Energy Savings for Process Heat Exchangers: Case Studies and Benefits

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Date:20 May 2025

The Problem

Process improvement projects based on energy savings alone fail to attract funding

Rate of return is too low

Reasons

- Traditional “pinch” analysis leads to increased plant complexity and requirements for new heat exchangers
- Plants without a well-defined pinch require modifications to a large fraction of the network to achieve savings
- New heat exchangers and modifications to pipework/structures are expensive

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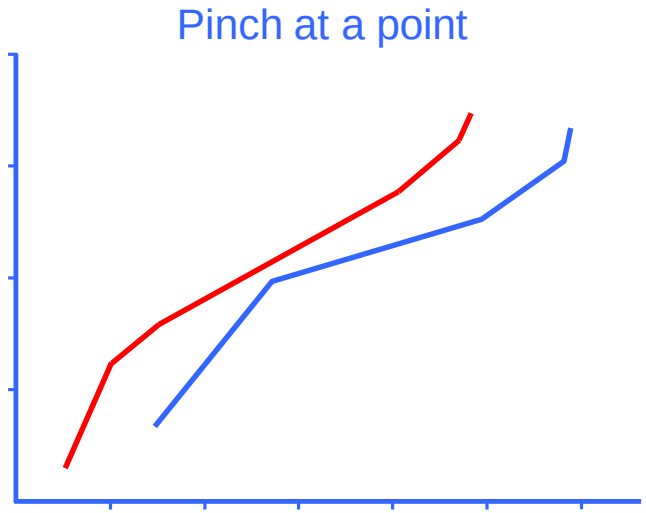
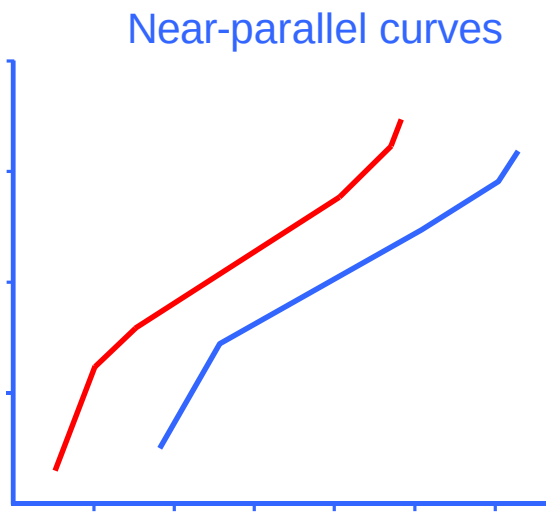
Composite Curves - Poorly Defined Pinch





A few plants have a clearly-defined pinch:

- Modest network modifications near pinch point will yield energy savings at low cost

For many plants composite curves are near-parallel:

- To achieve energy savings, modifications will be required across the majority of the network – high cost

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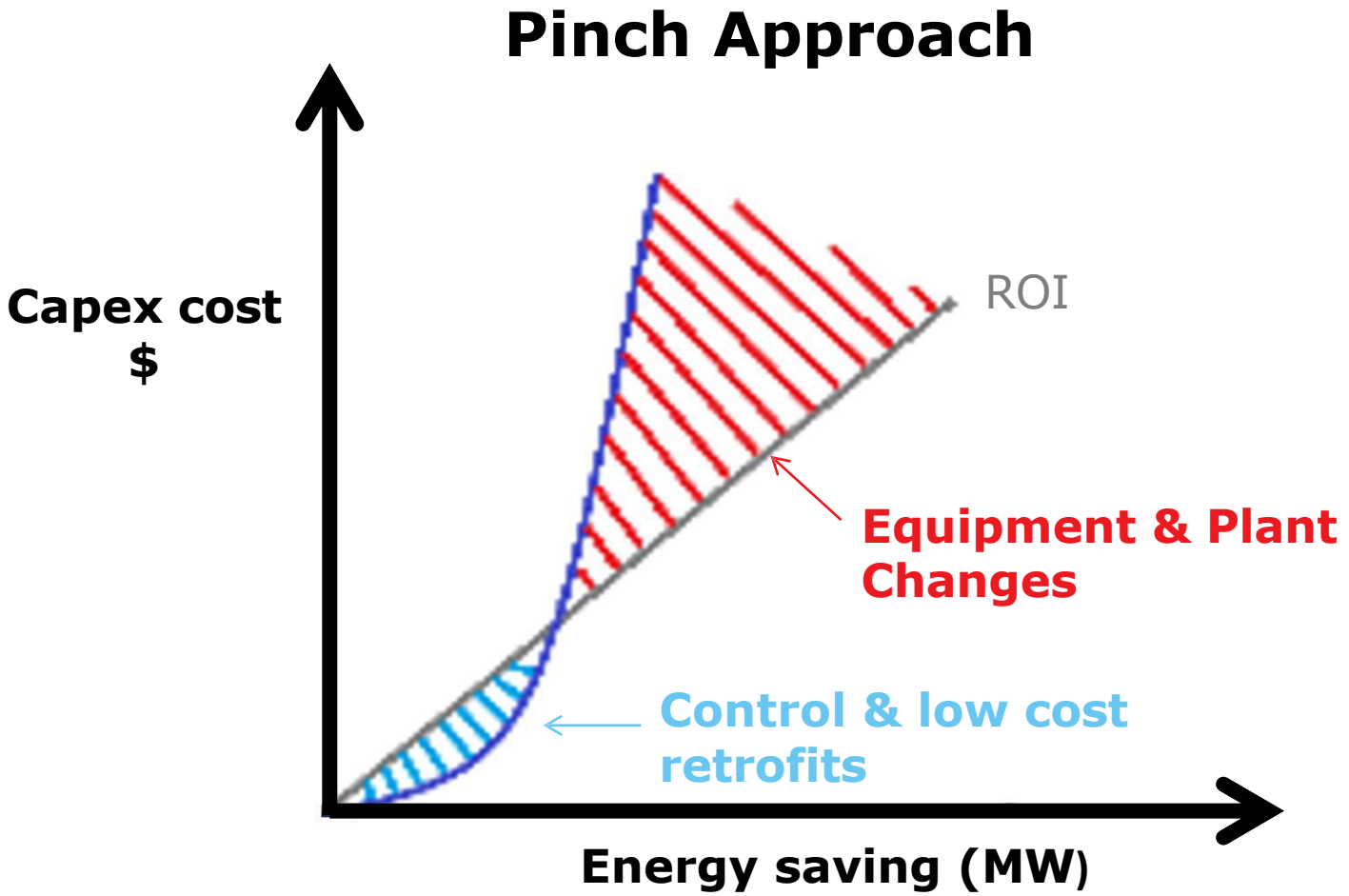
Project Costs vs. Energy Savings



