SHELL TURBO TECHNOLOGIES

Changing the game in gas processing

WHITE PAPER

SHELL CATALYSTS & TECHNOLOGIES
TRANSFORMING ENERGY TOGETHER

Innovative, game-changing design

Increase gas-processing capacity in existing columns by up to 200%

CAPEX

Reduce absorber costs in greenfield applications by up to 50%

Shell Turbo Technologies provide a drop-in solution that offers significant benefits to gas-processing facilities by improving absorber column hydraulics and mass-transfer efficiency. These innovations can potentially triple gas-processing capacity and reduce absorber costs in greenfield applications by up to 50%.

Although this technology is currently exclusive to Shell, Shell Catalysts & Technologies is exploring opportunities to bring it to the broader market, with the aim of enhancing gas production with minimal capital expenditure and process disruption.

If you are looking to boost capacity and avoid new train additions in acid gas removal units (AGRU) or triethylene glycol (TEG) dehydration units, this technology can be a game-changer.

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WHY DOES GAS-LIQUID CONTACTING TECHNOLOGY NEED IMPROVING?

Absorption involves transferring gas-phase species to a liquid solvent, useful for separating gas mixtures, removing contaminants, or recovering valuable substances. This process is often coupled with absorbent regeneration where the solute is stripped and extracted for further processing.

The industrial absorber columns, Figure 1, are equipped with internal devices such as plates or packages that improve the gas-liquid contacting. The contaminated gas and the fresh absorbent solvent are fed into the column where the column internals enhance gas–liquid interaction by bubbling gas through a bed of liquid or otherwise expanding the contacting surface area.

The lighter gas, driven by a pressure differential, ascends and is extracted from the top of the column for further processing. The denser liquid solvent, driven by gravity, descends to the bottom of the column where it is removed for regeneration.

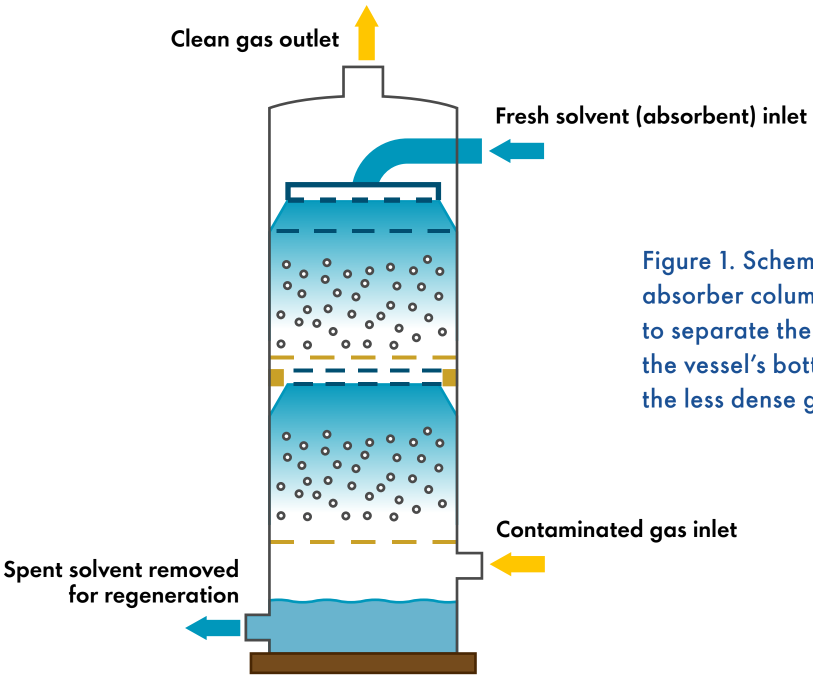


Figure 1. Schematic representation of an absorber column where gravity is harnessed to separate the denser liquid, which settles at the vessel's bottom and is withdrawn, while the less dense gas phase exits from the top.

