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HIGH FLUX™ Tubing

Petrochemicals

Introduction

High Flux tubing operates exclusively in the nucleate boiling mode, which is characterized by the formation and growth of bubbles on a hot surface. In conventional bare-surface tubing, bubbles originating at random pits and scratches on the surface promote vigorous liquid agitation. The High Flux surface, however, greatly improves heat transfer during nucleate boiling. A thin, porous metal layer or matrix is bonded metallurgically to the heat-transfer surface. Saturated liquid is drawn into the layer by capillary action and vaporizes from the extremely large number of stable generation sites which exist in the structure. A combination of good matrix thermal conductivity, highly extended microsurface area, and large numbers of re-entrant sites ensure heat-transfer coefficients 10-30 times greater than a bare surface.

Design Considerations

Design procedures for High Flux exchangers are similar to those using bare tube. Computer programs have been developed for the design of both horizontal and vertical High Flux exchangers. These programs are supplemented by proprietary heat-transfer correlations developed for in-tube condensation and condensation on vertical surfaces. Data from field installations is used to confirm design procedures.

Most configurations of heat exchangers using commercial High Flux tubing are either horizontal kettles and thermosiphons or vertical thermosiphon reboilers. All have TEMA designations such as BKM, BKU, AJS, BEM, BHU, and so on. Boiling may be on either the inside or the outside of the tube.

Economics

The use of High Flux tubing leads to substantial savings in capital equipment and in operating costs. Heat exchanger surface area and size are reduced. For large reboiler duties, a reduction in the total number of exchanger shells required is usually possible, resulting in additional savings in piping, controls, foundation, and plot plan space. And in retrofit situations, where existing U-bundles are replaced, substantial savings result from the reuse of existing heads, shells, piping, and so on.

Perhaps the most dramatic example of the economic impact of a single exchanger service is the reduction of steam and cooling-water requirements by heat pumping of distillation towers. The availability of high performance High Flux tubing offers a second incentive to use heat pumping. In big systems, the number of reboilers needed becomes impractically large because of the small temperature differences required. However, with High Flux tubing, the three-to-four times reduction in area results in a requirement for only one or two shells at 10°F reboiler ΔT in even very large systems.

Heat exchangers involved in boiling heat transfer in chemical processes and refrigeration systems often do not have the operational flexibility to allow for greater product throughput. Replacement of existing tubing with High Flux tubing can, in most cases, debottleneck the process and result in significantly increased production. An increase in product capacity may not be the only objective of heat-exchanger debottlenecking. Another might be to maintain design rates while reducing utility costs with lower pressure steam. Yet another might be to reduce energy consumption per unit of product produced. All are attainable objectives, in critical exchanger services, with High Flux tubing.

Upgrading the efficiency of operating plants

In plant revamps to increase capacity or operating efficiency, there may be an opportunity to purchase new heat exchangers or to replace tube bundles. When heat exchangers are the process bottleneck, retrofitting has the following advantages:

- Existing heads, piping, and valves can be reused, reducing capital costs.
- Plot plan space is conserved.
- Downtime is minimized (it is usually possible to change reboilers in less than 24 hours).
- Lead time is greatly reduced. New heat exchangers may require seven to nine months for delivery. Replacement bundles can be delivered in less than six months.

- Cost is considerably lower. Approval for replacement bundles can usually be obtained at local administrative level.
- The plant operating group usually has greater control over the design and specification of the replacement High Flux bundles than with new equipment.
- Minimum risk. In the majority of High Flux tubing retrofits over the past several years, minimum downtime and incremental risk were cited as the dominant justifying reasons, often taking precedence over the first cost of equipment.

High Flux tubing has been used in a variety of ways to eliminate heat exchanger bottlenecks. An increase in heat duty, or capacity, or the ability of an undersized unit to provide more reflux to a tower is improved when a feed stream becomes less concentrated with the desired product. In a partial condenser, High Flux tubing can permit chilling to lower process outlet temperatures providing increased recovery, for example, in de-ethanizing of natural gas. Increases in reboiler capacity can lead to an increase in product output or purity. Debottlenecking an existing exchanger with High Flux tubing can also allow the LMTD to be reduced, resulting in debottlenecking

Grassroots plants

Specifying High Flux tubing in the design of new plants can save considerable amounts of money in capital costs and installation costs, as well as lower the operating costs. The total heat exchanger first costs are lower with High Flux tubing. Even more significant, in larger-sized plants, is the reduction in the number of exchanger shells required.

Another type of new-plant operation that can benefit from using High Flux tubing is the separation of higher (C_8-C_9) aromatics. The high boiling points of the mixtures at the bottom of the towers lead to the use of higher pressure steam (600 psi) for the reboilers. However, High Flux tubing makes possible lower design MTDs and substitution of a lower steam-pressure level, leading to lower costs in the steam supply system.

Other examples of grass roots applications for High Flux tubing include natural gas de-ethanizing, heat-pumped propylene or isobutane fractionators, and ammonia plant syngas chillers.

Fouling

The evidence is that fouling is not a significant problem with High Flux tubing. The extremely active boiling surface tends to keep particulate matter from settling on substrate.

Test results (on ethylene plant reboilers and condensers) indicate that overall coefficients as large as 400 BTU/hr./ft.^{2}/°F could be readily maintained. Also, plant tests on High Flux heat exchangers in moderate fouling environments, such as ethylene glycol, showed that overall transfer rates on the order of 1,000 BTU/hr./ft.^{2}/°F could be maintained. Experience in these services exceeds 25 years.

Field experience has also indicated that surface performance is not significantly affected by small amounts of nonvolatile liquids in the boiling fluids. Such liquids include compressor oils in refrigerants, high molecular weight “green oils” in olefins plant refrigerants, or dissolved salts in aqueous solutions. Further test data from field units indicate that no special precautions (such as filtration of reboiler feeds) are required to prevent fouling or loss of performances. The classical TEMA fouling factors specified for conventional heat exchangers do not appear to be necessary for the boiling or High Flux side of the High Flux exchangers.

For more information

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