Internals for carbon capture plants

Koch-Glitsch is using its extensive experience to design cost-effective, energy efficient internals for post-combustion capture columns that still give optimum performance even for towers exceeding 20m diameter.

Traditional vs. Post Combustion CO2 Capture Design

For many years, various industries, such as fertilizer and gas processing, have used processes to remove carbon dioxide from gas streams. The majority of these processes use a chemical solvent (amine, hot carbonate, and so forth) or physical solvent (propylene glycols or chilled methanol) in an absorption tower that contains either trays or packing for contacting the solvent with the acid gas in the gas stream.

Over the years, Koch-Glitsch engineers have worked on hundreds of these columns and have developed industry leading design knowledge for the internals these towers need.

Post combustion CO2 capture processes present new challenges to the designers of mass transfer internals due to the differences in operating conditions compared to traditional CO2 absorption.

Traditional acid gas removal processes operate at high pressure with the result that even relatively low CO2 concentrations in the gas have a high partial pressure. In most traditional acid gas removal systems, the actual solvent recirculation is significantly more than the theoretical minimum solvent rate.

These two factors allow even relatively low technology equipment to provide reasonable performance. In a post-combustion CO2 capture plant, CO2 is removed from the flue gas at slightly higher than atmospheric pressure. Even at inlet concentrations of 10-15% CO2, the resulting partial pressure will be relatively low.

To minimize the parasitic energy demand required to regenerate the solvent it is crucial to minimize the solvent recirculation rate.

• Under these conditions, any maldistribution of liquid or vapor can cause a pinch between the operating and equilibrium line and will result in exit gas with higher CO2 levels than desired.

• Increasing the solvent recirculation rate above the desired design rate will result in a significant increase in the parasitic energy demand. This phenomena is illustrated in Figure 2.

The design requirements for column internals in post-combustion CO2 capture plants are, therefore, significantly more difficult than those for conventional acid gas removal plants. These additional requirements are well understood by Koch-Glitsch engineers. Using INTALOX™ Packed Tower Internals technology, which has been proven in numerous packed super fractionators, Koch-Glitsch can provide you with the internals to minimize the parasitic energy demand of the regenerator.

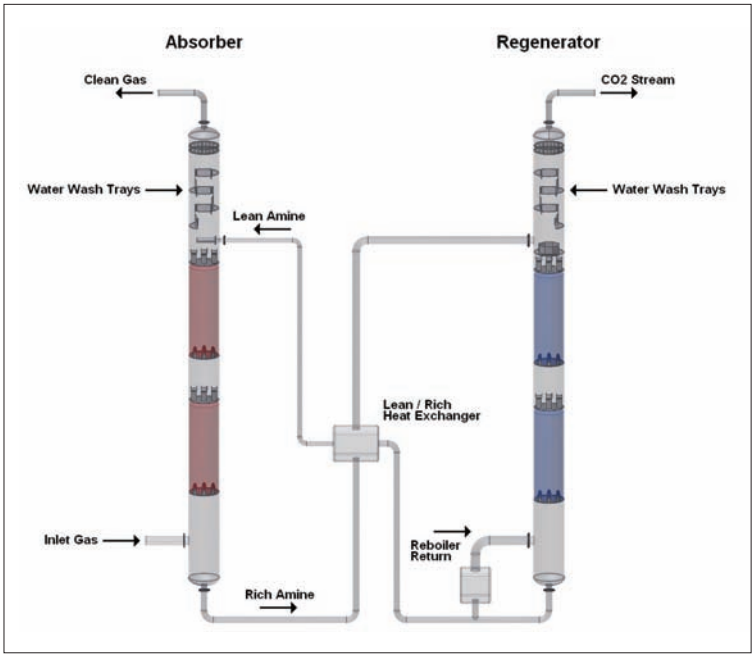

Figure 1 - Absorber and regenerator columns and piping

Size Matters

Commercial-scale post combustion carbon dioxide absorbers and regenerators will be very large because of the volumes of flue gas emanating from power plants. Tower diameters exceeding 20 m (65 ft) will not be unusual. The large dimensions present several challenges:

• Supporting the weight of packed beds and tower internals

• Proper leveling of liquid distributors to ensure good distribution

• Providing good vapor distribution

• Installing equipment in large diameter towers

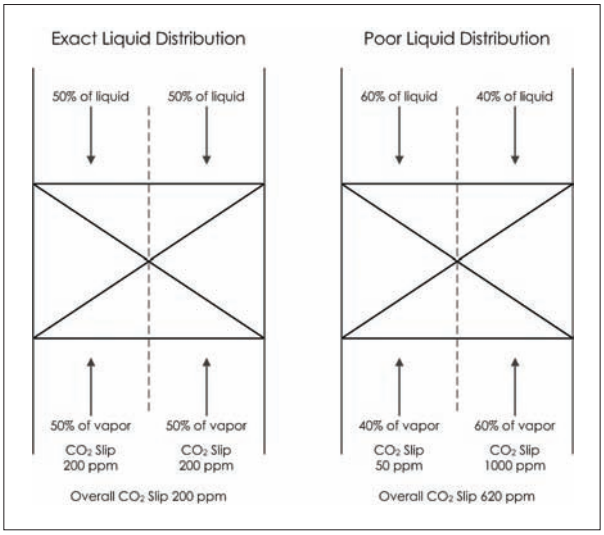

Figure 2 - Any maldistribution of liquid or vapor can cause a pinch between the operating and equilibrium line and will result in exit gas with higher CO2 levels than desired

Koch-Glitsch has extensive experience handling each of these challenges.

