Diffusion Bonded Compact Heat Exchangers - Compact Reactors

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MEGGITT
smart engineering for extreme environments

Agenda

- Meggitt and Heatric Companies Presentation
- Overview of Heatric compact exchangers (PCHE, FPHE, H²X)
- Overview of Heatric reactors (PCR)
- Conclusions
- Questions

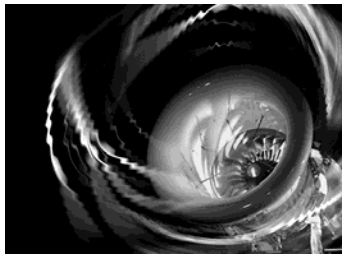
Meggitt and Heatric Companies Presentation

Meggitt plc

- FTSE 100 company
- 7370 employees in 2010 across 36 companies predominantly in USA (19), UK (10), Mainland Europe (5), China
- Focus on aerospace, defence systems and electronics sectors
- 2011 Results:
  - Capitalisation: €1.91 billion (December 2010)
  - Revenue: €1,81 billion
  - Underlying profit before tax: €402 million
  - Net income: €230 million
- Product development spend during 2011 was €57.52 million, 25% of Net profit

Meggitt Capabilities

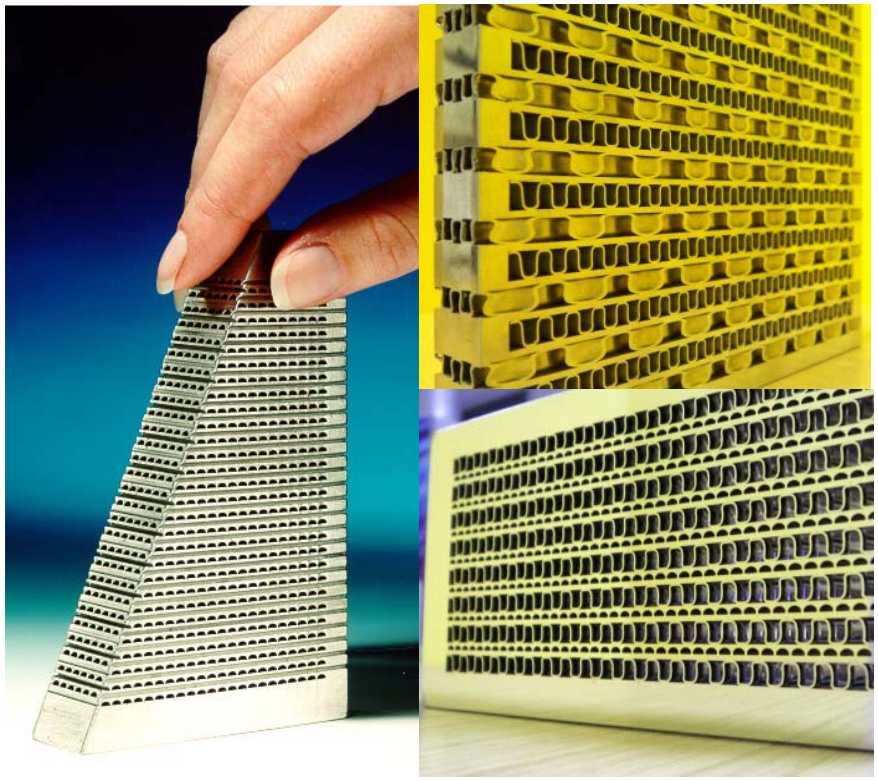
Meggitt Aircraft Braking Systems	Meggitt Polymers & Composites	Meggitt Control Systems	Meggitt Sensing Systems	Meggitt Equipment Group
Wheels Brakes Brake control systems	Seals for energy and aerospace Flexible fuel tanks and sealants Aircraft ice protection Aircraft interior composites	Thermal management Aerospace valves Electromechanical Environmental control systems Energy Aftermarket	Condition-monitoring systems High performance sensors	Avionics Combat systems Industrial components Printed circuit heat exchangers Safety systems



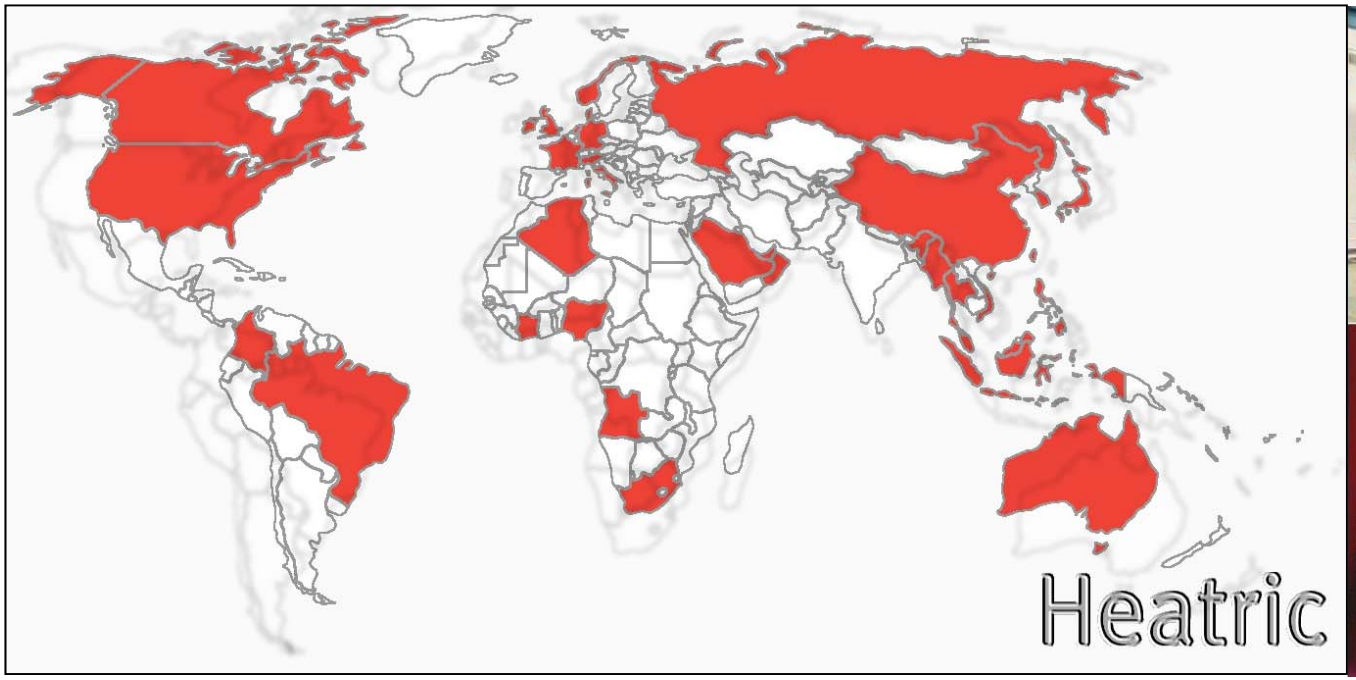
Heatric, Poole, UK

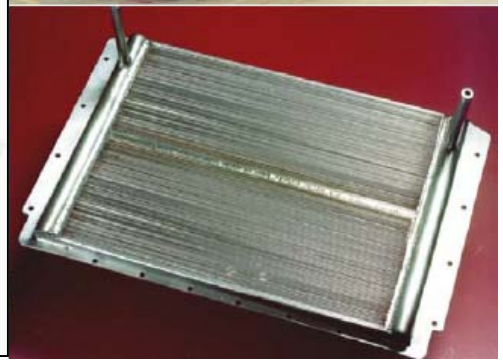
Heatric history

- 1980 PCHE developed – Sydney University
- 1985 Heatric founded in Australia
- 1989 First application in offshore gas processing
- 1990 Relocated to the UK - Joined Meg Group
- 2005 FPHE developed - Heatric
- 2006 H^2X developed - Heatric
- 2008 Factory extension, 100+ staff
- 2010 $70 Million Turnover
- 2012 Factory extension, 275 staff $130 Million



Heatric product supplied worldwide





More than 1700 diffusion bonded heat exchangers supplied. Almost 1200 in operation worldwide with a combined service life of over 5000 operating years.

