Cost Reduction Opportunities for Industrial Applications through Innovative Heat Exchanger Designs using Enhanced Heat Transfer Surfaces

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The Power of Enhanced Surfaces

- Low temperature approaches and energy savings
- Capital savings and/or improved performance
- Significant size reduction – smaller foot-print similar to compact Heat Exchangers
- Reduction in CO2 emissions – an indirect benefit
- De-bottlenecking from process-constraints or capacity improvements in operating plants
- Available for both single-phase and two-phase applications
- Retains Shell-&-Tube configuration
- Modifies Heat Transfer mechanism and therefore different from extended surfaces

Typical Enhanced Surfaces – Single Phase

Based on the following principal mechanisms:

Decreasing the Thermal Boundary Layer

Increasing Flow Interruptions and Mixing

Twisted tape inserts

Spirally fluted

Ribbed tubes

Off-set strip fins

Louvered fins

Active mechanisms such as vibration, electric fields etc.,.

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Typical Enhanced Surfaces – Two Phase

Based on the following principal mechanisms:

Boiling

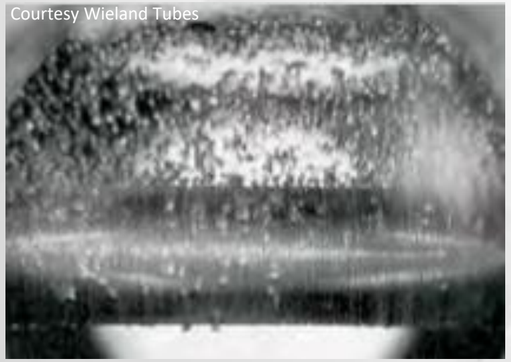
- **Providing re-entrant cavities that trap vapor and promote nucleate boiling**
- **Lower the temperature difference for incipience of boiling by controlling the shape and size of cavities**

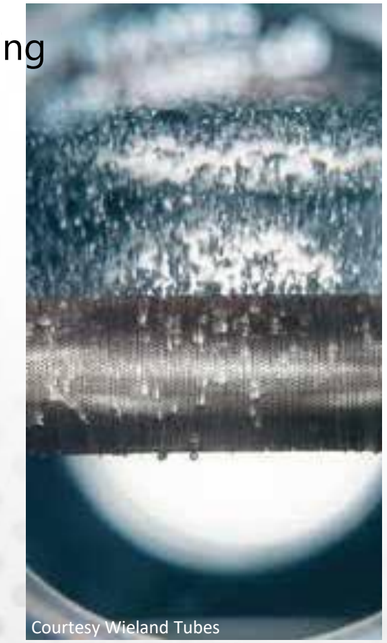
Condensation

- **Use surface profiles to assist condensate draining through surface tension**
- **Use of Hydro-phobic surfaces that promote droplet formation**

Evaporation and Boiling

- Treated surfaces such as porous boiling surfaces
- Structured boiling surfaces
- Active mechanisms


Courtesy Wieland Tubes


Courtesy Wieland Tubes

Condensation

- Fluted Surfaces - Surface tension
- Coatings – hydro-phobic surfaces
- Condensate layer Interruptions
- Active mechanisms

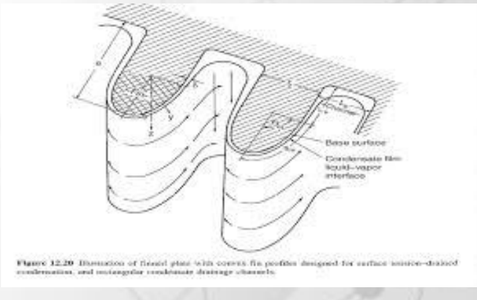
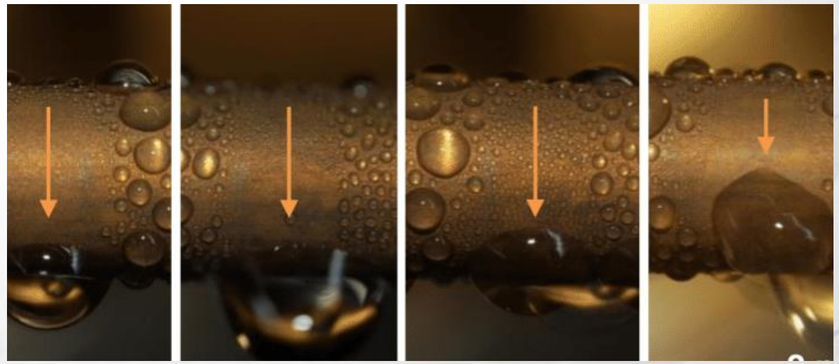


