Subsea boosting technology recently brought online at Chevron's Jack and St. Malo fields is expected to boost production rates for the next 30 years. Chevron's Chris Hey and Dan Broussard, and OneSubsea's Mads Hjelmeland and Oeyvind Reimers explain.

Accelerating longevity

The subsea boosting system now in place on Chevron's Jack and St. Malo development represents a major industry milestone and a first for Chevron, and is the result of significant collaborative efforts, dedication, and structured technology development. Successful deployments of subsea boosting systems such as this one have encouraged new development activities to expand the envelope of subsea boosting.

The Gulf of Mexico (GOM) Jack and St. Malo fields commenced production in 2014; the naturally high pressures driving production from the fields during the early stages of development are expected to decrease over time. Water depths in both fields are around 7000ft and the reservoirs lie about 5mi below the surface. Key challenges include low permeability, high pressures, high temperatures, as well as water and well depths. OneSubsea, a Schlumberger company, qualified, delivered, and deployed three single-phase subsea boosting systems.

Joint field development

The Jack and St. Malo reservoirs are tight sandstone reservoirs up to 1400ft thick, indicating a vast amount of oil in place. The large volume of oil equivalent reserves in place will be recovered over a lifetime of 30 years. Despite the high initial reservoir pressure, the energy to move fluids to the seabed declines with depleting reservoir pressures, resulting in lower production rates falling off plateau. While various artificial lift methods could be effective, seabed boosting systems were eventually selected, based on the net value added to the project's overall net present value.

A combined development was sanctioned for the two fields that are situated 25mi apart. This joint development strategy required new technology qualification in the deepwater environment due to the challenging reservoirs and the distance between the fields. Jack and St. Malo discoveries are to be developed in multiple stages. Stage 1 involved drilling of 10 wells; four tapping into the Jack reservoir and six tapping into the St. Malo reservoir. The wells at Jack are tied to one subsea manifold, whereas the wells at St. Malo are tied to two daisy-chained subsea manifolds. Three pump stations located downstream of Jack and St. Malo manifolds boost the fluids back toward the semisubmersible floating production unit

Pump module (left photo) and the three pump stations (above) prior to subsea development.
Photos courtesy of Schlumberger.

(FPU) located mid-way between Jack and St. Malo reservoirs through individual 10in pipelines. One combined power and control umbilical was laid from the Jack and St. Malo FPU to each of the two fields, supplying the pump systems with electrical power, communications, control fluid, and barrier fluid.

The use of subsea pumps downstream of the manifolds is expected to provide a significant increase in the oil recovery factor and the best return on investment of the evaluated artificial lift options. This is achieved as the wells are producing at lower wellhead pressure (WHP), which is enabled by the differential pressure generated by the subsea pumping systems.

Qualifying critical technology

The seabed pumping systems for the Jack and St. Malo fields were installed at a depth of around 7000ft with tiebacks of roughly 13mi. To comply with high shut-in pressure, deepwater, and tieback distance qualification efforts were needed with respect to the 13,000psi design pressure, the 3MW electrical motor, and the high-pressure subsea pumps.

Due to the water depth, a two-year technology qualification program was initiated to qualify all components to Jack and St. Malo specifications and to allow Chevron to gain confidence that the subsea pump system would deliver the expected results under challenging conditions such as significant step-out distances and high shut-in pressures.

There was a firm requirement that the pump system qualification be finished in order to comply with the installation schedule and campaign of the overall production system. The subsea boosting systems were installed and commissioned at the same time as the overall subsea facilities. The three pump stations were tied into the production system and initial natural production was routed through these pump stations. The subsea pumps were installed at the same time and placed in wet storage to wait for the reservoir pressures to deplete.

The technology qualification efforts took two years and were related to the subsea pump itself and the subsea transformer, including various subcomponent qualifications. A FEED study was conducted at the same time that included a complete boosting study prior to the final investment decision.

Project specifications called for the subsea pumps to generate a high differential pressure at 60,000 b/d capacity in large water depths in order to boost the fluids back to the FPU. An electrical motor with 3MW was qualified along with new pump and motor housings rated to 13,000psi design pressure. Also, a novel system was qualified to control the barrier fluid pressure subsea. A subsea barrier fluid regulation pod with directional control valves in tandem with subsea accumulators was applied in order to compensate for pressure transients during pump operation and transients. A 40-hour endurance test was performed as part of the pump performance test program.

