Abstract

Hard coal is a rock of organic origin, which has a very complex and heterogeneous physicochemical structure consisting of three basic components - organic substance, inorganic mineral substance and water.

These components are interconnected by physical and chemical interactions, sometimes resulting in significant problems during the extraction of coal and its subsequent storage on the surface. Among them, the low-temperature processes of coal self-heating leading to ignition are important. The mining practice to date proves that the methods of determining the self-ignition capacity of coal and early detection of fires unfortunately fail in many cases. Therefore, research was carried out in the present work aimed at determining the method of detecting and predicting the possibility of coal self-heating, as well as developing new methods of fire prevention. Attention was paid to the reactivity of coals, chemical components contained in coals and the interaction of coals with saline mine waters. The research was carried out for coals from the mines in the south-western part of the Upper Silesian Coal Basin and, in order to complete all lithostratigraphic series, for coals from the mines in the eastern part of the Basin. In general, furrow samples of coal mined in 2009-2011 were taken for analysis. Coal transformations resulting from the course of the processes of their interaction with waters were characterized by means of thermographs made by the oxy-reactive thermal analysis (OTA) method.

It was found that in the Carboniferous formations of the Upper Silesian Coal Basin there are generally two groups of coals with different thermodecomposition characteristics and contents of chemical components in them, indicating different heating capabilities leading to ignition and kindling. Coals containing up to: 2.85% Fe, 1.2% Ca, 0.15% Mg, 1.69% S, 0.39% Na and 1.68% Cl in the ash mass and characterized by two-stage addition processes air components (mainly oxygen) and two-stage gas evolution processes (e.g. carbon monoxide and carbon dioxide) are carbons with high reactivity, susceptibility to heating leading to ignition. On the other hand, coals containing large amounts of chlorine in the incinerated mass, reaching 4.08%, sodium 0.91%, calcium 3.94% and magnesium 0.98%, are characterized by a limited ability to attach air components and release gaseous components. The thermodecomposition characteristics of these coals indicate their low tendency to heat up leading to ignition.

On the basis of the studies on the impact of brines on coals in laboratory conditions, similar to the natural conditions prevailing in the Carboniferous orogen, it was found that brines cause changes in coals affecting the course of their thermal decomposition processes. The intensity of changes in coal properties is primarily influenced by the oxidation-reduction conditions of brines. Brines in which reducing conditions prevail, barium ion is present, reduce the susceptibility of coals to heating leading to ignition. On the other hand, brines with oxidizing properties, containing the sulphate(VI) ion, cause a transformation in most coals, resulting in an increase in their ability to ignite. Strong brines, from which sodium chloride (halite) crystallizes on the coals, affect coal transformations, causing the total loss of their ability to ignite.

Examination of the chemical composition of mine waters and coals as well as the characteristics of thermal decomposition of coals using the oxyreactive thermal analysis (OTA) method can be used in fire prevention in mines and at the same time to assess the ability of coals to gasify.

The results of the research on the chemical composition of the coals of the Upper Silesian Coal Basin have drawn attention to the presence of harmful chlorine and bromine components in them.

Chlorine analyzes showed that its content reaches 18090 ppm (up to 7.58% in ash after coal combustion), while bromine content reaches 229 ppm.