

# process HEATING

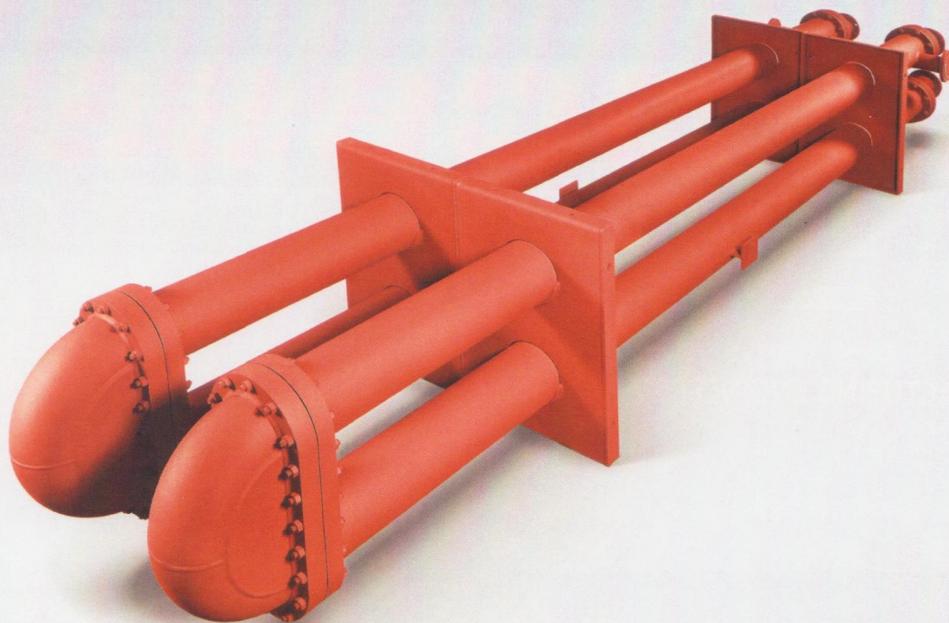
FOR MANUFACTURING ENGINEERS WHO USE HEAT PROCESSING EQUIPMENT AND SUPPLIES.

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## Advantages of HAIRPIN-STYLE HEAT EXCHANGERS

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# Advantages of **HAIRPIN-STYLE HEAT EXCHANGERS**

Hairpin heat exchangers are suited for applications that require high thermal performance and a compact footprint.

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**S**hell-and-tube heat exchangers come in many shapes and sizes, with features and attributes custom-designed for a range of applications. For end uses in process plants with challenging space restrictions and demanding thermal requirements, one option is a hairpin heat exchanger.

With a bent configuration and distinct closure styles, the hairpin heat exchanger can solve many of the problems associated with heat exchangers in applications that require high thermal performance and a compact footprint. These features include:

- Offers smaller footprint for compliance with overall length restrictions.
- Able to be stacked via special supports.

- Accommodates differential thermal expansion without the need for an integrated expansion joint.
- Withstands high terminal temperature gradients, preventing potential failure due to thermal stresses.
- Able to handle a temperature cross between the cold- and hot-side fluids because of the pure countercurrent flow design.
- Offers a more thermally efficient design with a smaller shell than traditional shell-and-tube heat exchangers.

This article will provide a closer look at each of these features.

#### **Smaller Equipment Footprint.**

Because the hairpin exchanger has two shell legs, only half of the overall length is required in comparison to its pure countercurrent shell-and-tube counterparts such as Type NEN or BEM. This smaller footprint provides an advantage where space is at a premium such as on

offshore platforms.

**Stackable Designs.** The design of the hairpin heat exchanger simplifies stacking of multiple units for series arrangement. Because of the upper- and lower-leg design of the hairpin, the support structures span the full height of the shells rather than providing only underneath support. This box-like structure allows stacking without requiring additional or custom supports.

#### **Differential Thermal Expansion.**

When differential thermal expansion is a concern, a traditional fixed-tube heat exchanger may not be suitable for the service. Expansion joints commonly are needed in such applications, which add cost to the heat exchanger, especially if higher pressures or high alloy materials are required.

Expansion joints are not required for hairpin exchangers because – just like TEMA styles with U-bends (Type BEU, NEU, etc.) – the tubes are free to expand.

The minimum bend radius is also large by design, which eases cleaning.

