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RESULTS FROM DEALING WITH ROCK AND GAS OUTBURST PREVENTION IN THE CZECH REPUBLIC

EFEKTY DZIAŁAŃ MAJĄCYCH NA CELU ZAPOBIEGANIE WYBUCHOM SKAŁ I GAZU, PODEJMOWANYCH W REPUBLICE CZESKIEJ

In the Czech Republic, the prevention of rock and gas outbursts is carried out in the course of driving mine workings in seams and in sandstone and conglomerate beds classified into a category with the highest degree of rock and gas outburst hazard. It is a case of active methods that aim at prevention of rock and gas outbursts by creating a protection zone in front of and in sides of mine workings being driven and passive methods that mitigate the effects of outbursts (Hudeček et al., 2009, 2010).

In this article, authors present recommendations and proposals for changes in rock and gas outburst prevention. These proposed changes should reflect in increased efficiency in coping with this anomalous geomechanical events.

Keywords: Outburst prevention, coal, gas mixture, gas pressure, boreholes

Działania w celu zapobiegania wybuchom skał i gazów w Republice czeskiej podejmowane są już na etapie drążenia wyrobisk w złożach oraz w piaskowcach oraz w pokładach zlepieńców sklasyfikowanych jako lokalizacje o najwyższym stopniu zagrożenia wybuchami skał i gazów. W tym przypadku mamy do dyspozycji metody aktywne, których celem jest zapobieżenie wybuchom skał i gazów poprzez stworzenie strefy ochronnej w części czołowej i bocznych częściach wyrobiska oraz metody bierne, mające na celu złagodzenie skutków wybuchu (Hudecek et al., 2009, 2010).

W artykule autor rekomenduje i zaleca dokonanie pewnych zmian w systemie zapobiegania wybuchom skał i gazów. Proponowane zmiany skutkować powinny zwiększoną skutecznością działania w przypadku wystąpienia zjawisk geomechanicznych uznawanych za anomalie.

Słowa kluczowe: zapobieganie wybuchom, mieszanina skał i gazów, ciśnienie gazu, otwory

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Introduction

In the field of prevention of coal and gas outbursts, any substantial changes in the principles of specific methods cannot be expected in spite of the fact that, from the technical point of view, the long-term stagnation of the methods, with the exception of the method of seam water infusion utilizing boreholes, is evident.

Prevention methods are based on:

- reduction in the pressure of gases in the rock mass by degasification or by effective influencing by overlying workings,
- creation of protection zones especially by blasting operations or stress relief boreholes, capture of gases in the pores of rocks by means of high-pressure water injection.

1. Coal and Gas Outburst Prevention

1.1. Active Methods

1.1.1. Prevention Method Utilizing Seam Water Infusion

For the implementation of a prevention method utilizing the infusion of water into seams, it is suitable, in the framework of a new Czech legislative standard, to use a technology of high pressure group water infusion as a set of measures carried out from development gates ahead of the advancing gate. Altogether, the efficiency in the implementation thus increases as a result of significantly better covering of the area into which water is infused by introduction of electro-hydraulic drilling rigs and flexible spiral drill rods and as a result of controlled high-pressure water injection into the seam in a rather large area in one cycle.

With reference to the existing negative experience of additional infusion of water (so-called "frontal" infusion) usually done from the space of the face in those areas that are not covered by water infusion boreholes drilled from face gates, we do not recommend the application of this prevention method any longer and recommend the replacement of it by other prevention methods. The basic reason is that this method of water infusion is not implemented through sealing stemming plugs of sufficient length, and thus water always runs away through cracks into the coal face. In these cases, the prevention measure is regarded as realized, but in reality (with regard to the defined water infusion requirements) it has not been carried out.

