Zonal disintegration of the coal seam as a phenomenon preceding the sudden shift of seam

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Experimental study of rock mass near openings at large depth often discover an unusual structural irregularity in induced cracking, i.e. zonal disintegration of rock when removed from the opening wall (Prof. V.N.Oparin et al., G.R.Adams et al., prof. V.V.Makarov et al.). As found by experimental study (prof. G.Y. Polevshchikov et al), such zones are also generated in coal seams which manifests itself in particular as wave-like changes in gas inflow into wells drilled in the seam as their length increases. There is recently much effort in Russia and China to develop a theory for zonal disintegration of brittle rock, however there are just few studies with gas-bearing seams. This paper describes a model for gas-dynamical destruction of coal seams basing on a concept of zonal disintegration of seams in front of the stope.

Stress state of a horizontal coal seam loaded by strong host rock is considered. An area of post-limit deformation is generated at the end part of the seam near the stope. This area is described by the descending branch of the stress-state relationship. The stress state of the seam is determined taking into account of the area of post-limit deformation. A relationship is found between the length of the area and a complex loading parameter reflecting the excavation length and pressure of the overlying rock. This relationship is shown to have a return point that is characterized in the mathematical theory of catastrophes as a point of the system stability loss. So, on reaching the loading parameter value corresponding to this point the quasi-static process of seam deformation should change to dynamical process of seam deformation and partial destruction. This phenomenon may be treated as a trigger effect in the seam deformation. The qualitatively new equilibrium state of the seam corresponds to the zonal disintegration as generation at least a main tensile crack and small cracks near it that cross the entire seam thickness and separating the marginal part from the rest of the seam.

Modeling was performed for the process of filling of the main crack by free methane due to methane filtration and diffusion from the seam into the crack. The relationship was found between the rise of gas pressure in the crack and time for various filtrational and diffusional parameters of coal. Critical value of gas pressure was found at which the marginal part of seam shifts dynamically towards the excavation. In practice this phenomenon is referred to as sudden shift of the coal seam. This coal seam deformation model is a version of the model proposed by prof. S.V.Kuznetsov and V.A.Trofimov. The principal difference is in analysis of the prime cause of the seam destruction.

It follows from our study that the concept of zonal disintegration may be useful to better understand mechanisms of coal seam destruction that induce release of large amounts of free methane in excavations.