

Sour Gas Production – The benefits of chemical free processing

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ABSTRACT

Today up to a third of the world's natural gas reserves contain high concentrations of sour gas, with the Middle East a region where such fields are prevalent. In the United Arab Emirates (UAE), for example, which holds the world's fifth largest gas reserves - approximately 214 trillion cubic feet – a large proportion is sour.

Yet sour gas and its extraction and processing come with significant challenges. H₂S in the gas stream is highly toxic with significant HSE implications, the dangers of toxic gas releases or leaks; and threats to both production and transportation infrastructure, with H₂S's highly corrosive nature requiring special handling. The corrosive nature of sour gas fields and processing and separation challenges has subsequently led to pressures on existing technologies and infrastructures. For example, fully manned glycol-based or amine gas treating production platforms come with the dangers of the potential venting of toxic H₂S, contamination of the glycol regenerator with H₂S, high H₂S gas inventories, intensive personnel and maintenance requirements, and logistical and safety challenges in operating from remote offshore locations.

The widespread use of chemicals also bring with it downstream operating challenges which negatively impacts plant reliability and availability. In the area of sour gas dehydration and dewpointing, the Twister proprietary gas-processing technology provides a reliable, low-maintenance alternative to chemical-based technologies, providing safety, sustainability and economic benefits. First commercially applied in 2003, the Twister Supersonic Separator technology has been successfully dehydrating sour gas on the PETRONAS operated B11 production platform in Malaysia producing 600 million standard cubic feet per day.

This paper will explain in more detail the challenges of chemical use in sour gas production and how the application of Twister technology can mitigate these challenges.

1. INTRODUCTION - KEY CHALLENGES

Sour petroleum and gas resources have always posed special problems for operators. If in the past, a highly sour resource (containing several mole% or more of H₂S in the associated gas) might have been considered unattractive for development relative to other assets, today operators are developing fields containing as much as 30% H₂S. The interest for these resources reflects several intersecting trends, including the diminishing availability of easy-to-produce conventional hydrocarbon resources, increased natural gas (NG) prices in North America, and the opening of Russia, Central Asia and the Middle East to international operators. Their sour petroleum resources, in fact, have historically characterized these geographical regions and international oil and gas companies must be ready to face the challenges of highly sour production in exchange for the opportunity to operate in these rich petroleum provinces. Hence, the development of sour oil and gas resources is rapidly emerging as a major industrial and technological theme.

Processing sour gas is characterised by the following key challenges:

- **Safety** - Due to its high toxicity, H₂S requires special operating procedures to ensure worker safety during drilling and in production operations. The chemicals involved traditionally in gas processing pose additional risks in handling.
- **Economics** - Removing H₂S in excess of the required specifications is one of the most expensive aspects of the treatment of gas streams requiring additional large installations. Specifically in an offshore environment, this dramatically increases project costs.
- **Sustainability** - Fully manned glycol-based or amine gas treating production platforms come with the dangers of the potential venting of toxic H₂S, contamination of the glycol regenerator with H₂S, and high H₂S gas inventories.
- **Flexibility** - Varying levels of H₂S require constant monitoring and adjustment and could require different technologies depending on H₂S and CO₂ content for an optimum gas treatment. Traditional chemical-based systems will often come with start-up and shut down delays. Contaminants such as salts, lube oil, condensate, crude oil and corrosion products are present in abundance in liquid phase and in minute “trace” amount in the gas. They continually plague operators in their glycol systems, and the symptoms of these problems are fouled equipment, foaming in the system resulting in expensive glycol losses, and insufficient process capability [1]. Shutting a plant down to thoroughly clean and repair all the equipment is a periodic necessity and very expensive.

Twister addresses these key challenges as follows;

2. SAFETY

The Twister technology combines dehydration and dewpointing in a closed loop system. This reduces HSE vulnerabilities, minimizes flaring and gas release, and brings an end to the risks from glycol-based systems, such as toxic H₂S contamination and high H₂S gas inventories.

