New Evidence Indicating Fracture Development in Coal Reservoirs Using Hydraulic Fracturing Curves: A Case Study in Yanchuannan CBM Field

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Abstract

Identification and prediction of fractures in coal seam has always been a difficult task in describing the coalbed methane reservoir characteristic. A great deal of corresponding work has been carried out by CBM experts globally, and the primary techniques include log explanation, well test curves analysis, seismic method, tectonic curvature analysis, hydraulic fracturing and production data analysis etc. Based on the research conducted before, this study supposes a new method to indicate the fracture development according to the hydraulic fracturing curves.

Regarding the NO.2 coal seam of Shanxi formation in Yanchuannan CBM field, Erdos basin as the research object, this paper collected fracturing curves data and coal cores from 162 production wells and 10 coring wells, respectively. The different coal structure types were analyzed and obtained from the cores in the study area, based on which, we summarized the corresponding hydraulic fracturing curves characteristics to different coal structure types. Then the fracturing curves could be used to indicate the coal structure types where there was no coring conducted and consequently to indicate the natural fracture development extent. The conclusions are as follows:

1. According to the natural fracture characteristics recognized through the cores, the coal structure was divided into three types: 1) primary texture coal, 2) technically crashed coal, and 3) granulated coal. The hydraulic fracturing curves corresponding to the coal structure types I and II indicate that the fractures developed pretty well and the other one type represents that the development extent of the primary texture is relatively low, thus a relatively low permeability.
2. The fracturing pressure could, to some extent, reflect the level of difficulty to create artifact fractures in coal seam, which then could indirectly be able to illustrate the fracture development extent. According to the fracturing curves characteristics at the bursting point, the curves could be divided into two different types, type a, the fracturing pressure is equal to the extending pressure, representing the natural fractures developed intensively in the perforation point and type b, i.e. the fracturing pressure larger than the extending one, which indicates there is less natural fractures developing at the beginning point. This is because the injection pressure needs to balance the stress concentration caused by the two horizontal stresses, which results in the bursting pressure larger than extending pressure, where the natural fractures developed scarcely.
3. More precisely, the type I fracturing curves could be divided into two different groups, one is the stable type, the extending pressure keep same value during the whole fracturing process meaning fluid injection rate is equal to the leak-off plus fracture initiation, which represents the natural fractures developed intensively; the other type is temporary sand up, presenting as the injection pressure soars but then decreases quickly. In addition to the excessive ratio of sand, the reason for sand up is closely associated with the fracture

development extent. It is frequently aroused by the connection of artificial fractures and natural one that increase the permeability, leading to large number of fracturing fluid leaks into the formation. It can also indicate the fracture develop well.

Type II fracturing curves could be divided into three groups:

1. Stable type, similar with that in curves type I;
2. Fluctuating type that is the pressure fluctuates in particular extent over the process, and could then be classified into two subgroups: zigzag and wave, according to the fluctuation frequency; the pressure of zigzag fracturing curve appears hackly. The reason for this phenomenon is that hydraulic fractures encounter natural fractures constantly and fracture stretches repeatedly between natural fractures and the coal seam in the process of extension. The phenomenon indicates there is a large fracture density but a small fracture scale in reservoir. Wave fracturing curve has great amplitude but a small frequency. It implies that the scale of the natural fracture in coal seam is huge. When the hydraulic fractures extended in the large scale of natural fractures, the pressure dropped rapidly. Due to the long extension distance of artificial fracture, the wave-fracturing curve has a small wave frequency.
3. Declining type, i.e. since the coal was fractured, the injection pressure drops consistently or falls in the previous stage of the hydraulic fracturing and then keep stable. Abundant of exogenetic fractures developed in tectonism in type II. When the exogenetic fractures showed good connectivity and great scale, artificial fracture could always propagate in natural fractures. The performance on the pressure curve is that the pressure drops consistently or falls in the previous stage of the hydraulic fracturing and then keeps stable.

In addition, type III could be classified into two groups:

1. Increasing type, the pressure keeps rising during the extending stage. It herein illustrates that the extent of fracture is restricted in the height and the fractures propagate slowly horizontally;
2. Stable type, similar with the curve shape in type I, but the fracturing pressure is pretty higher than that needed in type 1, and with no bursting type.