Exciting as Space Exploration

The New Frontier of Oil & Gas Technology Innovations

Enjoy a good adventure story? The next frontier in innovation with revolutionary potential is in the energy business. Practices engineered decades ago are being refined with historical ramifications. These innovations have made inaccessible oil and gas resources now economically viable. This has implications for energy availability, security, affordability, and sustainability. Innovation is transforming exploration and production as we know it, with potential benefits for every aspect of our society. In this article, we highlight a few areas of exciting innovation in oil and gas exploration and production.

Hydraulic Fracturing

Hydraulic fracturing (HF) has revolutionized oil and gas exploration by allowing oil and gas resources to flow out of rock resources that were historically to dense for production. HF was first used commercially in late 1949 by Halliburton. Stanolind Oil had experimented for two years beginning in 1947 in Kansas; this was the first recorded instance of a hydrafrac process. After a failure to improve production in the well by Stanolind, Halliburton was issued a patent in 1949 with an exclusive license to the technology based off an industry paper written by J.B. Clark, a Stanolind employee. Three-hundred-and-thirty-two wells were treated with the hydrafrac process in the year following the license, with an average production increase of 75 percent. In the decades to follow, HF has continued to evolve greatly. Industry has continued to improve the effectiveness of proppants and fluids, and analytical tools have been developed to assess the effectiveness of fracture stimulation.

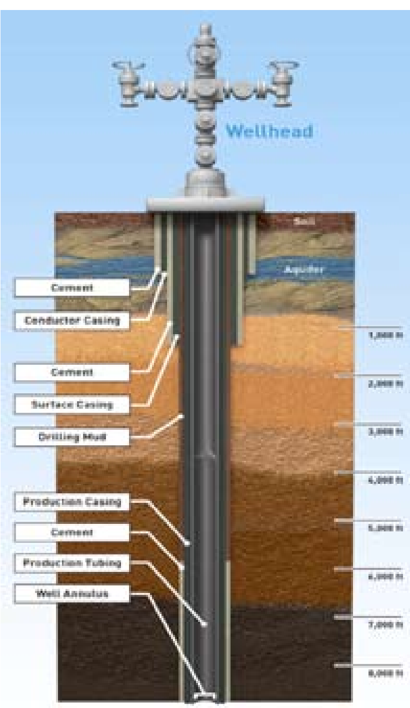

Figure 1. Standard casing diagram for an oil and gas well.

Horizontal Drilling

Aside from the economic efficiency and feasibility to produce in hydrocarbon formations that were previously inaccessible, horizontal drilling also reduces the production surface footprint. The lateral extending wellbore is exposed to a much greater section of the producing pay zone, and would require many more conventional vertical wells to achieve the same exposure. Multiple horizontal wells can be drilled from the same well pad, further reducing the surface footprint needed to produce a large section of land.

HF and Drilling Methods

Today, HF stimulation is achieved through the use of highly engineered processes, equipment, and materials. The two most commonly used forms of HF and horizontal drilling are commonly referred to as "plug-and-perf" (PNP) and Open Hole operations.

PNP operations have been the traditional method of HF for decades, with the use of cement and bridge plugs. In a horizontal or directional well, the production casing is cemented into place after drilling has been completed. After analytical tests are run down hole, perforation casings which contain small electrical charges are lowered into the well bore and fired at regulated intervals throughout the production zone of the

[1] Montgomery, Carl T. "Hydraulic Fracturing: History of an Enduring Technology" Journal of Petroleum Technology. Online. December 2010. Accessed April 22, 2011. http://www.spe.org/jpt/print/archives/2010/12/10Hydraulic.pdf

wellbore. Each production stage is then stimulated by HF and then separated from other fracturing intervals by lowering a composite bridge plug which isolates the producing stage from other fracture stages. The process is then repeated until all fracture stages have been perforated, stimulated, and plugged. A wireline unit then can lower and drill through the bridge plugs, releasing the pressure from the producing stages, which begins production of the well. A good video of this process can be found here.

Open Hole HF and drilling technologies have become increasingly popular with the recent increase in horizontal drilling. Commonly referred to as OHMS (Open Hole Multi-Stage) fracturing, this technology does not require the use of cementing or use of production casing throughout the producing zone. Instead, a steel cement production liner with components of other steel sleeves is lowered into the producing bearing formation. Since cement is not utilized, devices called open hole packers are used to isolate fracture stimulation stages, similar in a way that bridge plugs are used in PNP operations. When triggered, the packers, which can be swelling elastomers, rubbers, or other materials, form a barrier which isolates production zones.

