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Overcoming the Challenges of Developing HPHT O&G Wellbore Technologies

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Introduction

As oil and gas exploration and production extends into deeper buried reservoirs the technology challenges to develop products qualified for these increasingly extreme pressures and temperatures are becoming more challenging.

This abstract is to provide an overview of current technology limits. Additionally this abstract is to reveal ultra-HPHT technology development challenges, as well as communicate some applied strategies essential to overcoming the development challenges.

In summary, this abstract is to reveal the requirements necessary to expand HPHT technology capabilities in order to accelerate the advancement of state of art technology required to meet the industry's future demand for reliably sourcing oil and gas from deep ultra HPHT reservoirs.

Current State

Every member of the Oilfield Services Product Group (OSG PG) has a tool offering in the 300°F (150 ºC) – 600°F (315 ºC) temperature range.

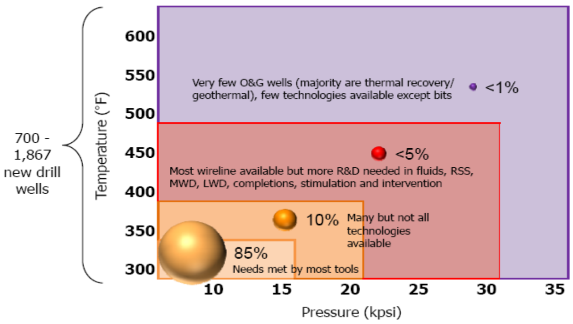

Figure 1: OSG PG technology offering and percentage of Operators with wells in specific tier (source RMI)

Development Challenges and Principles to Overcoming the Challenges

Seal Integrity – The development challenges that drive seal integrity at elevated pressures and temperatures are mainly associated with seal material strength and modulus of elasticity. Currently qualified Perflouroelastomer seal materials which have the required chemical, mechanical and thermal stability at elevated temperature are limited to 450ºF (230 ºC). Conditions that are detrimental to sealing reliability in ultra-HPHT environments are mainly associated with temperature fluctuations, permeation by H_2S and CO_2 and are unreliable when bonded to CRA materials.

Currently applied method to overcome seal integrity limitations and increase seal reliability are addressed through statistical modeling, the results of which are then confirmed through accelerated life testing methodologies.

Perflouroelastomer reliability evaluations should include determination of its chemical resistance, creep, extrusion, aging behavior, stability, and its mechanical properties at various temperatures; and determine its bonding ability to nickel alloy material.

There is critical ongoing research into new materials having elastomeric properties, non-elastomeric CRA composite materials, strength-enhanced polymers and self-healing seal materials - all targeted for ultra-high temperatures applications. Strength-enhanced polymers research involves the re-engineering of conventional seal material properties to address conventional materials strength and modulus deficiencies for ultra-high pressure and temperature conditions, and is yielding very promising results.

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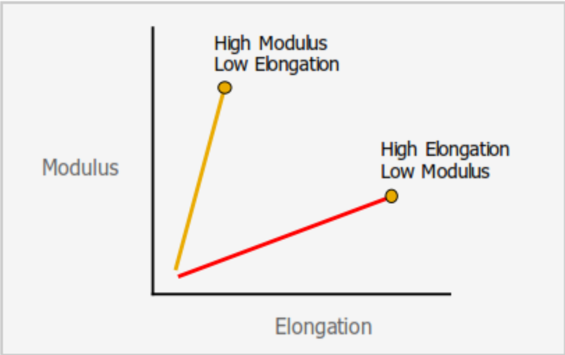

Figure 2: Conventional Seal Material Tradeoff (Strength vs. Flexibility)

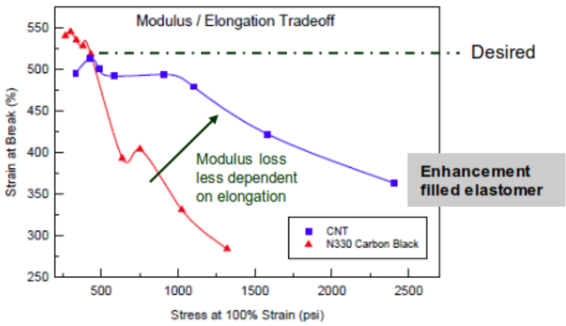

Figure 3: Seal Material Re-engineering

Qualified Metallurgy – For ultra-HPHT conditions components will be subjected to increased tri-axial stresses due to their requirements to perform in higher pressures and temperature conditions. This will cause the components to potentially require large diameter, heavy wall thickness and higher MYS materials. Typically heavier walls increase non-uniform properties. Currently NACE approved precipitation-hardening nickel alloy materials are limited to 450ºF (30 psia H_2S) and maximum 140,000 psi MYS. A precipitation-hardening nickel alloy material which meets the required MYS and NACE approved temperature rating requirements may not be currently commercially available.

