DOI: 10.18454/PMI.2017.3.360

UDC 622.418:622.276.55 (470.18)

SOURCES OF HEATING MICROCLIMATE IN THE PROCESS OF THERMAL MINING DEVELOPMENT OF HIGH-VISCOSITY OIL FIELDS

Mikhail A.NOR[1], Elena V.NOR[2], Nikolay D.TSKHADAYA[2]
[1] *Center of Oil-Titanium Production, OOO «LUKOIL-Engineering», Ukhta, Russia*
[2] *Ukhta State Technical University, Ukhta, Russia*

The paper examines main sources of heating microclimate in order to develop technologies of microclimate parameter normalization in mine workings as a part of thermal mining technology of high-viscosity oil extraction.

Operations under conditions of heating microclimate, whose parameters exceed threshold criteria, can provoke dehydration, fainting and heat stroke among workers. In order to guarantee safe working conditions, provisions are made to introduce norms on threshold values of temperature and humidity parameters, going above which is probable when applying existing thermal mining technologies of high-viscosity oil extraction.

Basing on temperature-humidity survey, a comparative analysis of dependency between air temperature in the producing galleries and their configuration has been performed.

A hypothesis has been suggested that, from the position of temperature limits, the period of efficient service of circular producing galleries is shorter compared to extended panel ones.

***Key words*:** thermal mining development, heating microclimate, temperature-humidity survey, heat emission, underground mining

How to cite this article: Nor M.A., Nor E.V., Tskhadaya N.D. Sources of Heating Microclimate in the Process of Thermal Mining Development of High-Viscosity Oil Fields. Zapiski Gornogo instituta. 2017. Vol. 225, p. 360-363. DOI: 10.18454/PMI.2017.3.360

Introduction. Modern systems of labor protection have a great number of systems and methods improving labor conditions for a wide scope of professions in various sectors, but sometimes these methods have to be implemented in field-specific or experimental enterprises, where normalization of working conditions is complicated by specific character of the technology. One of such technologies is thermal mining development of Yarega area at Yarega oil-titanium deposit of high-viscosity oil (YOTD).

In the process of thermal mining oil extraction from Yarega area, currently carried out by method of single-plane and underground-surface development, one factor of industrial environment is microclimate of mine workings, which is characterized by constantly rising values of temperature and humidity of return air from producing galleries in the operational block. According to data from research on microclimate parameters, temperature values in mine workings, attended by oil mine workers, can reach 45 °C at relative humidity of 80 %.

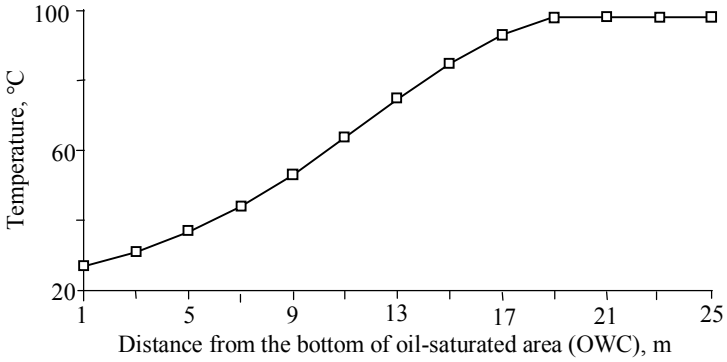
Consequences of working under conditions of heating microclimate include feeling unwell, decline in performance and productivity, as well as heat stroke risk, in certain cases followed by death [12, 13, 15]. Besides, it should be noted that health conditions of workers, subject to such harmful and hazardous effects, deteriorate because of arising dysfunctions of cardiovascular and central nervous systems [7, 9, 14]. With this in mind, temperature limits for microclimate parameters in operational zones have been introduced [2, 4, 6].

The purpose of this research is to carry out comparative analysis of two methods of operational block development – using extended panel galleries and circular ones – from the viewpoint of temperature-humidity characteristics of microclimate.

Research methodology. Analysis of thermodynamic processes, occurring in saturated bedrocks, at this stage is decidedly generalized – in the context of specific academic disciplines. Speaking of conditions at unique deposits, only results of field-specific operations matter, but they can only be obtained in the course of particular object development and for this reason such information is often commercial (i.e. classified).

