

Refinery Tests Demonstrate Fixed Valve Trays Improve Performance In Sour Water Stripper

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Abstract

Sour water strippers often present some difficult design and operating challenges as these towers must process sour water feed which often varies significantly in composition. Further complicating the situation, these towers often experience severe foaming as well as fouling. The severity of the foaming and fouling primarily depends on the origin and composition of the components in the sour water feed.

Shell Oil Products has two identical sour water strippers in its Los Angeles refinery. Each tower processed the same sour feed and had sieve trays with ½" orifices. Despite the normal experience that sieve trays have good fouling resistance, Shell's sour water strippers suffered chronic problems with fouling. Since the fouling of the sieve trays was so severe, each tower required several shutdowns each year for maintenance.

The parallel feed arrangement of the two identical sour water stripper towers created a unique opportunity to test the performance of new trays under the same conditions as the existing sieve trays. In the first test, Koch-Glitsch trays employing PROVALVE® fixed valves were installed at only two trays in the south stripper. After a typical run length, the south stripper was shut down for maintenance and the trays were examined. The two PROVALVE fixed valve trays had negligible visual evidence of fouling while the vertically-adjacent sieve trays showed considerable fouling with the flow area reduced by about 90%.

On the success of the first test, the entire north stripper was re-trayed with PROVALVE fixed valve trays. After a typical run length, the south tower with the sieve trays had to be shut down for cleanout. After the same run time, the north sour water stripper with the PROVALVE trays was processing more sour water feed with no significant increase in pressure drop.

The test results clearly demonstrated the improved performance and fouling resistance of the fixed valve trays in sour water service. The PROVALVE features of orifice size, directional push, and fixed valve shape prevent bridging of the fixed valve flow area in sour water service.

INTRODUCTION

Shell Oil Products has two identical sour water strippers in its Los Angeles refinery and each tower processes the same sour feed. Before 2001, each sour water stripper had sieve trays with ½" orifices. Despite the normal experience that sieve trays have good fouling resistance, Shell's sour water strippers suffered chronic problems with fouling. The fouling mechanism in this case was closure of the ½" orifices on the tray deck as shown in Figure 1. The tray deposits were a mixture of salts and insoluble organics. As these deposits reduced the effective open area of the orifices, the pressure drop across the stripper towers increased. Since the fouling of the sieve trays was so severe, each tower required several shutdowns each year for maintenance. Each shutdown required about four (4) days of around-the-clock maintenance to tunnel and hydro-blast the 40 tray stripping section. Most of the time, the maintenance cleaning on the unit focused on the sieve trays. Heat exchangers on the sour water strippers were also cleaned but on a less frequent schedule.



Figure 1.

**Fouling of Sieve Orifices
(Top View Of Tray Deck)**

TEST 1 CONFIGURATION

The parallel feed arrangement of the two identical sour water stripper towers created a unique opportunity to test the performance of new trays under the same conditions as the existing sieve trays. The arrangement provided a safe but "controlled test" in an actual refinery. If the new trays in one tower were a failure, the worst that would happen is that the routine shutdown in one stripper would have to occur sooner than usual. At the same time, excellent performance of new trays would be benchmarked against a tower running the same sour feed.

In the first test, Koch-Glitsch trays with PROVALVE® fixed valves were installed on only two trays in the south sour water stripper as shown in Figure 2. The two

test trays were located at trays 9 and 10 down from the top of the 40 tray stripping section where fouling was typically the most severe.

