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Deep geothermal energy

Improving Rate of Penetration with Directional Steel Shot Drilling

Verbesserung der Eindringtiefe durch gerichtete Stahlschrotbohrungen

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In 2023, the International Renewable Energy Agency and the International Geothermal Association released a report underscoring the pivotal role of geothermal energy in the transition to a CO2-neutral energy system. In Europe, where over 50% of energy demand is driven by seasonal heating, geothermal systems are crucial for the heat transition. However, uncertainty in well productivity and high upfront costs for well construction present significant financial risks, slowing market adoption. Multi-lateral wells are a proven method for addressing reservoir heterogeneity and enhancing productivity, but the challenge lies in making their construction cost-effective for geothermal operators. One of the factors that would improve cost-efficiency would be to increase the rate of penetration.

Directional Steel Shot Drilling (DSSD) technology uses high pressure jets containing steel shot particles, which are retrieved at surface after they have been supporting hole making. The steel shot particles are injected downstream of the mud pump in the drill pipe and circulated down into the bottom hole assembly. The steering sub converts the steel shot particle concentration into pulsed concentration synchronized with the rotation of the drill bit, a polycrystalline diamond compact bit with modified nozzle positions and configuration, which therefore is referred to as a hybrid bit. When the jets in the bit rotate across the hole bottom, there will be more particles and more erosion on one side of the hole bottom than the other. Next to the advanced and effective directional control method of the DSSD technology, the erosive action of the accelerated steel shot enhances rate of penetration up to a factor of three in hard rock. Mechanical specific energy (MSE) is widely used to quantify drilling efficiency for oil and gas well drilling. MSE is affected by the level of downhole torque and the effect of weight on bit. MSE is a well-known concept to quantify the cutting efficiency of the rock . However, with DSSD there is a rate of penetration increase based on the steel shot erosion and the change in bit-rock interaction due to the change in hole bottom profile. Therefore, the bit-rock interaction of a hybrid bit requires a modification of the MSE equation.

As part of the European GEOTHERMICA project ‘DEPLOI the HEAT,’ the DSSD system's operational performance is being evaluated in collaboration with various partners. The research includes large-scale component testing, factory acceptance testing, a field trial, and a pilot in a live well. Large-scale tests have demonstrated that with low weight on bit, the rate of penetration in concrete and various rock types increases a lot when compared to conventional bits, in particular in hard

rock types. This is to reduce overall drilling costs by significantly cutting drilling time. The tests also showed excellent borehole wall quality and effective hole cleaning.

This paper presents the latest on the DSSD technology including the rate of penetration improvement with DSSD and explains the rate of penetration results by a physical model that implements the erosive specific energy in the MSE-equation.