Part 2—Fourteen downhole and surface system developments from 11 companies for electric submersible pumping and other artificial lift related operations.

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What’s new in artificial lift

Part 1, presented last month, covered 20 recent developments from 10 companies in three categories of artificial lift technology: sucker rod and Progressing Cavity Pumping (PCP) and plunger lift.

This concluding article introduces and updates 13 artificial lift developments from 11 companies, plus a review of an ongoing related project. Four of the presentations include new downhole and surface equipment for ESP systems. The remaining 10 items cover miscellaneous contributions for new downhole pumps, operations monitoring/control, related downhole equipment, and deliquifying chemicals.

**ELECTRIC SUBMERSIBLE PUMPS (ESPs)**

Described here are four new systems for: an extreme temperature ESP; two downhole sensor/monitors; and a novel diaphragm ESP.

**ESP for extreme temperatures.** Baker Hughes Centrilift, Claremore, Oklahoma, has developed an extreme temperature system for Steam Assisted Gravity Drainage (SAGD) tar sand applications, Fig. 1. Production from tar-sands in Canada is growing dramatically; however, SAGD systems—two directionally drilled, stacked horizontal wells with the top for steam injection, the bottom to produce the melted tar—are severely challenge conventional ESP technology, due to extreme temperatures and temperature cycling.

To overcome these challenges, Centrilift minimized system elastomers; strengthened electrical connections and insulation; designed components for axial and radial thermal growth; and allowed for extra oil expansion. The SAGD environment test facility, a high-temperature, closed loop, allows for 18-day cyclic temperature testing of the ESP system to: fluid temperatures exceeding 500°F (260°C), pressures to 1,000 psi (6,900 kPa), and maximum flow to 27,800 bpd (50 l/s).

A key consideration in the extreme-temperature design is reducing overall rig time, to achieve earliest production. The seal section and motor are pre-assembled, prior to shipment, saving time during installation. The extreme-temperature, plug-in pothead vs. a tape-in design, minimizes field splice time during installation.

Primary design features of the system include, for the: 1) Motor—special internal metallurgy to withstand demanding downhole conditions; 2) Seal section—early testing indicated need for improved thrust/journal bearings, shaft seals and expansion chambers. Due to the elastomer, the seal is the most challenging design component for extreme temperatures; 3) Pump—thermal cycling characteristics of SAGD operations required special design considerations, including metallurgies/coatings to extend run life in abrasive/corrosive conditions. Additional mechanical design was required to handle stage compression issues specific to SAGD applications; and 4) Motor lead extensions—SAGD testing indicated the design must mitigate thermal expansion; and a robust, severe-duty, 4-bolt plug-in pothead, combined with motor-lead cable featuring individually encapsulated phases inside capillary tubing, was developed.

**ESP monitoring and automation.** Baker Hughes Centrilift has introduced a new downhole sensor designed to provide a broader range of measurements aimed at optimizing ESP-system run life and enhancing production. The WellLIF* sensor, Fig. 2, measures seven downhole parameters, including: intake pressure; fluid temperature; motor-winding temperature; gauge electronics temperature and vibration on both X and Y axis; and discharge pressure and temperature. The system also tracks 17 surface/diagnostic parameters, which allows high-level well management. Such costs can be further reduced by remote well monitoring and control through SCADA systems and via the Internet.

Centrilift also offers WellLINK*, a comprehensive well-data distribution, retrieval and analysis service that provides data acquisition, display, control and analysis of ESP surface/downhole systems. Well data can be accessed online with a standard web browser using the service.

WellLINK features the following capabilities: 1) esp-
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Global* is a low-earth-orbit communication device for remote data acquisition and ESP system management. It works over any distance or terrain, providing an end-to-end, remotely hosted system accessible through a secure web log-in, offering the advantage of SCADA without the support/maintenance. With SCADA, it provides real-time data collection/characterization via the internet or private network connection.

And espExpert* is a real-time data analysis tool used exclusively by Centrilift engineers. It merges well data with AutographPC* proprietary ESP system sizing/simulation software, to help understand downhole conditions and compare those to original system sizing, allowing experts to change well parameters or ESP performance to match well data via a user-friendly graphical interface.

Low Flow Hydraulic Diaphragm ESP. SmithLift, LLC, Provo, Utah, a division of Smith International, Inc., has developed and field proven the **Hydraulic Diaphragm Electric Submersible Pump (HDESP)**. The pump is powered by a three phase, triple insulated electric motor and uses two hose-like “diaphragms” to positively displace formation fluid into the production tubing, Fig. 3. The pump was designed for low-production-rate (<200 bfpd) oil, gas and coal bed methane applications with depths less than 2,500 ft. This pump has undergone a thorough development and testing program since its introduction in *World Oil* May 2004, “What’s new in artificial lift,” Part 2. The pump offers operators numerous advantages over rod pumps, PCPs and centrifugal pumps.

