Offshore®

Reviewing trends in subsea processing

Increased recovery with small topsides among the benefits

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Subsea processing has significant potential to increase reserves and production – and also reduce cost – by moving some of the traditional topsides fluid processing to the seabed. Subsea separation and local re-injection of produced water and/or gas to the reservoir can allow processing equipment to be used more efficiently. Subsea processing has many value-added applications that can address many offshore challenges – including boosting, separation, water injection, and gas compression. Typically, two or more applications are at work simultaneously.

Subsea gas/liquid separation and liquid boosting can increase reserves recovery and production rate in low-energy reservoirs. The technology may be applied to mature brownfield or new greenfield applications. Brownfield use usually is indicated by lower reservoir pressure and increased water-cut in later field life, as seen in Tordis and Marlim. Greenfield applications have been installed to overcome low initial reservoir pressure as well as weak reservoir and fluid properties, which often result in poor inflow with uneconomic production rates.

The first step into traditional subsea processing was pumping. Initial projects reduced back pressure on the reservoir by using a subsea pumping system. Soon, the trend moved from pumping alone to include separation and pumping. Gas and liquids were separated subsea, with the liquids pumped and the gas flowing naturally to surface in order to lower back pressures and maximize efficiency. These activities – called primary separation – soon evolved into secondary separation in which produced water was cleaned and then injected back into a reservoir. Continuing the trend, gas compression also became a value-added step during subsea processing by compressing the gas on the sea floor to reduce back pressure on the reservoir and prevent slugging.

Subsea processing techniques clearly have increased in sophistication over the years. In the early days, most companies thought of subsea processing as a form of artificial lift for subsea field developments. It was considered a brownfield activity, as evident by the early pumping systems being deployed only in late-life fields. Today, the techniques are used in both brownfield and greenfield developments.

Consider Petrobras' Marlim project. It will be the world's first pilot system for deepwater subsea separation of heavy oil and water that includes reinjection of water to boost production in a mature field development. The system aim is to increase production using the same topside facilities or, potentially, to replace the topsides all together.

Field architecture may be reconfigured to include more subsea separation to address existing wells. This enhances field production life without adding different topside facilities, and thereby improves revenue with the existing wells and floating units.

InLine ElectroCoalescer.

Subsea processing has become more refined, and that opens up new possibilities for some brownfields. Future field development could benefit from subsea separation technology as it enables a smaller topside processing facility which saves production platform cost.

Additionally, subsea processing in greenfield projects may be the key to an operator's economics from project start up. Lower Tertiary fields in the Gulf of Mexico, where oil is a little heavier and reservoir rock a little poorer, have benefited from separation and pumping systems installed when the field initially came onstream. These options are integrated as part of the field development plan. Having the systems in place at first oil may help the operator maintain production at a higher level for a longer period.

In remote or harsh regions, field development options using surface facilities may be limited. In these instances, as subsea processing technologies become more sophisticated, it is more likely to see full field development done subsea. For example, operators may not have the option to construct a surface facility while working in the Arctic.

Multi-phase desander.

In the future, there will be an alternative to traditional surface facilities.

Increasing production

A declining reservoir typically suffers from a reduction in pressure and an increase in water-cut. Through multi-phase pumping or gas/liquid separation and pumping, back pressure on the well and reservoir can lowered and boost capability increased. It "debottlenecks" host gas compression to allow gas to arrive at a higher pressure, thereby placing less load on the facility compressors. Water is then separated and re-injected into the reservoir for pressure maintenance, to boost hydrocarbon.

Subsea processing also can help reach longer tieback distances. High back pressure, flow assurance, and stranded hydrocarbons may be addressed by boosting. The capex for each incremental barrel is typically in the $10/bbl range. Boosting removes 500 to 1,500 psi (3.45 to 10.34 MPa) of back pressure and typically results in an additional five to 15% recovery of hydrocarbons over the life of the field.