The Twister Supersonic Separator (see Figure 1) is classified as piping due to its small volume and contains no moving parts. The result is that personnel numbers can be

brought down by as much as 50% and the inherent reliability of Twister's solutions can reduce operator intervention by 75%. The Twister Supersonic Separator is a combination of known physical processes, aerodynamics, thermodynamics and fluid dynamics that produce a robust and compact gas conditioning process. When the Twister Supersonic Gas Technology is combined with the patented Twister Hydrate Separator - used to separate hydrates and liquids from natural gas without using chemicals - the result is low maintenance, a low sour hydrocarbon inventory and reduced equipment count.

Unlike traditional glycol-based systems that often come with start-up and shut down delays, the chemical-free, fully automated Twister supersonic separation technology delivers on-demand gas almost immediately. Twister's light-weight, flexible gas processing solutions can be scaled up to handle varying gas flow rates unconstrained by operating pressure and can be optimized for a broad variety of applications from dehydration and hydrocarbon dewpointing applications through to NGL recovery applications at higher pressure drops.

First commercially applied in 2003, the Twister Supersonic Separator technology has been successfully dehydrating sour gas with up to 3500 ppm/v H₂S and 20 mole% CO₂ on the PETRONAS operated B-11 600 MMSCFD production platform in Malaysia [2].

The Twister Supersonic Separator is static equipment integrating expansion cooling and separation in a single device. The Twister process uses free pressure drop for cooling and separation. A schematic of the working principle is provided in Figure 1 below.

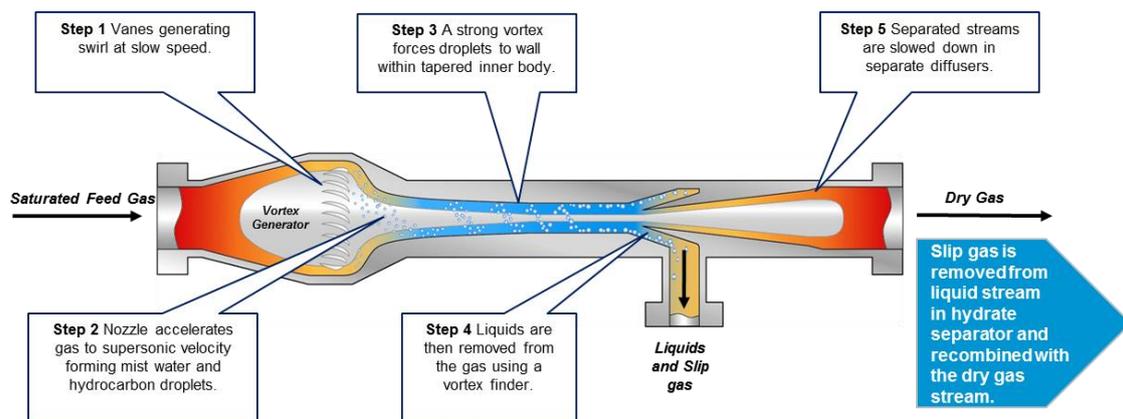


Figure 1: The Twister Supersonic Separator

A near isentropic expansion is achieved in a slender nozzle duct (Laval type) accelerating the gas to typically 500 m/s resulting in a rapid reduction in pressure and temperature. During this rapid expansion cooling process, saturated gas components start to form droplets which are separated by cyclonic principles. The liquid droplets are collected in the outer perimeter of the nozzle duct and separated by a simple co-axial tube operating at minimum pressure and temperature. After separation has been completed, both the dry gas stream and liquid enriched stream are recompressed in diffuser ducts which decelerate the flow from 500 m/s to pipeline velocity. During this deceleration and recompression, the pressure rises, rendering an overall pressure loss of typically 25-45% depending on the application and gas specifications required. The complete Twister separation process as described above takes < 5 milliseconds.

The liquid enriched stream produced by the Twister Supersonic Separator is fed to a Mono-Cyclone separator which is designed to separate gas hydrates. This so called Hydrate Separator is protected with heating loops to warrant that the internal surface temperatures are well above the Hydrate Formation Temperature.

