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Save a bundle

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Save a bundle

Chris Wajciechowski, Alfa Laval, USA, describes how one refinery managed to cut its emissions to a third of federal requirements by using new heat exchanger technology.

When a major US refinery set out to modify its refinery to achieve higher efficiency, it chose to voluntarily comply with standards that regulate emissions to less than a third of federal requirements. Eight new heat exchangers helped this facility reach this goal, among others.

Alfa Laval worked closely with the refinery's process development engineers to help them save space and money, cut down on fouling, and significantly improve the performance of their process for cutting particulate and sulfur emissions from fluid catalytic cracking (FCC). The compact heat exchanger technology was chosen for the installation specifically because it offers considerable advantages over shell and tube heat exchangers in these respects. The biggest Compabloc model, the Compabloc CPX 120, was chosen for the DuPont Belco™ prescrubber and the Cansolv amine stripper reboiler installations because of the sheer size of the installations. The remaining three heat exchangers were installed in other critical positions on the Cansolv unit.

The process

To control sulfur (SO_2, SO_3) and particulate (PM10) emissions, the refinery chose a Belco prescrubber and an amine based regenerative wet gas scrubber by Cansolv. The use of a regenerative amine scrubber is preferable to other scrubbing methods for SO_2 control because of its relatively low water use and elimination of an additional waste stream. Use of scrubbers for SO_2 and PM10 emissions is considered to be the highest practical level of control available.[1]

FCC flue gas is quenched and saturated with water in the prescrubber; which is designed based on the PM10 and SO_3 content in the gas.[2] The wet gas is then scrubbed with an amine based solution to remove SO_2 from the flue gas. The cleaned flue gas is then sent to the stack.

The amine solution, now rich in SO_2, is pumped from the absorption tower to a regeneration tower through a set of heat recovery exchangers. In the regenerator column, the SO_2 is stripped from the amine solution using heat provided by a steam

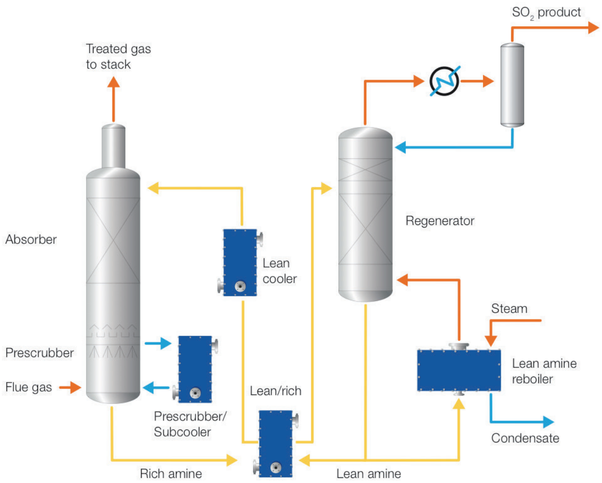

Figure 1. FCC flue gas scrubbing system.

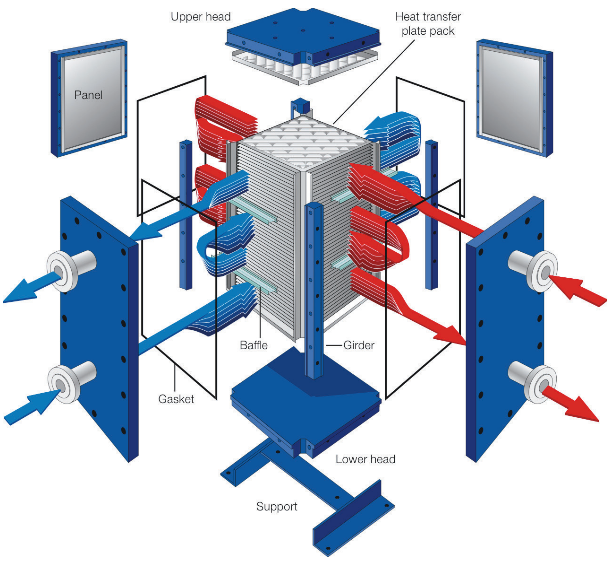

Figure 2. Alfa Laval Compabloc construction.

reboiler. The amine solution is then cooled, recovering heat as much as possible before returning to the absorption column to recover additional SO_2.

There are several locations in the process where high efficiency heat exchange can benefit the operation of the process. Most notable are the lean to rich heat recovery exchanger and the prescrubber water subcoolers, where cooler contacting temperatures increase the efficiency of the absorption operations. In addition, high efficiency heat exchange in the reboiler position allows the use of low temperature steam to drive the regenerator, saving steam costs and lowering the risk of thermal degradation of the amine. The refinery took full advantage of these advantages by properly integrating them into the process design at an early stage of the project.

