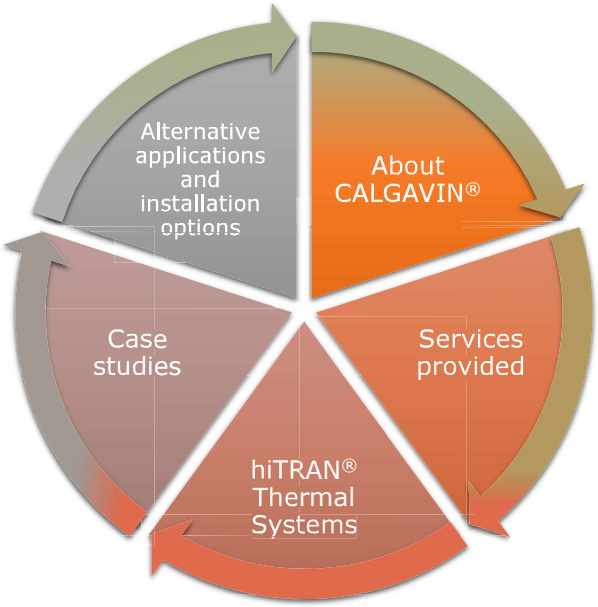
Energy Saving Technology

Vincent Chu
Taiwan Sales Representative

Topics for Discussion



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Who we are?

About CALGAVIN®

CALGAVIN

Global Consulting Engineers for Heat Transfer Solutions

Established 1980
Head Office: Alcester, Birmingham, UK

Manufacturing of technology carried out in UK

Extensive Research and Development in Hardware and Software
Work carried out at In-house Test Laboratory collaborating with 10+ Universities across Europe

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CALGAVIN Global Locations

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What we do?

Services Provided

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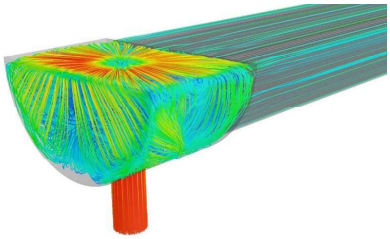
Engineering Services Provided

- **Analytical Engineering**
  - Analysing unenhanced designs and existing equipment and offering solutions for performance improvement
- **Design Services**
  - Evaluating specifications and modelling thermal & hydraulic ratings (HTRI®, Aspen Exchanger Design Rating & hiTRAN®.SP)
- **CFD Analysis**
  - Process simulation allows anticipation of problems such as maldistribution and stratification, can identify poor performance root causes and simulate proposed solutions



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hiTRAN® Thermal Systems

Product offering

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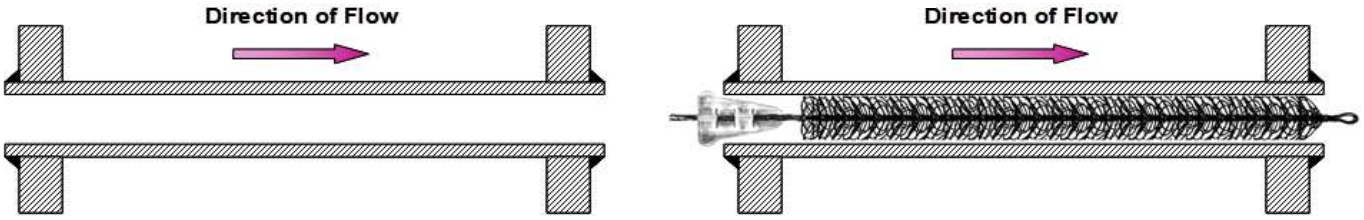

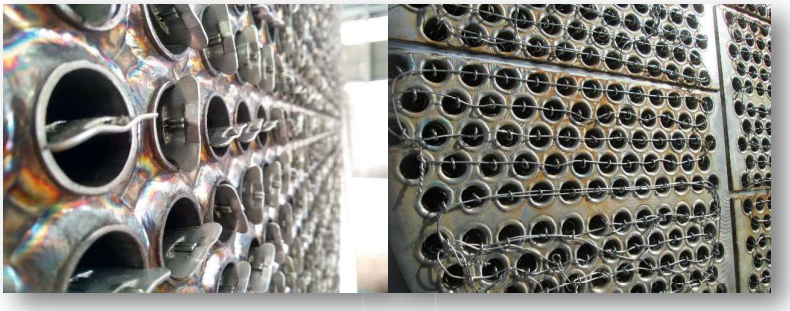

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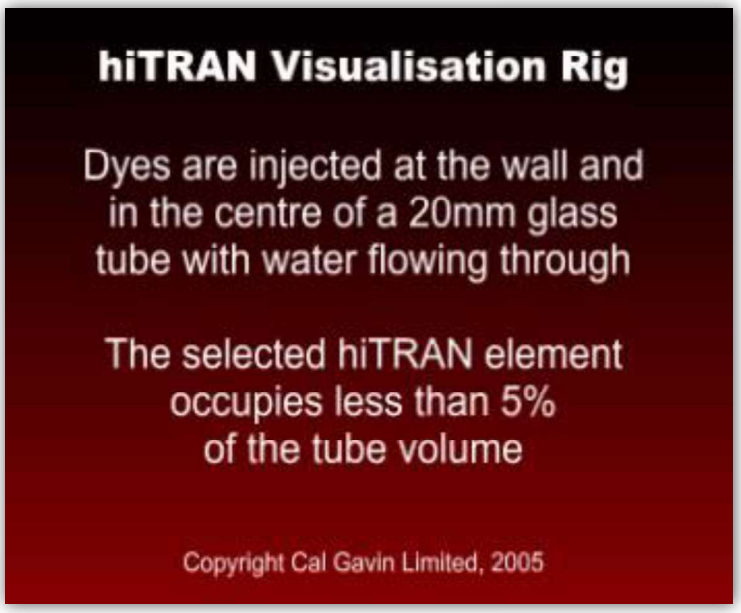
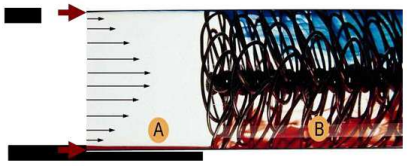
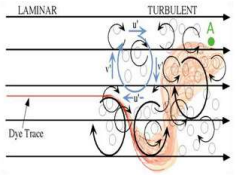
How Does hiTRAN® Technology Work?







