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Subsea processing offers advantages

Processing of produced fluids is a way of life in the oil and gas industry. Offshore, the seabed is looking better each day.

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Advancements in technology are making subsea boosting and processing a viable option using "wet" equipment located on the seafloor.

Subsea processing applications have increased rapidly in recent years, primarily due to higher commodity prices. Because subsea oil pressure boosting is a relatively simple yet high-return technology that increases production and recovery, it remains the most economic and common type of subsea processing. Boosting and other subsea processing technologies are being expanded to meet global needs.

Subsea boosting yields profits

Projects using subsea boosting occur in water depths from shallow water at approximately 500 ft (152 m) to ultra-deep water at more than 5,000 ft (1,524 m). Subsea pressure boosting reduces backpressure on wells, which provides several benefits:

- Enabling light oil production in ultra-deep water;
- Enabling deep and heavy oil production;
- Increasing ultimate recovery and reducing flow assurance costs; and
- Accelerating recovery and revenue.

Moderate-depth light oil wells often are economic without artificial lift. However, subsea boosting can add to ultimate recovery and can be an economic enabler for greater water depth and more viscous fluids.

Subsea oil boosting is proven in moderate water depths to approximately 3,000 ft (915 m) using seafloor pumps and up to 8,000 ft (2,439 m) with electrical submersible pumps (ESPs) in caisson systems. Boosting is planned in deepwater and ultra-deepwater projects beyond the water depths for existing seafloor boosting applications.

When seafloor pressure boosting methods can meet lifting requirements, they are more cost-efficient than subsea downhole methods due to lower intervention costs, more economical higher-power motors and pumps, lower power distribution costs, and ability to use a single boosting station for multiple wells.

Reported subsea oil boosting methods

Six subsea pressure boosting methods have been deployed to date.

ESP/caisson systems are installed in a dummy well or caisson on the seafloor. The caisson also can be used as a gas/liquid separator to accommodate oils with high gas content. In 2009 to 2010, two major projects were installed – one in Brazil (subsea with and without gas/liquid separation) and in ultra-deep Gulf of Mexico (GoM), directly beneath a vertical riser with gas liquid separation.

Challenges of the technology are the limited pump power available for ESPs and a relatively high intervention cost and time for subsea systems. ESPs also are inefficient for heavier oils. Limited horsepower results in more pumps, umbilicals, and risers for a given application, considerably driving up costs compared to a higher-powered seafloor boosting system.

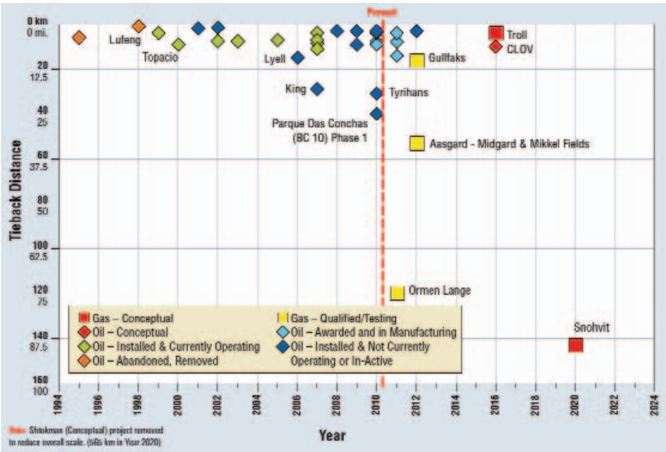
Helicoaxial multiphase pumps are rotodynamic pumps capable of boosting lighter oils at relatively high gas volume fractions, with boosting capability up to approximately 1,000 psi. It is limited in boost and liquid throughput primarily due to the maximum tolerable gas volume fraction. Compared to ESPs, larger motors are practical, intervention is simpler, and costs are relatively lower. Consequently, both capital and operating costs are lower compared to an ESP/caisson system for larger applications. Ten projects have been implemented using helicoaxial technology and several more have been announced.

Hybrid helicoaxial/centrifugal pumps are partial multiphase solutions. They can handle moderate amounts of gas at the pump suction. Several helicoaxial stages are used at the suction to boost the pressure sufficiently to drive most of the gas into solution followed by conventional centrifugal stages. These can achieve a higher efficiency and potentially higher boost than helicoaxial multiphase pumps. A hybrid pump has been qualified and manufactured for the first commercial application in a pumping/separation project in West Africa.

