Monitoring of physical condition changes in strata boreholes during coal mining

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Abstract. The approach to determine the length of degasification boreholes by profilometry using echolocation method in mine conditions is substantiated. The results of cameral processing of echograms obtained in field studies are presented. The relationship between the effective length of boreholes and their methane content has been established. The bearing pressure zone influence of on physical condition of horizontal boreholes drilled to undertake strata degasification is shown.

1. Introduction

During gassy coal seams mining, the methane content in workings is one of the main factors limiting the load on the longwall face and the construction rate of development workings. With increasing depth of mining operations, the gas content in excavation sites increases. Moreover, the maximum possible amount of air supply does not always ensure the required methane content in mine atmosphere, and thus, the improved efficiency of coal seams degasification is an essential factor to ensure the mining work safety.

2. Main part

Coal seams degasification may be done by drilling boreholes from mine workings to prevent methane migration to the near face zone of the extraction column and methane recovery for its subsequent possible utilization. To improve the degasification efficiency, it is necessary to monitor physical condition of boreholes, which are used to recover methane from coal seams and gob areas. [1, 2].

To control the physical condition of degas boreholes in mine conditions, the echolocation method was applied, which implies the recording of a time interval between the signal initiation and the arrival time of the wave reflected from the interface (figure 1).

Figure 1. Schematic representation of the echolocation method.
To conduct mine measurements, a set of equipment, including devices for initiating and receiving acoustic signals, was installed at the wellhead. After the measurements (figure 2), the equipment was delivered to the laboratory for subsequent processing of the recorded acoustic signals, which included the sequential application of filtering procedures for the amplitude-frequency characteristics, determination of the first mark of the reflected acoustic signal, and the elimination of noise and interference when receiving an acoustic signal.

![Figure 2. The resulting echogram of the borehole.](image)

Then, the length of boreholes was determined by the formula:

$$L = \nu \cdot t = \sqrt{\frac{\gamma RT}{M}} \cdot t = \alpha \sqrt{T} \cdot t,$$

(1)

Where $\nu$ – acoustic wave velocity (m/s); $t$ – acoustic wave transit time (s); $\gamma$ – adiabatic exponent; $R$ – universal gas constant; $T$ – absolute temperature (°K); $M$ – the molar mass of the gas mixture (g / mol); $\alpha = \sqrt{\frac{\gamma R}{M}}$ [3]

The results of length measurements for horizontal degas boreholes drilled from mine workings in one of the coal mines in Leninsky geological and economic region of Kuzbass, as well as the methane content in them, are summarized and shown in table 1.

**Table 1.** Monitoring results of length changes (L) and methane concentration variation (C) at the wellhead, when a distance to the longwall face (d) varies.

| № bhl. | Drilling completion date | Borehole Initial length (m) | Measuring date | 
|-------|------------------------|-----------------------------|----------------| 
|       |                        |                             | 7.05.20 yr. | 24.05.20 yr. | 31.07.20yr. | 14.08.20yr. | 
|       |                        |                             | $L_s$ (m) | $d_s$ (m) | $C_s$ | $L_s$ (m) | $d_s$ (m) | $C_s$ | $L_s$ (m) | $d_s$ (m) | $C_s$ | $L_s$ (m) | $d_s$ (m) | $C_s$ | 
| 1     | 16.06.18 yr.           | 180                         | 29        | 14      | 1.2  | -        | -        | -     | -        | -        | -     | -        | -        | -     |
| 2     | 25.06.18 yr.           | 154                         | 39        | 10      | 0.8  | -        | -        | -     | -        | -        | -     | -        | -        | -     |
| 3     | 13.03.19 yr.           | 180                         | 42        | 12      | 3.8  | -        | -        | -     | -        | -        | -     | -        | -        | -     |
| 4     | 25.06.18 yr.           | 180                         | 37        | 31      | 2.5  | -        | -        | -     | -        | -        | -     | -        | -        | -     |
| 5     | 28.06.18 yr.           | 180                         | 85        | 40      | 2.6  | 39       | -        | -     | -        | -        | -     | -        | -        | -     |
One of the important parameters of coal seams mining with mechanized long wall shearers is the length of a bearing pressure zone, in which the stress state of rocks is redistributed due to the violation of the rock mass integrity [4]. The life cycle of boreholes is significantly affected by a bearing pressure zone (figure 3).

The distribution of a bearing pressure zone is described by the formula [5, 6]

$$\sigma_y(x) = \gamma H + \sigma(x),$$

(2)

Where $\sigma(x)$ – additional normal stress to the coal seam; $\gamma$ – weighted average density of overburden rocks; $H$ – mining work depth.

With the load $P$ on the rock mass increase in the bearing pressure zone, degas boreholes are destroyed, entailing degasification efficiency decrease (figure 4).

As a result of work implementation to determine the effective length of boreholes at various stages of its life cycle, it was found that the length of boreholes drilled from a conveyor entry into the formation varied from 17 to 158 m. Figure 5 shows the length variation of boreholes drilled through the coal seam over time. The methane concentration at

| Date       | Length | Pressed Coal Zone Width | Stress Level in Virgin Massif | Methane Concentration |
|------------|--------|--------------------------|-------------------------------|-----------------------|
| 6 02.08.18 yr | 180    | 110                      | 47                            | 10.2                  |
| 7 19.03.19 yr | 194    | 121                      | 78                            | 10.5                  |
| 8 21.03.19 yr | 190    | 46                       | 85                            | 10.8                  |
| 9 07.07.18 yr | 205    | 95                       | 123                           | 10.9                  |
| 10 14.06.19 yr | 190    | 84                       | 212                           | 10.5                  |
| 11 26.06.19 yr | 190    | 91                       | 282                           | 10.1                  |
| 12 29.03.19 yr | 179    | 158                      | 1099                          | 10.2                  |
| 13 30.03.19 yr | 205    | 93                       | 1098                          | 10.0                  |

Figure 3. Bearing pressure zone distribution: C – pressed coal zone width; $\gamma H$ – stress level in a virgin massif.

Figure 4. Bearing pressure zone influence on degasification boreholes.

Figure 5. Length variation of boreholes drilled through the coal seam over time.
the wellhead on 07.05. 2019 yr. varied from 0.8 to 40.6%; on 05.24.2019yr. – from 0.9 to 40.8%; on 31.07.2019 yr. from 5.2 to 42.5%; on 14.08.2019 yr. – from 0.8 to 38.9%.

![Graph](image)

**Figure 5.** Length variation of boreholes drilled through the coal seam over time.

Assessment of degasification boreholes state over time showed that the length of boreholes drilled from the conveyor entry decreased, as the longwall approached. Moreover, in the bearing pressure zone (25–40 m from the working face), the length of boreholes was 29–42 (m), with their initial length of 154–205 m. With a decrease in degas boreholes, methane concentration in them also decreased.

3. Conclusion

Thus, the echolocation method application for degas boreholes profilometry in mine conditions allows you to control boreholes physical condition. Data on boreholes length can be used to adopt decisions about coal mine methane recovery duration by degasification facilities, the necessity to drill additional wells, and their placement in a coal rock massif with the purpose to increase the coal seams degasification efficiency and mining work safety.

References

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