Abstract

In this work, the fatigue analyses of cement bridge plug under different oil-gas well conditions are performed. By using the state-of-the-art modelling framework by application of SolidWorks and ANSYS Workbench finite element softwares, the three-dimensional models of cement, bridge plug and casing with consideration of three different materials is explored and analyzed. The analysis shows that there are tensile stress concentrated in the area of connection between slips and cones of bridge plug. This finding in terms of safety factor reveals that considered bridge plug structures are safe against fatigue under most working conditions but it tends to fail when it comes to high pressure and high temperature (HPHT) condition as expected.

Executive Summary

As deeper and more complex well designs proliferate throughout oil and gas fields, well completion methods are challenged. Reliable and effective annular barriers continue to be crucial to well management for safety and performance[6]. The cementing has been the industry conventional means of creating these barriers and has improved significantly over the past few decades. The cement composition in the early days of the oil industry is similar to what is used today, but todays cement uses a number of additives that enhance the sealing of the cement in the wellbore. cement typically is used to create a seal between formations or to seal off the surface of the wellbore. Other materials which do not offer the same strength or durability as cement, including drilling mud, gel, and clay, are used to fill in the spaces between cement plugs. Additionally, the use of mechanical bridge plugs in lieu of a large cement plug since the bridge plug is extremely strong and nearly completely impermeable. However, mechanical plugs are susceptible to corrosion, and therefore the regulations typically require the bridge plugs to be capped by a specified amount of cement.

Based on these realistic consideration, the problem of fatigue analysis of bridge plug under different well conditions is of interest for oil-well operating companies, industrial practitioners and/or regulated state agencies who seek the insurance when it comes to possible emissions from the abandon wells.

Motivated by the above question in this work the state-of-the-art modelling framework of the well and cement plugging is considered by the application of the SolidWorks and ANSYS Workbench finite element methods. The plug is designed to be set in a wellbore and then have cement set on top to provide a complete seal of the reservoir below. In particular, the large scale 3D modelling of the relevant well size and cement bridge-plug geometry is considered in the simulation studies and reveals that bridge plug structures are safe against fatigue under most working conditions. It has been shown that bridge-plug degradable polymer content has a significant risk of failure in harsh downhole well environments. This is expected since polymer structure deteriorates over the time and changes as function of harsh environmental conditions (large fluctuations in the temper-

ature and/or pressure).
On the other hand, the study found that the mechanical bridge plugs usually have good compressive strength, corrosion resistance, and elastoplasticity [5]. In particular, after the stress is eliminated, the properties can be restored to its original state in a short time. The high strength characteristics of the cement plug can form a floor protection for the wellbore. Mechanical plugs are used in some wells to reduce the amount of cement required to plug a well or to provide additional protection from formation pressure in the well. Bridge plugs are typically made of cast iron with duel slips with a sealing element between the slips. Therefore, the main characteristics of using cement plugs and mechan-ical bridge plugs can not only improve the sealing quality, but also greatly improve the safety of the implementation of squeeze measures and achieve permanent well closure. By plugging wells correctly, future environmental issues, related to fluid or gas leakage, can be avoided and thereby preserve savings otherwise eroded by remediation or litigation costs.