Over 15 FPHEs sold since market launch in 2005, including titanium sea water coolers

Countries supplied to by Heatric shown in red

PCHE Reference List

Example of offshore installed equipments

Kerr McGee Nansen & Boomvang Spars – 1000 ft² deck savings

Example of offshore installed equipments

Statoil Asgard FPSO & Semi-Sub – 2000 tonnes topside weight saving

Heatric

Overview of Heatric compact exchangers (PCHE, FPHE, H²X)

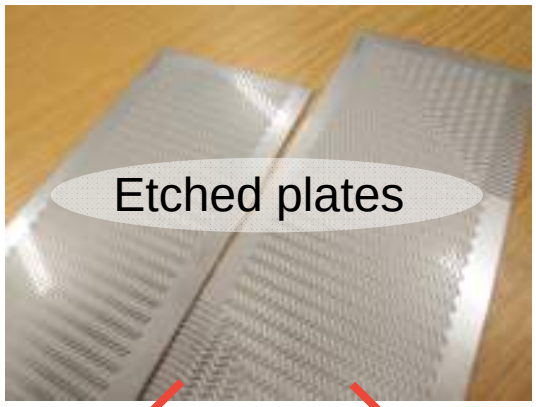
Heatric Compact Heat Exchangers Benefits

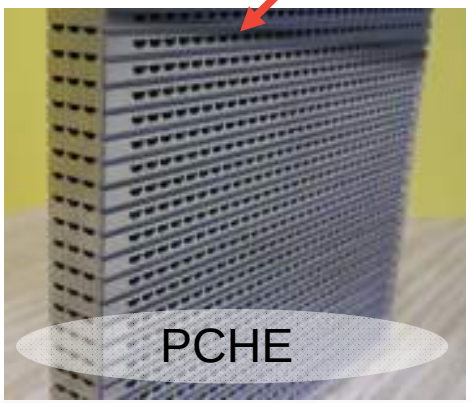
- Compactness
- Integrity
- Robustness
- Safety
- High efficiency (>98%)
- High pressure & temp.
- Choice of alloys
- Retrofit options

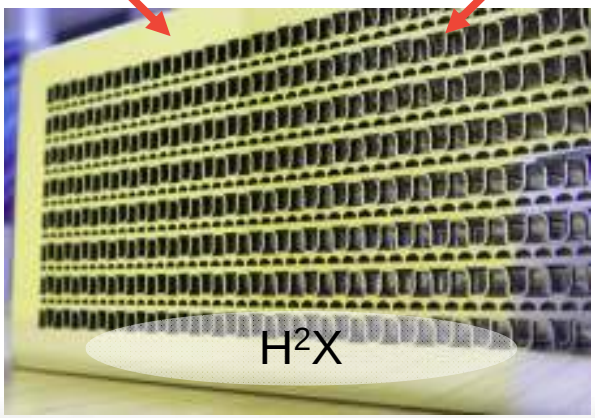
Design Codes

- *ASME "U" Stamp*
- NBIC "R"
- ISO 9001:2008
- ISO 14001:2004
- BS EN OHSAS18001:2007
- Approved by DNV manufacture of welded pressure vessels class I & II
- Manufacturers License of Special Equipment (PRC)
- EC Certificate of Conformity (PED)