Figure 12.20 Illustration of fluted plate with convex fin profiles designed for surface tension–drained condensation, and rectangular condensate drainage channels.



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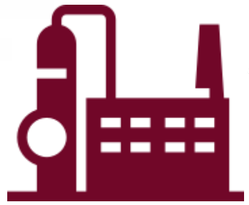
Common Applications of Enhanced Surfaces

HVAC & Refrigeration using doubly enhanced tubes

- Evaporators
- Condensers



Air Separation Plants

- Evaporators
- Condensers

Hydrocarbon Processing

- Evaporators
- Condensers

Power Plants

- Condensers

Machinery Equipment

Are enhanced surfaces suitable for applications involving fouling ?

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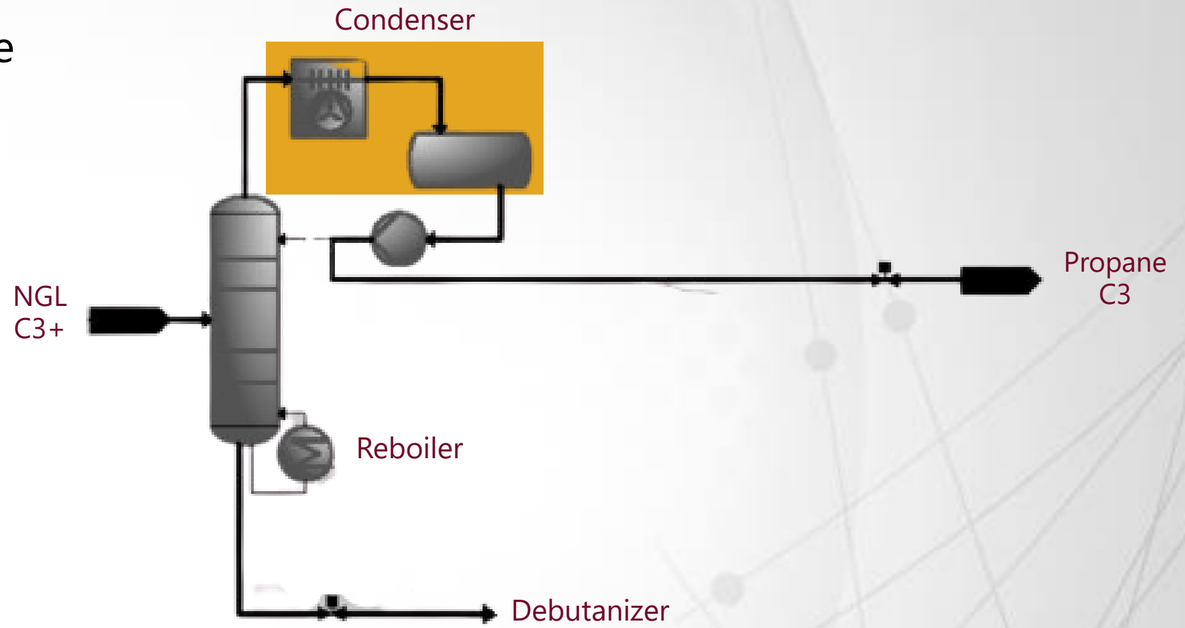
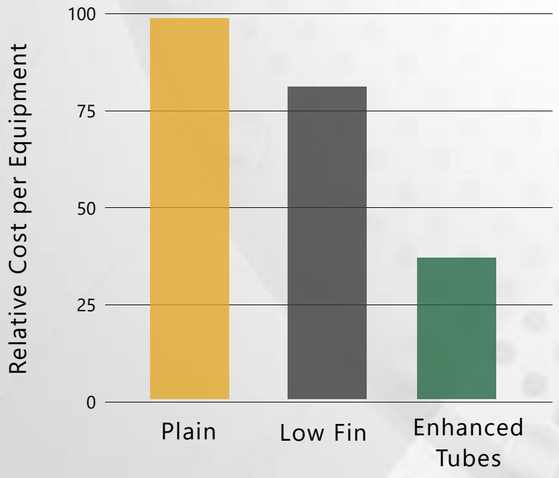
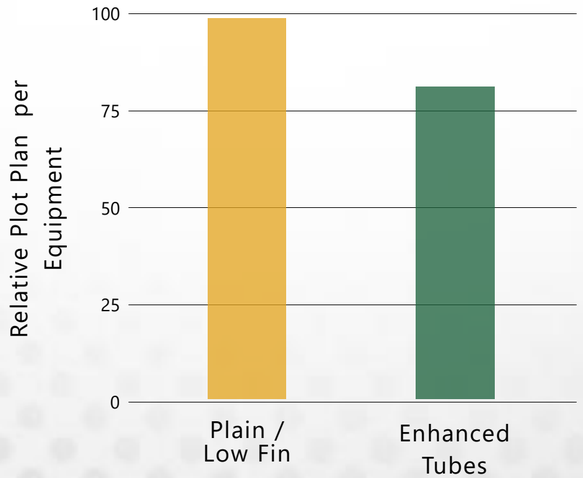
Case Study – Depropanizer Condensers