Liquid Distribution

INTALOX™ high performance liquid distributors apply the following ideal attributes:

• Uniform distribution over the entire cross sectional area of the tower

• Proper operation through the operating flow range

• Low vapor phase pressure drop

• Resistance to plugging or fouling

• Optimal use of vessel height

Good liquid distribution depends on equal liquid levels throughout the distributor. Orifice flow is directly proportional to the liquid head above it and can be uneven if the distributor is not precisely leveled. Koch-Glitsch offers trough distributors with discrete drip points or enhanced baffles that are easily and accurately leveled. Both distributors can be supported directly on the structured packing.

This approach is beneficial for extremely large towers where mechanical deflection becomes an issue. Independent leveling mechanisms for each part of the distributor ensure point to point liquid flows are within the criteria for good liquid distribution.

This strategy has been applied to many critical distillations in tower diameters up to 12 m (40 ft.) and proven on Koch-Glitsch's liquid distributor test facility.

Figure 3 - Test of 12.2 m (40 ft) diameter High Performance INTALOX™ Model 156 Liquid Distributor

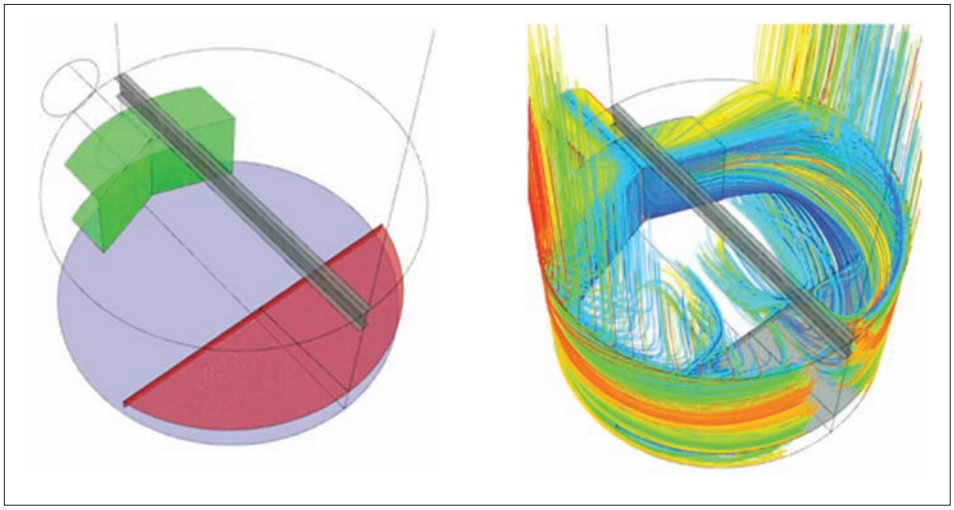

Figure 4 - Koch-Glitsch uses computational fluid dynamics (CFD) modeling technology to analyze the performance of existing equipment or to develop new designs

Vapor Distribution

Good vapor distribution is essential to achieve superior separation efficiency. Poor vapor distribution can lead to vapor/liquid channeling and reduced packing efficiency. Distributing the inlet gas evenly across the entire tower cross section in a very large tower is challenging.

Koch-Glitsch uses computational fluid dynamics (CFD) modeling technology to analyze the performance of existing equipment or to develop new designs. Computer modeling of the three dimensional configuration of the column internals provides detailed predictions of fluid flow.

