».

У статті виконано обґрунтування необхідних фізичних параметрів повітря, що подається у камери газо-відсмоктуючих установок для їх провітрювання, які забезпечують санітарно-гігієнічні норми за температурою. Встановлена залежність витрати повітря, що надходить у камеру вентиляційних і газо-відсмоктуючих установок, від його максимально припустимого значення, згід но з санітарно-гігієнічними нормами. Визначено, що для забезпечення нормативного температурного режиму у камерах вентиляційних газо-відсмоктуючих установок у гірничо-геологічних умовах «Шахтоуправління «Покровське», застосовувати холодильні установки недоцільно.

Це дозволить знизити економічні витрати на забезпечення нормативного температурного режиму у цих камерах і забезпечити безпечну роботу пов'язану з ізольованим відведенням метану з виробленого простору після виїмки вугілля.

Ключові слова: рекомендації, метан, вироблений простір, температура, провітрювання.