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Solutions

Increase the energy savings

- Limited by thermodynamics

Reduce project cost

- Avoid structural changes to the network
- Avoid new equipment
- Improve performance of installed assets

Introduce other motivating factors

- Increased throughput
- Improved product quality
- More profitable product mix

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Software and Analysis

Bring together two technologies

- Heat exchanger network simulation/optimisation
- Heat exchanger enhancement

Use specialist software to

- Identify opportunities to use enhancement
- Select the most appropriate enhancement technique
- Quantify the outcomes
- Demonstrate operational flexibility

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Global Consulting Engineers for Heat Transfer Solutions

- CALGAVIN established 1980
- Head Office: Alcester, Birmingham, UK
- Manufacturing of technology carried out in UK

Extensive Research and Development in Hardware & Software

Work carried out at In-house Test Laboratory collaborating with 10+ Universities across Europe.

Engineering Services Provided

- Analytical engineering
  - Advise on design and performance improvement of new and existing heat exchangers
- Design services
  - Evaluating specifications and modelling thermal & hydraulic ratings (HTRI®, Aspentech® EDR & CALGAVIN®.SP)
- CFD analysis
  - Identify heat exchanger poor performance root caused by maldistribution, stratification or other causes via CFD

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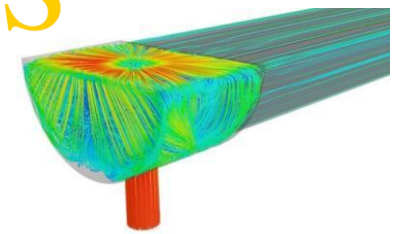
Xchanger Suite

