Rational ventilation mode of mountain manufactures in cryolite zone

Aleksandr Galkin

Professor, Doctor of Science
Saint-Petersburg National Mineral Resources University

Abstract
Comparison of different ventilation modes of a face space zone is made for guaranteeing steady condition of a loose part of a face space zone. Introduced calculation methodology for rational temperature parameters and speed of ventilation air flow, combination of these factors gives frozen state of geological material during all sinking cycle.

Key words: VENTILATION, THERMAL CONDITIONS, MOUNTAIN MANUFACTURING, REGULATION, FACE SPACE ZONE, CALCULATION METHOD, FROZEN ROCKS.

Introduction

Great attention is paid to problems of ventilation and air conditioning in buildings and facilities of various types [1,2,3,4,5]. The concerns are related to both intentions to create comfortable working environment and to save energy resources. Underground constructions are not exception, but have their particularity. The comfort of working conditions is closely related to the safety of work. The problem is gaining especial importance when underground facilities are constructed in areas of cryotic soil, because the thermal regime is influencing the stability of the soil. Steadiness of mountain manufacturing in cryolite zone is determined by dependency of strength properties from temperature. Moreover in dispersed mountain rocks this dependency is the governing factor. The problem mostly appears during mountain rock sinking in cryolite zone or during construction in artificially frozen earth. Researches of U.D. Dyadkina, N. G. Trupaka, V.N. Skuba, U.M. Liberman, V.A. Sherstova, G.S. Ushakova and others showed that with help of rational temperature mode it is possible to provide steady condition of frozen rocks both in fast and loose mountain manufactures. In this work there studied regulation scheme and selection method of temperature regime of a mountain manufacture, with help of rational ventilation modes, which allow guarantee frozen state of mountain rocks in a fast part of a face space zone of a mountain manufacture and, therefore increase safety of mountain works [6,7,8].

Problem statement

Scheme of temperature and ventilation adjustments consists of the following. From thermal mode control's perspective the whole sinking cycle is divided into two parts:

1. Ventilation of a face zone by air flow with parameters, that provide comfort work of miners and work of machines and mechanisms accordingly to technical operating rules;
2. After boulder blasting intense ventilation of a face zone by air flow with parameters and duration, that guarantee frozen state of a fast face zone during the whole first stage.

The speed of air flow in a face zone and ventilation duration period of a mountain manufacture should meet norms stipulated by safety regulation.

Main condition of rational selection of temperature regime is maintenance of a temperature less or equal than given during first ventilation stage on a conditional surface of a face zone:

$$(T)_{R=\delta^*} \leq T. \tag{1}$$

By a conditional surface of a face zone implied a surface, which lies on a depth $R_0 + \bar{\delta}*$, where $\bar{\delta}*$ - intense cracked edge layer formed in a result of boulder blasting, which ability to collapse is not dependent from temperature regime. In case of a presence of such layer its temperature on internal surface can be defined by dependencies, which are provided in [7].

Temperature field change of mountain rocks, which is caused by periodical change of temperature parameters of air flow, can be defined by introduction of an average temperature of mountain array term [8]. In this case it is assumed that before next intermittent parameters change of ventilation air flow temperature of mountain rocks has constant value that equals some average temperature by volume, which is limited by radius of temperature influence. With this assumption the problem that should be solved can be formulated as – what value of average temperature of mountain rocks should be by the end of the second phase of ventilation in order to meet the condition of not warming of mine working during the whole first phase (1). For average temperature of mountain rocks was taken volumetric average temperature of mountain array near face zone. By initial time in calculation scheme was taken time of intense ventilation start after boulder blasting, during which mountain rocks are cooling, while before that mountain rocks had constant initial temperature typical for given deposit.

Result analysis

In result of the task solution there were taken the following expression defining temperature field of mountain rocks near face area

$$T_{ox}^{I} = T_e + \left(t_{ox} - T_e\right) f_{ox} \tag{2}$$

where

$$f_{ox} = \frac{B_{iox}\left(\delta_{ox} - 1\right)^3 \left(\delta_{ox} + 3\right)}{4\left(\delta_{\text{пр}}^3 - 1\right)\left[B_{iox}\left(\delta_{ox} - 1\right)^2 + \left(\delta_{ox}^2 - 1\right)\right]} \tag{3}$$

$\delta_{\text{пр}}$, δ_{ox} - values of dimensionless radius of temperature influence in the end of heating and cooling periods respectively; t_{ox} - air temperature in a face zone during cooling period, °C; T_e - initial temperature of mountain rocks, °C; Bi_{ox} - dimensionless number Bio during cooling period.

