Integrated use of mine openings in cryolithic zone

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Abstract
The results of theoretical and practical research on basis of modular type underground facilities design and construction are under analysis. Some mine openings of underground facilities were suggested to use as heat-exchange modules in order to reduce the energy costs for establishment of the thermal condition in the main mine openings. The worn mine openings can be used as heat-exchange modules for producing mines. It was discovered that the inclusion of additional openings in mine ventilation system do not cause the additional costs because the result of costs reduction for the mine air aeration is more efficient than the costs increasing for conditioning of additional openings. Moreover, the heat-exchange module openings can be used as protective shelters for workers and residents in case of natural or man-caused emergency. It is suggested to spread the experience practice of underground facilities design and construction in Sakha Republic (Yakutia) over the whole area of cryolithic zone.
Keywords: MINE OPENING, DESIGN, UNDERGROUND FACILITIES, NORTHERN REGIONS, THERMAL CONDITION, ENERGY SAVING, EMERGENCIES

Introduction

Regardless of the code specification SP-11-107-98 [1] introduction, the necessity and possibility of openings integrated use is not considered while designing of underground facilities in cryolithic zone. Mining projects sections “Engineering and technical civil defensive measures and in an emergency” are of regular and typical nature, which provides neither volume preservation and maintenance of worn openings in case of emergency nor integrated use of openings involved in technical processes of underground facility. The quick changing economic situation and priorities of the country cause the absence of regions administration and industrialists planned nature and interest in maintaining some worn mine openings in proper working order, which can be used as protective shelters in case of emergency, without mentioning the budgeting of these purposes.

Problem statement

In this paper the reasonability of mine openings integrated use of underground facilities in cryolithic zone is substantiated. By this we mean the possibility of openings use both for the intended purpose and as protective shelters for workers and residents in case of natural or man-caused emergencies and accidents. By underground facilities we mean pits, ore mines, underground cold-storage plants, stores, parking areas and other objects both related and unrelated to mining production located under daylight area either totally or partially.

Analysis of recent researches

In distinction from the heartland of Russia, where there are large-sized underground facilities unrelated to mining production, which are considered as the facilities of twofold purpose at the design stage (e. g. underground railway), there are practically no such facilities in cryolithic zone. Special protective underground facilities are designed and constructed, and the use of worn mine openings of going (tied-up) mining companies for workers and residents protection is foreseen. The regional construction norms TSN-31-323-2002 “The underground facilities of mine openings in cryolithic zone of Yakutia” [2] have been developed on the request of the Ministry of Construction and Architecture of Sakha Republic (Yakutia) with the aim of such situation remediation. In these rules exploitation distinctive features of underground facilities in emergency conditions and required design choices are considered. The developed norms consist of the following sections: “The protection and safety of the mine openings objects in case of natural or man-caused emergencies”, “Solutions and organizational-technical measures for underground facilities protection against breakings and natural or man-caused emergencies”, “Construction-engineering and technical solutions for emergencies containment of hazardous underground facilities”. The section “Space-planning and constructive decisions” is the first to suggest to the designing engineers new technological solutions for mine openings integrated use, in particular, for design and construction of modular underground facilities. This design approach is that some openings of underground facilities have twofold purpose while some have only process purpose. At that the twofold purpose openings are under operation in general process scheme at the usual time and can be under standalone operation in case of emergency. At that the intercoupling between twofold purpose openings and simple process openings must be minimal (it is minimized by quality maintenance of specified parameters of underground facilities processing technology), that is not to impair the general processing technology of underground facilities used for the intended purpose. From the economic point of view the main requirement to the twofold purpose openings must be inclusion of underground facilities operating at the usual time in the general process scheme. From our point of view the use of heat-exchange modules as twofold purpose openings is the most reasonable for conditions of the North, where the most of technical processes are distinct in higher energy intensity including thermal control processes. In this case the openings are included in the common system of underground ventilation structure and serve for ensuring of small-scale climate specified parameters. This technical solution allows reducing the energy costs for conditioning by means of efficient use of atmospheric air heat (cold) accumulate by rock formations around the openings. For the energy efficiency increasing of such mine technical systems of thermal control they can be under operation with a special ventilation modes, which also ensure the efficient energy use of return air [3,4,5]. The integrated theoretical researches for the main types of mine technical systems have been conducted. These types are the following: ordinary, recuperative, regenerative, mixed (when recuperative is working as regenerative), and combined including mine openings and borehole collectors. Computations of mine technical systems considered as systems with distributed constants are based on developed and numerically run model for thermal conditions prediction of openings and rocks surrounding them considering moisture phase transformation in rocks. The model includes the following: the rocks property change in time and over a distance, barring variable thermal resistance along the length of opening, the availability of absolute and relative heat generation sources arranged irregularly along the length, seasonal and diurnal temperature variations of outdoor air, etc. For recuperative and regenerative systems we developed the mathematical models based on the use of modern experimental researches methods and the computational mathematics (similarity method, factor analysis, design of experiment, regression and statistical analysis, different systems theory). Particularly, regressional dependence between basic influential system parameters has been obtained on the basis of numerical statistical experiment. It allows previous assessing of design alternatives shortening numerical calculation time. Due to experimental researches the basic

