Journal of Engineering and Applied Sciences 13 (7): 1621-1623, 2018
ISSN: 1816-949X

Research of the Dynamics of Cryogenic Processes in Man-Made Deposits Presented by Dressing Plant Waste

Kaerbek Rafkatovich Argimbaev
Saint-Petersburg Mining University, 21 Line V.O., 2, 199106 St. Petersburg, Russia Federation

Abstract: Improvement of methods and technologies of dressing plant waste storage during man-made deposits formation is an urgent task today in conditions of subsoil complex use in areas with low temperatures. This study presents, the results of researching cryogenic processes at various depths of freezing that occur in man-made deposits. The results obtained can provide an assessment of formed man-made deposit dams stability as well as the bearing capacity of a man-made deposit surface when it is involved in development.

Key words: Man-made deposit, cryogenic processes, temperature, cryogenic inclusions, tailings, stability

INTRODUCTION

Accidents at mine-engineering facilities including tailing dumps (man-made deposits), happen in different countries almost every year and consequences of these destructions speak for serious risks for people, engineering constructions and elements of the environment (Danilov *et al*., 2015).

In this regard, construction and maintenance of upstream tailing ponds in the safe mode with the least accident risk is of increasing importance and requires planning and taking actions aimed at risk reduction and increase in stability of a man-made deposit in the shortest time possible. The stability may be related to technological peculiarities of dams erection and construction (Kholodjakov and Argimbaev, 2014; Filatov *et al*., 2015).

There are necessary technical capabilities for fast adjustment of parameters that determine the thermal state of the slurry: dimensions of alleviation maps, the direction of flow spreading, etc. in case of formation of man-made deposits with high flow rates of slurry, its low density (the ratio of Solid (S): Liquid (L) phase is below 1:15) and an insignificant length of the above-water beach (up to 100-150 m).

However, the pond can be at a significant distance from the protecting dam edge during operational build-up of tailing dumps, especially, when it comes to storage of iron-and-steel industry dressing plant tailings (Argimbaev and Kholodjakov, 2015). In addition, the craving for the use of energy-saving efficient schemes for tail facilities leads to an increase in the S:L ratio and a corresponding increase in the density of slurry fed to the beach. The specific nature of the Winter hydraulic fill under these conditions is based on the possibility of suspension-bearing flow supercooling when it reaches the pond and as a result, formation of frost and cryogenic inclusions within the above-water beach.

Assessment of such tailing dumps stability, issues related to the management of erection and operation of upstream man-made deposits, taking into account the forecast of the directionality of cryogenic processes in a washed tail mass generate an independent actual task of great scientific and practical importance (Argimbaev, 2016; Loganina *et al*., 2016).

MATERIALS AND METHODS

Methods and the object of study: The directionality of cryogenic processes was evaluated based on the results of engineering and geological surveys as well as numerical simulation of heat conduction problems.

The analytical forecast was based on the results of field studies of tailing dump temperature and hydrothermal regimes as well as conditions for heat exchange between the beach and the atmosphere. The following single-dimensional heat conduction problems were solved: the thermal effect of the tail layer of the tailing pond washed above the design level of filling and assessment of the average rate of frost degradation in the area of the filtration flow.

The tailing pond of Kachanarsky Mining and processing combined research is located in an area with a sharply continental climate. Absolute maximum air temperature (+36°C) falls on July, minimum (-52°C) falls on December. The annual volume of tailings impounding is 30 million tons or 16.7 million m^3. The annual pulp output is 320 million m^3/year with an average consistency of 1:9. The primary coastal bund wall which is 3-5 m high was made by a hydraulic fill method from local soils. After that, it was built up to a height of 60 m by an operational method layer by layer with the help of tails edge washing without the trestle. Washing is held depending on the season according to the following two schemes: during the period of stable positive air temperatures, a lateral prism of the tailing dump is built up and a beach slope of

1:40 is formed; at a negative air temperature, tailings are stocked by pulp discharge from the end of pipes with a diameter of 1,000 mm, taken outside the lateral prism by 150-250 m from the axis of the embankment dam. At the same time, the length of the above-water beach is up to 700-1000 m.

