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SUPERSONIC GAS CONDITIONING - COMMERCIALISATION OF TWISTER™ TECHNOLOGY

Peter Schinkelshoek MSc Eng
Twister BV – Principal Process Engineer
Peter.Schinkelshoek@TwisterBV.com
Tel: +31 70 300 2256

Hugh D. Epsom BTech FIMechE
Twister BV - Sales Director
Hugh.Epsom@TwisterBV.com
Tel: +31 70 300 2207

Rijswijk, The Netherlands

ABSTRACT

Twister™ is a proven gas conditioning technology. Condensation and separation at supersonic velocity provides several unique benefits as the short residence time within the Twister tube prevents hydrate problems, thereby eliminating the use of chemicals and associated regeneration systems. The simplicity and reliability of this static device with no rotating parts, operating without chemicals, ensures a simple, environmentally friendly facility, with a high availability, suitable for de-manned operation.

The first commercial offshore Twister application on the Petronas/Sarawak Shell Berhad B11 facility offshore East Malaysia has now been in continuous operation, with more than 98% availability, for over four years. A complete Twister gas conditioning module has been supplied to Shell Nigeria for chemical-free fuel gas treatment for a gas turbine driven power plant and a contract has been signed with Petrobras for an onshore Twister system. These plants will be commissioned during Q1 and Q2 2008, respectively.

This paper presents an overview of how Twister supersonic technology is utilised to remove Natural Gas Liquids, including the results of two studies evaluating the performance of Twister against both a JT system and a turbo-expander for NGL recovery, together with initial development details for LPG extraction.

A brief introduction is also included regarding the development of Twister technology for H_2S removal.

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Twister Technology Description

The Twister™ Supersonic Separator has similar thermodynamics to a turbo-expander, combining expansion, cyclonic gas/liquid separation and re-compression in a compact, static, tubular device. A turbo-expander transforms pressure to shaft power; Twister achieves a similar temperature drop by transforming pressure to kinetic energy (i.e. supersonic velocity). The Twister process is a simple, safe, environmentally friendly, quick start up, gas conditioning system which enables chemical free, high availability and unmanned operation. The compact and lightweight Twister system allows the platform size to be reduced which results in an overall lower project cost for offshore applications. The ability to operate unmanned also facilitates significant operating cost savings in allowing the de-manning of offshore platforms. This gas conditioning technology can be used to simultaneously condense and separate water and hydrocarbons from natural gas. Significant potential has been identified for future application of Twister technology for various other gas processing applications including deep LPG extraction, bulk removal of CO_2 and H_2S, mercury removal and sub-sea gas processing. See figure 1 below for a cross-section view of a Twister tube.

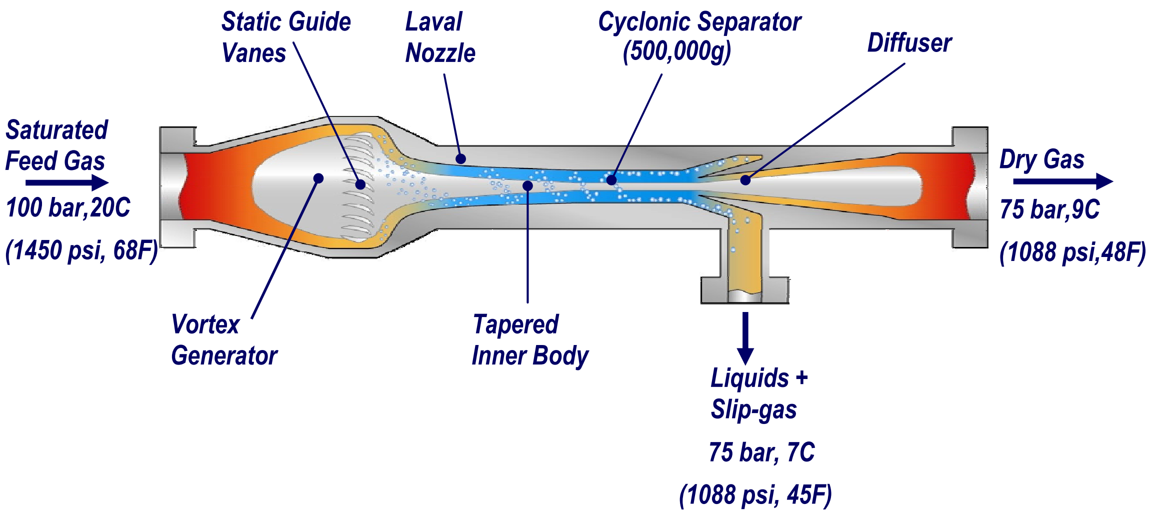

Figure 1 – Cross-section of Twister tube

Twister BV has now achieved over 50,000 hours operating experience on Twister systems which includes earlier pilot plants in the Netherlands, Nigeria and Norway, as well as over four years of continuous operation on the SSB B11 offshore gas processing facility. The Twister system dehydrates up to 600 MMscfd of non-associated sour gas which feeds the onshore Malaysian LNG plant at Bintulu, Sarawak, The 2004 GPA paper ***"Twister Supersonic Gas Conditioning – First commercial offshore experience"***, details this system.

