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Abstract

Objectives/Scope:

Perforation is a well completion technology used to establishing communication between the wellbore and hydrocarbon-bearing formations; it is critical for optimal production. The proposed new perforation technology utilizes high power laser. The technology attracted the oil and gas industry due to its unique properties; it is a non-explosive and adaptable method, which enables precise control over the tunnel's geometry (shape, size, and orientation) and increases permeability along the perforated tunnel. The successful research effort led to a field deployment strategy in the next two years.

Methods, Procedures, Process:

The laser completion system consists of the HPL source mounted on a coiled tubing unit at surface, optical fiber cable(s) to transmit the beam, and optical bottom hole assembly (oBHA). The oBHA incorporates optical, mechanical, sensing, and electronic systems to drive the smart laser tool. All these components work together to create any perforation design. AI, sensors, and robotics the guide real-time adaptation and optimization. The result is a smart and adaptable perforation tool that can operate in any subsurface condition, target all formations, and precisely create several perforated shots in any desired direction.

Results, Observations, Conclusions:

Shaped charge and laser perforation tests were compared; experiments were conducted at identical conditions. Pre, real-time, and post-perforation characterization used different methods such as thermal imaging, mineralogical analysis, spectroscopy, rock-eval, and distributed permeability and sonic measurements. The tunnel made with HPL tool was clean and without melt, there were no signs of compaction nor deformation, the permeability increased along the tunnel. Similar results were observed in all rock types. The experimental data was analyzed using a statistical learning workflow. The analysis provided an insight into the interaction and evinced important relations; it showed the different conditions and optimal parameters to create deep perforations. Similarly, the analysis of real-time spectral and thermal imaging data suggests that both could be used to assess some aspects of the process in-situ (e.g. substrate evaluation, fluid content, or perf evolution). These results are the foundation in the development of smart laser perforation tools. In the field, the system would use deep learning and reinforcement learning to make decisions based on the information from various sensors, well logs, and desired perforation design (target). This neural engine would drive different components to manipulate the beam and create the perforation design needed to enhance production from all rock types, including unconventional shales and tight sands.

Novel/Additive Information:

The technology has the potential to bring perforation into a new generation of intelligent completions. This state-of-the-art high power laser perforation technology is innovative, safe, and non-explosive. It enables precise control of the perforation's geometry and orientation. These and other properties make the technology attractive for downhole applications.