

Performance of ULTRA-FRAC[®] Trays in Light Hydrocarbon Service

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ABSTRACT

Field data on mass transfer performance of ULTRA-FRAC trays have been collected from a number of commercial installations and analyzed using process simulation to obtain tray efficiency estimates. Pertinent applications include deethanizers, depropanizers, and debutanizers, where surface tensions are extremely low. Performance is compared with conventional crossflow trays and evaluated in terms of the O'Connell correlation. Although exact details of ULTRA-FRAC trays cannot be given, reasons for the efficiencies found are discussed.

Introduction

ULTRA-FRAC trays represent a technology with unheard-of vapor and liquid handling capacity—typically 50% to 60% greater vapor capacity and 200% to 300% greater liquid capacity than any of the so-called high performance trays. ULTRA-FRAC trays also have extremely good rangeability (turndown).

When discussing ULTRA-FRAC trays, Bravo and Kusters (2000) stated, "Efficiencies appear to be in the range of those achievable with normal trays, but this still is subject to confirmation." Bravo and Kuster's comment is well take. ULTRA-FRAC trays are not crossflow trays and cannot benefit from crossflow efficiency enhancement. They must operate instead with point efficiency. The question is, "What point and overall efficiencies should one expect for ULTRA-FRAC trays in light hydrocarbon service?" The purpose of this paper is to provide the confirmation that Bravo and Kusters sought.

Field Experiences

To date, Koch-Glitsch, Inc. has some 19 field experiences with ULTRA-FRAC trays in the United States, Canada, UK, Spain, the Middle East, Australia, and Russia, for the most part in light hydrocarbon (deethanizing, depropanizing, and debutanizing) service. Tower diameters

range from 1.5 m (5 ft) to 4.6 m (15 ft). For many of these columns, operating and performance data have been collected.

The operating data for a tower generally consist of tower feed, product, utility, and reflux stream flows, pressures, temperatures, and compositions, together with tower nozzle locations. Each tower was process-simulated using one of the commercial simulation packages and the efficiencies of the trays in the stripping and rectification sections (or sometimes a single overall column efficiency) were adjusted until a match was obtained between measured and simulated product compositions with respect to the key components. This is a somewhat tedious process but, given good material balances around the tower, relatively straightforward. To improve the reliability of the results, the tower product streams frequently had to be tied back into a synthesized feed stream.

The field results obtained are summarized in Table 1 where they are compared with predictions from the O'Connell correlation. The O'Connell correlation is perhaps the most popular, and certainly the most successful, publically-available correlation for overall column efficiency. It is:

$$E = 0.492(\mu_L \alpha)^{-0.245}$$

where the liquid viscosity, μ_L , is in centipoise, and the tower-average relative volatility is α .

The most important observation from Table 1 is that in every field experience the efficiency of ULTRA-FRAC trays is between 75% and 90%, making them quite efficient trays indeed. In fact, as the comparison between the predictions from the O'Connell correlation and the data in this table shows, they have almost exactly the efficiency that the O'Connell correlation would predict for a conventional crossflow tray!

ULTRA-FRAC trays are comprised of unit cell devices in which phase contact, via biphasic formation, and mass transfer take place. The residence time of the biphasic is quite short, on the order of only one second, yet that contact time produces an on-average 80%

**Table 1 ULTRA-FRAC Tray Efficiencies Measured in the Field
Compared With Predictions From the O'Connell Correlation
for Various Light Hydrocarbon Services**

Service	Relative Volatility	Liquid Viscosity (Cp)	Predicted Efficiency (%)	Field Observed Efficiency (%)
Debutanizer	2.23	0.113	70	75-85
Demethanizer	4.03	0.040	77	
Deisobutanizer	1.42	0.110	78	
Depropanizer	2.14	0.141	79	78-82
Deethanizer	2.33	0.054	82	75-90
C3 Splitter	1.14	0.088	89	
C2 Splitter	1.39	0.057	91	

efficient mass exchange between the phases. The reason for this high efficiency is the quality of the biphasic.

Laboratory visual observation of the flows within an ULTRA-FRAC unit cell reveals that the biphasic consists of a finely-dispersed vapor within a continuous liquid at high liquid rates, and a finely-dispersed liquid within a continuous vapor at low liquid rates. Conventional crossflow trays tend to operate unstably, with large geysers of liquid randomly jetting from the biphasic, i.e., with a biphasic that exhibits both small-scale and very large-scale turbulence (implying large volumes of vapor with poor contact). ULTRA-FRAC trays exhibit little or no large-scale, violent, turbulent fluctuations. The biphasic is more uniform and the dispersions are finer than with crossflow trays. This fineness of the biphasic probably accounts for the high efficiency of ULTRA-FRAC trays despite the fact that the actual contact time between the phases is quite short.

For crossflow trays at low liquid rates, a fine dispersion of liquid droplets in a continuous vapor spells high entrainment and flooding. This does not happen with ULTRA-FRAC trays. The centrifugal-flow character of these trays allows them to become highly efficient deentraining devices at low liquid rates, while the concomitant fineness of the biphasic allows them to retain their high efficiency. Therefore, ULTRA-FRAC trays will be highly efficient over a very wide range of operating conditions. Currently, this type of thinking is being tested by gathering mass transfer performance data over a wide range of operating conditions in a commercial-scale research tower located within Koch Hydrocarbon's NGL fractionation plant near Medford, Oklahoma. This is a 5-ft diameter depropanizer called the "Swing Depropanizer", or "4P" (see Figure 1).

