Diffusion Bonded Compact Heat Exchangers - Compact Reactors

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Renaud Le Pierres
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
- Wheels
- Brakes
- Brake control systems

Meggitt Polymers & Composites
- Seals for energy and aerospace
- Flexible fuel tanks and sealants
- Aircraft ice protection
- Aircraft interior composites

Meggitt Control Systems
- Thermal management
- Aerospace valves
- Electromechanical
- Environmental control systems
- Energy

Meggitt Sensing Systems
- Condition-monitoring systems
- High performance sensors

Meggitt Equipment Group
- Avionics
- Combat systems
- Industrial components
- Printed circuit heat exchangers
- Safety systems

Aftermarket
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 Meggitt Group
- 2005  FPHE developed - Heatric
- 2006  H²X 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.
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
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

- Etched plates
- Formed fins
- PCHE
- H²X
- FPHE
PCHE – Temperature and pressure
## Current PCHE and FPHE Heat Exchangers

<table>
<thead>
<tr>
<th>Requirements</th>
<th>PCHE</th>
<th>FPHE</th>
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<tbody>
<tr>
<td>High Temperatures</td>
<td>800°C+ (limited by material)</td>
<td>800°C+ (limited by material)</td>
</tr>
<tr>
<td>High Pressures</td>
<td>600 Bar+ (Max Typical)</td>
<td>200 Bar+ (Max Typical)</td>
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<tr>
<td>High Effectiveness</td>
<td>98% +</td>
<td>98% +</td>
</tr>
<tr>
<td>Low Pressure Drop</td>
<td>Based on Design</td>
<td>Bigger channels</td>
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<tr>
<td>High Compactness</td>
<td>Highly Compact</td>
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</tr>
<tr>
<td>Erosion Resistance</td>
<td>Limited by material</td>
<td></td>
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<tr>
<td>Corrosion Resistance</td>
<td>Limited by material</td>
<td></td>
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<tr>
<td>Longer Life</td>
<td>Limited by material</td>
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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 (H²X)

H²X bonded stack
Hybrid Heat Exchangers

H₂X Section – H³X 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

Reformer

Flue heat recovery

Syngas heat recovery
Steam Reformer – Proof of concept
Steam Reformer – Test facility
Steam Reformer – Industrial prototype
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 offer 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

Renaud Le Pierres
Business Development Engineer

HEATRIC
46 Holton Road
Holton Heath
Poole
Dorset BH16 6LT
England
Tel: +44 (0) 1202 627077
Fax: +44 (0) 1202 632299