Abstract

A phenomenon of coal self-heating constitutes one of the major natural hazards affecting fire hazard in hard coal mines. In order to minimize it, various methods of assessing the development of the coal self-heating process are used. They consist in determining the concentrations of gases emitted from the entire coal mass at a certain constant temperature and in analysis of the values of fire indices determined on their basis. In underground conditions, however, the temperature of spontaneous fire source is not constant but varies from the maximum value in the source centre to the temperature of the rock mass on the source edges. Moreover, the methods used so far do not take into account the influence of the physical parameters of coal on fire hazard. Thus, the values of fire indices determined in the laboratory conditions differ from the ones obtained in the real conditions. Given the above, the need was identified to carry out experimental studies on the process of coal heating and cooling that would take into consideration the temperature distribution in the heated and cooled coal deposit. Based on the assessment of the state of art in the field of research and development on the coal self-heating process and the methods used to evaluate its development, the elements of novelty of the undertaken research topic were determined. They include: an original laboratory installation for the study of the coal heating process allowing for registration of changes in the coal temperature during heating and cooling, model development of the process of coal heating and cooling taking into account different values of the volumetric gas flow rate and various coal grain size distribution; and determination of the impact of changes in the primary rock mass temperature on the composition of gases emitted from the heat source at a constant temperature. The scientific aim of the PhD thesis was to determine the changes in the temperature distribution in the coal sample and the composition of gases released from the sample during heating and cooling phases. The utilitarian purpose was to determine the applicability of the PhD thesis results to evaluate the state of fire hazard in hard coal mines.

As part of the PhD thesis, a method was developed for the evaluation of self-heating and cooling of coal, taking into account the impact of grain size, volumetric flow rate of air and nitrogen through the coal sample and the primary rock mass temperature on these processes. Laboratory tests and analysis of the process of coal heating and cooling were performed, taking into account the composition of gases and the full temperature range of the entire potential spontaneous fire source. The tests were carried out in a research installation designed and constructed as part of this study, enabling measurement of the temperature distribution, simulation of the maximum temperature in the spontaneous fire source and the primary rock mass temperature for a given coal seam as well as collection of gas samples in conditions similar to the real ones. The detailed scope of the research carried out included:

– studies of the temperature distribution in coal in the heating and cooling phases, providing information about the heat distribution around the spontaneous fire source, analysis of changes in gas concentrations during heating and cooling, determination of the value of the so-called gas background at the primary rock mass temperature as well as analysis of changes in the values of fire indices for the heating and cooling phases,

– studies of the impact of changes in coal grinding on the process of coal self-heating and cooling, indicating a change in the ratio of concentrations emitted from standard crushed coal to coarsely crushed coal for individual gases, both in the heating and in the cooling

phase, and that with increasing temperature the effect of coal grinding on the release of ethane, ethylene, propane, propylene and carbon monoxide decreases,

– studies of the effect of the volumetric flow rate of gases through the coal sample on the process of coal heating and cooling, which proved that in the heating phase with increasing temperature the ratio of ethane, ethylene, propane, propylene and acetylene concentrations decreases and the ratio of carbon monoxide concentration to carbon dioxide concentration changes,

– studies of the influence of the primary rock mass temperature on the process of coal heating and cooling, which showed that a slight increase in the primary rock mass temperature has a significant impact on the increase in the concentrations of emitted gases, which is important in the conditions of coal mining from seams located at ever greater depths with the higher primary rock mass temperature.

Analysis of changes in the concentrations of gases emitted during coal heating and cooling as well as of fire indices showed that the adoption of common assessment criteria for fire hazard for the coal heating and cooling phases may lead to incorrect conclusions. The study results presented in the PhD thesis supplement the knowledge on the self-heating process of coal and may be applied in the assessment of fire hazard in hard coal mines and in coal waste dumps.