- Removes the laminar boundary layer
- Mixes fluid with bulk flow
- Improves heat and mass transfer- changing the mode of heat transfer at the tube wall from **conduction** to **convection** – higher rate of heat transfer

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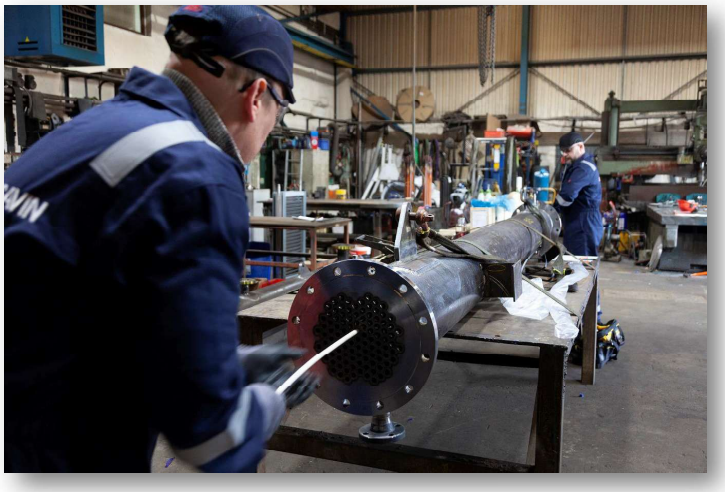
Heat Transfer Benefits

New Equipment

- Reduced number of bundles for the same duty
- Reduced weight
- Reduce space requirement
- Lower energy demand
- Lower installation cost
- Lower maintenance costs



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Heat Transfer Benefits

Existing Equipment

- Overall improvement and optimisation of existing equipment
- Increase in production and reduction in energy use
- Maintained performance through mitigation of fouling
- Reduction in Operational cost
- Low Capital cost

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What companies do we work with and in what applications?

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	O.NO.	ITEM TYPE	APPLICATION DESC.	CUSTOMER BENEFIT	END USER	INSTALL COUNTRY	TUBESIDE FLUID
INDUSTRY:	**Bulk Chemical (plastics, resins)**						
	7621	Shell and Tube	Gas Dehydration & TEG Regeneration Unit	Reduced Fouling	Banagas		
	7623	Shell and Tube	Dephosgenation condenser	Reduced Size	BAYER	USA	
	7649	Shell and Tube	Sulfuric acid	Reduced Fouling	Sumitomo Chemicals	Japan	Conc. Sulfuric acid
	7673	Double Pipe	single condenser tube	Improved Duty	Wacker Chemie	Germany	Ethylacetat
	7674	Double Pipe	single condenser tube	Improved Duty	Wacker Chemie	Germany	Ethylacetat
	7676	Shell and Tube	Polyol exchanger	Improved Duty	STEPAN	USA	Polyol
	7709	Shell and Tube	TMP heater	Reduced Size			TMP
	7725	Shell and Tube	BASF Product cooler	Reduced Size	BASF	Singapore	Product
	7728	Reactor	Reactor cooler	Improved Duty	BASF	Belgium	
	7811	Shell and Tube	Polyol Heater	Reduced Size	STEPAN	Germany	Polyol
	7812	Shell and Tube	Polyol Heater	Reduced Size	STEPAN	Germany	Polyol
	7821	Shell and Tube	Vertical condenser	Improved Duty	Wacker Chemie	Germany	
	7832	Double Pipe	Falling Film Test	Improved Duty	BASF	Germany	
	7833	Double Pipe	Falling Film Test	Improved Duty	BASF	Germany	