The 2005 GPA ***"Supersonic Gas conditioning – Introduction of the Low Pressure Drop Twister"*** details the development and testing of the improved Twister tube. Since completing the development and testing on our 40 bar test-loop at the Gasunie facility, we have now also carried out a successful high pressure test of one new Twister tube on the B11 installation.

Twister vs. JT-LTS Studies

Twister expands much deeper into the phase envelope than a turbo-expander, and thus can recover significantly more NGL than a turbo-expander and JT system when no hydrate inhibition chemicals are used.

a) Onshore Gas Distribution System

A recent study looked at the performance and benefits of a Twister NGL recovery system compared to a turbo-expander and a Joule-Thomson (JT) system for an onshore domestic gas supply project. In this project associated gas is dehydrated at a central processing facility to 7 lb/MMSCF in a TEG contactor after which the majority of the gas is sent to an LNG liquefaction facility via a long-distance pipeline. The pipeline inlet pressure is 100 barg. The remainder of the gas is sent to the domestic gas grid, which operates at 60 barg. The available pressure drop is utilised to recover valuable NGL components from the gas, without using any hydrate inhibition chemicals. The recovered NGL are spiked back in the main gas export line and are then extracted at the gas pre-treatment section of the LNG plant.

The available pressure drop enables an expansion process without the use of a compressor. Whereas the hydrate formation temperature limits the operating temperature in the LTS for a turbo-expander and JT system, the hydrate formation temperature only limits the Twister system at the inlet of the Twister tube. Inside the Twister tube no hydrate formation takes place due to the very short residence time and hydrates in the secondary outlet of the Twister tube are managed in the Hydrate Separator™ using heat input. In other words, the minimum acceptable temperature in the LTS for a turbo-expander and JT system is more or less the same as the minimum acceptable temperature at the Twister tube inlet. Therefore Twister is able to expand much deeper into the phase envelope and recover significantly more NGL than a turbo-expander and JT system without the use of hydrate inhibition chemicals.

This study also showed that the Twister system has a similar simplicity, robustness and order of magnitude project CAPEX to the JT system, which results in a higher NPV.

b) Third Party Study

A new and independent study to compare the NGL recovery rate of Twister and a JT system has been conducted by Genesis Oil & Gas Ltd covering a wide range of water contents, gas compositions and operating conditions. See ***"Twister NGL Recovery Study"***, December 2007. The C3+ recovery rate has been presented in figure 2.