- A depropanizer is a distillation column that is used to separate propane from a mixture containing heavier hydrocarbon components such as butane and other heavier components.
- The separated propane – overhead vapor from the distillation column – is condensed in the overhead condensers
- This case study concerns the optimization of the condenser heat exchanger using enhanced heat transfer tubes







Case Study – Propane Pre-coolers in LNG Processes

$3 per MM Btu

Pipeline

+

$3 per MM Btu

Distribution

$3 per MM Btu

Liquefaction

$3 per MM Btu

Regasification & Delivery

Total Cost

$12

per MM Btu
(from 12 gal of LNG)

$1 LNG final cost per gal (delivered as gas)

Liquefaction Cost is directly related to refrigeration power and Heat Exchangers used have a direct influence on the refrigeration power

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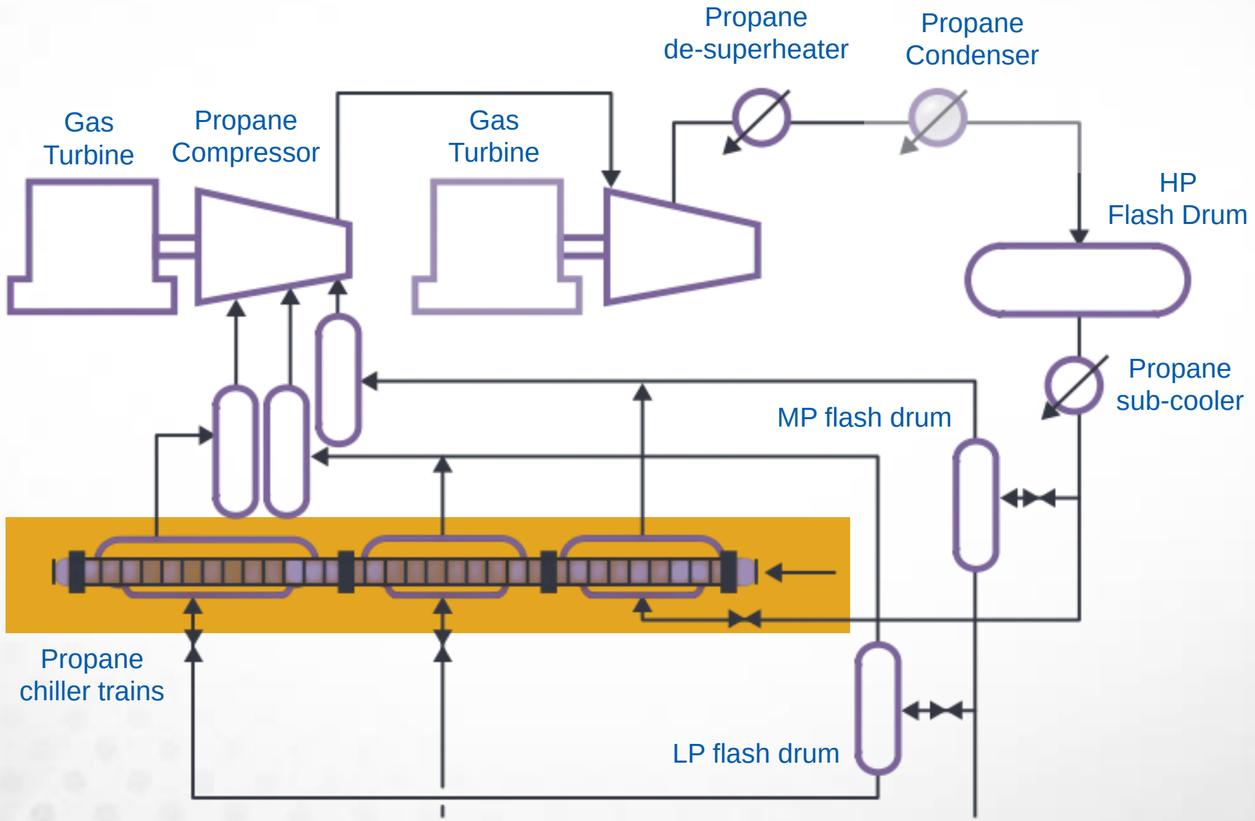
Case Study – Propane Pre-Coolers in LNG Processes

- LNG process and the Propane fore-cooler cycle
- Reducing approach temperatures in the chilling train heat exchangers reduces overall refrigeration power



Propane Refrigerant Cycle

Case Study - Cost savings

Sl No	Description	Existing Configuration - Plain tubes	Proposed Configuration - Enhanced Tubes
1	Size of the Exchanger	1423mm ID x 6096mm Tube Length	**1525mm ID x 6000mm Tube Length**
2	Qty of Tubes	2834 Nos (Plain Tubes)	**3106 Nos (Enhanced Tubes)**
3	Heat Duty	18,805,612 Watts	**18,872,000 Watts**
4	Required Exchangers	2 Nos in Parallel	**1 No**
5	Pump capacity	More	**Less**
6	Space requirements	More	**Less**
