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A Real Application of Air Recirculation in Underground Coal Mine

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Abstract

Controlled air recirculation for ventilation of mine tunnels in Bosnia and Herzegovina mines, as in most other countries, is prohibited by law. In the past few years a lot of professional and scientific papers about controlled air recirculation have been written, which are based on computer simulations. In addition several experimental studies giving measured results have been presented. A new long wall panel in the pit at RMU "Banovici" was developed and a recirculation circuit was introduced to increase the airflow. To gain more experience with this recirculation circuit all relevant ventilation parameters were monitored, including volume flow, air velocity, gas content, temperature, dust, This information has been analysed and viable conclusions drawn.

Introduction

For a new long wall panel that was being developed, controlled recirculation of air was introduced and the actual ventilation conditions were monitored. Brown coal is mined in the presence of methane and explosive coal dust.

250 m^3/min of fresh air flows through the intake tunnel towards (TP) point 1 which it has cross-section area 15 m^2, arch shaped and with general ascending gradient of 60. Fresh air in the return ventilation tunnel (VP) work site (point 4), is provided by the 7.5 kW axial fan mark 3 and a 800 mm ventilation duct. In the final stage of preparing the longwall panel one part of the intake tunnel was temporarily closed by an insulating barrier.The methane concentration in the tunnel was monitored with a fixed (stationary) methane detector number 10. This sensor has an alarm which is set at 1.5% CH_4 and if the amount of methane exceeds the limit the sensor switches off power to the site. The return air leaves the mine via the main return (Figure 1, Figure 2).

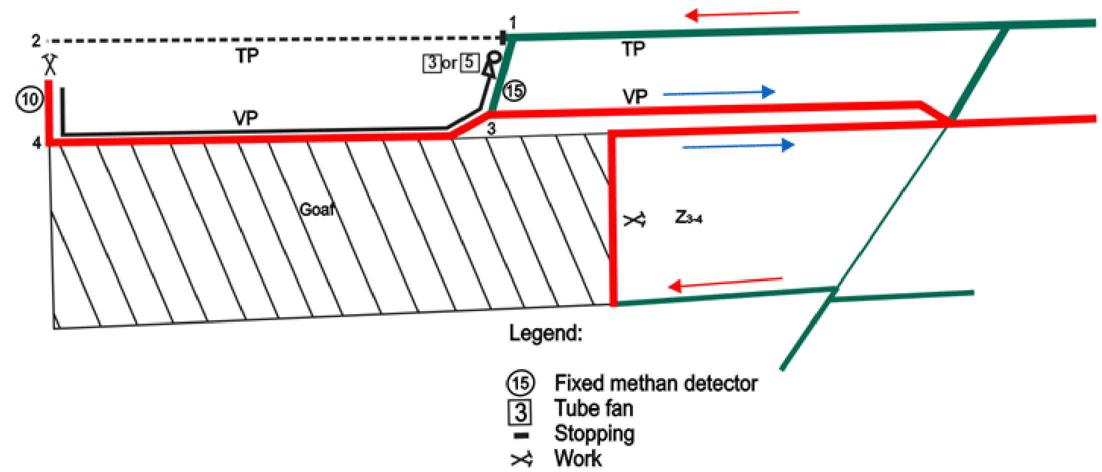

Figure 1: Ventilation Scheme

In the process of constructing the longwall, and to ensure improved microclimate conditions, a new 15 kW axial fan mark 5 power was installed which increased the total amount of air. Due to the increased capacity of the fan, there was a general increase in the air quantity and as expected there was recirculation of air. In the vicinity of the fan a fixed methane detector [number 15] was installed. This detector is set at 0.5% CH4 and if the amount of methane exceeds this value the detector switches off electrical power to the work site. The main reason for introducing recirculation of air is to increase the air quantity since there was an inability to bring fresh air to the fan from other parts of the mine. It should however be noted that there was an increase in the electrical power consumption (Figure -2).

