HYDROCARBON ENGINEERING
Volume 8 Number 11 - November 2003

A reboiler for the space age

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Photograph courtesy of Baker Petrolite

A reboiler for the SPACE AGE

Patrik Arvidsson, Alfa Laval, Sweden, describes an innovative reboiler solution, comparing installation costs and space constraints.

Alfa Laval's Compabloc™ is one of the most compact reboiler solutions available on the market today. The Compabloc reboiler was designed with demanding duties in mind and provides distinct advantages over other types of reboilers when it comes to installation costs and space. The Compabloc reboiler is welded, fully accessible and available in almost any choice of material.

Shell-and-tube reboilers

The shell-and-tube reboiler is available in many different configurations. The most common types are the thermosiphon reboiler and the kettle reboiler. Both types can be used in most cases, but the trend is that more and more customers are installing thermosiphon reboilers where possible. Vertical thermosiphon reboilers are preferred if there is a tendency towards fouling and corrosion, but they may require extra height, which results in the static head being elevated. The kettle reboiler is suitable for vacuum operation because of the low static head. However, it is difficult to clean and collects dirt and contaminant liquid in the shell.

The shell-and-tube is a reliable and robust reboiler. It tolerates high design temperatures and pressures and can be tailor made to undertake almost any type of duty. The technique is very old and well proven. Most engineers and process designers are so familiar with shell - and - tube reboilers that they frequently choose them for their particular purposes. This is not surprising, as many of them are not even aware that anything else is available on the market.

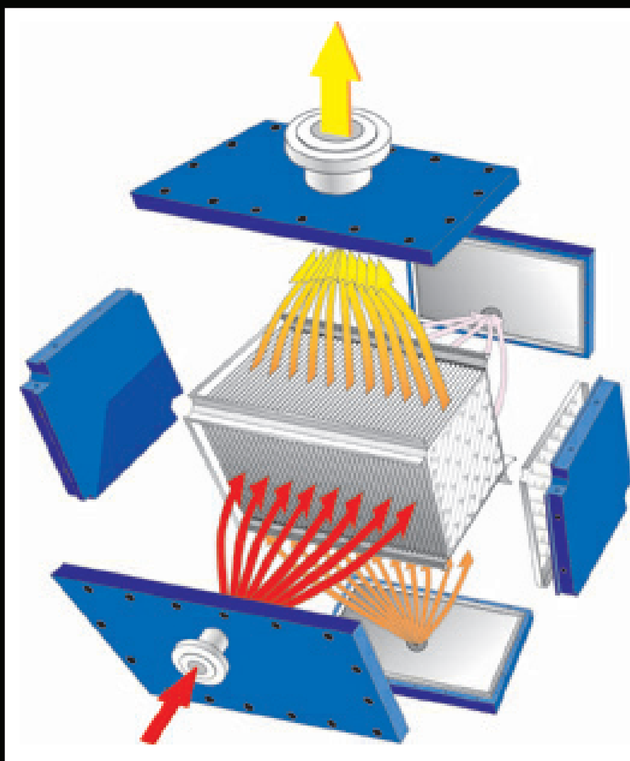

Figure 1. Exploded view of the Compabloc reboiler.

Commercial calculation programs can also be supplied for shell-and-tube reboilers.

However, the shell-and-tube is a large, heavy construction, which entails high installation costs. In many cases, a compact solution is required, especially in connection with retrofitting and solving bottleneck problems. In such cases, there is frequently no space available for a larger unit. The shell-and-tube requires a large heat transfer area as a result of a rather low overall heat transfer coefficient. In addition, the construction often involves the use of materials that are rather thick compared with plate type reboilers. The result is a large, heavy shell-and-tube, which is very expensive in materials other than carbon steel, such as 316L, Hastelloy™ and titanium. Another disadvantage is the slow response time to control, which is due to a large hold up volume.

Compabloc thermosiphon reboiler

The Compabloc thermosiphon reboiler is shown in Figures 1 and 2. The process medium enters at the bottom of the unit and is distributed through the channels. As the liquid passes through, it is brought to boiling point and a mixture of vapour and liquid exits from a larger connection in the top. The service medium can be either steam (as shown in Figures 1 and 2) or a hot liquid. The service medium meets the process medium in a cross flow arrangement. If the service medium is a hot liquid, baffles can be fitted to force it to undertake several passes in order to maximise velocity and turbulence and thereby the heat transfer efficiency.

