temperature rising
The unforgiving downhole environment of steam-assisted gravity drainage (SAGD) wells might be considered the Dante’s Inferno of heavy oil extraction — despite the extreme temperatures and difficult conditions inherent in SAGD production, with conventional crude reserves shrinking and with oil prices reaching unparalleled heights, producers are destined to go there.

And with operating temperatures that can ravage equipment, and the high viscosity and density of the crude that can make getting the bitumen from depths a challenge, artificial lift has become an integral component to unearthing the prize and improving production methods and results.

The evolution of artificial lift technology for heavy oil thermal recovery continues to advance as the industry attempts to establish increasingly reliable pumping mechanisms in a quest to improve on such established technologies as electrical submersible pumps (ESPs) and progressing cavity pumps (PCPs).

In the extreme temperature ESP market, both Baker Hughes Centrilift and Schlumberger are offering the latest technology in an effort to meet the ever growing and always demanding needs of oilsands producers, both in terms of performance and reducing capital costs.

Lawrence Burleigh, marketing manager for SAGD systems with Centrilift, says the company has invested “significant resources” to develop an extreme-temperature, harsh-environment ESP suitable for SAGD operations. He says the company’s efforts to develop ESP system technology for SAGD applications has resulted in equipment designed and developed specifically for applications in higher temperature wells.

“We have been in the geothermal market since 1994 so we’ve been developing high-temp equipment for some time. But SAGD required some unique developments of its own and so to accelerate and better focus the development for SAGD’s unique requirements, we leveraged our hot loop,” Burleigh says.

The hot loop facility, located at company headquarters in Claremore, Oklahoma, allowed Centrilift to forgo extensive field testing prior to launching the product, streamlining the process from concept to reality. In fact, Burleigh notes that in-house development and testing of all phases of Centrilift’s new extreme-temperature ESP product offering would have been impossible without the construction and availability of the hot loop test facility.

Centrilift’s hot loop allows for entire systems to be tested, and equipment can be brought up to temperature and accelerated research and development tests performed. In addition to the high-temperature test capability, Burleigh explains that Centrilift has a “constant viscosity” loop, and a “variable viscosity” loop. An additional loop is used to test with liquid and gas, while another is a slurry loop to test pump performance in abrasive conditions.

“You combine all those resources together and it’s very complementary to the SAGD application because you have all those factors,” Burleigh notes.

Adds Kelvin Wonitoy, Canadian operations engineering manager for Centrilift: “To put that into context, another supplier has been develop-
tions required special pump design modifications, and based on the results of many SAGD environment loop tests, Centrilift applied special metallurgies to the pump stages along with stage coatings aimed at extending system run life under abrasive and corrosive conditions. As well, additional mechanical design changes were required to handle the stage compression issues specific to high-temperature applications such as SAGD.

Designed for operation in harsh environments, the extreme-temperature motor features special metallurgy to withstand demanding downhole conditions. The high-temperature stator design is manufactured with robust internal components. The company says numerous Centrilift motors have operated successfully in fluid temperatures of 240 C (465 F).

Burleigh explains that early extreme temperature product testing indicated the need for improved thrust and journal bearings, shaft seals and expansion chambers in the Centrilift seal design and that testing throughout the development process has achieved exceptional performance improvements in all of these functional areas.

“When it comes to ESP systems, really the big difference is going to be the seal section, or the protection between the pump and the motor,” Wonitoy says. “An electric motor is an electric motor. A centrifugal stage pump, whether it’s red, blue, green or pink, they all have the same hydraulic design and principle, but the most critical piece of the system is the unit that protects the motor from the well fluid, and that’s your seal section.”

With oilsands producers striving to raise the bar on upper-end temperatures for SAGD, Centrilift is well into the process of further enhancing its ESP system to withstand an even hotter operating environment. “I would tend to say that we’ve reinforced our effort on a viable 250 C environment system, and that development is well underway. We anticipate trialing portions of that development in Q1.”

Wonitoy believes the quest in attaining higher temperature performance could well be the determining factor of which company emerges as market leader in the future. “[Producers] want higher temperatures. Whoever reaches that plateau will put themselves very much above everyone else in the market.”

Pushing the limit

Currently running its REDA Hotline550 high-temperature ESP system, Schlumberger, too, is escalating efforts to increase the extreme temperature capabilities of its SAGD ESP offering. “Naturally, there is a desire [from producers] to put more heat into the reservoir. In doing so, they will exceed the present bottomhole temperature threshold [218 C] of current ESP systems,” says Robb Pollock, Schlumberger’s Canadian artificial lift sales manager.

Responding to that collective industry desire, Schlumberger continues to work with operators to develop new products to operate in higher temperature and higher pressure well conditions. “Continued R&D efforts are underway to stay ahead of the game and take us to that next level. As the game continues to change, we continue to push the envelope of technology without changing the physics of the pumping system,” Pollock explains. “With clients running the gamut of producers, currently, Schlumberger has installed over 300 REDA Hotline550 ESP units with over 100 operating.”

The system consists of ESP downhole equipment, pump, motor, protector, gas handling equipment and power cables, and has a maximum bottomhole temperature rating of 218 C (425 F). It accommodates material expansion and contraction and thermal fatigue resulting from temperature cycles and extremes.

Each component has been designed to extend system run life in high-temperature applications. For instance, the pump tolerates abrasive fluids at high temperatures by using compression construction combined with abrasion-resistant materials and bearing systems. The motor uses special high-temperature materials rated to 288 C (550 F); the motor pothead has non-elastomeric, metal-to-metal seals that act as a barrier to prevent fluids from entering the motor.

