The **KITTEL**™ II Tray: Using a Round Peg in a Round Hole

Izak Nieuwoudt, Ralph H. Weiland, Jeff DeGarmo & Eric Cole
Koch-Glitsch, LP
Wichita, KS & Dallas, TX

Abstract

KITTEL™ Trays have a radial liquid-flow pattern that is inherently much better suited to the circular cross-section of distillation columns than typical cross-flow trays. On alternate KITTEL trays, the liquid flows radially from the column center to the column wall, and from the wall back to the center. The original version of the KITTEL tray was sold mainly into gas processing applications by Johann Stahl GmbH. By the time Stahl's tower internals business was acquired by Koch-Glitsch LP, there were more than 180 columns containing traditional KITTEL trays in use world-wide.

Koch-Glitsch LP has been engaged in a development program to modernize the KITTEL tray. This has been done in part by applying our patented tray technology, but it has also involved the invention of some completely new approaches. The result is the **KITTEL**™ II Tray, which has vapor and liquid handling capacities that put it somewhere midway between the very best that can be obtained from cross-flow trays and our extremely high capacity **ULTRA-FRAC**® Tray.

In addition to the collection of comprehensive, hydraulic data from air-water simulators, efficiency measurements on KITTEL II trays at 12-inch tray spacing have been made in our hydrocarbons research column, a depropanizer, located within the Medford, Oklahoma complex of Koch Hydrocarbon, LP. In terms of research facilities, the Medford column is rather unique. The KITTEL II trays showed good efficiencies in the Medford depropanizer. Capacity measurements in Medford confirmed that the KITTEL II tray has a higher capacity than the best cross-flow trays. This capacity advantage, as well as the good efficiencies, was re-confirmed in a recent debutanizer application.

Paper for presentation at the AIChE Spring Meeting, New Orleans, LA, April, 2004.

1. Introduction

Crossflow trays have been the workhorse mass transfer device of the refining and chemical sector for a very long time. It is easy to see that the liquid flow profile of these trays would best suit a column with a rectangular cross-sectional area. Rectangular distillation columns exist – for instance in high temperature metals distillation. However, the columns in the refining and chemical sector have circular cross-sectional areas. The problem with a circular cross-sectional area is that both the downcomer exit and the weir are shorter than the column diameter. The liquid thus has to be fanned out across the tray and focussed again to get it into the downcomer. Engineers have devised several vanes, weir modifications and valve modifications to try and even out the liquid flow across the tray. It was shown that failing to do this might lead to flow patterns which may limit the tray capacity and harm the mass transfer performance. However, in crossflow trays the designer is constantly fighting a mismatch between the tray and column geometry, akin to driving a square peg into a round hole. Wouldn't it be better to put a round peg into a round hole?

Walter Kittel, who had a prolific patenting spell in the 50's and 60's, provided one possible solution. He developed and patented several radial-flow tray ideas. In 1958, Kittel developed a radial flow tray that was commercialized (1). A sketch of the tray, taken from the patent, is shown in Figure 1.

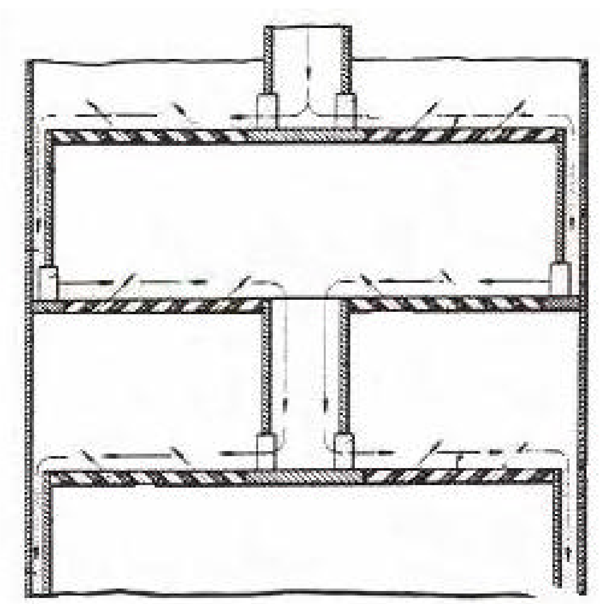

Figure 1: Sketch of KITTEL radial flow trays (1)

