The impact of EXtreme weather events on MINing operations

TEXMIN

DELIVERABLE D2.3. REPORT ON PHYSICAL AND CHEMICAL IMPACTS ASSOCIATED WITH CHANGES IN ATMOSPHERIC PRESSURE – SUMMARY

SUMMARY

Gas emissions from a closed hard coal mine is a phenomenon that has been recorded in most mining regions in the world, e.g. in the United States, England, France, Germany, China, Czech Republic, Greece, Ukraine, Australia, South Africa, and also in Poland. Pressure drops are considered a major cause of gas emissions from abandoned mines to the surface and then to the atmosphere. For the TEXMIN project pressure tendency for following hours separately was assigned as *dp* and when averaged for the entire pressure drop period it was assigned as dp_{av}.

In the case of the TEXMIN project, in addition to determining pressure drop intensity during the measurement series (quantitative analysis), gas emissions were also measured from a closed mining shaft. During the duration of the task, SUT recorded several upcoming storms which can be classified as extreme weather events (e.g 22.08.2020 and 26.09.2020 when hourly pressure drop was up to -0.5 hPa/h. In the terms of mentioned above (chapter 1.2) quantitive analysis. For the total number of recorded measuring series equalled 71 (11 were rejected as unreliable), for 38 series value of pressure drop was lower than -0.5 hPa/h. Selected results of measurements are presented in Chapter 5. Four shafts were selected, however, three of them were rejected as emissions were not detected. Ultimately selected site (according to confidence agreed with SRK it is called „II" and no other details can be given. The measurements were based on good practice methods recommended in the document prepared by the Intergovernmental Panel on Climate Change (IPCC) which is titled ''PCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy, Chapter—Fugitive emissions'' [Report 2] and on an adequate Polish regulation (PN-EN 15259:2011) and other following standards:

- Polish Standard [PN-ISO 10396] "Emission from stationary sources. Taking samples for the automatic measurement of the concentration of gaseous components"- for measurements in an open field, and
- Polish Standard [PN-Z-04008-7] "Air purity protection. Sampling. Principles of air sampling in the work environment and interpretation of results"- for indoor measurements. After the preliminary series due to possible high concentrations of CO_2, aspiration, isolation and passive methods were abandoned. However, the automatic research method was adopted, i.e. with the use of a gas analyser. The adopted method of analysis can be classified as "in situ" analysis using portable measuring instruments, where qualitative determinations were made (gas analysers and monitors).

There were 15 specific series (days) taken on: 11.05.2020, 23.05.2020, 30.05.2020, 03.06.2020, 29.06.2020, 10.07.2020, 27.07.2020, 22.08.2020, 26.08.2020, 26.09.2020, 19.11.2020, 28.12.2020, 28.01.2021, 21.03.2021, 13.05.2021.

The measurements were divided into two groups:

- G1 - measuring of gas emitted through the emission point – temperature, velocity, gas concentrations (carbon dioxide, oxygen, methane and carbon monoxide).
- G2 - measuring of carbon dioxide and oxygen concentration in the vicinity of II shaft at two levels – ground level and 1 meter above the ground.

In addition following data in the vicinity of II shaft was gathered:

- temperature of atmospheric air (ambience),
- wind speed,
- wind direction.

CH_4 and CO were NOT detected (but it must be mentioned that according to literature studies these gases can be expected in other post-mining regions or even in a tested region in the future). The highest value of CO_2 concentration in emitted gases was 9.0% vol. and the highest gas emission velocity from the shaft was 2.86 m/s. The lowest oxygen value in the emitted gases was 4.9% vol. it was found when the mean negative value of the baric trend was -0.83 hPa/h.

It was also found that the process of gas emission from closed mines is subject to inertia, which can be observed during very dynamic weather phenomena (e.g. an extreme weather event). The period of atmospheric pressure increase does not always mean a safe gas situation in the vicinity of the shaft, as stated on August 22, 2020, the emission of gases from a closed shaft may persist even an hour after the baric tendency has changed from negative to positive.

In addition, it was discovered that during the measurements there were hourly pressure changes (*dp*) ranging from +1.0 hPa / h to -1.0 hPa / h. The obtained results indicate that both the overall average value of the baric tendency and its type (introduced in chapter 2, Fig. 2.1) have an impact on the values of the measured parameters (emission velocity, gas concentrations), but the hourly pressure changes may cause some additional fluctuations.

Analysing variation of gas distribution around the shaft II during a pressure drop it can be stated that in the measuring area, an increased concentration of carbon dioxide and a reduced oxygen concentration were found up to the border of the area, i.e. at a distance of 40 m from the emission source E. This is the main conclusion resulting from the conducted measurements in situ, which, according to the assumptions of the project, constitutes a premise for determining the safe distance from the shaft in WP 4, task 4.1.2, where it is one of the factors influencing the assessment of the gas hazard on the surface near the decommissioned shaft.

Basing on the results following formulas can be given. A second-order polynomial function, linear function and a logarithmic function were matched based on the highest value of R^2:

For concentration of CO_2:

$$CO_2 = 16.893(dp_{av})^2+29.503(dp_{av})-4.05 \quad (1)$$

when $R^2 = 0.7937$.

For concentration of O_2:

$$O_2=-8.874\ln(dp_{av})+2.3264 \quad (2)$$

when $R^2 = 0.6418$

For velocity of emissions (w):

$$w = 3.1715(dp_{av})-0.2789 \quad (3)$$

Correlation coefficient R^2 varies between 0.717 and 0.6418. Thus, the obtained formulas enable a reliable prediction of the measured values in the assumptions of numerical simulations of extreme weather phenomena in WP3.

In addition, SUT, has studied the impact of increasing temperatures on gas emissions from abandoned coal mines. It was presented in D.2.2 and this report compromises only a summary of the findings presented there.

HIGHLIGHTS

- Gas emissions from a closed hard coal mine is a phenomenon that has been recorded in most mining regions in the world.
- Pressure drops are considered as a major cause of gas emissions from abandoned mines to the surface and then to the atmosphere, the emissions are the most probable when a closed shaft is not filled up with backfill material.
- There were 15 measuring specific series (days) containing 71 hourly subseries during every season of the year.
- The highest value of CO_2 concentration in emitted gases was 9.0% vol. and the highest gas emission velocity from the shaft was 2.86 m/s. The lowest oxygen value in the emitted gases was 4.9% vol. it was found when the mean negative value of the baric trend was -0.83 hPa/h. It was found that during the measurements hourly pressure changes were ranging from +1.0 hPa/h to -1.0 hPa/h. Although, during the duration of the project an extreme pressure drop was detected with the dp_{av} = 4.5 hPa/h.
- It was found that the process of gas emission from closed mines is subject to inertia, which can be observed during very dynamic weather phenomena (e.g. an extreme weather event). The period of atmospheric pressure increase does not always mean a safe gas

situation in the vicinity of the shaft, as stated on August 22, 2020, the emission of gases from a closed shaft may persist even an hour after the baric tendency has changed from negative to positive.

- Analysing variation of gas distribution around the shaft II during a pressure drop it can be stated that in the measuring area, an increased concentration of carbon dioxide and a reduced oxygen concentration were found up to the border of the area, i.e. at a distance of 40 m from the emission source.
- The results indicate that both the overall mean value of the baric tendency and its type has an impact on the values of the measured parameters (emission velocity, gas concentrations), but the hourly pressure changes may cause some additional fluctuations.