Schlumberger’s Advanced Motor Protector uses a patented metal bellows expansion chamber that eliminates risks encountered with elastomers operating in high temperatures and high corrosive environments. It has dual elevated shaft seals and a special sand diverter system to prevent sand from migrating into the protector system.

“[The Hotline550] has actually become quite popular because we were successful in getting run times that were acceptable to producers,” Pollock says. “They always want more, but if you can provide a product that meets their economic thresholds, then it’s considered to be successful.”

PCP alternative

Touting its PCM Vulcain as a “pumping revolution in the thermal recovery of heavy oil,” Calgary-based Kudu Industries Inc. and its sister company, Paris, France-based PCM (formerly PCM Pompes), are offering up an alternative to high-temperature ESPs with metal PCP technology.

“Standard progressing cavity pumps, sucker rod pumps [SRP] and electrical submersible pumps are limited in terms of maximum operating temperature. In contrast, the PCM Vulcain is the only pump that works efficiently at the high temperatures of thermal recovery,” says Nicolas Parisé, director, PCM Oil & Gas Business Unit. “Elastomeric stators make standard progressing cavity pumps unsuitable for use at extremely hot temperature — and other existing pump technologies are not as inherently efficient or reliable as progressing cavity pumps.”

With its all-metal design, the patented PCM Vulcain is capable of pumping extremely hot (350 C/660 F) and extremely viscous fluids. According to Alex Damnjanovic, vice-president of sales and business development for Kudu Industries, the rotary action of PCM Vulcain outperforms other forms of artificial lift in overall system efficiency and is far simpler and more flexible than electric submersible pumps. PCPs are more energy efficient than other pump technologies, he notes, and the PCM Vulcain provides extremely low submergence production capability and can operate at low downhole pressures and higher viscosities.
Lower lifecycle costs also benefit producers who use the technology, Damnjanovic explains. “With the inherently reliable, robust eco-design of PCM progressing cavity pumps, PCM Vulcain has lower capital expenditures than comparable submersible and rod pumps. It also offers lower workover costs and reduced installation and operational complexity.”

As well, the high-temperature drive-head seals reduce the risk of on-site leakage and the compact installation footprint reduces its visual impact on the landscape, thus reducing the environmental footprint of operations.

“When you look at the operating performance, the pump can operate under varied pressure differentials, under varied viscosities and under varied temperature differentials,” Damnjanovic says. “So, for example, in cyclic steam operations, downhole conditions vary from 330°C to as cool as 60°C, so there’s a very wide temperature range and the pumps are very adaptable, very flexible.”

The relative ease of installing the PCM Vulcain is also a benefit to producers. “The installation is very simple, the footprint is extremely small,” Damnjanovic says. “It’s just a much neater and tighter package on surface.”

In the past few years, PCM Vulcain has been field tested extensively at Total E&P Canada Ltd.’s Joslyn field, where Total is the operator. And, by all accounts, it’s measured up to expectations.

“[Total] was there from day one sponsoring the technology back in the mid-’90s and now they wanted to use the technology out in Joslyn ... they said this is a great application of the metal pump,” Damnjanovic says. “I’m proud to say that Total was the first company to actually use the technology in almost an exclusive way in SAGD at Joslyn. Almost all of their wells are running a PCM Vulcain PCP. The lion’s share are run by this technology.”

Gilles Chalier, well technology manager for Total E&P Canada, says the PCM Vulcain has proved its worth in the field after prior use of ESP technology failed to deliver the results the company was looking for. When the Paris-headquartered Total S.A. subsidiary acquired Deer Creek Energy Limited and its Joslyn assets in 2005, existing plans called for the use of high-temperature ESPs and Total followed through with those plans — at least initially.

“The plan at the time was to start with ESPs so we did that when we took over from Deer Creek. We completed three new wells with the ESPs and basically tried to produce the wells — ramp them up and get production from them,” Chalier recalls. “We had a lot of issues getting the ESPs to perform because, basically, inflow was too low and viscosity was too high. Basically, ESPs could not cope with the erratic inflow and the constant change of the viscosity.”

Having familiarized himself with PCP technology from his time working in the heavy oilfields of Venezuela, Chalier was convinced that technology held promise for application at Joslyn. About the same time the first PCM Vulcain became available for field testing and Total, at Chalier’s urging, gave it a try in October 2006.

“We ran it in one well and the performance was just unbelievable. The ramp up was extremely fast compared to what we were seeing at the same time on the wells equipped with an ESP,” he says. “PCPs can handle any kind of viscosity. In fact, the higher the viscosity, the better. As well, any kind of erratic inflow will not stop the pump — it will continue to pump and that’s what we needed at the time to really get the temperature up in the producer.”

Chalier says a second field test also was successful and subsequently Total has installed the PCM Vulcain on new wells or swapped out existing ESPs for PCPs on 11 of the 12 wells the company currently has producing at Joslyn.

He admits the one current drawback to the high-temperature PCP is its efficiency. In the first field test using the PCM Vulcain 550 series the unit had a volumetric efficiency of 40% while the second field test, using a smaller version of the PCM Vulcain (400 series), operated at about 50% efficiency.

“We’re working with [Kudu and PCM] on some efficiency issues. Efficiency has not been very consistent,” Chalier says. “We want to make sure we get at least 60 to 70% efficiency from this pump and Kudu and PCM are doing a lot of work on that.”

EnCan Corporation’s Adrian Dodds says his company has “multiple pump vendors operating,” including Schlumberger, Centrilift and Kudu. “ESPs have been made for the high-temperature market for about five years and are starting to show their value,” he says.

“EnCan has the most extreme or very high temperature pumps in operation. The metal-to-metal pumps show promise but have not been in operation as long.”

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