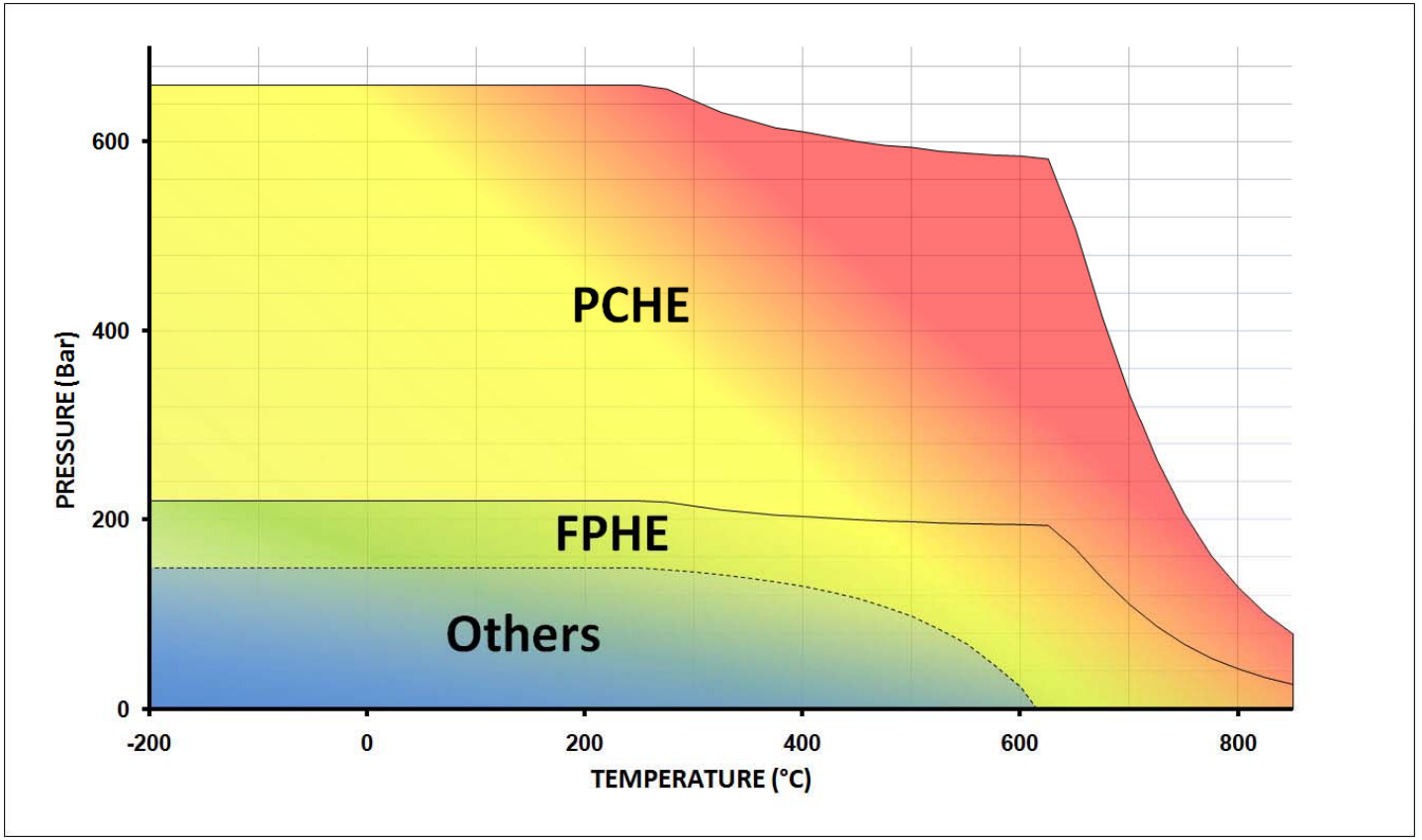
Heatric Heat Exchanger Products







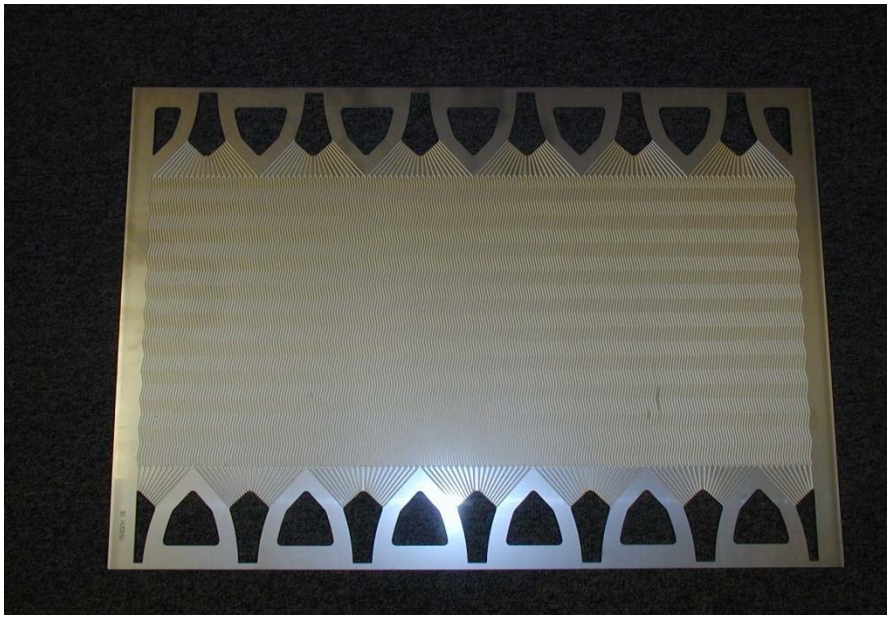
PCHE – Temperature and pressure



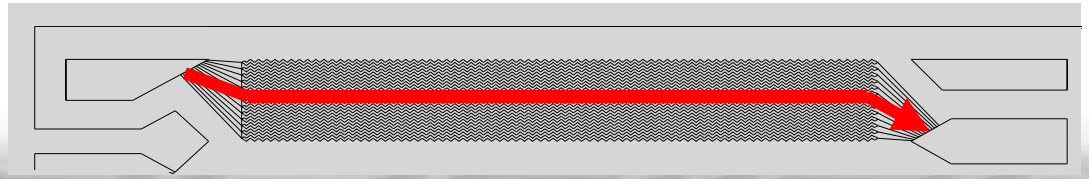
Current PCHE and FPHE Heat Exchangers

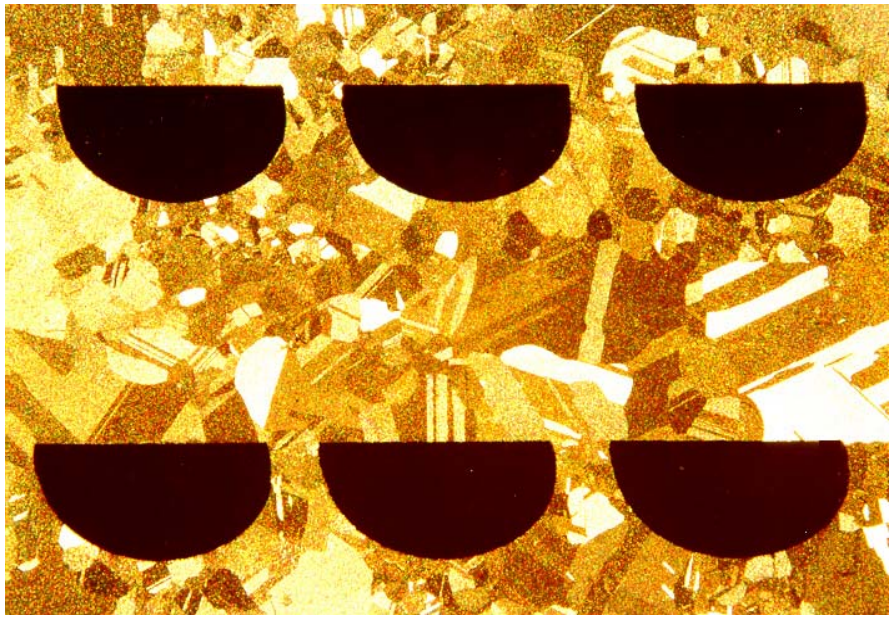
Requirements	PCHE	FPHE
High Temperatures	800°C+ (limited by material)	800°C+ (limited by material)
High Pressures	600 Bar+ (Max Typical)	200 Bar+ (Max Typical)
High Effectiveness	98% +	98% +
Low Pressure Drop	Based on Design	Bigger channels
High Compactness	Highly Compact	
Erosion Resistance	Limited by material	
Corrosion Resistance	Limited by material	
Longer Life	Limited by material	

Printed Circuit Heat Exchanger (PCHE)



PCHE platelet configuration.





Micrograph of section through diffusion bonded PCHE core.

Printed Circuit Heat Exchanger (PCHE)

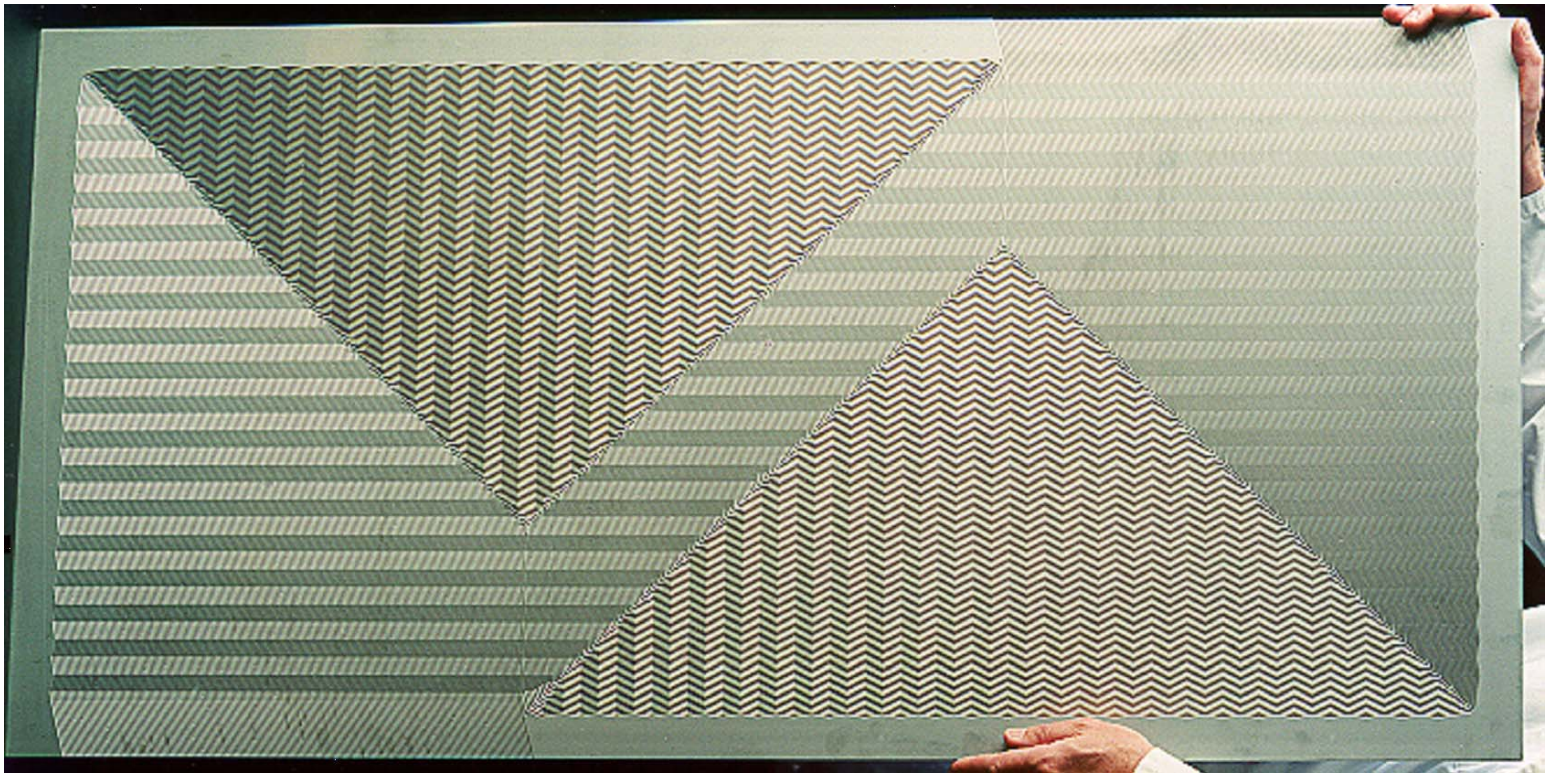
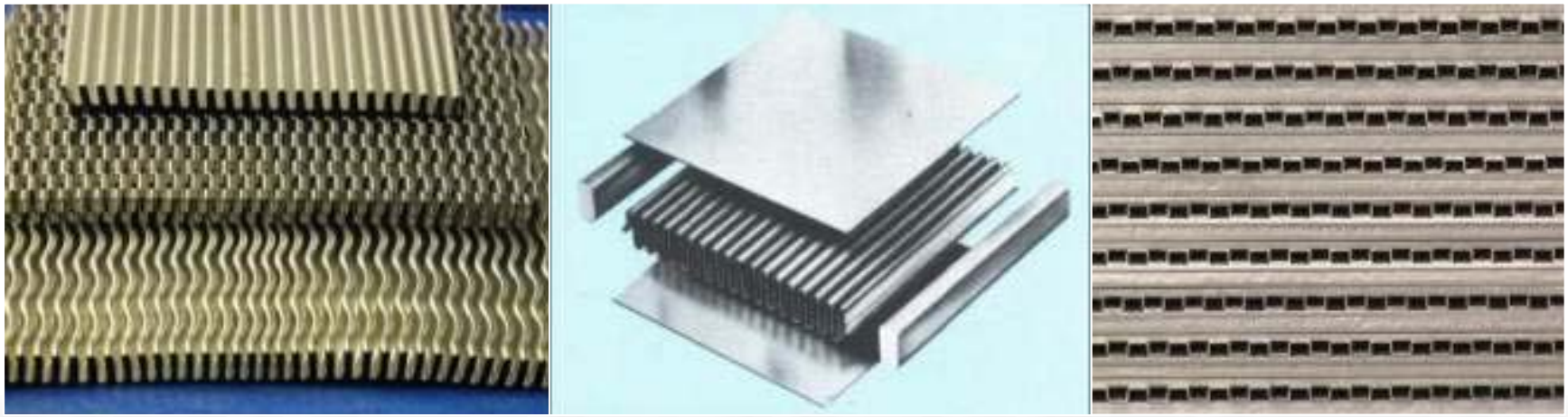