The technology

A Compabloc heat exchanger is a type of welded plate heat exchanger, and its features include efficient heat transfer at low temperature differences and full mechanical cleanability on both sides. The technology has been successfully used in demanding heat exchanger duties in the petrochemical and refining industry for over 20 years.

Recently, Alfa Laval developed a bigger Compabloc model that dramatically reduced the number of shells required to perform duties of any size. The new model is nearly three times larger than previous models. This larger design means that the technology is able to replace several shell and tube heat exchangers in series, while also allowing several shell and tube heat exchangers in parallel to be swapped for a single shell.

Specially designed corrugated plates in a stack are alternately laser welded together to form an alloy heat transfer bundle. The bundle is inserted in a pressure vessel, where passes are fitted according to the service the heat exchanger will perform. The location of the passes is engineered to ensure the highest possible turbulence in the corrugated channels, which effectively limits fouling in the unit. Rectangular panels are then fitted with a gasket and bolted to the vessel, allowing complete access to the bundle for mechanical cleaning and maintenance.

This technology can be easily adapted to all kinds of heat transfer challenges, including high heat recovery liquid to liquid duties and demanding reboiling and condensing applications. It can perform at 3 – 5 times the heat transfer efficiency of shell and

Figure 3. The heat exchangers ensure environmental compliance in a Belco flue gas scrubber (Jim Hill).

Figure 4. Reboilers efficiently add heat to a Cansolv lean amine stripping tower (Jim Hill).

Figure 5. Compabloc heat exchanger recovering heat in a Cansolv lean to rich service (Jim Hill).

tube heat exchangers, and can be utilised as a heat recovery exchanger or in low mean temperature difference (MTD) services. It is able to handle crossing temperatures in a single unit and with a temperature approach as close as 3 °C.

Technology in action

In the US refinery's Dupont Belco prescrubber installation, an important requirement for meeting the ambitious emissions targets was to sufficiently cool the hot process water before it comes into contact with the FCC flue gas. Since March 2011, two Compablocs operating in parallel as prescrubber quench subcoolers have consistently performed at approximately 100 million Btu/hr at a temperature difference of less than 5.5 °C, thus meeting the target temperature for the water.

The two Compabloc CPX 120s cool the process water adequately, while taking up 85 ft^2 of elevated structure space. At least six large shell and tube heat exchangers occupying over 800 ft^2 of floor space would have been required to perform the same duty, and target temperatures would not have been met.

The compact design of the new technology significantly cut down on floor space, foundations, piping and installation work, so the refinery also saved time and money. In addition, unlike most shell and tube heat exchangers, the Compabloc is made of a corrosion resistant high alloy, made affordable by the relatively small amount of metal needed due to the efficiency of the technology. The upshot of this is that corrosion issues are completely avoided.

Compablocs necessarily operate in a position where the risk of fouling is high, but the high amount of turbulence in the plate channels ensures that fouling seldom occurs. (The same turbulence is responsible for the high heat transfer coefficients.) No fouling has been seen since commissioning. If and when there is a need for maintenance, the units can be fully mechanically cleaned by removing their outer panels and hydroblasting the surface area. No extra space is required around the installation for tube bundle access, which means further savings on installed space and costs.

The space requirements for the new Cansolv amine stripper reboiler were tight and the duty the reboiler must perform is a demanding one. Therefore two large Compabloc 120s were selected for application. Because each one is almost three times bigger, fewer of them were needed than would have been needed of the smaller models, meaning that a significant amount of space was saved around the units. Each of the reboilers performs 95 million Btu/hr of duty and takes up under 60 ft^2 of real estate.

Even the biggest Compablocs typically occupy only a fraction of the space needed for shell and tube heat exchangers. This installation is estimated to take only a fifth of the installation space and a third of the heat transfer area than a comparable installation based on shell and tube heat exchangers.

Conclusion

With almost two years of successful operation, the Compabloc heat exchangers in the FCC flue gas system have proven to perform consistently and reliably over time. All operating targets have been met and the reported efficiencies have been verified with actual operating data. The heat exchangers have proven to be particularly effective in recovering heat with low temperature differences; this helped the refinery to reduce their emissions to a third of the federal requirements. HE

References

1. CABRAL, B. *'Summary of Bay Area Air Quality Management District Best Available Retrofit Technology Determinations', California Air Resource Board, Appendix D.*
2. *Cansolv State of the Art Gas Absorption Solutions brochure. Montreal, Quebec.*