2. Original KITTEL tray

The German engineering company, Johan Stahl GmbH, had done 180 KITTEL installations by the time it was acquired by Koch-Glitsch in 1999. These trays typically have been used in high liquid rate applications running at pressure from 12 psig to 1080 psig. A picture of the trays as they have been manufactured by Stahl is shown in Figure 2.

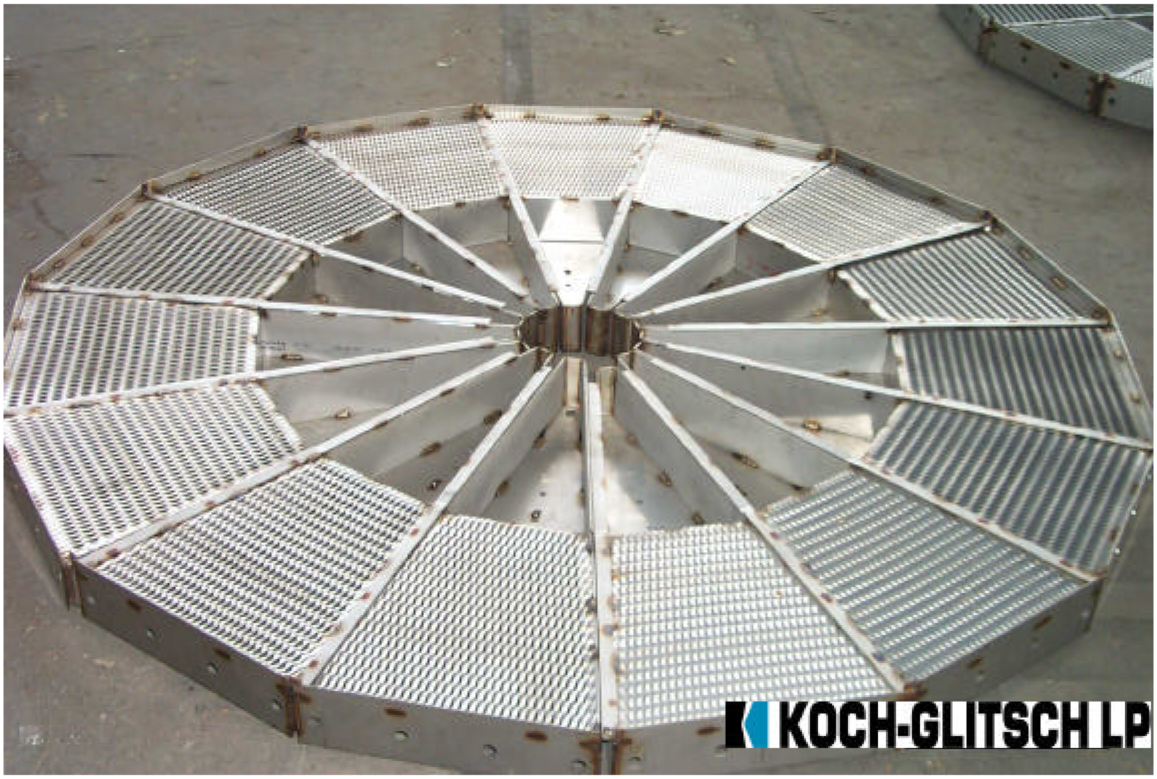

Figure 2: Original KITTEL design

It is clear that this tray design with its radial liquid-flow patterns is much more like a round peg in a round hole. The question is, however, whether this layout offers efficiency and capacity benefits. The original KITTEL tray was compared with an advanced crossflow tray in the 7-ft diameter Koch-Glitsch air/water column in Dallas. As is shown in Figure 3, the original KITTEL design gave jet flood capacities similar to those of an advanced crossflow tray at low liquid loads. At high liquid loads, the jet flood capacity of the advanced crossflow tray was higher than that of the original KITTEL tray.