Figure 2. A swollen packer, isolating production sections

The overall OHMS operation is implemented through a multi-layered steel casing. This casing is not like traditional well casings; instead it has many working parts. These layers are called sleeves, and have triggers, holes for production, and are able to be open or closed, similar to an "on/off" switch, which controls production. The use of explosive charges in perforating guns is generally not used for OHMS operations. Instead after a packer has been swelled, isolating a fracture stage, high pressure air will be pumped down, forcing pressure against a particular stage, which will provide the initial "crack" of the rock in its weakest point. HF fluids can then be pumped down to further propagate the initial fracture. This method can allow for better fracture propagation than using a PNP method. More information about OHMS fracturing can be found here.

HF Fluids Going Green

Completion and service companies are continually improving their array of HF fluids and methods of stimulation to address new geological challenges. Companies such as Halliburton, Schlumberger, and BJ Services have all developed and implemented new HF fluids that are green and environmentally friendly. For example, CleanStim™, developed by Halliburton, is a new HF fluid composed entirely of agents sourced in the food industry including enzymes, and acids.

Water is not always used for stimulation. Superior Well Services has developed a nitrogen foam fracturing technique which uses cooled nitrogen (-320º F) to fracture and stimulate a reservoir.

Most recently, Liquid Petroleum Gas (LPG) fracturing through GasFrac has been seen as a highly regarded eco-friendly alternative. One of the most notable advantages is the recovery rate of the fluid used. Since LPG is primarily composed of hydrocarbons (propane and butane), after stimulation, the flowback of the fluid migrates up the well usually in a gaseous form which enables nearly 100% recovery of the fluid which can be captured and reprocessed or sold. The LPG stimulates and propagates fractures in the form of a gel, and eliminates the need of biocides which normal water fracturing needs. Due to the gelled nature, flowback water is eliminated and improves the overall production of the well. Typical LPG processes require about 20 percent of the fluid equivalent than fracturing with water.

The development and use of green HF fluids and processes continues to expand. Each reservoir requires a unique solution to unlock its resource technologically and economically.

Seismic Surveying Transforms Subsurface Mapping

If you live in the Denver-Julesberg Basin, you may have seen three trucks roaming in tandem thumping the ground. Originally developed in the 1970's, three dimensional (3D) seismic surveying has become a widely used technology which enables subsurface mapping. Onshore, seismic crews use vehicles that lightly pound the ground. These vibrations are then registered via geophone sensors placed a certain distance from the vehicle. The data is then collected via a data collection vehicle that travels with the surveying vehicles. More sophisticated than its 2D counterpart, 3D seismic surveying collects data on latitude, longitude, and depth, and thus require more complex geophone sensors. 4D seismic surveying adds yet another dimension of time, tracking how the resources in the formation change over time, and after production.

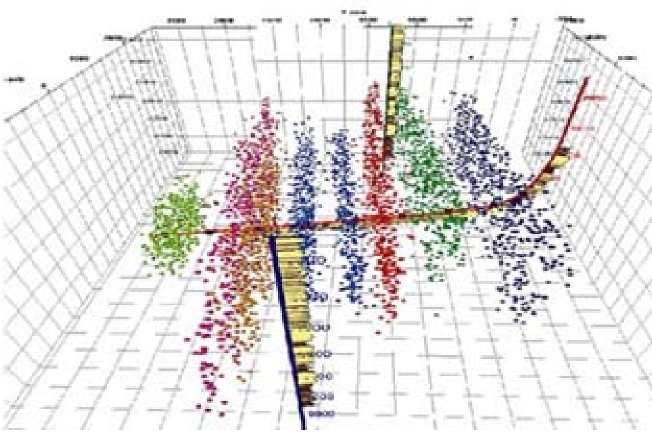

Figure 3. Example of a microseismic HF mapping

Micro-seismic Maps HF as It Occurs

Micro-seismic monitoring allows the mapping of fractures to show their extent subsurface. Rock formations are rarely uniform in measure of resistivity to fracturing; there are weaker and stronger parts that are either more resistant or more conducive to fracturing. Monitoring fractures as they occur involves drilling about 50-100 feet into the ground to place sensors near where the fracture stimulation takes place. After data is collected and presented, an operator can identify the path of the fracture networks created, and thus determine if refracturing is required of a specific section.

Technology in the field is constantly evolving. These methods, and others, are constantly improving and enhancing resource recovery, all the while conforming to state guided safety standards. The oil and gas industry has a long history of technological improvement, adapting and discovering new methods of extraction and analysis. Resources that were previously inaccessible or unprofitable are becoming unlocked, greatly increasing our domestic resource base; and that is something we can all be happy about.

[2] "Nitrogen as a Fracturing Fluid." Superior Well Services. Technical Brocure. Accessed April 30, 2011. http://www.swsi.com/pdf/NITROGEN/N2_Frac.pdf