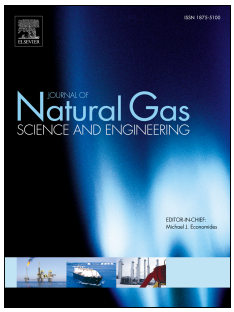
Accepted Manuscript



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PII: S1875-5100(18)30376-7

DOI: 10.1016/j.jngse.2018.08.028

Reference: JNGSE 2700

To appear in: *Journal of Natural Gas Science and Engineering*

Received Date: 16 February 2018

Revised Date: 25 August 2018

Accepted Date: 29 August 2018

Please cite this article as: Misra, S., Nikolaou, M., A Data-Driven Modeling Approach to Zonal Isolation of Cemented Gas Wells, *Journal of Natural Gas Science & Engineering* (2018), doi: 10.1016/j.jngse.2018.08.028.

A Data-Driven Modeling Approach to Zonal Isolation of Cemented Gas Wells

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Abstract

Gas leakage through the cemented section of a gas well, from a producing zone to other zones or to the open air, poses serious threats to safety and the environment. A number of design variables during drilling and cementing jobs may possibly contribute to such leakage. Decisions on these variables are best made during the design and well construction phase, as remedial operations after the well begins production have limited success rate. Therefore an approach that avoids the problem by ensuring robust zonal isolation during well construction jobs is more suitable. Such an approach involves decisions on a fairly large number of design variables. Building a model based on first principles to predict the effect of all of these variables on leakage is a formidable task. An alternative examined in this paper relies on using multivariate statistics to build an empirical model from available data. The model can then be used to make decisions on design variables such that leakage is avoided. The proposed approach is explained using data from 105 gas wells. The model built predicts leakage with about 75% accuracy in cross-validation tests. In addition, it ranks decision variables in the order of importance and suggests which ones need to receive more attention. The approach presented can be extended to include additional variables for which data is available.

1. Introduction

Migration of natural gas from a formation zone in a cemented hydrocarbon well to another can cause severe environmental pollution problems to water aquifers and the atmosphere. It may also undermine the safety of personnel at the well site, and create additional costs for well intervention and repair. Gas leaks through poorly cemented sections of a well may be due to a number of factors relevant to well drilling or completion. Therefore, it is important to ensure that good decisions are made on such factors when well construction jobs are designed, to minimize unwanted leaks. The design objective is formally known as zonal isolation and has been the subject of intense study recently.

In well construction jobs that do not ensure zonal isolation, natural gas may move through the small channels created in the cement sheath in the annulus between the well casing and the wall of the well. This gas may eventually reach the wellhead. To detect inadvertent flow of gas through cementing to the wellhead, the following simple procedure is followed: A pressure gauge followed by a needle valve is installed at the wellhead. The needle valve is temporarily opened, to lower pressure by bleeding off a small amount of gas, and then returns to

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