While gravity-driven gas–liquid separation remains a simple and effective method, ongoing technological advancements, including improved internals and materials, have boosted separation efficiency in various applications.

Counter-current contacting technology for gas treatment

Counter-current contacting is a foundational concept in chemical engineering. It plays a pivotal role in diverse separation and mass-transfer processes, particularly in natural gas processing for the removal of contaminants such as water, hydrogen sulphide (H_2S) and CO_2. The principle involves the convergence of multiple fluid streams (Figure 2) moving in opposing directions, often influenced by gravity, to optimise mass transfer. Initially reliant on packing and tray technologies, this concept has evolved considerably over time, with advancements in materials, designs and fluid dynamics knowledge giving rise to various tray and packing systems, each with distinct advantages and specific applications.

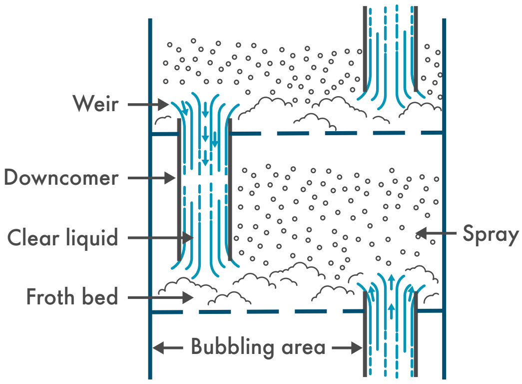


Figure 2. Schematic representation of a counter-current gas–liquid separator where gas and liquid streams move in opposite directions to enhance mixing and maximise mass transfer.

Conventional gas-contacting methods – whether they are the more traditional types such as bubble-cap trays or sieve trays, or the more recently developed advanced trays and packing materials – tend to suffer performance issues such as liquid entrainment, foaming and flooding.

These challenges often lead to suboptimal gas–liquid interaction, uneven liquid distribution and increased pressure drop. This can result in diminished separation efficiency, elevated energy consumption and decreased sustainability across diverse chemical processes.

TURNING THE PROBLEM AROUND TO ACHIEVE DEEP CONTACTING AND BETTER SEPARATION

For more than five decades, we believe the industry has been approaching gas and liquid contacting incorrectly. Shell researchers identified the shortcomings of traditional approaches and pioneered Shell Turbo Technologies – an innovative contacting technology for absorption columns that is capable of potentially doubling or even tripling the capacity of current absorbers. Shell Turbo Technologies revolutionise mass transfer and separation processes by removing the dependency on gravity for contacting, utilising the tremendous energy stored in the gas stream to increase the contacting efficiency to unprecedented levels.

This technology is not only a significant advancement but also a testament to the organisation's extensive expertise in mass transfer and separation processes. It highlights Shell's commitment to achieving the highest standards of deep contacting and separation efficiency. This innovative approach is based on the principles of novel **gas–liquid contacting and separation principles**, that ensure high degrees of operability **without compromising the overall pressure drop**. These principles have been realised through a combination of innovative design features and engineering excellence.

Enhanced gas–liquid contact

Shell Turbo Technologies' distinctive design greatly improves gas–liquid contact, promoting a highly efficient exchange of mass between phases. The innovative design features a co-current flow of the gas and liquid on each tray while gravity is used only to help the liquid to move from one tray to the next. Shell Turbo Technologies incorporates design components, that utilise the high velocity of the gas entering each tray to turn the liquid on the tray into fine droplets that mix vigorously with the gas stream. These components disrupt flow patterns to create micro-mixing zones that dramatically increase contacting efficiency, to double or triple that of conventional trays or packing.

Enhanced gas–liquid separation

Having created a turbulent zone on the tray, the gas and liquid need to be separated, permitting the gas to move up to the next tray while the liquid flows under gravity to the tray below. Shell has extensive knowledge and expertise in gas/liquid and gas/solid separation using centrifugal force and leverages this to design highly efficient separation zones on the tray where the co-current moving gas and liquid disengage.

