Troubleshooting a dehydration train

Advanced liquid distributor solutions increase reliability and profitability

Norbis Velazquez and Michael Krela **Koch-Glitsch**
Juan Ruiz **Gas Processing Expert**

In the current global energy environment, natural gas is expected to hold a strong position as a reliable fuel in the years to come, and it is considered a bridge fuel towards an era of more sustainable energy sources.[1]

Although conditioning of natural gas is a mature field, operators, along with licensors and equipment vendors, keep chasing opportunities to improve processes and optimise designs to minimise their environmental footprint, improve energy efficiency, increase reliability, and reduce operational costs. However, in a field where everything seems to have already been said and done, finding such opportunities constitutes a challenge of its own.

Natural gas dehydration is one of the ubiquitous processes that almost any natural gas stream undergoes, as the presence of free water in the gas at pipeline conditions can lead to operational issues, including hydrate formation and corrosion. The degree of dehydration depends on the use and the transit of the gas stream from its source to its destination; the colder the temperature the gas is expected to reach, the more stringent the dehydration specification will be.

There are different technologies available to desiccate natural gas streams, and most of them require, to some extent, the use of absorption or distillation processes equipped with mass transfer equipment such as trays, packing, and distributors. Choosing the right process depends on several factors, including the initial water content, process character, operational nature, economic factors, and the water specification required downstream.[2] One such method is water removal by compression and cooling, which aims to decrease water saturation content, first by compressing the gas and then cooling it to an adequate temperature to generate the desired dehydration level.

A plant gas operator in Western Canada, which runs several midstream assets throughout North America, faces the challenges of conditioning and dehydrating its natural gas production. In its Canadian operation, it operates several proprietary Ifpexol units. This technology allows dehydration and dew point control by using a cold process in the presence of a methanol solution as a single solvent.

A methanol-water solution is recovered from the dried gas and recycled back to the two strippers, where a partial stream of raw wet gas is used to strip out and recover methanol from the recycled methanol-water mixture. The objective of the stripper is to obtain pure water at the bottom and an overhead gas stream loaded with methanol, which serves as an antifreeze agent downstream.

The Ifpexol process focuses on the economy generated by a highly integrated dehydration process using a compression-cooling approach. In this technology, a methanol closed-loop aqueous solution is recirculated to control hydrate formation in the cold section of the unit. If the methanol losses through the bottom of the strippers are low, the process offers attractive operational costs while being environmentally friendlier than other dehydration technologies, as there are no harmful vent emissions.[3]

Operating principles

The methanol regeneration of the Ifpexol process occurs in the stripping section, where a water-saturated hydrocarbon gas stream is contacted in counterflow with a methanol solution in a packed stripper tower. The stripping process

