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Effects of Startup and Shutdown of HPHT Wells on Wellbore Hydraulic Control-Line Design

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Abstract

The operations of a High-Pressure High-Temperature (HPHT) well may expose the hydraulic control line (HCL) in the wellbore annulus to significant pressure and temperature changes, which can cause severe pressure differential across the wall of the HCL. To prevent the associated control-line failure (burst or collapse) and high repair cost, the maximum pressure differential across the wall of hydraulic line needs to be determined at the design stage for the worst scenario, including the situation when normal operation cannot be followed. For example, the control valve of the HCL fails to open during well operation. The wellbore condition-change induced HCL failure may occur in both production and water-injection wells.

This paper provides an approach to evaluate the effects of startup and shutdown operation of a HPHT well on the design of a wellbore HCL. Note that the pressure change across the wall of a control line is the result of many coupled factors, for instance, (1) pressure and temperature in the wellbore annulus, well profile and constraints on the HCL; (2) compressibility of fluid in HCL; (3) thermal expansion of the HCL; (4) related stress-strain variation (or elasticity) of the HCL. The proposed approach has considered the above factors. The results indicate that the HCL failure could occur during a HPHT well operation if the control line is not correctly designed or properly operated. Suggestions are provided to improve the HCL design to avoid the possible failure.

Introduction

The HCL considered in this paper is a small diameter tube in the wellbore annulus used to deliver hydraulic power for adjusting the downhole sliding sleeves to a reservoir zone. This type of control lines are applied in both production and water injection wells.

If the hydraulic fluid in the control lines is isolated by closed valves, the wellbore temperature change combined with resultant annulus pressure change could cause severe pressure differential across the wall of a HCL, leading to over-pressure (burst or collapse) of the control lines. So far, the importance of the HCL design has not been emphasized as much as other technology gaps in the HPHT field development that is moving toward to reservoirs of 20 to 30 ksi and 400 to 500°F (Maldondao, 2006). The purpose of this study is to determine if there is a safety concern in the design of a HCL in a HPHT wellbore, and if so, to aid in the design of a reliable HCL.

Based on thermal-hydraulic study, the pressure and temperature change in the wellbore annulus for a typical startup and shut-in cycle is determined. Then, the worst scenario is defined for a HCL in the wellbore annulus. Finally, the pressure differential across the wall of the HCL and stress-strain is estimated. The main procedure includes:

1. Determine the extreme pressure and temperature distribution in the wellbore annulus caused by the startup and shutdown operation cycles. The wellbore temperature is bounded by the geothermal ambient temperature and the production/water-injection flowing temperature.
2. Identify the worst scenario of the annulus temperature and pressure profile for burst and collapse conditions, accordingly
3. Calculate the extreme pressure differential across the wall of the HCL with the selected worst scenario.
4. Compute the stress and strain in the HCL, which is coupled to the pressure calculation above.
5. Apply criteria to assess the mechanical strength of the HCL and determine solutions to prevent the HCL over-pressure failure