1.1.2 Degasification Method

Another prevention method that is suitable for use (need to be included in Czech legislation) is a degasification method. This method is commonly applied in the course of exploitation of coal faces and leads to a reduction in gas pressure in associated rocks above the faces. The method is used owing to the low permeability of the environment that is caused by stress-deformation changes induced by mining operations. The same effect can be achieved in the seams where structural-tectonic anomalies occur. In areas adjacent to the structural-tectonic anomalies, the gas permeability of the seam is always of the higher order and the degasification will be functional here; it means that the gas pressure in the zone in front of the mine working being driven will be reduced regardless of changes in the stress field in the rock mass. The system of degasifica-

tion boreholes, i.e. the layout and the number of the boreholes in these conditions cannot be determined according to a uniform scheme without considering variability in the position of the structural-tectonic anomalies. In the Czech legislation, the preparation of projects, corresponding to specific conditions, for individual cases should be prescribed (Hudeček & Pintzker, 2003; Hudeček et al., 2010; Chlebowski, 2009).

1.1.3. Method Utilizing "Break-free" Blasting Operations in Associated Rocks

In connection with the fact that areas negatively affected by increased stresses will always occur in the rock mass as a consequence of its complicated structural-tectonic conditions and as a consequence of mining operations performed there earlier, it seems necessary to include "break-free" blasting operations, carried out in associated rocks in seam roofs, in the active preventive measures. In this case, the purpose of "break-free" blasting operations is to release increased stresses in the areas that are predisposed like that (Hudeček, 2008, 2009; Skoczylas, 2012).

Because conditions for the execution of "break-free" blasting operations will vary from case to case, the implementation of this method based on individual projects, prepared for each case individually and reviewed by expert organisations, should be enabled by the Czech legislation.

1.2. Strategic Methods

In addition to the above-mentioned methods (active prevention), strategic methods, which are not part of existing Czech legislation solving the problems of rock and gas outbursts, should be accepted as well.

From the previous experience that is analysed in detail in Stage 3 of the science-research project No. 57/07 and that proves the influence of additional stresses on the occurrence of coal and gas outbursts, it appears to be suitable to include also the principles of driving of mine workings in seams endangered by coal and gas outbursts in new Czech legislation minimally to the extent defined in the conclusions of Stage 3 (Hudeček et al., 2009, 2010) as given below:

Mine workings should be driven in areas influenced favourably by the existence of mine workings, i.e. in the protected areas, where stresses acting in the rock mass are lower than the primary stress. If this cannot be ensured, then in the areas where the initial stress acts.

Long mine workings are to be planned and driven lest they should lead to the formation of pillars in the vicinity of abandoned areas and structural-tectonic elements; the pillars being below the size limits and in the limit state of stress.

The mining out of end faces should be planned so that the length of them may be really large, without pillars that are below the size limits and are situated in the zone in front of the faces; the pillars are most frequently designed for achieving the maximum productivity of machinery.

1.3. Passive Methods

In addition to these proposed changes in the active measures to prevent coal and gas outbursts, other passive measures should be included in the Czech legislation as well. This means that a set of activities, measures and equipment mitigating the effects of outbursts should be defined. Besides the passive measures determined earlier (e.g. emergency signalling, mercaptan signalling, inducing an outburst in the absence of people, etc.), other measures should also be

included. What is meant is the selection and the type of supports, the stabilization of weakened parts of the rock mass by means of grouting and anchorage, the method of support of faces in the course of implementation of active preventive measures, the remote control of machines and the protection of a crew against mechanical effects of an outburst and against an unbreathable environment, and reduction in the number of employees in endangered areas.

2. Sandstone, Conglomerate and Gas Outburst Prevention

2.1. Active Methods

With reference to the fact that mine workings in the Czech Republic's mines have not been driven in thus predisposed zones on a long-term basis, any practical experience in dealing with prevention is not available.

In the framework of legislative changes, the following three prevention methods that can be applied individually as well as in combination with each other are proposed for sandstone, conglomerate and gas outburst prevention:

- "break-free" blasting operations in beds classified into a category with sandstone, conglomerate and gas outburst hazard,
- infusion of water into beds classified into a category with sandstone, conglomerate and gas outburst hazard,
- degasification of beds classified into a category with sandstone, conglomerate and gas outburst hazard,
- combined prevention method utilizing water infusion into and degasification of beds classified into a category with sandstone, conglomerate and gas outburst hazard (2 variants), and
- combined prevention method utilizing "break-free" blasting operations in and degasification of beds classified into a category with sandstone, conglomerate and gas outburst hazard (2 variants).