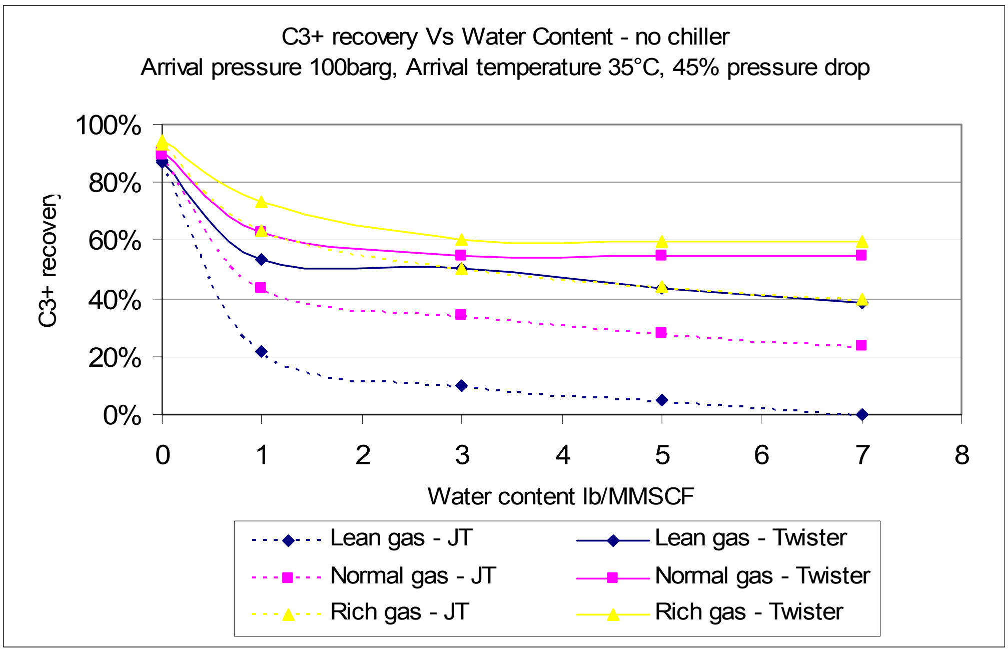

Figure 2: C3+ recovery as function of water content for Twister and JT-LTS

This study clearly shows that Twister recovers significantly more C3+ down to very low water contents. The JT system can only utilise the maximum possible heat integration, without hydrate formation in the LTS, at extremely low water contents, thus improving the C3+ recovery rate and approaching the Twister recovery. At these low water contents the Twister system may become limited by its heat integration, which means that the margin between the Twister inlet temperature and hydrate formation temperature is large. By applying an upstream chilled water and/or mechanical refrigeration system, the Twister inlet temperature can be again reduced to just above the hydrate formation temperature. As expected, this resulted in a further increase in the NGL recovery as presented in figure 3.

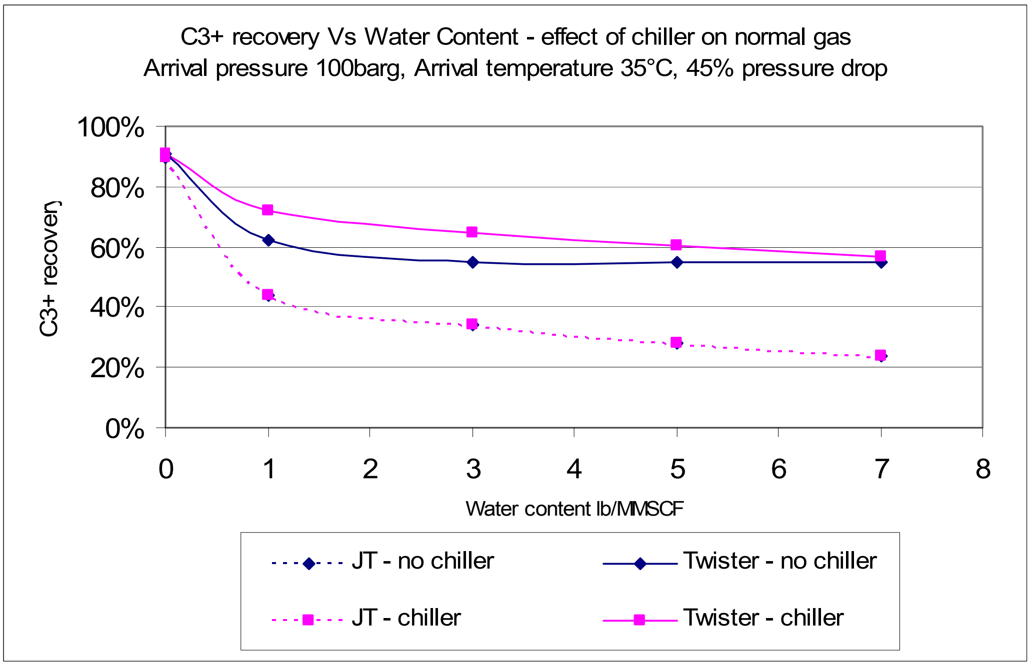

Figure 3: NGL recovery as function of water content for Twister and JT-LTS using a chiller

The Twister C3+ recovery increases by approximately 10% (from 50-60% range to 60-70% range) when upstream chilling is applied. The JT-LTS system does not benefit from adding a chiller, since its heat integration is limited by the water in the gas. The same results can be expected for non bone-dry gas applications, where Twister is compared to a turbo-expander, as the water content will limit its LTS temperature.

c) Benefits of Pressure Drop Reduction

These two studies (as presented above) focused on NGL recovery. However, the JT system is often used for controlling gas dew point by using chemicals to prevent hydrate formation. Whereas a Twister shows a higher NGL recovery for the same pressure drop compared to the JT system, Twister can also be used to reduce the pressure drop for the same performance as a JT system. This can be particularly interesting for brownfield applications – that is the de-bottlenecking or upgrading of existing gas plants. The availability of partially dehydrated gas, and/or hydrate inhibition chemicals, enables the Twister system to expand much deeper into the phase envelope than the JT system. Twister can maximise its heat integration since the gas-gas heat exchanger of a JT system is always much larger than for a Twister system. As a result the Twister system can be operated at a significantly lower pressure drop than the JT system. This enables either the installation of a compression system to be postponed, or the compression costs to be reduced. In both cases the NPV of the operations will be improved.

Even though a turbo-expander has a similar isentropic expansion to a Twister tube, thus enabling a lower pressure drop than a JT valve for a similar expansion, it will have the same limitations as a JT system with regard to the minimum acceptable temperature in the LTS. Twister in combination with the hydrate separator therefore has a unique advantage over the turbo-expander by being able to replace JT valves in brownfield applications where gas conditioning at a lower pressure drop is required.