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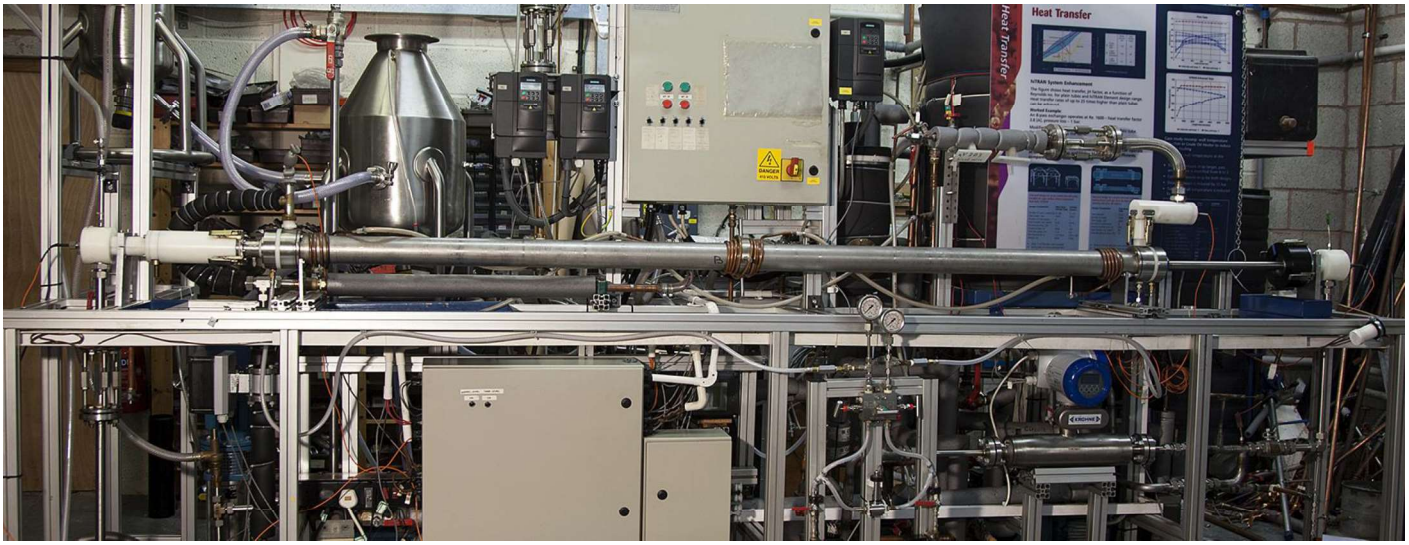

In-House Heat Transfer test Facility

- 4 double pipe heat exchangers
- 10mm to 32mm tube ID
- Heating & cooling duty

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Test Ranges

Tube side flow rates
- 20kg/hr < V <4000kg/hr

Test fluids
- Heat Transfer and Lube Oils
- Glycerol;water

Viscosity range
- 0.3cP < eta < 2000cP

Dimensionless numbers
- Reynolds range
  0.5 < Re < 200000
- Prandtl range
  2 < Pr < 10000

Heat balance accuracy
- <+-5%

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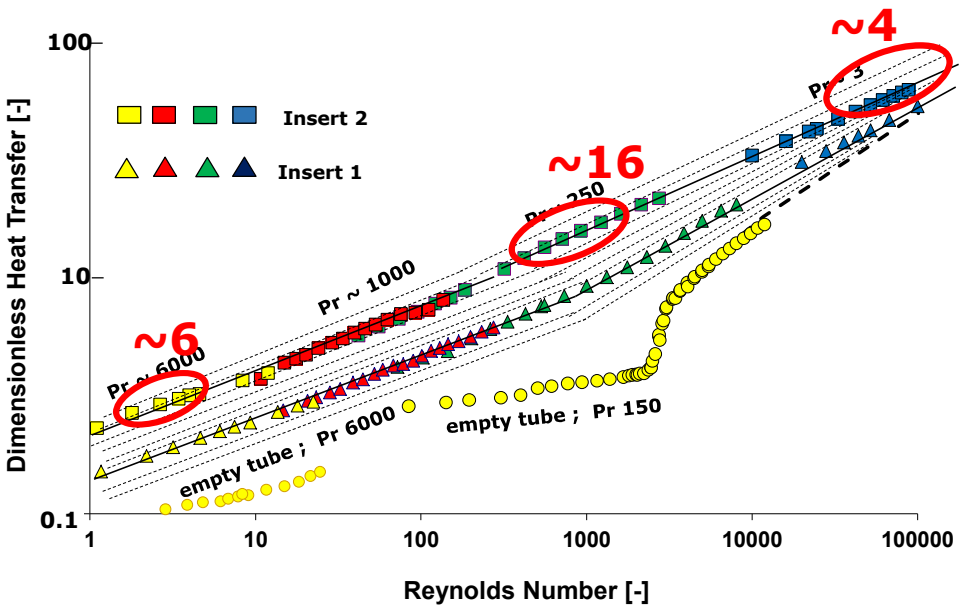
hiTRAN® Range in Comparison to Empty Tube Data



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hiTRAN®.SP design & selection program

Desktop Modelling

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hiTRAN®.SP Software Tool

Correlations for tube side enhanced heat transfer and pressure drop are implemented in hiTRAN™.SP

Free to download after application from www.calgavin.com

Integrates as plug in for single phase with:

For clean recirculating fluids CALGAVIN® warrants tube side heat transfer and pressure drop performance

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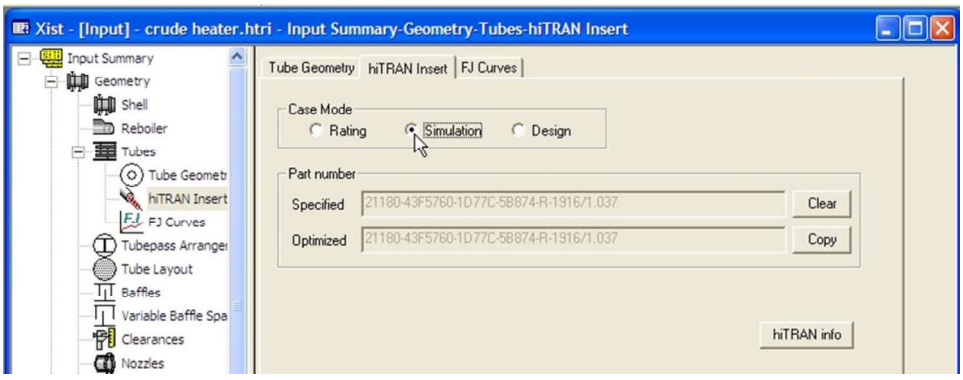
hiTRAN®.SP Software for HTRI Xchanger Suite®



