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The Three-Zone Composite Productivity Model of Multi-Fractured Horizontal Wells under Different Diffusion Coefficients in a Shale Gas Reservoir

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Abstract : Due to the nano-micro pore structures and the massive multi-stage multi-cluster hydraulic fracturing in shale gas reservoirs, the multi-scale seepage flows are much more complicated than in most other conventional reservoirs, and are crucial for the economic development of shale gas. In this study, a new multi-scale non-linear flow model was established and simplified, based on different diffusion and slip correction coefficients. Due to the fact that different flow laws existed between the fracture network and matrix zone, a three-zone composite model was proposed. Then, according to the conformal transformation combined with the law of equivalent percolation resistance, the productivity equation of a horizontal fractured well, with consideration given to diffusion, slip, desorption, and absorption, was built. Also, an analytic solution was derived, and the interference of the multi-cluster fractures was analyzed. The results indicated that the diffusion of the shale gas was mainly in the transition and Fick diffusion regions. The matrix permeability was found to be influenced by slippage and diffusion, which was determined by the pore pressure and diameter according to the Knudsen number. It was determined that, with the increased half-lengths of the fracture clusters, flow conductivity of the fractures, and permeability of the fracture network, the productivity of the fractured well also increased. Meanwhile, with the increased number of fractures, the distance between the fractures decreased, and the productivity slowly increased due to the mutual interference of the fractures. In regard to the fractured horizontal wells, the free gas was found to majorly contribute to the productivity, while the contribution of the desorption increased with the increased pressure differences.

Keywords : multi-scale, fracture network, composite model, productivity
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