As seen in OILFIELD TECHNOLOGY

BREATHING SPACE

Rodney Uchytil and David Kulakofsky, Impact Fluid Solutions, USA, review an environmentally friendly, high-temperature cement spacer designed to prevent losses while cementing.

Cementing in loss-prone, depleted, or fragile formations is a delicate balance in the narrow pressure window (with little to no room for higher pressures) that must be used to displace the drilling fluid and spacers. If the displacing fluid's yield stress is too low, the mud and/or spacer will not be removed properly, resulting in a poor cementing job. If the ECD is too high, the formation can fracture resulting in losses that can jeopardise the cement placement. In a high-temperature, high-pressure (HTHP) or geothermal well, the consequences of a poor cement job and resulting lack of wellbore integrity are serious and can have long-term consequences including corrosion and compromised zonal isolation.

A new-generation, high-temperature cement spacer has been designed to address lost circulation issues and protect fragile formations by creating a 'shield' across the formation matrix. This Wellbore Shielding Spacer (WBS Spacer) provides a low-invasion shield, or barrier, protecting the formation and a progressive rheology profile which assists in removing mud/debris prior to cement placement in weak formations, thus greatly reducing or eliminating the need for costly remedial cement treatments.

This spacer is environmentally friendly and is capable of operating in HTHP wells including geothermal wells. The spacer also works in wells where the equivalent circulating density (ECD) is close to the fracture gradient, wells with partial or total losses, wells with large fractures, and wells in unconsolidated and fractured/fragile formations.

Cementing

Quality cementing is critical to ensuring zonal isolation and wellbore integrity. To achieve proper placement of the cement and improve the cement bond with the formation, the wellbore must be cleaned of the drilling fluid and any cuttings or debris not previously removed. The spacer system must generate sufficient force to displace the drilling fluid. In the same manner, the cement must have slightly more hydraulic force to displace the spacer. Applying a stronger hydraulic force to remove the previous fluid and debris is a delicate balance of downhole density, rheological properties, and the flow rate.

However, these higher force requirements of the spacer and cement, place an additional burden on the formation. This can be a critical increase for formations that have either

already suffered lost circulation or, due to narrow pressure windows, will fail under the slightly higher ECD, rheology, or flow regimes necessary for hole cleaning and cement placement. If the fluid pressure exceeds the fracture gradient, it typically leads to formation failure, induced losses, and diversion in cement placement resulting in failure to achieve top-of-cement requirements. By effectively strengthening the wellbore wall, the WBS Spacer extends the pressure window allowing for a slightly higher pressure from the spacer to successfully clean and prepare the hole for proper placement of the cement in the annulus.

Lost circulation can jeopardise both the cement placement and long-term integrity of the zonal isolation. If lost circulation is unchecked while running the spacer and cement operations, the mud and debris may not be adequately cleaned from the hole due to reduced circulation as fluid is lost to the formation. Mud and debris left in the hole must either be displaced by the cement, or the cement will fail to secure that area of the wellbore for zonal isolation. If the losses continue, and significant volume of cement is lost to the formation, the cement placement will be jeopardised and failure to reach the top-of-cement target necessary to fully isolate the zone may occur. Therefore, losses must be prevented, cured, or greatly minimised, to ensure that the hole is cleaned and the cement is properly placed to achieve a quality cement job.

Using a spacer that can clean the hole and prevent or mitigate lost circulation makes the cementing process more successful.

New technology

The WBS Spacer contains differentiated components which are engineered to form a tough, but thin shield. The spacer, composed of thermal stabilisers, can be enhanced with weighting agents to adjust density, surfactants to water-wet the formation, and a synergistic, biodegradable lost circulation material (LCM). The rheology and density of the spacer can be customised to meet the specific needs of each unique downhole situation including high temperature, up to 21 lb/gal. density, and compatibility to displace both aqueous and non-aqueous drilling fluids.

One of the unique components of the spacer is its shielding particles, which can reconfigure from a small, discrete combination of sizes to an effective shield on the formation wall under differential pressure. Any leakage pulls the WBS shielding particles to the fracture opening so that the particles form a nearly impenetrable surface layer that adheres to the formation wall and bridges the fracture opening, but resists invading the formation itself. Thus, the spacer creates a very thin, impermeable shield, or barrier, next to the wall of the wellbore to protect the depleted or fragile formation against induced losses by minimising the induced pressure invasion of fluids, thus blocking the propagation of induced fractures without altering the in-situ geology. The progressive rheology of the WBS Spacer is designed to withstand differential pressure up to 7000 psi. Once the differential pressure is released, the shielding particles relax and reconfigure in the fluid as small, discrete materials, leaving the formation undamaged. Lab testing has shown a 90 - 95% return permeability for production zones.

This nearly impenetrable layer against the wellbore wall allows the ECD to exceed the fracture gradient with minimal-to-no losses. Adhering to the formation wall also aids the cementing process by providing a water-wet surface the cement can adhere to readily, thus assisting in cement bonding.

