Direct Strain Mapping of a Cement Sheath; A New Tool for Understanding and Preventing Cement Failure in Thermal Wells

Thermal Well Integrity

<ins>Challenge:</ins> Thermally stimulated wells place cement under high stress
<ins>Solution:</ins> Understand how cracks initiate, propagate and terminate

- Failure is not when the cement has yielded but rather when cement fails to provide zonal isolation
- Need an economic modular test system that can evaluate cement pre/post-yield

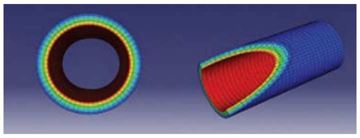
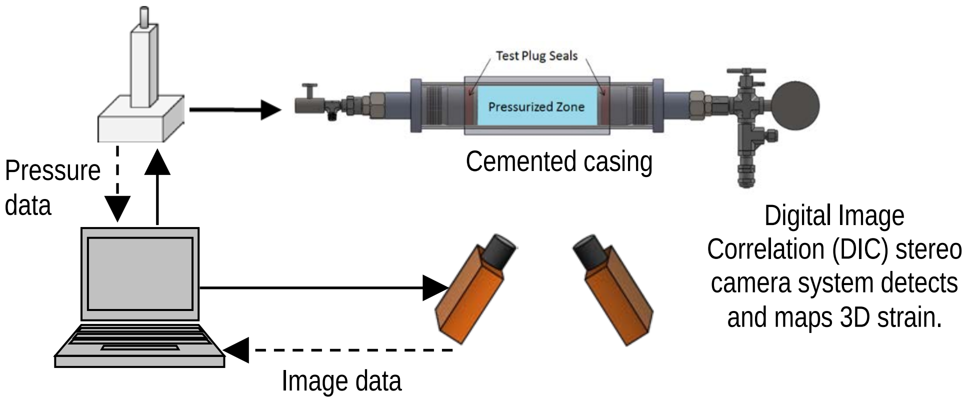


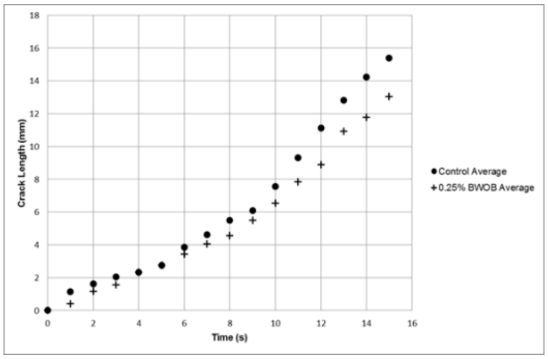
Illustration of temperature gradient upon the introduction of steam

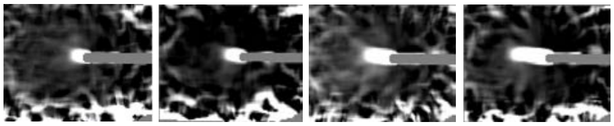
Test System



Quantifying Crack Propagation – Fiber vs. Non-Fiber

- 0.25% LCF-7 fibers in thermal blend
- 28% increase in failure load
- Non-fiber 0.88 mm/s
- Fiber containing 0.66 mm/s.
- Significantly slower than theory predicts
    - ~3500 m/s
- Complex failure mechanism is slowing the process





Images of crack propagation

Summary

- Innovative new real-time visual testing of cement failure
- Better understanding cement failures will lead to technical improvements
- Fibers can help limit the severity of a micro-failure and avoid loss of isolation
- Technology translates to improved well integrity in all areas of conventional and unconventional wells

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Abstract

The design and application of a new cement integrity validation test apparatus for improving thermal cement integrity will be presented. This novel approach allows direct strain mapping of to-scale cement sheath as it deforms under different wellbore stress scenarios. Not only does this novel technique provide insight into elastic cement deformation but also helps elucidate how cracks form and propagate as the cement sheath deforms. Strain mapping is achieved through Digital Image Correlation (DIC) utilizing dual high speed and resolution camera systems. Reliably capturing crack initiation in the frame of view of the stereo camera system proved to be a significant challenge. After multiple design iterations, the best results were achieved with creating a predefined defect site in the cement sheath. Detailed crack initiation and propagation strain maps were created for thermal cements with and without fiber additives. This testing demonstrated how fibers are able to blunt crack propagation and dissipate energy through a fiber pull out mechanism leading to a more ductile failure. Early results are promising and are consistent with previous tests showing an increase in ultimate failure strength in tensile samples with fiber additives.

To learn more about our findings, contact your Client Solutions Representative or reach us at sales@sanjel.com.

You can also access the entire paper online
https://www.onepetro.org/conference-paper/SPE-188151-MS