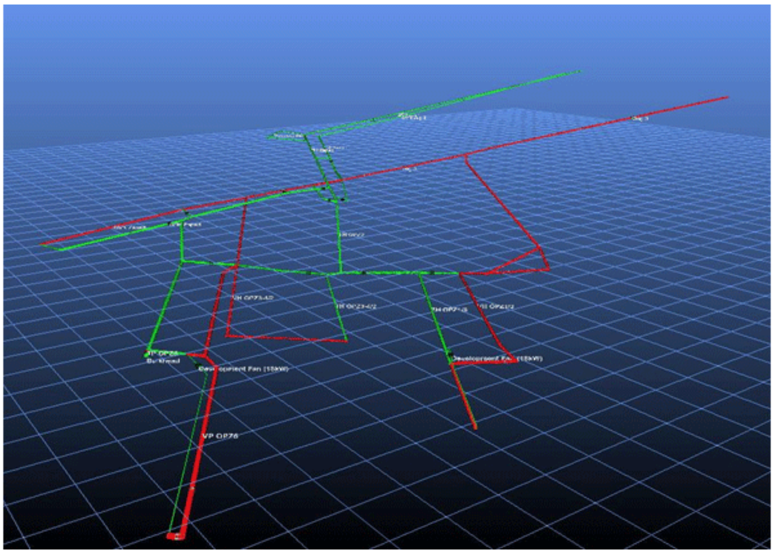

Figure 2: Coal Mine Banovici

Research Methods

In preparation for this study the new fans, methane sensor and full environmental measuring sensors [air velocity dust levels temperature] were installed in addition the absorbed power by the fans were monitored.

The study included the measurement of the concentration of methane at typical points, using hand instruments and fixed methane detectors, measurement of air velocity and volumetric flow as well as temperature measurements. Standard mine equipment was used for all measurements. The study was from 17 to 27.02.2019.

Results

Installation of the new axial fan number 5 was on 17.02.2019. The first measurements were taken on the same day, at the workspace (point 4), and the measured airflow was 350 m^3/min of and the methane concentration was 0.21 % [sensor Number 10]. The new axial fan was working normally. The ventilation worked without problems for four days. Abruptly on the 21.02.2019. at 8h36am detector 15 (Figure 3) measured a methane concentration of 2.07 % . The safety system worked as designed and the power to the site was switched off. With no power to the site the ventilation

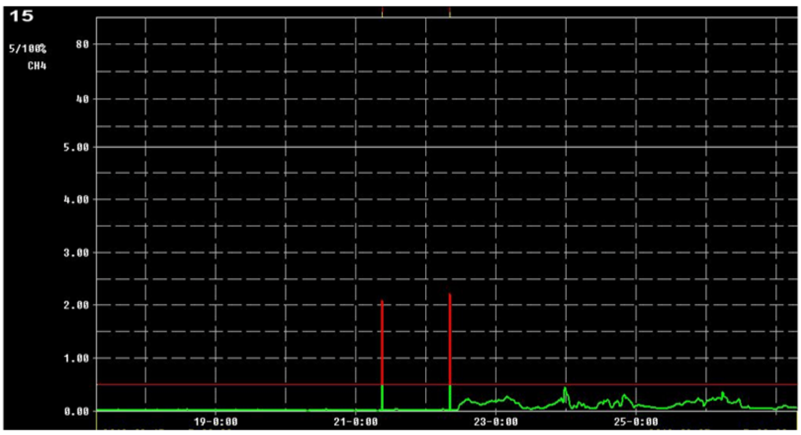

Figure 3: Fixed Methane Detector 15

was reduced and the workers left the workspace. At the same place the fan 3 was installed, the tunnel was degassed, and fan 5 reinstalled on 22.02.2019. at 7h48am. Detector 15 measured a methane concentration of 2.21 % and electrical power to the site was switched off and the worksite was vacated; without power ventilation was discontinued and there were no regular work operations workers. After this, fan 3 was installed and it remained in operation until the end of the development of the longwall tunnel. During this period, the highest measured methane concentration was 0.45 % which was measured on 23.02.2019. at 11h16pm (Figure-3).

At the time of these events methane sensor 10 (Figure 4) detected 1.95% methane on the 21.02.2019. at 9h08am, 1.57 % methane on the 22.02.2019. at 8h20am and on 23.02.2019. at 10h28pm 1.39% of methane was detected (Figure-4).

