Temporary Heat Exchangers Keep Plants Running Profitably

Solving Emergency, Process Improvement, Debottlenecking, and Turnaround Challenges

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Executive Summary

Heat exchangers are both a vital process component of every refinery and petrochemical plant and a potential limiting factor in a plant's operations and profitability. Heat exchangers can foul, leak, or corrode. And whether they occur suddenly or develop slowly over time, these problems may force a plant to:

- Reduce plant/unit rates;
- Miss out on potential profit opportunities;
- Exceed permitted environmental limits with the prospect of significant fines.

Plants are always striving to optimize operations. Given that they are usually operating *far* beyond their design limits, heat exchangers are often a bottleneck to increasing capacity or maintaining product split.

During the summertime, many process units often experience cooling limitations. Usually, these are due to warmer cooling tower water or because fin/fans have become less effective.
During a turnaround, vessels need to be 'steamed out' to remove containments, which requires additional heat exchangers. In addition, chillers and additional exchangers are often used as part of novel approaches to quickly cool hydrotreater, hydrocracker, and reforming catalyst before opening a vessel.

This paper demonstrates how temporary heat exchangers can be installed to solve these problems and streamline catalyst cool downs. A case study shows how a temporary heat exchanger solution helped anethylene oxide producer avert leaking product to the atmosphere. This solution not only helped the producer avoid steep fines, but it also yielded tens of millions of dollars of profit that would otherwise have been lost.

Introduction

Of all the operations in a refinery or petrochemical plant, heating and cooling of process streams is probably the most common. A typical refinery has anywhere from 200 heat exchangers on the low end to almost 350 for a large, complex facility. Other process plants tend to have a smaller, though still significant, number of exchangers.
Many of these heat exchangers are in relatively clean service, with only a small probability of failure. However, other

exchangers are in ‘dirtier’ service, or process fluid streams containing corrosive materials. These exchangers are more prone to foul, leak, or experience corrosion problems. These problems often develop slowly, but they can also come on suddenly.

When failures or excessive fouling occurs, the usual result is either a reduction in unit throughput or a complete unit shutdown. For the most part, refiners have learned to live with these problems, and let their heat exchangers ‘limp’ through to the next turnaround at reduced throughput. Refiners are increasingly asking themselves, “Are there any alternatives by which I could potentially clean, repair or replace the exchanger without having to reduce production?”

Temporary heat exchangers represent one such alternative. They can be used for emergency, process improvement, debottlenecking, or turnaround purposes.

Emergency

Leaks represent a common emergency situation. When an exchanger experiences a leak from the process side to cooling water, for example, the material will potentially vent hazardous or flammable material into the atmosphere from the cooling tower. Given the strict environmental limitations placed on plants, the exchanger must immediately be replaced or the facility will have to shut down operations.

Seasonal Cooling Limitations

Heat exchangers can also limit a process unit’s operation during hot summer months. Process units may experience cooling limitations due to warmer cooling tower water or, in the case of air-cooled heat exchangers, because the fin-fans have become less effective. Good examples are the overhead of a distillation tower or a separator interstage drum. In these scenarios, the temporary exchanger remains in place only during the summer months. The exchanger can easily be re-used each summer if a problem occurs, thereby avoiding a capital expenditure.

Process Enhancement/Optimization

Many process plants look for new ways to maximize production capacity. Given that they are usually operating *far* beyond their original design specs, heat exchangers can be a limit to increasing throughput, or maintaining product split. However, a temporary exchanger can often be used to alleviate a bottleneck.

For example, consider that by adding an exchanger to the crude preheat train, heat recovery could be maximized to the extent that the crude furnace inlet temperature increases. If the crude furnace was the bottleneck, then raising the crude furnace inlet temperature would allow more crude to be processed. A supplemental exchanger might remain in place until the next turnaround, when a more permanent solution could be installed.

Turnarounds

Most heat exchangers are a fixed and normal part of a plant's operation. However, temporary exchangers are often needed during turnarounds, for vessel steam-outs or for cooling catalyst. During a turnaround, refiners must cool the catalyst in hydrotreaters, hydrocrackers and reformers from the unit's normal high operating temperatures to near ambient temperatures in two separate steps. In the first step, the feed is blocked in and the furnace is shut down. A recycle gas compressor is typically used to circulate hydrogen-rich gas through the feed/effluent exchanger, through the furnace, and into the reaction vessel where the gas picks up heat from the catalyst bed. The heated gas is then cooled in fin-fans and a cold-water exchanger before entering a high-pressure, low-temperature separator. The loop is then repeated until the catalyst temperature reaches approximately 150°F - 200°F.