- Fully Integrated hiTRAN® insert calculation in Xist & Xace
- Optimised design algorithm to utilise entire tube side allowable pressure drop to maximise heat transfer performance for single phase applications

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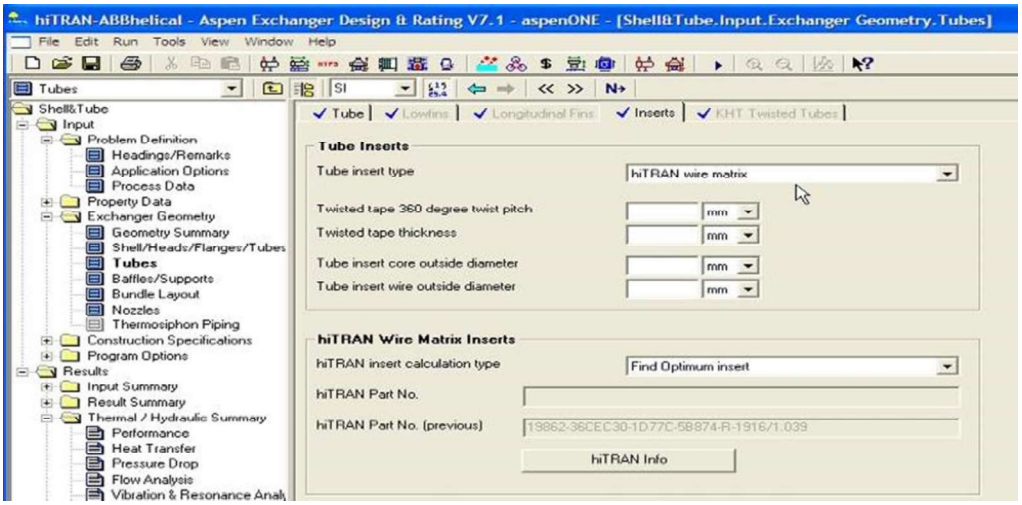
hiTRAN®.SP Software for Aspentech EDR



- Fully Integrated hiTRAN® wire matrix calculation in Shell & Tube and Air-cooled design software from Aspentech

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Product Heater Case Study

Single Phase

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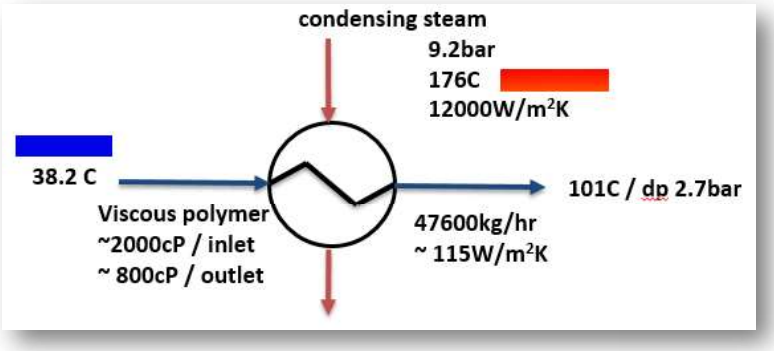
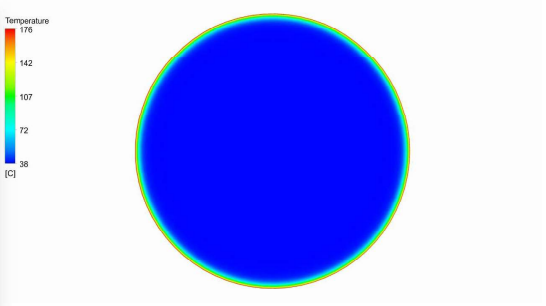
Viscous Product Heater
Revamp Goal: Increased Outlet Temperature

TEMA Type: AEL 4 Pass
372 Tubes 25.4mm x 1.65mm x 4000mm





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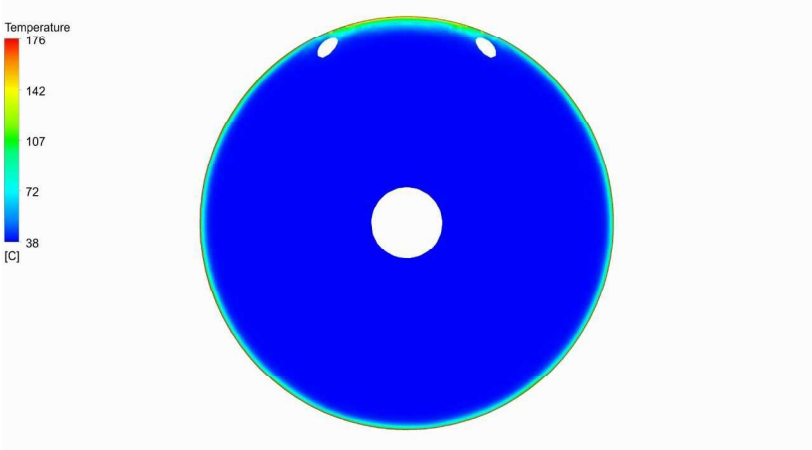
Viscous Product Heater Revamp
Retrofitting with hiTRAN®