The WBS Spacer can be configured to handle persistent lost circulation situations with the addition of a specialised LCM that is synergistic with the spacer and can prevent or mitigate losses already encountered.[1] The spacer is field proven to seal up to 3500 Darcy permeability or 3000 µm fractures at temperatures of up to 350˚F (177˚C). Field usage has shown that the WBS Spacer

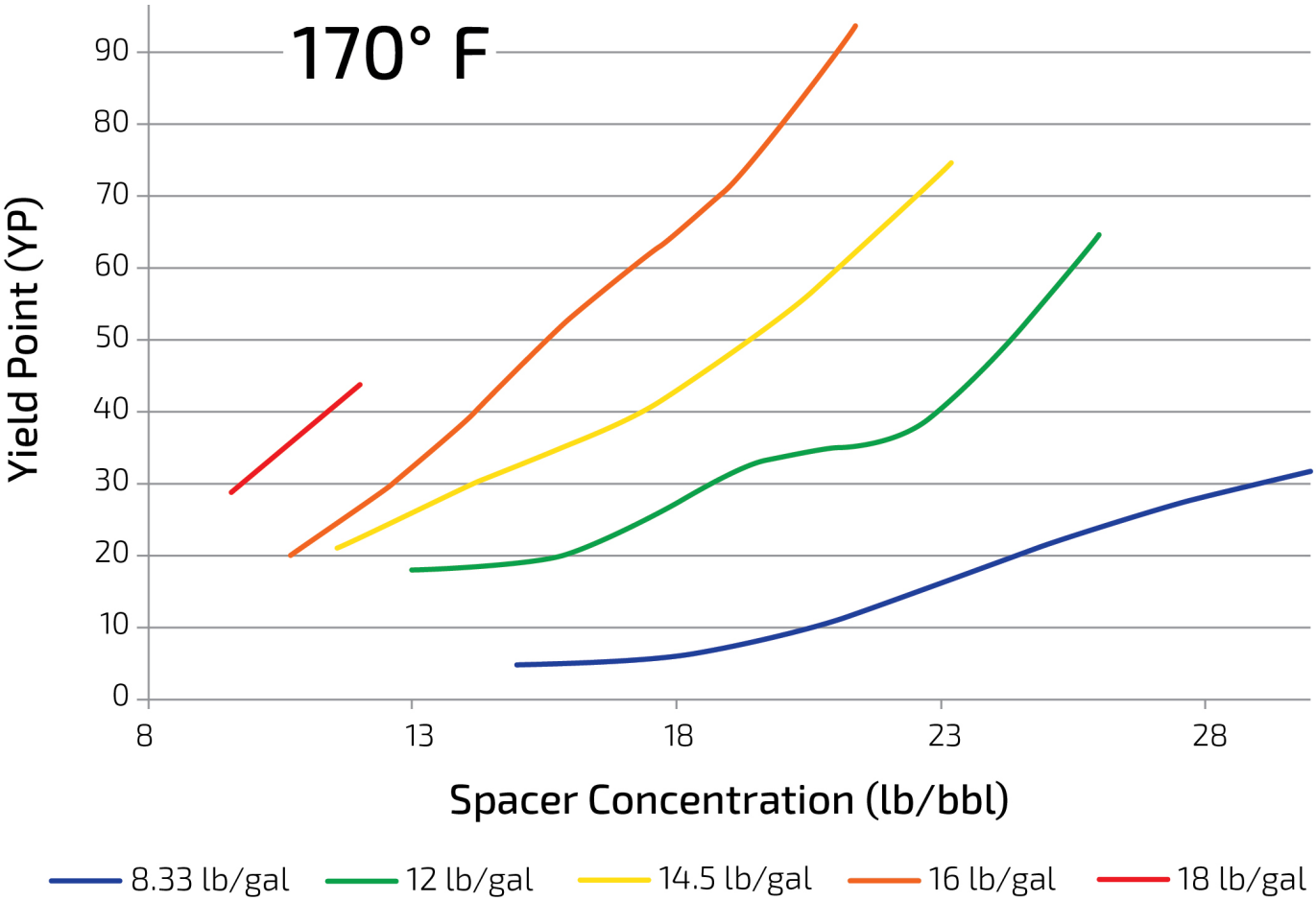

Figure 1. *The new spacer is designed to allow optimised hole cleaning with easily adjusted YP. (Source: Impact Fluid Solutions LP).*

can prevent or mitigate the losses to a level that permitted a fully compliant cementing job to be performed. By mitigating the losses, the spacer minimises the cement engineering changes necessary to either replace lost cementing fluid or adjust thickening times and compressive strength. Stopping lost circulation at this stage improves the quality of the cement bond and saves money in remedial costs both in cementing operations and in potential remediation of the well long term.[1,2]

Certain components in generic spacers are thermally stable below approximately 250˚F and will rapidly lose viscosity where temperatures exceed the limitation of the polymer agent. The polymer and other components in the spacer are designed for high temperature and can perform at temperatures up to 350˚F (177˚C) without serious viscosity issues. Field case histories, confirming the extensive lab design work, have shown the significant benefit of the WBS Spacer over other spacers at high temperatures.

The spacer was developed to pass environmental compliance for use in most areas. It was also designed to provide customisable properties to ensure that the necessary yield point (YP) could be easily achieved for optimising the hole cleaning. Figure 1 shows the optimised hole cleaning with easily adjusted YP

Field use in geothermal and HTHP wells

Numerous field uses of the WBS Spacer have shown to significantly reduce rig time, number of cement jobs and the amount of cement required during cement operations. Case histories also show excellent results in high-temperature, HTHP conditions or geothermal wells. The specialised LCM is also designed for use in geothermal wells.

Kenya

A geothermal field in Kenya had previously experienced severe losses while drilling. During cement operations, cement was lost to the formation resulting in a serious reduction in reaching the top-of-cement target requiring numerous remedial cementing jobs. Using the WBS Spacer with the synergistic LCM product, the unconsolidated formation was sealed, losses were significantly reduced, and only very minimal remediation of the cement was required. The amount of cement was only 13% of that required for the previous well to get acceptable cement placement. This amounted to a significant saving in cementing materials and rig time during cement remediation.[3]

Conclusion

The WBS Spacer has been shown in the field to allow safe operations above the fracture gradient. While lifting the spacer and subsequent cement, the ECD can exceed the fracture gradient with minimal or no losses. Zonal isolation, critical to all cement jobs, is not compromised when this spacer is part of the cement programme, helping improve cement bond in loss prone areas.

References

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