The structure of the dam is characterized by an extremely heterogeneous stratum composed of interbedded thawed and frozen deposits of tails and ice. Frozen layers and ice are not extended along the strike and their typical dimensions are 100-300 m (length) and 1-5 m (thickness). The content of cryogenic inclusions increases as the distance from the dam to the crest increases, reaching the maximum value of Λ = 0.4-0.6 (the ratio of the total capacity of cryogenic inclusions to the total depth of the stratum of washed deposits explored by the engineering and geological research) at a distance of 400-500 m.

RESULTS AND DISCUSSION

The results of thermometric observations across the tailing dump depth are shown in Fig. 1, in the form of a thermogram combined with the lithologic column of the exploratory well.

Almost, similar temperatures of frozen and thawed tails reflect the presence of sluggish frost with a temperature close to the temperature of the phase transition. At depths below 7-10 m, the temperature range varies from -0.5 to -0.4°C.

It was calculated that within the crest and the training berm where Summer washup scheme is used, tails are significantly heated the process of degradation of the underlying frost takes place; the more intensive it is, the thicker the annual layer increase and the lower the total moisture of frozen sediments.

Depending on these factors, the rate of zero isotherm movement downwards can vary from 1-7 m/year. At beach areas where Winter tailings washup takes place, the phase state of the material does not change and its temperature practically retains its negative values. Moreover, it was found that under certain conditions complete freezing of unfiltering dam sections is possible. These conditions include, for example, Winter washup conditions with an effective thermal insulation of the beach at a positive air temperature.

The spatial stratification of the filtration flow experimentally established by means of hydrothermal studies was taken into account. Stratification sections of the in the vertical direction are confined to tails interlayers in different physical condition and are characterized by temperatures differences up to 7-8°C at flow depths of 8-20 m.

The temperature of the filtration flow varies from 0-2°C (pre-pond area) to 14-16°C (the crest and the bottom slope of the dam) along the filtration flow. The filtration flow in the area of the lateral prism has the greatest influence on the dimensions of the thawing layer. Its temperature is much higher than the temperature of water in the pre-pond area due to feeding by

