# HYDRAULIC AND GEOLOGICAL ASPECTS OF COAL MINES CLOSURES IN RUSSIA

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The restructuring of the coal mining enterprises of Russia have been carried out from the early nineties. The main purpose of the restructuring was to transform the coal mining industry into one of the highly profitable and competitive branch of the industry.

During the last five years 96 of non-profitable or having no prospects for economical production coal mines were closed. The low efficiency of their work was depending mainly upon the state of the raw materials bases, primarily the quality of coal reserves, concentrated into the seams with unfavourable natural conditions for their mining.

The existing experience show that the closure of unprofitable coal mines exerts a heavy impact on the changing of the hydraulic, geological and ecological situation.

In most cases the closure of the coal mines is accompanied by their flooding and restoration of the hydro dynamic balance of underground waters closer to the natural. An exhaustion of underground waters is ceased, the natural water table and streams are restored. The disposal of waste mine waters into the river systems is sharply reduced.

The flooding of coal mines is also resulted in the restoration of the natural gas dynamics balance and in repeated reductions of methane and $CO_2$ outbursts into the atmosphere.

As the results hydrogeological and ecological situation in coal mining regions are on the whole improved.

But at the same time the negative consequences of coal mines closure determined by joint natural and industrial factors, specific in different coal fields, are clearly manifested.

There are also the negative consequences of the coal mines closure, which are stipulated by combination of natural and technological factors specific for each coal field. The main general consequence of such situation is the threat of partial flooding of residential districts and industrial buildings and premises as the result of the raising of mine waters and their effuse in the lower portions of the earth surface and the bottom lands of the rivers. Such partial flooding and swamping are mostly widespread in Kuznetzk and Donetzk coal fields as well as in the Far Eastern region of the Russia.

For forecast and prevention of undesirable consequences of coal mines closure "The methodical directives on evaluation of hydraulic and geological aspects of coal mines closure, validity of measures for underground waters behaviour control and assuring of the environment protection" have been prepared by specialists of academic and industrial scientific and research institutes. These "Directives" were adopted and put into effect by the Ministry of Fuel and Energy in 1997.

The requirements for the complex evaluation of hydrogeological conditions for flooding of separately located coal mines, individual or in groups, as well as adjacent to working coal mines and main information ensuring the reliability of such evaluation are included in this document.

The discharge of mine waters onto the earth surface and partial flooding are the results of alignment of water levels into the worked out area of the mine and the rise of supplementary mine water heads in the lower areas of the earth surface, exceeding natural levels of underground waters. In some cases it is necessary to resettle the local population. In particular, during the Pioneerka coal mine flooding (in Kuzbass coal field), it has been necessary to relocate the inhabitants from the residential houses in Belovo city, located in the bottom land of the Bachat river. It was envisaged in the project of the coal mine closure to relocate citizens from the blocks of the city with raised water level and partially flooded.

There are cases of partial flooding of industrial premises. During the flooding of Ordjonikidze coal mine in Kuzbass the danger of partial flooding of the territory of Kuznetsky Steel Plant was raised.

During the mass closure of coal mines in Donbass the serious problems of partial flooding of site areas of different cities were raised

The largest problem was occurring during the closure of group of coal mines, which are hydraulically interconnected. This can lead to the outflow of mine waters on the surface in the volume up to several hundreds of cu. m per hour (Donetzky and Kyzelovsky coal fields). The presence of hydraulic interconnection between coal mines lead to the possibility for greater pollu-

tion of surface waters due to outflow of mine waters from the lower horizons onto the earth surface (Figure 1).

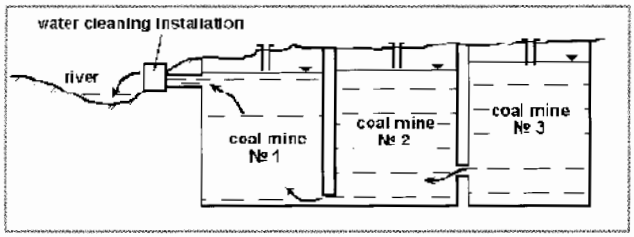


Figure 1. Schematic diagram of pollution and cleaning of mine waters.

For the coal mines of Donbass, characterised by arid climate and limited water resources, high pollution of the mine waters, having mineralisation up to 6 g per litre, exclude the direct effusing them in great volumes into the river system without preliminary cleaning.

The pollution of surface and underground waters by acid mine water is most sharply revealed in the Kyzelovsky coal field. The causes of such pollution are natural (pyrite oxidation) and technological (hydraulic interconnection of coal mines at deep horizons). The outflow of large volumes of highly mineralised (from 3 to 15 g per litre) acid water with pH = 2.5 – 3 require construction and permanent functioning of the system of installations for treatment and cleaning of mine waters.

The problem of pollution of underground waters – sources of potable water supply is manifested at the coal mines in the Moscow brown coal field. The pollution of underground waters is promoted by flat and lightly inclined bedding of coal seams, little depth of mining works resulting in damage of the water-bearing horizons, which are the main sources of urban water supply.