Plate size – up to 1.5 m long by 0.6 m wide

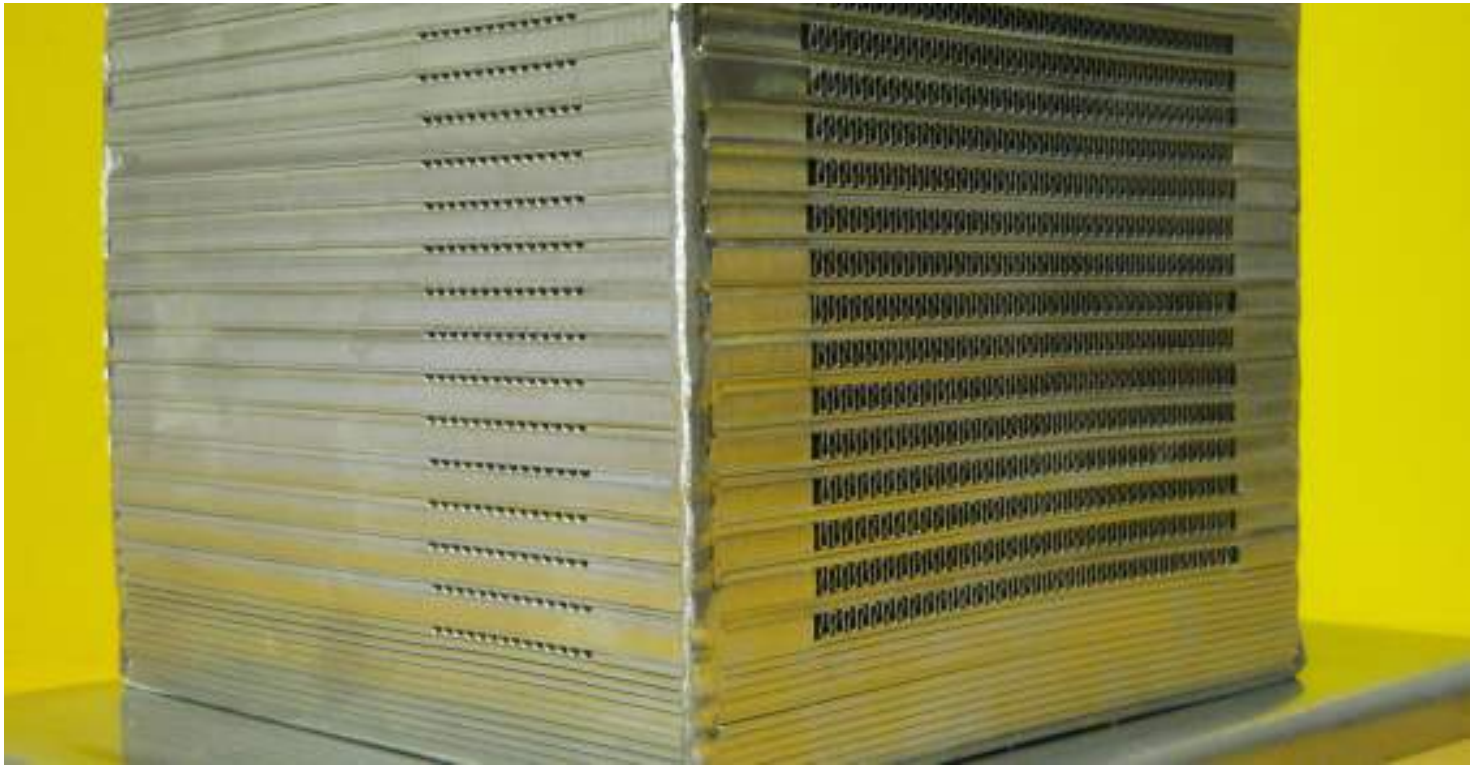
Single Core size – up to 1.5 x 0.6 x 0.6 m

Formed Plate Heat Exchanger (FPHE)

- Plate-fin style construction
- Pressures capability to 200 bar, temperature capability same as PCHE
- Channel cross section up to 3mm x 3mm

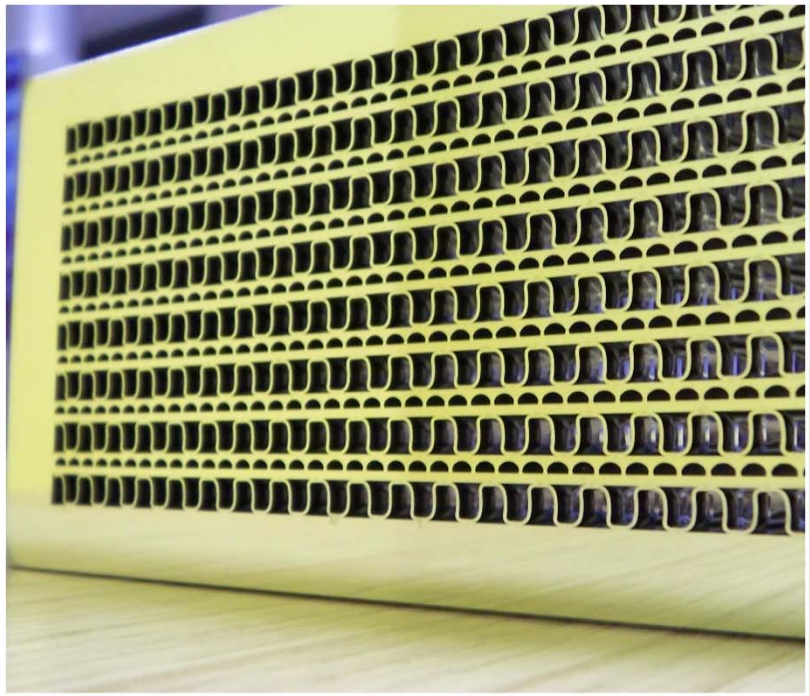


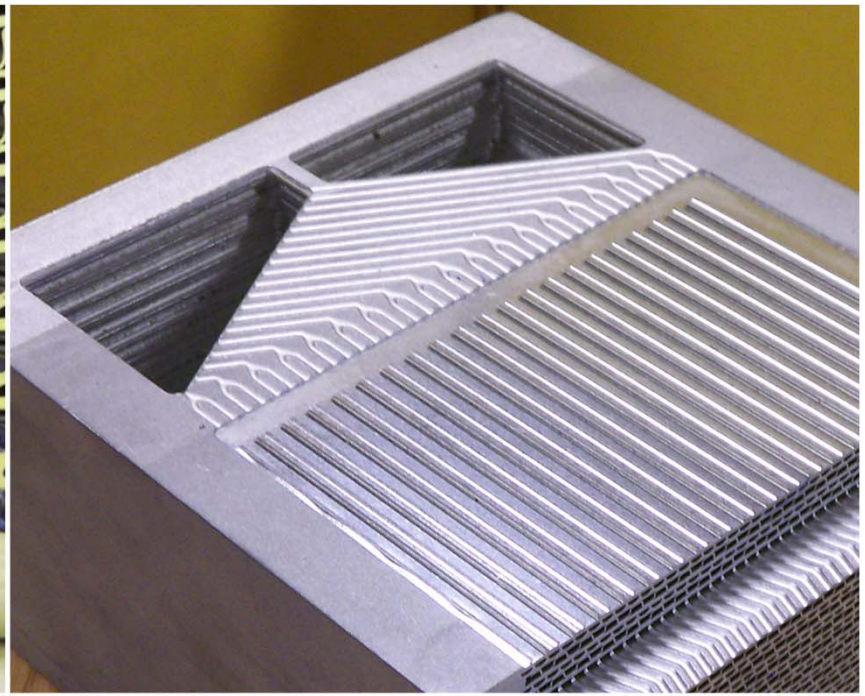
Hybrid Heat Exchanger (H^2X)