With regard to the fact that conditions (structural-tectonic conditions of the rock mass and overburden, mining conditions, lithological structure, etc.) will generally vary from case to case, the sandstone, conglomerate and gas outburst prevention cannot be regulated in the Czech legislation according to a uniform scheme. In this case, for legislative changes it is recommended to define the realization of these measures in a form of individual projects reviewed by expert organisations. In figures (diagrams) given below, the fundamental principles of implementation of sandstone, conglomerate and gas outburst prevention methods are illustrated.

2.1.1. Method Utilizing "Break-free" Blasting Operations

The principle of the method utilizing "break-free" blasting operations as a method of sandstone, conglomerate and gas outburst prevention is to create a network of gas communication channels in the rock mass. This will enable gas migration and will reduce gas pressure in the zone in front of the mine working being driven. Simultaneously, as a consequence of rock damage, a decrease in stresses in the zone in front of the mine working being driven will take place. A diagram of the prevention method using "break-free" blasting operations is given in Figure 1.

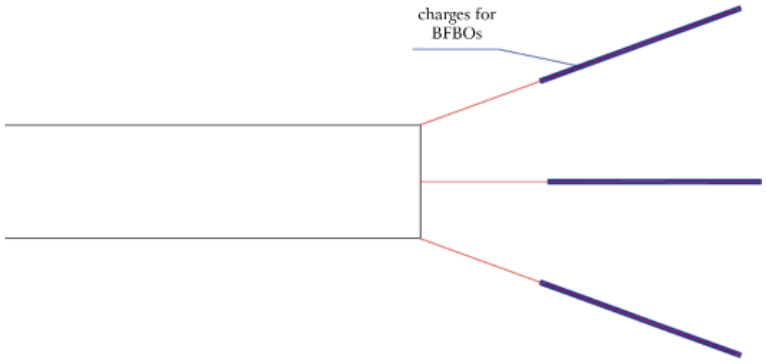

Fig. 1. Diagram of prevention method utilizing BFBO

2.1.2. Method Utilizing the Water Infusion of Beds

The principle of the water infusion method as a method of sandstone, conglomerate and gas outburst prevention is the displacement of gases in the zone in front of the mine working being driven from the pores of rocks to outside the protection zone being formed. In the course of water infusion into rocks, the strength of the rocks will decrease as well. A diagram of the prevention method using water infusion is given in Figure 2.

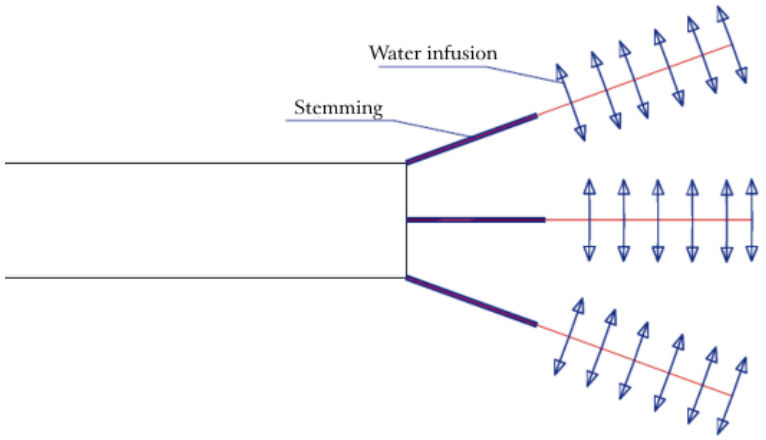

Fig. 2. Diagram of method of sandstone, conglomerate and gas outburst prevention utilizing water infusion

2.1.3. Degasification Method

The principle of the degasification method as a method of sandstone, conglomerate and gas outburst prevention is the forced exhaustion of gases from the pores of rocks in the zone in front of the mine working being driven as a result of negative pressure induced by the degasification