DOI: 10.18454/PMI.2017.3.360

Modeling of thermophysical processes is carried out for the conditions of mine workings, based on results of research on microclimate parameters of mine air and can produce only a very superficial thermal model, based on statistical data; however, it offers no help in understanding thermodynamical processes.



Temperature changes along the thickness of operational block South-2

Currently there is no complex model of thermal mining development of Yarega field, and forecasts can only be based upon results of statistical processing of research data on microclimate parameters (air-depression and temperature-humidity surveys), compared to modeling data from thermal processes in the oil reservoir (e.g. software module CMG) and technological development processes.

Results and discussions. At present, operational blocks of Yarega area at YOTD are developed using technology of thermal steam treatment of the formation. Application of this method heats the formation throughout, which causes heat emissions into the air of mine workings, located directly in the productive beds [1, 8, 10, 11].

In the course of mathematical modeling of thermophysical processes for this technology three sources of heat emissions have been identified:

1) rock mass;
2) wellhead equipment;
3) outflowing liquid.

At initial stages of development, temperature of extracted liquid can vary across a wide interval (from 35 to 80 °C in the first 2-3 years of block exploitation), whereas heating of the air stream depends on the rates of extracted liquid withdrawal.

Temperature of wellhead equipment varies from the lowest temperature of extracted liquid to the temperature of steam injected into the formation. The influence of wellhead equipment on air temperature directly depends on the number of heated wells.

Due to specific features of the development process, the rock mass (according to field data and modeling) has an uneven temperature distribution across thickness (see the figure), which basically depends on the oil recovery factor [5].

According to the chart (recovery factor = 0.244), when oil recovery reaches 0.8, the formation temperature at the level of producing gallery (3-6 m) will correspond to the equilibrium temperature of heat transfer agent, changing due to diffusive mixing in the interval from 50 to 65 °C at constant injection volumes of the heat transfer agent.

Results of conducted temperature-humidity survey of mine workings in the operational blocks «Panel №1, block 345-North» and «1-T9» have shown that in case of five-fold difference in producing gallery lengths (500 and 110 m respectively) and identical temperature-humidity parameters of intake air, temperature and relative humidity of return air are approximately equal for both cases (deviation – 5 %):

	Panel N 1 block 345-North	Block 1-T9
Intake air temperature, °C	21	20
Intake air humidity, %	14	15
Return air temperature, °C	38	39
Return air humidity, %	33	40
Heat difference from the rock mass, kW/ %	154/64	100/58
Heat difference from extracted liquid, kW/ %	82/34	69/39.3
Heat difference from wellhead equipment, kW/ %	5.1/2	4.7/2.7

DOI: 10.18454/PMI.2017.3.360

Average wall temperature in the workings across the block is approximately 40 °C (38-43 °C).

Thus, obtained data allow to suggest that the heating of the rock mass in case of circular galleries is to a greater extent predetermined by high density of producing and steam-distributing wells, which results in a higher percentage of heated rock area in the overall rock mass, and in case of extended panel galleries – only in rock mass heating across the formation. However, average wall temperatures for both workings are equal, which causes a logical contradiction provided that development period is the same for both cases. Compared blocks have different development periods: 345-North – 10 years (recovery factor = 0.5), 1-T9 – 4 years (recovery factor = 0.24).

Performed analysis allows to suggest that the system of underground-surface development with circular galleries has a «temperature limit» on the direct involvement of personnel in the processes of producing well drainage.

This limit is set at the level of 36 °C for short-term presence of personnel in the operational zone, not more often than 1-2 times per working shift [3].

Reduction of the ventilation stream temperature by increasing the airflow rate has its own limit too – maximum speed of the air stream (6 m/s).

Percentage share of heat emission sources into the air of producing galleries will allow to calculate threshold exploitation period of circular galleries from the position of permissible temperatures in case of constant oil withdrawal rates, which are responsible for the need to apply specific technologies to reduce the temperature in mine workings, applying the technology of thermal mining development.

Conclusion

1. The method of thermal mining development has a significant disadvantage – high air temperature in the producing workings, which can limit applicability area of this efficient technology of extracting hard-to-recover high-viscosity oils.

2. Performed analysis showed advantages of using workings with smaller concentration of producing and steam-distributing wells as related to the length of producing gallery.