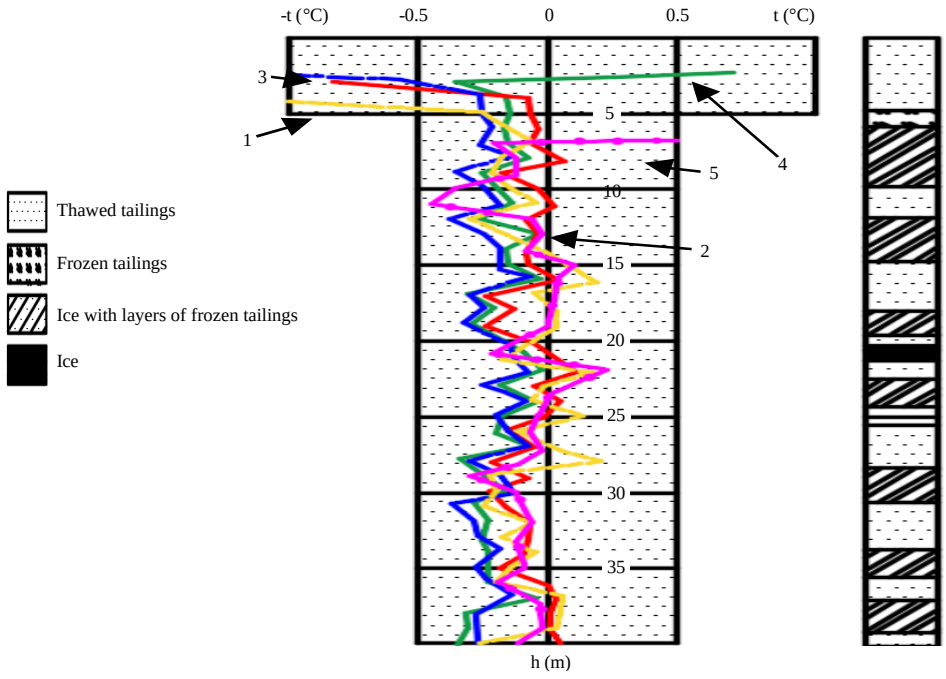

Fig. 1: Geothermograms of washed up tailings at various observation periods 1-5

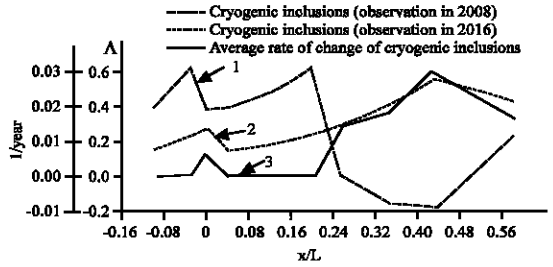

Fig. 2: The relative content of cryogenic inclusions Λ and the average rate of their change ξ along the above-water beach: 1: line of cryogenic inclusions (observation in 2008); 2: line of cryogenic inclusions (observation in 2016); 3: line average rate of change of cryogenic inclusions

warm infiltration waters. This shows that the prevailing direction of frost degradation is from the dam crest to the pond.

Quite a low total rate of ice-rich tailing deposits thawing (W = 40%) due to the thermal impact of the filtration flow in the pre-pond area and the area of the lateral prism equal to about 1 m/year was received.

The obtained regularities are confirmed by the results of engineering and geological surveys-re-drilling of the same-name wells in the period from 2008-2016.

The most characteristic wells were selected as duplicates both from the point of view of their location (on the slope, the beach and pre-pond area) and the number of cryogenic inclusions. In total, 11 duplicated wells were drilled. About 10 of them were drilled with a calculated time interval of 7 years and one of them with an interval of 3 years. Corresponding values Λ were calculated for each pair of wells. They characterized the relative content of frost and ice below the mouth of the duplicated wells at the moments of initial and repeated drilling as well as the average relative speed of thawing (freezing) of cryogenic inclusions over the period of research $\xi = \Delta\Lambda/\tau$. Changes in values Λ and ξ along the above-water beach at the time of repeated drilling are shown in Fig. 2.

CONCLUSION

The analysis of the obtained results made, it possible to distinguish three characteristic sections in the cross section of the tailing dump, differing in the direction and the rate of development of frost processes.

The outer slope of the dam and the beach area on a relative length of x/L = 0.20-0.24; value A is almost equal to zero within this area, it reflects a complete degradation of the pre-existing frost (ξ = 0.02-0.03/1 year). The central beach area (x/L from 0.24-0.50) with a high content of cryogenic inclusions which phase state almost does not change over time (Λ = 0.28-0.6; ξ≤0). The pre-pond area of the tailing dump (0.5≤x/L<0.7) is characterized by an insignificant heating effect of the pond (Λ = 0.45-0.34; ξ = 0-0.1 1/year).

The established regularities of cryogenic processes development were used to justify the possibility of an additional build-up of the tailing dump at a height of 30 m above the design elevation. Despite the decreased rate of tailing dump capacity utilization, the research confirmed the possibility of applying the technology of year-round storage of ore wastes.

REFERENCES

Argimbaev, K.R. and H.A. Kholodjakov, 2015. Erection methods and constructions of primary tailing dike. Intl. J. Ecol. Develop., 30: 47-54.

Argimbaev, K.R., 2016. Simulation of a geomechanical monitoring algorithm for open-pit mining. Res. J. Appl. Sci., 11: 811-815.

Danilov, A.S., U.D. Smirnov and M.A. Pashkevich, 2015. The system of the ecological monitoring of environment which is based on the usage of UAV. Russ. J. Ecol., 46: 14-19.

Filatov, V.I., I.S. Ilya and Y.L. Svetlana, 2015. Analysis of the existing technologies for heat and power application of waste. Res. J. Appl. Sci., 10: 505-508.

Kholodjakov, H.A. and K.R. Argimbaev, 2014. Waste storage feasibility of concentrating mill in overburden dumps. World Appl. Sci. J., 30: 738-740.

Loganina, V.I., J.P. Skachkovb, O.V. Tarakanovc and J.G. Ivaschenkod, 2016. Evaluation of the destruction of the coating depending on its thickness. Res. J. Appl. Sci., 11: 891-893.