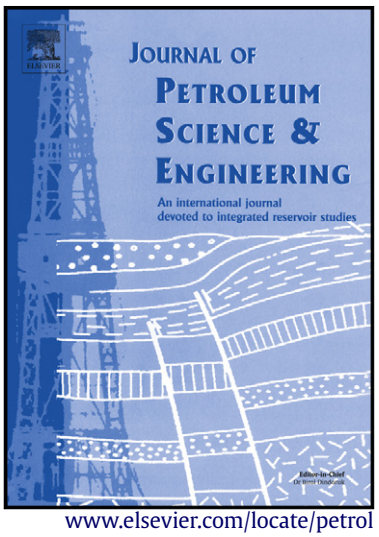

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PII: S0920-4105(13)00120-4
DOI: http://dx.doi.org/10.1016/j.petrol.2013.04.019
Reference: PETROL2417

To appear in: *Journal of Petroleum Science and Engineering*

Received date: 27 June 2012
Revised date: 13 April 2013
Accepted date: 26 April 2013

Cite this article as: Kurt C. Wilson, Louis J. Durlofsky, Optimization of Shale Gas Field Development Using Direct Search Techniques and Reduced-Physics Models, *Journal of Petroleum Science and Engineering,* http://dx.doi.org/10.1016/j.petrol.2013.04.019

Optimization of Shale Gas Field Development Using Direct Search Techniques and Reduced-Physics Models

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Abstract

The economics of oil and gas field development can be improved significantly by using computational optimization to guide operations. In this work, we present a general framework for applying optimization to the development of shale gas reservoirs. Starting with a detailed three-dimensional full-physics simulation model, which includes heterogeneous geology, highly-resolved fracture networks, dual-porosity, dual-permeability regions, and gas desorption, the approach first entails the generation of a much simpler, and much more computationally efficient, reduced-physics surrogate model. This reduced-physics model is tuned using a procedure akin to history matching to provide results in close agreement with the full-physics model. The surrogate model is then used for field development optimization. During the course of the optimization, the surrogate model is periodically 'retrained' to maintain agreement with the full-physics representation. In the optimizations considered here, we seek to determine the optimal locations, lengths, and number of fracture stages for a set of horizontal wells. A direct search optimization procedure (generalized pattern search) is applied. In two examples, involving models with properties representative of the Barnett Shale, optimization is shown to provide field development scenarios with net present values that are considerably higher than those of base case designs. In addition, speed-ups of about a factor of 100 are achieved through use of the surrogate modeling procedure.

Keywords: Shale Gas, Unconventional Resources, Optimization, Well Placement, Reduced-order Modeling

1. Introduction

Natural gas production from shale reservoirs has increased rapidly in recent years and now accounts for a substantial fraction of total US gas production (EIA, 2012). Horizontal drilling combined with multistage hydraulic fracturing has unlocked both gas and oil from shale reservoirs. These resource plays are characterized by large drilling programs involving hundreds of wells drilled per year.

Given the very low permeability of shale formations, the underlying physics of gas production differs from that associated with more permeable (conventional) reservoirs. Clarkson et al.

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