3. The KITTEL II tray: An improved radial-flow tray

It was clear that the KITTEL tray had several attractive geometric features. Upon studying the tray it became evident that several improvements were possible. These included improvements to the active deck layout, the layout of the downcomers and the mechanical construction. The improved KITTEL II tray was extensively tested in the Koch-Glitsch 7-ft diameter air/water tower in Dallas. Some of the test results are shown in Figure 3. A comprehensive set of KITTEL II design correlations was developed from the air/water studies.

At low liquid rates, the KITTEL II tray has up to 25% higher vapour handling capacity than the original KITTEL tray. At high liquid loads, the KITTEL II tray has up to 40% higher vapour handling capacity than the original KITTEL tray. More significant is the fact that the KITTEL II tray has about 15-20% more capacity than the best advanced crossflow tray.

Based on these results, the KITTEL II tray can be classified as a high capacity tray capable of handling high liquid loads.

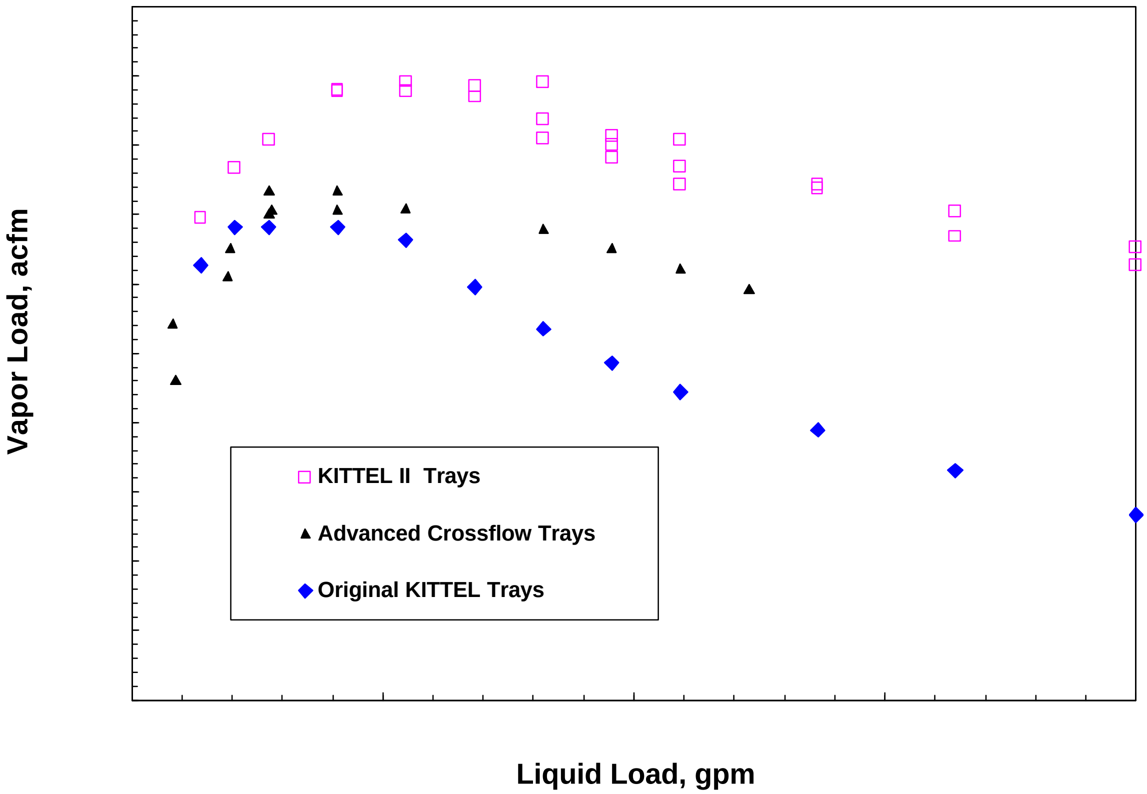

Figure 3: Comparison of capacities of KITTEL II trays, Advanced cross-flow trays and original KITTEL trays