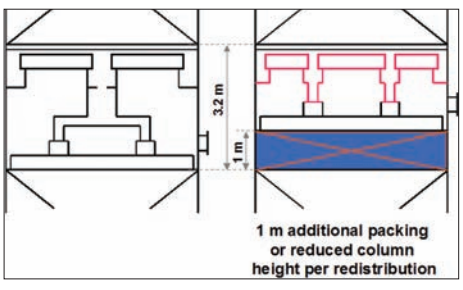

Figure 5 - Mixing drum vs. collector

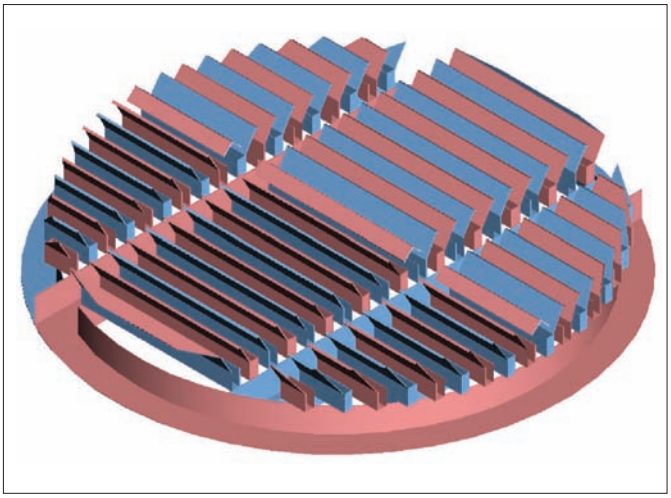

Figure 6 - Koch-Glitsch has developed a patented Cross Mixing Vane Collector that can minimize the space required for liquid mixing, which can result in significant vessel cost savings.

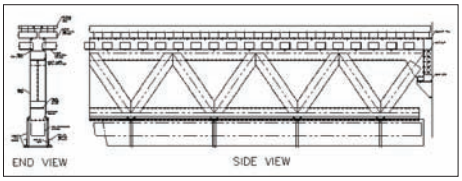

Figure 6 - The patent pending FLOW-THRU™ truss design combines the functions of support truss and liquid collector

Using this comprehensive approach with patented vapor distribution technology has proven very successful in towers as large as 15 m (50 ft.).

Liquid Mixing

In the absorber column, the required packing volume is likely to be split into two or more beds. Even in columns with excellent liquid and gas distribution, small differences will exist in the liquid to vapor ratio. These differences will result in variations in the CO2 content in the solvent across the column.

To ensure these variations do not cause a pinch further down the column, any liquid coming from a higher bed must be thoroughly mixed before being distributed to the lower bed. The column height necessary to perform this mixing can be very expensive in columns with large cross sectional area. Historically mixing between packed beds has been done using mixing chambers or tanks that take up valuable column height.

Koch-Glitsch has developed a patented Cross Mixing Vane Collector that can minimize the space required for liquid mixing, which can result in significant vessel cost savings. As illustrated in Fig. 5, liquid from all points in the column is strategically moved to provide complete mixing prior to delivery to the bed below.

An alternative to the Cross Mixing Vane Collector is an integrated internals design concept. The patent pending FLOW-THRU™ truss design combines the functions of support truss and liquid collector. The weight of packed beds in CO2 capture systems can exceed 300 metric tons (330 tons). To support the weight, allow free passage of vapor and liquid, and keep costs down requires unique beam designs with a minimized footprint and lower material usage.

The combined functionality of the FLOW-THRU™ truss design allows for a more robust structure without consuming valuable cross-sectional area for capacity and is better suited to higher liquid flow rates. The concept also allows for a reduction of 1-1.5 m (3.28-4.92 ft) of vessel height at each liquid redistribution point.

Hydraulic benefits include prevention of mechanical deflection induced mal-distribution, reduced liquid gradients and reduced leakage.

Equipment Installation

Installing tower packing and internals is a specialized job that requires knowledge of the equipment and years of experience. Very large towers make this job even more difficult. Koch Specialty Plant Services, Inc. (KSPS) has performed thousands of tower revamps and new installations around the world, including towers up to 15 m (50 ft) in diameter.

This experience ensures proper installation so there are no column performance issues on start-up. Combined with equipment from Koch-Glitsch, KSPS can provide turnkey services that include engineering, material procurement, project management, and field erection of vessels.

Figure 7 - Commercial scale distillation towers used to test performance of a wide range of equipment including trays, packing and vapour and liquid distribution services

Figure 8 - A complete CO2 capture pilot unit is available for testing a wide variety of solvents

Research and Development

Reliable tower designs depend on accurate performance data developed in the laboratory. Koch-Glitsch has constructed a 1.7 m (5.5 ft) diameter commercial scale distillation tower to provide better performance characterization of trays and packing.

In addition, a complete CO2 capture pilot unit is available for testing a wide variety of solvents. The use of these facilities reduces technical risk and allows for the advancement of overall tower performance.

Conclusion

Although Post Combustion Carbon Capture provides challenges for the design of mass transfer internals, Koch-Glitsch engineers, using the wealth of experience available within the organization, are able to supply cost effective, energy efficient column internals.

In fact, this has been demonstrated by a number of Post Combustion Carbon Capture pilot and demonstration units that are operating with Koch-Glitsch internals installed in them.

By having comparative performance data in the same system and operating conditions for columns of 50 mm (2 in) diameter to in excess of 15 m (50 ft) diameter, Koch-Glitsch can effectively produce tower internals arrangements that will provide you with optimum performance even in the largest of towers.

More information

INTALOX is a trademark of Koch-Glitsch, LP and is registered in the US and various other countries. FLOW-THRU is a trademark of Koch-Glitsch, LP.

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