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Enhancement of CBM Production by Optimising Operation Pressure

Xingjin Wang[1]

[1]Austar Gas Pty Ltd and China University of Geoscience

Abstract

Production from coalbed methane (CBM) wells is especially sensitive to changes in how pumps are operated. Even when reservoir parameters are highly favourable, production can decline dramatically because of improper pumping operations. The most commonly used completion method for vertical CBM wells is fracture treatment. Successful fracture treatment can result in high peak gas production. However, fractures may close and if production declines too abruptly, bottom hole pressure may not be controllable. In order to optimise pumping operations in fractured wells, it is necessary to first analyse possible changes in permeability and conductivity and how these might affect production. Adsorbed gas saturation is also relevant in any change in permeability and conductivity of fractured formation during production.

This study uses data from the Bowen and the Surat Basins in Australia; the Ordos Basin in China, as well as CBM pilot projects in Russia, to analyse the relationship between gas saturation, mechanical properties of coal, gas saturation, and conductivity of fracture systems. Petroleum engineers are often confronted with the difficulty of trying to optimise production wells that have been damaged by improper operation. This study presents typical cases showing how production has been improved through refinement of the pumping system while keeping in mind the specific attributes of individual reservoirs.

This study provides useful engineering methodologies in diagnosing well behaviours using case studies. Inflow Performance Relation (IPR) can be used to analyse the drainage efficiency of CBM wells. For example, if production data scatters when plotted on an IPR graph, this would indicate that coal fines have blocked gas flow within fracture network. Alternatively, if, the fractures have efficient conductivity this would be manifest on an IPR plot as a clear linear trend. Experience shows that control on annulus pressure is helpful in protecting fracture from collapse.

Permeability Change During Production

Figure 1 shows the results of one experiment carried out at a hydrostatic stress of 10.34 Mpa. Permeability initially declined with decreasing gas pressure but started increasing below 6 Mpa. The increase trend is steeper than the decreasing trend. When the gas pressure dropped to 1 Mpa, the final permeability reached 3.77 mD, higher than the original value of 2.8 mD. This demonstrates the relationship between desorption pressure and permeability for methane. Once desorption starts, which is significant below 6 Mpa, permeability starts increasing. The initial decrease in permeability above desorption pressure, prior to desorption, is a result of cleat compression when water flows out, as shown in Figure 2. After desorption, the matrix may shrink as shown in Figure 3. The change in coal matrix volume in relation to gas pressure can be determined through this experiment. It is clear that the volume of matrix decreases with decreasing gas pressure, and the decrease in matrix volume is quicker with pressure drop.

As shown in Figure 2, the cleat tends to close when the water flows out from the cleat. As result, the permeability of the cleats decreases during the dewatering period. In contrast, cleat apertures tend to expand when the gas desorbed from the matrix. Consequently, the permeability could increase after the pressure is lower than the critical desorption pressure. For coal seams with low gas saturation, dewatering may take a long time. For cases such as these, operation pressure should be controlled.

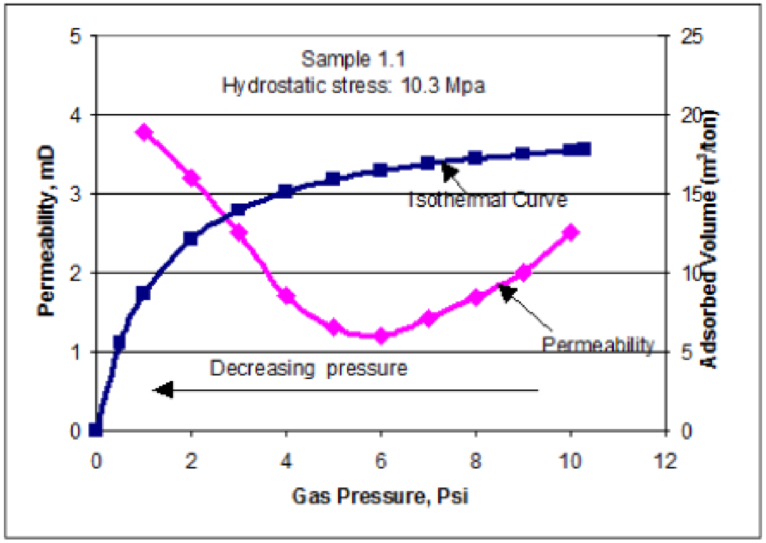

Figure 1. Changes in permeability of coal and adsorbed gas with decreasing gas pressure.