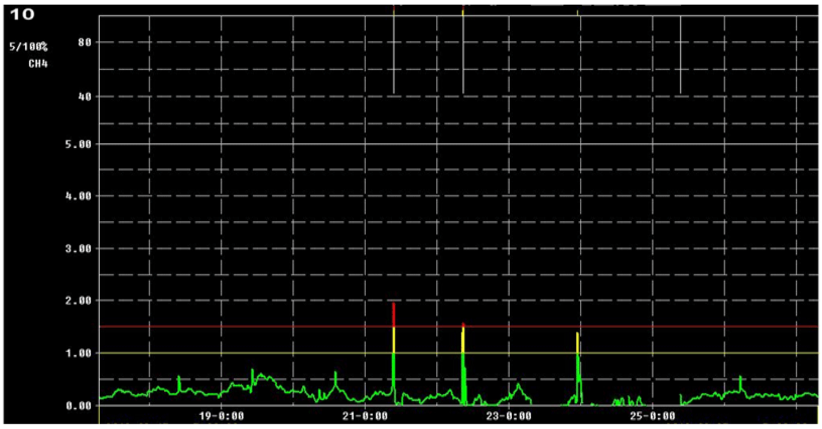

Figure 4: Fixed Methane Detector 10

Analysis of Results

The first time that methane was suddenly detected both the portable and fixed sensors showed increases in methane concentrations. On 21.02.2019. and 22.02.2019. methane was first indicated by sensor number 15 and then sensor 10. In both cases, the difference in time was 32 minutes, and the detector 15 measured slightly higher concentrations of methane than detector 10. In these cases the 15 kW axial fan mark 5 was working. Also, in these cases 125 m3/min of air was being recirculated

On 23.02.2019. when the 7.5 kW axial fan 3 was operating, methane was first indicated on the sensor 10 and then sensor 15. In this case the difference in time was 48 min and the sensor 10 measured a significantly higher concentration of methane than sensor 15.

While the 7.5 kW axial fan number 3 was in operation (point 4) the measured velocity air at the workspace was 0.22 m/s with a flow rate of 200 m^3/min. In the case when the 15 kW axial fan number 5 was operating the measured air velocity at the workspace was 0.41 m/s and the volume flow was 370 m^3/min. It is clear that fan 5 provided significantly more air to the site and that the microclimate conditions were slightly better (lower temperature by 2^0C, 27^0C in the first case and 25^0C in the second case).

By analyzing the causes of the sudden appearance of methane it was determined that methane came from the goaf Z_{3-4} when the atmospheric pressure dropped. On the 21.02.2019. the atmospheric pressure dropped from 988 mbar to 984 mbar. Similarly on the 22.02.2019. and 23.02.2019. the atmospheric pressure declined to 977 mbar.

In these cases, the methane flow from the goaf Z_{3-4}, increased when there was a drop in atmospheric pressure. Because of air recirculation, when fan number 5 was operating the increased methane concentration was first detected by sensor number 15 and by the axial fan and ventilation ducts which supply air to the workspace. At a time when the concentration of methane at the sensor 15 increased to above the limit of 0.5 %, the workers left the site and the axial fan was switched off. Then methane slowly filled the tunnel and arrived at sensor number 10, which explains why there was a delay a of 32 minutes. In the case when fan 3 was operating, there was no recirculation of air, and the methane through the return tunnel flowed towards the exit of the pit. Sensor number 10 registered an increase in methane concentration however, the concentration did not exceed the permissible value (1.5 %).

Conclusion

Controlled recirculation of air is a topic about which much has been written and spoken. In our studies we have tried to apply recirculation of air at the workplace in order to create better climatic conditions. In this respect the project was successful and there was a reduction in temperatures and humidity. In addition the increase in air speed created the impression of 'a better job feeling'.

Unfortunately the project was curtailed before the effects of recirculation on dust levels could be measured. The main, problem arose due to an increase in methane concentration in the mining workspace which forced the study to be curtailed.

However, the question arises how circulations of air in real conditions can be controlled? It is known that the gas relations in mine tunnels are influenced by several factors. In our case, at the time of the research, the crucial influence was the changes or fluctuation in atmospheric pressure. We know from experience that even a small drop in atmospheric pressure can cause significant inflows of methane into the mine tunnels from the goafs and coal seams. This is a characteristic for all relatively shallow coal mines with significant values of methane.

The drop in atmospheric pressure caused an increase in the flow of methane which was detected by the methane sensors and electricity to the site was switched off. Of course we could not, in any way, affect the change in atmospheric pressure. Also, the question arises whether the same thing would happen with certain changes in the goafs (falls of ground and consolidation of the goaf, mine fire, etc.).

Although air recirculation offers a number of, primarily economic benefits, certainly in our case it resulted in a number of production stoppages as well as the deterioration of the general safety conditions at the site.

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