Positive displacement twin screw pumps are capable of boosting heavy oils efficiently but are less efficient with light oils. Boosting capability currently is limited to approximately 1,000 psi. The pump can operate with very high gas volume fraction. Several twin screw pumps have been installed and operated subsea, with one additional unit recently installed and pending operation.

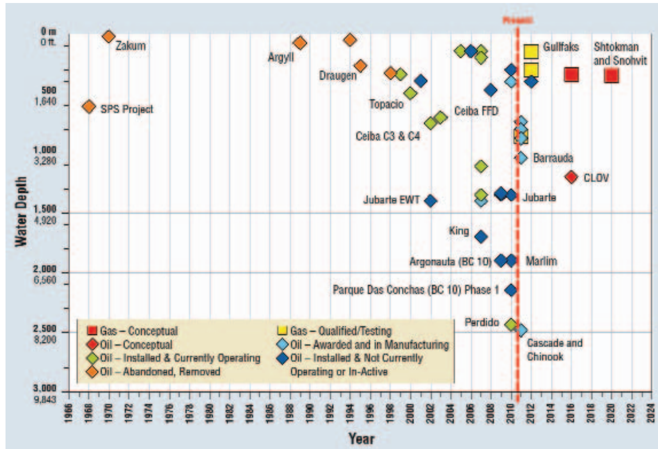
Horizontal (seafloor) ESP systems are intended for a low gas/oil ratio and use two pumps in series. One horizontal (seafloor) ESP system has been installed in the GoM and currently is being commissioned.

Tieback distance vs. time



Subsea processing projects are displayed chronologically by tieback distance to the production facility. (Charts courtesy of INTECSEA)

Water depth vs. time



Subsea processing projects are displayed chronologically according to water depth.

Improved capabilities needed

Based on the potential applications and technology limitations of available solutions, it is desirable to achieve the boost and gas tolerance of the ESP/caisson along with the high power and low intervention cost of seafloor multiphase pump technology.

General directions for improved subsea oil boosting technology are increased boosting capability and power for seafloor pumps and bulk gas separation upstream of a gas-tolerant pump to avoid loss in volumetric efficiency at low suction pressure or high gas-oil ratios.

Together, these measures enable the high volumetric efficiency and high boost of an ESP/caisson system while achieving the economies of scale available for seafloor pumps.

A seafloor system with adequate boost for ultra-deep water and gas/liquids separation to improve efficiency by pumping primarily liquid phase with a high boost is ideal.

Pumps used in conjunction with seafloor separation will require significant gas tolerance because the liquid discharged from a seafloor separator is at saturation pressure. The head provided from a seafloor separator generally will be lower than is required to prevent gas breakout at the pump suction for conventional centrifugal pumps. In addition, a seafloor separator can be expected to have some gas undercarry in transient conditions.

Bulk subsea water separation, re-injection can boost production

Bulk subsea water separation and re-injection can be used to relieve the topsides water processing capacity where topside water handling is a bottleneck, enabling additional production to an existing host. Because topside debottlenecking is possible for many hosts, subsea water separation has selected applicability. To date, two systems have been installed and operated in the North Sea, with one pending in Brazil. One system includes solids handling components for separated water.

Electrostatic coalescers using a subsea-compatible design have been tested in topside facilities to increase separation efficiency for difficult emulsions. Oil/water separators for deep and ultra-deep water remain a technical and economic challenge.

Subsea water, gas injection looks promising

Three subsea water injection systems have been built or installed. These systems use proven subsea centrifugal injection pumps, redesigned versions of solids filtering components that have been proven in topside applications, and chemical injection support or disposal.

Subsea raw seawater injection can be used to debottleneck topside facilities where additional topside injection capacity cannot be accommodated, but has limited applicability to situations where topside water injection is not feasible due to higher cost and lower water quality than for topside systems.

Subsea gas systems work well under specific conditions

Subsea gas compression competes with onshore compression for shorter offsets and floating compression for longer offsets. Economies of scale and high power delivery costs favor large fields at moderately long offsets. At shorter offsets, subsea compression can add value where liquid holdup is substantial and topside compression is not consequently effective. A large and complex dry subsea gas compression application is under development for a long-offset project. Wet gas compression has been selected for a shorter-offset project and currently is in qualification testing. Complexity and cost are roughly comparable to multiphase pumping.

Driven by the need to improve recovery rates, subsea processing capabilities will continue to advance. However, straightforward single or multiphase subsea boosting will be the simplest and most economically favorable application. Larger projects favor subsea processing applications due to significant economies of scale. E&P