HYDROCARBON ENGINEERING

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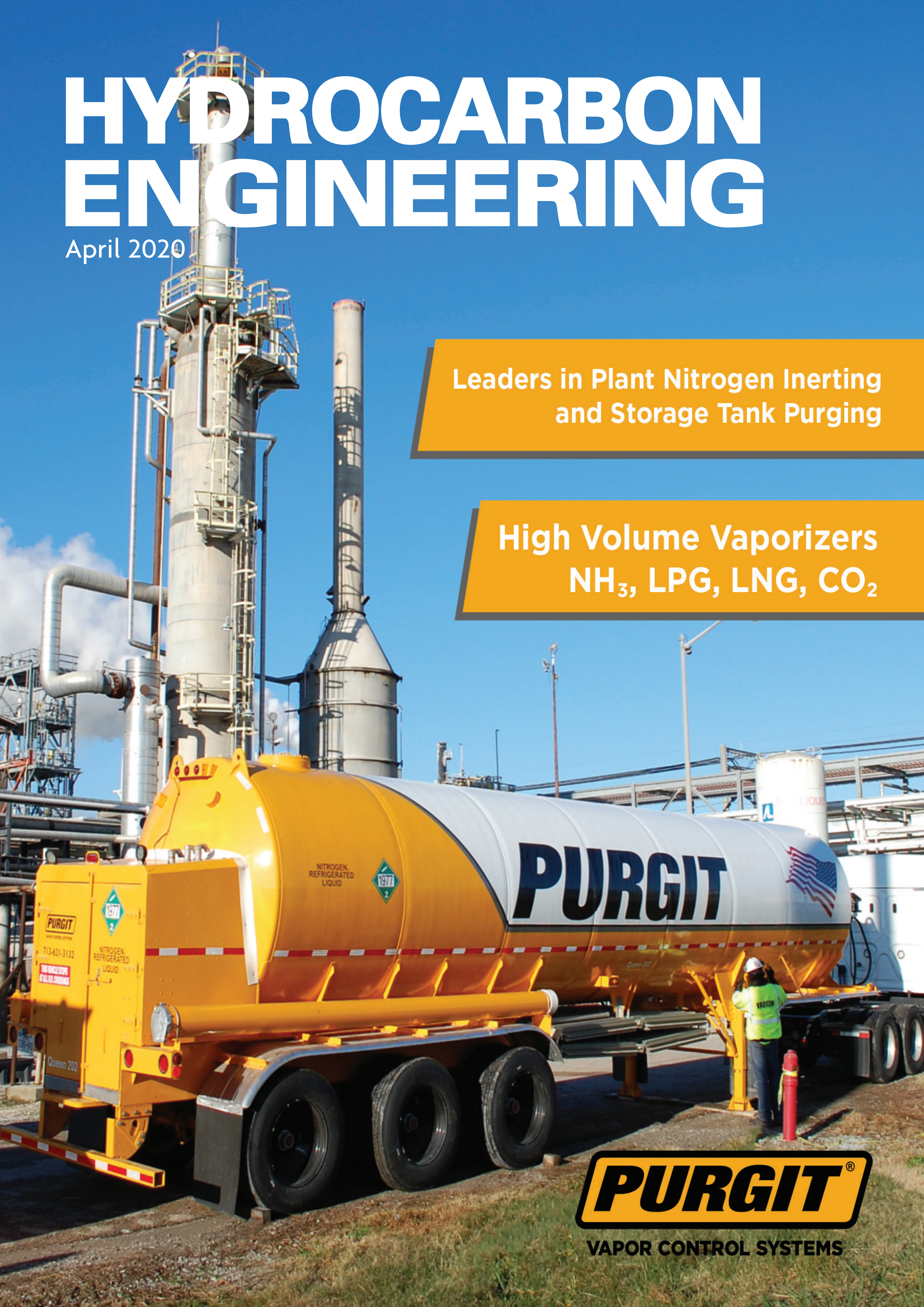

AMINE SCRUBBING OPTIMISATION

Chris Wallace, FTC, USA, discusses the challenges to efficient amine scrubbing in natural gas processing, and new filtration technologies aimed at tackling these issues.

