

Get more out of your heat exchangers with heat transfer enhancement: Part 3 – Use of externally finned tubes

In this series of articles we will look at the idea of heat transfer enhancement. The benefits of enhancement are that your heat exchangers will provide the same performance at a lower cost or provide better performance at the same or smaller overall size and footprint.

By Himanshu Joshi, Heat Exchanger Specialist, Lou Curcio, Heat Transfer Advisor, and Craig Thomas, Director of Technical Sales, NEOTISS Inc.

In the first two articles we looked at the different enhancement techniques which are commercially available. In this part we will take a detailed look at fins on the OD (outside) of heat exchanger tubes. Such tubes are also called Low-Fin tubes or Integral Fin Tubes (IFT).

When to use low-fin tubes

There are several factors to consider as shown in Ref. [1]

New vs Retrofit: The value proposition for low-fin tubes will vary depending on whether the project is for new equipment or a retrofit or debottlenecking of existing units. When designing a new heat exchanger, first consider if the shell side resistance is controlling (see Part 2 for an explanation of “controlling resistance”), meaning the resistance to heat transfer is much higher on the shell-side compared to the tube-side. When retrofitting an existing heat exchanger with the goal of increasing the heat duty, low-fin tubes will increase the shell side surface area by 2.5 to 3 times without having to change the shell size or piping layout. Even if the shell side resistance is not controlling, low-fin tubes may still aid in the debottlenecking goal of a retrofit.

Cost vs Benefit: For new equipment, if the shell side resistance is higher by a ratio of at least 3:1, this is typically the threshold where the added cost of the fin tube is more than offset by the reduced size and cost of the overall heat exchanger. There are exceptions to this rule of thumb when considering multiple shell designs and expensive materials of construction. Two examples of cost savings are shown below, using Ref. [1]:

A compressor intercooler with a single-phase gas being cooled on the shell side with seawater on the tube side would easily meet the 3:1 ratio of shell side controlling resistance and

designing with finned tubes would likely show a significant size, weight, and cost saving compared to a smooth tube regardless of the materials of construction.

See Table 1, comparing two designs for cooling high pressure air with seawater, using 25.4 mm (1 in.) Titanium tubes. There is an 18% reduction in the shell diameter, 42% reduction in the number of tubes, 33% reduction in the quantity of seawater required to maintain a reasonable velocity, and a 3.6 ton lower weight. The weight savings could be important in certain cases, such as an offshore platform. Note that the surface area is based on the outside surface, with a fin density of 1181 fins/m (30 fins/in). In the smooth tube case the heat transfer resistance ratio is about 10:1. We have assumed some fouling resistance in the evaluation.

The second example is of a condenser with the controlling resistance on the shell side but by a smaller ratio of 2:1, which might normally not be a consideration for finned tubes. However, if a very expensive material of construction is required such as titanium, super duplex, or alloy 625, it may still be worth considering low-fin tube because as the material cost increases the ratio of finning cost proportionally decreases. For example, consider a 19 mm (0.75 in.) tube:

- Smooth Alloy 625 tube: USD 20/linear foot cost divided by the surface area 0.20 (sqft/ft length) = USD 100/sqft
- Finned: USD 25/linear foot cost divided by the surface area 0.50 (sqft/ft length) = USD 50/sqft
- The finned tube, while 20% more expensive per linear foot in this alloy type, is half the cost per square foot of external surface area.

Multiple Shells & Total Installed Cost: When a heat exchanger requires multiple shells, it is often a good case for finned tubes as a way to reduce the number of shells. When comparing a finned vs smooth tube design, it is important to evaluate the total installed cost, not just the fabricated heat exchanger cost. Let's say that the smooth tube design requires six shells in parallel, but the fin tube design allows four shells in parallel. Even if the fin tube design does not reduce the direct equipment cost compared to the smooth

Table 1. Comparison of smooth tube and low-fin tube designs.

	Shell OD	No. of Tubes	Surface Area	Heat Exchanger Weight (wet)	Water Requirement
	mm		m ²	T	T/hr
Smooth Tube	850	394	181	11.3	432
Finned Tube	700	232	275	7.7	288

tube design, the total installed cost, including piping, foundation, and indirect costs, may still yield a substantial project cost saving. The reason for this is that the installed cost of a heat exchanger is typically 2 or 3 times the fabricated cost per shell.

We recommend that as a designer, if in doubt, check it out. It does not take long to run a quick screening design comparison on finned vs smooth tube design. Low-fin tubes can be a powerful tool in the hands of a creative and open-minded engineer. If you are too busy to perform the comparison or do not have the rating tools or expertise, NEOTISS can perform a quick screening design review based on the principles described in this article.

