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Integrated Analysis of Tight Gas Exploration Well Fracture Treatment in China

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Abstract

This paper describes simulations and history matching performed on a new tight gas well in the Sulige Field, Northwest China. Pre-frac simulations were performed with a 3D fracture model. A new tool automatically generated a reservoir simulator input deck, including all the information needed to model the initial post-fracture cleanup (filtrate invasion profile, capillary pressure data and relative permeability data which varied per layer and for the filtrate invaded zone). Initial pre-frac simulation results indicated that very little filtrate would be recovered, but that this would not impact the production.

Once the fracture treatment was actually performed, net-pressure history matching was done with the 3D model to estimate fracture dimensions. A new reservoir simulator input deck was created based on the history matched fracture dimensions and filtrate penetration profile. A range of different relative permeability functions was used, in the absence of laboratory measurements, to predict the possible post-fracture filtrate recovery and water production. The predictions were compared to the actual initial post-fracture water production in order to determine which relative permeability function gave the most accurate prediction. This prediction was then compared to the actual long-term water production.

Introduction

The Sulige field is a tight onshore gas field located in Inner Mongolia, Ordos Basin China. Hydraulic fracturing is utilized for production enhancement. There are a large number of different horizons and a complicated geology including the presence of coal layers between the producing intervals. Some horizons have been ignored in the past due to the difficulty in performing effective fracture stimulations. A new effort to better understand the cleanup mechanisms in these very low permeability formations has been started in order to improve the application of hydraulic fracturing technology in this field. By better understanding what is responsible for controlling the post-fracture performance, the best choice of fracturing fluid can be made. Various alternatives exist for tight gas wells, such as nitrogen and CO_2 based foams, methanol based fluids and the use of surfactants. In order to determine what the most appropriate technology for this reservoir is, a realistic model of the fracture needs to be created in a reservoir simulator, including the effects of the fracture fluid filtrate on the post-fracture production.

A tool has been created that allows the automatic generation of a reservoir simulation input file, including an accurate description of the hydraulic fracture geometry, conductivity and the fracture fluid filtrate invasion profile. The reservoir simulation input file describes separate regions for the filtrate invaded and non-invaded zones in the reservoir, allowing for different capillary pressure curves and relative permeability curves to be used for each region and for each layer in the reservoir. This tool has been used in this study to predict the post-fracture fluid recovery for a number of different scenarios for a normal water based gel. The results of these simulations will help point the way to determining what the best type of fracture fluid is for this type of formation.

Background

A new well was drilled, cased with a 7” liner and completed with a 3 ½” tubing in the spring of 2007. A hydraulic fracturing treatment was carried out in the fall of 2007 in the Shilezi reservoir. The well was cleaned up and flowed for six months. Currently, the well is shut down for recording a long-term build-up. One of the intervals of interest is the Permian Shilezi HE-8 formation at a depth of 3550 m below surface, with reservoir formation temperature and pressure of 115 ºC and 315 bar. The main Permian reservoir is a thin and fairly complex braided channel sandstone formation with porosities ranging