Temperature of mountain rocks on an artificial surface of a face zone of mountain manufacture by the end of heating period is defined

$$\left(T_{\text{пр}}\right)_{R=\delta*} = T_{ox}^{I} + \left(t_{\text{пр}} - T_{ox}^{I}\right)\bar{f}_{\text{пр}}\,, \tag{4}$$

where

$$\bar{f}_{\text{пр}} = \frac{B_{i\text{пр}}\left(\delta_{\text{пр}} - \delta*\right)^2}{\delta*\left[B_{i\text{пр}}\left(\delta_{\text{пр}} - 1\right)^2 + \left(\delta_{\text{пр}}^2 - 1\right)\right]} \tag{5}$$

$t_{\text{пр}}$ - air temperature in a face zone during heating period, °C; $Bi_{\text{пр}}$ - dimensionless number Bio during heating period.

Expressions (2)—(5) and condition (1) allow to define necessary parameters ventilation air flow and durability of the second ventilation phase, which guarantee steadiness of a fast part of a face zone during the whole sinking cycle with a condition that installation of temporary or permanent support after each cycle by length, which equals to a step of working face advance. After transformation we get:

$$t_{ox} = T_e + \frac{T_{п} - T_e + \bar{f}_{\text{пр}}\left(T_e - t_{\text{пр}}\right)}{\left(1 - \bar{f}_{\text{пр}}\right) f_{ox}} \tag{6}$$

In case installation of a support is done skipping cycle a fast part of a face zone twice undergoes heating and cooling and an expression for air flow parameters definition and time of intense air ventilation has the following form

$$t_{ox} = \left[T_{п} - t_{\text{пр}}\bar{f}_{\text{пр}} - t_{\text{пр}} f_{\text{пр}}\left(1 - f_{ox}\right)\left(1 - \bar{f}_{\text{пр}}\right) - T_e\left(1 - f_{ox}\right)^2\left(1 - \bar{f}_{\text{пр}}\right)\left(1 - f_{\text{пр}}\right)\right] \Big/ \\ \Big/ \left[f_{ox}\left(1 - \bar{f}_{\text{пр}}\right) + f_{ox}\left(1 - f_{ox}\right)\left(1 - \bar{f}_{\text{пр}}\right)\left(1 - f_{\text{пр}}\right)\right], \tag{7}$$

where

$$f_{\text{пр}} = \frac{B_{i\text{пр}}\left(\delta_{\text{пр}} - 1\right)^3 \left(\delta_{\text{пр}} + 3\right)}{4\left(\delta_{\text{пр}}^3 - 1\right)\left[B_{i\text{пр}}\left(\delta_{\text{пр}} - 1\right)^2 + \left(\delta_{\text{пр}}^2 - 1\right)\right]} \tag{8}$$

The value of dimensionless parameters $\delta_{\text{пр}}$ and δ_{ox} are calculated by expression from (3) with corresponding values F_0 and Bi. Result of test calculations by given expressions (initial data: time of intense ventilation $1{,}8 \cdot 10^3$s; first phase duration $14{,}4 \cdot 10^3$ s; $Bi_{ox} = 10$; $Fo_{ox} = 10^{-3}$; $Bi_{\text{пр}} = 1; 0{,}5$; $Fo_{\text{пр}} = 8 \cdot 10^{-3}$; equivalent diameter of a face zone — 3m ; initial temperature of mountain rocks - 5°C) are given in the table.

Table 1. Required air temperature in period of intense ventilation for proving steady condition of mountain rocks of a face zone

Initial data		Value t_{ox} (expression 6)				Value t_{ox} (expression 7)			
Value $t_{пр}$,°C		5,0	4,0	3,0	2,0	5,0	4,0	3,0	2,0
$T_п$ =-4°C	$Bi_{пр}$ = 1,0	-11.7	-7.4	-3.0	+1.3	-30.1	-25.8	-21.4	-17.1
	$Bi_{пр}$ = 0.5	-7.9	10.3	12.2	14.4	-9.4	-7.3	-5.1	-2.9
$T_п$ =-4,5°C	$Bi_{пр}$ = 1.0	-13.6	-10.8	-8.1	-5.3	-23.1	-20.3	-17.6	-14.8
	$Bi_{пр}$ = 0.5	-1.1	+0.3	+1.6	+3.0	-9.9	-8.6	-7.2	-5.8

From the table we can see that air temperature during second phase (t_{ox}) varies in a wide range and depends significantly from air temperature on the first phase and heat emission coefficient. With proper selection of the former ($Bi_{пр}$) adjustment scheme can be used even with positive air temperature (t_{ox}) on the pipe output, which significantly increases capabilities of the offered adjustment method.

