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MINE DEGASIFICATION AS BASIC SAFETY ELEMENT IN THE UNDERGROUND PARTS OF GASSY COAL MINES IN THE OSTRAVA – KARVINÁ COALFIELD

OTPLINJAVANJE RUDNIKA KAO TEMELJNI SIGURNOSNI ELEMENT U PODZEMNIM DIJELOVIMA PLINOVITIH RUDNIKA UGLJENA NA UGLJENONOSNOM PODRUČJU OSTRAVA - KARVINÁ

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Abstract

In the article, degasification methods to drain the gas from the underground parts of coal mines in the Czech Republic are described. The authors are concerned with the possibilities of and new trends in ensuring safety by means of drilling operations. Examples of applications of degasification in mine plants in the Czech Republic, above all in a hard coal deposit in the Ostrava-Karviná Coalfield in the Upper Silesian Basin are presented.

Sažetak

U članku su opisane metode otplinjavanja podzemnih dijelova rudnika ugljena u Republici Češkoj. Autori se bave mogućnostima i novim trendovima u osiguranju sigurnosti primjenom bušačkih operacija. Prikazani su primjeri primjene otplinjavanja rudnika u Republici Češkoj i to posebno u ležištima kamenog ugljena na eksploatacijskim poljima Ostrava-Karviná u ugljenom bazenu gornje Šleske.

Introduction

Mine degasification is understood as set of technical equipment and organizational measures that are implemented to capture methane being emitted from various underground sources and to drain it separately to the surface. Very often, degasification is used in gassy coal mines and when working under the main haulage level. By this method of coal mining, methane that could endanger the safety of underground workers can be utilized, after the degasification of underground parts of the coal mine, as valuable energy raw material and as chemical raw material in industry.

The main parts of a degasification system are a degasification plant, degasification pipeline and degasification sources (mainly degasification boreholes). In the degasification plant, negative pressure is produced by water rotary vacuum pumps; by this pressure, methane is exhausted from the degasification sources and transported through the degasification pipeline to a consumer or discharged to the surrounding atmosphere (Prokop, 2007).

Figure 1 Water ring vacuum pump RLP - 62/73
Slika 1. *Vakuum pumpa s vodenim prstenom RLP – 62/73*

According to the location, the degasification plants are divided into surface (central degasification), underground (local degasification) and temporary surface degasification plants.

Degasification from the surface is referred to if boreholes, through which the gas is drained by means of the deposit pressure, are drilled from the surface to a gas deposit or to a Carboniferous formation. The gas is usually drained directly or through the compressor plant to the consumer pipeline.

Degasification plant

The degasification plant is a masonry building constructed of non-flammable material that is situated in the vicinity of an upcast air shaft; a ground plan is shown in Figure 2. The building is usually one storey high, with a basement. Building dimensions are designed on the basis of the number of gas mixture pumps. In the basement, there is a building piping, wiring and cabling systems, service water circulation pumps and building ventilation equipment. The ground floor is divided into two parts by a gas impermeable partition. In a potentially explosive space, water ring vacuum pumps including explosion-proof electric motors are installed. In the Ostrava-Karviná Coalfield (henceforth referred to as OKC), water ring vacuum pumps of the RLP 62/73 (see Figure 1) and 200-SZO types are used (Kusina, 2010). The degasification plant is to be situated minimally 20 m from the nearest buildings. A sufficient number of lightning rods protecting the whole premises against possible strokes of lighting must be installed on the roof of the degasification plant.

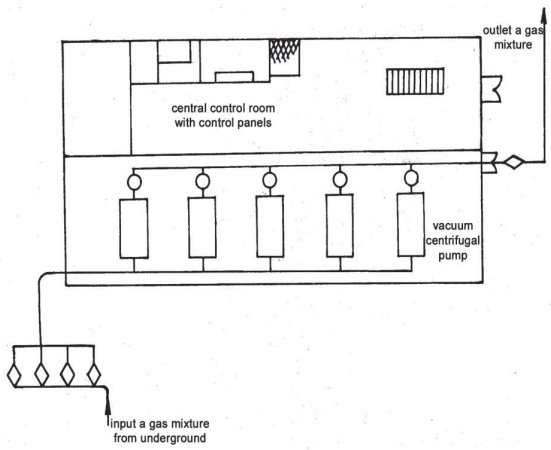

Figure 2 Diagram showing the lay-out of ground floor of degasification plant
Slika 2. *Shema koji prikazuje izgled prizemlja postrojenja za otplinjavanje*

Degasification pipeline

Through the degasification pipeline the negative pressure produced by the degasification plant should be transferred to boreholes at as little loss as possible and the drained gas should be transported back to the degasification plant, from which it is further transported to the consumer or discharged to the atmosphere. Degasification pipelines are divided into mains and lines. The gas mains are placed in the shaft; their diameter is mostly 300 – 400 mm, including a connection to the degasification plant. The gas lines, having usually the diameter of 100-250 mm, are there in other mine workings.