EXCHANGER OPTIMIZER

aspentech

ANSYS



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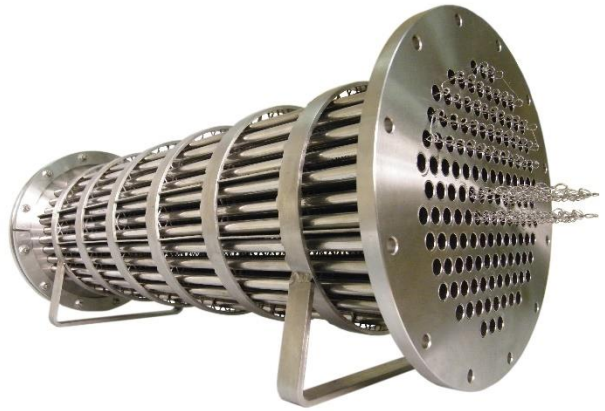
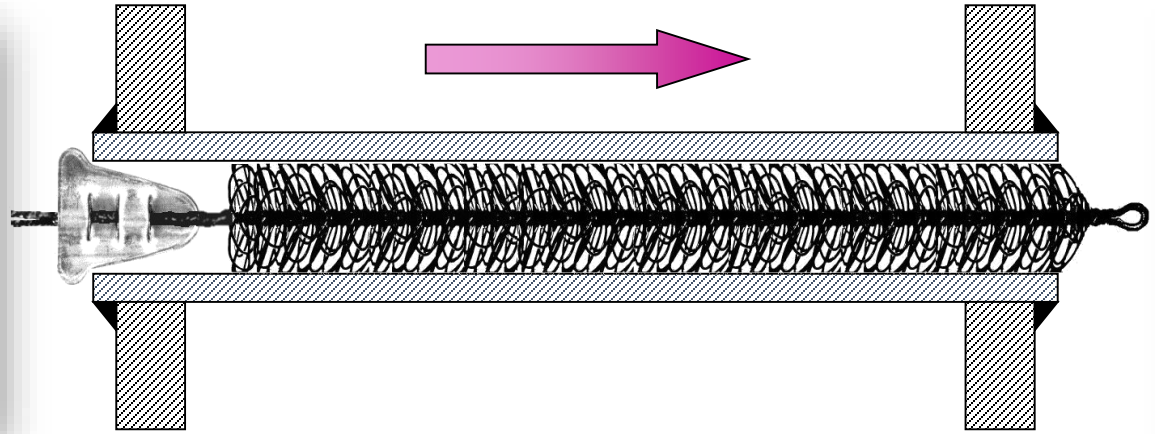
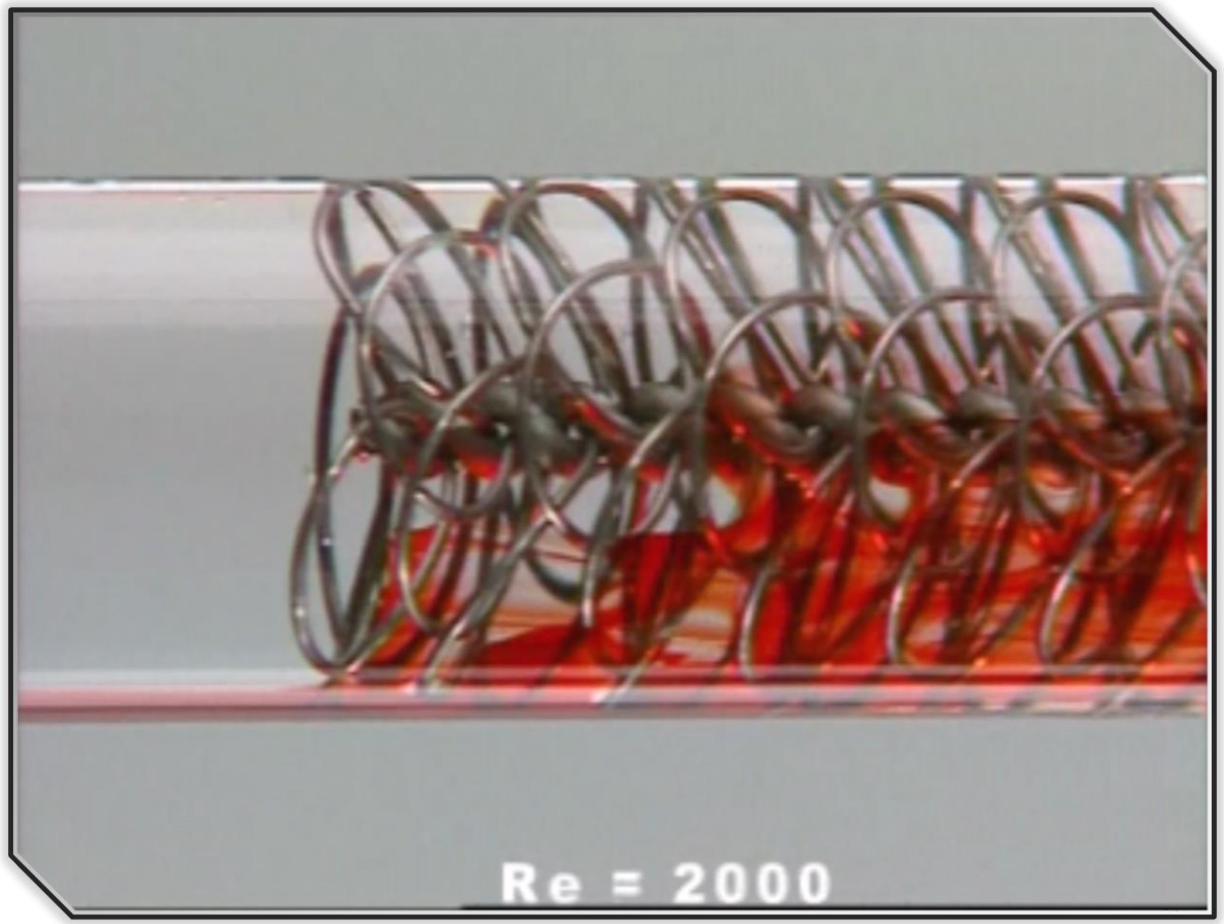
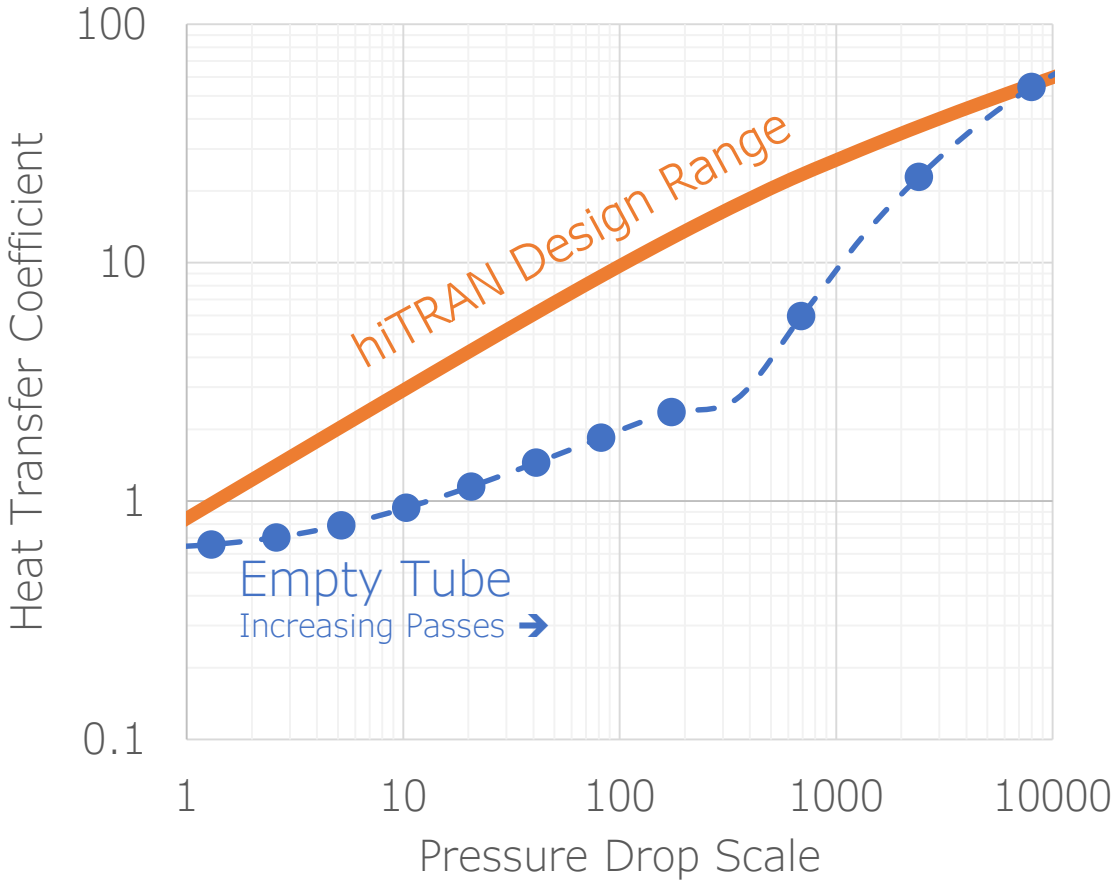