Another trend in subsea processing is its use in the development of Lower Tertiary production. Several factors contribute to the challenges in these regions, including water depth, high initial pressure, lower reservoir quality, and undersaturated crude which combine to cause a low natural flow rate. This often couples with long tiebacks due to the location of the reservoirs and limited drilling offsets. Subsea pumping may enable these fields to become economic despite low production rates generated by the natural flow. Subsea boosting typically enables an incremental addition of 2,500 – 7,500 b/d per well. Fewer wells are needed to reach the plateau rate.

Additionally, subsea processing improves ultimate recovery in greenfields where production might be constrained by rising operating costs or operation problems such as flowline and riser slugging. There are cases in which the plateau rate can be doubled through the use of subsea processing. The improvement in field economics is obvious.

New developments

There are several solutions for compact separation that are designed specifically according to pipe code, which is of particular interest in ultra-deepwater. Whether for liquid/liquid, gas/liquid, or solid separation, the equipment can be combined to suit all conditions and separation requirements. These inline solutions are based on cyclonic technology.

The challenges for liquid/liquid conditions vary. Heavy oil applications require compact, efficient solutions. Many upstream processes do not meet target separation performance. Subsea requires separation efficiency for long-distance transportation of oil. Some oil fields require an electrostatic coalescer suitable for subsea application.

Electrostatic coalescers physically change the droplet size distribution of the water inside the oil phase. Increasing water droplet size allows faster and better separation of the oil and water phases, whether gravity or cyclonic separation is used.

The key is equipment that has higher coalescence efficiency but less power consumption in a more compact package. As a solution, FMC and its CDS Separation Systems subsidiary developed a highly efficient InLine ElectroCoalescer (IEC) that fits into a pipe spool. This IEC can be placed on the inlet, oil outlet nozzles of separators, or at certain locations in pipelines to enhance water/oil separation. The hardware also is fabricated to standard piping codes.

As for maintenance, there will be no need to shut in production during inspection of the IEC as it can be bypassed easily. One 12-in. IEC system can treat as much as 80,000 b/d of liquid.

Testing currently is under way with different crude oils to observe the electrocoalescence effect on water droplets. Since typical specification for crude oil sold to refineries is less than 0.5% basic sediment and water (BS&W), it is important to remove as much water as possible to get the highest revenue.

Another trend in subsea processing is sand handling. For instance, FMC and CDS have designed an InLine DeSander for multiphase streams containing sand, water, oil, and gas. This is the first cyclonic desander used in a subsea separation system.

The Petrobras Marlim subsea separation pilot system is the most complex subsea processing project to date. Water is separated from the well stream and re-injected into the reservoir. The system delivers less water to the topside to allow the processing of more oil in the floating unit. Separating and injecting water subsea improves flow rate to topside facilities, which increases well production. Water injection helps pressurize the reservoir, which also improves oil production. This is the first pilot to address all of these operational benefits while handling heavy oil in deepwater.

The inline desander removes most of the sand from the multi-phase well stream which helps avoid sand accumulation and erosion in downstream separation equipment and pumps. The system contains two InLine DeSanders. The one on the water outlet of the separator removes solid particles in the water stream from the separator to protect the hydrocylones, reinjection pump, and the reservoir. The separated sand is combined with the oil and routed to the topside facility.

Additionally, with several oil and gas operators around the globe reporting increasing sand production in gas fields, FMC and CDS developed an InLine Gas DeSander. Sand carried in the gas stream at high velocities causes severe erosion. Existing gas desanding technologies are limited in performance and control as well as in practical and logistical considerations such as bulky size. The InLine Gas DeSander design is free of the above limitations. The InLine Gas DeSander solves several issues, such as protecting flexible gas risers used for LNG production, choke valves, and separation equipment.

InLine products can be combined to suit all conditions and separation requirements. The efficient, compact separators achieve complete line phase separation using pipe segments, replacing conventional technology that requires several large vessels to do the same job.