Operators have reported production gains due to higher drawdown while avoiding problems associated with cavitation and gas locking. As the pumping mechanism is completely isolated from the well fluid, the pump can handle relatively more solids than conventional beam pumps and centrifugal ESPs that use small vane openings for low liquid volumes. Operators also report other advantages, such as: ease of installation due to the pump’s compact size (3¾-in. OD, 8-ft long, weighing less than 120 lb); a single integrated pump and high-efficiency electric motor; reduced electric power costs; pump-off tolerance; and decreased overall operating costs.

Artificial lift downhole monitoring. The **Phoenix Select** monitoring tool from Schlumberger is the newest addition to Phoenix* artificial lift downhole monitoring systems. This cost-effective system features the latest generation of downhole sensors for in-depth diagnostics and analysis in wells and fields on artificial lift. By accurately identifying operating problems or anomalies in real time, it facilitates effective intervention strategies, protects lift systems, improves well integrity, and helps optimize production and maximize ultimate recovery.

The downhole systems can be used to monitor ESPs, beam (rod) pumps, PCPs, and gas lift systems. When monitoring an ESP, the sensor is connected to the pump motor; and the system transmits data to surface via the pump cable, Fig. 4. Monitoring options are: 1) Lite: Basic ESP monitoring and protection; 2) Standard: Adds discharge pressure, temperature and vibration for improved pump protection and performance analysis; 3) Advanced: Complete monitoring of both pump discharge and intake conditions; and 4) Reservoir: Extends pressure, temperature and vibration measurements to the sand face. This flexibility allows operators to select the appropriate level of monitoring for any artificial lift system.

Traditional monitoring applications require data sampled at higher rates; the new system adapts sampling rate for key downhole parameters so that sufficient data is available. Trip and alarm relays for all monitored parameters are field-programmable to match individual reservoir, well and operating conditions, thereby reducing false alarms. This reduces compatibility issues by using a single data acquisition/communications platform for...
all monitored wells. The combination of advanced transducer technology, state-of-the-art microelectronic components and digital telemetry ensures reliable and accurate information.

Phoenix* monitoring systems are fully compatible with other monitoring/control technology, enabling an integrated system comprising: a sensor unit, an integrated surface panel or universal site controller, a surface choke assembly, software for manual data retrieval, and an optional portable data collector. They are SCADA-ready, with a MODBUS remote-terminal-protocol port and RS232 and RS485 ports for continuous data output. Downhole and field components can be further integrated with the espWatcher* surveillance and control system for: real-time, remote data acquisition; alarms and alerts via satellite; remote pump startup and speed control; and remote resolution of a variety of pump problems.

**MISCELLANEOUS**

Ten items under this category include: a subsea jet pump, a paraffin protection tool, gas well software analysis, deliquifying foamer, a downhole SCSSV tube bypass, wireless automation, an electronic flow meter, a capillary tube bottom running tool, what’s new with ALRDC, and a report from a consulting engineer on tubing flow control progress.

**Planned subsea jet pump.** Weatherford, Houston, has designed and manufactured a special wireline-installed 7-in. subsea jet pump, currently planned to be installed for offshore operator, Lundin, in late December 2006, or early January 2007. The operator is drilling the well about 100 mi off the coast of Tunisia in 820-ft water. The subsea completion will include 11¾-in. casing and 7-in. tubing. The well is expected to produce in the range of 20,000 bpd.

Lundin recognized up front that cost for intervention after the well is put on production would be prohibitive. Therefore, it commissioned a study by another company to determine the best method of artificial lift. That study determined jet pumping to be the best choice. Weatherford was then contacted by Lundin and, in response, proposed a 7-in. wireline jet pump. While a 5-in. pump would handle expected production, the larger size was selected to minimize fluid velocities inside the pump for the longest run time. The special jet pump, as illustrated in Fig. 5, was designed and manufactured for installation as noted.

The initial power-fluid rate of the wireline-installed pump in the 7-in. tubing will be about 13,500 to 15,000 bpd, depending on reservoir response. Lundin plans to use water, but that is open to change. Initial injection pressure will be about 3,500 psi and will be limited to 4,800 psi as watercut increases; initial watercut is expected to be 1.0%. This is believed to be the first subsea jet pump installation. And a 7-in. jet pump is rare. The only other one known to exist was in Oman long ago, reportedly producing 50,000 bpd. The expected 20,000 bpd will likely decline over time, with increasing watercut and the injection pressure limit of 4,800 psi. The gas oil ratio is only 25:1, so gas is not an issue. If it were, the throat would be sized to accommodate any free gas at the pump.

**Downhole paraffin protection tool.** Para Service Inc., Calgary, Alberta, manufacturers Enercat*, a downhole tool used for prevention and removal of scale, paraffin and asphaltene deposition in oil/gas production. When installed in a producing oil or gas well, current treatment methods such as wireline scraping, chemical and hot oil circulation, can be eliminated. The tool, which has been used successfully since 1993, comprises a 4-ft tubing pup joint, with a jacket containing a solid-state quartz compound. The crystals are encased in molten aluminum and formed into a mold that can be attached to a tubing pup joint. The quartz crystals and semi-precious metals,