3. ECONOMICS

By combining the dehydration and dewpointing processing steps in one unit operation, the equipment count and subsequent weight and space can be reduced significantly on offshore structures. Twister is a strong advocate to reduce the number of operations and complexity on offshore facilities. When focussing offshore operations on mitigating flow assurance in subsea pipelines issues like hydrate formation, corrosion and slugging, the gas processing consists of dehydration and hydrocarbon dewpointing. This reduces the size of the offshore structure and hence CAPEX. More complex operations such as H₂S and CO₂ removal should ideally be conducted onshore, where space is not at a premium. Decreasing the complexity of offshore operations by applying compact technology enables application of remote operated platforms reducing CAPEX and OPEX even further. For a typical 600 MMSCFD gas processing plant, the Twister Supersonic Separator technology can save up to topside weight savings of between 30 and 60% and CAPEX savings of a similar percentage.

When operating in chemical-free dehydration and dewpointing mode, the Twister Supersonic Separator technology will not reduce the H₂S content of the export gas. As no free water is present in the export gas, the H₂S containing gas can be safely transported to onshore facilities for further processing. With chemical-free gas processing using Twister technology, dehydration can be down to a water content of 5 lbs/MMscf; Hydrocarbon dew pointing to 0 °C (Cricondentherm).

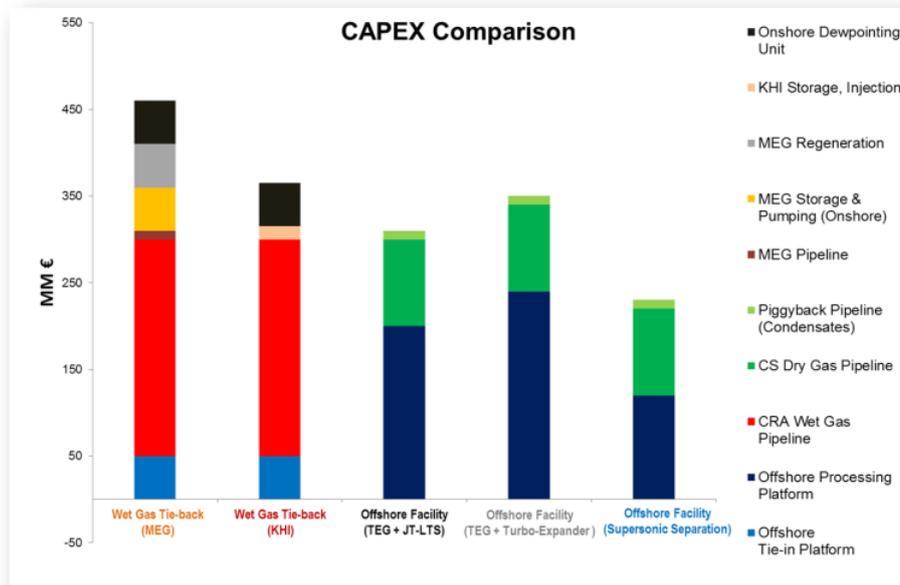


Figure 2: CAPEX comparison for a 600 MMSCFD offshore processing plant

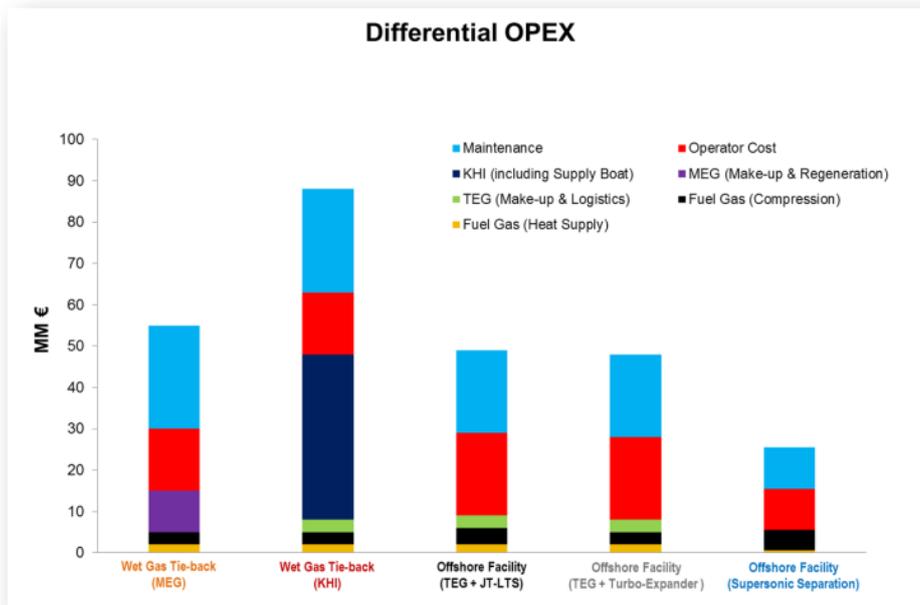


Figure 3: OPEX comparison for a 600 MMSCFD offshore processing plant



Figure 4: Up to 8 Twister Supersonic Separators can be connected to the Twister Hydrate Separator

4. SUSTAINABILITY

The gas processing industry has a long history of applying chemicals in all of its aspects. Typical chemicals applied are: corrosion inhibitors, Oxygen, CO₂, and H₂S scavengers, antifoamers, demulsifiers, dehydration agents, and antifreeze. Unfortunately, these chemicals can also cause severe problems. The problems can be generated from the products of decomposition, reaction, oxidation, and reduction of the chemicals in the systems. For instance, a corrosion inhibitor can turn into a corrosive material if it is hydrolyzed in brine to form acidic compounds such as inhibitors with sulfonic acid and phosphoric acid derivatives. A corrosion inhibitor can also be decomposed or polymerized. Most corrosion inhibitors can cause foaming and emulsion problems in the gas-liquid or liquid-liquid reflux