The flooding of the coal mines create the danger of sudden inrush and high effusion of water into adjacent coal mines and for this reason it is necessary to fulfil special safety measures and reconstruction of the system of water pumping out at the active mines.

During the flooding of coal mines the mine gas is forced out on the surface. As a result it can be noted cases of gas accumulation in the basements and at ground floor of houses, leading to poisoning of people and sometimes to their death.

As a preventive measure against the negative consequences of coal mines closure in the corresponding plans advancing forecasts of the changes in the hydrodynamic conditions and measures to be taken to ensure the industrial and environment safety. Such measures are included: total or partial pumping out mine water, organisation of natural or controlled (by self-effusive boreholes) exhaustion of mine waters onto the earth surface with subsequent their treatment and cleaning, construction of water-tight and infiltration stoppings in the mine workings, anti-filtrating screens, controlled gas release from the possible traps and others.

With the danger of raised head of mine water and partial flooding of areas in the lower parts of the surface in the zones of worked out coal seams outcrops, in the plans for coal mines closure it is envisaged the drilling of self-effusive boreholes, construction of the drainage ditches for controlled interception and diversion of mine water. At the high degree pollution of mine waters and large volumes of their outflow .it is envisaged the construction of water treatment and cleaning installations and system for acid mine waters neutralisation.

In the separate groups of coal mines in Kyzel coal field the outflow of highly mineralised and acid mine waters will be reached 500 cu.m per hour and even more. For treatment and neutralisation of mine waters it is envisage to use polyacrylamide and lime. In general, for Kyzel coal field the volume of water treatment can be characterised by the yield of extracted from mine waters the hydroxide sediments – 200 t per day. The main components of those sediments are salts of iron, aluminium and accompanying heavy metals.

At some coal mines being under closure it is necessary to sustain the water exhaust or to ensure the lowering level of flooding by use of submersible pumps. Such methods of coal mine closure are used in the cases with unsecured or broken barrier pillars on the boundary with adjacent active mine, if the later have any reserve in pumping water out and if it is impossible to receive the supplementary inflow of water. The united pumping installations are constructed for the hydraulically interconnected coal mines in Prokopievsko-Kiselevsky region of Kuzbass and in Donbass coal field. Supporting of the lowered level of coal mine flooding is used in circumstances when it is a threat of partial flooding of residential districts and industrial premises.

To prevent the abnormal overreffusings of water among the coal mines the construction of water-tight barrier or stoppings into the workings connected adjacent coal mines or separate worked out coal seams. The stoppings or filtrating filling of the mine shafts are used to limit abrupt changes of water level into vertical shafts, induced by tectonic shoves or rock bursts, sudden settlings of hanging rocks in the filled adjacent shafts, water inrushes from overlying horizons, releases of mine gases left in workings in the result of stopping crushing or caving of roof which hamper the free exit for gas.

At the coal mines in Donbass the method of prevention of water inrushes into adjacent coal mines or into more profound mine workings on other coal seams by the construction around mine shafts the plugging anti-leakage screens made from argyle-cement hardening mixtures. Such screens are constructed at the coal mines in Novoshakhtinsk and Shakhtinsk coal regions. Their construction give the possibility to protect the working into the deeply bedding coal seams against serious water inrushes from the above-lying workings of adjacent coal mines which are under closure.

To control the gas emission at the places of its possible accumulation, the gas exhaust boreholes are drilled into the goaf (worked out area) of the coal mines. Simultaneously, the systematic control of gas concentrations must be organised in the zones dangerous by gas emissions into the atmosphere as well as in basements of the houses.

The compulsory constituent of each plan for coal mine closure is the program of hydrogeological and ecological monitoring. The monitoring program is based on prognosis of negative consequences of coal mine closure and measures for their prevention. This program include the control of coal mine flooding level, sites and volume of coal mine outflow on the earth surface, its inrush into the adjacent coal mines, degrees of pollution of the mine, underground and surface waters, measurement of gas concentrations at the sites of its possible emission on the earth surface. To ensure the appropriate control it was created the network of observation boreholes in which the sampling of gas and water for comprehensive chemical and bacterial analysis was done. The basic significance of monitoring is to ensure the industrial and ecological safety during the process of coal mine closure.

It is necessary to refer the resent accident at the Glubokaïa coal mine in Donbass, which has been under closure with partial flooding. This accident has not any precedent in coal mining industry. It is an example of dangerous interaction of two media – water and mine air, blocked in the workings of the closed coal mine.

During the Glubokaïa coal mine closure it was envisaged for prevention of possible water overflow into adjacent Oktyabrskaïa Revolutzia coal mine in the volume of 1500 cu.m per hour to construct the stationary pumping installation on the level – 241 m, between the cage and skip shafts (Figure 2). The shafts with the depth of 765 m each are located at a distance 60 m between them. At the date of accident – 07.06.99,- gradually rising in both shafts water reached the level – 290 m. At the levels – 247 m and – 241 m the shafts were connected by horizontal workings. The lover one sert as a sump, the upper - as a pump chamber in which the pumps for maintaining stable level of mine waters have been assembled (Figure 3).