regularities of heat exchange process in mine technical systems of different type have been established and optimum critical characteristic value ensuring minimum energy and economical costs has been substantiated. The comparative evaluation method for economical and energy efficiency of various mine technical systems use has been developed. The particularities of thermal condition generation in underground facilities of various purposes were experimentally explored including the operation in overall and partial isolation mode. The problem simultaneous solution method of air distribution and thermal condition in mine openings network of cryolithic zone has been developed and realized in the form of independent software product [3,6,7,8,9].

The main peculiarity of modular underground facilities ventilation is the possibility of cooperative as well as independent aeration of the main technical models openings and the twofold purpose openings. The complex evaluating heat calculations showed that in case of emergencies it is possible to ensure the small-scale climate specified parameters in protective facilities, which are arranged in twofold purpose openings, within the established time frame keeping to the ventilation and thermal condition of the main technical models. Modular approach can be also used in operating mining companies. As the subsurface mining develops it is necessary to predict the preservation of openings certain volume and their changeover when required with the aim of their further inclusion in general mine ventilation system as heat-exchange openings of twofold purpose. The scientific substantiation of inclusion reasonability of mining companies worn openings in the systems of mine air ventilation and conditioning has been provided and the new methods of northern pits and ore mines thermal control have been worked out considering the possibility of mine openings integrated use. This approach was carried out during constitutional design development of ore mine “Saryilah” JSC “Sahazoloto” due to mining operation changeover to underground mining and ore mine and design development of anhydrite mine JSC “Yakuttsement” due to increasing of production extent.

The special noncombustible hi-tech load-carrying heat protective coatings which are sprayed by dry-mix method and based on concrete binding agent have been developed and introduced for more efficient use of twofold purpose openings. During openings normal operation, such coverings prevent rock formations from drying out, in other words enable to preserve the thermal-physical properties of rock mass within the active layer. During the use of openings for protective purposes, these coverings allow providing comfortable and safe living conditions during the whole normative working service period of facility in emergency condition [3,10,11,12]. The series of technical solutions for twofold purpose openings supports have been developed. The use of these solutions allows ensuring desired level of openings safe operating both in normal and emergency condition. We developed the procedural basis for evaluation and selection of optimum ventilation modes, methods of single network connecting, quantity and geometrical parameters of twofold purpose openings, and other characteristics, which in the aggregate allow obtaining the maximum energetic and economic efficiency from the use of heat-exchange modules in underground facilities[3,4,9,13,14].

Conclusions

The integrated theoretical and experimental long-term researches, including the large-scale natural experiments, allow maintaining that for continuous permafrost zone condition, the most reasonable means for mine opening integrated use both from technical and economical standpoints are design and construction of special heat-exchange twofold purpose modules for new mining companies, and inclusion of the part of redesigned worn mine openings in the mining operation scheme for producing mines. Due to results of researches we managed to show not only principle possibility of integrated use of underground facilities mine openings, but also prove the energy and economic efficiency and legitimacy of this approach to solving the problem of protective facilities construction in continuous permafrost zone over the whole territory of the country.

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