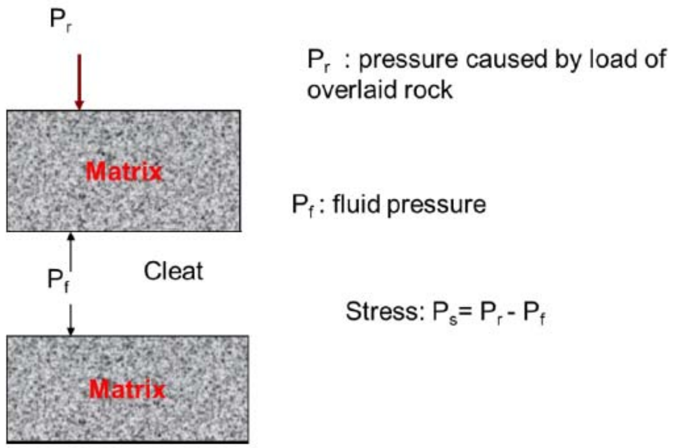

Figure 2. Illustration of cleat closure when water flows out from the cleat.

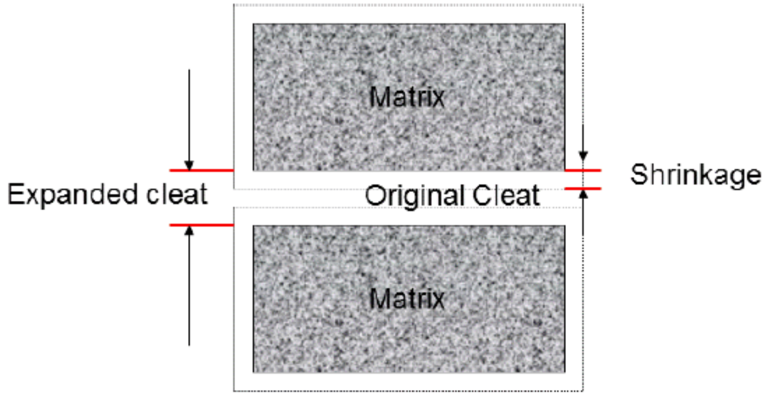

Figure 3. Illustration of matrix shrinkage caused by desorption.

In most circumstances, operators attempt to stimulate the reservoir using fracturing treatment. However, most coal is soft (and highly compressible). Commonly, the fracture can be generated initially and kept open by proppant when bottom hole pressures are higher than reservoir pressures (Figure 4). Fractures could collapse and the proppant mix with coal fines if the bottom hole pressure falls sharply during pumping. As result, the deliverability of the well will also fall abruptly.

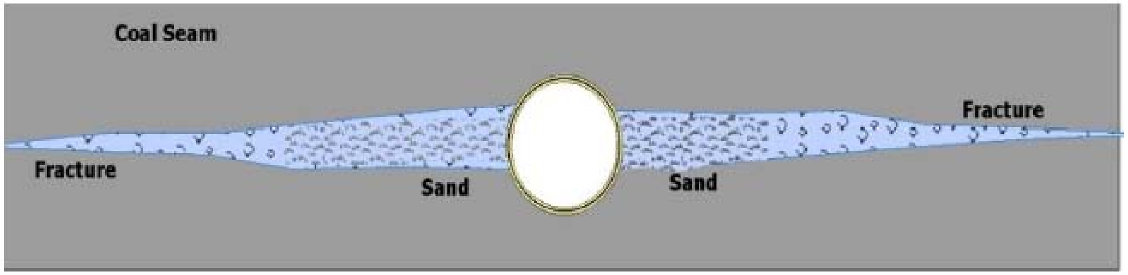

Figure 4. The fracture is propagated and kept open when injection is occurring.