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Viscous Product Heater Revamp
Retrofit Results

	Empty 9.2 bar	hiTRAN® 2.7 bar	hiTRAN® 6.3 bar
No. of passes	4	2	2
Steam Pressure (bar)	9.2	2.7	6.3
Steam temp. (°C)	176	128	160
Tube side HTC (W/m^2K)	100	**207**	**206**
Tube side outlet Temp (°C)	101	101	124
Tube side dP (bar)	2.7	3.3	2.9

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Export Oil ACHE Case Study

Reducing Cost

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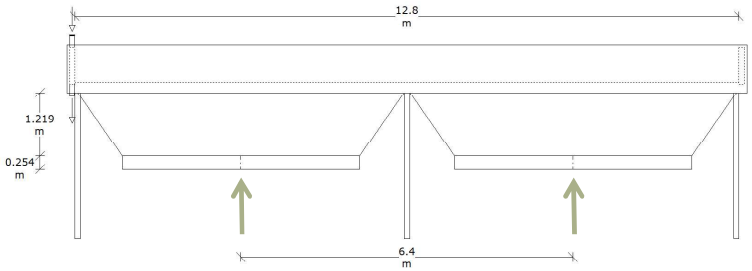
Design Case

Air Cooler Duty - 9.7 MW duty

Oil Mass Flow
Oil: 124.66kg/sec
dP Allowed:
103.4Pa



(2 Pass)

Airflow
Ambient Temperature: 50°C
dP allowed: 200 Pa
Air Rate: 2.1 m/sec

Tubeside Temperatures
Inlet: 100°C
Outlet: 60°C

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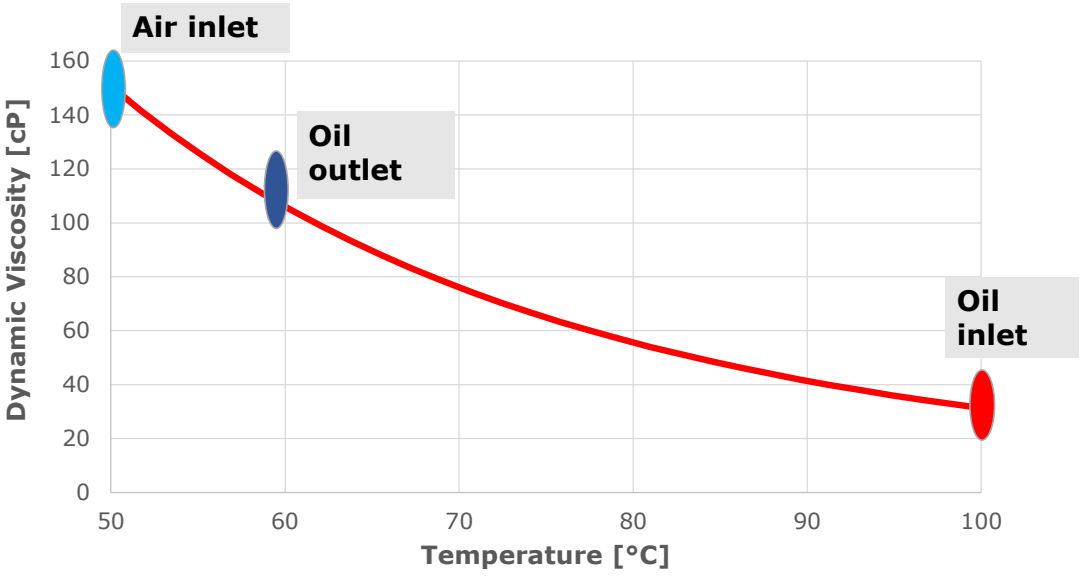
Properties of Export Oil (Heavy Crude)



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Empty Tube/hiTRAN Design

Process Conditions	Empty Tube Design	hiTRAN® Design
Temperature Oil In/ Oil Out (°C)	100 / 60	
Oil flow rate (kg/s)	124.7	
Temperature Air In/Air Out (°C)	50 / 55.5	50 / 62.8
Air face velocity (m/s)/ heat transfer (W/m^2K)	2.1 / 685	2.1 / 685
Tube side heat transfer (W/m^2K)	50	**243.6**
Tube side Velocity [m/sec] / Reynolds (-)	0.19 / 67	**0.11 / 45**
Tube side pressure drop Total / Allow (kPa)	80.9 / 103.4	**101.9/ 103.4**
Duty (kW)	9680	

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Operative Data

Process Conditions	Empty Tube Design	hiTRAN® Design
Tube side pressure drop Total / Allow (kPa)	80.8 / 103.4	101.9 / 103.4
Tube side Velocity [m/sec] / Reynolds (-)	0.19 / 67	0.11 / 45
Mean wall shear stress (Pa)	5.39	5.61
Residence time of crude in tubes (sec)	539	213
Average skin Temperature	54.6	64.7
Average skin viscosity	130	90

