

Get more out of your heat exchangers with heat transfer enhancement: Part 6 – Case studies in applying dual enhanced tubes for shellside condensing

This article will explore three examples of how low-fin and dual enhanced tubes are used for condensing services to improve heat transfer efficiency and reduce capital expenditure.

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The design of most compact and efficient heat exchangers for new plants or maximal performing heat exchangers in a revamp/upgrade situation in an existing plant demands innovative solutions. In this article we focus on the shellside condensing services with cooling water on the tubeside. The cases presented demonstrate the performance improvement capabilities with low-fin and dual enhanced tubes. Depending on the situation for an existing or new plant design the focus varies between the optimization of OPEX and CAPEX. Refer to Parts 2-4 of this series of articles for background on controlling resistance, finned tubes, and dual enhanced tubes.

Case 1: Petrochemical Plant C3 Refrigerant Condenser

This case is a water-cooled C3 refrigerant condenser and a simple tube bundle upgrade from plain to



Figure 1. Low-Fin GEWA-K tube. Image courtesy of Wieland.

low-fin Wieland GEWA-K tubes (Fig. 1). During summer months with high cooling water inlet temperatures of 27 °C, the C3 condenser capacity limits the compressor performance. Given the constraint of the cooling water flow rate, the only choice to boost the capacity from 6.3 to 9.4 MW (+49 %) is to add surface on the shellside for the condensing C3 refrigerant stream. As shown in Table 1, a low-fin tube with 19 fpi was selected. Selecting the optimal fin density for shellside condensation is essential for performance improvement. The key parameter for good liquid

Table 1. C3 refrigerant condenser in petrochemical plant - Heat duty and feed rate improvement using low-fin tubes (Case 1)

TEMA type AEM	Existing plain tube	Wieland GEWA-K tube upgrade
Heat duty, MW (% increase)	6.3	9.4 (+49 %)
C3 flowrate, kg/s (% increase)	13.5	20.2 (+49 %)
Mean Temp Difference, K	11.0	8.0
Tube Type	19.05 mm OD x 2.77 mm AW*	19 fpi, 19.05 mm OD x 2.34 mm AWUF*
Shell ID x tube length x tube count	1200 mm x 6.1 m x 1820 tubes	
Effective area, m ²	651	1668

*AW – average wall, AWUF – average wall thickness under fins

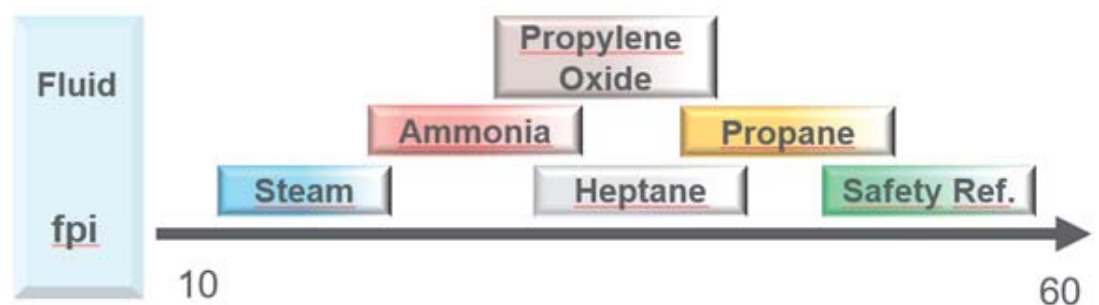


Figure 2. Preferred fin densities for selected condensing fluids [1]



✎ Figure 3. Dual enhanced GEWA-CLF tube. Image courtesy of Wieland.

condensate drainage is the surface tension. The condensation model developed by Rudy and Webb in 1985 [1] offers a very good starting point for calculating fin density (Fig. 2). However, for a comprehensive design, additional parameters such as fin efficiency, which depend on the thermal conductivity of the tube material, and bundle effects, impacted by bundle size and tube layout, must be considered.

