New Choke-Valve Design Improves Separator Efficiency

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The efficiency of the gas/liquid separation process can have a significant impact on the economics of planned and potential oil and gas developments, as well as on the profitability of existing production operations.

A new type of choke valve that improves the efficiency of downstream gas/liquid separators by enhancing the coalescence of dispersed liquids in a fluid stream has been developed recently by Twister. The initial field test of the technology, known as the SWIRL valve, was performed at a JT-LTS production unit operated by NAM in the Netherlands.

The test demonstrated that the replacement of a conventional JT valve with the coalescing choke valve resulted in a significant improvement in the dewpointing performance of the gas-processing facility. This retrofit also allowed the maximum plant operating flow rate to be increased from 650 000 to 735 000 m^3/d, while still meeting export gas specifications. It was additionally found that by using the coalescing valve, the temperature in the cold separator (SMSM type) could be increased by 4–5°C while still meeting specification, allowing a reduction of approximately 3 bars in the plant feed pressure. Furthermore, it was demonstrated during the field test that the glycol losses normally experienced were significantly reduced.

This article presents the initial field-test results and an overview of the subsequent development and deployment of the coalescing-valve technology.

Technology Description

Pressure throttling in a conventional choke valve is achieved by dissipation of the kinetic energy present in the gas flow through randomly distributed eddies. The new coalescing valve, which was developed with the aid of proprietary computational fluid-dynamics models, uses the excess free pressure in a fluid stream to establish a coherent vortex motion. The total pressure inside the vortex core is gradually reduced along the axis of the flow path. By reducing the total pressure in a vortex flow, the flow shear rates are lower, compared with conventional chokes, thereby avoiding excessive breakup of liquid drops. However, and more importantly, these micron-size droplets are concentrated around the perimeter of the flow path, thus enhancing the coalescence to larger, more easily separable droplets.

To assess the coalescence efficiency of the two different valve designs, analytical calculations and numerical analyses were performed. These data showed that the time to increase droplet sizes from 4 (nonseparable) to 20 micron (separable) is in the order of milliseconds for the coalescing valve, compared with several seconds for normal choke-valve designs.

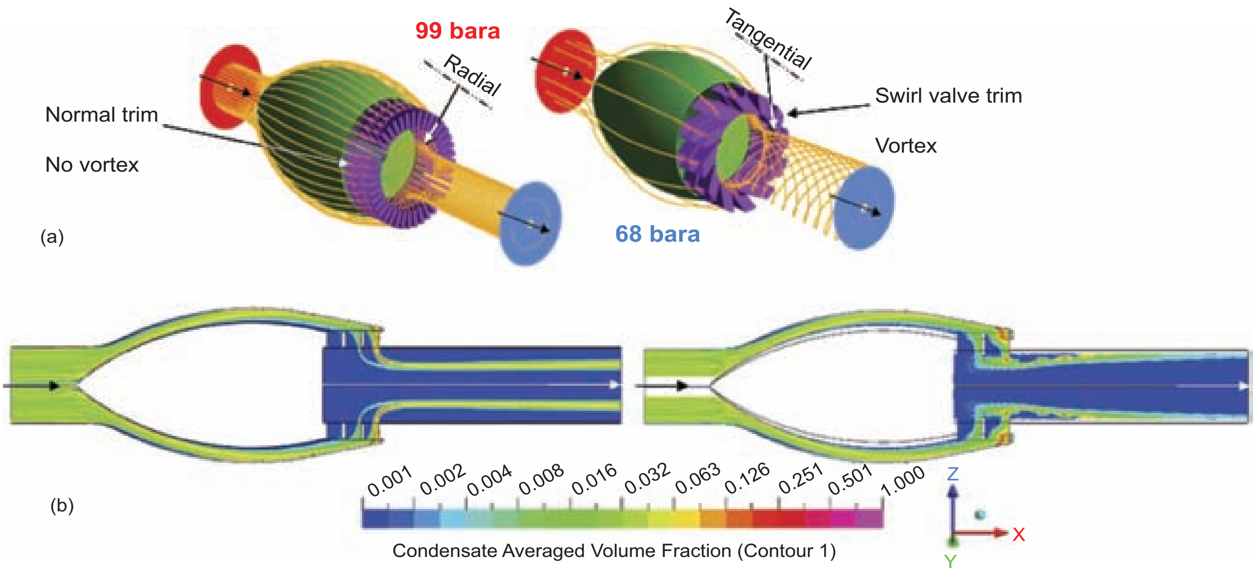

Fig. 1—a) Flow paths of conventional cage valve (left) and the coalescing cage valve; b) Liquid volume fractions for a conventional cage valve (left) and the coalescing cage valve.