Twister System for SPDC Nigeria

The improved Twister tube is to be installed in several new commercial applications during Q1 2008. A firm contract has been secured for one of these applications from Shell Petroleum Development Company (SPDC) for an onshore 120 MMscfd fuel gas conditioning application at their new Okoloma Gas Processing facility. The gas from the wellhead is cooled in an air-cooler after which free liquids are removed in a knock-out vessel. The overhead gas from this knock-out vessel goes directly to the Twister module. The key advantage of Twister technology for this application is that it does not require a gas-gas heat exchanger and hydrate inhibition chemicals to dehydrate and hydrocarbon dew point the gas. If a gas-gas heat exchanger is added in the future, the temperature at the inlet of the Twister tubes can be reduced to just above the hydrate formation temperature, which will result in a significant increase in LPG recovery, still without the use of hydrate inhibition chemicals. This will obviously improve the economics of the fuel gas treatment plant.

Twister BV is supplying a single module containing a Hydrate Separator, six Twister tubes, as well as all associated valves, piping, instrumentation and control.

Figure 4 – Twister Gas Processing Module for SPDC Nigeria

Petrobras Joint Technology Development – Sub-sea Gas Processing

An agreement has been signed with Petrobras to enter into a technology development co-operation to design and test a Twister system suitable for sub-sea applications. The first phase of this agreement involves the Petrobras purchase of a Twister unit for an onshore plant which is expected to come into operation during Q2 2008. The Twister 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 sub-sea testing of the Twister sub-sea system. The sub-sea Twister project is supported by a subsidy from the European Commission and it is expected that commercial sub-sea Twister units will be available by 2014/15.

Figure 5 – Twister Gas Processing Module for Petrobras

Future Developments

Twister Applicability for Deeper Liquids Recovery

The comparison between a JT-LTS system and a Twister system discussed in this paper focused on moderate NLG recovery. When deep NGL recovery is required, a turbo-expander, together with a demethaniser column, is normally used. A separate study is currently being executed, which compares the deep NGL recovery performance of Twister and a turbo-expander. Initial results show that Twister is capable of recovering 98% propane for the same specific power, i.e. compression power divided by C3+ flow, as a turbo-expander scheme. The ongoing study will cover a variety of gases and inlet conditions and we expect to report the results of this study in a future paper.

Twister for H2S Removal

It is estimated that one third of the global natural gas reserves are sour and that this figure will increase as producing sweet gas reservoirs deplete. As such, there is an increasing interest in Twister technology for enabling and enhancing the bulk removal of H_2S.

A process scheme has been developed in which a pre-cooled 30% H_2S stream enters the Twister tube. H_2S condenses inside the Twister tube and is therefore concentrated in the secondary outlet. This stream, which is approximately 1/3rd of the feed gas, enters a distillation section which creates a rich (80%) H_2S stream in the bottom and a lean (<10%) H_2S stream in the top. The lean H_2S stream can then be fed to a conventional amine system for polishing. The methane recovery of this scheme is approximately 95%, which means that Twister technology can be used for selective bulk removal of H_2S from a natural gas stream. Further studies and development work are continuing in co-operation with several interested third parties.

Conclusions

Extensive testing has proved the predicted enhanced performance of the improved Twister design.

An independent third-party study has shown that Twister can recover considerably more NGL than a conventional JT-LTS system.

Further study work has shown that at any level of dehydration Twister (with external cooling if desired) produces significantly more NGL (and specifically LPG), than a turbo-expander and a JT.

Preliminary results of a new study have shown that Twister has the same propane recovery for the same specific power as a conventional turbo-expander system.

A new application for Twister technology has been identified as the selective bulk removal of H_2S and is under further development.

The first phase of a joint technology co-operation with Petrobras is on-going. This is expected to result in commercially-available sub-sea gas processing systems using Twister technology.

All of the above, together with an increasing market interest in this proven technology, confirms the on-going successful commercialisation of Twister Supersonic Gas Conditioning.

References

1. Job M. Brouwer, Gonneke Bakker, Huib-Jan Verschoof, Hugh D. Epsom, ***"Twister Supersonic Gas Conditioning – First commercial offshore experience"***, GPA paper, 2004

2.Pascal van Eck, Hugh D. Epsom, ***"Supersonic Gas conditioning – Introduction of the Low Pressure Drop Twister",*** GPA Europe 2005.

3. Genesis Oil and Gas Consultants Ltd. - ***"Twister NGL Recovery Study"***, December 2007.

Abbreviations

JT	:	Joule-Thomson
LNG	:	Liquefied Natural Gas
LTS	:	Low temperature separator
NGL	:	Natural gas liquids
NPV	:	Net present value
SPDC	:	Shell Production Development Company of Nigeria
SSB	:	Sarawak Shell Berhad