

Separation goes supersonic

Efficient separation from multiphase wells offers economic and environmental advantages.

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Upgrades in cyclonic separation improved performance on the Shell-operated B11 platform offshore Sarawak on the Malaysian portion of the island of Borneo.

Twister BV, launched in April 2001, installed its first commercial Supersonic Gas Conditioning Unit on the platform in December 2003. That first unit consists of 12 tubes dehydrating up to 600 MMcf/d of sour gas on the platform.

The tube

The tube is the heart of the system that combines adiabatic cooling, in which no heat enters or leaves the system, with cyclonic separation in a single, compact device.

Adiabatic cooling is accomplished through a Laval nozzle — an aerodynamically shaped venturi tube — which achieves an isentropic expansion efficiency of more than 80%. The swirling motion is generated by a fixed static vane ring at the entrance of the Laval nozzle. The swirl strength increases strongly due to the contraction in the nozzle, resulting in a centrifugal field of around 500,000 g. The fine dispersed liquids formed during the adiabatic expansion and cooling are separated as a result of the centrifugal forces exerted by the strong swirling flow, and removed from the dry flow at minimum temperature and pressure with significantly high separation efficiency. At the point where liquid/gas separation takes place, the total fluid velocity is around 1,312 ft/second (400 m/second) resulting in a maximum gas residence time inside the tube of less than 2 milliseconds. The remaining kinetic energy in the separated flows within the tube is transformed to increased static pressure in the diffuser sections.

The design incorporates an inner body

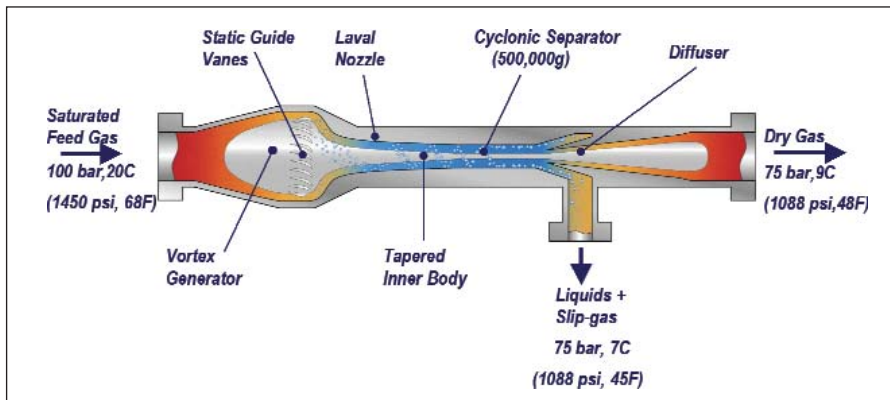


Figure 1. A cross-section view of the tube shows separation elements. (All graphics courtesy of Twister BV)

which allows the principle of conservation of angular momentum to be harnessed. Computational fluid design (CFD) models confirm that the induced centrifugal force is greatly increased with this design. The inner body also ensures that the vortex is concentric ensuring high separation efficiency. This results in a more stable flow and reduces the risk of liquid entrainment to the primary dry gas outlet. The separator has no rotating parts and does not require the use of hydrate inhibiting chemicals even when operated in the hydrate forming regime due to the extremely short gas residence time within the tube. It enables a simple processing facility with a high availability, suitable for normally unmanned operation.

Since 1998, the company has obtained extensive full-scale experience with pilot installations in three different gas plants, one in the Netherlands, one in Nigeria and one in Norway as well as with almost four years of commercial operation on the Sarawak Shell Berhad (SSB) B11 platform. With more than 50,000 accumulated total system running hours to date, these units have proved the viability of the system's gas conditioning to typical pipeline specifications, as well as reliable and safe operation.