H^2X bonded stack

Hybrid Heat Exchangers





H^2X Section – H^3X Section

PCHE CONSTRUCTION

Fabrication

Completed Exchanger

Materials

Available

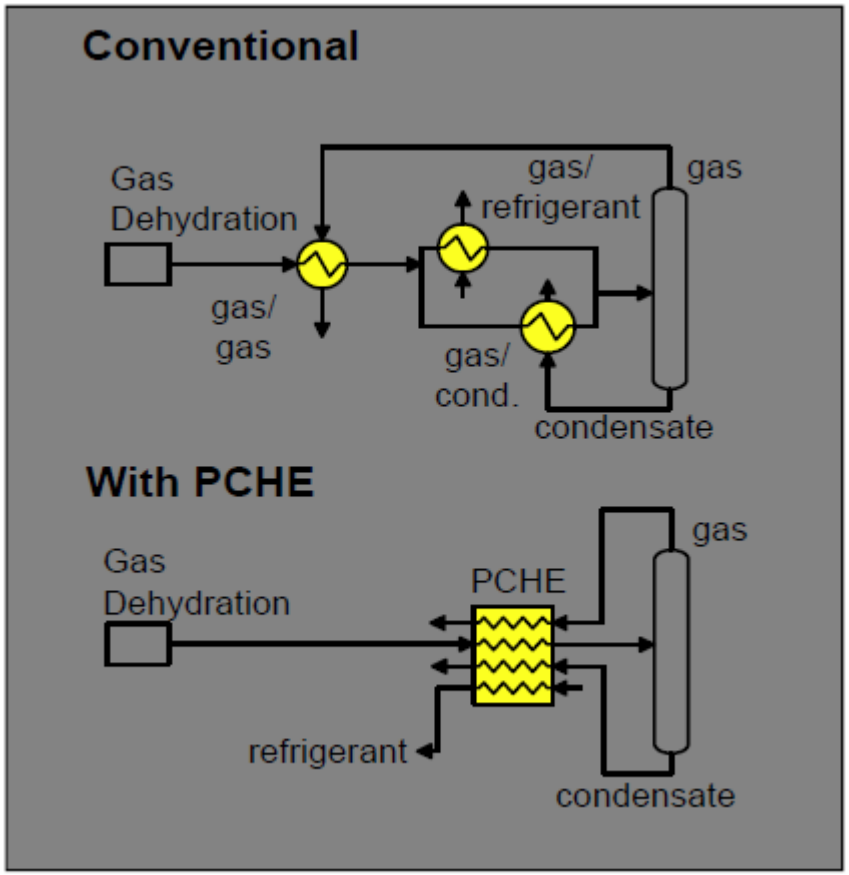
- Stainless steels 316L/316, 304L/304
- Duplex 2205 (S 31803)
- Titanium grade 2
- 6 Moly (NO 8367)

Development:

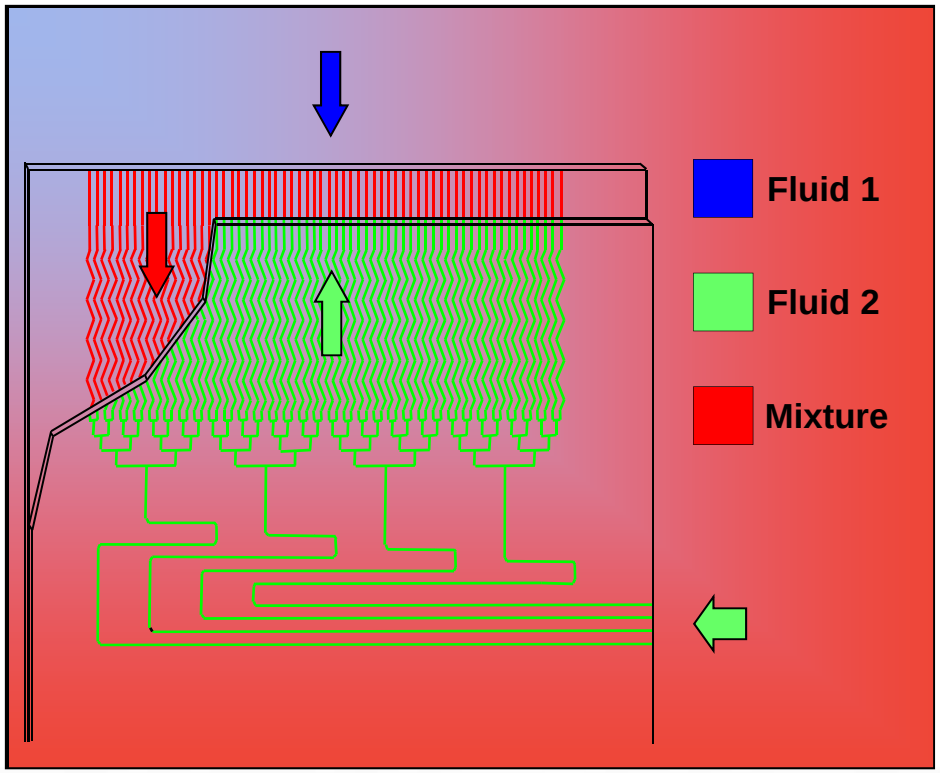
- Alloy 59 (NO 6059)
- SS 310 (S 31008)
- 800H (NO 8810)
- Alloy 617
- Dual material (copper to stainless)

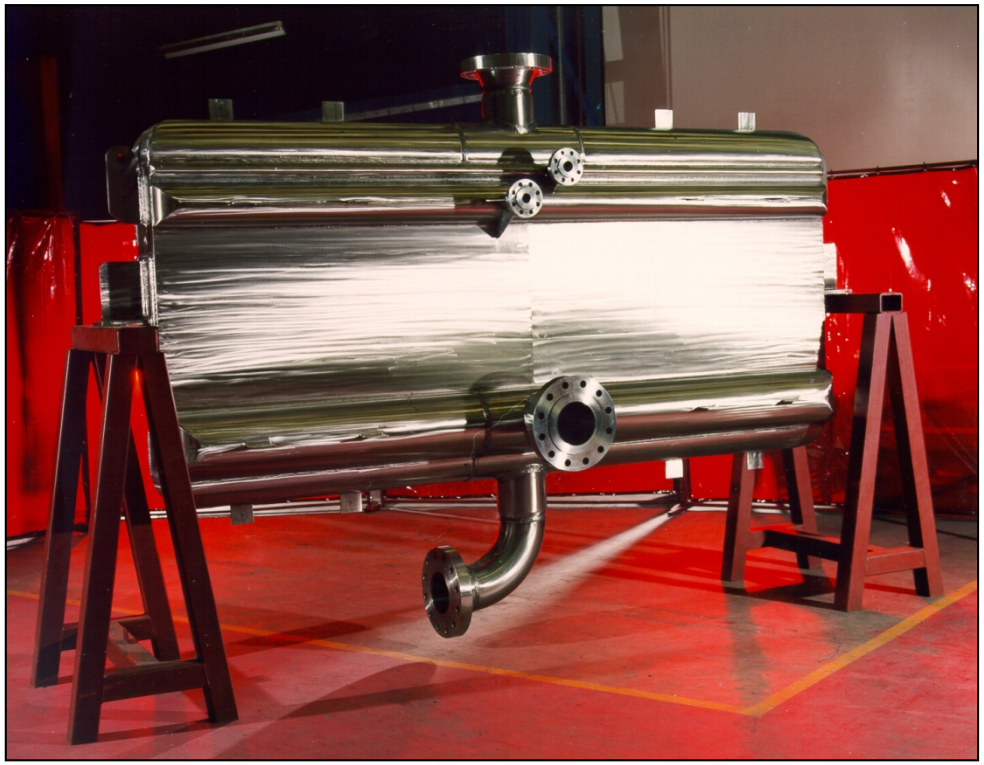
Process intensification – Multifluid Capability