4. Determining KITTEL II tray efficiency in an industrial column

In 2001, the Koch Hydrocarbon LP Medford No. 4 depropanizer (4P) was converted into a research tower [2] (see Figure 4). In making this conversion, it was important to ensure that the column would still function as a commercial depropanizer. The following additions, amongst others, were made:

- Mass flow meters
- Additional T, P and sampling points
- Changing the reflux location and reducing the tray count to get steeper composition and temperature profiles

The details of the Medford tower operation were described in a recent paper [2] dealing with the efficiency of the high capacity ULTRA-FRAC tray.

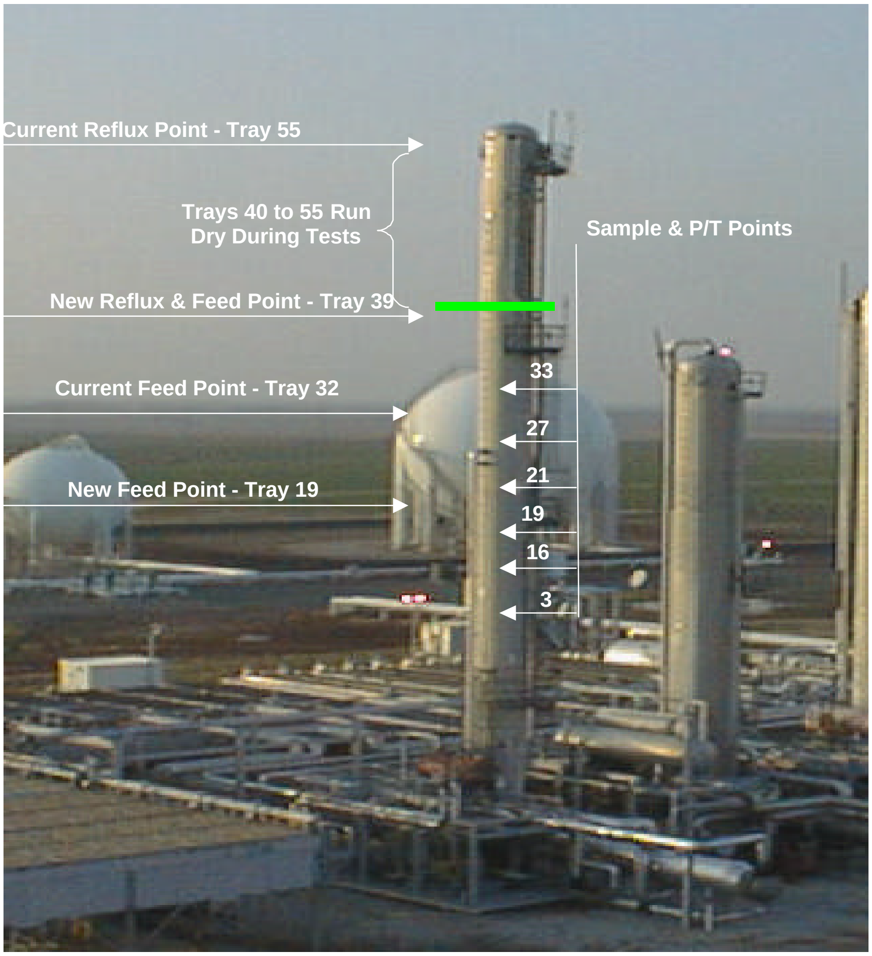

Figure 4: Medford depropanizer (5 ft diameter)

In 2003, the Medford depropanizer was fitted with KITTEL II trays on a 12-inch tray spacing. Historically, the vast majority of the original KITTEL tray installations had been in absorption service. The purpose of the project was to acquire efficiency data on the KITTEL II tray in hydrocarbon service.