Pump systems

Each pump system is comprised of a bypass line to allow for natural production as well as the pump module itself and a recirculation line with a retrievable control valve to allow for recirculation of fluids to remedy turndown flow rates. The pump systems also include all required process valves, instrumentation, and process connectors to safely operate the systems. The systems are equipped with hot stab connections and chemical injection points. In addition to the installed subsea equipment, two spare pump modules and a spare transformer module were contracted.

Two pump stations (one submerged in test pit with pump module and transformer module installed) during system integration testing prior to final delivery. Another pump module is shown next to the pump station.

The pumps are powered by adjustable speed drive (ASD) systems located topside at the host platform via an integrated power and control umbilical. The systems are operated through subsea control modules and the control system communicates with the subsea equipment through high-speed fiber.

The subsea pumps started continuous operation in 2016 to maintain desired production. Based on this success and numerous other deployments of subsea boosting technology, new development activities have been kicked off to expand the technology envelope.

Additional development phases

A second stage development planned for Jack and St. Malo call for drilling new wells and supporting infrastructure. Over the project's 30-year lifetime it is expected that the preferred artificial lift method will change. An expanded design of the subsea boosting system has already been developed. Initially single-phase fluids will be produced through the pumps as the inlet pressure to the pump system will be above the bubble point pressure. As the reservoir pressure depletes, it is anticipated that the pump system will be operating below the bubble point pressure, allowing for multiphase flow to enter the pump system; future connectors are in place as part of the initial design. These allow for installation of a multiphase pump upstream of the single-phase pump system for stage two, or alternatively, deployment of a high-boost multiphase pump.

Pushing boundaries of subsea boosting

Since the very first deployment of a subsea boosting system in 1994 in the North Sea Draugen field at 885ft with a tieback of 3.7mi, the technical boundaries for subsea boosting have been extended, making remote deepwater assets economically viable. Based on market demand and the increasing complexity trend associated with undeveloped reservoirs, extensive qualification programs have been in place for subsea pumping systems, and experience has taken subsea boosting technology into harsher, more challenging environments.

Subsea boosting at the seabed enables the wells to produce at a lower WHP, which in turn increases production rates from the wells. In the case of the Jack and St. Malo fields, the reduction in pump inlet pressure, as well as the increase in pump discharge pressure, is generated by the single-phase pumps using centrifugal impellers. Now online, the pumps are expected to boost production rates from these two fields for the next 30 years.

New subsea boosting technology development activities now being implemented based on successful implementation of the technology include higher differential pressures as well as design pressures and smart auxiliary solutions. An example of such boundary expansions for subsea boosting also include the first 15,000psi system to be installed in the GOM Stones field at a water depth of 9500ft.

Emphasis is being placed on maintaining compact design and reliability of subsea boosting systems while applying proven technology components to keep solutions cost efficient, as being witnessed by Chevron in their first implementation of subsea boosting technology to accelerate longevity in the Jack and St. Malo fields.

The inherent benefits of subsea boosting systems for field developments, and in particular subsea tiebacks, represent significant upside compared to conventional developments, based on accelerated and improved recovery in addition to reduced investment costs as important parameters. OE

Reference

This paper, OTC 27800-MS: Qualification and Deployment of the World's First High Pressure Subsea Boosting System for the Jack/St. Malo Field Development, originally appeared at the Offshore Technology Conference held in Houston, Texas, USA, 1–4 May 2017.

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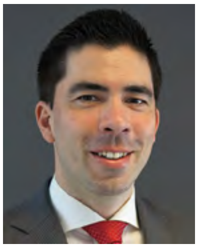
Daniel Broussard *holds a BS and MS in mechanical engineering from Texas A&M University, and currently works a Subsea Pump Engineer for Chevron. Working for both Texaco and Chevron since 1991, Daniel has served as technical lead engineer in multiple multiphase pump field deployments to enhance reservoir recovery at field locations in the Gulf of Mexico, Trinidad and Venezuela.*



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