1.4 MW, 66 bar Gas/gas
Gas/condensate
Gas/refrigerant

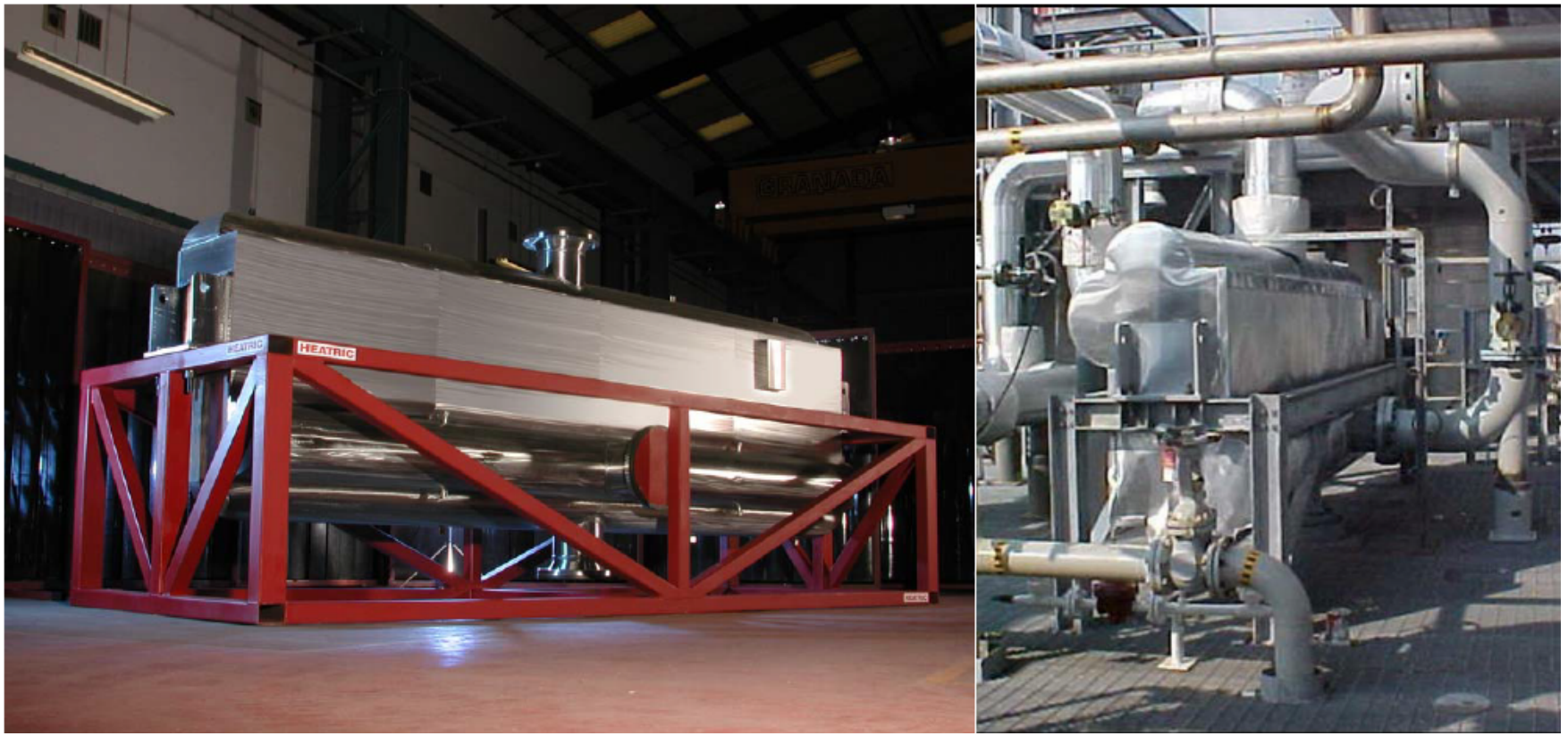


Potential for mixing and 2 phases handling





Example of onshore installed equipment

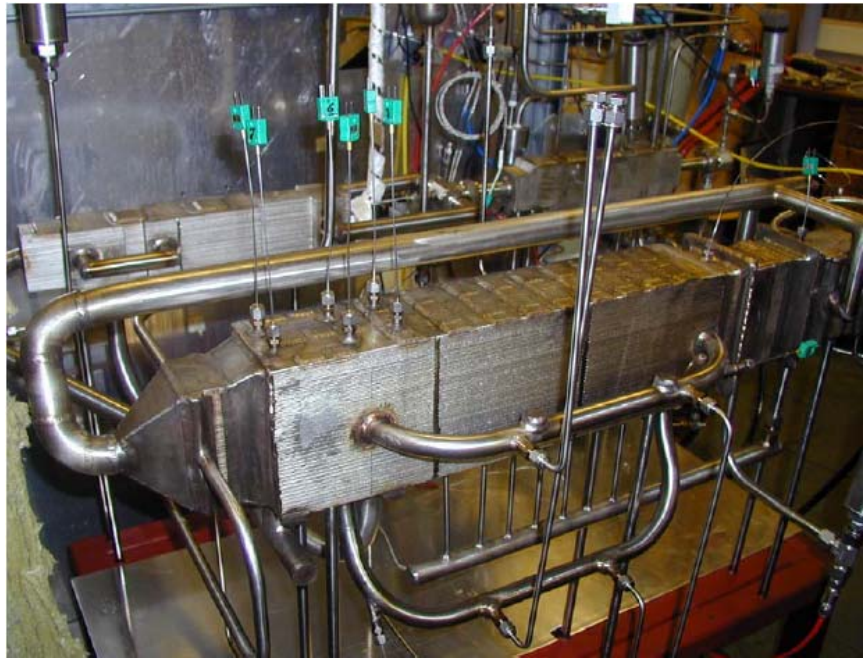


BASF Geismar Ethylene Oxyde Lean/Rich Exchanger

Overview of Heatric reactors (PCR)

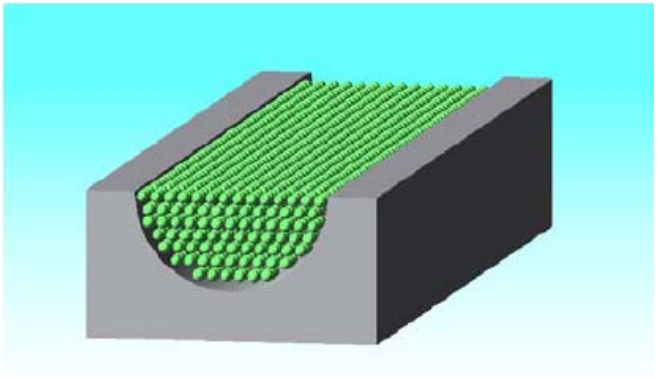
Heatric Reactors Benefits

- Compactness
- Integrity
- Low inventory
- Close temperature control (1°C)
- High pressure & temp.
- Corrosion resistance
- Catalyst inserts
- Retrofit options