**High Terminal Temperature Gradients.** Hairpin exchangers can accommodate high terminal temperature gradients (terminal ends are decoupled). The hairpin dual-tubesheet design also handles large temperature swings from inlet to outlet. The single-tubesheet design of a TEMA U-type would have a large temperature gradient across the single tubesheet between the hot and cold sides of the tube-side fluid. This can lead to warpage and potential failure due to thermal stresses.

#### **Pure Countercurrent Flow.**

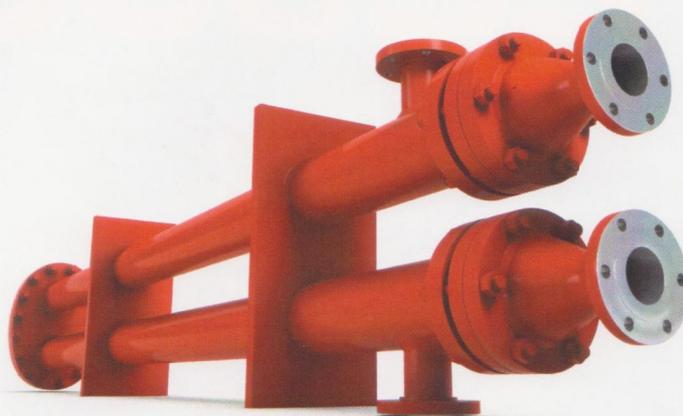
When a large temperature cross exists between the process streams, pure countercurrent flow is necessary. A temperature cross is defined by the outlet temperature of each fluid crossing over each other; that is, the hot-side outlet temperature is lower than the cold-side outlet temperature.

Hairpin exchangers have pure countercurrent flow; that is, media flows in a single pass on both the shell side and the tube side, in opposite directions. Even a close temperature approach and/or a high temperature ratio can usually be accomplished in a single hairpin instead of multiple shell-and-tube exchangers in series.

**Thermally Efficient.** Special closure styles are available when the tube-side design pressure is high. In many of these cases, the hairpin design can be more thermally efficient than a traditional shell and tube. Additionally, the design typically results in a smaller shell.

#### **Hairpin Design Features**

Several configurations of heat exchangers fit into the hairpin classification. Traditionally, these consist of double-pipe and multi-tube hairpin designs. The multi-tube configuration includes designs with an all-welded/nonremovable tube bundle, a common closure/removable tube bundle, and a separated closure/removable bundle. The common characteristic among



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these designs is the hairpin-shaped design. In simpler terms, this means the heat exchanger is essentially a straight-tube heat exchanger completely bent in half.

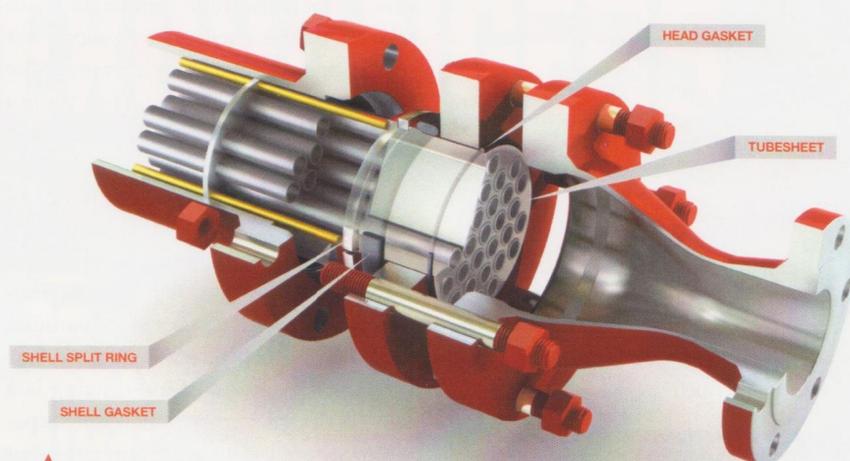
#### **Nonremovable Tube Bundles.**

Nonremovable tube bundles are the cost-effective option when a fixed tubesheet design is feasible.

