ASSESSMENTS ON THE SENSITIVITY TO IGNITION OF EXPLOSIVE ATMOSPHERES IN UNDERGROUND FIREDAMP MINES

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Abstract: This paper presents the results of a statistical analysis study for the influence of air humidity on the ignition sensitivity of gaseous explosive atmospheres in underground firedamp mines. The first half of the paper briefly presents the experimental results used. Since the results are probabilistic, methods of statistical analysis have been used. The second section presents the results of statistical analysis of experimental data.

Key words: sensitivity to ignition, moisture, firedamp mines.

1. INTRODUCTION

Coal mining in underground tunnels is always associated with a risk of explosion due to the presence of methane gas and coal dust.

According to the classification of explosive atmospheres [9], [11], the atmosphere of a subtenant firedamp mine has the highest ignition threshold, regardless of whether electrical criteria (260 μJ) or thermal criteria 450 °C (for suspended dust) are taken into account.

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Previous studies have shown that the probability of ignition in capacitive circuits depends almost exponentially on the value of the voltage. Other approaches have shown that the probability of ignition in inductive circuits depends exponentially on the logarithm of the current value [8], [12], [14].

Another factor affecting the ignition sensitivity of the underground atmosphere, characterized by the presence of methane, is the moisture content [1], [13].

Explosion propagation events lead to precompressive events and an increase in the propagation speed of the explosion wavefront in space, which is mainly characterized by one-dimensional development (galleries).

Such situations can have very serious consequences, including loss of human life and property [7], [10], [18].

In addition, explosions damage underground ventilation structures, reducing their ability to evacuate methane gas and also reducing the availability of oxygen needed by workers involved in related underground mining activities [2], [15], [19].

Analysis of experimental data showed that the probability distribution of the number of revolutions at which ignition of the test mixture occurs is variable.

2. BRIEF OVERVIEW OF EXPERIMENTAL DATA

The experimental data were obtained using a spark test apparatus (spark test apparatus). A transducer for measuring air humidity is connected to the intake path.

During the tests, a mixture of 8,3% air and methane was used, and the relative humidity of the air at the entrance to the mixture ranged from 11 – 38% RH.

The parameters of the electrical circuit to which the eclator was connected were : Uo=24Vcc, L=121mH, Io=110÷111mA.

During the test, the humidity of the intake air varied as shown in Figure 1 and the number of revolutions at which ignition occurred varied as shown in Figure 2.

The experimental procedure was conducted sequentially :

- conditioning the eclator according to B.1.3 at the beginning of the test process, then :
- each of the 15 tests is repeated as follows :
  - Purge the transducer chamber with air within 4 to 10 minutes;
  - Purge the eclator chamber and attached gas path with a gas mixture of 10 volumes;
  - The eclator is switched on in an electrical circuit whith the specified electrical parameters;
  - Record the number of revolutions at which ignition occurs;
  - Read off the specified value of incoming air humidity and record the same value for all tests performed in 15 test cycles.

Reserve a test interval of 15 times to stabilise the indicator of the humidity value.

The ignition probability values [3], [16], [20] were calculated according to the humidity of the incoming air that can be seen in Figure 1.

The regression curve is also shown in Figure 1.

According to regression curve trend analysis, it is appreciatiated that sensitivity increases when the relative humidity of incoming air is about 23%.

To identify the trends in the variability of ignition probability, the matrix of humidity and rotation value was first sorted. Then moving average was used for a predetermined number of values [4, 5].

Figure 2 shows the diagram of intake air humidity values (placed in order).

Figures 3 and 4 show the change in the moving average of the logarithm of the probability of ignition (according to relation 3) depending on the mean value of humidity in that range [6], [17].