For natural gas processing plants, amine scrubbing is a common unit process that relies heavily on filtration and separation technology. It is well documented that solid contaminants in the amine stream contribute to process challenges such as corrosion, erosion, fouling, and foaming. Therefore, the operational stability of gas 'sweetening' plants is largely dependent on the mitigation of contaminants.

Operators understand the high cost of inefficient filtration. They recognise that low efficiency filtration units and undersized filtration systems can both lead to issues including frequent and prolonged process upsets, downtime due to equipment fouling, repeated filter change-outs, and higher process-related operating costs. Additionally, frequent filter change-outs result in higher direct consumable costs as well as indirect costs related to safety, labour, inventory, and disposal.

It is important to review the process and discuss the primary sources of contamination during the amine sweetening process.

Amine sweetening

Natural gas processing facilities and refineries use treatment solvents to remove acid gas components from gas streams. Amines such as MDEA, DEA, MEA, and specially designed formulations absorb hydrogen sulfide (H_2S) and carbon dioxide (CO_2) to 'sweeten' the gas stream. A standard amine sweetening unit process is shown in Figure 1.

In the operation of a typical gas-sweetening unit, the inlet gas first passes into the bottom of the contactor, also referred to as an absorber, and flows upward through a series of trays, counter-current to the aqueous amine solution which absorbs the acid gas components. The 'rich' amine solution, which has absorbed CO_2 and H_2S molecules, flows

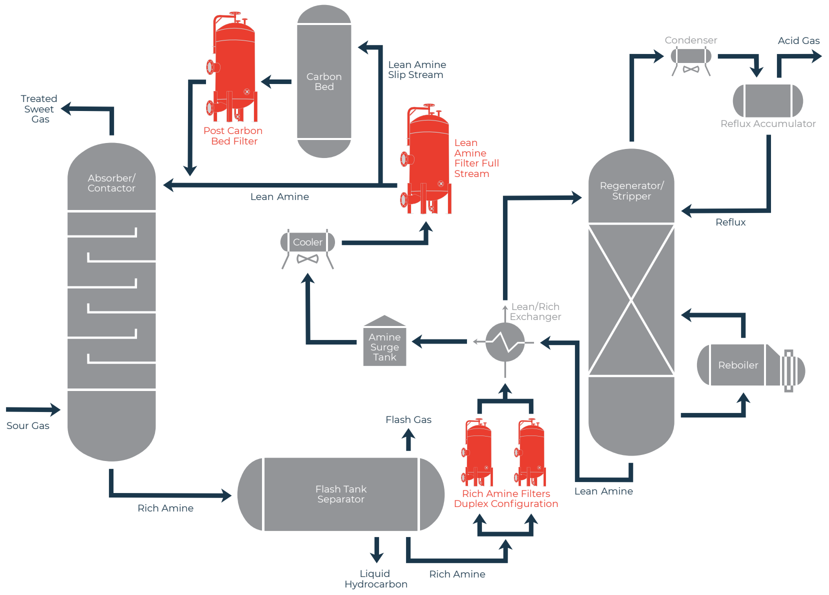

Figure 1. Amine sweetening unit process diagram.

from the bottom of the contactor through a heat exchanger where its temperature is elevated to minimise the additional heat required for regeneration. The rich amine is then sent to the upper section of the stripper, also known as the regenerator column, where it flows downward under low pressure, contacting the hot vapours from the reboiler. The contact with the hot vapour strips the acid gas molecules from the amine solution. This acid gas flows out the top of the stripper to a condenser, referred to as a reflux accumulator, where liquid vapour is recovered and recycled back to the system. The hot 'lean' amine solution, which no longer contains acid gas, flows from the reboiler back through the lean/rich heat exchanger and is cooled before being pumped back to the contactor for reuse. Prior to being sent to the contactor, a 15 – 30% slipstream of lean amine is sent to a carbon bed to remove dissolved hydrocarbons.