Better operability

The main driver for developing the new technology is to improve gas-liquid contacting. However, this should not be achieved at the cost of operability in real-world scenarios. The design of Shell Turbo Technologies accomplishes both high performance and excellent operability, surpassing conventional tray and packing technologies.

Compared with conventional trays and packing, the new design principles greatly reduce foaming and fouling. The trays can achieve high capacity levels with even less liquid carryover. Although the pressure drop per tray is higher for Shell Turbo Technologies, it requires a lot fewer trays per column than conventional tray designs. The overall pressure drops and turn-down ratio of a contactor with Shell Turbo Technologies is similar to a conventional tray.

Efficiency in separation processes goes hand in hand with the optimisation of pressure drop. Shell Turbo Technologies employs meticulously engineered trays with optimised openings and geometries designed to minimise pressure drop while maintaining the highest level of gas–liquid contact efficiency. This delicate balance is essential to ensure that separation processes remain not only efficient but also energy-conscious. Additionally, the trays can be customised to suit the specific requirements of various processes and applications, thus further optimising performance while reducing energy consumption.

SHELL TURBO TECHNOLOGIES: A GAME-CHANGER IN GAS PROCESSING

The key element of the Shell technology (Figure 3) is the combination of contacting and separation zones in one integrated tray package that can easily be retrofitted into existing absorber columns.

In the contacting zone, natural gas and the solvent are thoroughly mixed and contaminants are absorbed from the gas. Liquid enters into the contacting box through liquid ports or slits at the base of the contacting box, while gas rises from the tray below and flows into the contacting box through gas inlet channels (Figure 4: 1).

In the contacting box, upward co-current flow allows time for the absorption of contaminants from the gas by the solvent (Figure 4: 2). Next, the gas–liquid mixture enters a swirl tubes located just above the contacting box that serves as a separation zone (Figure 4: 3). Here, the centrifugal force generated by the swirl tube sends the liquid towards the wall to drive effective gas–liquid separation. A specially designed cap at the top of the swirl tube then deflects the liquid towards the outside of the tube, where it collects in the liquid pool on the tray while the liquid-free gas exits from the top of the cap.

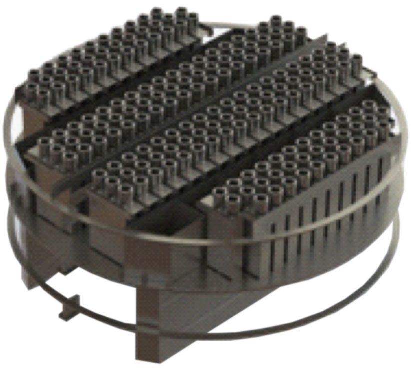


Figure 3: Shell Turbo Technologies tray assembly ready to fit in a column.

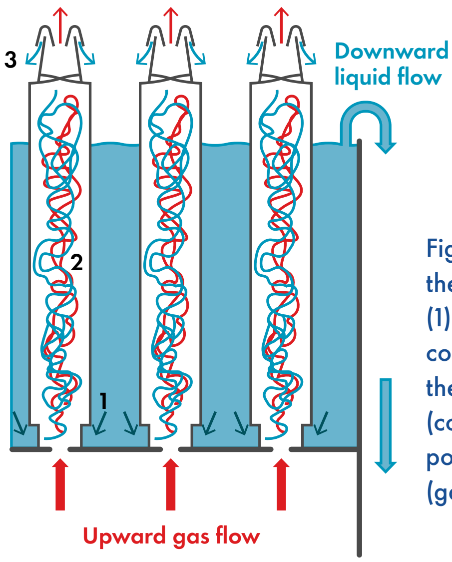


Figure 4: Schematic diagram of the gas and liquid flows. Point (1) shows liquid entering the contacting box, point (2) shows the absorption of contaminants (co-current upward flow) and point (3) shows the swirl tube (gas–liquid separation).

