

HYDROCARBON ENGINEERING

April 2017



FFC TM PLUS

INNOVATING CAUSTIC TREATING TECHNOLOGY



MASTERING ENERGY EFFICIENCY



Mike Buettner, Alfa Laval, Asia, outlines how petrochemical producers can optimise condenser heat recovery in their aromatics processes.

For aromatics producers, becoming more energy efficient is important in order to reduce emissions and to become more profitable. Hence, the design of aromatics plants includes a level of heat recovery, however, these are primarily based on using traditional shell and tube technology. Innovators in the aromatics industry, such as Hyundai-Cosmo Petrochemical, are finding ways to update these heat integration philosophies by applying plate technology to recover energy in condenser applications.

A focus on adding capacity of aromatics production in recent years has dramatically impacted the profitability of producers globally. Manufacturing these petrochemicals, which include benzene, toluene, and xylene (BTX), provides key building blocks for everyday consumer goods such as polyester, polystyrene and nylon. It requires a tremendous amount of

energy to drive the distillation columns used to separate these products. New approaches in heat integration now make it possible to upgrade outdated facilities that used heat integration philosophies optimised around traditional heat exchanger technology. The adoption of more energy efficient technologies can help aromatics industry plant managers cut energy costs while maintaining product quality. One area that is found to be under utilised in making the plants more efficient is in the condensers of the distillation columns.

Challenges in condenser heat recovery

A recent survey at a fully integrated production facility revealed just how much energy is needed to produce paraxylene. An estimated 740 MW of utility cooling design capacity is needed to produce 1.4 million tpy of paraxylene. This is a sufficient

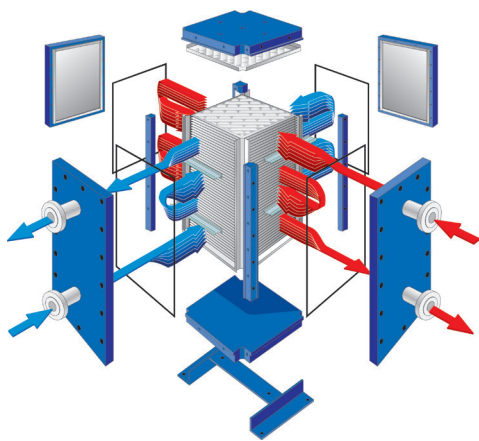


Figure 1. Alfa Laval Compabloc welded plate heat exchanger.

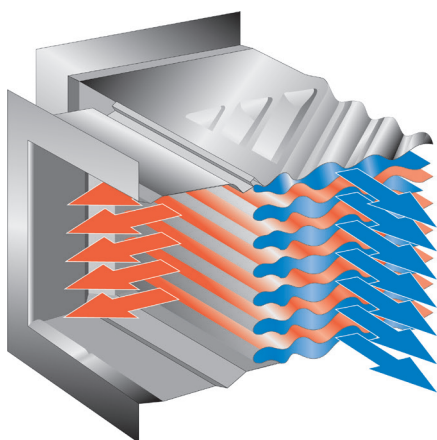


Figure 2. Turbulence in process fluid.



Figure 3. Compabloc installation on a platform.

amount of energy to provide power to a community with 37 000 homes, if this energy was transferred into electricity. Most of this cooling capacity was used in condensing applications, where air coolers or cooling water trim coolers are utilised.

In aromatics plants, the energy contained in the distillation column as overhead vapour, in the form of latent heat, is typically classified as low to medium-grade. With condensing temperatures ranging from 100°C to 170°C, this energy is both an opportunity to make the plant more efficient, but also a

challenge in finding ways to utilise it. There are four main challenges to heat recovery in condensing applications:

Heat integration

Identifying a heat sink where condenser energy can be utilised often presents a challenge for existing plants. If a plant has energy needs associated with utilities, such as preheating boiler feedwater or creating low pressure steam, then it is relatively easy to use the heat recovered to match the duty for those streams. It is much more complex to evaluate opportunities within a process when some degree of heat integration already exists in the process design. Adding energy to one area of the plant naturally has an effect on the other heat exchangers in the process. Determining the best heat sinks in any process will require the support of an experienced solution provider or external process consultant. They will need to review the current process design and determine how it can be reconfigured to meet energy savings goals.