Amine system contamination challenges

It is important to remember that the amine sweetening process represents a closed loop, with introduced agents and existing contaminants trapped within the system until removed.[1] As such, filtration and separation play critical roles in the process and can have a dramatic impact on operating and maintenance costs. Maintaining good amine health through proper filtration results in a significant reduction in fouling, corrosion, foaming, solvent degradation, and overall energy consumption.[2] Specifically, these benefits include:

- A significant reduction in fouling of the contactor trays, heat exchanger, reboiler, and carbon bed.
- A significant reduction in under deposit corrosion due to particulate settling in the piping or low velocity zones.
- Lower energy consumption because of good exchanger efficiencies in the lean/rich exchanger.
- Protection of the regenerator and reboiler from solids accumulation 'hot spots' that can cause degradation of the amine solvent.
- Reduced potential for erosion of the passivation layer from abrasive solids.

Heat stable salts

Heat stable salts (HSS) are formed when acid anions like acetate, thiosulfate, thiocyanate, and chloride bind with an amine molecule to form a salt that will not regenerate when heated. They reduce the acid gas carrying capacity by tying up the amine, and they also have a strong corrosive effect. HSS increase the viscosity and density of amine and require higher circulation rates to provide enough free amine to react. These turbulent higher velocities can erode the protective iron sulfide passivation layer, resulting in increased solid contaminant levels.

Process chemicals

Corrosion inhibitors and well-treating fluids from upstream operations, as well as excessive amine system anti-foam chemical injections, tend to lower surface tension of the aqueous solution. While anti-foams are excellent in controlling operating problems, their injection into an amine system over time can build up to a concentration level that begins to stabilise the foam and increase foam severity. A large build-up of anti-foaming chemicals can lead to carbon bed fouling.

Hydrocarbons

Heavy hydrocarbons from natural gas streams can condense in the contactor and, along with lubrication oil from upstream reciprocating compression equipment, they can accumulate in amine systems over time. These hydrocarbons reduce the surface tension and increase the foaming tendency of amine solvents.[3]

Make-up water

Fresh amine is usually delivered to the plant as 100% or 85% amine and must be diluted to target solution strength. Virtually all amine systems lose water from the amine solution during normal operation. The amine solution loses water as vapour in treated gas at the absorber, and some water is continually lost to the sulfur recovery unit in the acid gas from the regenerator. Water is frequently purged from the regenerator overhead to control ammonia in the reflux system. As a result, water is routinely added to the amine system. Steam condensate is the preferred water choice, but other sources of water are often used. If a proper water source such as demineralised water is not used, the water could be a source of amine solution contamination.

Particulates released during operations/start-up/turnaround

Pipe scale readily forms on steel exposed to air, especially in moist environments. Any pipe scale or rust in the unit when H_2S is introduced gets immediately converted to iron sulfide, and a relatively robust, protective layer of iron sulfide called the passivation layer is formed on metal surfaces.[4] Iron sulfide not bonded to pipe and equipment walls is carried away by the circulating solution. These very fine particles are major

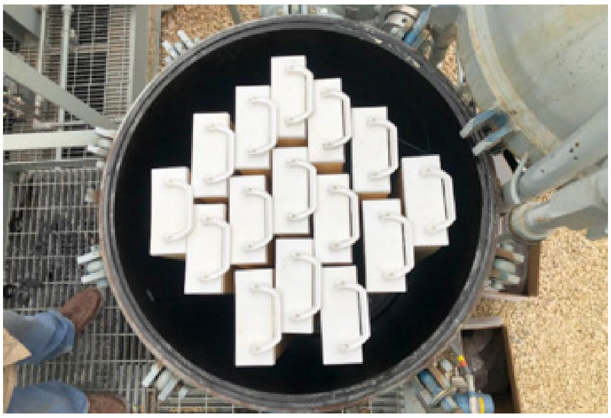

Figure 2. FTC Invicta offers good filter media packing density within the same vessel footprint.

contributors to foaming as they tend to concentrate in liquid-gas interfaces, causing foam stability. Rich amine filtration is one of the primary means to control high concentrations of soluble iron in the lean solvent that have the potential to precipitate in the contactor. Additionally, insoluble particulates including metals from corrosion, carbon fines released from the carbon bed, and other particulates from upstream units can contribute to the total amount of solid contaminants in the circulating stream.