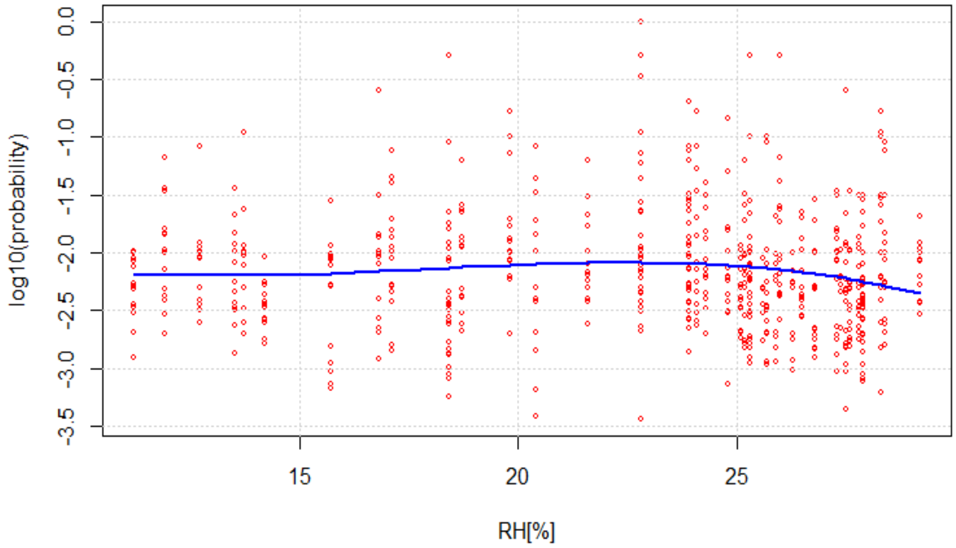

Fig.1. Decimal logarithmic variation in ignition probability as a function of intake air humidity

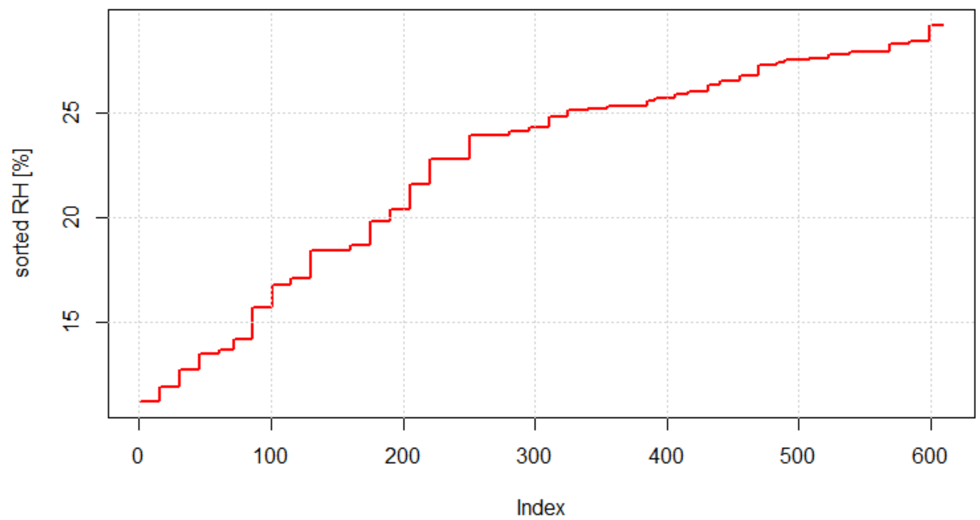

Fig.2. Sorted values of air humidity at intake

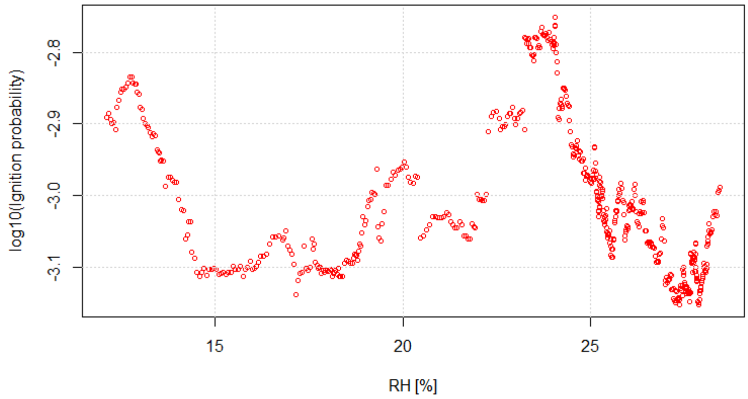

Fig.3. Variation of the decimal logarithm of the moving average of the probability of ignition as a function of air humidity at the intake with averaging interval = 50