Direction of flow



Heat Transfer Enhancement





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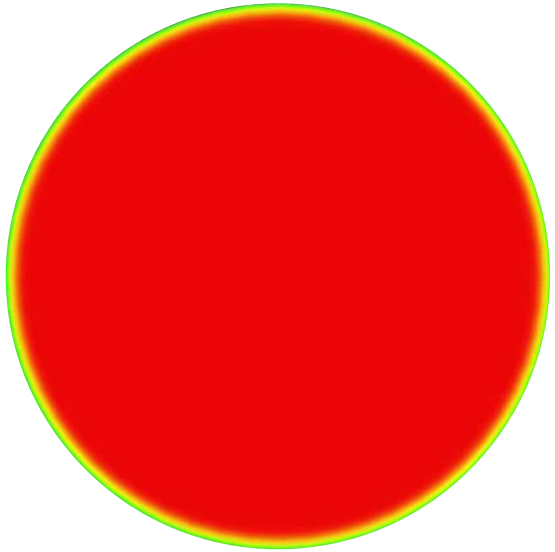
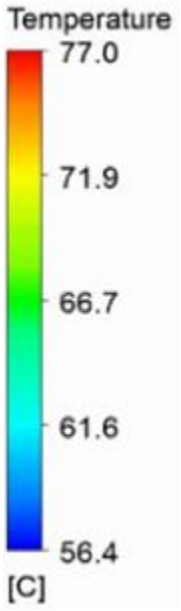
CFD Simulation of Laminar Flow vs hiTRAN-Enhanced

Plain Empty Tube
Stratified flow
Lower half of tube not effective



8m
Tube



Enhancement with hiTRAN Tube
Fully mixed flow
Common temperature across tube

3.5m
Tube

Natural convection:

- Cold, heavy fluid sinks to the bottom of the tube

- hiTRAN-enhanced flow delivers a reduced flow length by 56%

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Target Applications for hiTRAN® Technology

