SPE 114928

Importance of Predicted Cementing Temperatures for Critical HP/HT Casing Design: Guidelines and Case Studies

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This paper was prepared for presentation at the 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.

Abstract

Estimation of drilling and cementing temperatures using standard models and simulation tools is essential for robust casing design of critical HPHT wells. Standard casing and tubular analysis defines loads in terms of changes in thermal, pressure and mechanical conditions from an initial installed state. Often, the casing initial temperature conditions are assumed to be prevailing geothermal undisturbed temperatures (UDT). This is typically considered a conservative assumption which simplifies the design process and avoids definition or verification of the relevant sequence of drilling and cementing operations. However, for critical HPHT wells where design margins can be narrow, it may be necessary to describe the initial physical conditions as accurately as possible and to incorporate them into the casing design analysis. In this paper, the general methodology of engineering based casing design is reviewed and practical guidelines are presented to suggest when extra effort to accurately model initial casing temperatures may be critical and why conventional assumptions may be non-conservative.

Because the current industry environment is placing significant demands on operator organizations and engineering staff, the time and effort required to gather data or to determine proper assumptions for detailed well design has to be justified. All other things being equal, simple worst-case assumptions which facilitate quick analysis and decision processes are favored over more detailed modeling.

However, with the wells being constructed today increasingly classified as critical HPHT wells, the need for thorough and realistic model-based casing design must be identified when it is required. The case studies considered in this work result from a review of a wide range of critical HPHT well designs. It is significant that some combinations and load conditions indicate that assuming undisturbed geothermal temperatures is not necessarily conservative. This can be related to constrained thermal expansion in cemented zones.

1. Introduction

Standard industry simulation tools which model and predict wellbore temperatures during drilling and cementing operations as well as production operations are widely available. Prediction of initial and subsequent wellbore temperatures feeds directly into rigorous tubular stress analysis which is often critical for robust casing and tubing design for HPHT wells. Mitchell and Wedelich (1989) describe in detail a comprehensive wellbore simulator with coupled thermal-hydraulic effects and discuss its application to optimal wellbore design. Goodman and Halal (1993) describe application of a model to predict of thermal and trapped annular pressure loads. The challenges associated with HP/HT wells underscore the importance of including state of the art thermal simulation in the well design process (Hahn et. al., 2000, 2003).

The current industry environment presents many challenges to the effective use of the available simulation tools. Operator and engineering services organizations are all confronted with a shortage of experienced personnel. At the same time, challenging wells which require substantial design effort are becoming more prevalent. As with any detailed modeling technique, a great variety of input parameters must be accurately determined before thermal simulation and stress analysis can be effectively and competently evaluated. The identification, estimation and collection of correct input data can be a significant organizational cost in and of itself. Hence, the time and effort required to gather data or to determine proper assumptions for detailed well design has to be justified.

In this environment, any simplifying assumptions which can streamline the design process or by-pass intensive modeling effort are quickly adopted. All other things being equal, simple worst-case assumptions which facilitate quick analysis and decision processes are favored over more detailed modeling. More rigorous, detailed modeling will be conducted on a selective basis only where the costs can be justified.