The second step typically requires purchasing liquid nitrogen and injecting it once through into the reactor system to cool the catalyst further. This process presents several disadvantages, including the multiple days required to completely cool the catalyst and allow entrance into the unit. The large volumes of liquid nitrogen required add both significant costs and logistics challenges in the form of a steady stream of tanker trucks coming in and out of the refinery. The used nitrogen is typically relieved via the flare system, which may snuff out if too much nitrogen is present in the flare gas stream. Another potential strike against liquid nitrogen arises in situations where the system's metallurgy is sensitive to the extremely cold temperatures introduced when the nitrogen enters the vessel.

Fortunately, a new, patented process now exists for this second phase that can typically accelerate catalyst cooling from 200°F to under 100°F within 12-24 hours, and without the need for liquefied nitrogen. Accelerating catalyst cool down allows for faster entry to the reactor vessel, permitting the operator to move this vessel off the 'critical path' and allowing the plant to restart the units faster.

Temporary Heat Exchanger Requirements

A temporary heat exchanger must meet certain criteria before a refiner will consider installing it. No refiner will install a heat exchanger with an uncertain or incomplete prior work history. The exchanger must be sourced from an available fleet of diverse, refinery-grade heat exchanger equipment. In addition, the exchanger must be certified as being contaminant free. Exchangers need to be pressure tested on a regular basis and undergo periodic eddy tests.

Temporary Heat Exchanger Installation Work Process

The design and implementation of a temporary exchanger application should begin with a job walk. Its purpose is to review the site where temporary equipment will be placed and to assess how to safely connect rental equipment to the process with minimal disruption. Important to the design process is the proper selection and 'sizing' of the equipment for the streams and temperature required. This step should be conducted by an experienced group of process engineers who have performed these tasks on similar temporary exchanger applications.

The installation of the temporary heat exchangers will have to comply with all of the customer's MOC or HAZOP processes. After all safety criteria have been addressed, the temporary exchangers can be integrated into the process flow and commissioned by experienced technicians.

Case Study – Temporary Heat Exchanger Solution for EO Process

A leading Ethylene Oxide (EO) producer experienced a leak in its recycle gas heat exchanger. Emissions of EO, a toxic substance regulated by the EPA, exceeded permitted limits. The EO process gas side of the exchanger was operating at 250 psig, which was higher than the cooling water side pressure. Therefore, EO was entering the cooling water in the recycle gas heat exchanger and then into the atmosphere as it was being cooled in the cooling tower. The producer ordered a replacement heat exchanger, but faced a long lead-time of approximately 12 weeks until the exchanger arrived.

The plant estimated that if it had to shut down due to this problem, it would lose an estimated $700,000of profit per day. However, continuing to operate the leaking exchanger was not a viable option due to the safety risks and potential for significant fines.

To alleviate the issue, a system was designed that ensured any leak would be from the cooling water side into the process gas side. Since EO ultimately reacts with water in the downstream reactor, there wasn't any issue with water in the EO stream. The solution was installed in only six days and consisted of multiple 1,000-ton cooling towers, 2,000-square foot shell and tube heat exchangers, high-pressure pumps, and high-pressure piping that was custom-made to meet the EO producer's welding specs.

The three-month installation enabled the plant to continue operations, resulting in $64,000,000 in profit that would have otherwise been lost due to the leaking heat exchanger. Final customer return on investment (ROI) for the project was 40:1.

Conclusion

Given the range of problems that can quickly hinder the operation of their process-critical heat exchangers, refiners and petrochemical plant operators are increasingly turning to short-term solutions afforded by temporary heat exchangers. While they offer a means to keep processes running at optimal rates during emergencies, hot summers, process enhancements and turnarounds, temporary exchangers can only deliver on this promise through careful planning, design and installation. Partnering with a service provider with the right experience, expertise and equipment is critical to ensuring that temporary heating and cooling solutions protect a plant's profitability while minimizing environmental impact.

About Aggreko Process Services

Aggreko Process Services (APS) has provided full-service rental solutions to the refining and petrochemical industries for over 25 years. Beyond equipment rentals, APS employs teams of highly credentialed chemical, mechanical, and electrical engineers that design complete, packaged engineering solutions for emergency, process improvement, or debottlenecking purposes. Projects are implemented on short schedules — days or weeks — and have been shown to increase throughput while reducing turnaround times and costs. APS's benefit-to-cost ratios of between 5:1 and 40:1 are some of the very best in the industry.

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