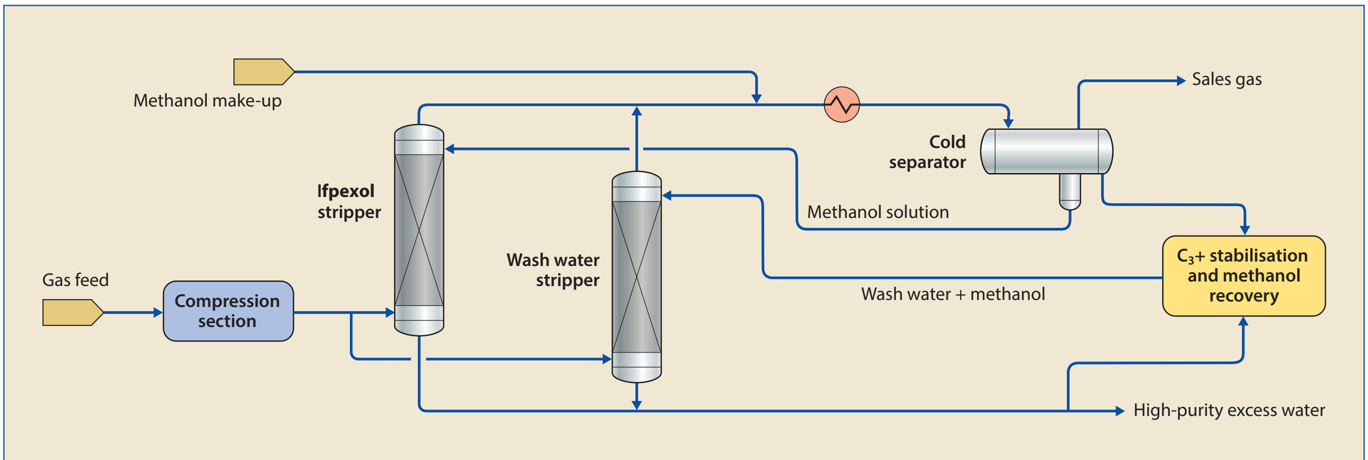

Figure 1 Overview of Ifpexol process for dehydration

relies heavily on a high surface area packing to promote the stripping of the methanol from the methanol-water solution coming from the cold section and stabilisation section. Given the different temperature levels and nature of the available methanol solutions, two strippers are required to regenerate the methanol; these are referred to as the Ifpexol stripper and water wash stripper (see **Figure 1**).

The technology licensor specified the use of wire gauze structured packing with a bed height of about 6,000 mm, one inlet feed distributor for the saturated wet gas, and an overhead distributor for the methanol solution liquid feed.

Although the fluid properties and operational conditions were not optimal for the use of wire gauze structured packing – due to the high surface tension and relatively high viscosity of the liquid phase, as the liquid would not be able to harness the advantage of the capillary effect of the woven material – the high surface area of wire gauze structured packing required (in the range of 500 m^2/m^3) makes it an appealing option. It allows for enough stripping stages from a rather small amount of liquid compared with a sizeable flow of gas.

After the commissioning of the unit, the operator started struggling with stripping efficiency in both towers, leading to a higher fresh methanol consumption and an unsteady operation, especially in the Ifpexol stripper. Similar situations presented after the operator commissioned analogous units in different locations. According to the licensor models, the methanol recovery performance of the strippers was about 50% lower than expected, and the methanol losses were at least twice as high as the design target.

While studying the preliminary information received from the field, it was highlighted that the fouling of the distributors (and consequently their cleaning) was more prevalent in the stripper, which operates at cryogenic conditions in the overhead of the tower. This, along with evidence from elsewhere in the plant, supported the idea that the fouling was generated by an accumulation of paraffinic compounds with a tendency to solidify, especially at low temperatures. These compounds were inherent to the gas composition, even if they were not expected to be present at the design stage of the plant.

As a result of these findings, it was determined that the cause of the unexpected poor performance was due to the inefficiency of the original internals in the strippers, rather than being inherent to the technology or process design. Consequently, The operator decided to collaborate with Koch-Glitsch to leverage its expertise in addressing the plant's operational issues.

Process evaluation

The operational challenges were varied, affecting the process in multiple ways. Operators faced a higher-than-expected pressure drop in the packing, poor methanol stripping, freezing in the cold section due to insufficient methanol circulation, blockages in the liquid feed distributor, and increased consumption of make-up methanol. To cope with this situation, operators had to constantly adjust the process to try to optimise mass transfer in the strippers.

Some of the usual actions included increasing the use of fresh methanol upstream of the cold process to mitigate freezing, manipulating the gas split ratio of the gas feed between the strippers to optimise the methanol recovery, and performing 'blowbacks' in the tubular liquid distributor to try to improve the quality of the distribution.

Preliminary hydraulic studies were conducted at design and operational conditions, and no indications of evident constraints were found in the packing or the internals. However, the saturated gas was not able to produce enough stripping of the water-methanol feed. Even after a series of operational adjustments, the methanol recovery targets were not met.

A grid gamma scan was conducted on both strippers but given the very low liquid flux in both towers, the results of the scan were deemed inconclusive. Knowing the packing was not hydraulically constrained, and the issues could be summarised as a lack of efficiency and operational reliability, additional efforts were aimed at studying the liquid distribution.

In theory, the original design for the tubular liquid distributors made sense, but they generated significant shortcomings during the operation of the strippers. To achieve high drip point density, essential for effective liquid distribution in tubular designs, the holes in the laterals were set at 1 mm in diameter, which led to persistent clogging and poor distribution, making the operation unreliable, impractical, and inefficient.

Even when the original distributor showed a high drip point density of 200 points/m^2, a distribution quality assessment using a widely accepted method in the industry[5] produced a rating of 64%, whereas the expectation for wire gauze packing is to use high-performance distributors with distribution qualities surpassing the 90% threshold.

The distributors frequently became plugged, and methanol losses grew unsustainable due to decreased stripping efficiency. Operators would stop the methanol-water flow and use the tower's high pressure to clear obstructions back into the feed piping system, temporarily restoring flow. This process subjected the system to process and reliability issues, potentially compromising its mechanical stability and losing stripping capabilities for a few hours at a time, at least once a week, with all the attached consequences this brings to the operation downstream. However, even after cleaning, the efficiency was not on target, and it quickly declined from there, starting the cycle again.