Degasification boreholes

The degasification boreholes are extensions of the degasification pipelines. That is why they must satisfy certain conditions. The first condition is the tightness of a borehole in relation to the surrounding mine workings to avoid the suction of mine atmosphere to the borehole; the borehole is secured with a preventer. The other condition is the diameter of the borehole that has to correspond to the amount of gas drained. The length of degasification boreholes depends on the strength of rocks in which the boreholes are drilled.

For drilling the boreholes, drilling rigs are used (Figure 3). In strong rocks the lengths of degasification boreholes move in the range from 120 to 200 m, in less strong rocks the lengths range from 60 to 80 m. The diameters of the boreholes depend, in addition to the strength of rocks, on the performance of a drilling machine. Because space underground is limited, drilling machines of performance ranging from 10 to 40 kW are used, to which borehole diameters in the range from 52 to 104 mm correspond. In the year 2009, degasification boreholes of the total length of 39 980 m were drilled in the mines of Ostrava-Karviná Coalfield, of which 25 681 m were drilled by the supply company Green Gas DPB. Figure 4 shows a diagram of degasification borehole drilling.

Figure 3 Degasification borehole drilling
Slika 3. *Bušenje bušotina za otplinjavanje*

According to the position of degasification boreholes in the mining area, *boreholes* are divided as follows*:*

- in-mine inclined in the roof
- in-mine horizontal
- in-mine inclined in the floor.

In-mine inclined boreholes drilled in the roof are used most widely in mine degasification because the prevailing part of degasification sources are boreholes drilled into the roof of a coal seam. From the point of view of water drainage of the boreholes, these boreholes do not cause any problem.

In-mine inclined boreholes drilled in the floor are used in degasification practice less frequently. This is given by substantially worse conditions in the course of draining of water from these boreholes that are often flooded and put out of operation, which means high-vacuum conditions.

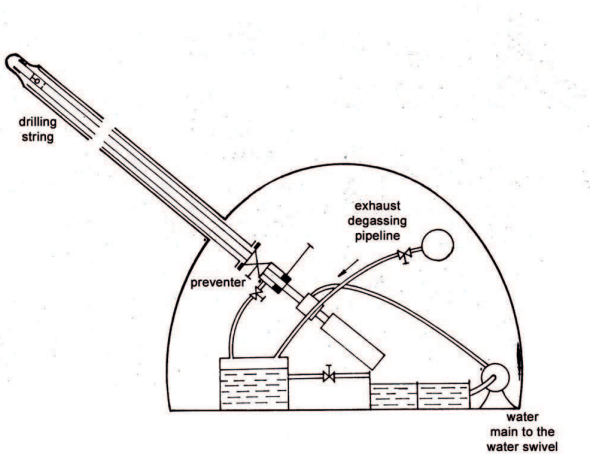

Figure 4 Diagram of degasification borehole drilling through a drill rod seal
Slika 4. *Shema bušenja otplinjavajuće bušotine sa protuerupcijskim uređajem*

According to the lay-out of several boreholes, the degasification boreholes are divided as follows:

- parallel,
- cross-measure,
- combined.

Face degasification

In the case of degasification of advancing and retreating faces, the principle that degasification boreholes are drilled mainly from return airways is kept. The prevailing majority of degasification boreholes for face degasification are drilled into the roof, in a smaller degree into the floor of the seam being mined. The efficiency of face degasification in the mines of OKC moves in the range of 52 – 74%. The overall efficiency (faces, long mine workings, total gas emission) of mine degasification in the OKC is 32 – 35% (Hudeček at al., 2008).

Retreating face degasification

When using the method of retreating face, mainly parallel boreholes are drilled into the roof of the face. A borehole of adequate length undergoes all pressure phases at the advancing face. That is why efficient degasification takes place as early as the time when the mouth of the borehole is there several ten meters ahead of the face line. The effect of parallel degasification boreholes usually ends in the undermining of the conductor string due to

high leakage. The efficiency of this method is 40 - 50% in the case of thin seams and 20 - 30% in the case of thick seams.

Figure 5 Drilling of degasification boreholes with preventers
Slika 5. *Bušenje otplinjavajuće bušotine sa protuerupcijskim uređajima*

In the zone of efficient life of the boreholes, the production of up to 2 500 m^3 of CH_4 per day can be considered. The production of gas through parallel boreholes drilled into the floor is substantially lower. In the majority of cases, a considerably smaller number of boreholes are thus drilled into the floor. Borehole spacing depends on the expected gas emission rate of the rock mass. The higher the gas emission rate is expected, the smaller spacing of boreholes is designed. Optimum spacing in the mines in the OKC moves in the range of 20 – 40 metres.