The Compabloc reboiler combines the operating advantages of a vertical shell-and-tube and a kettle reboiler. It is a thermosiphon reboiler with a low static head. The flow path of the medium is short and the cross section is large. The short flow path is an important benefit, because it makes better use of the static height, compared with a vertical shell-and-tube thermosiphon reboiler.

The corrugated pattern in a Compabloc creates a high level of turbulence, which results in very efficient heat transfer. The heat transfer coefficient in a Compabloc reboiler is normally 2 - 4 times higher than that in a shell-and-tube, and the required heat transfer area is consequently 2 - 4 times less. In addition, the design of the Compabloc is in itself extremely compact. In summary, it is possible to downscale the total space occupied by the reboiler by a factor of five, sometimes even more.

The compactness of the unit also means that the hold up volume is very low. This low hold up volume provides quick startups, easy control and a fast response time.

The high heat transfer efficiency in the Compabloc makes a closer temperature approach possible compared with a shell-and-tube. A temperature approach of 4 - 5 ˚C (7 - 9 ˚F) is not a problem.

Corrosion

Corrosion is a common problem when dealing with reboilers, and lower grade material is often used with some corrosion allowance. The best option is to use a higher grade material, but this can be very expensive because shell-and-tube units require a lot of material. The amount of material in the Compabloc is substantially less and an upgrade to a higher grade material is therefore an option that saves many problems in the long run.

Fouling and cleaning

Any fouling problems in a reboiler are normally restricted to the boiling side. The high turbulence created by the corrugated pattern in the Compabloc reboiler minimises this problem. The shear stresses achieved at the heat transfer wall are much greater than in a shell-and-tube unit, even for the same pressure drops. This low fouling tendency means

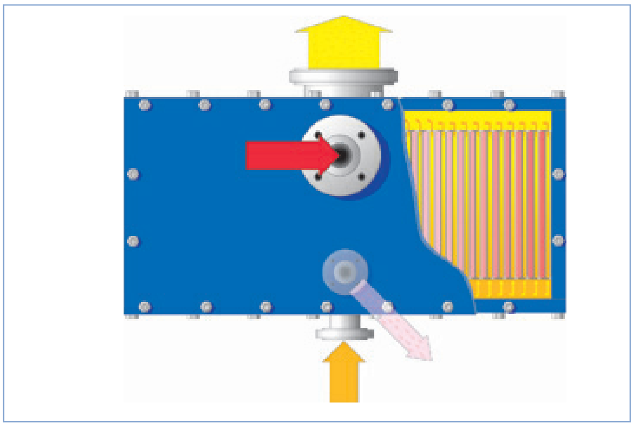

Figure 2. The Compabloc reboiler.

Figure 3. Stripper tower at Yukos refinery. The Compabloc reflux condenser and reboilers are highlighted.

Table 1. Brief facts about the Compabloc reboiler

Design temperature	-100 ˚C (-148 ˚F) => 350 ˚C (660 ˚F)
Design pressure	Full vacuum => 35 barg (500 psig)
Heat transfer area	0.7 m^2 (7.4 ft^2) => 320 m^2 (3440 ft^2)
Materials available	AISI 304L, AISI 316L, titanium, titanium-palladium, Hastelloy C2000, alloy C22, alloy C276, alloy B-2, 254 SMO, 904L, Monel, Incoloy 825, tantalum

Figure 4. Compabloc thermosiphon reboilers at Yukos refinery working with steam as heating media.