7	CAPEX	100% of cost	**60% of cost**
8	OPEX	100% of cost	**50% of cost**
9	Installation cost	More	**Less**
10	Heat transfer / boiling coefficient	Normal	**Enhanced / High Boiling**
11	Lead time & handling	More	**Less**
12	Revamping Capacity & Energy efficiency	Normal	**Improved**
13	Temperature constraints	Yes	**Eliminated**
14	Overall Thermal Performance	X	**2X to 5X**

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How Precision Equipments can help you Implement cost savings through enhanced heat transfer tubes

- Your requests/opportunities would be divided into one of the following 3 categories :
  - **Category A: Immediate Implementation**
    - Short term for immediate implementation.
    - Similar applications are working in the field.
    - No development work. Known design methods would suffice for this approach.
    - The steps are: Design, Economic Analysis and commercialization. We should see results within 6 months to a year.
  - **Category B: Medium term Implementation**
    - Medium term for implementation in 2 to 3 years.
    - Would Require field tests
    - Would not require any laboratory scale work.
  - **Category C: Long term for Implementation**
    - In 5 years these opportunities would require some fundamental studies such as determining the boiling or condensation heat transfer coefficient. This will be followed by prototype tests and beta tests before full commercialisation
- PECPL is willing to work with interested customers to provide the best solutions that would meet the comprehensive needs of customers world-wide.

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