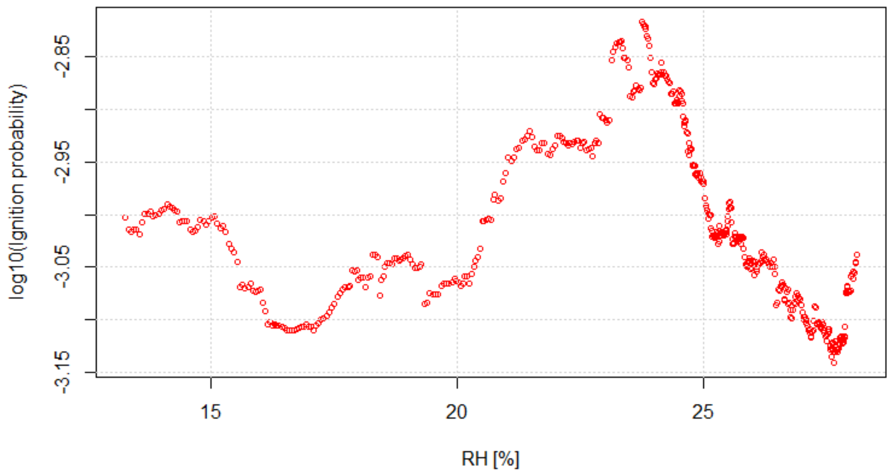

Fig.4. Variation of the decimal logarithm of the moving average of the probability of ignition as a function of air humidity at the intake with averaging interval = 100

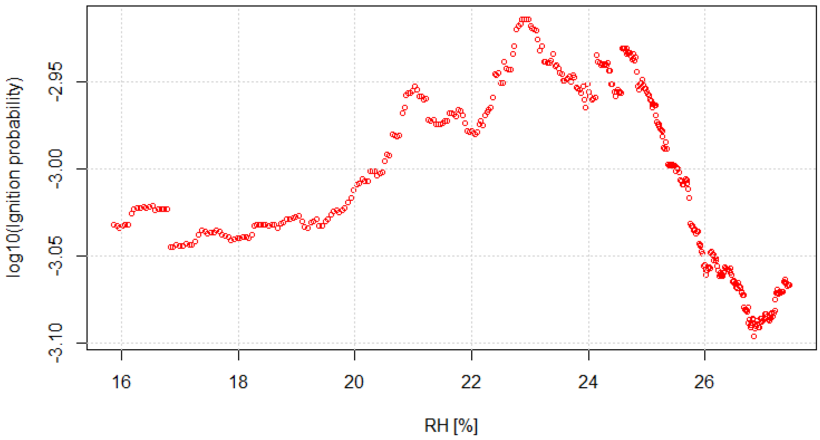

Fig.5. Variation of the decimal logarithm of the moving average of the probability of ignition as a function of air humidity at the intake with averaging interval = 200

$$log_{10}(p) = -log_{10}(mean(4 \cdot rotations)) \quad (1)$$

Analysis of the change in the decimal logarithm of the ignition probability obtained with the help of moving average confirms that the probability of ignition increases at an input air humidity of about 23% RH.

All other peaks disappeared when increasing averaging interval was performed.

3. CONCLUSIONS

Preliminary analysis of experimental data shows that ignition sensitivity, measured by the decimal logarithm of the ignition probability, is characterized by high static variability.

The cubic regression curve of ignition probability as a function of intake air humidity showed a maximum around 23% RH.

When using the moving average method as a means of reducing variation, it was observed that ignition sensitivity increased when the relative humidity of the intake air was about 23%.

When the relative humidity of the intake air exceeds 23%, the ignition sensitivity of the methane air atmosphere, quantified by the probability of ignition, decreases exponentially.

This paper summarizes a study on the effect on ignition sensitivity of the humidity of the air used to produce the air + methane test mixture of 8,3%.

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