Development of device for interval-by-interval hydraulic fracture

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Development of device for interval-by-interval hydraulic fracture

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Abstract. Under consideration is the experience gained in design and manufacture of tools for mining machines meant for operation in uncontrollable conditions. It is shown that equipping the mining machines with disk tools reduces specific consumption of the tools, specific power-input and dusting during breakage of hard rocks.

1. Introduction

Low-permeability zones decelerate tunneling speed and entail high face outputs due to small volume of gas drainage work and under-efficiency of drainage mechanisms in many mines in Russia. In highly productive longwalls in gas-bearing coal seams, the in-seam drainage technology has found widest application [1–3]. By estimates, the current gas drainage techniques applied in Russia extract from 20 to 30% of total methane released [4–7]. Surface-based gas drainage is connected with the known difficulties detailed in [8]. Further improvement in safety, environmental security and efficiency of underground mining in coal mines with high gas content is inextricably connected with development of special measures and techniques aimed to stimulate gas recovery from high-stress coal [9–12].

Gas recoverability in high-stress coal seams can be enhanced by improving coal permeability using multi-stage hydraulic fracturing (Figure 1); a variant of this approach is described in [13, 14]. Multistage hydraulic fracturing is used to shorten and intensify pre-mine gas drainage process. In a coal seam, a set of hydrofractures of assigned configuration is created for partial unloading of rock mass and for making filtration channel for water (dehydration) or gas drainage.

Hydraulic fracturing improves permeability of coal faces by means of initiation or opening and elongation of natural cracks. The fractures created during directional multistage hydraulic fracturing can reach a length of a few tens of meters and, when merged, considerably improve permeability of gas drain hole [15].

The hydraulic fracturing tool (Figure 2) is advanced in the hole in the column of high-pressure pipes (Figure 3) using a drilling rig.

2. Results of practical application of the hydraulic fracturing method

In Yubileinaya Mine in Kuzbass, pilot multistage hydraulic fracturing was carried out in conveyor drive 16–19 in an experimental hole with a length of 145 m and diameter of 93 mm (Figure 4).

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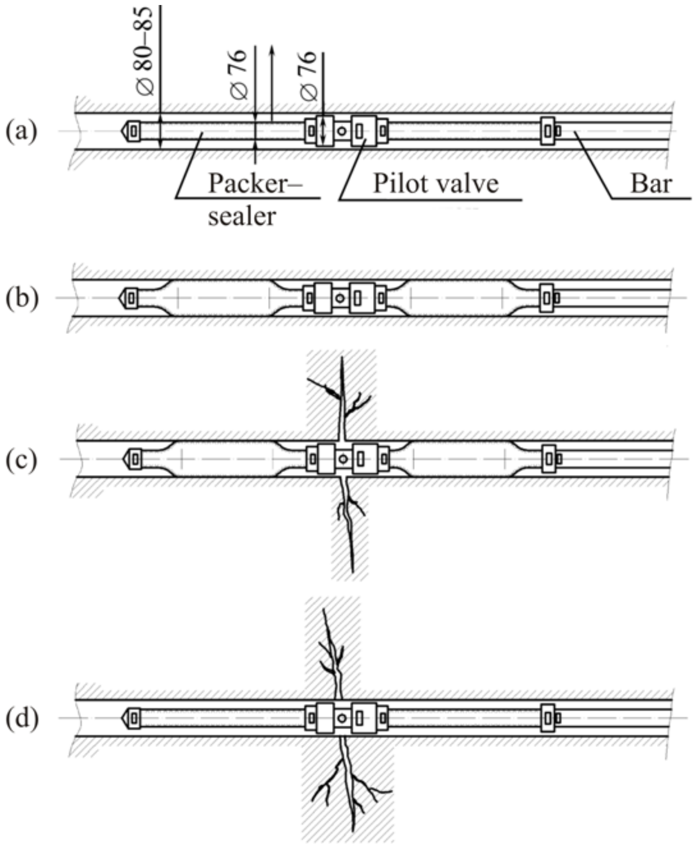

Figure 1. Process chart of multistage hydraulic fracturing of coal: (a) inlet of packer in hole; (b) sealing of hole; (c) hydraulic fracturing of coal; (d) unsealing of hole and advance of packer.