Up to several months before accident, during the flooding of the pump chamber at – 610 m level, beneath arch of the working mine air with initial volume about 1000 cu.m has been closed. With gradual rise of water level into both shafts on the average of 0.7 m per day the increasing pressure compress air and at the moment of the accident the pressure has been reached 32 kg per sq.cm. In the same time in the earlier filled mine shaft, located at the distance of 330 m from the above mentioned shafts, the caving of hovering rocks has been happened. This leads to the hydraulic bump contributing to press out the air "bubble" from the pump chamber through inclined passageway into the cage shaft. Raising through the water

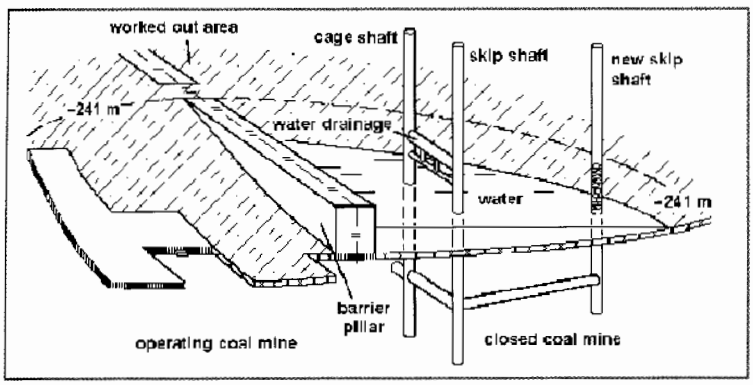


Figure 2. Control of the clogging at the Glubokaïa coal mine.

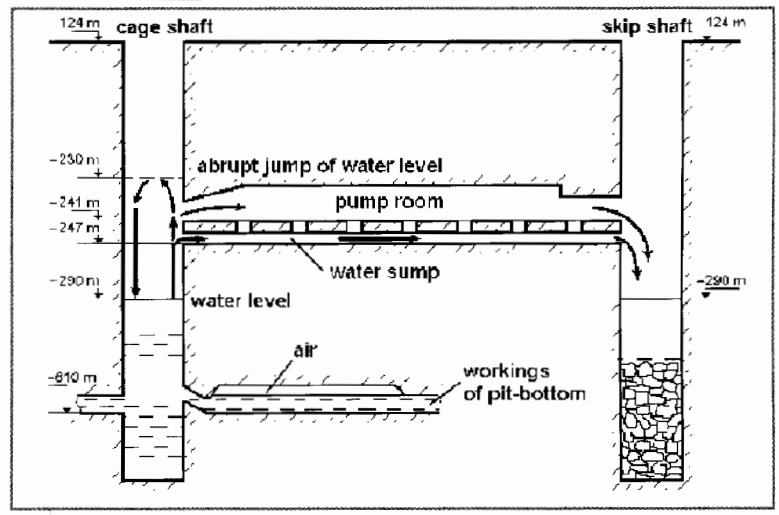


Figure 3. Schematic drawing of the place of accident at the Glubokaïa coal mine.

along cage shaft this "bubble" has been increasing in volume, filling out the total cross-section of the shaft, tear off the part of the water column and push it out on the height of about 60 m. Simultaneously, the stream with high cynetic energy has been directed into the horizontal workings, connected the cage and the skip shafts, deforming the mine support, bending rails, moving two mine cars in the direction to the skip shaft at the distance of several tens meters, rejecting the welding apparatus, washing out three mine workers into the skip shaft. Two of the workers have been perished and only one worker has been saved.

The time span of this accident was not more then several minutes and the water was sinking into the skip shaft. By the measurements carried out only after some hours after accident it was noted, that the previous level of water into the shafts was restored and its raise has been continued with the same speed as before an accident.

The analyse of this accident show that it is preferable to use in such cases submersible pumps, excluding the permanent presence of the workers into the coal mine. Moreover, it is necessary to organise special control for the total evacuation of mine air from the flooding mine workings.

To rise the safety of continued work on the reconstruction of the drainage system at the Glubokaïa coal mine it is planned to accomplish the partial filling of the cage shaft with the large size broken highly filtrating materials in view to suppress the unforeseen hydrodynamic burst. It is envisaged to drill from the surface into the pump chamber of the pit-bottom at the level –610 m the directed borehole to release the possible residual volume of mine air.

In conclusion it is necessary to note that with diversity of combinations of natural and technogenous factors determining the consequences of coal mines closure it is possible to choose coal mines without negative effect of their closure, which can be theoretically used for storage different products and certain wastes. Among this are coal mines of Far North, located in the zone of permanent froth, as well as the deep coal mines in other regions, having in overburden cover mostly clays and argillites with absence of hydraulic connection of the worked out areas with surface and underground waters at shallow depths.