At column scale, the liquid and gas flows are counter-current (gas moves up while the liquid solvent moves down). However, on each tray within each element, gas and liquid flow co-currently. The overall flow patterns of gas and liquid within a column are shown schematically in Figure 4.

HOW WELL DO SHELL TURBO TECHNOLOGIES WORK?

Shell Turbo Technologies' tray design achieves near-equilibrium conditions rapidly within the contacting boxes, thus ensuring optimal mass transfer and improved hydraulic performance (Figure 5). This intense contacting process leads to impressive separation efficiency, making it an invaluable asset for brownfield projects looking to enhance their existing infrastructure without costly replacements.

In addition, they operate over a much wider range of F-factors (vapour load) than other contacting technologies (Figure 6).

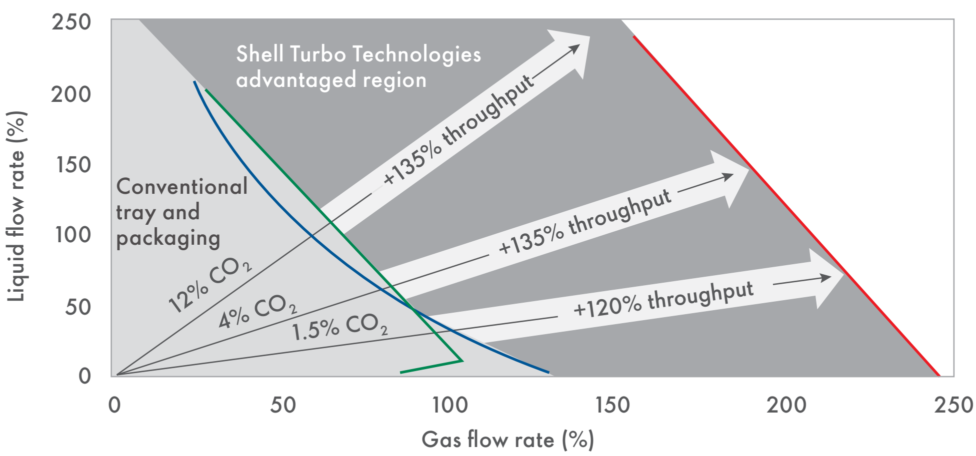


Figure 5. Hydraulic performance of Shell Turbo Technologies compared with that of conventional trays and packing.

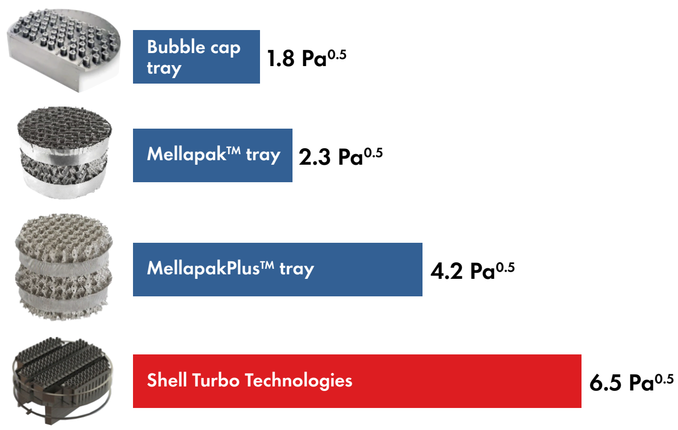


Figure 6: F-factors of different contacting technologies.

What makes Shell Turbo Technologies truly game-changing in the brownfield context is their ability to offer a seamless and efficient drop-in solution for existing absorber columns. This means minimal disruption to ongoing operations while unlocking the technology's efficiency-boosting capabilities. For industries looking to upgrade and modernise their gas processing facilities without undergoing extensive overhauls, Shell Turbo Technologies offer a clear advantage.