From temperature regime adjustment perspective most rational method of ventilation should be such as the one that provides given temperature conditions in a face zone and on the full length of mountain manufacture [9]. From mountain rocks stability and providing mine workers comfort work conditions perspectives ventilation method and air flow parameters should be selected in a manner that guarantees required temperature values on a surface of mountain rocks on each phase of the ventilation. This can be achieved with adjustment of heat emission coefficient values from air to mountain rocks in a face zone, which depends on ventilation method, geometry of a face zone, pipeline diameter and the speed of air flow on its output.

In dependence of heating emission coefficient value can change not only air flow parameters, but a ventilation method as well. It is known, that heating emission coefficient value within upstream ventilation method is lower in a couple times, than within downstream [10]. Its value almost does not depend on ventilation installation productivity (air speed on the pipeline input), thus in this case, when the multiplicity of air renewal in a face zone should be high during the whole first ventilation period, for an instance during the work of diesel equipment it makes rational to apply mixed ventilation method: first phase – upstream, second phase – downstream. In case of necessity maintain positive air temperature in mountain manufacture during two periods, on the second period combined ventilation method should be planned.

Conclusions

Completed theoretical research showed, that with help of rational selection of air flow parameters, particularly temperature and speed, during different periods of sinking cycle, stable state of frozen mountain rocks can be guaranteed even by ventilation with positive temperature air flow during the whole time of existence of a fast part of a face zone. Choice of a rational ventilation method (upstream, downstream or combined) also significantly influences temperature regime formation, stability of mountain rocks of a face zone and requires in each particular case justification of the offered methodology as well as with temperature selection and of air flow speed.

References

1. Gari Pozin, Vera Uljaševa. (2013). Convergence of Numerical Modeling of Heat-Air-Exchange Processes in a Ventilated Room. *World Applied Sciences Journal 23* (Problems of Architecture and Construction), p.p. 117-121.
2. Behzad Rahmani, Mohd Zin Kandar, Parisa Rahmani (2012). How Double Skin Façade’s Air-Gap Sizes Effect on Lowering Solar Heat Gain in Tropical Climate? *World Applied Sciences Journal* , No 18 (6), p. p.774-778
3. Farah Habib, Ensieh Ghorbani Nia, Hashem Hashem Nejad (2012). Evaluation of a Sustainable Lahijan Vernacular Settlement (N Iran) and its Landscape: Architectural Typology and Building Physics. *World Applied Sciences Journal.* No 20 (4), p.p. 527-531.
4. Muhammad Abid, Hafiz Abdul Wajid, Naeem Dad Khan, Saddam Akhtar, Mirza Ahsan Zahid, Muhammad Usman (2013). Optimization of Ventilation System For Existing Environmentally Controlled Poultry Sheds in Pakistan. *World Applied Sciences Journal* No 24 (9), p. 1221-1233.
5. Tamara Dacjuk and Aleksandr Grimitlin (2013). Aeration of Industrial Buildings. *World Applied Sciences Journal 23*

(Problems of Architecture and Construction): p.p. 50-54.

6. Galkin A.F. (2008). Thermal regime adjustment during sinking of mountain manufacturing in frozen rocks. *Industrial safety*, No7, p.p.28-31.
7. Ushakov G.S., Galkin A.F. (1976). Calculation of steady aisle chamber with additional freezing of mountain rocks. *FTPRPI*, No 4, p.p. 18-21.
8. Galkin A.F. (2000) Thermal regime underground facilities of Northland. Novosibirsk: VO Nauka, 304 p.
9. Galkin A.F. (2009). Effective ventilation method of mountain manufactures of cryolite. *Gornyi Zhurnal*, No 4, P.65-67.
10. Fronchek P. Air temperature increment definition in face areas of dead-ends of mountain manufactures in book.: Mineral resources mining. Kiev, 1976. Iss. 43, p.p. 58-61.