Geothermal drilling successes offer potential gain for petroleum industry

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Texas A&M University researchers Dr. Sam Noynaert and Fred Dupriest recently presented results from a geothermal project that drastically reduced well-completion times and drill bit changeouts to an audience of mostly petroleum drillers. The Department of Energy (DOE) funded the project, which improves geothermal drilling practices with physics-based instruction and oil and gas techniques to lower the high cost of drilling geothermal wells. The time and equipment saved suggests the oil industry should take note.

"How you use a technology is usually more important than what technology you use," said Dupriest. "It's not just the geothermal industry that benefits from this. The petroleum industry could have an enormous opportunity here."

Dupriest and Noynaert, professors of practice in the Harold Vance Department of Petroleum Engineering, presented their results in March during the International Association of Drilling Contractors and the Society of Petroleum Engineers conference and exhibition.

Both geothermal and oil industry drillers have access to the same equipment and face similar challenges. The difference is that petroleum wells are drilled in vast numbers compared to geothermal wells, so those companies have more experience cutting costs and drilling times. Yet oil companies often lack time to question unusual bit wear or understand all the fundamentals behind drilling processes, so problems are usually met with quick fixes based on guesswork.

The DOE project proves that basic knowledge of physical principles, when coupled with communication and teamwork to document drilling issues or limiters, reduces costs and improves the ability to address and fix problems with information, not guesses.

Over the course of three geothermal wells completed by different teams over the last two years, Noynaert and Dupriest trained the managers and workers on two of the wells before field operations began. The training created a fundamental, physics-based understanding of exactly what happens downhole, in both the rock cutting process and how the equipment functions. After training, the researchers continued to help the teams identify and redesign performance limiters and dysfunctions each day, as well as implement a more effective workflow to support real-time practices.

All three teams drilled at the DOE Frontier Observatory for Research in Geothermal Energy (FORGE), which features a nearly mile-deep formation of hard granite similar to kitchen countertops. Previous wells drilled through that rock at a rate of 15-20 feet per hour, but these three teams started at 250 feet per hour and maintained 100 feet-per-hour speeds while drilling through the stubborn material.

The first well, with a trained team, was a highly angled directional well. It was finished in about half the time expected and under budget.

The second team was not trained but copied what they could from the first team's efforts while maintaining the same speeds. Their well completion time was less than the first well, mostly because it was vertical rather than directional.

The third team was trained and also drilled vertically. This team cut the untrained team's completion time in half by drilling much faster and cut costs further by using bits for far longer.

"We had a huge gain with the first well," said Dupriest. "But, directional drilling aside, we've cut everything in half again with the third well. Plus, we made advances to fundamental drilling science."

The trained teams changed their work methods to include scientifically documenting equipment changes as drilling progressed. This required taking specific pictures of bit wear from standard angles. The types of damage noted identified the causes of dysfunction, and drilling parameters were quickly adjusted to prevent the same damage on the next run. The photos were immediately shared with the bit vendor, who could improve bit designs based on the evidence.

Since the training instilled better physical knowledge of drilling vertically in hard rock, the third team tested the equipment to its limits. During operations, they safely increased the amount of weight they put on the bit far beyond normal expectations because they understood how to identify and reduce the dysfunction that previously prevented this. The additional weight improved drilling times and surprisingly extended bit longevity.

The third team also used dysfunction evidence to come up with a novel solution to a common but little-understood problem: ductile strengthening of the rock. When the bit didn't respond to increased weight and failed to move forward even with tremendous energy use, they reasoned that the drilling mud created the limitation and came up with a simple experiment to prove it. A 100-gallon water "pill" was circulated down through the bit to alter the rock-progress situation. The bit's energy consumption was reduced by half, and the drill rate doubled.

"Water would not have been used before," said Noynaert. "It would have been a 'that's just the way granite works, so better change the bit' moment. By understanding the physics, they could get the solution to the problem right the first time."

Geothermal companies initially thought the training was a "petroleum thing," but the first team quickly realized its value. After seeing the results, the second team asked for the training, but scheduling conflicts prevented this. The third team fully embraced the project goals and made great strides in improving performance.

Dupriest and Noynaert now say they must prove the education and processes work in all drilling applications to dispel a growing petroleum belief that the successes are a "geothermal thing" or only work in granite. The future goal of the project will involve finding geothermal drilling teams to learn and test the methods in a variety of geologic regions, ideally common to both energy industries.

More information: Fred Dupriest et al, Drilling Practices and Workflows for Geothermal Operations. DOI: 10.2118/208798-MS

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