Moreover, compared with traditional structured packings, Shell Turbo Technologies excel in robustness thanks to the higher liquid content within the column. This critical attribute prevents contaminant breakthrough during well switchovers, thus ensuring consistent and reliable performance even in challenging operational scenarios.

Shell Turbo Technologies deliver remarkable capacity increases of up to 100% for CO_2 and H_2S removal and up to 200% for TEG dehydration. The technology also addresses foaming issues, reduces operational complexity and facilitates the processing of more challenging feed streams, **with the potential for up to a 300% increase in feed CO_2 concentration**. These benefits collectively establish Shell Turbo Technologies as a transformative force in the field of gas processing, offering unparalleled efficiency, versatility and adaptability, particularly in brownfield applications because of seamless integration into existing infrastructure.

HOW DO SHELL TURBO TECHNOLOGIES PERFORM IN THE REAL WORLD?

Proof point 1: Debottlenecking an AGRU

The operator of a natural gas treatment facility using Sulfinol*-X gas processing technology (licensed by Shell) wanted to debottleneck the sour gas absorber but was concerned that upgrading the unit would be expensive and would disrupt operations. Previous attempts to increase natural gas throughput had led to H_2S levels significantly exceeding regulatory limits (Figure 7).

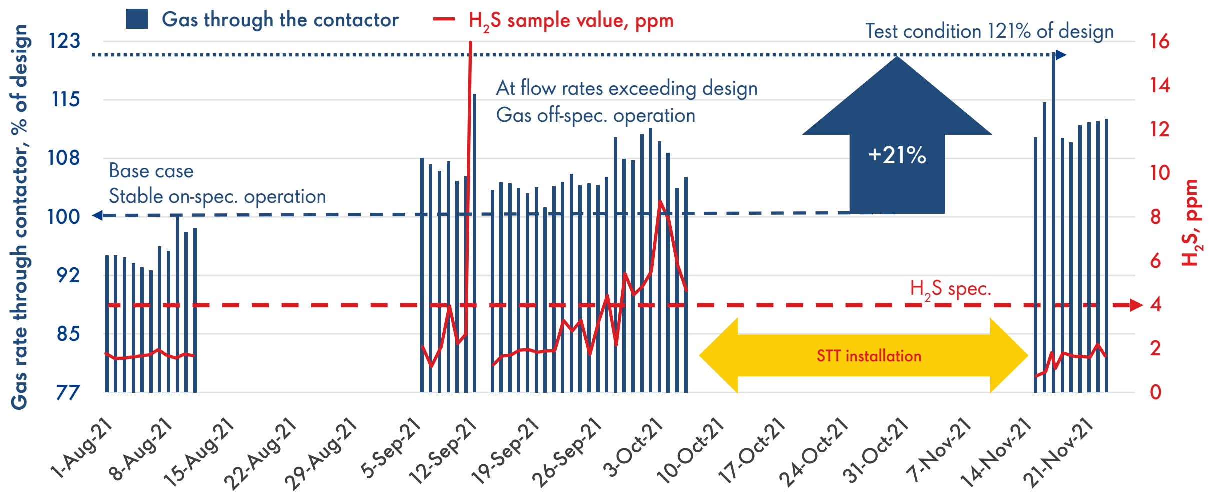
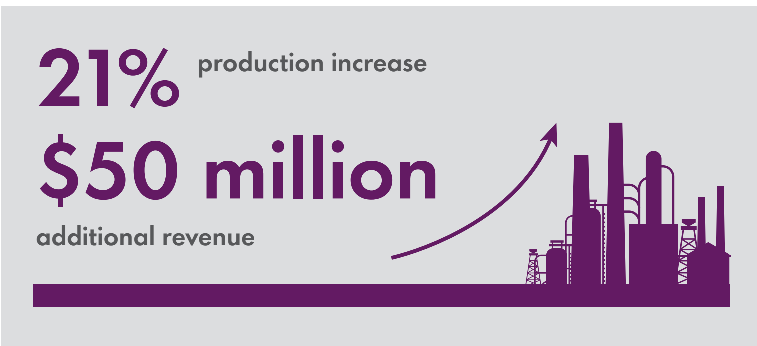


Figure 7: Shell Turbo Technologies enabled the operator to increase natural gas production capacity by more than 20% while keeping H_2S levels within specified limits.