and separation areas such as in separators, glycol and amine treaters, stabilizers, or distillation columns. The inhibitors, or other chemicals, can also be carried by gas or liquid hydrocarbons into treaters and dehydrators to shorten the service lives of desiccants (molecular sieves), glycols, alkanolamines and caustic, or filter components. Sometimes these problems become so severe that the systems need to be shut down or cleaned up. Products in the systems can be lost or damaged.

As the hydrate inhibition application is changing rapidly with substantial research and development, commercial application of low dosage hydrate inhibitors (LDHI) such as a Kinetic Hydrate Inhibitor (KHI) has seen an increase in use. This is due to the fact that the KHI offers in general significant CAPEX/OPEX advantages over traditional thermodynamic inhibitors. Nevertheless, various performance factors such as the hydrate structure, salt content and the presence of other chemicals might adversely affect the KHI performance. H₂S enhances hydrate formation and has a very strong tendency to form hydrates. This means that as the gas field gets sourer, wet gas production requires a higher dosage of corrosion inhibitors, which limits the performance of the KHI. Furthermore, as the gas becomes leaner and higher in H₂S and CO₂ content, it tends to predominantly form hydrates with structure I, which makes the application of KHI's more challenging as compared to gases with structure II hydrates. Concerns over the performance of KHIs, and in many cases their significant costs, are obstacles to their more widespread usage. In a paper at the 9th North American Conference on Multiphase Technology in 2014, Saudi Aramco discussed the challenges of qualifying a compatible KHI in the Karan sour gas field [3][1]. It is against this context of both safety and the need to make sour gas fields commercially viable that operators are looking to alternative gas separation and processing technologies.

A number of chemicals used are compounds that lower the surface tension (or interfacial tension) between two liquids, or between a gas and a liquid. This will severely hinder condensate water separation, or create smaller liquid droplets in two-phase separators, resulting in increased carry-over [1].



Figure 5: Clean condensate above water as sampled from the Twister Hydrate Separator

The most obvious solution to problems associated with interaction of chemicals with (sour) gas and condensate and with other chemicals, is removing the source of the issues. By applying a technology for gas dewpointing and dehydration based on physics instead of chemistry, a cascade of benefits arises.