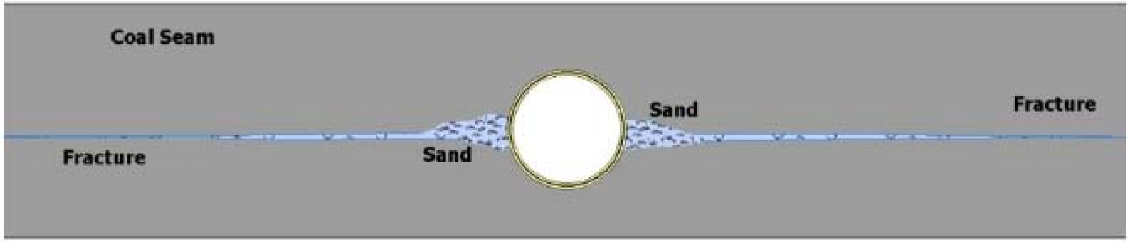

Figure 5. The fracture collapses when bottom hole pressure falls abruptly.

Case Study

Figure 6 is a production profile of a vertical well in the Ordos Basin in China. The target seam is 6m in thickness and 650m in depth. The well was cased and fractured at the target seams. In the fourth month, the well achieved a peak rate of 3200m^3/day. This seems to indicate that the fracture treatment was successful. However, the operator did not control the operation pressure very well. At the 260th day, the annulus was fully open. As result, the annulus pressure drops to 20 kpa from 800 kpa in 24 hours. Then the gas rate drops to 80 m^3/day while the water rate falls to 0.5 m^3/day. After this, neither water nor gas has recovered to former rates. This abrupt fall in operation pressure may cause permanent closure of the fracture.

Figure 7 is a production profile of a vertical CBM well in the Bowen Basin. Both bottom hole pressure and annulus pressure have been controlled properly. Even during pump maintenance, the annulus was still shut in. The gas rate and water rate are stable as the operation pressure is controlled properly.

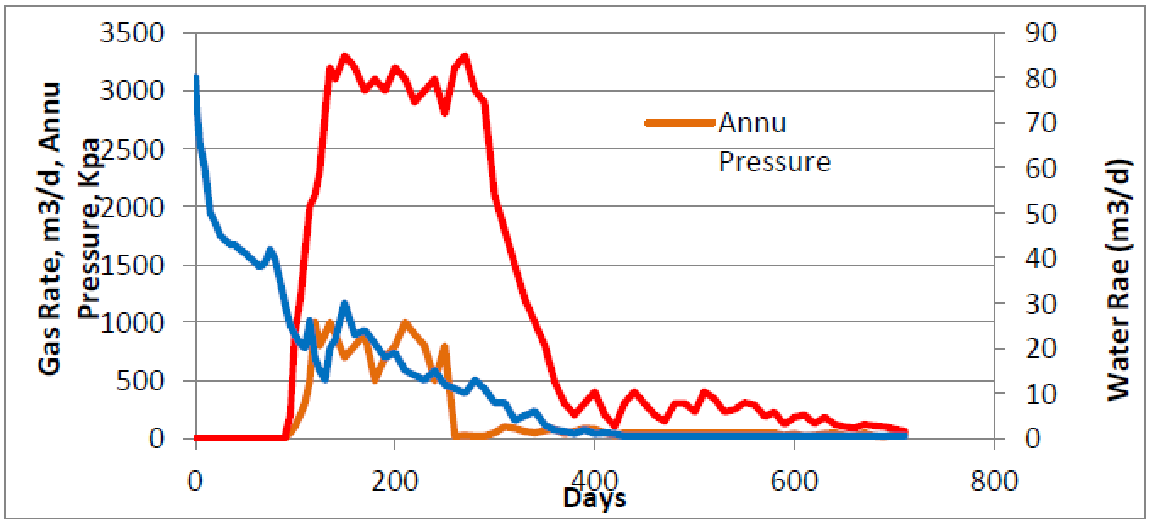

Figure 6. The well nearly stops flowing both water and gas after annulus pressure falls sharply.