TOTAL
Angola, Wet/Dry Crude Exchangers

PTT
Thailand, Lean/Rich TEG Exchanger

SINOPEC
China, EOG Condenser

LUKOIL
Russia, Feed Effluent Exchangers

ESSAR OIL
UK, Diesel Rundown Cooler

BASF
Germany, Thermosyphon Reboiler

DOW Chemicals
Germany, Epoxy Resin Cooler

TOTAL
Belgium, Ethane Vaporiser

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Case Studies

Heat Recovery & Energy Savings

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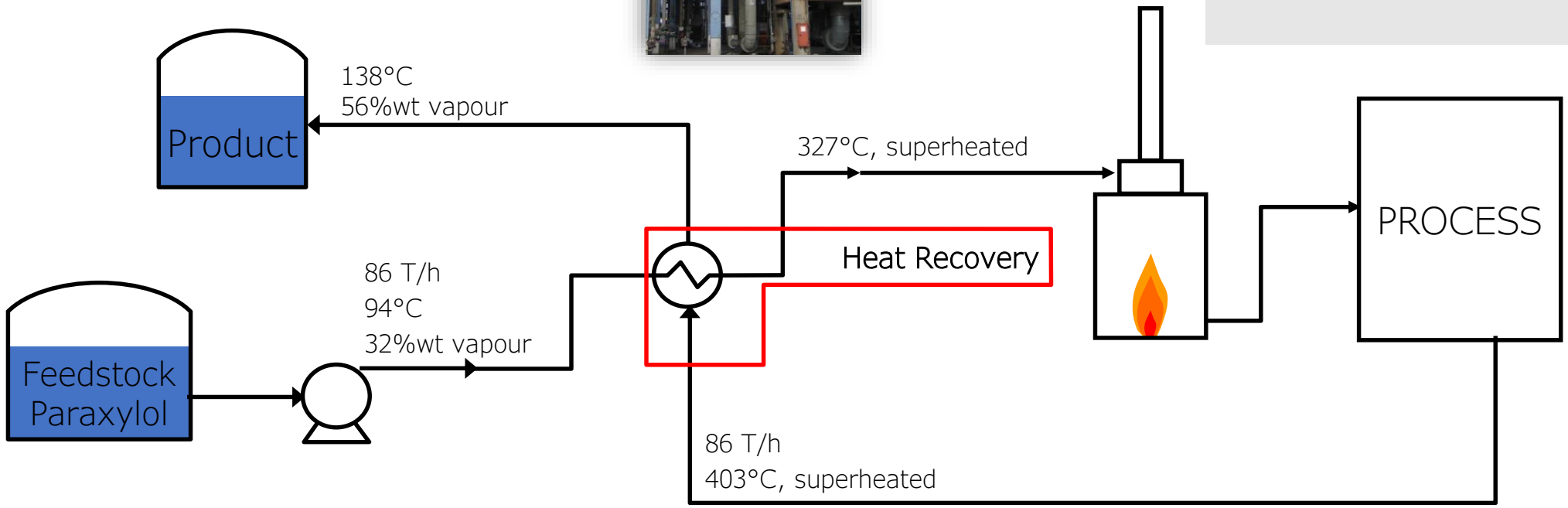
Heat Recovery - Feed / Effluent HEX

Feed / Effluent Scholven
BP refinery
Shell-and-Tube Type AES

Duty: 19.7 MW
1734 tubes: 20mm x 2mm x 12m
Single Pass

Revamp target:

- Upgrade – 15% plant capacity increase
- Texas Tower as key equipment unable to meet increase



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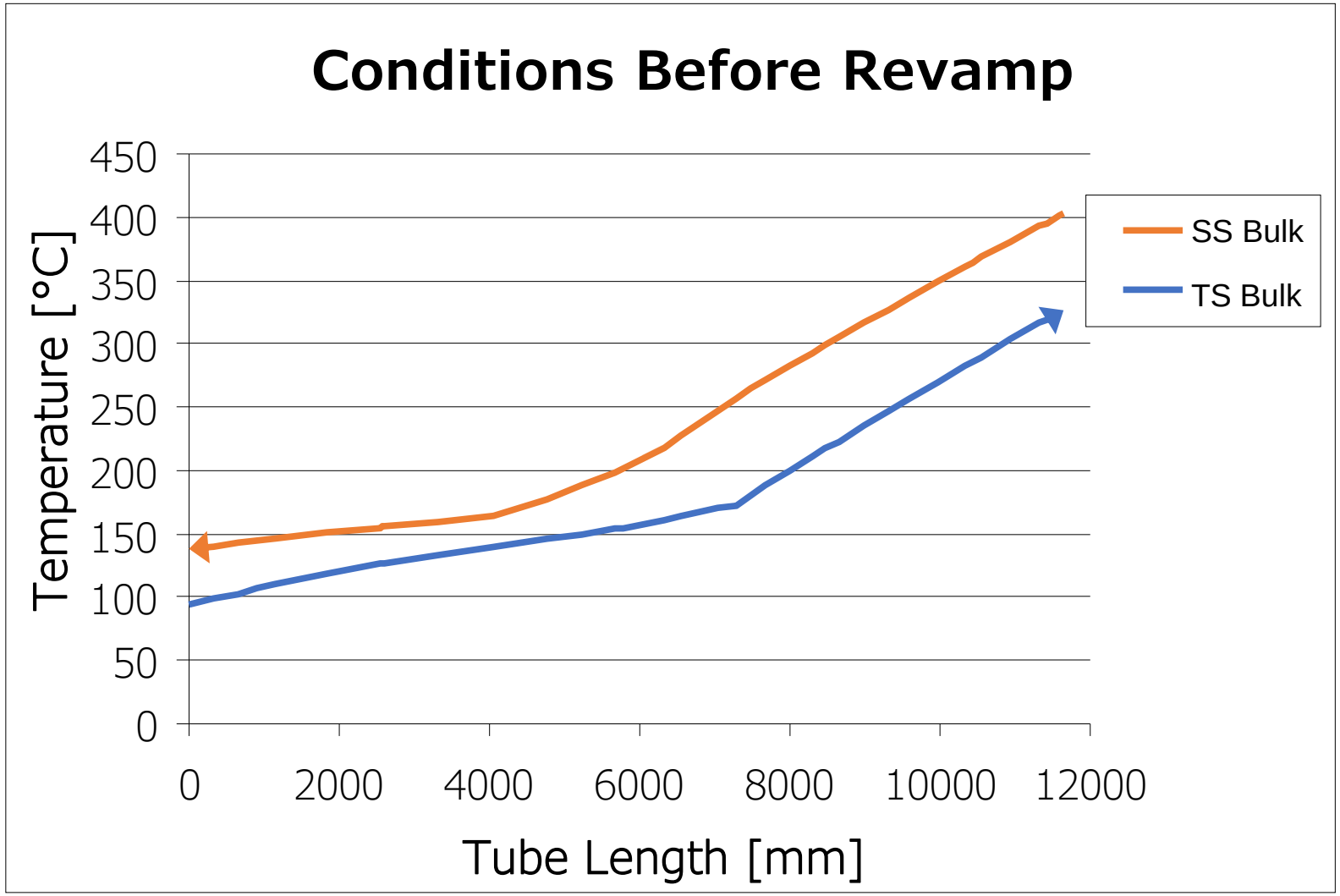
Temperature Distribution



