JCPT

TECHNOLOGY BRIEF

Evolution of Coil Tubing Instrumentation in SAGD Applications

History of Multiple Pressure Coil Tubing Instrumentation

The evolution of coil-tubing instrumentation has been primarily driven by the ongoing development of SAGD projects. In 1995, one of the earlier proponents of the technology, Alberta Energy Company, went looking for a company that could provide a means to instrument horizontal well pairs used in the SAGD process. Concurrently, PROMORE Engineering Inc. had embarked on an initiative to develop high temperature pressure sensors. The two companies set out to design and manufacture coil-tubing instrumentation that would remain dry with special ports accessing the wellbore. Initial prototypes were designed for injection and production well(s) and incorporated multiple pressure and temperature sensors, bubble tubes and conventional thermocouples (Figure 1). Based on continued co-operation, the two companies patented the CT-MORE (Coil-Tubing Conveyed) monitoring system in 1998, which provides the instrumentation cornerstone of most SAGD projects today.

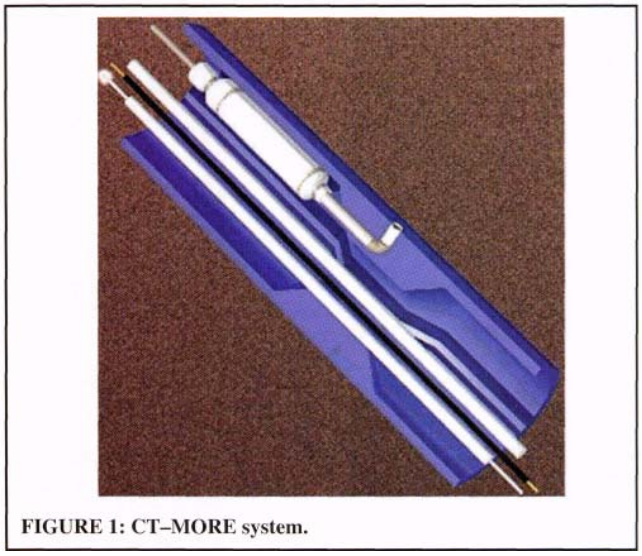

FIGURE 1: CT–MORE system.

Based on the commercialization of SAGD and the ensuing need to reduce costs from pilot project phases, PROMORE set out to streamline the manufacturing and installation process. With an initial investment exceeding $1.0 million, the company was able to reduce the dependence on coil-tubing services in conjunction with reducing the average size of CT-MORE Systems (Figure 2). Several design changes allowed the CT-MORE diameter to be reduced from 1-in. to 1 $^{1}/_{4}$-in. Other designs were developed to improve overall wellbore hydraulics and 1-in. and $^{3}/_{4}$-in. CT-MORE's became available. These changes and investment reduced manufacturing costs resulting in savings to the operating companies. Figure 2 shows the decrease in manufacturing costs, which resulted in large savings to the operating companies. As noted on the plot PROMORE's investment in SAGD resulted in a service entity with complete control over manufacturing.

Note: third part coil tubing services are no longer required for manufacturing.

In addition to the manufacturing process, it became evident that new deployment techniques and procedures would have to be developed, especially in consideration of the use of smaller diameter CT-MORE strings. Two unique systems allowed the CT-MORE systems to be deployed economically.

- Thermal Shear Sub (TSS)—this system was patented by PROMORE in conjunction with AEC. It is used when there is production/injection tubing, which will remain at the toe of the well. The production tubing is used to pull the CT-MORE system into the wellbore using a special sub at the end of the tubing. This sub melts when heated, allowing either the CT-MORE or the tubing to be pulled independently.
- Mechanical Drop Sub (MDS)—this technology (patent pending) is a sub attached to the production/injection tubing, which allows the CT-MORE to be pulled into the wellbore. The MDS permits the CT-MORE to be unlatched and left at the toe while the tubing is pulled back to the heel or mid-point.

Further developments included the design and manufacture of a multiple CT-MORE deployment system (Figure 3) which allows installation and handling of up to five strings, resulting in significant savings to operators by reducing both travel and CT spooling costs. To further reduce costs, PROMORE built a 2000-meter CT-MORE manufacturing facility (Figure 4) and developed dedicated manufacturing and engineering teams. Today, over 10 CT-MORE systems can be manufactured per week.