Electronics Reliability – The lifespan, accuracy and reliability of electronic components and sensors are adversely affected by temperature. The high temperature specifications for oil field applications are the most challenging requirement for electronic components. The current temperature limit for electronics to function in oil and gas well applications is less than 300°F (150ºC). While components for consumer and industrial electronics have a maximum temperature requirement of 160ºF (70°C), the oil field requirements of up to and beyond 350ºF (175°C) even surpasses the specifications for military and aerospace applications. In those applications temperature shields and thermal management technologies can be used that are not feasible in downhole tools based on space limitations. Compared to other industries, oil and gas industry needs are low volume and high-reliability at high- temperature. Circuit board heat management and high temperature compatible wire bonding is crucial.

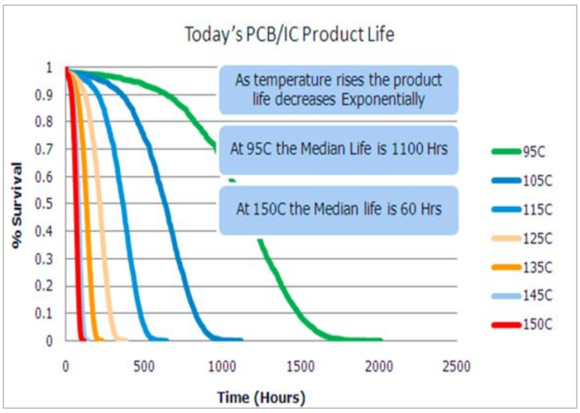

Figure 4: Current PCB/IC Product Lifespan

Product life becomes more of a challenge as every increase of the temperature by 50 ºF (10 °C), which leads to the average life of the components being reduced by 50%. Based on the typical temperature requirements outside the oil and gas industry, suitable components are not readily available and standard manufacturing processes are no longer applicable.

Finally, the temperature profiles in a wellbore are not well defined. They are based on extrapolation of information from offset wells and actual temperatures may vary widely. The gap in available temperature profiles adds to the challenge of designing appropriate test set ups and parameters, especially as down hole vibrations are also a key contributing factor for reliability.

Technology Development Practices – Reliability is not a function of testing. Maximizing product reliability starts in the concept phase and needs to be designed and manufactured into the product. The design should be analyzed through modeling and then testing performed to validate the product reliability. New technology must have testing targets to improve and ensure reliable product performance.

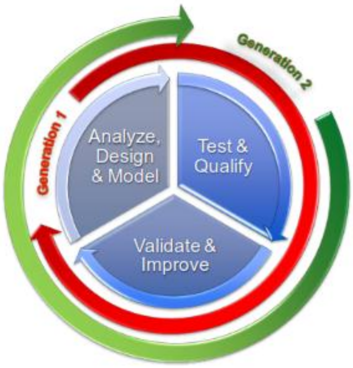

Figure 2: Technology Development Cycle

Investment in Infrastructure – The trend toward exploration of ultra-HPHT reservoirs requires oilfield services companies and technology providers to have advanced research labs and expanded testing capabilities to ensure reliable products are available to the industry. The infrastructure must push the envelope to address Lower Tertiary applications which some industry experts believe to be the next frontier. Test capabilities should be expanded to go well beyond the industry's current requirements and into the future, up to 40,000 psi and 700ºF.

Critical Research – Critical research is another element that is crucial for successful technology development. Subject matter expert teams should be formed around key critical research needs. This type of high level critical research is vital to continually fill the pipeline with new ideas that can translate into new generation products and services.

In Summary

The future is promising in meeting the industry needs to provide products and technology that meets the requirements for sourcing oil and gas from deep ultra-HPHT reservoirs. Not only are strategies and capabilities crucial for success in overcoming the challenges in developing advanced HPHT technologies, but also a synergistic environment for collaboration between operators and service companies, and the forging of alliances is crucial for success in developing application based technology.