5. FLEXIBILITY

Unlike traditional glycol-based systems that often come with start-up and shut down delays, Twister Supersonic technology delivers on-demand gas almost immediately. The Twister Supersonic technology's light-weight, flexible gas processing solution can be scaled up to handle varying gas flow rates unconstrained by operating pressure and can be optimized for a broad variety of applications from dehydration and hydrocarbon dewpointing applications through to NGL recovery applications at higher pressure drops.

The Twister Supersonic technology operation is not affected by variations in H₂S content. The H₂S content merely determines the material selection (through NACE standards) for the construction of the Twister Supersonic technology, as this will be working in a sour wet gas environment.

In order to enable chemical free dehydration, the inlet temperature of the Twister Supersonic technology is maintained above the hydrate formation temperature. This is in order to protect upstream equipment such as heat exchangers and separator vessels from hydrate induced flow assurance issues. Downstream of the Twister Supersonic technology the gas is dehydrated and can be safely transported to onshore facilities for further processing.

A basic flow scheme based on Twister Supersonic Separator technology is shown in Figure 6.

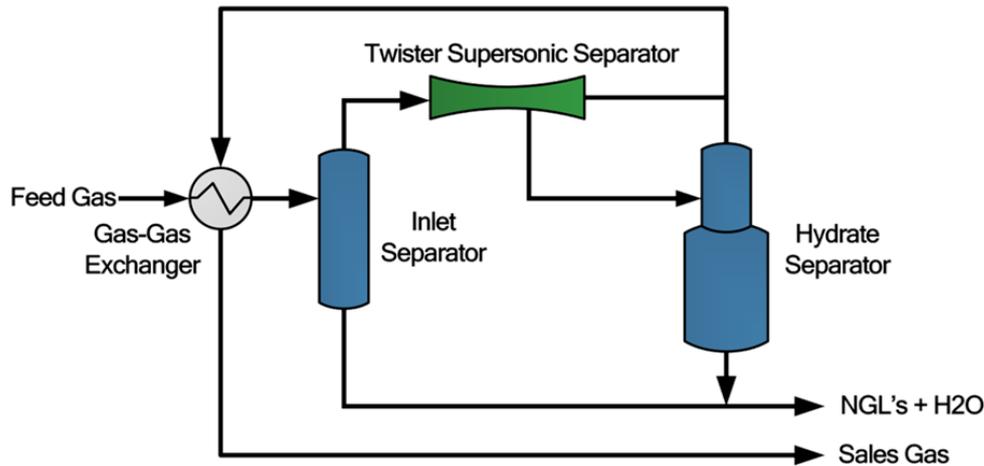


Figure 6: Twister Supersonic Technology - Typical flow scheme. Up to 8 Twister Supersonic Separators can be connected to a single Hydrate Separator providing turn-down capability.

6. OPERATIONAL EXPERIENCE

Since December 2003, Twister technology has been in continuous operation on a large offshore gas production platform in the South China Sea, near Sarawak, Malaysia. The B-11 field is located 160 km north of Bintulu Sarawak and has been developed to deliver gas to the MLNG facilities via the existing E-11 platform. The B-11 field was delivered under the MLNG-DUA Production Sharing Contract (50% Shell & 50% PETRONAS Carigali). It was the first sour gas development in the offshore region of Sarawak Malaysia and contains up to 3500 ppm/v H₂S and 20 mole% CO₂.

In 2000 the following field development concepts were considered:

- Option 1: Wellhead Platform and wet gas tie back to E-11 with 65 km 28" CRA pipeline and MEG inhibition
- Option 2: Production Platform based on TEG dehydration unit with 65 km 2-phase CS pipeline to E-11
- Option 3: Production Platform based Twister dehydration unit with 65 km 2-phase CS pipeline to E-11

A wet gas tie-back was discarded because of the additional sour gas treatment required to the existing sweet gas operations at the E-11 platforms and the high costs for a 65 km CRA pipeline. TEG dehydration being a fully manned operation (30 – 50 operators) was regarded a high safety risk in view of the high H₂S content. Therefore, an unmanned or normally not attended operation was highly desired. Also, operational risks associated with the solubility of H₂S in TEG caused concerns including:

- Treatment of H₂S rich tail gas stream evolving from the glycol regeneration pack
- Increased corrosion risk in the glycol re-boiler due to low pH of rich glycol.
- Degeneration of glycol by pH control and risk of foaming (high pH) or precipitation (low pH)

The envisaged risks associated with TEG sour gas dehydration, made the operator decide in 2001 to select the Twister Technology as the base case, based on the following premise:

- Safety : Closed system (no H₂S emissions); Minimum inventory.