In addition to manufacturing and deployment systems, instrumentation also improved. A unique PROMORE "oilwell" style thermocouple was developed to replace troublesome conventional thermocouples, which are not well suited to SAGD applications. One of the more significant evolutions in SAGD instrumentation has been the dramatic rise in the utilization of fiber optic distributed temperature sensors. Fiber optics provides finite measurement of temperature (0.5° C) at up to every 0.5 meters along the wellbore. Seeing this coming evolution, PROMORE embarked on an aggressive development program that would see fiber optic sensors as one of the options available to SAGD operators. This included the integration of optical computing technologies, fiber optic sensors, deployment systems and interface to client SCADA and network. Clients are no longer just interested in downhole

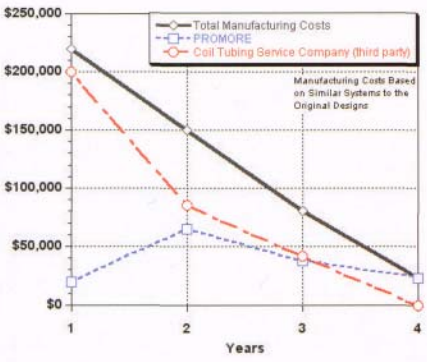

FIGURE 2: Construction cost of CT-MORE systems.

FIGURE 3: PROMORE multiple CT-MORE deployment system.

instrumentation but wanted complete turnkey solutions in large development projects. Project management, engineering and dedicated CT-MORE manufacturing teams were developed in a short time frame. As a result of this commitment, PROMORE is the recognized industry leader.

Data Acquisition

As downhole instrumentation and deployment techniques continued to evolve, so did the necessity for the continued developed of surface data acquisition and distribution systems. The PRO Vision Data Acquisition System was released in 1999 to improve the resolution of PROMORE sensors and streamline the overall data acquisition and distribution environment.

Based on the same protocols that drive the Internet, PROMORE offers an Encrypted Communications System that provides military grade encryption and uninterrupted access to data. The ECS network allows continuous, real-time communication with PROVision Systems, which allows monitoring from any computer connected to the Internet.

"DataWEB" service allows multiple clients to view and retrieve data from PROMORE's Webserver using a standard browser. DataWEB was developed to streamline clients' access to data, particularly where current network/SCADA infrastructure is at a minimum.

The rapid acceptance of fiber optic distributed temperature systems, propelled the company towards the development of the "FibreNET" Distributed Temperature System (DTS). In addition to downhole fiber optics, optical computing technology had to be integrated into an entire system including termination methods, surface fiber, termination panels and interface of the DTS to an OPC (Object Linking and Embedding for Process Control) interface (Figure 5). The rapid development of the OPC server allows the multiple monitoring of several fiber optic systems through conventional SCADA, MMI, PLC or custom software programs in a

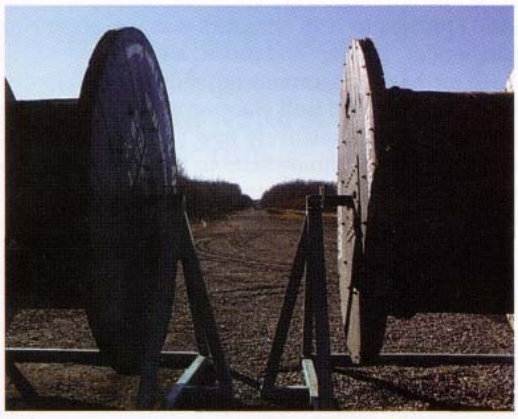

FIGURE 4: PROMORE Manufacturing facility.

The Future Looks Bright

No one knows for certain what the future holds for the evolution of SAGD, however it is safe to envision completions designs and process methods will change. Instrumentation systems will likely confirm that operators will require better isolation, control and distribution of steam injectors, in addition to improved systems to control production from SAGD well pairs. The evolution of thermal packers, liner hanger systems, and better methods to control sand production will undoubtedly be supported by access to the continual data provided by instrumentation systems.

A new system, ZoneBoss™ Extreme (Figure 6), is currently being under design to provide for better isolation and control of production from SAGD wells. ZoneBoss™ will also incorporate multiple pressure, temperature, and distributed temperature fiber optic sensors. Future incorporation of microseismic interwell imaging may also be possible. ZoneBoss™ is expected to provide a more effective and cost efficient means to complete and optimize SAGD wells.