Commercial operation

Petronas and SSB successfully started up the first commercial system on the B11 offshore gas processing facility in

December 2003 to dehydrate up to 600 MMscfd of non-associated sour gas fed to the onshore Malaysian liquefied natural gas plant at Bintulu, Sarawak, to control pipeline corrosion. The dehydration system on B11 has exceeded the guaranteed 98% availability. The system has two 60% parallel dehydration trains each comprising six tubes mounted vertically around a hydrate separator (low temperature liquid degassing vessel). The hydrate separator is a proprietary company design, based on conventional LTX technology, which uses heating coils to melt hydrates and which has a liquid removal efficiency of more than 98%. The produced hydrocarbon condensate is separately dehydrated and recombined with the export gas. Produced water is disposed offshore after treatment.

The operation of the system in a commercial green field environment provided the opportunity to fully evaluate its performance under actual working conditions. The experience gained on the B11 facility has been invaluable and has instigated significant further development improvements including the decision to modify the design to further reduce the required pressure drop. This decision resulted from the fact that the well-head pressure was declining faster than expected due to unexpected reservoir characteristics, which drives the need to reduce the back pressure on the wells in order to



Figure 2. The 300 MMcf/d module on the B11 platform has operated with no downtime for 4 years.

extend the B11 production capacity. For this reason, during 2004, SSB asked the company to develop a reduced pressure drop tube system which will allow SSB to operate longer at a lower nominal inlet pressure.

Upgrade development

The company upgraded the design using proprietary CFD modelling expertise, and tested the prototype at the Gasunie Engineering & Technology (GET) test facilities in Groningen in the Netherlands. Four prototypes were tested during 2006. The results confirmed:

- C5+ removal as predicted by CFD models;
- Water recovery as predicted by CFD models;
- Stable supersonic operation;
- Reduction of pressure drop from 33% to 25%;
- Liquid separation efficiency over 95% at a 45% pressure drop; and
- Performance of the tube not affected by liquid carryover from the inlet separator and is tolerant of condensate/gas ratio variations of up to +/- 25%.

The hydrocarbon recovery of components C1 to C12 measured during the closed loop testing were compared with

calculated values using simulation software and showed good correlation with the predicted results specifically exhibiting an excellent natural gas liquids (NGL) recovery performance. These results further validated the CFD design of the upgraded system. Further testing confirmed that a higher pressure drop across the tube further increased the liquid recovery.

The upgraded system was tested on the SSB B11 facility between April and August 2007. The tube operated at inlet pressures of up to 145 bar and successfully removed approximately three times more liquids than the originally installed units at the same pressure drop. Noise levels were lower than for the original tube design. The primary tube outlet exhibited a water content 30% below that of the original tube design. The water content was measured at around 10% below the SSB target confirming that the upgrade will meet the B11 design water export specification with a 25% lower pressure drop.

Market uptake

The technology makes commercial sense not only due to the reduced life cycle costs (LCC), but also due to the potential to increase revenues via simul-

taneous dewpointing and enhanced NGL recovery performance. Examples include use on smaller offshore platforms and reduced overall project cost. The lack of moving parts permits operation on de-manned (or not normally manned facilities) and hence enables significant operating cost savings. Finally, chemical-free processing means lower operating cost and reduced logistical problems.

Flexibility is another attribute. The system provides on-demand gas delivery and is considerably easier to operate than conventional tri-ethylene glycol (TEG) systems, avoiding typical TEG equilibrium (ramp up/ramp down) delays. The systems can be scaled up to handle increasing gas flow rates by simply adding additional tubes and/or modules. The system is not constrained by operating pressure and can be optimized for either dehydration and hydrocarbon dewpointing applications at minimum pressure drop or for NGL recovery applications at higher pressure drops. Finally, it can simultaneously dehydrate, dewpoint and recover NGL, thus reducing the equipment required to meet the gas specifications.

Operation feedback to date has demonstrated zero downtime, which means fewer spares and lower capital expenditures.

Twister technology has been selected, or is being considered, for a significant number of new project applications. Current market project activity includes:

Nigeria

A firm contract has been secured from Shell Petroleum Development Company (SPDC) for an onshore 120 MMscfd fuel gas conditioning application at the new Okoloma Gas Processing facility in Nigeria supplying gas to the SPDC-owned and operated 970 MW Afam VI Power Plant. The separation technology company is supplying a single module containing a hydrate separator, six tubes and associated valves, piping, instrumentation and control. It will be commissioned in early 2008.