Although the Ifpexol and wash water (WW) strippers aim for similar results, their operations differ. The Ifpexol stripper is designed to contact the cold water-methanol mixture (>70 wt% methanol) from the cold process with saturated gas. In contrast, the WW stripper is focused on recovering any remaining methanol that may have migrated from the cold process to the C_3+ stabilisation section.

The liquid feed to the WW stripper is largely dependent on the feed gas composition and is not directly linked to the Ifpexol stripper's overhead liquid feed. Despite these differences, having the same diameter enabled the original equipment manufacturer (OEM) to make a design shortcut, where a single-design distributor was used in both towers instead of using two distinct distributors calibrated for each.

Improper initial liquid distribution can severely impair the efficiency of packed towers. Severe forms of initial maldistribution, such as those induced by inadequate liquid distributors, lead to inconsistent liquid flow across the packing. This maldistribution manifests as chordal, peripheral, and central blanking profiles, each severely affecting column efficiency by creating over- and under-irrigated zones within the packed bed. When a scenario of initial gross maldistribution is presented, a packed bed cannot self-correct this situation[4], and the performance is destined to bear the consequences.

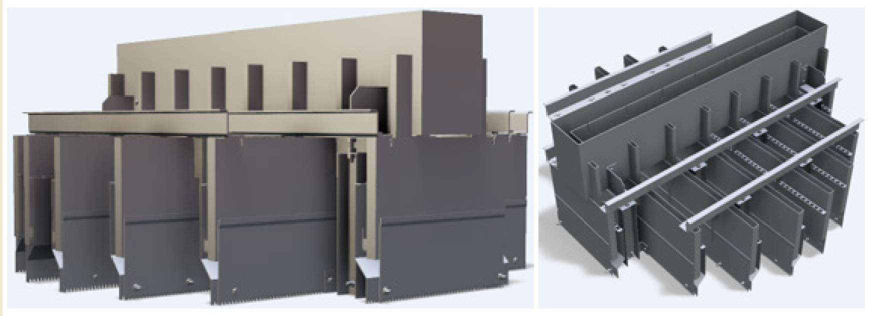

Figure 2 Comparison of liquid distributors Models 166 (left) and 156 (right)

Once the issues with the distributor designs were identified, the task was to produce a new set of distributors that aligned with the internal rates and operational ranges of the towers. After receiving feedback on a set of new operational conditions from the technology licensor, a new simulation model of the strippers was generated using operational data, updated gas compositions, and current saturated gas flows to each of the strippers. This new set of information revealed the nuances between the operation of each tower, informing the design choices in each case.

Selecting the right liquid distributor

Packed towers operate as a system, with the performance of the packing being directly linked with the type and design of the liquid and vapour distributor. Improper feed distributor design accounts for a considerable number of troubleshooting issues in mass transfer columns, even for relatively simple distillation and absorption systems.

The choice of a liquid distributor for a packed tower is informed by several factors, such as the packing type, process application, liquid load, operational range, and fouling tendency. However, sometimes variables like the available overhead space above the packing, existing tower attachments, manway size, and installation time constraints can play a role in defining the final design of a liquid distributor, potentially compounding the complexity of the retrofit. Hence, a one-size-fits-all approach is rare, especially in revamp scenarios.

Considering that the original liquid distributors in the strippers were pressurised, a compact design was possible, as no static head of liquid was required as a driving force. As a result, the vertical spacing for a new installation was limited.

Designs for liquid distribution systems require thorough hydraulic knowledge and a deep understanding of the operational windows and process conditions. Therefore, close collaboration between the parties involved is crucial to the success of the design.

There are generic rules for the selection of liquid distributor types, but in general, these are just guidelines and should be treated as such. Therefore, looking at the distributor types just in terms of flow range is simplistic, and this approach should not be used as a replacement for a comprehensive evaluation of the system.

The final selection of a liquid distributor must be the result of a judicious assessment of operational conditions, packing type, fouling potential, mass transfer requirements, available installation spacing, and operational flexibility, among others. To adapt to all these parameters, there are several levers that can be moved. Although having two identical distributors in towers with different operational conditions can save money during the project phase, it can prove costly in the long term due to poor performance during operation.