Method of cross-measure boreholes

In quite a number of cases, when drilling parallel holes in the return airway is owing to the size of the airway considerably labour intensive, the method of so-called cross-measure boreholes is implemented successfully in the mines of OKC. In a return airway, in a gravity incline or in an overlying seam (coal road), a stable hole is created where a drilling machine can be placed. From this stable hole, degasification boreholes of various lengths, which cover the whole area to be mined, are then drilled to the roof of the seam being mined (Figure 6). A great advantage of this method consists in less labour intensive drilling works, easy control of all boreholes and a possibility of easy regulation.

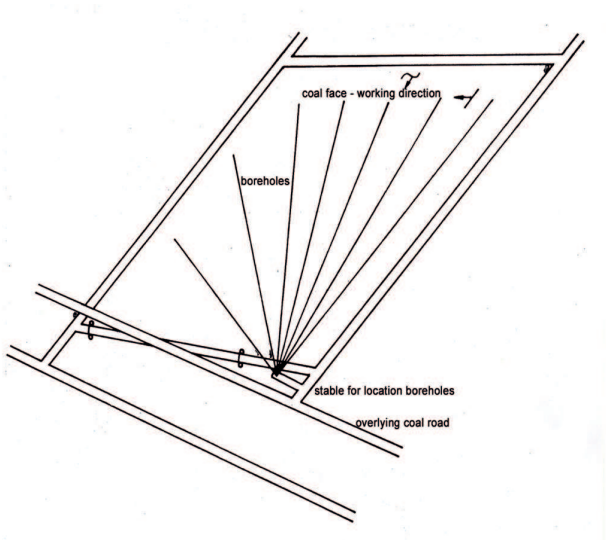

Figure 6 Method of cross-measure boreholes
Slika 6. *Metoda poprečnih bušotina*

Retreating face degasification in the course of caving method of mining of thick seams

If the caving method of mining of thick seams (up to 6.0 m – Karviná part of the Coalfield) is used, the effect of parallel boreholes is diminished just by the large thickness of the seam. In this case, the efficient life of the borehole is markedly reduced. To prevent these negative phenomena and to increase gas production at efficient gas drainage from the working, another entry is driven parallel to the return airway about 30 m apart. From this entry, degasification boreholes are drilled into the roof of the seam being mined. This entry and also the conductor strings of boreholes are protected against destructive effects of the advancing face. Individual boreholes can be checked and regulated. The degasification method enables the rationalization of drilling because two boreholes can be drilled from one location of the machine. With regard to the long life of degasification boreholes, the 50-80% efficiency of face degasification is achieved using this method.

Cases of lost gas pipeline

In the case of retreating working and decommissioning of return airway behind the face, the efficient life of the degasification boreholes is shortened by the pass of the face. To extend the life of the borehole in the most productive phase, a method of lost pipeline was developed. The principle of the method is the disconnection of boreholes from the gas pipeline simultaneously with the passage of the face. The pipes themselves are lowered to the floor of the return airway, perforated and covered

with rather large pieces of rock to prevent from being damaged. The lost pipeline laid like that exhausts the gas mixture from the return airway. However, the content of methane must be measured regularly and regulation has to be carried out. This method is used exceptionally in cases of a high gas emission rate of the face, when the uppermost part of the face and the return airway are gassed due to the disconnection of the degasification borehole.

Closed gob degasification

After the mining out of a face and the closure of the face with a dam, a considerable amount of methane accumulates in the closed space, especially if this space communicates with the face being mined in the same seam or in the underlying seam. In these cases the degasification pipes are laid as far as possible behind the dam to decrease the suction of mine air through leaks in the dam and its surroundings. The exhaustion of gas must be regulated carefully as for both the content of methane and the value of depression. The amount of gas obtained by gob degasification forms up to 35% of total amount of gas obtained by mine plant degasification.

History of mine degasification in the Czech Republic – Ostrava-Karviná Coalfield (OKC)

The commercial production by means of boreholes from the surface began in the Czech Republic in 1945, namely in the deposits of Ostrava-Karviná Coalfield (Mitrovice and Příbor).

The development of mine degasification in the advanced technical conception with degasification vacuum pumps dates from the year 1958, when a surface degasification plant near the Barbora 5 upcast shaft was put into operation for the mine field of the 9. květen Mine in the OKC. In addition to the degasification vacuum system, a degasification positive pressure system had been operated in this mine field from the 1st of July 1957. During that time, the positive pressure system had turned out to be little effective, and thus it was connected to the degasification vacuum pump as well. As time was passing by, degasification plants were constructed in other mines of the OKC so that the gas mixture was exhausted, with the exception of Jan Šverma Mine, in all mines of the OKC. An overview of results from the very beginning of degasification in the OKC concerning the overall exhaustion of gas mixture, supplies of gas to customers (the main customer is the company Severomoravské plynárny - SMP) and mixture blow-off into the atmosphere is given in Table 1.