As described by Angelino *et al.*, this column was completely refurbished earlier this year. It has new feed and reflux nozzles, additional manways, and can operate in production (60 trays) and research (40 trays) modes, in either case with a mid-tower feed. The tower is equipped with high quality mass flow meters, multiple sample ports and pressure taps, and an abundance of thermocouple wells. For the current tests, the Medford research tower is being run with 40 ULTRA-FRAC trays. The tests are designed to show how ULTRA-FRAC tray efficiency depends on both vapor and liquid flow rates through the tower. These new results will be used to validate and modify insights into the separation performance of ULTRA-FRAC trays in light hydrocarbon service.

Conclusions

In addition to their extraordinary vapor and liquid handling capacity, ULTRA-FRAC trays have efficiencies comparable to crossflow trays. Measured efficiencies range from 75–85% for debutanizers to 75–90% for deethanizers. ULTRA-FRAC tray efficiencies are well predicted by the O'Connell correlation.

References

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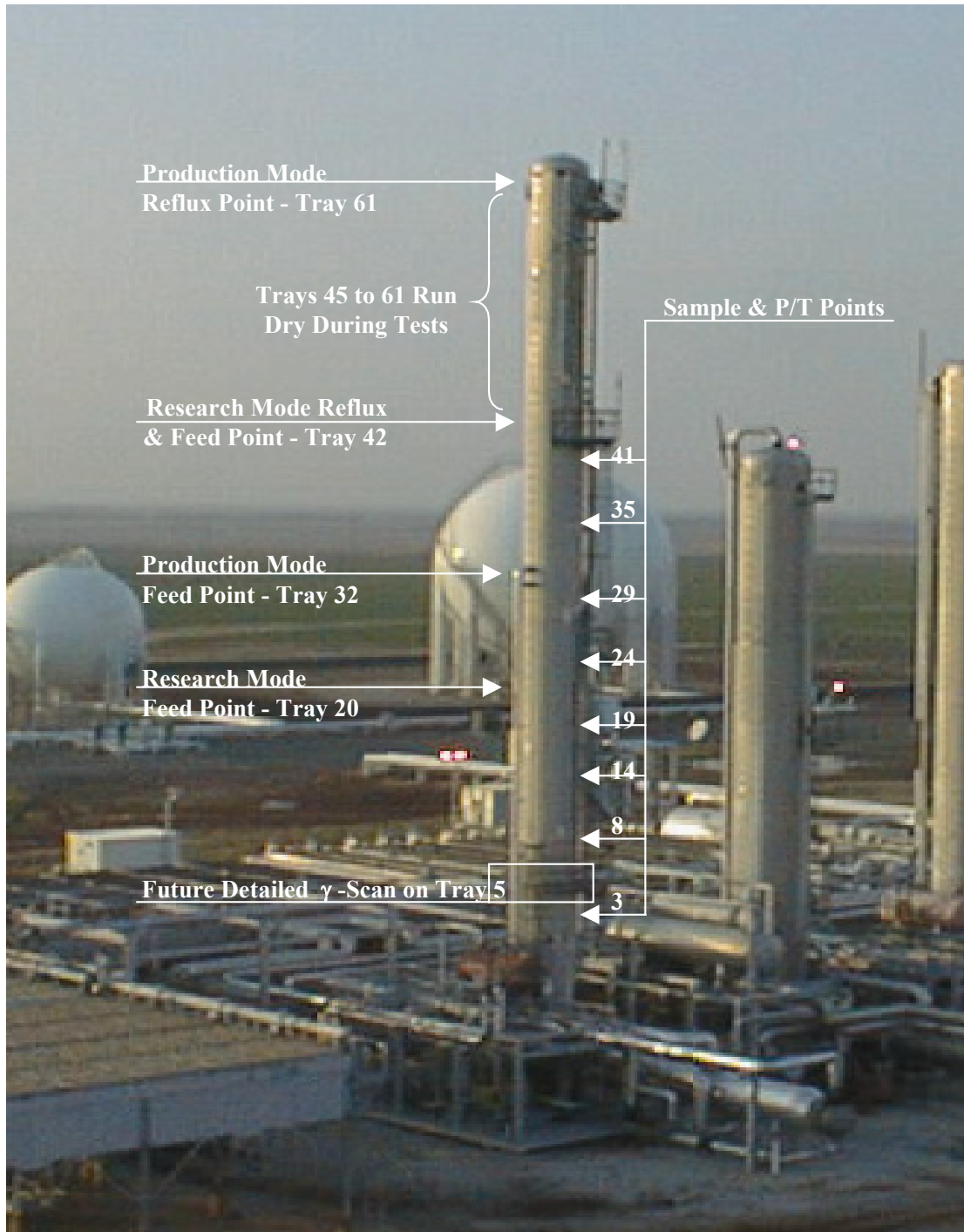


Figure 1 The Koch-Glitsch Research Tower Within the Koch Hydrocarbon Company NGL Separation Plant, Medford, Oklahoma. ULTRA-FRAC Tray Efficiencies Are Currently Being Collected Here as a Function of the Vapor and Liquid Loads in the Stripping and Rectifying Sections.