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Stimulation Design and Post Fracture Production Analysis: A Tight Gas Sand Case History

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Abstract

This manuscript will outline the stimulation design criteria for wells in the Lobo Trend in south Texas and fracture design changes based on post fracture production analysis using commercial software.

Production data will be modeled with the corresponding fracture geometry. Model results will be used as the benchmark to discuss fracture design changes and the effect on well performance. Case histories will focus on tight gas sands with reservoir quality ranging from 0.05 to 1.5 md with some pressure depletion. Multiphase flow effects in areas with higher water production will be investigated. Some discussion will focus on the details of calibrating fracture model inputs using open hole logs, radioactive surveys, sonic logs, production logging tools and mini-frac analysis.

Results comparing post fracture well production, utilizing a pseudo 3D fracture design model and industry available production matching models, will show the effects of permeability, pressure depletion and multiphase flow effects on well performance. Understanding this information will allow the stimulation design engineer to better predict how geometry and fracture conductivity will alter well performance under varying reservoir conditions. With this knowledge, the engineer can better design 'fit for purpose' treatments, including those that may require extreme design changes in order to improve gas reserve recovery.

Introduction

The Wilcox (Lobo) trend in Webb and Zapata counties in south Texas is a series of geopressured, low permeability sands with an average depth from 5,000 to 12,000 ft. The Wilcox (Lobo) section consists of a sequence of stacked Paleocene age sands and shales overlain by the Lower Wilcox shale of Eocene Age. Extensive faulting, present in the Lobo section, has resulted in a slump complex of rotated fault blocks. The Lobo trend extends from Webb and Zapata counties to the south and west into Mexico. Permeability ranges from less than 0.1 md to 1.5 md. Figure 1 shows the location of the Lobo fields adjacent to the Mexico-USA border in south Texas.[1] As an operator in this prolific gas producing area in south Texas, implementing effective hydraulic fracture treatments is a requirement in order for Conoco to economically produce the low permeability sands in the Lobo trend. This paper describes the engineering activities that were part of the development of a process to design and implement a pseudo three-dimensional (P3-D) fracture-modeling program in the Lobo trend in south Texas.

The technique of hydraulically fracturing a formation to increase production rates and available reserves to commercial levels is a common practice within the petroleum industry. From industry surveys in the 1990's, approximately 56% of the wells drilled in the various geographic areas of the United States of America require fracture stimulation.[2] The placement of a conductive fracture in the producing sands requires an optimal proppant fracture design process and proper field execution of the design.

The engineering tools available for proppant fracture design have evolved during the past two decades. In the early 1980's, two primary mathematical models were developed and refined for modeling the complex hydraulic fracturing process. One model developed by Khristianovich and Zheltov[3] incorporates the assumption of a rectangular shape in the vertical cross section of the fracture. A second model developed by Perkins and Kern[4] and modified by Nordgren[5] incorporates the assumption of an elliptical shape in the vertical cross section of the fracture. These two-dimensional (2-D) fracture models that assume a constant height vertical fracture have been widely used in the petroleum industry. Comparisons of these 2-D fracture models[6] indicate that both models adequately agree with field data and that both models need to take into account changes in instantaneous shut-in pressure during treatments.