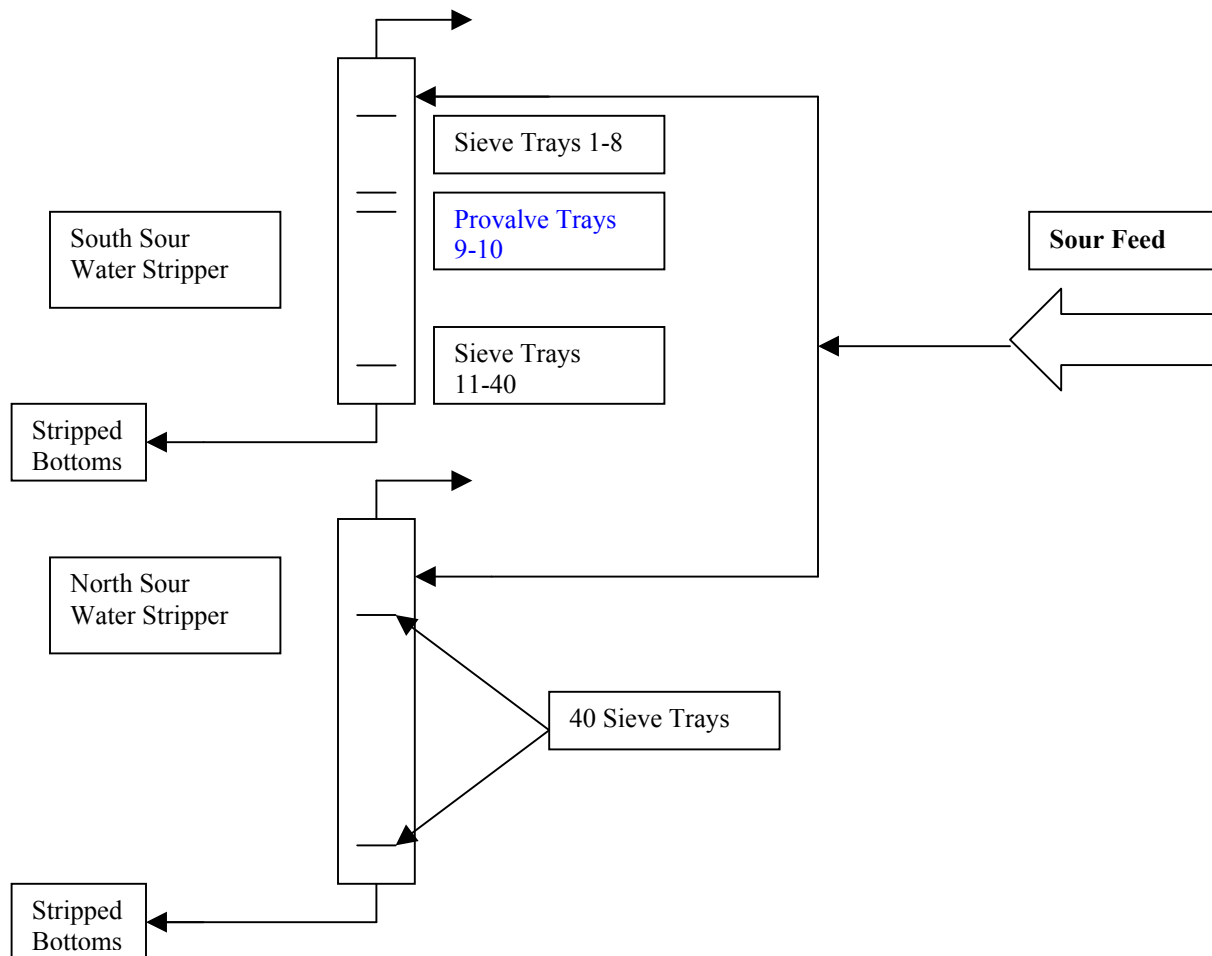


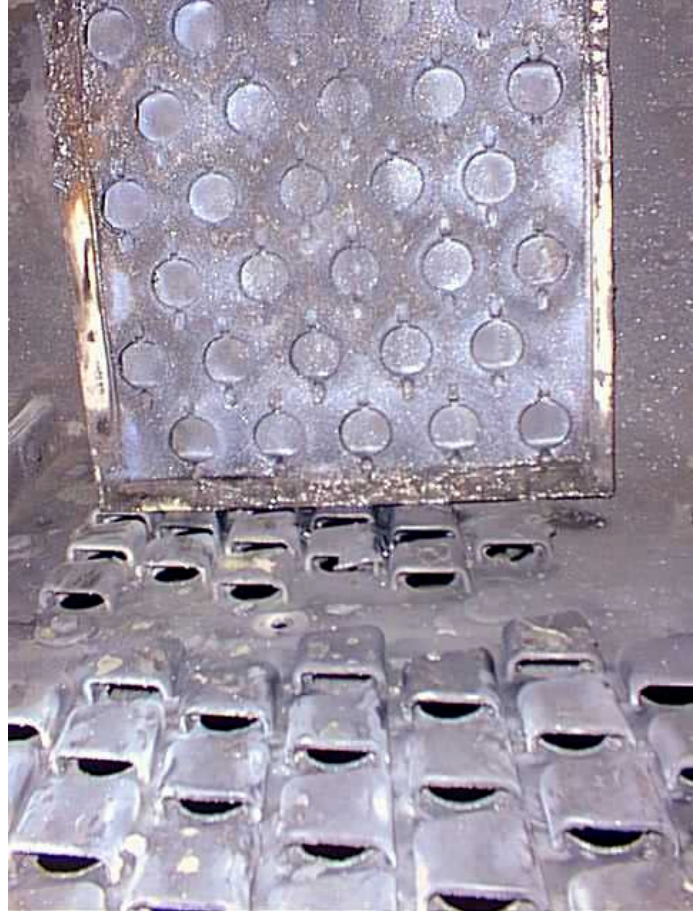
Figure 2. Test 1 Process Flow Configuration