Once the operational conditions and expectations were revised between the operator and Koch-Glitsch, the decision was made to use trough distributors for both towers, as they offered the most comprehensive solution, addressing most of the issues captured during the evaluation. However, if a single design was required (following the original design philosophy), high flow variations were expected for the WW stripper at intermediate and low rates, which would produce severe maldistribution and poor stripping efficiency.

Redesign approach

Several issues needed to be fixed within the confines of the mechanical constraints of the strippers. For instance, the disruptive cleaning process of the liquid distributor using blowbacks (backflushing the feed distributors into the feed line utilising the high internal pressure of the gas in the tower) was addressed by removing the pressurisation from the distributors and using an open pipe to transport the liquid feed into the tower.

However, without pressure as a driving force to spread the fluid through the packing, the distribution would rely on any static head the new design could generate in the limited available space. Even if one would aim for a very compact design, a precise distribution was not possible at face value, given the overhead space available.

The available vertical distance to install the distributor was about 600 mm from the centreline of the feed nozzle to the top of the packing. The preliminary assessment showed that about twice this distance was required to allow spacing for pre-distribution feed piping, the main parting box, and the secondary distribution trough, but the overhead space did not allow for this increase.

An additional step to complement the solution was proposed to the operator, consisting of replacing the packing

Comparison of the stripper configurations before and after the revamp				
	Ifpexol stripper (1524 mm ID)		Water wash stripper (1524 mm ID)	
	Original	Modified	Original	Modified
Packing type	Conventional	Koch-Glitsch's high-capacity	Conventional	Koch-Glitsch's high-capacity
Bed height (mm)	6,000	5,500	6,000	5,500
Distributor type	Tubular	156 trough distributor	Tubular	166 low flow distributor
Flow mechanism	Pressurised	Gravitational	Pressurised	Gravitational
Methanol consumption (normalised basis)	1	0.48	1	0.48
Frequency of distributor blowbacks	Weekly	Eliminated	Monthly	Eliminated

Table 1

with Koch-Glitsch's proprietary high-capacity wire gauze packing and decreasing the bed height by about 500 mm. Although counterintuitive (as removing packing in a low-efficiency scenario yields fewer chances for the phases to interact), Koch-Glitsch was confident that the combination of packing replacement and the finely tuned liquid distribution would offset the decrease in bed height.

When considering the design of a trough distributor, each transition of the liquid flowing downwards from the feed pipe to the first packing layer must be thoroughly assessed. In the case of Koch-Glitsch trough liquid distributors, the liquid is received by a pre-distribution channel, which equalises and disperses liquid from the feed pipe into a parting box located underneath. Adequately sized holes along the parting box proportionally distribute the liquid into each trough according to their respective sizes.

Depending on the operational range required and the expected distribution quality throughout the design range, a few different design configurations can be provided for the final liquid delivery mechanism after the troughs under the parting box. In this case, orifices on the side of the troughs facing towards a splash baffle (Model 156) were chosen for the Ifpexol stripper.

For the WW stripper, given the lower liquid flux expected at turndown conditions, the analysis showed that one additional stage of equalisation was required. Therefore, the perforations on the troughs were guided towards secondary troughs with narrower dimensions (Model 166) that would allow for a healthier and more equalised liquid head throughout the operational range. **Figure 2** shows a comparison between the two designs of troughs utilised in lieu of following the original design approach of using identical liquid distributors.

Results

Table 1 shows a comparison between the original and modified design for the strippers. The results after the modifications were markedly positive, reducing the methanol make-up by more than 50%, finally achieving the targets for methanol usage as per the licensor's design values, which is one of the most significant advantages of the process (see **Figure 3**).

