Design of Steam Injection – Integrated Digital Oil Fields

A NEW APPROACH FOR BENEFITS MAXIMIZATION

CHALLENGE

Steam injection is the most commonly used method for delivering energy to heavy oil reservoirs in order to increase recovery factors and extend productive life. However, under the prevailing low oil price environment, the profit margins of heavy oil projects can be narrow.

A traditional field development design and execution approach involves a small number of stand-alone solutions that are not designed to achieve a common objective. Decisions are often made reactively, on a day-to-day basis, rather than through proactive planning. This approach has to evolve to take into account the complexity of upstream or downstream consequences of operational decisions.

The digitalization of heavy oil fields offers an excellent way to improve operational safety and to project economics. Literature reports downtime, and operational and maintenance cost reductions, as well as oil production and recovery factor increases that result in profitability improvements up to 40 percent.

However, many companies typically focus more on developing the technology than on how to get their people to use the technology. This is due, at least partially, from a resistance to change and from profitability uncertainty.

SOLUTION

Halliburton has developed an innovative Digital Heavy Oil Field (DHOF) concept for continuous and cyclic steam-injection projects with four unique characteristics:

» Fully integrated optimization of the reservoir, wells, and surface network
» Optimization of both cyclic and continuous steam injection
» Three workflow swim lanes (injection, production, and reservoir) that can work both independently or coupled
» Automated reservoir optimization using smart algorithms and stochastic calculations

The project design includes a tailor-made implementation plan that addresses the people, processes, and technology challenges of the operator to ensure that the workflows run as designed and support user adoption. The project is conducted in three stages:

BENEFITS

Our approach considers processes, technology, infrastructure and people. The early assessment of essential aspects for the operator, along with our extensive digital field knowledge and continuous improvement are keys for success. (continued on page 4)

CASE STUDY

The design conducted for a National Oil Company included 3 business cases, all of them with encouraging results pointing the convenience of implementing digital heavy oil field for better operations and economy. (continued on page 4)
Stage 1: Review and Assessment
The objective of Stage 1 is to review and assess the current situation and the operator’s plans to determine what business processes and indicators are required for designing a DHOF that is aligned with the operator’s mission and vision.

Typically, 10–15 processes and 50–100 indicators are identified and segmented into different hierarchical levels and distinctive groups, and each group of indicators is focused on a critical performance aspect of the DHOF.

Stage 2: Optimum Design
The main objective of Stage 2 is to determine the operator’s desired level of functionality of the DHOF solution, and to tailor a real-time data monitoring and management system design that allows for production, reservoir, and operational optimization.

The DHOF processes and automation opportunities identified in Stage 1 are inputs to the workflow design activity, which includes the following tasks:

» Identify the workflows required
» Confirm the logic connecting workflows in the digital oil field
» Outline the specific characteristics and flow diagram of each workflow
» Confirm the best mathematical model for each workflow

Our approach uses swim lane communication (Figure 2), which fully integrates the DHOF.

For model update workflows, the objective functions, constraints, and decision variables are defined – and, for optimization workflows, the uncertainty variables are specified.

Stage 3: Roadmaps and Supporting Plans
The main objective of Stage 3 is to provide the roadmap and implementation plan for the successful deployment of the integrated DHOF and for the measurement of derived economic benefits. Outputs and lessons learned from Stage 1 and Stage 2 are used in Stage 3 to yield the following deliverables:

» Conceptual roadmaps
» Final business case definition
» Definition of technological challenges and proposed solutions for the reservoir and network

Figure 2 > Workflow communication scheme

Figure 1 > DHOF indicator hierarchy and groups
BENEFITS

Our approach provides an early assessment of the operator’s key processes to be digitized, along with our extensive digital oilfield knowledge, our hardware/software availability, and our willingness to conduct the required organizational changes.

The swim lane communication shown in Figure 2 works for both cyclic and continuous steam injection to ensure:

» Maximum flexibility in the DHOF
» The ability to execute the workflow and to make decisions depending on field conditions and operational urgency
» Built-in safeguards for potential stoppages and shutdowns of some of the automated workflows
» Staged implementation of the DHOF, scaling from basic implementation to the ultimate possible functionality

The ultimate benefit of the swim lane workflows is to improve asset performance by increasing operational efficiency and uptime, monitoring and optimizing injection/production, promoting collaboration between teams, reducing operational costs and nonproductive time, and increasing production and recovery factors.

Our approach also anticipates the change-management strategy required for the implementation of a DHOF that is tied to a robust business plan. The roadmaps are meant to provide an easy-to-understand and concise route to the DHOF, whereas the implementation plans include technical and change-management work streams that address people, processes, and technology – thus ensuring that all workflows run as designed and support user adoption.

CASE STUDY

A national oil company wanted to implement a DHOF to improve energy management as a means to increase the profitability of a large steam project that was to be deployed starting with cyclic injection and, after a short period, switching to continuous injection.

This project focused on visualization and design of workflows for technical and business processes. Using the methodology described above, Halliburton estimated the cost of the workflow and model development, along with hardware acquisition, software licenses, and additional instrumentation duplicating the system for disaster recovery. The dynamics are described in Figure 3 below.

Three business cases were addressed, all considering two-staged implementation. Scenarios including stochastic economic analyses of full implementation, partial implementation, and no additional instrumentation were conducted, and information on the variability of the possible economic outcomes was obtained. The economics of all three scenarios were encouraging, pointing to the benefits of implementing a DHOF that included reservoir optimization.

This project is one of the first digital oilfield projects of this magnitude in steam flooding and cyclic steam that considers the integrated optimization of production networks, injection networks, and reservoir models. One expected benefit of this project is a substantial reduction of the production cost per barrel. For the operator, this is a benefit of paramount importance, given the current low oil prices and the relatively high operational costs associated with many heavy oil fields. This project proposes a new industry standard for the operation of heavy oil fields and enhanced oil recovery (EOR) fields.

For more information, contact your local Halliburton representative or visit us on the web at www.halliburton.com