Fig. 2—The LTS train of the NAM Opende Oost gas plant.

The concentration of the liquid fraction along the outer perimeter of a coalescing valve, vis-à-vis a traditional valve, is shown in **Figs. 1a and 1b.** The centrifugal forces exerted on the liquid droplets in the new valve design (Fig. 1a, right) result in the concentration, and hence coalescence, of droplets around the perimeter of the valve outlet. In a conventional cage-piston valve (Fig. 1a, left), the liquid fraction will not coalesce along the wall surface (Betting 2006).

Field Tests

A field trial was performed during September–November 2008 with a coalescing valve applied as a JT choke in an LTS train at the NAM Opende Oost gas plant **(Fig. 2).** New production wells came on stream in September 2008, feeding the Opende Oost production facility. This made the maximum operating flow (650 000 m^3/d) the constraining factor, and hence the preferred test location for the test of the coalescing valve.

The plant has a feed pressure of 99 barg (nominal) and a design capacity of 670 000 m^3/d. The facility's vertical SMSM cold separator operates at a temperature of –18°C (nominal) and pressure of 68 barg (nominal). Maximum operating gas flow <650 000 m^3/d. Export specifications are a PHLC of 5 mg/m^3 at –3°C, a hydrocarbon dewpoint of –3°C at 27 barg, and a water dewpoint of –10°C at 70 barg. The current operating limit is a maximum flow of <650 000 m^3/d, to avoid off-specification and excessive carryover of diethylene glycol.

TABLE 1—PERFORMANCE MEASUREMENTS AT 600 000 m^3/d

	Standard Trim	Swirl Trim
ΔP [barg]	29.5	30.0
Cold separator pressure [barg]	62.7	63.1
Cold separator temperature [°C]	–19.6	–19.9
PHLC [mg/m^3]	0.15	0.03
Bovar* [°C @ 27 barg]	–7.0	–8.1

TABLE 2—PERFORMANCE MEASUREMENTS AT 650 000 m^3/d

	Standard Trim	Swirl Trim
ΔP [barg]	33.0	33.7
Cold separator pressure [barg]	63.7	64.0
Cold separator temperature [°C]	–20.4	–20.6
PHLC [mg/m^3]	0.80	0.50
Bovar* [°C @ 27 barg]	–2.0	–8.0

*The commercial name for a hydrocarbon dewpoint analyzer.

The export gas quality was monitored during the test by means of an online hydrocarbon dewpoint analyzer (type: Ametek) and a mobile automatic condensate metering unit, both provided and operated by Gasunie Netherlands. The latter method measured the liquid dropout (=PHLC in mg liquid/m^3 gas) at –3°C and 27 barg.

The traditional low-noise valve performance was measured during the period from the end of September to mid-October 2008. The coalescing-valve test was operated from mid-October to the end of November 2008.

From the test plan, the following flow regimes were foreseen:

1. Nominal flow: 600 000 m^3/d
2. High-flow case: 650 000 m^3/d (operating maximum)
3. Low-flow case: 100 000 m^3/d
4. Ultimate-flow case: >700 000 m^3/d

The performance measurements for each flow case were:

Test Case 1:
Nominal Flow: 600 000 m^3/d.
From **Table 1** it is concluded that both tested valves were within the hydrocarbon export specification, although the coalescing-valve performance showed a slightly enhanced separation.

Test Case 2:
High Flow: 650 000 m^3/d.
Table 2 shows that the hydrocarbon dewpoint of the conventional-valve trim exceeded the export specification. It was therefore decided not to increase the flow any further by means of the labyrinth trim. The coalescing valve showed a steady low dewpoint reading. It was further observed by the NAM operators that the glycol makeup rate increased when operating a standard-JT-valve trim at this flow rate.

Test Case 3:
Low Flow: 100 000 m^3/d.
From **Table 3** it was concluded that, for the turndown case, both valves operate within the export specification. As expected, the differences in performance in this low-flow regime were negligible.