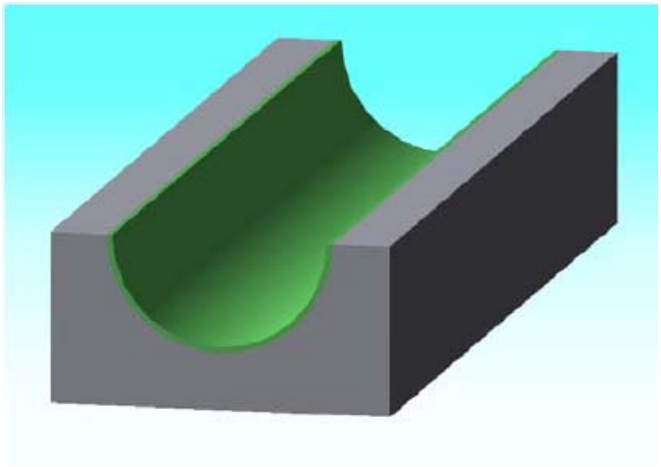
Various options for catalysts

Packed passages



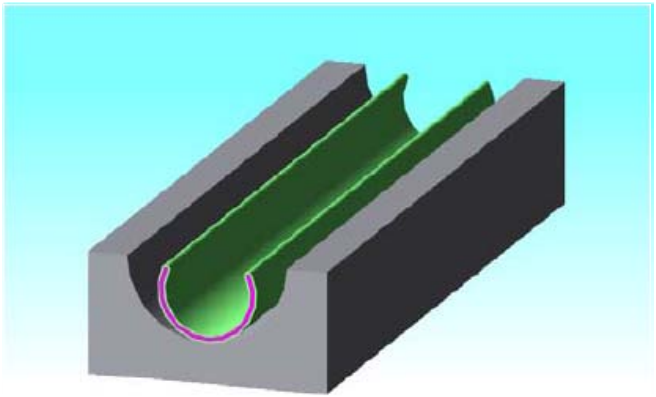
Various options for catalysts

Coated passages

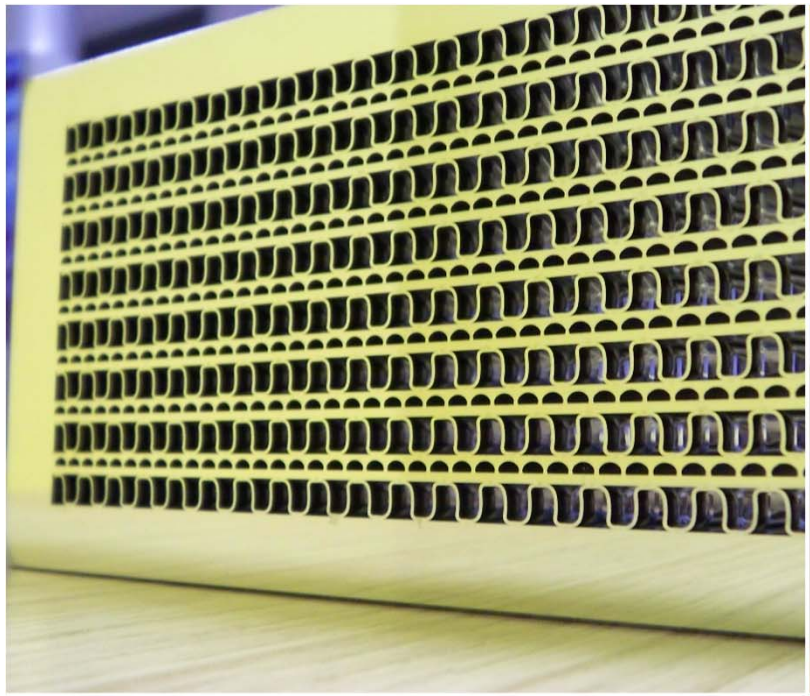


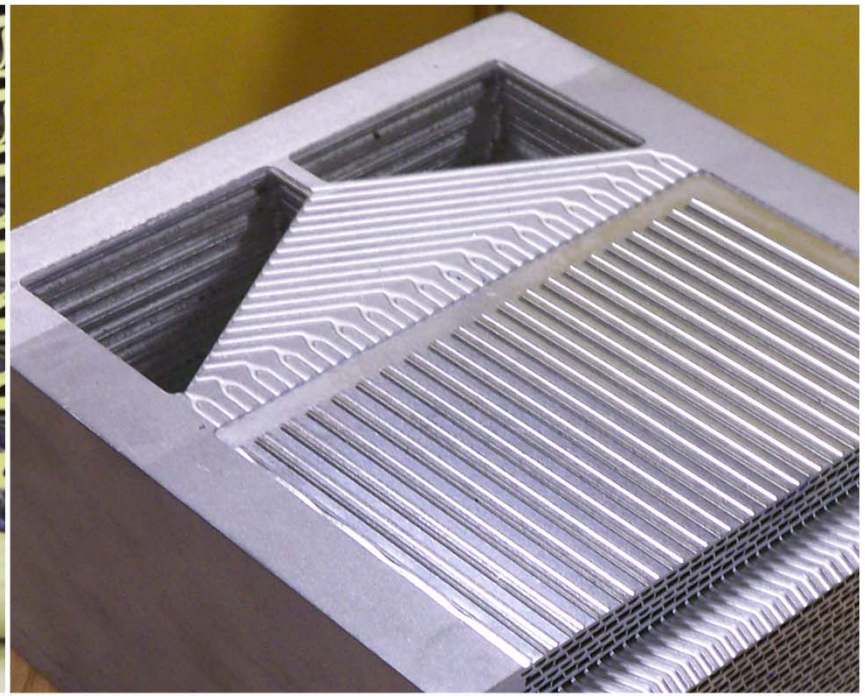
Various options for catalysts

Catalyst inserts



Channel Sizes

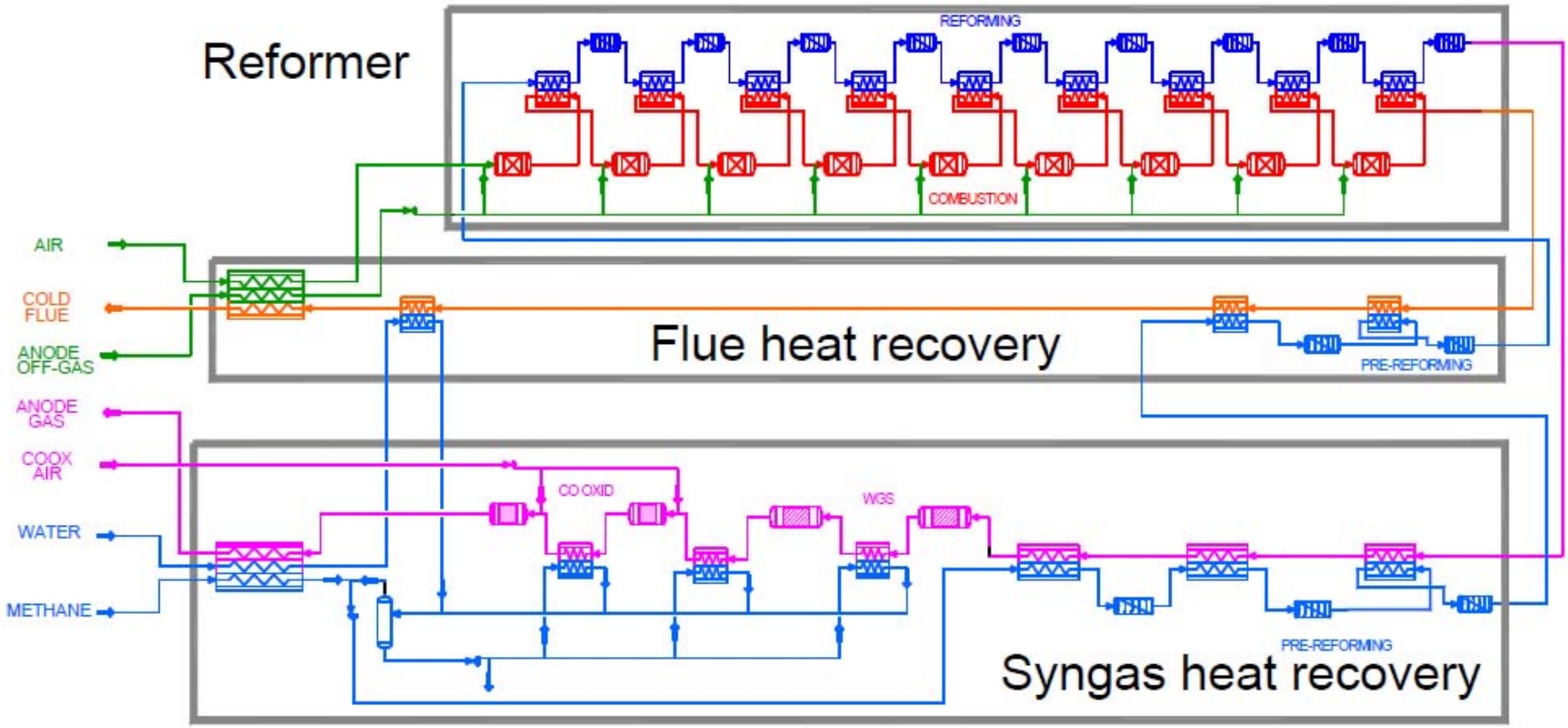




PCHE – 0.1 < dH < 3 mm Typical

FPHE – 1.2 < dH < 3.3 mm Typical

Steam Reformer – Proof of concept



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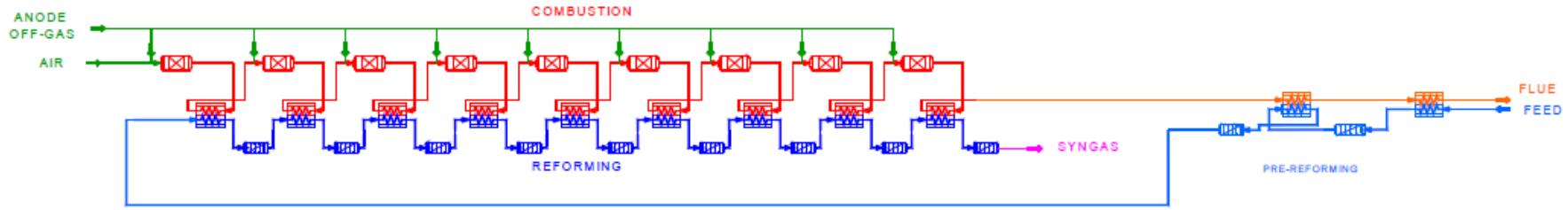
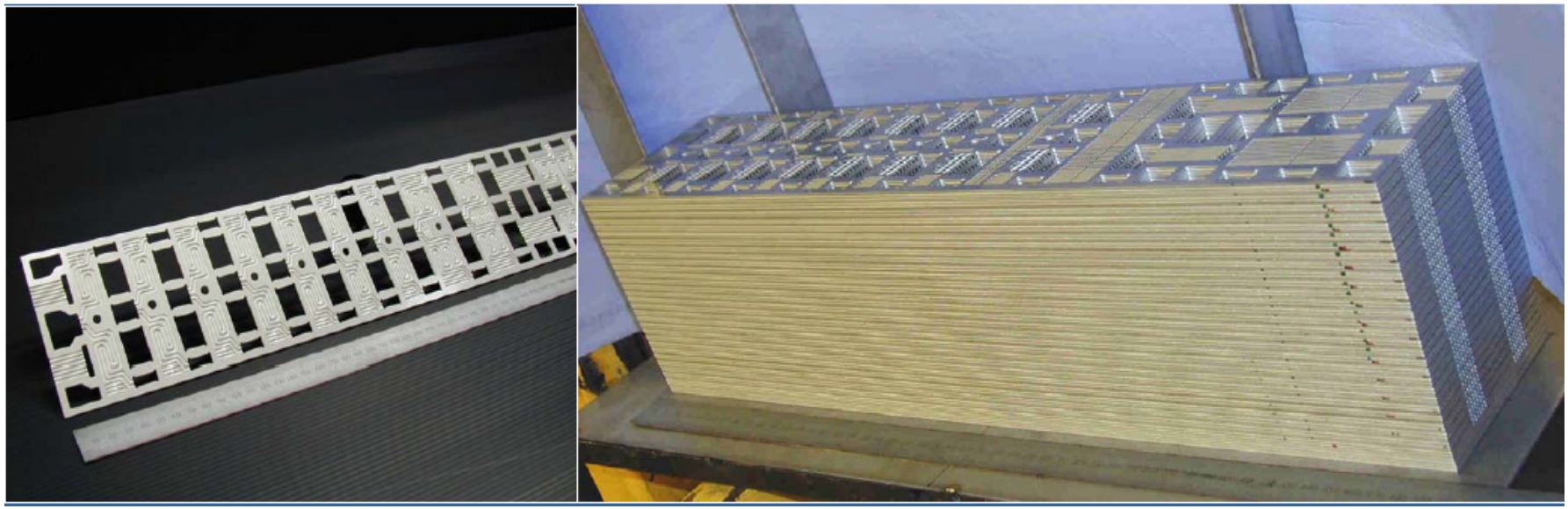
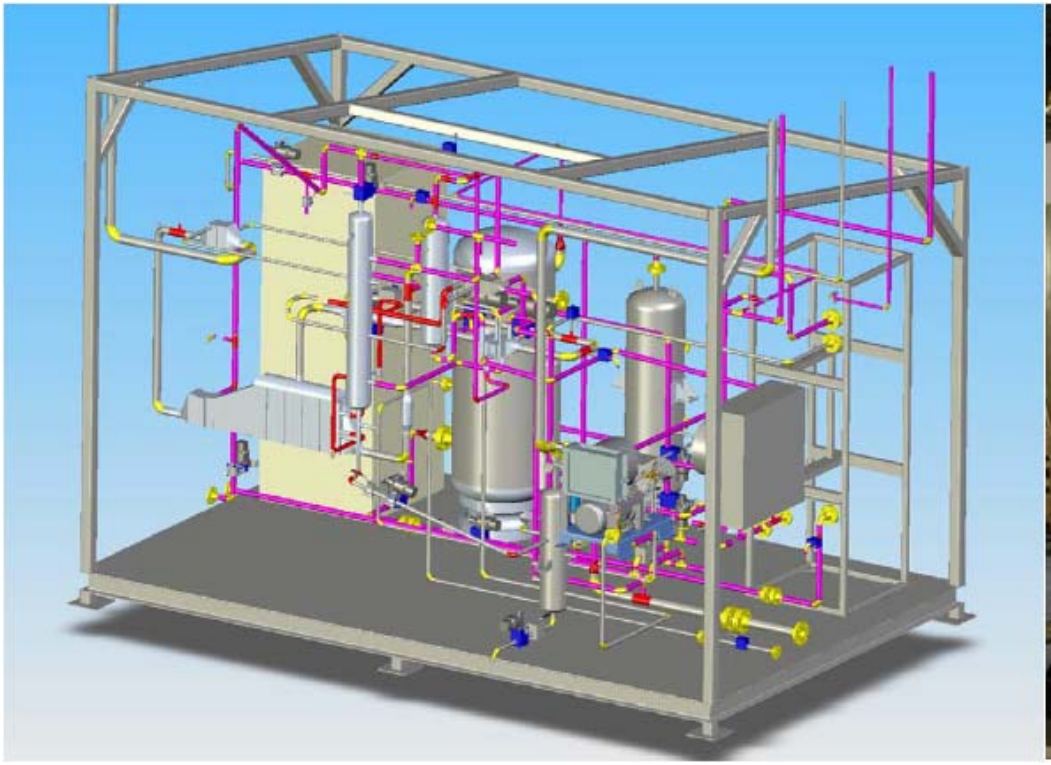




Steam Reformer – Test facility

Steam Reformer – Industrial prototype