Following consultation with experts from Shell Catalysts & Technologies, the operator opted to install Shell Turbo Technologies, which could be integrated into the existing absorber column without the need for up- or downstream modifications, thus minimising facility downtime.

Deploying Shell Turbo Technologies together with Shell's Sulfinol-X solvent **increased natural gas production capacity by more than 20% while keeping H_2S levels within specified limits** (Figure 7). This increased capacity has the potential to unlock an extra $50 million of revenue per year[5].

Furthermore, debottlenecking the natural gas processing facilities enabled the operator to increase light crude oil production by as much as 8,000 barrels per day, **unlocking up to $200 million in additional annual revenue[6]**.



[5]Assumes a natural gas price of $5 per million Btu

[6]Assumes a crude oil price of $70 per barrel

* Sulfinol is a Shell trademark

Proof point 2: Enhancing TEG dehydration train capacity

The operator of a natural gas treatment facility using Sulfinol-X gas processing technology (licensed by Shell) wanted to debottleneck the sour gas absorber but was concerned that upgrading the unit would be expensive and would disrupt operations. Previous attempts to increase natural gas throughput had led to H_2S levels significantly exceeding regulatory limits (Figure 8).

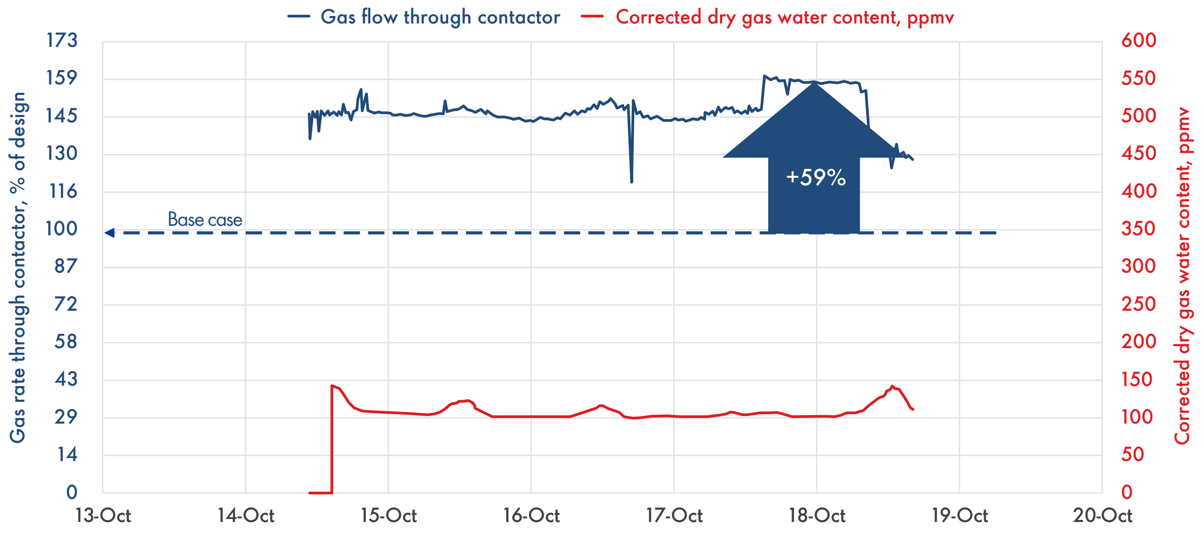
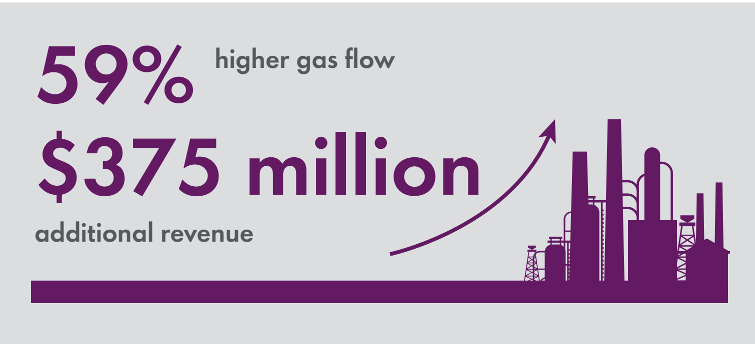