After a typical 5 month run length, the south stripper was shut down for maintenance and the trays were inspected. The two PROVALVE fixed valve trays had negligible visual evidence of fouling while the neighboring sieve trays showed considerable fouling with the flow area reduced by about 90%. The inspection photographs are shown in Figure 3. The tray manways are shown in the upper section of the inspection photographs to reveal the underside of the tray decks. It can be seen that some sieve orifices are completely plugged.

Sieve



PROVALVE® Fixed Valve



After a 5-month run, about 90% of the sieve tray orifice area was plugged. The Provalve® tray orifices show negligible signs of fouling.

Figure 3 Inspection Photographs of a Sieve tray and PROVALVE® Test Tray

TEST 2 CONFIGURATION

Based on the success of the Test 1 trial, the 40 sieve trays in the north sour water stripper were replaced with PROVALVE fixed valve trays in February of 2002. Approximately two weeks later, the sieve trays in the south sour water stripper were cleaned according to the routine schedule.

After 130 days of operation, the south sour water stripper was flooding at 200 gpm of sour feed and had to be shut down for cleanout. During the same time period the north sour water stripper (with the PROVALVE trays) was processing 550-600 gpm of sour water feed with no apparent increase in column pressure drop after 150 days in operation. For this operating period, the operating performance of the sour water strippers was summarized in Table 1.

TABLE 1. Comparison of North and South Sour Water Strippers

	Trays	Sour Water Feed (start)	Sour Water Feed (130 days)	Column Pressure Drop (130 days)
North Sour Water Stripper	PROVALVE® fixed valve	600 gpm	550-600 gpm	No increase
South Sour Water Stripper	½" sieve	480 gpm	200 gpm	Flooded