Other considerations

Refer to the cross section shown in Fig. 1. Because of the finning process where material is taken from the smooth tube wall to form the fins, the tube wall thickness under the fins is smaller than the starting fin tube. Also, the inside diameter (ID) of the finned section is smaller than the smooth end (compare the left portion of the top sketch to the right). This will create extra pressure drop on the tube side (for the same flow rate), which must be considered during the design or retrofit.

As seen in the bottom of Fig. 1, the fin thickness could be significantly smaller than the tube wall thickness. As a result, the tube material may need to be upgraded to achieve the desired fin life if shellside corrosion is a concern. A lifecycle cost analysis can be conducted to justify the tube material upgrade, for example changing from brass tubes to duplex stainless. The process benefits needed to justify finned tubes will usually be large enough in the more critical services, like FCC fractionator overhead condensers. A common limit can be the cooling water flow which is controlled by the system hydraulics, and fouling. In a bundle retrofit scenario, it may be necessary to adjust the baffle spacing in response to changes in tube material or wall thickness. TEMA guidelines for unsupported tube spans do not account for potential flow-induced tube vibration; therefore, additional tube supports might be required. It is advisable to conduct a vibration analysis using the mechanical drawings provided by the heat exchanger fabricator to ensure that tube damage is unlikely across the range of operating conditions.

With regard to meeting design pressure codes, the wall thickness under the fins and the fin-root diameter are used to calculate the allowable pressures. In the case of high-pressure on the shell side, the ASME Code case 2149 may be used (titanium and Cu-Ni) to empirically calculate from the sample collapse test the design wall thickness under fin. This will result in a much thinner wall allowed per ASME code because it takes into account the stiffening (strengthening) effect of the cold formed OD fins. This design approach can yield further cost savings for the designer and end client.

References

[1] Thomas, Craig, on LinkedIn: <https://www.linkedin.com/pulse/when-should-i-consider-using-low-fin-tube-craig-thomas>

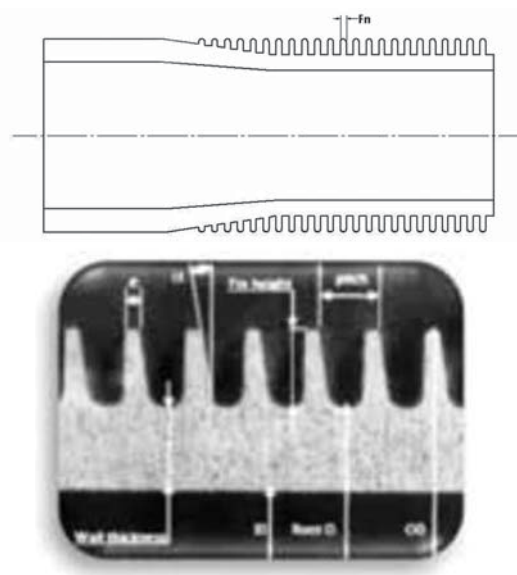


Figure 1. Low-Fin Cross Section (courtesy NEOTISS-HPT Fin Tube, Ref. [2]).

[2] Favrat, Olivier, Enhanced Welded Tubes - From the Strip to the Heat Exchanger Performance, Heat Exchanger World, March 2025

Upcoming in this series

The next few articles will continue with finned tubes, looking at internal finning and special fins and surfaces for two phase services. ■

About the authors

Himanshu Joshi retired from Shell in 2021 after 34 combined years with ExxonMobil and Shell, during which he specialized in heat exchangers and fouling. He was part of a team that was granted a patent related to fouling deposit analysis at ExxonMobil, and led applied fouling R&D projects at both companies. He has made several presentations about the field aspects of fouling and fouling mitigation, and deployed many mitigation technologies in the field. He can be reached by email at alph.hmj@gmail.com.



Lou Curcio has over 30 years of experience in design, troubleshooting and repair of all types of heat exchangers. Leader of technology development projects and advisor for ExxonMobil's global manufacturing teams. Co-inventor of two U.S. patents and co-author of papers on enhanced heat transfer and fouling of heat exchange.



Craig Thomas is currently the Director of Technical Sales for NEOTISS, Inc., a manufacturer of high-performance heat transfer tubing with operations in USA, France, China, and India. Craig has over 33 years of experience in applications engineering related to shell and tube heat exchangers. He is a member of the National Association of Corrosion Engineers, The Materials Technology Institute, Heat Transfer Research Inc., and The American Society of Heating, Refrigerating and Air-Conditioning Engineers. Craig has a degree in Engineering Science from Loyola University Maryland. He currently resides in Nashville TN.