The evolution of gas treatment filtration

Over the years, filtration and separation technology has advanced to help refine and improve amine sweetening processes. From string wound filters to modern absolute-rated pleated media cartridges, the filtration industry has improved its offerings to customers. Still, operators routinely struggle with the hidden costs associated with poor amine health; prolonged upsets, inefficient stripping in the absorber, loss of solvent to foaming incidents, downtime due to fouling of equipment, and most of all, the costs associated with operator safety. In today's amine process environment, the need still exists for reliable, high-efficiency, operator-friendly filtration with minimal change-outs, manageable consumable costs, and the smallest possible footprint.

Indeed, costs associated with operator safety provide an important example of how standard filtration options negatively impact process efficiency. With high concentrations of H_2S typically found on rich amine streams, operators must comply with the full range of safety regulations governing job safety analyses (JSA), personal protection equipment (PPE), and associated documentation for every change-out operation. With these safety costs adding to other operational costs, effective filter life is now an extremely important metric for operators.

There is a growing demand for advancements in process filtration efficiency. Recent innovations in filtration and separation design are enhancing the reliability of contamination control in gas sweetening processes.

Case study

A gas processing operator in the Permian Basin had four amine filter vessels per train with three trains operating at 200 million standard ft^3 each. Two of these vessels were used to filter rich amine, one was used for lean amine filtration, and the last was used for post-carbon filtration on the lean side. Each of these vessels originally held 59 2.5 in. x 40 in. cylindrical filter cartridges. The process conditions involved an amine flow rate of 355 gal./000 ft^3 and an operating temperature of approximately 150˚F.

Although the existent quality of filtration delivered by FTC's Clarify 250 filters was acceptable to the operator, the frequency of filter element change-outs was putting a strain on the plant since they had limited operators, and each change-out operation was very time consuming.

Invicta™ was proposed as an option to provide extended filter life, requiring a retrofit to the existing filter vessel, easily completed for all four vessels over the course of two days (approximately two hours per vessel). The operator gained 84% more effective media filtration surface area per vessel over the original configuration with only 15 cartridges replacing the 59 cylindrical cartridge filters previously in use.

Upon start-up, the operator was pleased to note that while effluent quality was as previously experienced, downtime requirements with Invicta were dramatically lower. Before, the operator had been changing filters once a week, with two workers required for the change-out. Following the installation of new filters, the facility saw run times of four to five weeks and longer. Additionally, the ease of filter change-out has lowered indirect costs, with only one worker required.

After several months of successful operations, the documented benefits of the new filters and vessels include:

- An 84% increase of effective surface area.
- Increased filter life by 4 – 5 times.
- Reduced direct consumable costs.
- Reduced labour costs, shipping costs, disposal costs.
- Coreless filters pack better in disposal containers.
- Reduced process upsets with excellent amine fluid quality.

With these filters, the operator enjoyed both top-line and bottom-line cost savings and has reported positive results from the change. At the request of the operator, FTC has completed work retrofitting the remaining amine sweetening trains at the facility as well as upgrading several of their other facilities in the region.

Conclusion

For gas processing plants and refineries focused on efficient amine scrubbing operations, advances in liquid-solids filtration and separation technology that deliver reliable process efficiency are naturally received as welcome news. New cartridges and vessels from companies such as FTC support peak amine scrubbing process efficiency and provide lower costs for operators. HE

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