A Stellar Technology White Paper

Stellar Technology's Oil Field Sensors

Chuck Pitzen

Director of Marketing

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In this article, I'm attempting to give you a flavor of how our STI sensors are used in the upstream (exploration and production) phase of the oil and gas cycle. The other phases are midstream (operations, pipeline operations, commodity transfer) and downstream (refining product, manufacturing product, marketing product, and retail network).

Improving the efficiency of extracting hydrocarbons (oil, gas, bitumen, coal-bed methane, etc.) involves a myriad of methods. In addition, the life cycle of the well and the producing field are important considerations.

1. New well (Primary recovery)
2. Mature well (Primary recovery)
3. Declining/Marginal well (Secondary and tertiary recovery)
4. Non-producing well (Tertiary recovery)

For new wells, the technologies used for seismic evaluation, formation and reservoir modeling, and drilling techniques have made significant advances in the past 5 – 10 years. In addition, many of the new wells are being drilled to greater vertical depths requiring sensors that can handle higher temperatures and pressures. Due to these drilling depths (20,000 ft. to 30,000 ft.), the smaller the physical size of the sensor, the more value for our customer. New drilling techniques, such as directional drilling and underbalanced drilling have also increased drilling efficiency. Stellar Technology's miniature flush mount pressure transducers are used for these applications. These sensors are rated up to 20,000 psi and 425ºF. (Increasing temperature ratings to 500ºF for both the sensor and the sensor electronics is something we are investigating because it would give us a significant differentiation in the market.) As a result, they provide our customers the ability to increase the effectiveness of their drilling tools which then have a positive impact on the overall process of extracting hydrocarbons.

For mature wells, as well as for marginal wells, our customers (service companies such as Halliburton, Schlumberger, Baker Hughes, BJ Services, Crown Energy, Frank's Casing, etc.) have used technology to develop improved techniques for improving production enhancement, well monitoring, and well stimulation products and processes. These customers use our above ground pressure sensors and force sensors for improve well production. The techniques increase the extraction of the original oil in place (OOIP) to almost 60%. Prior to the use of these techniques, OOIP percentages were in the 12%-20% range. Therefore, our Hammer Union, Series FT110, FT260, GT16XX, GT18XX, GT2450, GT2250, GT23XX, GT25XX and FT36XX pressure transducers and

pressure transmitters are components of these advanced systems that increase the overall extraction percentage from the formation.

Coiled Tubing applications are becoming very popular techniques for increasing the efficiencies of both well intervention, production enhancement, and drilling deeper on existing wells. Rather than setting up a complete derrick or mast system, a coil tubing string is placed downhole and reeled off a coil tubing rig. STI's load cells are used in the coiled tubing ejector head. Again, this is an example of our sensors being used in a process that directly or indirectly impacts a more efficient method of extracting oil and/or gas from existing formations.

In addition, our wireline tension force (Series RDE900 and RDE915) load cells are used in well logging applications that determine if a well service is economically justified. Therefore, these Stellar Technology sensors play an important role is determining the cost effectiveness of taking an underperforming well and making it a producing well.

(Note: The following comes from the April, 2007 issue of Well Servicing magazine…"there are in the neighborhood of 600,000 to 700,000 producing oil and gas wells in the U.S. This number changes everyday and is impossible to track exactly. For example, the U.S. Energy Information Administration (EIA) estimated more than 35,000 new American wells were completed in 2005. New wells are drilled and completed daily. Some wells are pumped only once a week or once a month. …… Thousands of wells are plugged and put to rest every year…The industry cranks out some 5 million barrels of oil per day, plus some 50 billion cubic feet of natural gas, on average, and throws in a few million barrels of petroleum liquids. The fact we as a nation use more than 20 million barrels of oil everyday is another issue. That's where the re-entries come in. Plugbacks, reopens, drill deepers or other kinds or re-completions can give a well new life. Already tens of thousands of such wells are producing around the American oilpatch. And with the incentives of $50+ oil and $10+ natural gas, many more re-entries are being permitted everyday……Combining the Texas and California totals for last year (2005), more than 6,000 re-entry permits were granted in the two states."

The above article validates the continuing use of well enhancement activity. Technology drives improvements in well enhancement products and processes. Since our Stellar Technology products are part of this advancement of both well enhancement activity and improved well enhancement techniques, we are contributing to the optimization of oil and gas extracting.

Intelligent well systems utilizing sensors and software can assist in maintaining well production for longer periods of time because of the intelligent well system's ability to manipulate downhole valves from different contributing zones to the objectives of maximizing oil production at different times. This is particularly true in a formation with water surrounding the oil/gas.

