Monitoring of degasification boreholes status by echolocation

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Abstract. An approach for estimating the extent of degasification boreholes drilled from mine workings, based on the recording of acoustic signals is described. The “Echolot” apparatus was used as a recording device and it registered the time of acoustic signal initiation and the repeated arrival of the wave reflected from the medium boundary. The results of depth measurements of degasification boreholes in mine conditions are presented.

1. Introduction
In modern mining and technical conditions of intensive coal mining, methods of coal seams associated degasification with boreholes drilled from mine workings are widely used to reduce methane emission volumes in mine extraction sections, to prevent methane supply from a near face zone of the extraction column, and also to recover methane with the purpose of its further utilization [1, 2].

Regarding this, the online analysis of degasification boreholes productivity is of great importance. Determination of gas recovery from coal seams and its delivery into degasification boreholes allows us to predict the degas system operation and to calculate amount of drilling works required to attain the desired degasification efficiency [3, 4].

2. Methods of measurement and apparatus
A set of mining equipment was used to determine the length of degasification borehole in conditions of Kuzbass coal mines. As a recording device the “Echolot” apparatus was employed to measure the length of degasification boreholes and exploration wells free from liquid and slime. The core of the method implies the registration the time moment of signal initiation and re-arrival of a wave reflected from the medium boundary (figure 1). Length determination was carried out in boreholes drilled through the coal seam. The designed length of a borehole was 150 m.

2.1. Process of measurement
Before starting research the operator sets up performance parameters of “Echolot” apparatus in accordance with the Operational Manual instructions. The device receiving acoustic signals is installed at the wellhead. Before conducting the first measurement the operator sets the date, the number of measurements at the point, the borehole number, etc. on the registration unit. The device is switched to
a standby mode of a start-up momentum. Then the acoustic signal is generated using a harmonica. If the level of the starting pulse is sufficient, then the process of echogram recording in real time is visualized on the screen. If the self-start of the registration process has not occurred, the registration of the echogram is forced to start. A forced registration start is recommended only for recording current acoustic processes in a slimed or flooded borehole, and normally, in this case, the maximum measurement time is set, equaling to 30 seconds. Then, the received and stored echogram is analyzed on a PC. The microphone registers an acoustic signal and converts it into an electrical one, information about which is stored in the memory of the recording unit. In each borehole, three repeated measurements are performed to eliminate induced noise and interference.

![Figure 1. Schematic image of echolocation method](image)

The operator tracks the reference number and the apparatus readings and, if they meet the requirements, proceeds to the next picket. After the measurement, the recorded echogram, a borehole length value, a number of clicks and storage modes are displayed on the screen. The operator stores the information in the instrument’s memory for further processing and interpretation of data. Basic information about the object and measurement parameters is recorded in field notes.

2.2. Desktop processing.
The desktop processing stage of the recorded data is necessary to improve the accuracy of borehole length measurements by eliminating noise and interference. Also, the filtering of amplitude-frequency characteristics of the signal is conducted and the acoustic signal first reflection check mark is determined. The borehole length is determined by a formula:

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

where \( \nu \) – acoustic wave velocity; \( t \) – acoustic wave time; \( \gamma \) – adiabatic index; \( R \) – universal gas constant; \( T \) – absolute temperature; \( M \) – molar mass of gas mixture; \( \alpha = \sqrt{\frac{\gamma R}{M}} \) [5].

According to the results of obtained data processing a borehole length is determined with an error not exceeding 1.0%.

2.3. The results of recorded data processing and interpretation by method of echolocation
The data recorded in the borehole wells employing the “Echolot” apparatus are interpreted. The results of degas wells length measurements are shown in table 1. Data undergo a process of prep and filtration. The resulting echogram is shown in figure 2.
Table 1. The borehole length measured with “Echolot” apparatus.

| A borehole number | Results of desktop processing (m) | Methane concentration at the wellhead (%) | The month of a borehole drilling | Remarks |
|-------------------|----------------------------------|------------------------------------------|---------------------------------|---------|
| bh. No.18         | 6                                | 7                                        | April                           | Flooded and slimed |
| bh. No.19         | 6                                | 10                                       | April                           | Flooded and slimed |
| bh. No.20         | 6                                | 14                                       | April                           | Flooded and slimed |
| bh. No.22         | 138                              | 14                                       | April                           | A borehole in good conditions |
| bh. No.23         | 143                              | 12                                       | April                           | A borehole in good conditions |
| bh. No.25         | 18                               | 13                                       | April                           | Flooded |
| bh. No.27         | 134                              | 12                                       | April                           | A borehole in good conditions |
| bh. No.36         | 145                              | 15                                       | July                            | A borehole in good conditions |
| bh. No.40         | 112                              | 25                                       | July                            | A borehole in good conditions |
| bh. No.43         | 135                              | 26                                       | August                          | A borehole in good conditions |
| bh. No.46         | 138                              | 28                                       | August                          | A borehole in good conditions |
| bh. No.51         | 149                              | 50                                       | September                       | A borehole in good conditions |
| bh. No.53         | 125                              | 62                                       | September                       | A borehole in good conditions |
| bh. No.55         | 120                              | 66                                       | September                       | A borehole in good conditions |

Continuation of Table 1.

| A borehole number | Results of desktop processing (m) | Methane concentration at the wellhead (%) | The month of a borehole drilling | Remarks |
|-------------------|----------------------------------|------------------------------------------|---------------------------------|---------|
| bh. No.58         | 99                               | 75                                       | September                       | A borehole in good conditions |
| bh. No.60         | 142                              | 65                                       | September                       | A borehole in good conditions |
| bh. No.62         | 130                              | 60                                       | September                       | A borehole in good conditions |
| bh. No.64         | 148                              | 77                                       | September                       | A borehole in good conditions |
| bh. No.66         | 144                              | 71                                       | September                       | A borehole in good conditions |

Figure 2. The resulting echogram of the borehole No.66 (1 – start of the acoustic pulse; 2 – the first response from the medium boundary; 3 – the second response from medium boundary; 4 – the third response from medium boundary; 5 – the borehole length).

During the obtained data analysis, the methane concentration dependence on the degas well lifetime was established. For example, the methane concentration in boreholes drilled in April 2018 is...
less than the methane concentration in boreholes drilled in September 2018 (figure 3). In boreholes that are slimed and flooded at the wellhead No. 18-20, 23, 27, 36, the “Echolot” readings were set at 6 m, which corresponds to the minimum measured distance to the medium boundary.

![Figure 3. Methane concentration in boreholes.](image)

3. Conclusion
According to the results of the work performed, the successful application of the echolocation method to control the degasification boreholes conditions is confirmed. It was established that the research quality depends on duration of time elapsed from the drilling work start till the moment of measurements taking.

Resulting echograms analysis revealed that on echograms relating to boreholes free from slime and water, a starting signal phase and the phase of reflected signal arrival are clearly recorded. Otherwise, the boundaries are not visible. It should be noted that the quality of registered signals in boreholes drilled across coal seam roof is higher than in those drilled through the coal seam directly or into its bottom.

According to the results of conducted work on the approach approbation to estimate degasification boreholes conditions to ensure the mining work safety by means of the degas work enhanced efficiency during the period of boreholes drilling, recommendations were given, including the higher quality of boreholes washing in the course and upon the drilling works completion; and, when it is possible the boreholes drilling predominantly in the uprising direction.

References
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