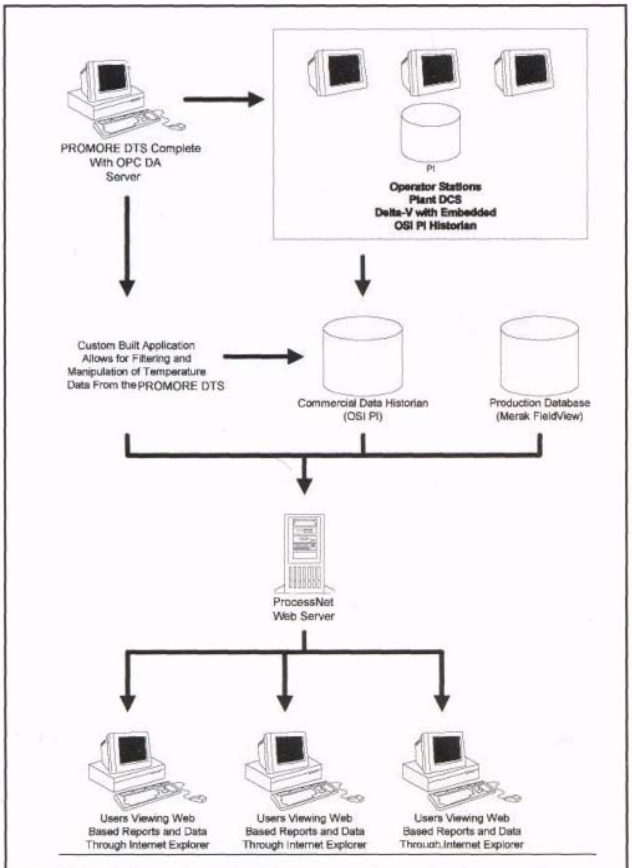

FIGURE 5: Interface of optical computing technology to client networks.

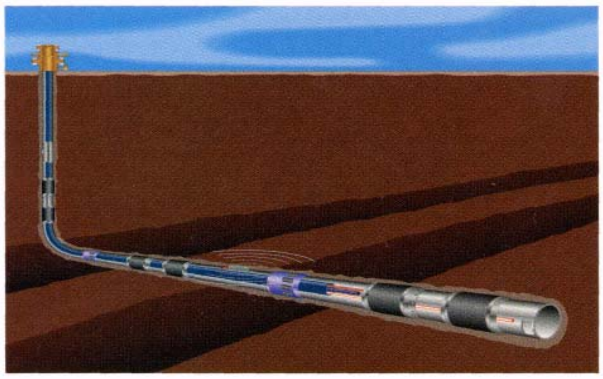

FIGURE 6: ZoneBoss™ Extreme.

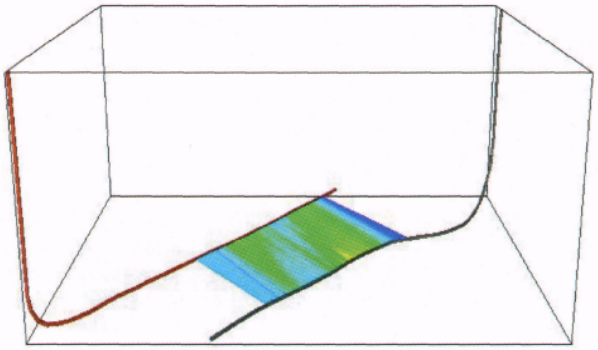

FIGURE 7: Crosswell Seismic Imaging

Another instrumentation system that has shown early promise with some operators is Crosswell Seismic Imaging provided by TomoSeis (PROMORE sister company). This logging process allows for the assessment of reservoir heterogeneity, including shale barriers as thin as one meter, which has proven in the past to adversely affect the SAGD process (Figure 7). In addition time-lapse tomography provides a method to monitor the progress of the steam front between wells. Crosswell instrumentation has been recently demonstrated in imaging reservoir properties between two horizontal wells (Li, Washbourne, et al., presented at SEG Annual meeting, 2001). Changes in seismic velocity over time indicate the progress of the steam front between wells. Crosswell provides resolution up to 10 times better than surface seismic methods, using a seismic source in one well and seismic receivers in adjacent wells. In the future, permanent seismic sensor will allow real-time monitoring of the steam progress without the level of well intervention currently required. Crosswell tomography may be one of the key elements in more effective management of SAGD sweep efficiency.

Real-time instrumentation systems have become a standard part of the SAGD process to help operators manage steam injectivity, steam chamber development and subsequent production. The data has provided the basis to ascertain steam quality, aid in the design of completion systems and well placement, and improve the overall understanding of this relatively new technology. New uses of the data provided by instrumentation will ultimately occur as SAGD moves forward as a commercial process.◈

Authored by **Miodrag Pancic,** the SAGD Project Coordinator for PROMORE (A Core Laboratories Company). Miodrag provides project management and engineering to a large variety of clients. He has been involved in the design of downhole tools, instrumentation systems, wellhead configurations, wireline and well testing for over six years. He holds a mechanical engineering degree and diploma of petroleum technology.