In addition, intelligent-completion (IC) technology helps to optimize hydrocarbon production by improving the management and recovery methods associated with enhanced oil recovery (EOR), providing time monitoring as well as zonal isolation and subsurface flow control in both vertical and horizontal well configurations. Stellar Technology's pressure transducers are used to improve pressure maintenance for EOR systems. EOR projects offers several benefits that promote enhanced oil recovery and improved economics, including:

- ∞ Enhanced recovery of individual layers thru commingled production
- ∞ Improved pressure maintenance
- ∞ Controlled drawdown and fluid production from individual zones
- ∞ Superior management of water cut

Our pressure sensors are used in our customers' modular sensor packages allowing for adaption to a multitude of tubing sizes without altering the primary packaging configuration.

For upstream activity, which consists of exploration, development, and production of crude oil and/or natural gas, optimizing the extraction of oil/gas could be addressed from the exploration, development, and production perspectives respectively. It needs to be noted that optimizing the extraction hydrocarbons can be somewhat misleading. It does not mean bringing as much oil and/or gas out of the reservoir as soon as possible. It means controlling the reservoir and maximizing the total amount of oil and/or gas that can be extracted from the formation. Often time this means monitoring, evaluating, and managing the output from the geological formation.

Our STI upstream oilfield sensors are used in each of these phases (exploration, development, production) to assist our customers in optimizing their operations and thus improving the overall economics of oil/gas recovery.

<u>Exploration</u>:
During the drilling phase some emerging technologies are being used which use our miniature flush mount pressure transducers. These are:

1. Directional drilling…reduces the number of vertical wells that must be drilled and thus reduces the cost.
2. Underbalanced drilling…Provides faster rates of penetration (ROP's) and thus optimizes the drilling process.

Our wing union pressure transducers are intrinsically safe and rated for applications requiring Class I, Div.I hazardous location ratings. These sensors are used on the effluent side of the mud pumps and in the standpipe.

Development:

At this stage, our load cells are used for torque calculation on casing as it is lowered into the well. Our pressure transducers are used during cementing applications when the production casing is cemented to the geological formation. Our load cells and pressure transducers are used during well logging as the operator and the driller determine the location of the pay zone.

Production:

Many of our pressure transducers are used in the closed loop production system for filter monitoring, choke manifold control, and monitoring pressures in circulating mud system.

As part of a recent survey, 10 technologies were indentified as the top petroleum technologies. One of the ten was:

Measurement & Logging While Drilling (MWD and LWD) – Rather than hauling up a drill string that's three miles long and sending down wireline logging tools, MWD and LWD tools are run right behind the drill bit, sending data in real time to the driller's console to enable prompt decision-making.

This is a specific example where our miniature flush-mount pressure transducers are being used.

Current trends:

1. Drilling to deeper depths (to 35,000 ft.)
   requires sensors that can handle higher temperatures (250ºC) and higher pressures (20,000 psi)
2. Offshore drilling in deep water (10,000 to 15,000 ft. of water)
3. Intelligent drilling
4. Smart reservoirs
5. Increased use of Coiled Tubing (CT) for well intervention
6. Refining intelligent completion technologies
7. Digital oilfield of the future (e-field)…applying information technologies and computer applications to the various upstream applications.
8. Remote asset management
9. Management disciplines (robust project and program management)

At the first-ever SPE (Society of Petroleum Engineers) Intelligent Energy Conference and Exhibition held in Amsterdam on April 11-13, 2007, the following

were identified as the three major areas of focus as the E&P (Exploration and Production) segment of oil and gas moves thru the 21st century:

- ∞ Technology enablers, including intelligent wells, advanced sensors, process control systems, and other technologies and tools that are improving E&P operations worldwide
- ∞ Case histories and proposals for integrating systems and processes across the spectrum of E&P operations
- ∞ People and organizational issues, including collaborative models, knowledge management, and industry cultures.

Stellar Technology, with it's combination for oil field-proven products, experience sales staff, engineering design expertise, and flexible manufacturing capability, is positioned to support the E&P agenda of the future.

Sources used over the weekend:

1. Hart's E & P (Monthly publication on Global Exploration & Production News Technology Updates) www.EandPnet.com
2. Journal of Petroleum Technology (Official publication of The Society of Petroleum Engineers) www.spe.org
3. Offshore Engineer (Publication by Atlantic Communications) www.offshore-engineer.com
4. World Energy (A publication written by the leadership of the global energy industry) www.WorldEnergySource.com
5. Oil & Gas Journal (A publication on the International Petroleum News and Technology) www.ogjonline.com
6. Well Servicing (A publication covering the Oil and Gas Service Industry) www.aesc.net
7. Offshore (A PennWell publication on the World Trends and Technology for Offshore Oil and Gas Operations) www.offshore-mag.com
8. API (American Petroleum Institute) new web site: www.factsonfuel.com
9. Baker Hughes web site for data on production activity.