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Design of Colloidal Gas Aphron Drilling Fluid Formulations for Enhanced Deep Geothermal Energy Recovery Operations

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Drilling operations required for recovery of deep geothermal energy are often challenging. This is due to the harsh downhole conditions encountered in geothermal wells, including high-pressure-and-high-temperature (HPHT) and the toughness of the rock found in many geothermal formations. Drilling in such environments requires special drilling fluid formulations that have high thermal stability, good rheological properties, and excellent lubricity. A review of the literature reveals two commonly observed problems in deep geothermal drilling operations, significantly increasing drilling costs: a) **lost circulation** of drilling fluids in highly permeable fractured rock formations and b) very **low Rate of Penetration (RoP)**. Our literature review shows that RoP can be significantly improved by underbalanced drilling using low viscosity and low-density drilling fluids, such as **foams** and **Colloidal Gas Aphron (CGA)** systems (Zhu et. al., 2019). Note that such systems to date have only been studied at relatively low temperatures and the challenge of increasing the thermal stability of the formulation components needs to be addressed. Here we investigate novel CGA systems and report preliminary results on the stability and rheological properties of novel CGA formulations. In particular, we investigate the effect of laponite as a thermally stable alternative to Xanthan Gum (XG) as a drilling fluid viscosifier. A domestic high shear homogeniser was utilised in this study, which to our knowledge is a novel approach following low-cost innovation principles. The advantages of this approach include higher degree of homogenisation and mixing speed tuneability compared to other household mixers commonly used in the literature. First, we observe that the resulting CGAs have low measured densities of 0.43-0.56 g/ml, allowing underbalanced drilling conditions. Second, all CGA drilling fluid formulations demonstrated shear thinning behaviour, following the Herschel-Bulkley rheological model. Third, our formulations after aphronisation showed demonstrably higher low shear rate viscosities (LSRV) than before, which is a desirable property for any drilling fluid. Fourth, we observed that laponite has a positive effect on the LSRV in drilling fluids, and also supports the formation of CGAs. Our study proved that laponite is an effective viscosifier in combination with organic polymers such as XG. Future research will investigate whether XG can be substituted with laponite, as this enhances the thermal stability of drilling fluids (Huang et al., 2019). Fifth, and most importantly, we observed that the surfactant chosen to stabilise the CGA suspensions influences the size distribution of aphron bubbles in solution. In all samples, the use of SDBS results in a larger bubble count compared to SDS. In addition, SDBS shows a narrower size distribution of bubbles, see Fig.1. To **minimise lost circulation of drilling fluids** in highly permeable fractured geothermal reservoir formations, a **larger bubble count** is a positive factor with respect to rock formation sealing capabilities of the drilling fluid. However, an optimal **CGA bubble size distribution** will depend on the **pore size distribution (PSD)** of the rock formation. Here we propose that CGAs can potentially be designed as Lost Circulation Materials (LCM), by **tuning bubble size distributions to match the PSD** in fractured geothermal reservoir formations.

Participation

In-Person

References

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