Efficiency data were collected over a wide operating range. The trays were pushed to the point of incipient flooding. The efficiency results are shown in Figure 5. The Medford results confirmed the capacity data from the Dallas air/water column studies as well as the Koch-Glitsch design correlations.

Comparing the Medford KITTEL II results with the ULTRA-FRAC tray results that were also generated in Medford, and with **SUPERFRAC®** advanced crossflow tray results from Koch-Glitsch's vast installation base, it can be concluded that the capacity of the KITTEL II tray is between that of the SUPERFRAC and ULTRA-FRAC trays.

The Medford studies underlined that the KITTEL II tray is a high capacity mass transfer device with good tray efficiency.

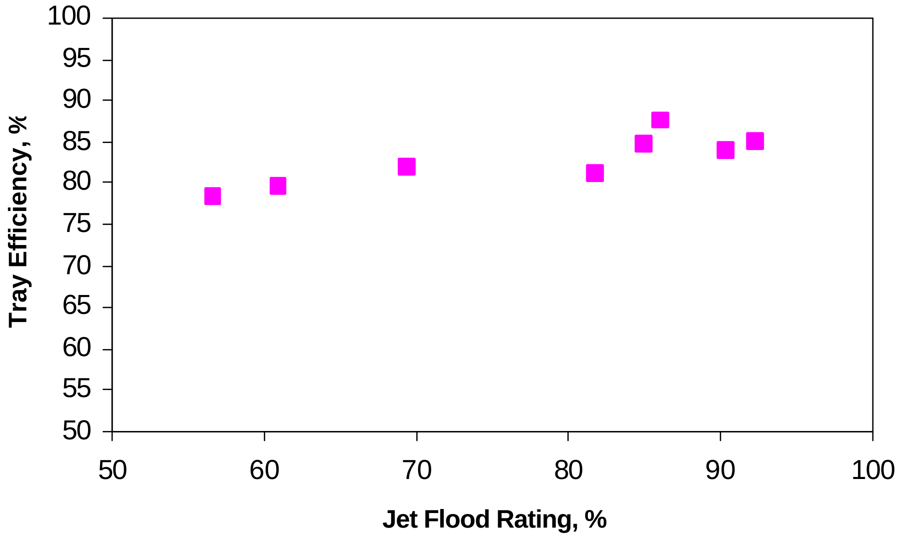

Figure 5: Efficiency of KITTEL II trays in Medford depropanizer

5. KITTEL II tray case study

KITTEL II trays were recently used to debottleneck an 8-ft diameter debutanizer that was originally fitted with 2-pass NYE TRAYS®. The objective was to get to a capacity that was at least 10% higher than the proven limit of NYE TRAYS. The NYE TRAYS were switched out one-for-one with KITTEL II trays.

The KITTEL II trays have been running successfully and the feedback from the operating company is that: "The column is easily handling rates well beyond the capacity of the previous trays." Good separation is obtained, which indicates good tray efficiencies.

6. Summary

The Koch-Glitsch KITTEL II tray is a high capacity mass transfer device with capacities between that of SUPERFRAC and ULTRA-FRAC trays. The KITTEL II trays show good efficiencies in hydrocarbon service and have been successfully used in refinery applications.

7. Literature Cited

1. Kittel, W. *Contact plate arrangement for contact column*, US Patent US3045989

2. Weiland, R., DeGarmo, J., Nieuwoudt, I. *Converting a Commercial Column Into a Research Tower*, Chemical Engineering Progress, Accepted for publication, April 2004