Figure 8. TEG dehydration column gas flow and dry gas water concentration. Following the installation of Shell Turbo Technologies, gas flow increased by 59% (top) while treated gas remained within the moisture specification limit (bottom).

In this specific case, the primary aim was to enhance the capacity of one of the trains, thus enabling more streamlined operation with fewer trains. However, it is worth noting that, had the goal been to expand the overall capacity of the system, adopting Shell Turbo Technologies would have translated into a substantial increase of $375 million in annual revenue. This would have resulted in a very rapid return on investment. Additionally, this project not only reduced glycol losses but also led to improved personnel efficiency and productivity.

The client has also chosen Shell Turbo Technologies for another application where increased TEG dehydration capacity is required, with the ultimate goal of meeting export pipeline capacity limits. The alternative option would be to add another TEG unit in parallel, which would take more than two years and cost over $70 million to complete.



CONCLUSIONS

Shell Turbo Technologies offer significant advantages for gas-processing facilities. The innovative design improves column hydraulics and enhances mass-transfer efficiency. The innovative co-current liquid and gas contact on each tray can lead to substantial reductions in column size or increased throughput, which is particularly beneficial for brownfield applications. Rigorous testing and successful commercial unit operation have validated the trays' suitability for and impact on gas-processing facilities.

In practical terms, Shell Turbo Technologies can potentially triple gas-processing capacity in existing columns, handle higher contaminant loads, reduce absorber costs in greenfield applications by up to 50% or effectively debottleneck absorbers in brownfield setups. These benefits extend to improving AGRU performance in project-specific conditions through, for example, tolerance to tilting, fouling resistance, and addressing transport and construction limitations linked to column size.

Although this technology is currently exclusive to Shell and its joint venture facilities, Shell Catalysts & Technologies has received authorisation to explore a limited number of deployments to the broader market. We are offering insights into this cutting-edge contacting technology as we actively search for high-value opportunities and partnerships.

If your company aims to significantly enhance the capacity of existing AGRU and/or TEG dehydration units constrained by the absorber column, or wishes to avoid adding new trains, we encourage you to explore the potential advantages of this technology.

ABOUT SHELL CATALYSTS & TECHNOLOGIES

Shell Catalysts & Technologies exists to provide Shell and non-Shell businesses with tools, technologies and insights to help navigate the energy transition.

We are…

…pushing boundaries in the energy transition space. For decades, we have been developing game-changing technological innovations to solve seemingly insurmountable challenges. Now we have, or are developing, a wide range of differentiated solutions that offer attractive decarbonisation opportunities, including biofuels, carbon capture and decarbonised (blue) hydrogen technologies.

…an owner–operator–licensor. What sets us apart is the knowledge we have gained from Shell's corporate heritage as the operator of refineries and petrochemical plants around the world. It also gives us a unique perspective on how refiners can remain competitive as, for example, demand for transport fuel declines.

…a leader in the molecular engineering of hydrocarbons. Our world-class catalyst and research and development expertise has enabled us to establish an enviable track record for developing leading-edge zeolites and catalysts, advanced solvents and pioneering processes, and provides a strong foundation for our future technology development.

For further information, please visit our website at **www.shell.com/ct**

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