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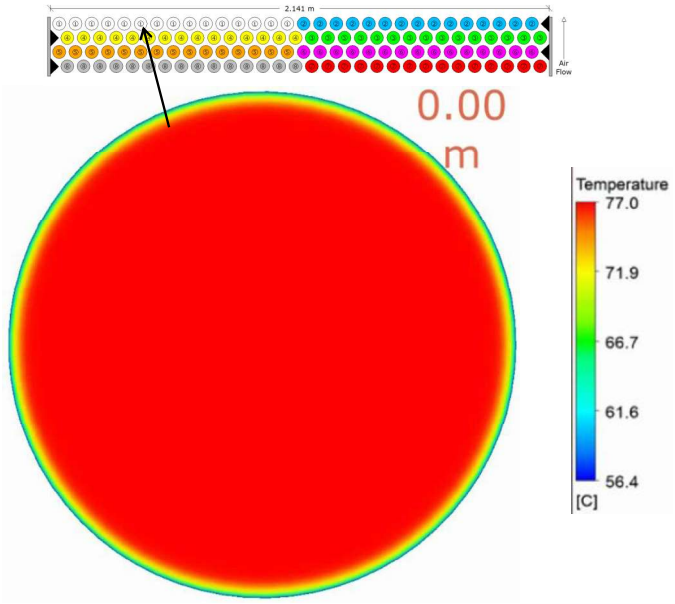
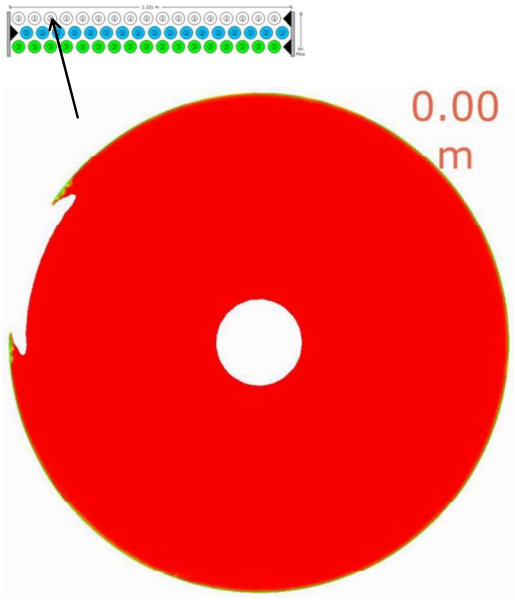
Oil Cooler Flow Simulation





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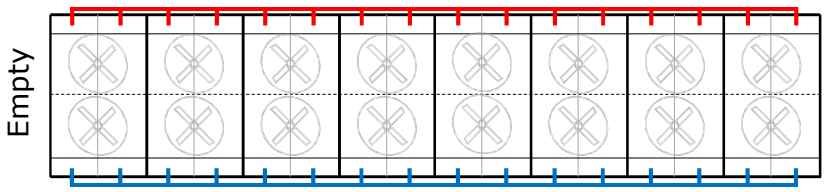

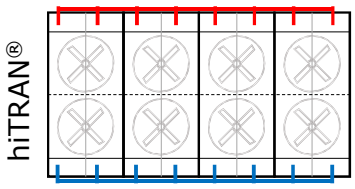

Geometry	Empty Tube Design	hiTRAN® Design
Bays in parallel	8	4
Tubes per row / tube rows / No of passes	50 / 12 / 8	43 / 11/2
Tube per bundle / Total	600 / 9600	473 / 3784
Tube length (m)	12.8	12.8
Plot area (m^2) bundle / total	712.3	309.7
Fan Power bay / total (kW)	34 / 271	26.8 / 107

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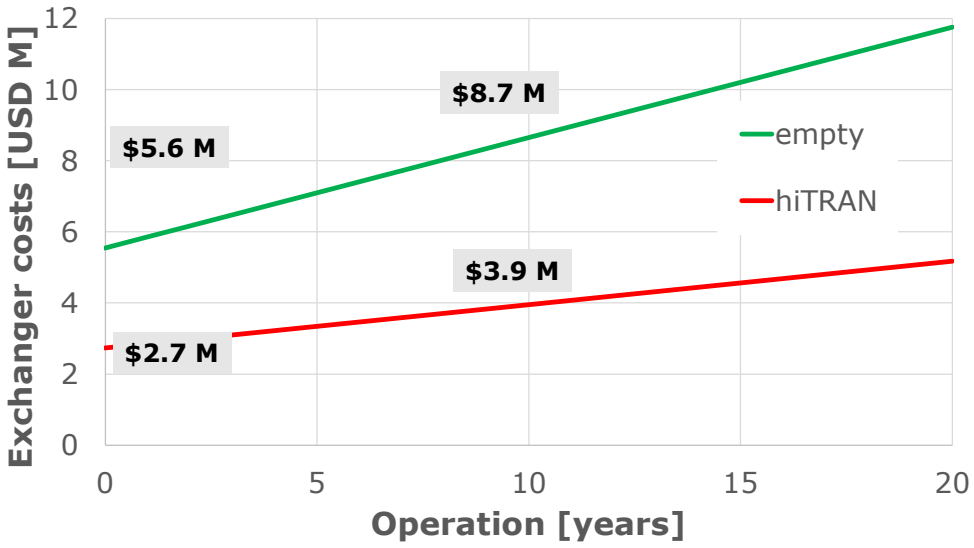
Economics

