Amine still column revamp

With the old trays in the scrap yard and no working drawings available, an amine still revamp called for engineering detective work

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The amine still column at an energy plant was designed to treat 300 million scfd of sour gas containing H_2S and CO_2 with alkanolamine. The sweet gas after treatment is routed to an energy company. The unit, on the Gulf coast of the US, was shut down in September 2009 for regular maintenance. On opening the amine still, engineers found that the trays were all damaged, corroded and plugged with iron sulphides and scale.

Almost all of the trays had fallen to the bottom of the still. Due to a very tight schedule, the turnaround contractor removed all of the damaged trays and threw them away in a scrap yard. The operator then realised that it no longer had drawings of the existing trays and there was not enough time to carry out a complete process and equipment design for replacement trays. Hence, the company decided to replace the trays with new versions to the same design. However, no process data were available and there were no existing tray drawings, factors that together posed great challenges in duplicating the design and fabricating replacements. Amistco was called in to design and supply new trays.

Conventionally, the design of distillation column internals involves two main steps: process design and optimisation, and equipment design. The process design, after a number of iterations and optimisations, specifies the internal vapour and liquid flow rates and properties across the number of theoretical stages required to achieve separation efficiency, while the equipment design and

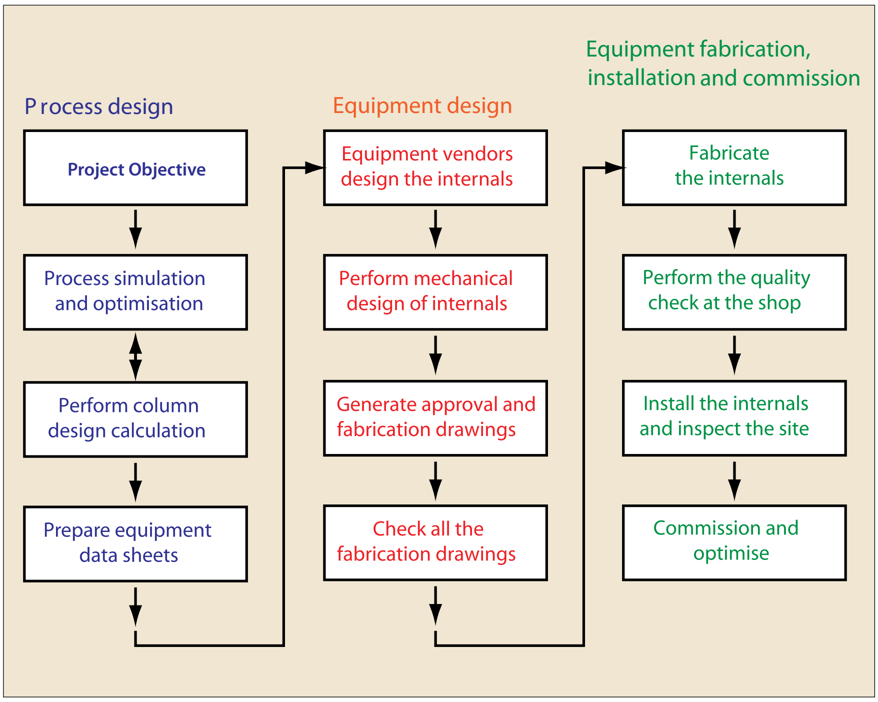

Figure 1 Conventional steps in the design of distillation column internals

fabrication step uses this data to design the actual hardware (see Figure 1). Ideally, the equipment's design and fabrication would also evolve from an earlier set of design operations and drawings.

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The process design and optimisation step mainly determines how close the tray geometry is to reaching maximum capacity. However, in this case, due to the non-availability of process data, this first step was bypassed. However, detailed discussions with the operational and process staff of the gas plant concluded that the column and existing trays were working to their satisfaction in terms of capacity and efficiency, and there were no plans to either increase or decrease the unit's operations in the near future. Hence, the decision was taken to duplicate the existing geometry in new trays.

Since drawings for the existing trays were not available, an inspection crew consisting of engineers, designers and drafters was