Figure 2. Hydraulic fracturing tool: *1*, *2*—elastic inflatable hoses; *3*—inter-packer valve, *4*—shat-off nose-piece, *5*—connector sleeve.

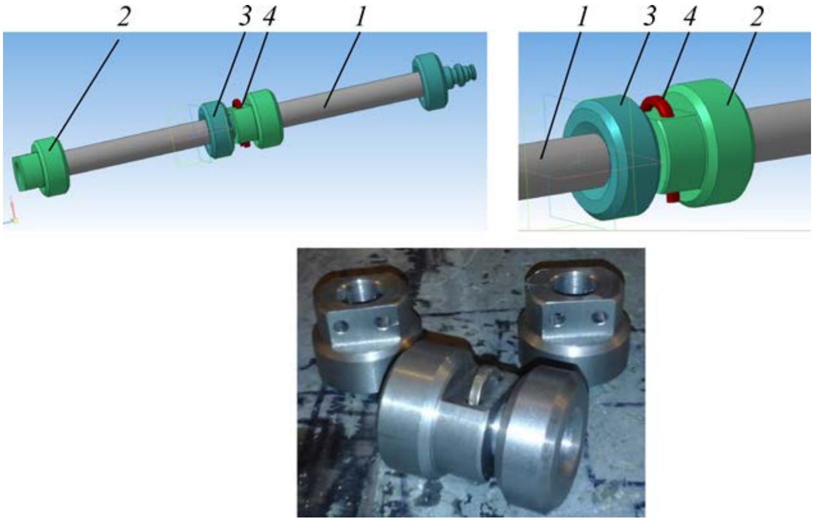

Figure 3. High-head pipe width quick-release coupling: *1*—pipe; *2*—sleeve; *3*—nipple; *4*—clip.

