Investigation of Hydraulic Fracture Re-Orientation Effects in Tight Gas Reservoirs

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Abstract

Introduction: In tight gas formations where the low matrix permeability prevents successful and economic production rates, hydraulic fracturing is required to produce a well at economic rates. The initial fracture opens in the direction of minimum stress and propagates into the direction of maximum stress. As production from the well and its initial fracture declines, re-fracturing treatments are required to accelerate recovery. The orientation of the following hydraulic fracture depends on the actual stress-state of the formation in the vicinity of the wellbore. Previous investigations by Elbel and Mack [1] demonstrated that the stress alters during depletion and a stress reversal region appears. This behavior causes a different fracture orientation of the re-fracturing operation. Use of COMSOL Multiphysics: For the investigation of re-fracture orientation a two-dimensional reservoir model has been designed. The model represents a fractured vertical well in a tight gas reservoir of infinite thickness. A time dependent study was set up to simulate the reservoir depletion by the production from the fractured well. The Poroelasticity physics interface was used to couple the fluid flow and geo-mechanical behavior. The stress state is initially defined as uniform (Figure 1) and the attention is concentrated to the alteration of stress due to the lowered pore pressure. Different cases with anisotropic and heterogeneous permeability are set up to determine its significance. Results: The simulation shows that an elliptical shaped drainage area appears around the fracture (Figure 2). The poroelastic behavior effects that the stress re-orientates and a stress reversal region originates (Figure 3), if the difference between minimum and maximum horizontal stresses is small. The consideration of time indicates that the dimension of the region initially extends fast until it reaches its maximum. Subsequently, the stress reversal region's extent shrinks slowly until it finally disappears. The reservoir characteristics, e.g. the permeability, influence the dimension and time development of the stress reversal region in this process (Figure 4). Conclusion: The success of re-orientated fractures depends on the actual dimension of the stress reversal region. The work demonstrates that COMSOL Multiphysics enables the simulation of stress reversal during depletion. The reservoir model can be extended and used to select candidate wells for re-fracturing treatments. Furthermore it helps predicting the optimum timing of re-fracturing in order to maximize production. The findings will support effective field development in tight gas reservoirs.

Reference

1. J.L. Elbel and M.G. Mack, Refracturing: Observations and Theories, paper SPE 25464, 1993 Production Operations Symposium, Oklahoma City, USA, March 21-23.

Figures used in the abstract

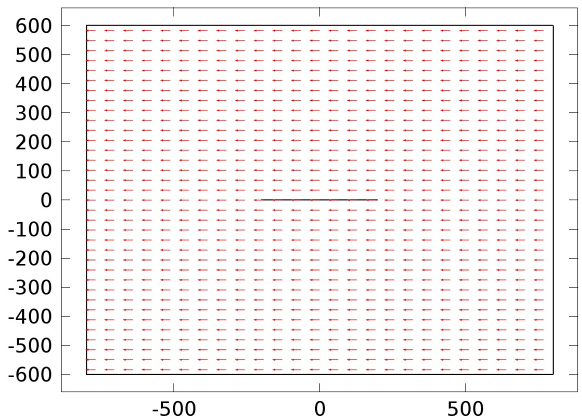

Figure 1: Initial maximum principle stress direction.

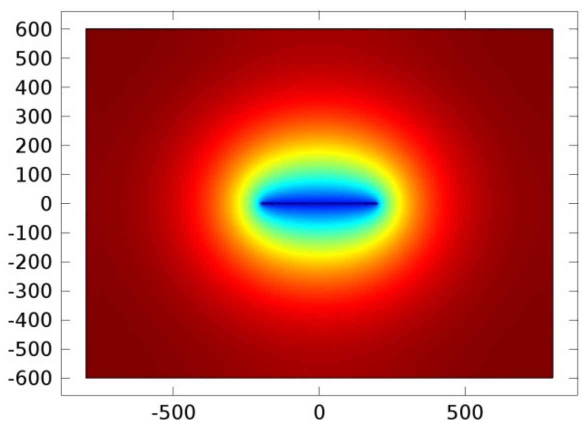

Figure 2: Fluid pressure distribution after five years.

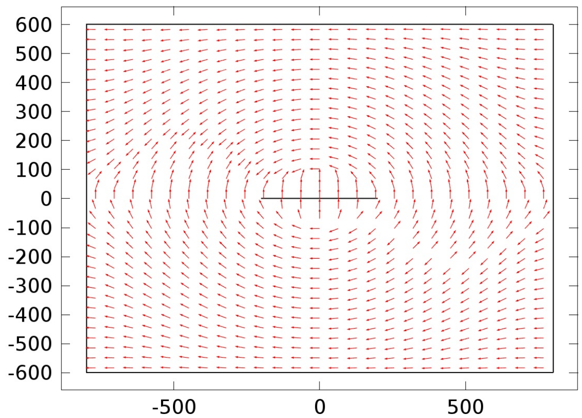

Figure 3: Maximum principle stress direction after five years.

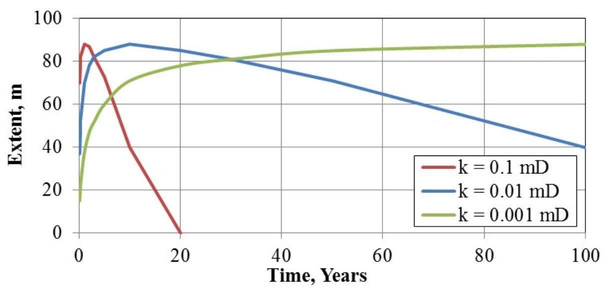

Figure 4: Stress reversal region's extent in perpendicular direction to initial fracture.