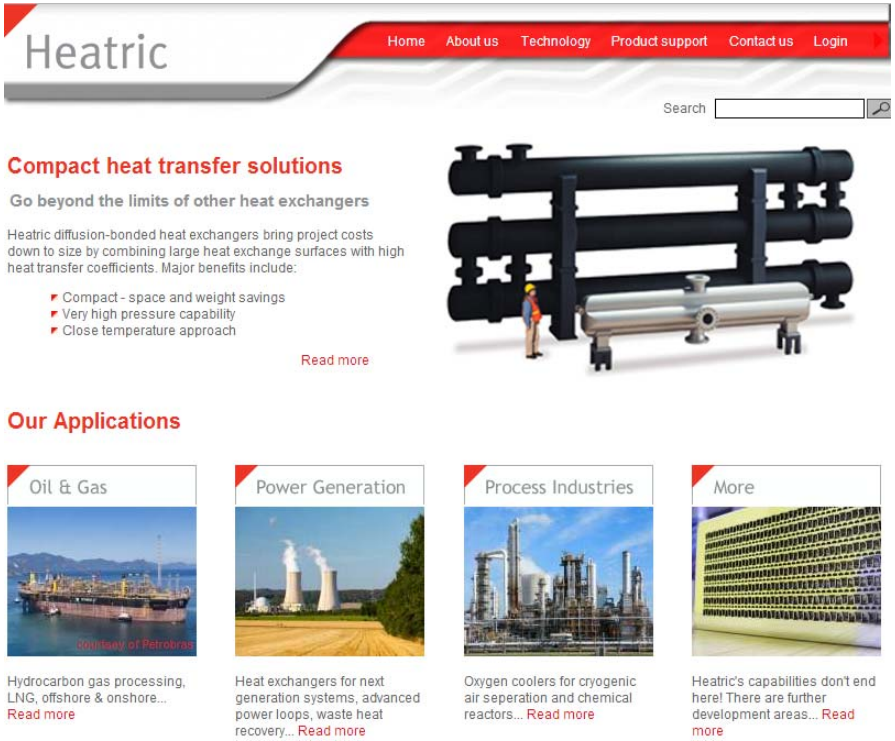
Conclusions

Conclusions

- Heatric heat exchangers are proven technologies with 27 years experience in the field
- Heatric heat exchangers can operate in a wide range of challenging processes from small to very large duties
- Heatric heat exchangers offers very high performances with very high safety

- Heatric reactors are using the same proven technology as Heatric heat exchangers
- Heatric reactors can be designed to suit many chemical processes, and integrate multiple processes into a single unit, including mixing.
- Heatric reactors provide a safe and high performance solution to the chemical industries

Questions



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