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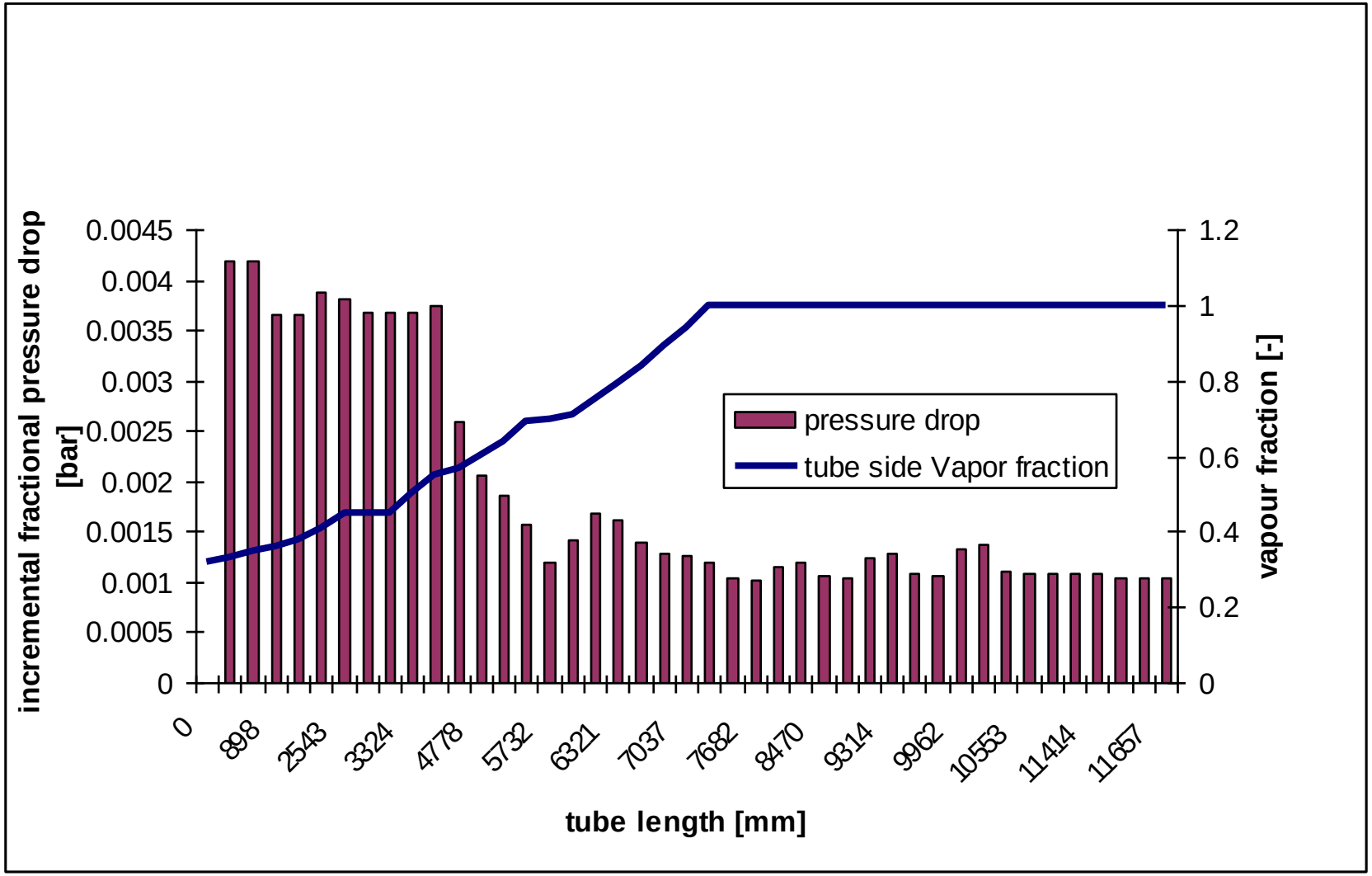
Problems with Current Design

- Temperature cross; single tube pass only
- Low tube-side heat transfer
- 1 bar pressure drop allowable, only 0.1bar used

Options for Upgrades

1) Size Increase (New exchanger, incl. new piping & civil eng.)
2) hiTRAN Enhancement technology

Provided Solution



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The Benefits

- 3MW increase in duty, 18% higher throughput
  - Negated need for larger unit, saving in CAPEX
  - No additional civil engineering costs
  - No additional piping costs

- Reduction in Fired Heater duty
  - Reduced energy use
  - Reduced CO_2 output (80,000 t since installation in 2008)
  - $3.2 M savings since 2008 with a Carbon Credit price $40/t