UPSET TEST

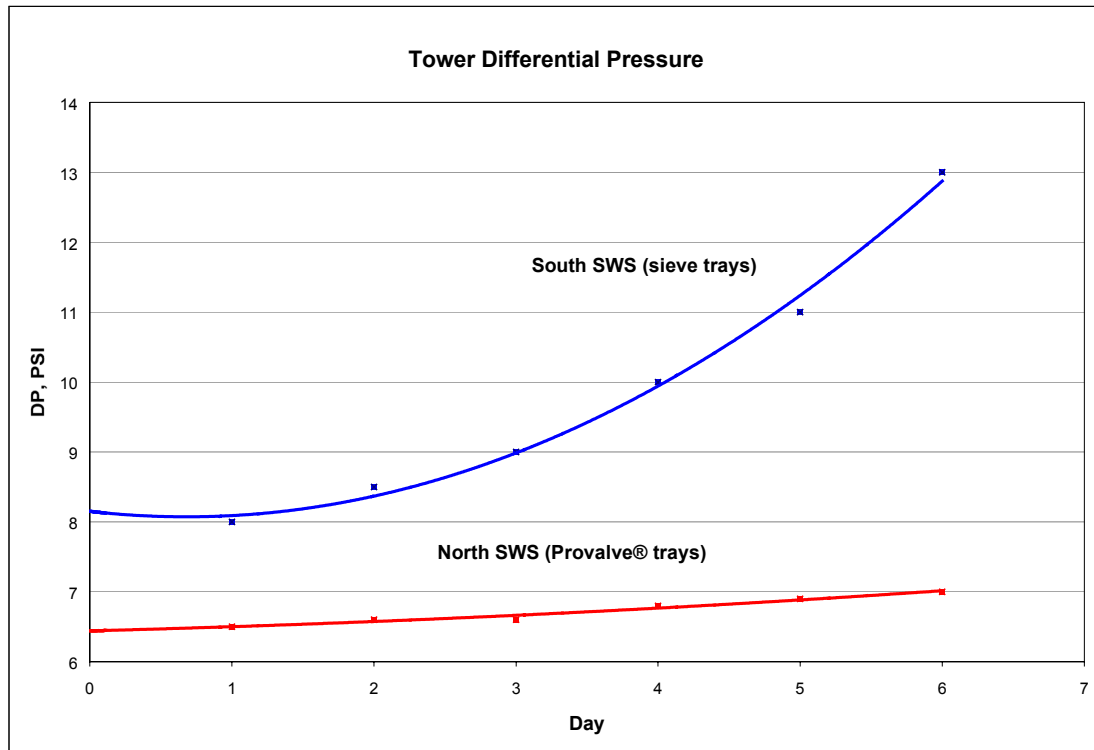
While the first two tests were controlled “experiments” intended to compare the operating performance of the PROVALVE fixed valve trays to the existing sieve trays, an inadvertent “upset” provided another comparison. In September of 2002, the sour water feed became contaminated with an inordinate amount of caustic, which greatly increased the fouling tendency in the sour water strippers. Over the next two weeks, the tower pressure drop of each sour water stripper was plotted as shown in Figure 4 below. At day 0 after the upset, the south sour water stripper with sieve trays had been online 42 days since the last cleanout. Meanwhile, the north sour water stripper with the PROVALVE trays had been online for 191 days. During the time plotted below, both strippers were charging the same feed at a constant rate of 345 gpm each.

On day 8 after the caustic contamination (day 50 online), the feed to the south sour water stripper had to be reduced by 50% due to the excessive pressure drop. The south sour water stripper was then shut down within 30 days after the caustic contamination (80 days online) again for cleanout.

Meanwhile, the north sour water stripper with the PROVALVE trays remained on line. However due to the caustic upset, its capacity (after 260 days) was reduced to 350-450 gpm. After 350 days online, the north stripper could still process 350-400 gpm (depending on H₂S/NH₃ loading).

Based on the success of the in-plant tests, the refinery replaced the sieve trays in the south stripper with PROVALVE trays in February of 2003.

FIGURE 4. Tower Pressure Drop After Caustic Contamination



CONCLUSIONS

Test 1 showed that in the same sour water stripper tower, PROVALVE fixed valve trays were more fouling resistant than sieve trays. After a typical 5 month run, visual inspection of the sieve trays showed about 90% of the orifice area was plugged while the reduction in orifice area on the PROVALVE trays was much less (about 10%-15%).

Test 2 showed that with the same sour water feed, the north sour water stripper with the PROVALVE trays had more feed capacity than the south sour water stripper with sieve trays. Furthermore, the north stripper with PROVALVE trays achieved a longer run time than the south stripper achieved with sieve trays.

In the upset test, the south stripper plugged faster than the north stripper even though the sieve trays had been online for only 42 days before the upset. The caustic upset resulted in a much-reduced run time for the sieve trays while the PROVALVE trays remained on line.

AUTHORS' COMMENT

The intent of this paper was to document and report the results of a rather interesting series of tests performed in the Shell Oil Products Los Angeles refinery. The parallel feed arrangement enabled a unique opportunity to establish a true “baseline” for real-time comparisons between the sieve trays and PROVALVE trays. The real-time comparisons eliminate any possibility that the performance difference was impacted by changes in the feed or column operation as is often the case in many revamps. While PROVALVE trays have been shown to reduce fouling in many cases,^{1,2} the results presented here represent the best *real-time* comparison between PROVALVE trays and other tray devices. Shell has reportedly employed various directional fixed valve trays to mitigate fouling in sour water strippers and hydrocarbon/petrochemical distillation towers with general success in many cases, without attempting to compare the PROVALVE tray with competitive designs.

REFERENCES

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