Heat Exchanger		
Item	KHE_total_plain	KHE_total_hiTRAN
Bare Surface Area Per Bay	1332.1	1207.8
Bay S		
Bundl		
Bays		
Condit		
HTRI		
Over		
Bundl		
Struct		
Unit W		
Nozzle		
Tube		
Tube Diameter (mm)	----	----
Tube Count	600	473
Materials		
Tube	Seamless Carbon Steel	Seamless Carbon Steel
Header	Carbon Steel	Carbon Steel
Purchase Price		
Purchase Price Per Bay	403473	408971
Unit Purchase Price (USD)	3302514	1671977
Purchase Price Details (Each Bay)		
Tube Material (USD)	57031	44959
Header Material (USD)	26787	21922
Aluminum (USD)	32003	25229
Structure, Fans, and Motors	122768	112975
Bundle Labor (USD)	164884	140472
Installation		
Inlet Line	Main line: 600 DN - Class 150 x 9.144 m Material: Carbon Steel with paint and insulation	Main line: 400 DN - Class 150 x 9.144 m Material: Carbon Steel with paint and insulation
Outlet Line	Main line: 600 DN - Class 150 x 9.144 m Material: Carbon Steel with paint and insulation	Main line: 400 DN - Class 150 x 9.144 m Material: Carbon Steel with paint and insulation
Installation Cost		
Freight (USD)	237164	98723
Equipment Setting (USD)	130000	65000
Foundation and Structure	115483	57741
Piping (USD)	261114	90512
Electrical (USD)	223654	109805
Instrumentation (USD)	94127	47063
Insulation and Paint (USD)	44006	16058
Engineering and	136000	88000
Construction Overhead	117109	54666
Insurance and Taxes (USD)	200426	100013
Contingency and Fee (USD)	684482	338048
Total (USD)	2243565	1056620
Operations and Maintenance		
Motor Electricity	Description: Motor electricity Electricity unit price: 0.08 USD/kWh Motor average power: 27.702 hp Cost per year: 3106.18 USD/year Duration: 10 years Evaluation period cost: USD0	Description: Motor electricity Electricity unit price: 0.08 USD/kWh Motor average power: 21.811 hp Cost per year: 122.81 USD/year Duration: 10 years Evaluation period cost: USD0
Total (USD)	3106184	1222807
Total Prices		
Purchase Price (USD)	**3302514**	**1671977**
Installation Cost (USD)	**2243565**	**1056620**
Operating Cost (USD)	**3106184**	**1222807**
Total (USD)	**8652263**	**3951404**
		5% hiTRAN costs



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Condensing Case Study

Heavy Naphtha Feed/Effluent

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Case Study – Feed/Effluent Retrofit

User: LUKOIL Refinery

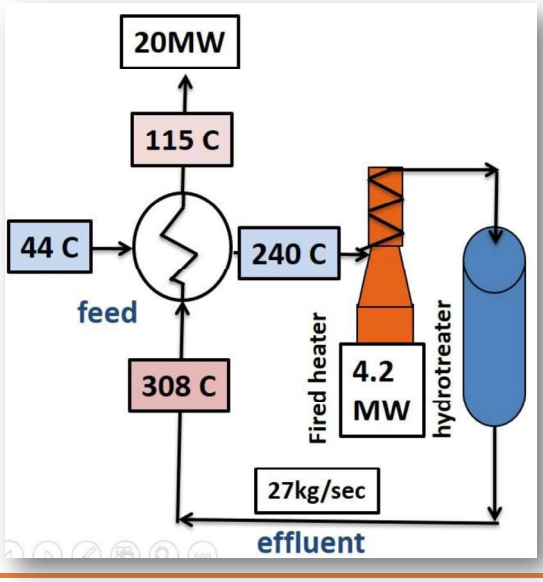
Location: Volgograd, Russia

Condition:

- Boiling feed on the shell side
- Condensing effluent on the tube side

Problem description:

- Calculated performance should be 60% higher
- No spare capacity of fired heater to increase throughput



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Exchanger Configuration

Shells	3 in series, 2 in parallel
Bundle	
Tubes	2521, 1 pass 20 mm x 1.8 mm x 9000 mm
Calculated Exchanger Performance	
Tube side dP calc./allow	**2.5 kPa** / 45 kPa
Shell side HTC	900 W/m^{2}K
Tube side HTC	**285 W/m^{2}K** (59% thermal resistance)
Duty	Measured 20 MW / 60% underperforming

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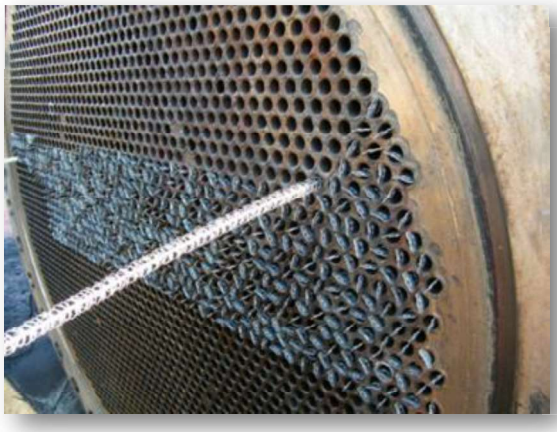
hiTRAN® Case Study Installation



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hiTRAN® Retrofit Benefits

	Before (Empty)	After (hiTRAN®)
Tube side pressure drop	25mbar (>85% nozzles)	200mbar (~10% nozzles)
Tube side heat transfer	<285 W/m2K	~980 W/m2K
Shell side feed outlet temperature	240°C	314°C
Tube side effluent outlet temperature	115°C	82°C
Mass Flow	27 kg/sec	**42 kg/sec**
Load on Fired Heater	4.2 MW	2 MW

