Effect of explosive impact on gas-dynamic destruction of coal seam

Odintsev V.N.

Institute of Comprehensive Exploitation of Mineral Resources Russian Academy of Sciences, Moscow, Russia

e-mail: Odin-VN@yandex.ru

Prevention of hazardous gas-associated events in coal mines remains an important problem occurring in mines of some countries. The catastrophic events are associated with sudden appearance of a huge amount of free gas (methane) while 90% of methane is initially in absorbed state inside coal substance. The appearance of free methane is due to coal seam destruction and coal and gas outburst into the excavation to follow. The paper addresses a mechanism of coal destruction due to methane transition from bound into free state under explosive impact on non-permeable coal seams.

The study was carries out in two fields. That are modeling of the explosive wave far from the explosive well (at a geomaterial preliminary fracture zone at a distance of more than 20 well radii) and modeling of development of microcracks induced by the explosive wave due to methane diffusion into the microcracks and crack growth caused by the free methane pressure.

Modeling of explosive wave effects in the indicated zone has demonstrated that pulses of compression and extension are generated at the wave front when high explosives are used. The extension pulse has a duration greater than 100mcs, and extension magnitude reaches several MPa which is sufficient for opening of natural defects in coal and generation of open cracks.

The methane release into the microcracks is described by a system of equations:1) equation of diffusion of methane molecules from coal into microcracks; 2) equation of free methane state in the crack; 3) equation of Langmuir isotherm to evaluate the portion of microcrack side surface free from adsorbed molecules to allow methane diffusion into the crack; 4) equation of crack opening in elastic medium due to free methane pressure; 5) Griffith-Irwin equation of limit equilibrium state of the crack.

The modeling discovered some consequences of the free methane transition from dissolved into free state. It was shown that microcracks exposed to methane filling were stable in some cases or might start to grow dynamically in other cases (a necessary condition for coal and gas outbursts) depending upon relationship between determining parameters. Time for crack preparation to the dynamical development was found for the later case, which was mainly determined by coal fracture toughness and gas-bearing capacity, and value of coefficient of diffusion. The time for crack preparation to the dynamical development was shown to vary from several seconds to several hours depending upon conditions.

As follows from the model study, explosive impact on non-permeable coal seams creates a metastable area of coal preliminary fracture within which induced microcracks are filled with free methane rather fast. This gives rise to generation of a source of coal and gas outburst in the seam. Consequently, the explosive impact is a sort of a trigger for coal gas-dynamical destruction. The study results may be useful for development of measures to optimize efficiency of shock explosion of coal seams which is used as a technique for artificial induction of coal and gas outbursts. The study is supported by RFBR (Project 18-05-00912).