Feed/Effluent Exchanger Enhancement

Exchanger

- Heat recovery from reactor effluent
  - Additional pre-heating provided by fired heater
- TEMA AES, 3 series x 2 parallel shells
- 2,521 tubes per shell (9m long)

Problem

- Insufficient heat transfer for higher throughput
- High fuel consumption in furnace (at firing limit)

hiTRAN® Benefits

- Improved heat transfer performance
- Reduced maldistribution on tube-side
- Increased duty of 2.2 MW (+50%)
- Increase plant throughput
- Alternative: Fuel saving of **$233,000 per year**

New Design: Export Oil Trim Cooler

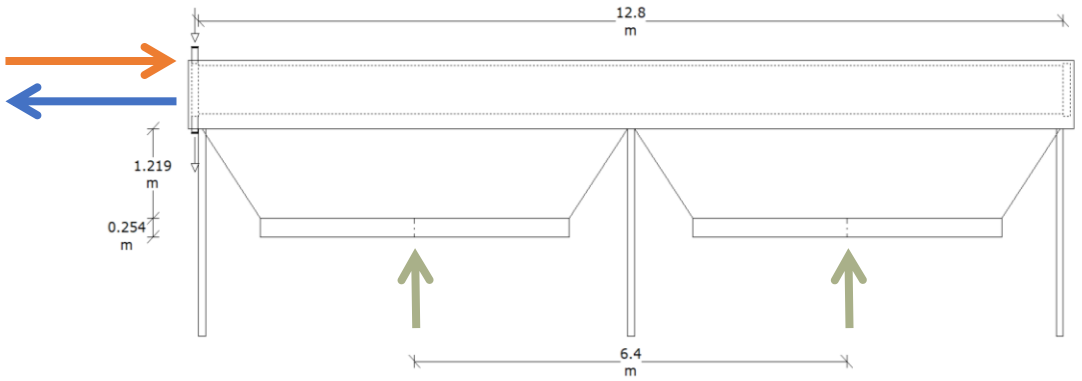
End User
Kuwait Oil

Service
Export Oil Cooler
Duty: 9.7MW

Exchanger
API 661 Forced draft air cooler
8 Bays in parallel, 2 bundles per bay 600 tubes per bundle
(31.75 x 2.1x 12,800mm)

Oil Flow
125 kg/sec
Inlet: 100°C
Outlet: 60°C
ΔP Allowed: 103.4kPa

Air Cooler Duty - 9.7 MW



Airflow
Ambient Temperature: 50°C
ΔP allowed: 200 Pa
Face Velocity: 2.1 m/sec

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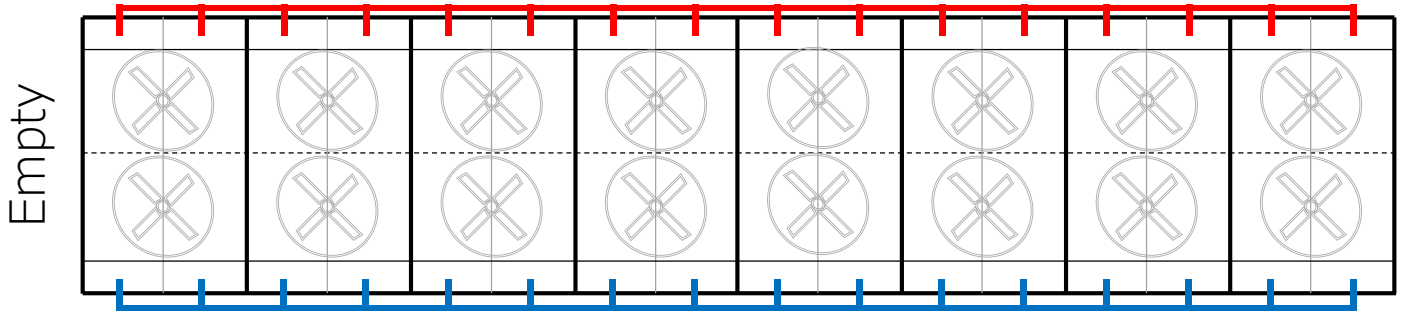
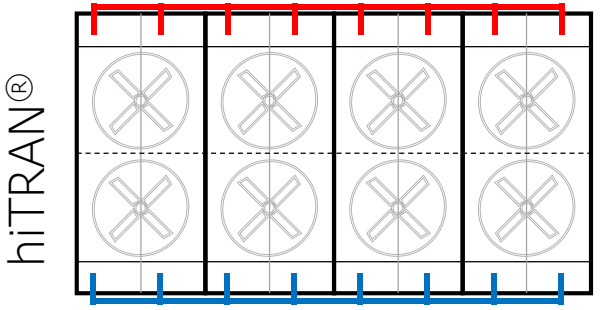
Case Study: Export Oil Trim Cooler