Annual Energy Savings of $233000

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Vaporiser Case Study

Ethylene Vaporiser

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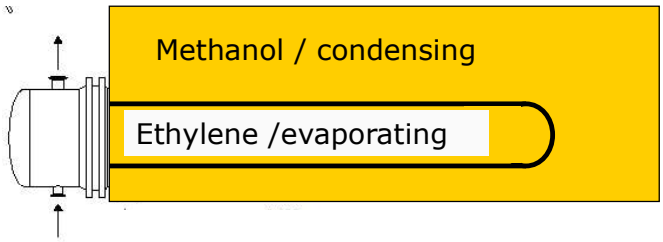
Ethylene Evaporator

After Installation Exchanger did not Perform



Type	BEU
Passes	2
Tube length [mm]	4000
Tube do [mm]	25.4
Tube count	702

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Summary Before / After

	Empty Tube / Plant	hiTRAN®
Tube side		
Flow rate [t/h]	52	**76**
Temp in / out [°C]	-100 / -1 (sat)	-100 / 30 (superheated)
Pressure in / out [bar]	40 / 39.93	40 / 39.74
htc [W/m²K]	613	2390
Pressure drop [kPa]	8	25
Shell side		
Pressure in / out [bar]	10.1 / 10.1	2.2 / 2.19
Temp in / out [°C]	138 / 137	86 / 85
General:		
Heat duty [kW]	261	618
EMTD [°C]	164	100

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Alternative Applications & Installation

Process Coolers, Installation videos

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Target Applications for hiTRAN®

• **Offshore**
Wet/Dry Crude Exchanger
Glycol Gas dehydration
LNG/LPG vaporisers

• **Refining**
Feed/effluent exchanger (lower streams)
Reactor effluent coolers
CDU/VDU Bottoms coolers

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Target Applications for hiTRAN®

• **Refining**
Crude oil heaters
Fuel oil heaters

• **Petrochemicals/Chemicals**
Oelfin coolers/condensers/vaporisers
Resin/polymer coolers
MDI
TDI
Amide coolers
Ammonia vaporisers

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Retaining Systems

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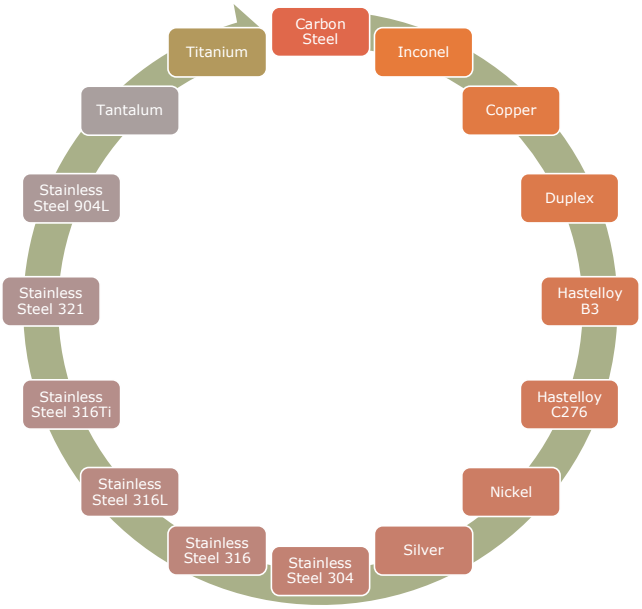
Materials of Construction



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New Design: hiTRAN® Enhanced Column Condenser (EO/EG/MEG)

1. **2009: Sinopec**
   - **7000 tubes**
   - **9000 tubes**
2. **2015: Reliance**
   - **15300 tubes**
3. **2018: ME Global**
   - **14100 tubes**

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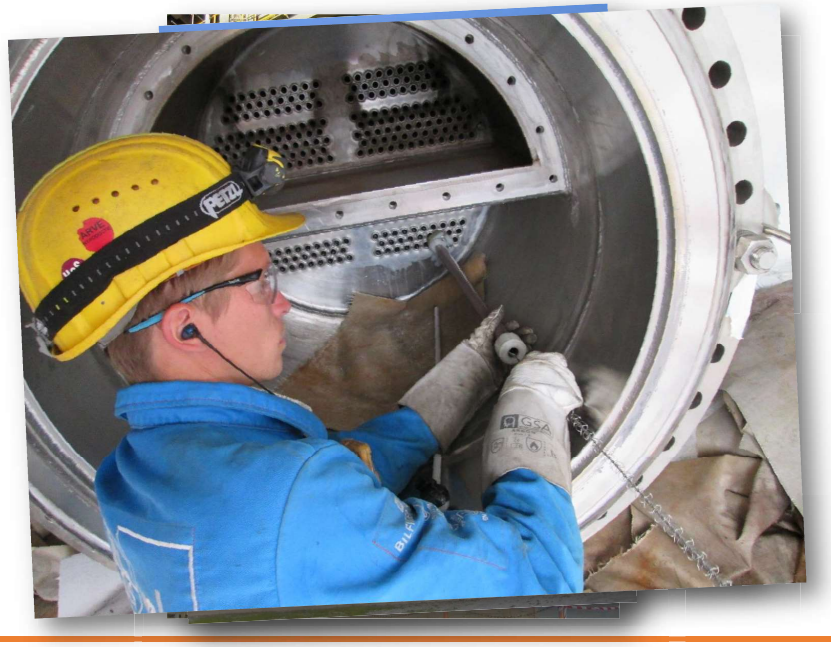
Previous hiTRAN® Vaporiser Retrofits



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Any Questions?

engineering@calgavin.com

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