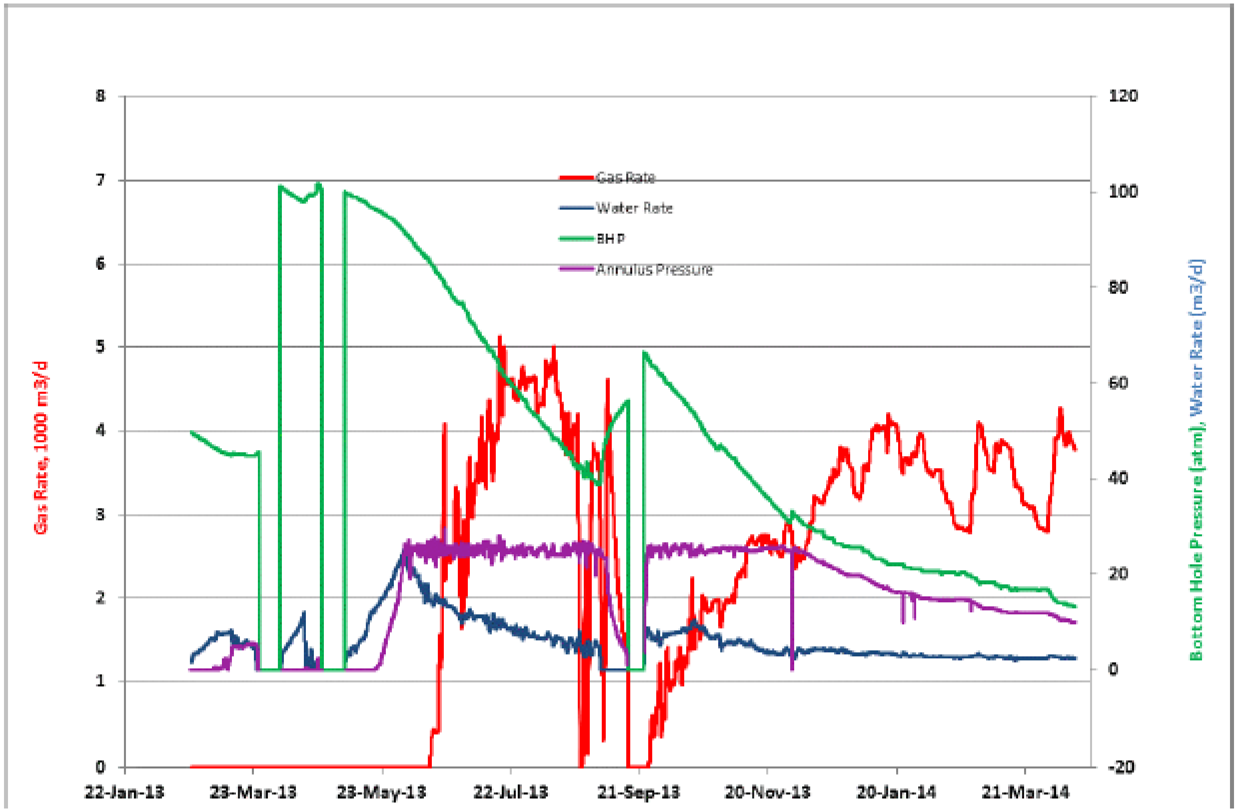

Figure 7. Water and gas production; note that both stabilise when the annulus and bottom hole pressure are controlled properly.