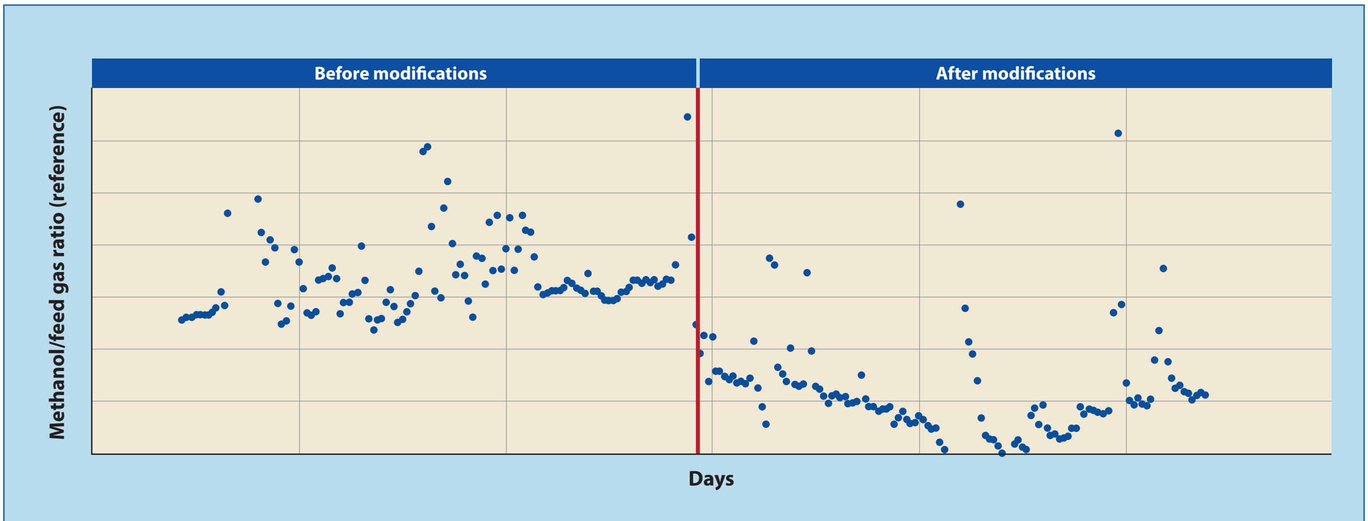

Figure 3 Methanol-to-gas feed ratio before and after the modifications

The improved stripping efficiency generated a more stable operation in the chiller system without no freezing occurring due to the higher methanol concentration in the circulation solution, even at much lower methanol make-up rates. The blowback practice was completely eliminated, thereby decreasing the risk of operator exposure, preventing potential flaring occurrences, improving the mechanical reliability of the liquid distributors and equipment, and increasing the system availability by at least four days a year.

Considering the criticality of the installation to the success of the revamp, the work on the first train was managed by Koch Specialty Plant Services (KSPS) via the One-Source Solution approach, which ensures the work done meets the highest standards, guaranteeing a successful outcome.

The operator, satisfied with the results, decided to revamp all five Ifpexol trains in its Canadian operation with the redesigned configuration. Each train was evaluated on its own merits, and modifications to the designs were generated where required. Savings due to increased efficiency in the strippers are in the order of C$3 MM/yr for all the trains. Additional savings on the reliability and operational fronts that are not easily quantifiable were also achieved.

IFPEXOL is a mark of Axens.

References

1 Canada's Energy Future 2023. Canada Energy Regulator. CER – Canada's Energy Future 2023: CER's first long-term Outlook modeling Net-Zero by 2050.

2 Huffmaster, M.A., Sheilan, M., Gas *dehydration fundamentals*, Laurence Reid Gas conditioning Conference Proceedings, 2016.

3 Minkkinen, A., Levier, J-F., *IFPEXOL™: Complete Gas Treatment with a Single Solvent, Laurence Reid Gas conditioning Conference Proceedings*. 1992.

4 Olujić, Ž., Jansen, H., Large-diameter experimental evidence on liquid mal-distribution properties of structured packings, *Chemical Engineering Research and Design*, 2015.

5 Moore, F., Rukovena, F., Liquid and Gas Distribution in Commercial Packed Towers, *Chemical Plants and Processing (European edition)*, August 1987, p.11.

Norbis Velazquez is a Chemical Engineer with Koch-Glitsch in the UK, with more than 15 years of experience in oil refining, petrochemicals, and midstream applications. His background spans operations, process engineering, and design of mass transfer and separation equipment. His work supports process optimisation and troubleshooting through data analysis and technical studies across all major unit operations. *Email: norbis.velazquez@kes.global*

Michael Krela is Global Product Manager – Mass Transfer with Koch-Glitsch and has 20 years of experience providing solutions for mass transfer and separations designs in refining and petrochemical plants. He has also been a Sessional Instructor for the Separation Processes course in the Department of Chemical Engineering and Applied Chemistry at the University of Toronto. He holds a BASc in chemical engineering from the University of Waterloo, Canada.
Email: Michael.Krela@KochGlitsch.com

Juan Ruiz is Lead of Process Engineering & Rotating Equipment at a major gas production company in Canada, focusing on driving process optimisation, enhancing equipment reliability, and delivering Opex reductions across operations. He has more than 25 years of experience in process engineering, chemical systems, and rotating equipment.