Table 1 Overview of exhaustion of gas mixture by degasification, gas supplies to consumers and mixture blow-off into the atmosphere in the deposits of OKC in 1958-2009

Tablica 1. *Pregled iscrpka smjese plina otplinjavanjem, plina isporučenog potrošačima te smjese plina ispuštene u atmosferu u ležištima OKC-a od 1958. do 2009. godine*

Year	Total production in m^3	Supplies to consumers in m^3	Consumption of mine itself in m^3	Blow-off in m^3
1958	4 300.000	2 100.000	-	2200.000
1960	14 300 000	12 100 000	-	2 200 000
1965	76 232 860	61 965 502	542 040	13725 318
1970	239 713 283	127 907 064	41 616 813	70 189 406
1975	235 700 334	168 970 400	61 158 468	5 571 466
1980	225 027 836	136 533 090	69 843 059	18 651 687
1985	207 458.893	120260.682	64 229 568	22 968 643
1991	132 351 164	59 261 390	57 429 149	15 660 625
1995	106 547 000	46 252 200	45 564 800	14 730 000
2000	107 627 200	65 106 600	35 450 200	7 070 400
2005	102 717 200	64 419 192	34 762 800	3 535 208
2006	76 857 569	40 956 371	35 140 276	760 922
2007	75 249 574	50 174 336	24 540 053	535 185
2008	78 600 000 *106 700 000**	48 300 000	30 300 000	0
2009	55 100 000 *102 700 000**	31 800 000	23 300 000	0

**Total underground gas production, including exhaustion from closed mines.*

**Ukupna podzemna proizvodnja plina zajedno sa iscrpkom iz zatvorenih rudnika*

It is clear from Table 1 that since 1980 a gradual decline in the total production of gas and subsequently a decrease in supplies to the gas company have taken place. On the contrary, the utilization of gas has increased as a result of reduced blow-off into the atmosphere. If these results are put to the context of financial calculations in the given time, it is evident that the OKC has received considerable sums of money through the sale of the drained gas.

Substantial part of mines of OKC have already been closed (Ostrava and Petřvald partial basins), and in the post-mining areas the controlled gas exhaustion from the underground parts is performed by Green Gas DPB Paskov, joint-stock company, and DIAMO Ostrava, national enterprise, with the industrial utilization of the exhausted gas by means of cogeneration units. Installed cogeneration units participate significantly in a decrease in amount of blow-offs from the degasification plants of OKC.

A development trend confirms a decreasing tendency in the amount of gas produced by degasification systems in the OKC in comparison with the year 1991, when the phase-out of mining began.

Decisive criteria for degasification implementation

A need for the implementation of degasification in the course of driving of long mine workings and advancing of faces is evaluated according to the values of their forecasted gas emission rates with regard to the maximum possibilities of ventilation from the point of view of required dilution of emitted methane. It is necessary to introduce degasification when the possibilities of ventilation are exhausted, the amount of airs cannot be increased any more, and in spite of this, the permissible content of methane in the mine air is not ensured.

Parameters of mine degasification in the mines of OKC in the year 2009

In the year 2009, the total methane production of OKC amounted to 56 957 385 m3 as given below:

ČSM Mine	10 921 768	m^3
Darkov Mine	11 774 688	m^3
Karviná Mine	13 526 031	m^3
Paskov Mine	20 734 898	m^3

Shares of degasification sources:

boreholes	32 685 924	m^3
dams	24 036 911	m^3
lost pipelines	234 550	m^3

Conclusion

In the mines of the Czech Republic, all so far known degasification methods are applied successfully. The application of them in practice is the basic safety parameter and forms an important part of ensuring the safety of mine workplaces. In individual mines, the gas produced by degasification systems is utilized by the mine itself, e.g. year-round combustion in boiler plants, in winters for the heating in thawing plants, further as a fuel for cogeneration units for electrical energy generation, and about 50% is supplied to the network of Severomoravská plynárenská společnost, JSC - RWE.

It is necessary to emphasise that efficient mine degasification is the basic measure to ensure the safety of work in underground mines (e.g. in coal and gas outburst-prone conditions (Hudeček at al., 2009)) and is very often used in working under the main haulage level (necessary for the keeping of ventilation indicators); simultaneously it is also one of elements of prevention of coal and gas outbursts.

However, in conclusion it is necessary to state that degasification is the basic safety element for ensuring the safety of mining operations and, on top of that, makes a profit.

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