Pressure drop

Most of the distillation columns in aromatics processes operate at low pressures, leaving a small amount of pressure drop available to use for the condensers. The challenge in heat exchanger design is that, typically, as the level of heat recovery increases in a condenser, the amount of pressure drop also increases. As the pressure drop increases in the overhead circuit, a higher operating pressure is required in the column to overcome it. This higher operating pressure requires the reboiler to add more energy to the system, making the net energy change a net-sum zero.

Investment costs

When evaluating any project, it is important to consider the total investment costs – not only the capital expenditure for the equipment itself, but installation, operating and maintenance costs, which often exceed the initial investment. Due to the nature of distillation columns, condensers tend to be located at the top of the structure. Modification of the structure to install heat exchangers can be costly, especially in regions where seismic conditions require structures to be more robust.

Reliability

Reliability is essential when selecting the right technology for these applications. If the heat exchanger is not reliable, the energy savings realised can be wiped out due to production losses. Aromatics plant owners and operators must select reliable solutions that can be maintained over the lifecycle of the equipment.

Improving energy efficiency in condensing applications

Based on these challenges, aromatics producers are looking for smart ways to recover and reuse energy in condensing applications. Aromatics producers in markets such as South Korea were early adopters of heat recovery practices for condensing applications due to high energy costs. However, increasingly more aromatics producers, as well as process licensors, are now using advanced plate technology in all regions to recover and reuse heat from condensing applications.

Figure 1 shows a typical configuration of plate technology that is easily cleaned, maintained, and reliably operated.

Plate technology benefits come from the concept of using corrugated metal to create a high level of turbulence in the fluid stream (Figure 2). In liquid applications, this turbulence creates heat transfer coefficients five times higher or more than traditional technology. The efficiency of condensing applications is based on the flow regime that the heat exchanger can be designed for. With plate technology, the high turbulence helps ensure that the condensing stays in the shear controlled regime, which has a much higher efficiency compared to the gravity controlled regime. This allows heat transfer coefficients that are two times higher or more than traditional technology. These higher heat transfer coefficients can be utilised in three different ways:

- Compact size: due to the higher heat transfer coefficients and plate pack design, the size and weight of the heat exchanger will be over 50% less than traditional technology. When condensers are located up in structures, this will be a significant saving in terms of cost, as in many cases it will not require modification to existing structures. Figure 3 shows a typical condenser installation on a platform in the plant.
- Increased heat recovery: in many projects, the level of heat that is needed to be recovered is high, but the thermal requirements for the heat exchanger would not allow it to be feasible. With the higher heat transfer coefficients that plate technology offers, more energy can be recovered with a reasonable amount of heat transfer area that offers returns that will allow projects to move forward.
- Debottlenecking: when producers are increasing the production of their facilities, there are pieces of equipment that become the bottleneck. This equipment needs to increase in size to handle the increased capacity, but in existing facilities the amount of plot space for new equipment is often limited. Plate technology allows the producer to increase the capacity of the facility in the same, or smaller, plot space of the existing heat exchanger.

The design of plate technology also allows for higher levels of energy to be recovered in a single unit. For condenser duties, this can be very interesting for two different reasons. The first would be in applications that require total condensing and significant subcooling (15°C). With traditional technology, it may take two steps to condense the vapour, and then subcool the vapour. With an understanding of how to design the plate technology properly, this can be done in a single unit. The second duty is where the application calls for a higher cold outlet temperature than the hot outlet temperature. An example of where this can be taken advantage of is in the condenser of a raffinate column used in paraxylene recovery. As the heat release curve has a steep drop near the end of the condensing curve, it is difficult to achieve a high cold outlet temperature. Figure 4 displays a typical profile.

By understanding the application and designing the plate technology properly, plant operators can have higher grade heat to use in their plant.

Reduced delta T for boiling

In heat recovery applications, the condenser energy can be used to vaporise the liquid, such as for steam generators or reboilers.

