High performance trays deliver the best capacity and efficiency

Trays with both high capacity and high efficiency can provide low cost solutions that increase profitability by improving recovery of hydrocarbons to higher value products and/or increasing throughput of existing units.

The increasing cost of energy and higher awareness of environmental concerns have led operating companies to look at ways to improve the energy efficiency of one of their highest energy consuming unit operations: mass transfer separation applications. Mass transfer is typically carried out in a separation column that contains one or more of the following: trays, random packing, and structured packing.

This article focuses on improving column performance using high performance trays to obtain significant economic rewards:

- An increase in column feed rates for the same energy consumption
- A reduction in the energy consumption for the same feed rate
- An improvement in product purity
- A reduction in absorption liquid circulation rates and a corresponding reduction in regeneration energy cost requirements
- A reduction in pollutant discharge levels with no increase in scrubbing/stripping costs

Beyond the conventional tray

Well-designed conventional trays generally provide a very economical solution for grassroots construction. However, as an operator’s throughput and product requirements increase, conventional trays become a primary constraint because of design limitations that include:

- Liquid and/or vapor maldistribution that can reduce tray efficiency and lead to premature flooding because of entrainment.
- Less-than-optimal downcomer design that can ultimately result in premature downcomer flooding.

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To enhance the performance of conventional trays, Koch-Glitsch targeted three major areas:

- Active area enhancements
- Advanced downcomer technology
- Inlet area enhancements

**Active Area Enhancements**
Research on valve types showed that small diameter valves have a higher entrainment flood capacity and higher efficiency than large diameter valves. In 1992, Koch-Glitsch introduced its patented MINIVALVE® tray technology, which included a fixed valve (VG-0) and movable valve (MV-1). FRI tests of a SUPERFRAC® high performance tray with VG-0 fixed valves showed unsurpassed efficiency over the whole operating range, even at operating conditions very close to the flood point. The results confirm that the MINIVALVE tray technology by Koch-Glitsch can be used on high performance trays to obtain good tray efficiency.

To maximize tray efficiency, it is also very important to maximize the plug flow effect by eliminating stagnant zones and retrograde flow. This is accomplished by strategic placement of proprietary push valves and other proprietary directional devices on the tray deck.

When designing a high performance tray, one has to be careful because too much push reduces tray efficiency. VG-0 valves on the SUPERFRAC tray tested at FRI demonstrated a higher efficiency than other FRI tested trays that imparted more push on the froth.

**Downcomer Enhancements**
Good valve performance alone does not ensure good tray performance. To maximize the capacity of a crossflow tray, it is imperative to make the downcomer only as big as it needs to be.

A thorough understanding of downcomer flooding mechanisms in a wide variety of services is critical to successful application of high performance tray technology.
Several semi-conical vapor tunnel downcomers patented by Koch-Glitsch follow the contour of the tower shell and free up bubbling area and area that would have been inside the downcomer. More bubbling area can be freed up by truncating the vapor tunnel downcomer and populating the area underneath with bubbling devices.

For truncated downcomers, it is important to give special attention to how the liquid exits the downcomer. Koch-Glitsch has several patented arrangements that direct the exit of the liquid from the downcomer:

- At the back of the truncation plate.
- Between the downcomer apron and the truncation plate.
- Through louvers in the truncation plate.

The vapor tunnel downcomer, and in particular the truncated vapor tunnel downcomer, maximizes the liquid flow path length, which maximizes the crossflow effect, which increases tray efficiency.

Oversizing the downcomer reduces the bubbling area and disengagement area of the tray. Advanced downcomer technology by Koch-Glitsch provides the capability to accurately size and shape the downcomer. This provides multiple options in the design and the relative dimensions depending on the particular application.

**Inlet Area Enhancements**

Bubbling area is only effective if bubbling actually takes place. An inlet weir and bubble promoters help ensure that the liquid from the downcomer starts bubbling right away, and that the active area gained by the vapor tunnel or truncated vapor tunnel downcomer is fully utilized.

Inlet area enhancements can provide improved capacity, better froth initiation, and improved bubbling activity on the tray, and thus increase vapor-liquid contact efficiency. SUPERFRAC trays use inlet area enhancements to eliminate the vapor and liquid maldistribution and stagnant zones that can occur on conventional trays. These enhancements promote uniform flow distribution, which improves the hydraulic performance and contact efficiency on the tray.

**SUPERFRAC Tray Technology**

Over twenty years of research and testing has led to a proprietary toolbox of technologies that is the SUPERFRAC tray:

- High capacity and high efficiency valves in sizes to meet different application requirements.
- Vapor tunnel or truncated vapor tunnel downcomers with various downcomer outlet shapes to maximize tray capacity and efficiency.
- Inlet weir and bubble promoters.
- Push valves and other directional devices.
- Multi-pass arrangements.
- Special anti-fouling features.
- Mechanical innovations to simplify installation.

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Significant economic rewards can be achieved by using trays with good capacity and efficiency.

Reduced efficiency drives up the energy cost of a distillation tower because more reflux is needed to achieve the desired separation. The additional reflux reduces the capacity of the tower because it consumes part of the tray capacity.

The influence of tray efficiency on the economics of a distillation operation is particularly pronounced for trays with a large number of downcomers and short flow path lengths. Using a SUPERFRAC tray design that is optimized for efficiency and capacity can yield a significant reduction in energy consumption and an increase in throughput.

In a distillation operation with a large number of downcomers and short path lengths, the options are to reduce the tray spacing to counter the loss in tray efficiency. This drives up the cost of the tray and creates installation issues. It also reduces the capacity of the trays. The only solution is to use trays that have high efficiency and capacity.

The superior efficiency and capacity of high performance SUPERFRAC trays can be used to extend the efficient capacity of towers to well beyond that of other high performance trays. The features used on these trays must be carefully selected to achieve the right balance between performance and cost. Given the cost of equipment and energy, it makes sense to pay special attention to the performance of trays in distillation towers.

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