This system offers:

- **Commercial advantage.** No gas-gas



Figure 3. Petrobras has commissioned the first subsea version of the cyclonic separation system.

heat exchanger required for inlet cooling by processing gas directly from the wellhead air-cooler and separator to fuel gas quality. The future addition of a gas-gas heat exchanger will further increase the commercial benefits by optimizing liquid petroleum gas extraction.

- **Operational advantage.** Removal of both the need for chemical purchase and associated logistical supply problems, plus reduced maintenance due to no moving parts.
- **Environmental advantage.** Chemical-free operation to meet water and hydrocarbon dewpoint specifications resulting in zero emissions.

Brazil

An agreement has been signed with Petrobras to enter into a technology development co-operation to design and test a system suitable for sub-sea applications. The first phase of this agreement involves the Petrobras purchase of a unit for an onshore plant which is expected to come into operation during 2008. The gas processing module will be used for dehydrating and dewpointing offshore gas before it is delivered as sales gas. Petrobras has identified the **Canapu** field in the

Espirito Santo Basin as the preferred location for subsequent subsea testing of the subsea separation system. The subsea project is supported by a subsidy from the European Commission and it is expected that commercial subsea units will be available by 2015.

This system offers:

- **Commercial advantage.** Subsea gas processing will radically reduce offshore gas production costs.
- **Reliability.** Lack of moving parts enables maintenance-free operation.
- **No chemicals.** No (or considerably reduced) chemical consumption is an ideal fit for gas processing in subsea environments.

Australia

A front-end engineering and design (FEED) contract was awarded by Nexus Energy Pty Ltd for the potential application of Twister technology on its high pressure offshore **Crux** gas/condensate field, a recycle condensate recovery project.

This system offers:

- **Commercial advantage.** The ability to extract NGL at high pressure (>120 bar), proven high availability and lack of moving parts and chemical usage, allow reduced whole life cycle costs compared to conventional gas processing options.
- **Reliability.** High availability means reduced sparring costs and more compact design.
- **No chemicals.** Avoiding potential glycol contactor problems when operating at high pressures.
- **Environmentally friendly.** No emissions due to closed system and no chemicals.

Southeast Asia

A FEED contract has been awarded by a major Southeast Asian national oil company to replace a TEG dehydration system on an offshore platform.

This system offers:

- **Commercial advantage.** Reduced operating costs. Also increased oil export due to increased condensate extraction combined with simultaneous dehydration.

- **Reliability.** High availability means continuous pipeline protection.
- **Compact.** Easily fits into the available space on the existing platform.
- **Ease of operation.** Almost instant start-up avoiding extended ramp up/ramp down periods as typically experienced with glycol systems. Also supports unattended operation.
- **Environmental friendliness.** No emissions due to closed system and lack of chemical usage.

United Kingdom

The cyclonic separation system has been selected as the base-case gas processing technology for an underground gas storage (UGS) system which will be developed and operated by a United Kingdom company. This UGS will use brine displacement to remove the gas from storage which allows the system to be operated at constant pressure – an ideal application for this separation technology.

This application offers:

- **Commercial advantage.** Lower life cycle costs than conventional technologies such as TEG or silica gel systems due to the lower energy requirements.
- **Operational flexibility.** On demand delivery allows increased gas sales at higher spot market prices.
- **Reliability.** High availability and reduced sparring.
- **Environmental friendliness.** No chemicals and reduced emissions.

Based on the current performance, the upgraded technology can be applied for more stringent gas processing specifications, where water dew point suppressions of more than 76°F (25°C) are required. Closed loop and offshore site testing has confirmed that the improved performance can, in addition to achieving chemical-free dehydration at a lower pressure drop without the use of moving parts, also demonstrate a significantly improved hydrocarbon dewpointing and NGL recovery performance at higher pressure drops. The improved NGL recovery enables a significant revenue stream which allows early payback of the capital expenditure. **ENP**