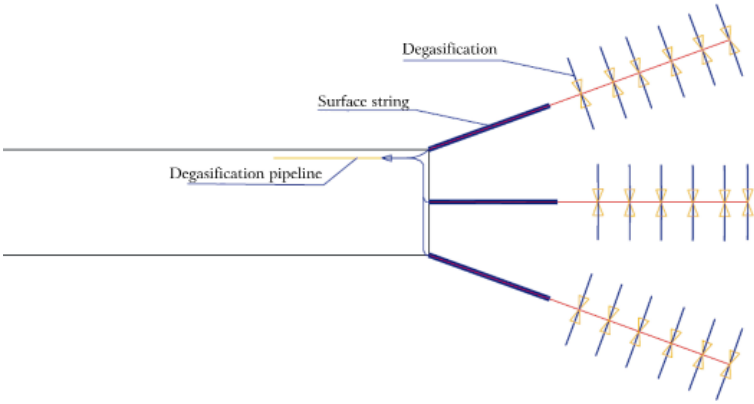

Fig. 3. Diagram of degasification method of prevention

system, reduction in gas pressure and creation of a protection zone. A diagram of the prevention method using degasification is given in Figure 3.

2.1.4. Combined Prevention Method Utilizing Degasification and Water Infusion

The principle of combining the degasification method with the water infusion method for sandstone, conglomerate and gas outburst prevention is the forced exhaustion of gases due to negative pressure induced by the degasification system; the exhaustion is supported by injecting water into rocks in the zone in front of the mine working being driven. In this way, a reduction in gas pressure will occur and a protection zone will be created. Simultaneously, the strength of the rocks will decrease. In principle, the combination can be carried out in two different ways. The first one is a combination of one degasification borehole situated in the axis of the mine working and two water infusion boreholes drilled to outside the mine working; the other is a combination of two degasification boreholes drilled from the mine working to outside the mine working and a water infusion borehole situated in the axis of the mine working (Prokop et al., 2011; Marchalsko et al., 2008). A diagram of the combined prevention method utilizing degasification and water infusion is given in Figures 4 and 5.

2.1.5. Combined Prevention Method Utilizing Degasification and "Break-free" Blasting Operations

The principle of combining the degasification method with the method utilizing "break-free" blasting operations for the purpose of sandstone, conglomerates and gas outburst prevention is the forced exhaustion of gases due to negative pressure of the degasification system, which is supported by "break-free" blasting operations performed in rocks in the zone in front of the mine working being driven. In this way, a decrease in gas pressure will occur and a protection zone will be created. Simultaneously, the strength of the rocks will decrease. In principle, the combination can be carried out in two different ways. The first one is a combination of one degasification

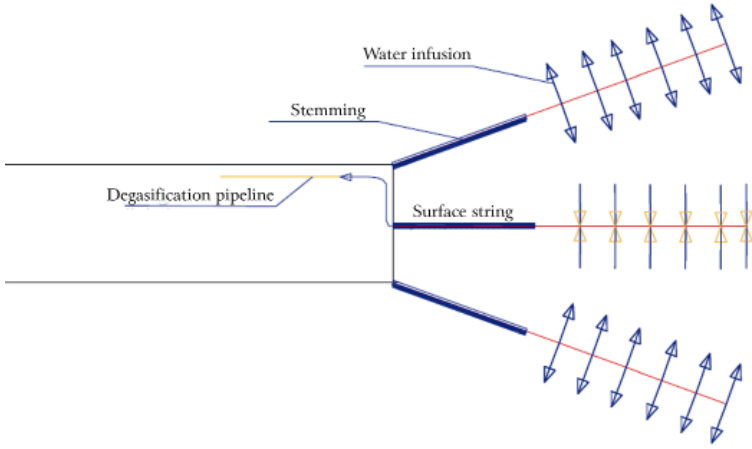

Fig. 4. Diagram of combined prevention method utilizing degasification and water infusion – 1st variant

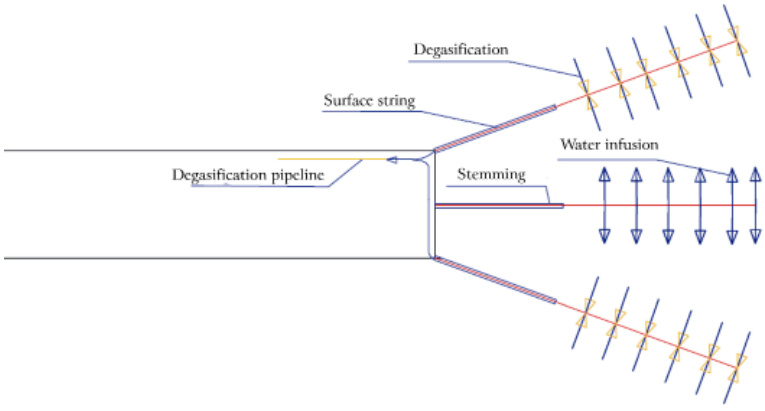

Fig. 5. Diagram of combined prevention method utilizing degasification and water infusion - 2nd variant

