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MODELLING OF HYDRO-FRACKING IN ROCKS USING COUPLED DEM/CFD APPROACH

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Hydraulic fracturing is a well stimulation technique to increase the productivity of petroleum reservoirs in which rocks are fractured by a pressurized liquid. The process involves the high pressure injection of fluid (primarily water, containing sand or other proppants suspended with the aid of thickening agents) into a wellbore to create cracks in the deep-rock formations through which natural gas and petroleum will flow more freely. When the hydraulic pressure is removed from the well, small grains of hydro-fracking proppants hold the fractures open. The economic production of gas/oil greatly depends on the effectiveness of hydro-fracking that is affected by rock fracture.

The aim of our research works is the description of a complex mechanism of the initiation and propagation of fractures in rocks due to the activity of the high fluid's pressure (higher than the strength of rocks) and temperature during hydro-fracking with an advanced mathematical model based on the three-dimensional (3D) discrete element method (DEM) combined with fluid flow computational fluid dynamics (CFD) and heat transport. In calculations the presence of pre-existing pre-discontinuities in rocks is taken into account. Since hydro-fracking strongly depends on a heterogeneous meso-structure of rocks, the discrete element method (DEM) is a suitable numerical tool for investigating a non-uniform formation process of complex fracture patterns in brittle rocks at the mesoscopic level [1], [2].

In this paper the 2D simulations results on hydro-fracking in shales are presented using DEM coupled with a two-phase fluid-gas flow using the so-called Virtual Pore Network approach. In this approach, the geometry changes of pores, pre-existing fractures and newly created fractures were precisely determined. Initially, the laminar, compressible and viscous Poiseulle flow was assumed in pores and fractures. In calculations the effect of the rock anisotropy, location, size and shape of natural existing organic layers and macro- and micro-pores, size, shape and density of discrete elements and fluid pressure on the shale behaviour was carefully investigated. Attention was paid to the propagation of hydraulic fractures in shales and fluid pressure evolution in hydraulically stimulated fractures.

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