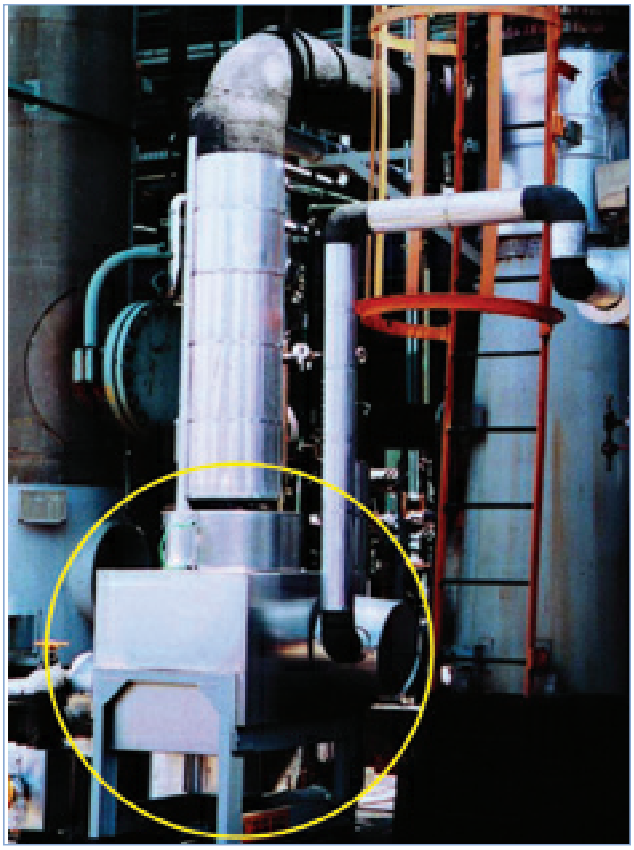

Figure 5. Compabloc thermosiphon reboiler at Rhodia.

longer operating periods.

Should fouling occur, it is easy to clean the Compabloc reboiler on site. Chemical cleaning, such as cleaning in place (CIP), is highly effective because of the high level of turbulence and low hold up volume. Mechanical cleaning is possible using hydroblasting with a high pressure water jet after removing the bolted panels.

Construction

The heart of the Compabloc condenser is a stack of corrugated heat transfer plates in stainless steel or some other exotic material, welded alternately to form channels. By simply unbolting the side panels, it is possible to gain access for inspection, service, or cleaning by hydroblasting. The Compabloc frame consists of four corner girders, top and bottom heads and four side panels with nozzle connections. The construction forms a cavity between the plate pack and the panel, which acts as a distribution box for fluids and vapours. The nozzle sizes are flexible and can be selected independently for each side and for inlets and outlets. Both the panel and nozzles in carbon steel can be unlined or lined in the same material as used for the plate pack.

Casestudy: refinery

The Yukos oil refinery in Syzran, Russia, has a capacity of 150 000 bpd of crude oil. When a new part of the plant was built, the Compabloc was installed instead of traditional shell-and-tube units, both as a reboiler and as a condenser.

The shell-and-tube is a well proven technology, but the engineers at the Yukos oil refinery were innovative and wanted to build a modern, profitable plant; they needed compact solutions for a stripper column.

The result was the installation of Compabloc thermosiphon reboilers at the base of the column, and a Compabloc reflux condenser directly mounted on the top of the column (Figures 3 and 4).

The Compablocs are installed at a stripper column in a gas sweetening process. H_2S is absorbed in 15% MEA solution and removed at the top of the stripper. The reboilers work at 125 ˚C and 2.3 bar, and the condenser at 115 ˚C and 2.1 bar. The H_2S is subcooled in a condenser down to 40 ˚C.

The decision to install the extremely compact Compabloc solution instead of traditional shell-and-tubes enabled Yukos to save both money and space. The Compabloc reboilers have been in operation since January 2002.

Casestudy: hydrocarbon processing industry

The Rhodia petrochemical company operates 110 factories worldwide, with seven plants in Brazil alone. When the company needed a new reboiler for its petrochemical plant at Paulínia, Rhodia turned to Alfa Laval for a solution. The result was the installation of a Compabloc thermosiphon reboiler at the base of a stripping tower that separates alcohol from water (Figure 5).

The production of solvent results in a waste stream that contains a small amount of alcohol along with traces of solvent. Since environmental restrictions prohibit returning this kind of waste to the ecosystem, a recovery solution had to be found. This also made it possible to recirculate the recovered alcohol, thus saving money at the same time.

The Compabloc is installed as a thermosiphon reboiler at the bottom of a stripping tower to supply heat for the separation process, which results in a flow of alcohol and solvent at the top of the stripping tower and clean water at the bottom. The heat transfer area for an alternative shell-and-tube in this specific case would have been 24 m^2, compared with 11 m^2 for the Compabloc reboiler installed.

Process engineers at Rhodia's Paulínia solvent plant explained that when people saw the Compabloc reboiler just before startup, they thought it would not work as it simply looked too small. After startup process operators explained that the reboiler has a smaller hold-up volume than a shell-and-tube tower, which means the startup process is quicker, and it also reacts more rapidly to changes in control parameters, which makes operation both simpler and more efficient.The Compabloc reboiler was installed in May 2001 and has been in constant round-the-clock operation ever since, with no downtime whatsoever.