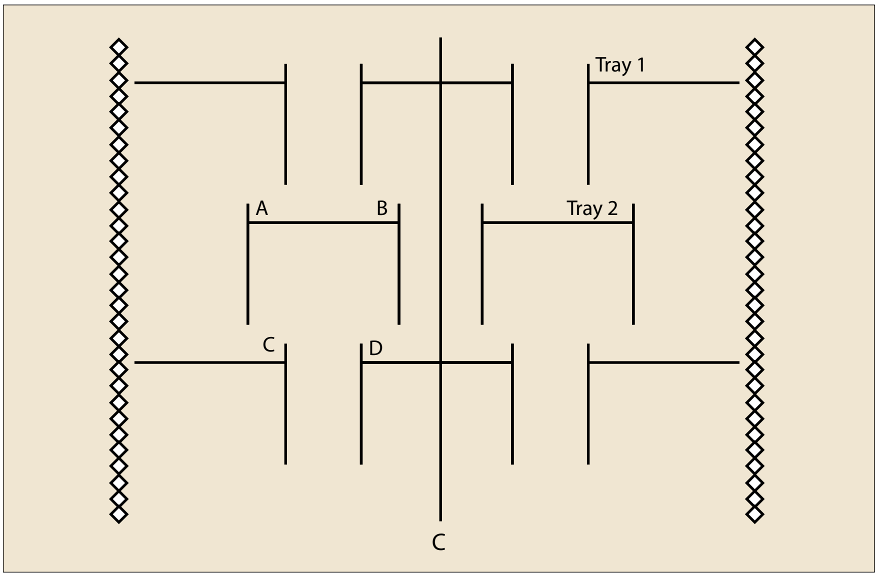

Figure 2. Schematic of a four-pass tray arrangement showing panel designation

dispatched to the plant to inspect the tower. The tower diameter was measured at several locations and confirmed to be 156in (400cm). Although, at some locations, the vessel's internal diameter was not uniform, the inspection crew recognised that the "out of roundness" was within the tolerance level of 1% of vessel internal diameter, in accordance with ASME UG80.

An inspection of the welds inside the tower revealed that the tower consisted of 20 trays, comprising four-pass trays with side and centre downcomer trays at the top tray, ending with off-centre downcomer trays at the bottom. Although some corrosion was observed at the support rings and downcomer bolting bars, with some cleaning required, they were deemed acceptable for the next run. An ultrasonic inspection of these weld-ins revealed that the support rings were 0.5in thick and 2.5in wide. Based on a turnaround schedule of five years, the support rings' thickness was deemed adequate to withstand the maximum allowable working pressure.

Given that this tower has four-pass trays, balancing the number of passes is critical, to avoid poor distribution of vapour and liquid

Based on the chord lengths of various support rings, width of inlet panel and the minor beam dimensions, it was concluded that the side downcomer widths were 11.75in (30cm), the centre downcomer widths were 12in and the off-centre downcomer widths were also 12in. At the same time, and based on the recovery of some material from the scrap yard, some of the downcomer panels were reassembled, to the point where it was possible to verify these dimensions. It proved interesting to note that the judgment made through chord lengths matched closely the widths of the downcomer panels. Measuring between the support rings provided an idea of tray spacing. An inspection of the tray panel indicated that the trays were round floating valves with 0.4375in (1.1cm) lift and they were 1056 in number.

Following discussions with the operator to confirm that the existing trays did not have any operational problems, the tray layout was decided upon, considering that the existing trays were operating in froth regime and there was no excessive entrainment, excessive downcomer backup or excessive downcomer choke, with reasonable pressure drop. Although some corrosion and fouling was observed on the trays, it was felt that their condition was acceptable following a five-year ????.

The column was required to operate in different cycles with varying gas rates. As a result, the percentage turndown would be most important. Hence, the decision was taken to continue using floating valves.

Given that this tower has four-pass trays, balancing the number of passes is critical, to avoid poor distribution of vapour and liquid, which would reduce the efficiency and/or the capacity of the trays. It is important to ensure that the vapour and liquid contact each other uniformly across each panel and to make sure that the vapour-to-liquid ratio is as close to unity on each of these panels. All four-pass trays have two different sets of configurations. One set consists of two side downcomers and a centre downcomer, while the other set consists of two off-centre downcomers, and these alternate in a given column. As a result, the trays will have four active panels, with

Tray design specifications for an amine still revamp

Tray geometry	Measurement
Tower diameter	156in
# of passes	4
# of valves	1056
Type of valves	Round floating valve
Valve lift	0.4395in
Side downcomer width	11.75in
Centre downcomer width	12in
Off-centre downcomer width	12in
Distance of off centre downcomer from tower wall	43.125in
Metallurgy	SS 304L, 14 Ga./12Ga.

Table 1.

panels A and B designated for the side and centre downcomer trays, and panels C and D designated for the off-centre downcomer trays (see Figure 2).

Within the still, the vapour and liquid streams are split, but recombine on each path. Hence, if the split is not uniform across each of these paths, the tray will flood prematurely or it will loose its efficiency. The liquid flows on the tray deck and downcomer are controlled by modifying the downcomer clearances and/or outlet weirs, while the vapour flows are balanced using the vapour tunnels or by providing the same bubbling area. Four-pass trays are balanced either by the equal bubbling area method or by providing equal flow path length.

In this case, the active bubbling area concept was used and the outlet weir lengths and weir heights for panels A and B were kept the same, with the same number of valves on each panel. As these downcomer panels were available, a study of all of these panels revealed that they were made of SS 304L, and ultrasonic measurements indicated that the downcomer trusses were 7 gauge thick and the tray panels were 14 gauge thick.

Thus, even in the absence of process data and drawings of the trays, a systematic evaluation of all the recuperated scrap, inspection of the tower and experienced engineering judgment helped to finalise the tray geometry for this four-pass mass transfer tray for an amine still (see Table 1).

Four-pass trays are balanced either by the equal bubbling area method or by providing equal flow path length

Based on the calculated geometry, mechanical designs such as stress calculations and deflections were calculated and found to be 90% allowable at design conditions and 0.173 respectively. The trays were then fabricated and delivered to the customer a week later. The amine column has been commissioned and is operating satisfactorily.

Conclusion

In the absence of process data and existing tray drawings, an innovative and systematic evaluation of all the damaged internals, inspection of the tower, and application of experienced engineering judgment and teamwork resulted in the effective design and fabrication of replacement fractionating trays for an amine still.