Case 2: Seawater-cooled C3 condenser

An opportunity arose to upgrade a boil-off condenser at a tank farm in southern France, coinciding with efforts to extend the service life of this seawater-cooled condenser. The original tubes were 19.05 mm OD, 90/10 CuNi tubes with 19 fpi which had been the reference in the early days of chiller packages. With the lifetime extension, the objective of the operator was to (1) maintain the duty of 2.7 MW at maximal summer cooling water temperature and, (2) to have maximal duty with maximal water flow rate if needed. The analysis of different enhanced condensing structures (Table 2) showed that using

the dual enhanced Wieland GEWA-CLF tube (Fig. 3) for Objective 1, the heat duty can be maintained at a higher sea water inlet temperature (28.0 degrees C vs 24.8 degrees C), and for Objective 2, a heat duty improvement of 50% can be obtained.

The heat exchanger design is with a BEM TEMA type, two tube-passes, shell ID 830 mm and 672, 19.05 mm OD tubes with a tube length of 4.275 m. This particular service is prone to tubeside fouling and in a future article we will address how that might affect the selection of enhanced surfaces.

Case 3: LNG plant – water cooled C3 refrigerant condenser

Dual enhanced GEWA-KS tubes (Fig. 4) have been applied in a major LNG plant design. In comparison to conventional low-fin tubes, a substantial size and weight reduction (-30 %) offers significant savings in CAPEX and plot space (-40 %) as shown in Table 3.

The reference case presented is with a condensing capacity of 292 MW distributed on four shells, TEMA

✎ Table 2. Boil-off condenser - Summary of improvements using dual enhanced Wieland GEWA-CLF tubes (Case 2)

Performance goal	Max. seawater temperature		Max. seawater flowrate	
Tube type	Low-fin 19 fpi	GEWA-CLF	Low-fin 19 fpi	GEWA-CLF
Duty, MW (% increase)	2.7	2.7	3.2	4.7 (+50 %)
Seawater flowrate, kg/s	153.0		193.7	
Seawater temp. in/out, °C	24.8/29.0	28.0/32.2	23.5/27.5	23.5/29.3
Mean Temp Difference, K	10.1	6.6	11.6	10.4

✎ Table 3. LNG C3 ref. condenser - Summary of improvements using dual enhanced Wieland GEWA-KS tubes (Case 3)

	19.05 mm GEWA-K tube (OD: 30 fpi, ID: plain)	19.05 mm GEWA-KS tube (OD: 30 fpi, ID: low fouling helical fins)
Shell ID, mm	2280	
Tube count	6448	
Tube length, m	12.2	7.32 (-40 % reduction)
Equipment dry weight, tons/shell	115	82 (-30 % reduction)

NXN type heat exchanger. After the desuperheater, the propane refrigerant is entering at saturated conditions with $T_{\text{sat}} = 46\text{ }^{\circ}\text{C}$ on the shellside. On the tubeside closed cycle cooling water is flowing in a 1-pass arrangement with $31\text{ }^{\circ}\text{C}$ at the inlet and $41\text{ }^{\circ}\text{C}$ at the outlet.

Summary

This article has highlighted three examples of common heat exchange services that can benefit from the application of low-fin and dual enhanced tubes in place of conventional plain and low-fin tubes.

- In the case of a tube-by-tube replacement of a petrochemical plant C3 refrigerant condenser, low-fin tubes replacing the existing plain tubes enabled a 49% increase in heat exchanger duty at summer conditions with maximal cooling water inlet temperatures.
- In the case of life-time extension of a seawater-cooled propylene boil-off condenser, dual-enhanced Wieland GEWA-CLF tubes in CuNi 90/10 resulted in a 50% increase in duty with operational improvements for high summer cooling water inlet temperature or maximal cooling water flow rate and duty.
- For a propane refrigerant condenser in a mega-size LNG plant Wieland GEWA-KS tube allowed for the maximal flexibility in both CAPEX and plot space reductions.



✦ Figure 4. Dual enhanced GEWA-KS tube. Image courtesy of Wieland.

Upcoming in this series

In the next few articles we will look at other case studies and how fouling might affect finned tube selection. ■

Reference:

- [1] Rudy, T.M. and Webb, R.L., "Condensate Retention of Horizontal Integral-Fin Tubes" ASME Journal of Heat Transfer, Vol. 107, No. 2, May 1985.