3. It is feasible to create a forecasting model of thermophysical processes in mine workings for the case of thermal mining technology of high-viscosity oil extraction, which will account for increased complexity of process modeling for Yarega deposit.

REFERENCES

1. Arens V.Zh., Dmitriev A.P., Dyad'kin Yu.D. Thermophysical Aspects of Subsoil Resources Development. Leningrad: Nedra, 1988, p. 336 (in Russian).

2. Dyad'kin Yu.D., Shuvalov Yu.V., Gendler S.G. Heat Processes in Mine Workings. Leningrad: LGI, 1978, p.104 (in Russian).

3. Safety Regulations for Mining Development of Oil Fields. Moscow: KhOZU Minnefteproma, 1986, p. 228 (in Russian).

4. SanPiN 2.2.4.548-96. Physical Factors of the Industrial Environment. Hygienic Requirements to Microclimate of Industrial Facilities. Sanitary Regulations and Standards. Moscow: Informatsionno-izdatel'skii tsentr Minzdrava Rossii, 2001, p. 20 (in Russian).

5. Buslaev V.F., Konoplev Yu.P., Yagubov Z.Kh., Tskhadaya N.D. Thermal Mining Development of Oil Fields. Ed. by N.D.Tskhadaya. Moscow: OOO «Nedra-Biznestsentr», 2006, p. 288 (in Russian).

6. Tskhadaya N.D. Complex Assessment of Labor Conditions in the Oil Mines in the Process of Thermal Steam Treatment of the Formation. St. Petersburg: Izd-vo SPbGU, 1997, p. 120 (in Russian).

7. Chebotarev A.G., Afanas'eva R.F. Physical and Hygienic Assessment of Workspace Microclimate in Mines and Quarries and Measures to Prevent Its Harmful Influence. *Gornaya promyshlennost'*. 2012. N 6, p.34-40 (in Russian).

8. Aziz M., Bories S.A., Combarnous M.A. The influence of natural convection in gaz, oil and water reservoirs. Petrol. Soc. Can. Inst. Mining, Calgary Pap. 8242. 1972, p.32.

9. Brake D.J. The Deep Body Core Temperatures, Physical Fatigue and Fluid Status of Thermally Stressed Workers and the Development of Thermal Work Limit as an Index of heat Stress: School of Public Health Doctoral Dissertation. Curtin University of Technology. Australia, 2002, p.294.

DOI: *10.18454/PMI.2017.3.360*

10. Hunt A.P., Parker A.W., Stewart I.B. Symptoms of heat illness in surface mine workers. *International Archives of Occupational and Environmental Health*. 2013. № 85 (5), p.519-527. DOI:10.1007/s00420-012-0786-0.

11. Jeffrey R. Experience and results from using hydraulic fracturing in coal mining. Proceedings of the 3rd International workshop on mine hazards prevention and control. Brisbane. 2013, p. 110-116.

12. Lees F. Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control. Butterworth-Heinemann, 2012, p.3776.

13. Lemke B., Kjellstrom T. Calculating workplace WBGT from meteorological data: a tool for climate change assessment. *Industrial Health*. 2012. N 50, p.267-278.

14. McPherson M.J. Subsurface Ventilation Engineering. London. 2012. URL: https://www.mvsengineering.com/files/Subsurface-Book/MVS-SVE_Chapter17.pdf (date of access 15.02.2017).

15. Vatanpour S., Hrudey S.E., Dinu I. Can public health risk assessment using risk matrices be misleading? Int. J.Environ. Res. Public Health, 2015. N 12, p.9575-9588. DOI:10.3390/ijerph120809575.

Authors: **Mikhail A.Nor**, *Engineer*, *Mikhail.Nor@lk.lukoil.com* (*OOO «LUKOIL-Engineering», Center of Oil-Titanium Production, Ukhta, Russia*), **Elena V.Nor**, *Candidate of Engineering Sciences, Associate Professor, Head of Department*, *enor@ugtu.net* (*Ukhta State Technical University, Ukhta, Russia*), **Nikolay D.Tskhadaya**, *Doctor of Engineering Sciences, Professor, Rector, info@ugtu.net* (*Ukhta State Technical University, Ukhta, Russia*).

The paper was accepted for publication on 24 March, 2017.