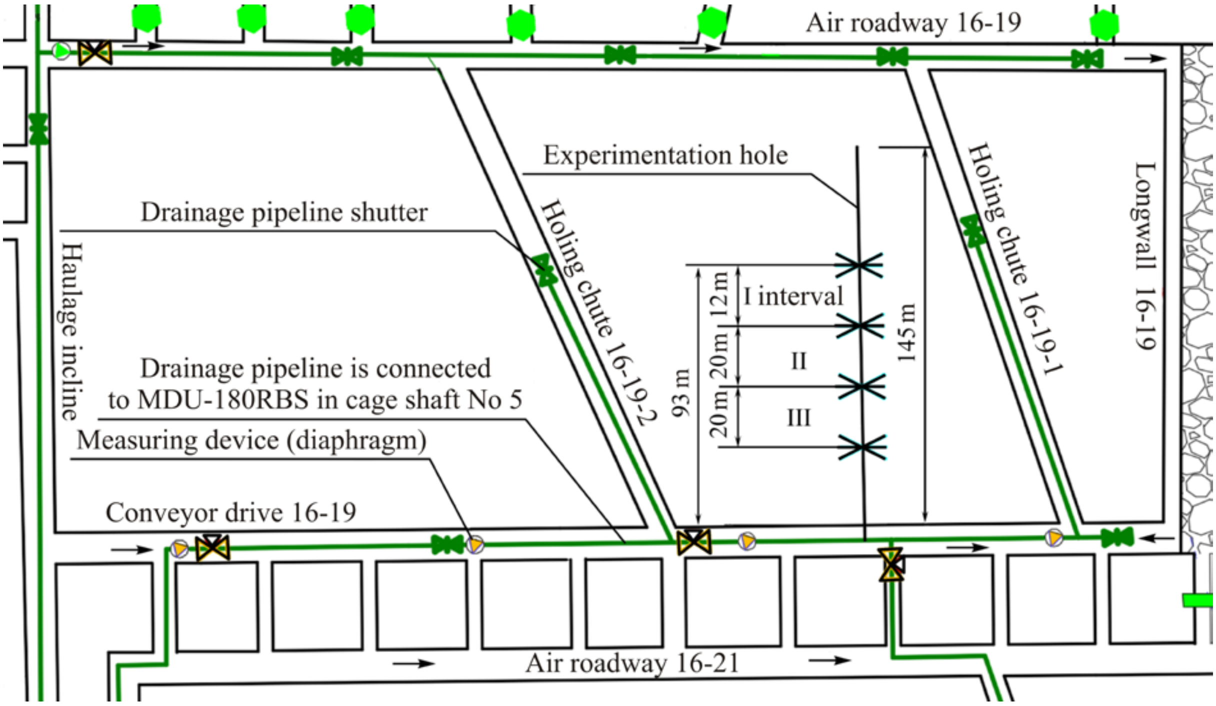

Figure 4. Experimental hole for multistage hydraulic fracturing: Layout.

The coal seam 16 is from 1.48 to 1.78 m thick, with average thickness of 1.60 m. Natural gas content is 11.8–25.0 m^3/t. The maximum depth of mining in longwall 16-19 is 730 m. The seam is rockburst-hazardous down from the depth of 150 m and outburst-hazardous down from the depth of 325 m. Before the experiment, the high-head equipment and instrumentation were assembled and installed (Figure 5).

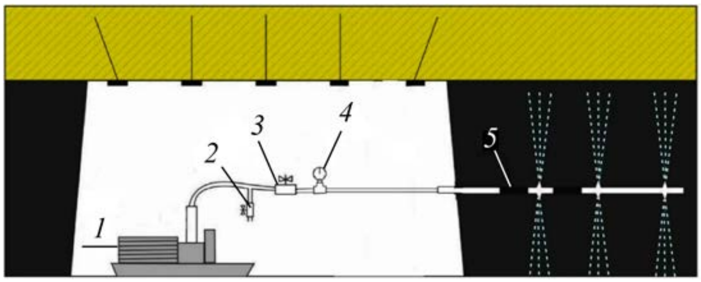

Figure 5. Equipment configuration: *1*—high pressure pump; *2*—dump valve; *3*—high-pressure screw-valve; *4*—manometer; *5*—hydraulic fracturing tool.

Multistage hydraulic fracturing was implemented in four intervals of the hole, at the distances of 93, 81, 61 and 41 m from the mouth. Fluid was injected in each interval for 15 min. Fluid injection pressure was no less than 16 MPa. As the high-head pipes were removed and the fracturing tool was displaced to the next fracturing interval, both fluid and methane-and-air mixture were jump-wise ejected from the hole.

After completion of experimentation, when water overflow stopped, the hydraulic fracturing hole was connected vacuum degassing network. From the monitoring, the average methane flow rate per one pre-mine drainage hole in the conditions of Yubileinaya Mine without hydraulic fracturing is 0.073 m^3/min, methane flow rate from the pilot hydraulic fracturing hole is 0.315 m^3/min. Methane concentration in the mixture reaches 72%, which is 0.23 m^3/min in terms of pure methane. Based on the measurement results, methane-and-air mixture flow rate is 13 l/min. Effectiveness parameters of hydraulic fracturing were measured for 55 days after the work completion.

3. Conclusions

The proposed technology and tools can be used for multistage hydraulic fracturing of coal for stimulation of methane recovery in drain holes. This will ensure safe and efficient operation of longwall faces at high outputs owing to deeper gas drainage of coal and mitigated risk of methane outbursts and rockbursts due to partial relief of stresses in coal by created fractures. Furthermore, volume of drainage drilling and toxic methane emission in coal mines is reduced.

Acknowledgements

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