- Operations : Normally unattended operation; Minimum LQ facility.
- Economics : Lowest CAPEX and lowest Life Cycle Cost (LCC); 25% topside weight saving.
- Simplicity : No glycol regeneration and associated operations.
- Availability : Guaranteed uptime of 98%.
- Flow assurance : Protection of 65 km CS pipeline (no free water).

The goal was to provide a safe gas processing solution with minimal environmental impact, while providing a significant reduction in capital and operational expenditure. 12 Twister Supersonic Gas separator units and 2 Hydrate Separators were provided with Twister and Shell Sarawak agreeing on a three-year Process Operation & Availability Guarantee (POAG).

Since the Twister option required a pressure drop of 35% at a nominal export pressure of 95 bar(g), a plateau pressure of 145 bar(g) was chosen, allowing for a plateau production of at least 500 MMSCFD for 5 years. Compared to TEG, Twister would bring compression investment forward from year 8 to year 6. However these 2 years difference in NPV did not outweigh the significant CAPEX an OPEX saving.

Following further development of the Twister technology, Sarawak Shell Berhad and joint venture partners Petronas supported field tests on the B-11 platform, offshore Sarawak. A second generation Twister Supersonic Separator system was installed alongside the existing Twister system in order to compare the performance of the two Twister generations. The outcome showed:

- Improved gas dehydration of about 50%, nearly halving the water content in the primary outlet stream.
- A good safety margin for the avoidance of hydrate formation in the cold piping system leading to the gas-gas heat exchangers
- A stable operation with minimal control requirements

This second generation Twister Supersonic Separator system is applied for all new applications.

Currently, the B-11 platform is operated by PETRONAS.

7. CONCLUSION

Twister technologies are particularly suited to sour gas fields the Twister Supersonic Separator is a robust, compact gas conditioning solution characterised by condensation and separation taking place at supersonic velocity; and the Twister Hydrate Separator isolates hydrates and liquids from natural gas without using chemicals by means of a heating coil and cyclonic separation which melts hydrates. The combination of the two technologies results in a closed system, low maintenance, a low sour hydrocarbon inventory and reduced equipment count. There is also no chemical degradation due to H₂S, no emissions and very limited operator intervention – always a significant benefit in sour gas fields. Furthermore, the fact that Twister's supersonic gas solution dehydrates gas on the basis of expansion cooling instead of glycol absorption, as well as being a closed system, means that it is the safest means of dehydrating and dewpointing sour gas on the market today. The reduced weight and plot space on offshore platforms

of the Twister Supersonic Separator and Twister Hydrate Separator also results in significant cost savings. There are also significant cost savings compared to Kinetic Hydrate Inhibitors, due to the removal of the need for a corrosion resistant alloy pipeline and the ongoing cost of KHI replacement.

The Twister Supersonic Separator technology was deployed on the Shell operated B11 600 MMSCFD production platform in Malaysia with higher than normal sour gas contaminant levels. The Twister technology was a key element of the overall sour gas management risk mitigation strategy and as a closed system, the Twister Supersonic technology provided an inherently safer system over traditional dehydration solutions.

8. REFERENCES

- [1] Notes MEG Regeneration Technical Meeting 18 June 2009, SPE, Port Campbell
- [2] *Ten Years of Twister Operations - Benefits Delivered*, Betting, M. , Prast, B., Proceedings of the GPA Europe Technical Meeting in Leiden, May 2014.
- [3] *The Challenges of Qualifying a Kinetic Hydrate Inhibitor for an Offshore Sour Lean Gas Field*, Rithauddeen, M.A.; Al-Adel, S., Proceedings of the 9th North American Conference on Multiphase Technology, 2014.