borehole situated in the axis of the mine working and "break-free" blasting operations performed in two boreholes drilled to outside the mine working; the other is a combination of two degasification boreholes drilled to outside the mine working and "break-free" blasting operations performed in the borehole situated in the axis of the mine working. A diagram of the combined prevention method utilizing degasification and "break-free" blasting operations is given in Figures 6 and 7.

We recommend solving the issues of sandstone, conglomerate ad gas outburst prevention as completely new problems in the framework of legislation by means of individual projects that will deal with the above-presented works individually from case to case and that will be reviewed by expert organisations (Wierzbicki, 2013).

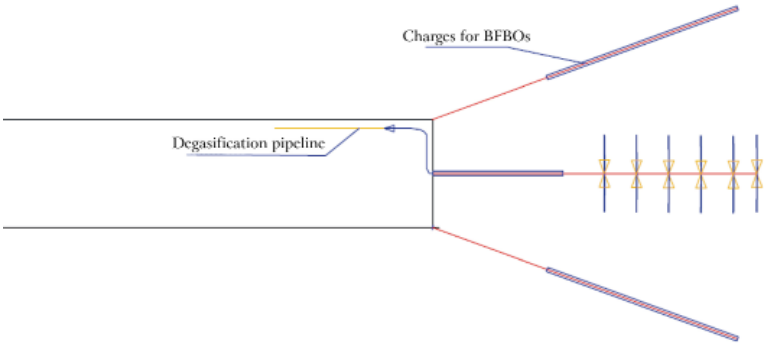

Fig. 6. Diagram of combined prevention method utilizing degasification and BFBOs – 1st variant

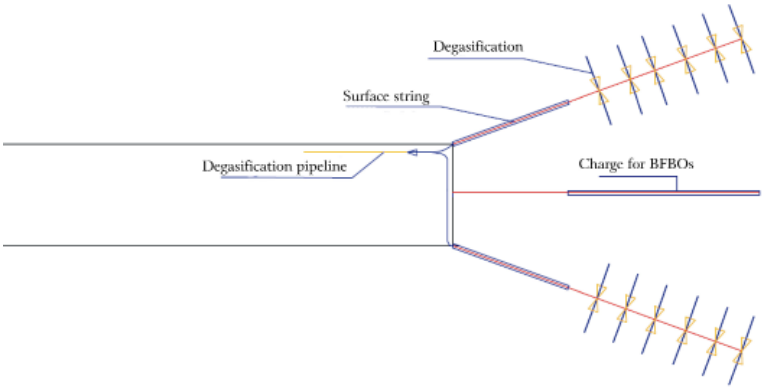

Fig. 7. Diagram of combined prevention method utilizing degasification and BFBOs – 2nd variant

2.2. Passive Methods

In addition to the above-presented proposed changes in active measures to prevent sandstone, conglomerate and gas outbursts, it is necessary to define passive measures. Besides the passive measures that have already been determined, other measures should be included in a new Czech legislative standard. What is meant is the selection and the type of supports, the stabilization of weakened parts of the rock mass by means of grouting and anchorage, the method of support of faces in the course of implementation of active preventive measures, the remote control of machines and the protection of a crew against mechanical effects of an outburst and against an unbreathable environment, and reduction in the number of employees in endangered areas.

The other passive measures are in principle similar to those as with coal and gas outbursts.

3. Conclusion

The aim of all preventive measures is to prevent rock and gas outbursts by creating a protection zone in front of and in sides of mine workings being driven and to mitigate the effects of outbursts. After verification, the proposed measures will be evaluated and, in a case of positive results, recommended for inclusion in outburst control measures (Ordinance No. 3895/2002; Hudeček at al., 2010).

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