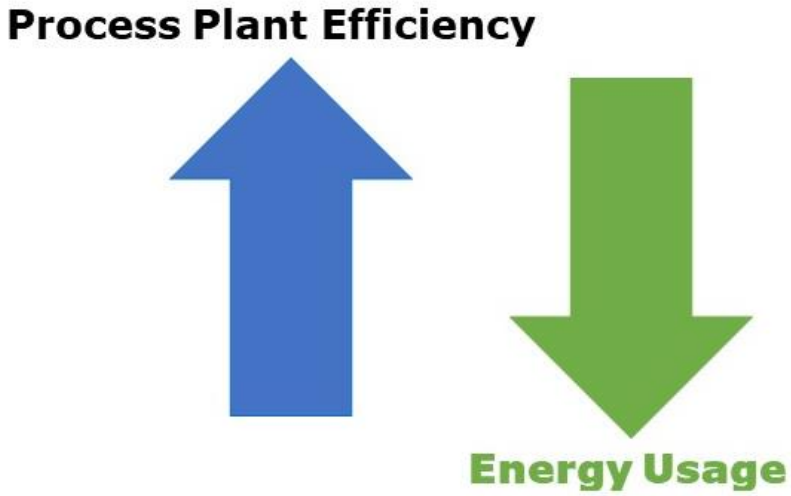
	Empty Tube Design	hiTRAN® Design
Heat Transfer Coefficient (W/m^{2}K)	50	**252**
Bays in parallel	8	4
No of rows / passes	12 / 8	11 / 2
Tube per bundle / Total	600 / 9600	473 / 3784
Plot area (m^2)	712.3	309.7
Fan Power (kW)	271	**107**
Predicted cost after 10 years	$3,100,000	**$1,200,000** (incl. hiTRAN®)

Cost and Energy Savings with Enhancement

- Good return on investment – Increased heat transfer but at small CAPEX cost compared to the alternative of replacement plant and re-piping.

- Reduced OPEX costs – Less cooling/heating utilities needed for required heat transfer duties.

- Increased productivity – Increases the duty of an exchanger enabling increased flows to be processed and increase throughput.



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Completed Orders
20,000+

Successful Retrofits
5,800+

Countries Supplied
50+

Number of Industries
15+

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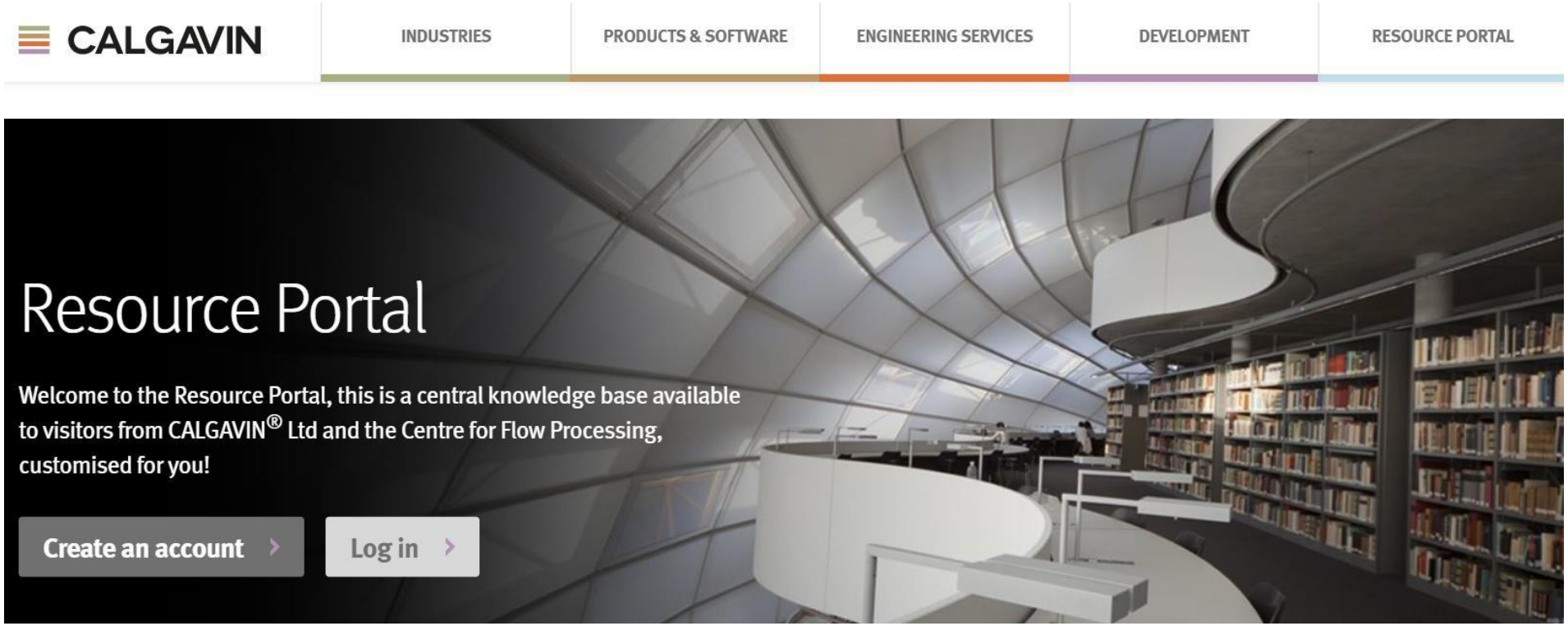
CALGAVIN Resource Portal

https://www.calgavin.com/resource-portal



CALGAVIN has a protected customer resource portal and knowledge base to explore and learn!

- Case studies (Offshore, Refining, Petrochemicals & Chemicals)
- Academic papers, conference papers & magazine articles
- Over 20 webinars (Heat exchanger design, condensation, maldistribution, vaporisation etc.)

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Any questions?

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