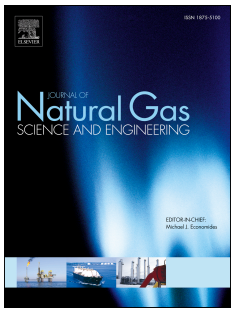
Accepted Manuscript



Effect of cement sheath induced stress on well integrity assessment in carbon sequestration fields

Ben Li, Hui Li, Boyun Guo, Xinhui Chang

PII: S1875-5100(17)30290-1

DOI: 10.1016/j.jngse.2017.07.014

Reference: JNGSE 2242

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

Received Date: 17 November 2016

Revised Date: 9 June 2017

Accepted Date: 21 July 2017

Please cite this article as: Li, B., Li, H., Guo, B., Chang, X., Effect of cement sheath induced stress on well integrity assessment in carbon sequestration fields, *Journal of Natural Gas Science & Engineering* (2017), doi: 10.1016/j.jngse.2017.07.014.

Effect of Cement Sheath Induced Stress on Well Integrity Assessment in Carbon Sequestration Fields

Ben Li, Hui Li, Fujian Zhou China University of Petroleum, Beijing, and State Key Laboratory of Petroleum Resources and Engineering, Beijing
Boyun Guo, University of Louisiana at Lafayette
Xinhui Chang, Great Wall Drilling Company, CNPC

Abstract

Carbon sequestration describes long term storage of carbon dioxide into geological formations. Depleted oil and gas reservoirs can be considered as a desirable storage vessel for carbon sequestration. Well cement is one of the vulnerable leakage pathways in high pressure and corrosive environments. The integrity of the cement sheath in high pressure environment must be maintained to avoid the contamination of atmosphere and underground drinking water.

This paper presented an analytical solution to evaluate the cement sheath integrity of wells exposed to CO_2 considering the effect of cement sheath induced stress (CSIS) and formation pressure variation due to CO_2 injection. The proposed model was validated through the comparison of the proposed model with Atkinson's analytical model and Carter's finite element model. The well logging records further verified the analytical model. A field case analysis indicated that the maximum injection pressure (MAIP) would be underestimated if CSIS is not considered. The proposed model can be used to evaluate the cement sheath integrity in carbon sequestration fields and other gas/water injection wells in oil production fields. It can also help to design and optimize the operation parameters of the hydraulic fracturing operations.

Key Words: Cement Sheath Induced Stress; Well Integrity; Carbon Sequestration; Analytical Model

1. Introduction

Cement sheath is one of the major barrier that prevents injected CO_2 from migrating upward to the formation. It is required that all the wells in carbon sequestration fields should maintain proper sealing abilities to avoid leaking of CO_2 into the underground potable water formations and atmosphere for long time scales. Inter zonal communication in a wellbore may lead to loss of reserves, contamination of zones, production of unwanted fluids, or safety and environmental issues (Boukhelifa et al. 2005). The injected CO_2 exists in the supercritical state in carbon sequestration formations and is highly mobile due to its low viscosity (0.05-0.1 mPa.s). The density of supercritical CO_2 (0.469 g/cm^3) is less than that of water (1g/cm^3) and oil (0.8-1.1 g/cm^3). The CO_2 would migrate up to the underground drinking water formation or the atmosphere due to the buoyancy. As CO_2 is injected into the depleted reservoir, the chemical properties of the cement sheath may not be able to withstand corrosive environment due to the carbonic acid. Combined with excessive injection pressure, cement sheath failure would appear at the outer casing/inner cement sheath interface due to tangential stresses generated by circumferential expansion. One problem associated with carbon sequestration is the possible leakage of CO_2 through existing wells and contaminates of shallow subsurface zones (Celia et al. 2003). CO_2 can migrate through the micro-annuli at the casing/cement