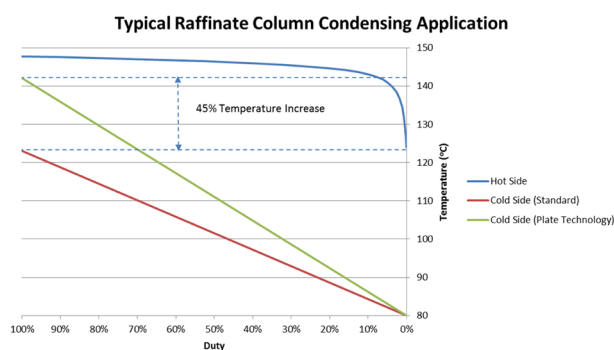
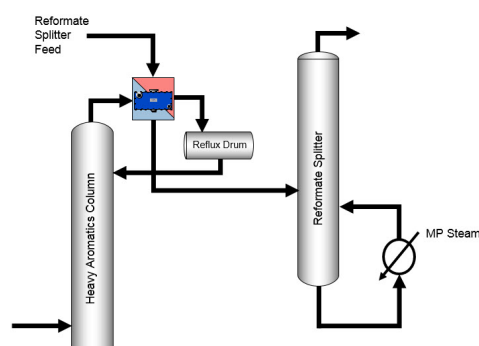


Figure 4. Heat release curve for raffinate column application.

HCP Heavy Aromatics Heat Recovery



Reformate Splitter Heat Recovery

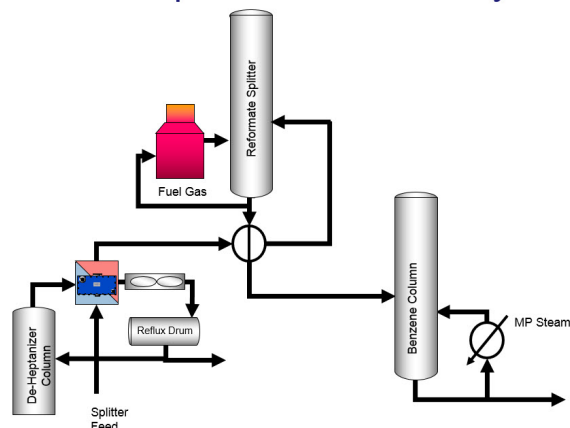


Figure 5. Process flow diagrams of applications.

Table 1. Energy savings

Column	Reboiler duty before installation	Reboiler duty after installation	Energy savings (Gcal/hr)
Reformate splitter	3.5	3.1	0.4
Tatoray stripper	3.9	3.0	0.9
Benzene column	2.2	2.0	0.2
Total	9.6	8.1	1.5

For traditional technology, there are traditional guidelines that state that there must be 20°C temperature difference between the process streams to start and sustain boiling. R&D and experience with numerous references has shown that lower temperature differences are needed in plate technology, down to 3°C in certain applications. This lower temperature difference can be used in one of two ways:

- Lower vapour inlet temperature for the same duty: in many cases when one is looking at this application, the column will be re-designed with a higher vapour temperature. This will require a higher column pressure and increased reboiler load. Utilising plate technology many times, the vapour temperature can be maintained while achieving the same duty.
- Higher boiling pressure/temperature: in applications where the customer is converting waste energy into steam, having a closer temperature approach will allow the customer to generate it at a higher pressure that could be more useful to the plant.

South Korean aromatics producer achieves significant energy savings

Hyundai Cosmo Petrochemical (HCP) considered cutting edge technology to help achieve its energy reduction goals. Energy costs in South Korea are among the highest in the world, with steam costing upwards of €80/t.

With the help of a process consultant, HCP identified three applications within the company's BTX complex that held potential to deliver significant energy reductions. Two of these involved condenser applications. The first condenser

application handled the deheptaniser overheads and used the recovered energy to preheat the feed to a stripper column. The second application involved the heavy aromatics column and used the recovered energy to preheat the feed to the reformat splitter (Figure 5).

There were also issues with the condensers; to achieve full condensation during the summer months, water had to be sprayed into the fans to increase the duty utilising evaporative cooling. The main challenge in both cases was the limited space available to install heat recovery condensers. Due to their high efficiency and compact size, Alfa Laval Compabloc heat exchangers were selected because they fit onto the current overhead structure without requiring any modifications.

After the units were started up, the customer saw an immediate impact on the energy savings in the reboilers for the columns. Table 1 shows the amount of energy used before and after the condensers were put into operation.

Conclusion

In today's highly competitive environment, global aromatics producers must find innovative ways to reduce OPEX. Heat recovery has proven to be a viable way to reduce fuel costs and optimise the condensing processes in the aromatics industry. To achieve a more sustainable business, producers must find ways to reduce furnace emissions. Today, aromatics processes must be evaluated to understand how to break away from conventional thinking for heat recovery and how high efficiency heat exchangers can deliver measurable energy savings. 