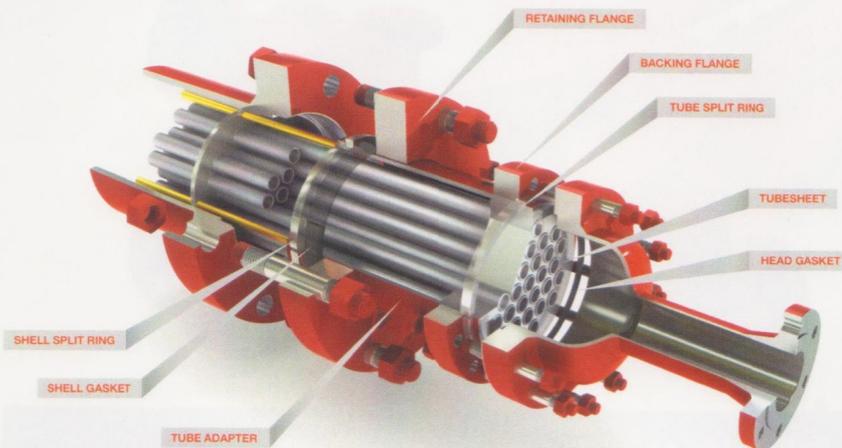
The double pipe provides the simplest of these designs, consisting of a single inner pipe and single outer pipe in a fully welded configuration. This design offers simple construction, high design pressures and low risk of fluid

mixing via mechanical failure. Heat transfer coefficients are limited, however, due to the minimal turbulence created both inside the relatively large inner pipe and in the annular space between it and the outer pipe. As a result, heat duties suitable for a double-pipe design are restricted.

The all-welded multi-tube hairpin offers similar advantages to the double pipe but with increased thermal performance due to the use of multiple tubes. An outer shell pipe is used with an internal tube bundle, much the same as a TEMA Type BEM or NEN



The common closure uses a set of common bolts to seal the floating tube bundle to the shell. This is the most cost-effective way to allow for removable tube bundles and is suitable for most hairpin heat exchanger applications.



The separated closure uses two individual sealing mechanisms with independent bolting to provide separation between the shell-side and the tube-side fluids.

heat exchanger. The tube bundle is not removable. The heads can be either a channel with radial nozzles or an elliptical head design with axial nozzles. The major difference in the overall design is simply the bent-in-half configuration of the hairpin style.

#### Removable Tube Bundles.

Hairpin heat exchangers also are offered with a removable tube bundle. Two bundle-closure configurations –

common closure and separated closure – allow for removal of the tube bundle for cleaning, repair or replacement.

First, the common closure type of removable tube bundle uses a set of common bolts to seal the floating tube bundle to the shell. This is the most cost-effective way to allow for removable tube bundles, and it is suitable for most applications.

The configuration consists of a shell flange, a split ring and a gasket together with an inner ring flange, a gasket and a nozzle or channel flange. The split ring acts to lock the tube bundle in place relative to the shell, and it allows for the bolting to adequately compress the aforementioned gaskets. This design provides a single sealing mechanism for both the shell-side and the tube-side fluids with a common set of bolting.

Second, the separated closure type uses two individual sealing mechanisms with independent bolting. The separated closure is used to provide separation between the shell-side and the tube-side fluids. If prevention of intermixing is a critical design feature, then the separated closure essentially eliminates that risk. Also, the individually sealed closure design is more resistant to thermal shock than shell-and-tube designs.

The separated closure consists of a shell flange, a split ring, a gasket and

a retaining flange together with a tube adapter, a backing flange, a gasket and a nozzle or channel flange. The independent nature of this design provides distance between the two sealing joints; thus, it prevents the possibility of a gasket leak allowing a path for intermixing of the two fluids. Due to the need for a tube adapter to bridge the gap between the two joints, the number of tubes that can be placed inside the shell is slightly less than with a common closure or all-welded design.

#### Return Housing Cover Design.

The removable nature of the bundle also is made possible by the return housing cover design. While the hairpin style is, in simpler terms, a bent Type NEN or BEM style exchanger, the U-bend at the back end is not adequately described in this manner. The shell-side configuration at the U-bend consists of a return housing cover and a shellsheet. The shellsheet is integral to the shell legs and attaches directly to the housing cover via standard bolting. This allows access to the tube bundle upon removal of the cover. As such, the pre-bent tube bundle can be inserted into or removed from the shell from the back side on the common or separated closure designs.

In conclusion, the typical enhancements associated with traditional shell-and-tube exchangers also are possible with hairpin exchangers. Features such as internal turbulators or low-fin tube designs can be integrated into the hairpin configuration to support demanding applications.

The hairpin exchanger's versatility gives it an advantage for demanding applications. When properly specified, hairpin heat exchangers can offer excellent performance throughout the lifecycle of the process equipment. ❀



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Christian Pawlak specializes in shell-and-tube heat exchangers for process applications at API Heat Transfer, Buffalo. For more information about hairpin heat exchangers from API Heat Transfer, call 716-684-6700 or visit [apiheattransfer.com](http://apiheattransfer.com).