Test Case 4:
Ultimate Flow: 720 000 m^3/d.
Table 4 demonstrated that the coalescing valve was able to operate continuously at a flow rate of 720 000 m^3/d,

while staying well within the hydrocarbon export specifications. The NAM operators experienced no increase in glycol consumption when operating at this higher flow rate.

The flow rate was increased to 735 000 m^3/d, the maximum possible rate of the fiscal export flowmeter, while still meeting export specifications. It was felt that this rate could have been increased.

Test Case 5: High Cold-Separator Temperature. The final performance test was a trial to increase the cold-separator temperature while operating the coalescing valve at 710 000 m^3/d, until the hydrocarbon export specifications were exceeded.

This test showed that the cold separator could be operated at 4–5°C higher temperature when using the coalescing-valve trim, compared with the conventional valve (which required the cold separator to be operated at −19 to −20°C). Translation of the allowable temperature increase of the cold separator to an allowable reduction of the feed pressure resulted in a 3- to 4-barg lower feed pressure for the NAM Opende Oost facility. This has the positive commercial impact of allowing the deferral of planned compression installation, thereby allowing fuel cost savings.

TABLE 3—PERFORMANCE MEASUREMENTS AT 100 000 m^3/d

	Standard Trim	Swirl Trim
ΔP [barg]	21.4	19.6
Cold separator pressure [barg]	63.3	62.6
Cold separator temperature [°C]	−18.1	−17.6
PHLC [mg/m^3]	0	0
Bovar [°C @ 27 barg]	−8.0	−8.3

TABLE 4—PERFORMANCE MEASUREMENTS AT 720 000 m^3/d (COALESCING-VALVE ONLY)

ΔP [barg]	25.3
Cold separator pressure [barg]	64.2
Cold separator temperature [°C]	−18.7
PHLC [mg/m^3]	0.17
Bovar [°C @ 27 barg]	−7.5

Noise-Level Measurements

As part of the test program, the noise levels of the coalescing valve were measured and compared with the measured noise levels of the standard trim (low noise). All noise measurements were carried out at the NAM Opende Oost plant.

The conventional low-noise trim (i.e., the labyrinth case of Mokveld) was the most silent valve. The coalescing valve produced a noise level close to a (standard) Tyco rotating-disk choke. However, it is thought that additional design refinements are possible that will further reduce the coalescing-valve noise levels.

These field test results were initially presented at the GPA Europe technical conference last year (Betting, et al. 2009).

Current Performance and Further Deployment

The coalescing valve was left installed at the request of the operator and has continued to perform consistently to date.

A second NAM JT-LTS production unit was modified with the installation of a 10-in. coalescing valve during October 2009 (at the NAM Anjum facility in the Groningen field, northern Netherlands). This unit has demonstrated a performance improvement similar in scope to that experienced in the initial field test.

The cold separator now operates at a temperature 4.25°C higher than before the installation of the coalescing valve, with an associated direct production benefit in increased processing capacity and reduced operating costs.

Other potential retrofits of JT-LTS production units with the new coalescing valve are under consideration by the operator, pending a review of all of its JT-LTS facilities. Looking ahead, the coalescing-valve concept has now been developed for liquid/liquid separation applications and will be tested through 2010. Several other operators have expressed an interest in participating in joint-development projects associated with this new technology.

Conclusions

A thorough field test of the coalescing choke valve has proved successful in reducing the hydrocarbon dewpoint of the export gas and debottlenecking the flow capacity of the NAM Opende Oost production facility. The application of this valve technology enabled the operator to achieve a 20% increase in plant capacity; a 20% reduction in pressure drop, compared with the JT valve; and a significant reduction in glycol consumption. The facility is continuing to operate with the coalescing-valve installed, and the technology has been successfully applied by the operator at an additional JT-LTS facility.

Future design and development work will be aimed at further reducing noise levels, determining the minimal pressure drop required for a coalescing choke valve to work (currently 10% of feed pressure), and at the application of this technology for oil-water/condensate-water separation.

References

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Nomenclature

GPA	Gas Processors Association
JT	Joule Thomson
LTS	Low-Temperature Separator
NAM	Nederlandse Aardolie Maatschappij
PHLC	Potential Hydrocarbon Liquid Content
SMSM	Schoepentoeter Mistmat Swirldeck Mistmat

JPT