Understanding the Process Intensification Opportunity

Nick Johnston, Svend Rumbold

Heatric division of Meggitt (UK) Ltd

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Agenda

- Background
- Heatric's PCHE Experience
- PI Technologies – The Underlying Principles
- Examples
- Barriers to Adoption
- The Way Forward

Background

“Process Intensification”

- PI concept for capital cost saving
- Intensified unit operations e.g. HiGee
- Early PCHE applications

Heatric's PCHE Experience

Heatric's PCHE Experience

1980 PCHEs developed at Sydney University

1985 Heatric founded in Australia

1990 Relocated to UK - joined Meggitt group

2003 >60 staff, $22 million annual sales

Heatric's PCHE Experience

A Typical Offshore North Sea Project

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BG Armada

BG Armada

Feasibility Study: PCHEs potential savings of up to $20 million for typical 10,000 tonne topsides (1991 basis)

Conceptual Design: Conservatism and insufficient detail result in failure to establish convincing PCHE savings - Still the lowest cost, but simplicity of direct system preferred

Detailed Design: Changes in Gas Sales Agreements meant project cost had to be reduced

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PCHEs contributed:

- 3m of deck length saving, on all levels
- 30 tonnes equipment weight reduction
- single module lift
- **Saved ~ $30 million**
  (British Gas estimate)

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PCHEs were the *Project Enabling Technology*

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Heatric's PCHE Experience

Since 1990 Heatric has manufactured many microchannel devices:

- More than 700 custom-designed heat exchangers
- 3000 tonnes of microchannel components
- Microchannel devices worth > $180 million

PI Technologies
–
The Underlying Principles

Underlying Principles – the Established Approach

Intensify a phenomenon: e.g.

- Mass transfer
- Heat transfer
- Rate of reaction

And/or

Perform multiple functions simultaneously: e.g.

- Mixing and reaction
- Reaction and heat transfer
- Heat transfer and separation…….

A Unit Operations approach

Underlying Principles

An Alternative Approach:

- Frame the problem – a conflict that needs to be resolved
- Identify potential solutions – at a fundamental level

Underlying Principles

Fundamental solutions could involve:

- Segmentation (e.g. multiple, smaller steps)
- More reactive species (e.g. O_2 vs. air, increased concentration)
- Higher activity catalyst
- Changed reaction conditions (pressure, temperature)
- Supercritical conditions
- Non-uniform, locally tailored conditions

Underlying Principles

An Alternative Approach:

- Frame the problem – a conflict that needs to be resolved
- Identify potential solutions – at a fundamental level
- Pursue a practical embodiment of the preferred solution

Examples

Batch vs. Continuous (microreactor)

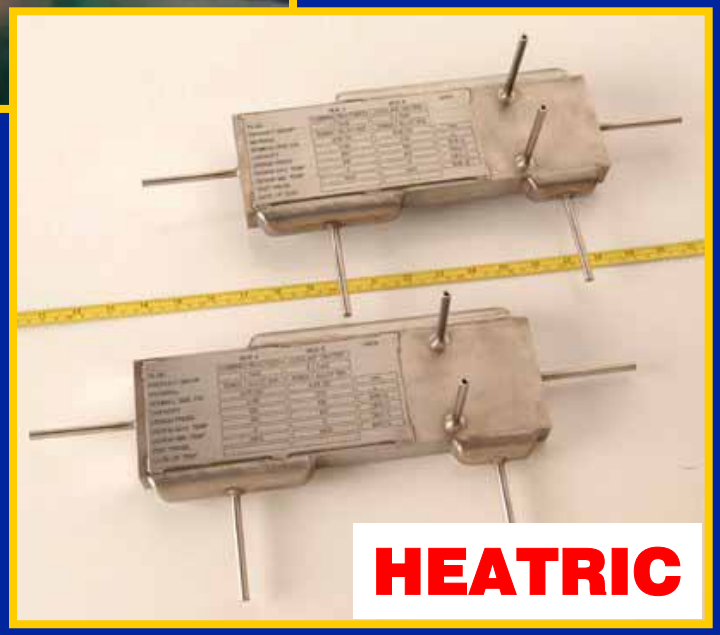
Product quality:

- Average particle size
- Particle size distribution

Parameters:

- Residence time
- Mixing
- Temperature

Courtesy of Clariant GmbH

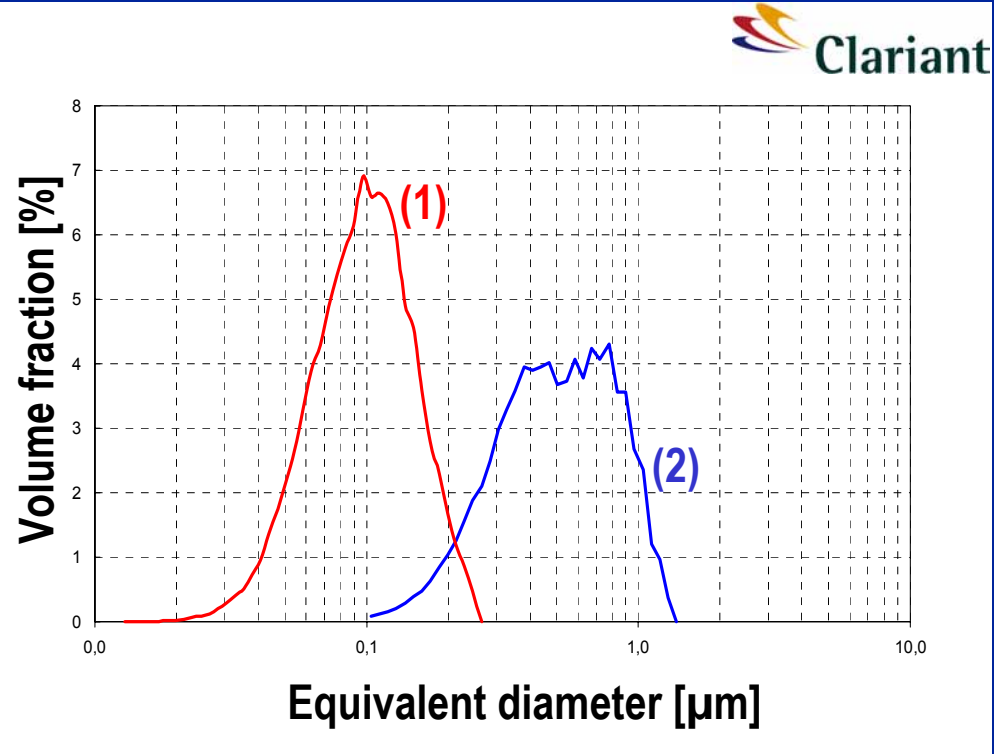


Batch vs. Continuous (microreactor)

Impact on:

- Mean particle diameter
- Particle size distribution

(log scale)



(1): Pigment out of microreactor, D_{50}= 90 nm

(2): Batch pigment, D_{50}=598 nm

Courtesy of Clariant GmbH

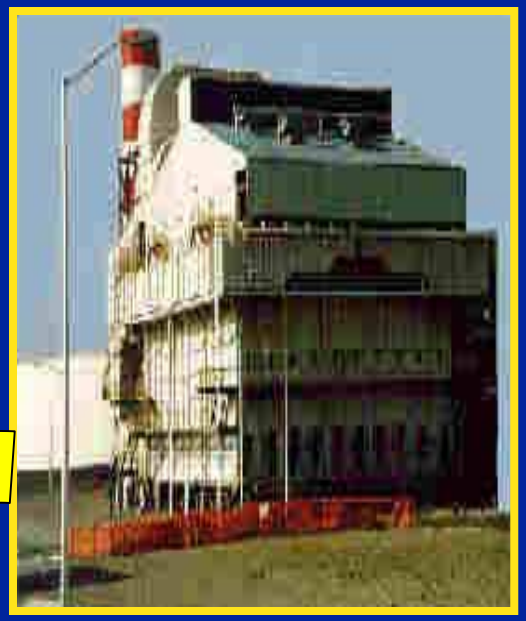
Compact Reforming

Emerging Syngas Users:

- Monetization of stranded gas (GTL)
- Distributed hydrogen
- Fuel cell systems

Challenges:

- Size
- Complexity
- Safety
- Emissions



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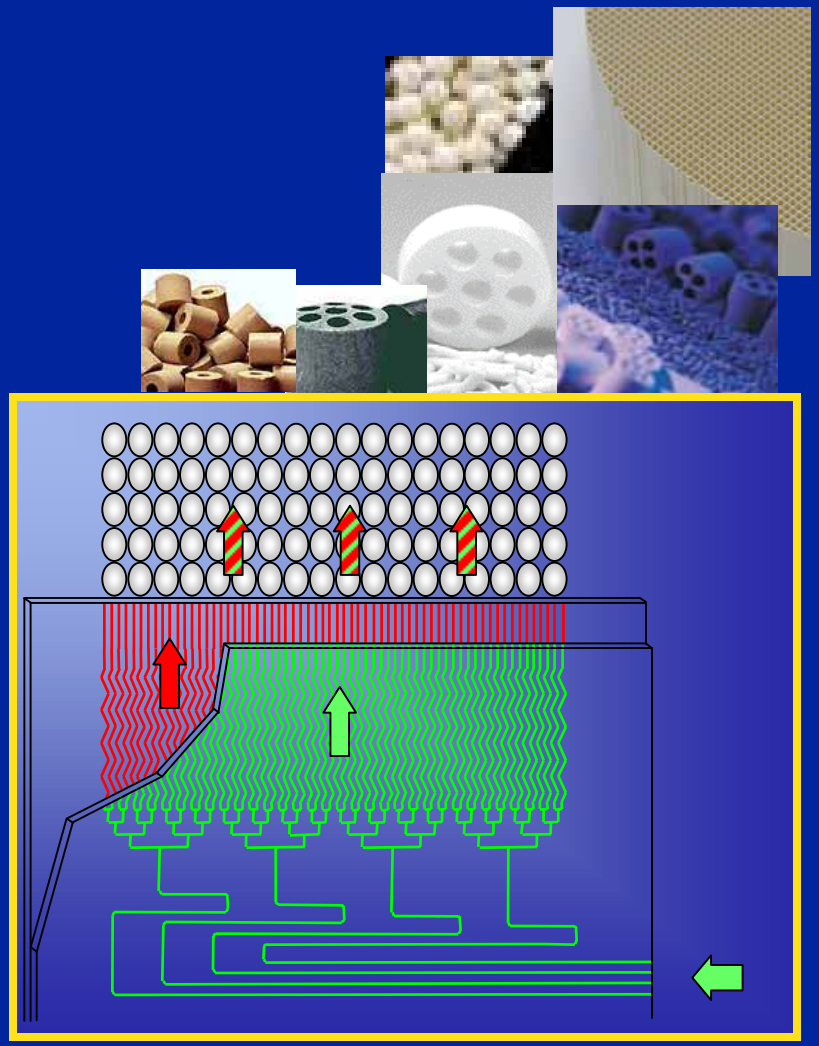
Compact Reforming

The **HEATRIC** solution:

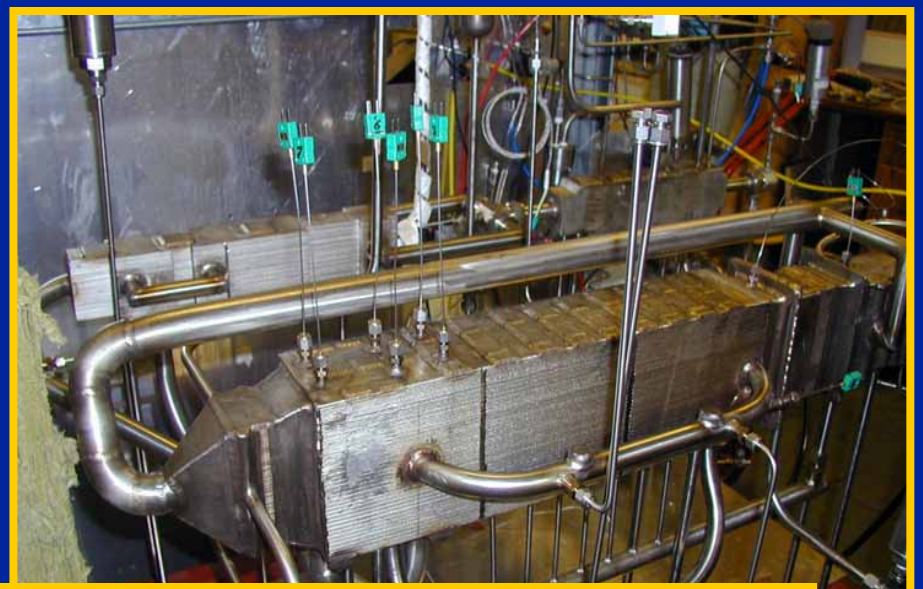
- Catalytic combustion
- Staged fuel addition
- Heat transfer to process between combustion stages
- Combustion within pressure-containing system



Compact Reforming

HEATRIC process (prototype):

- 9 x catalytic combustion stages
- 9 x reforming stages
- Conventional particulate catalyst (reduced size)



Barriers to Adoption

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- Lack of user understanding

Lack of User Understanding

Understand the NEEDS:

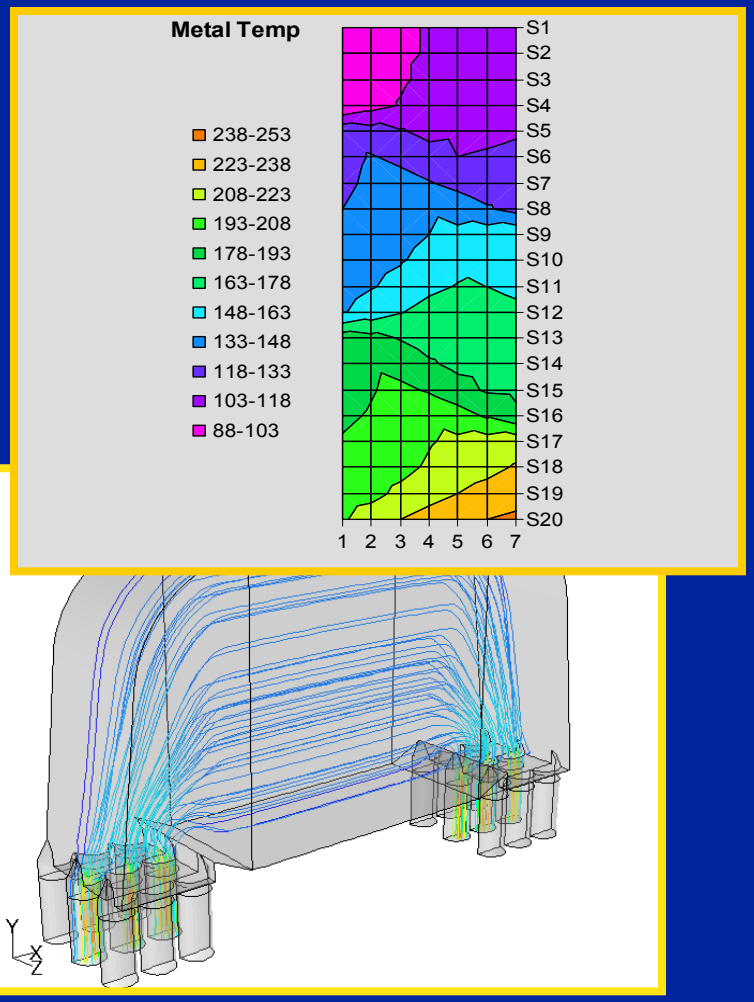
- Laboratory program
- Problem definition

Barriers to Adoption

- Lack of user understanding
- Perceived need for design tools

Perceived Need for Design Tools

- Tools generally exist
- Proprietary know-how
- Work with competent suppliers

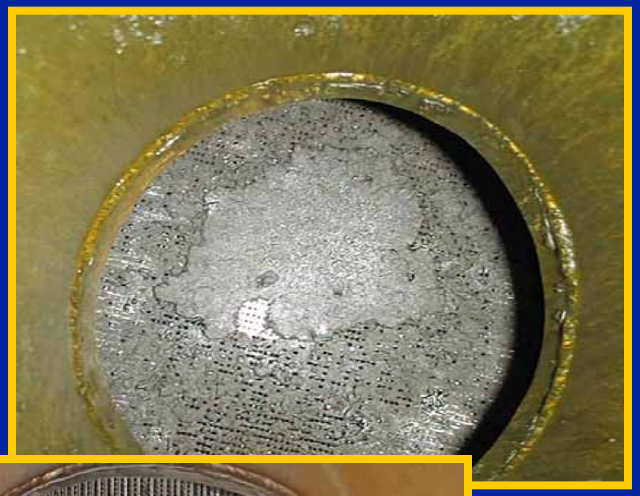


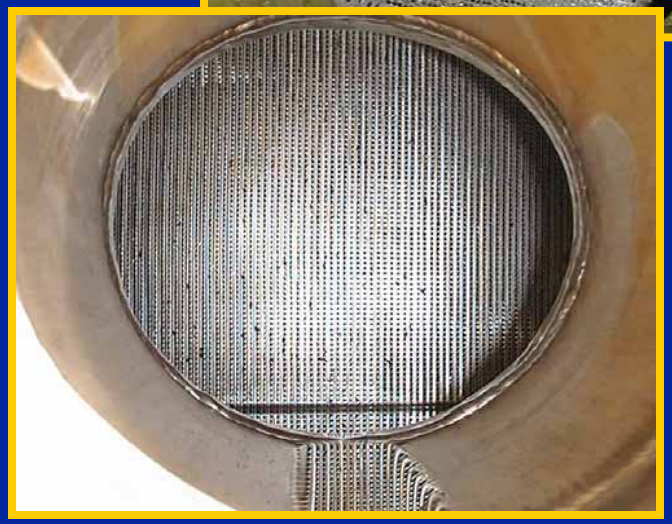
Barriers to Adoption

- Lack of user understanding
- Perceived need for design tools
- Impact on plant reliability, flexibility

Plant Reliability and Flexibility

- Comprehensive pilot trials
- Process understanding
- Prudent equipment design
- Appropriate sparing policy

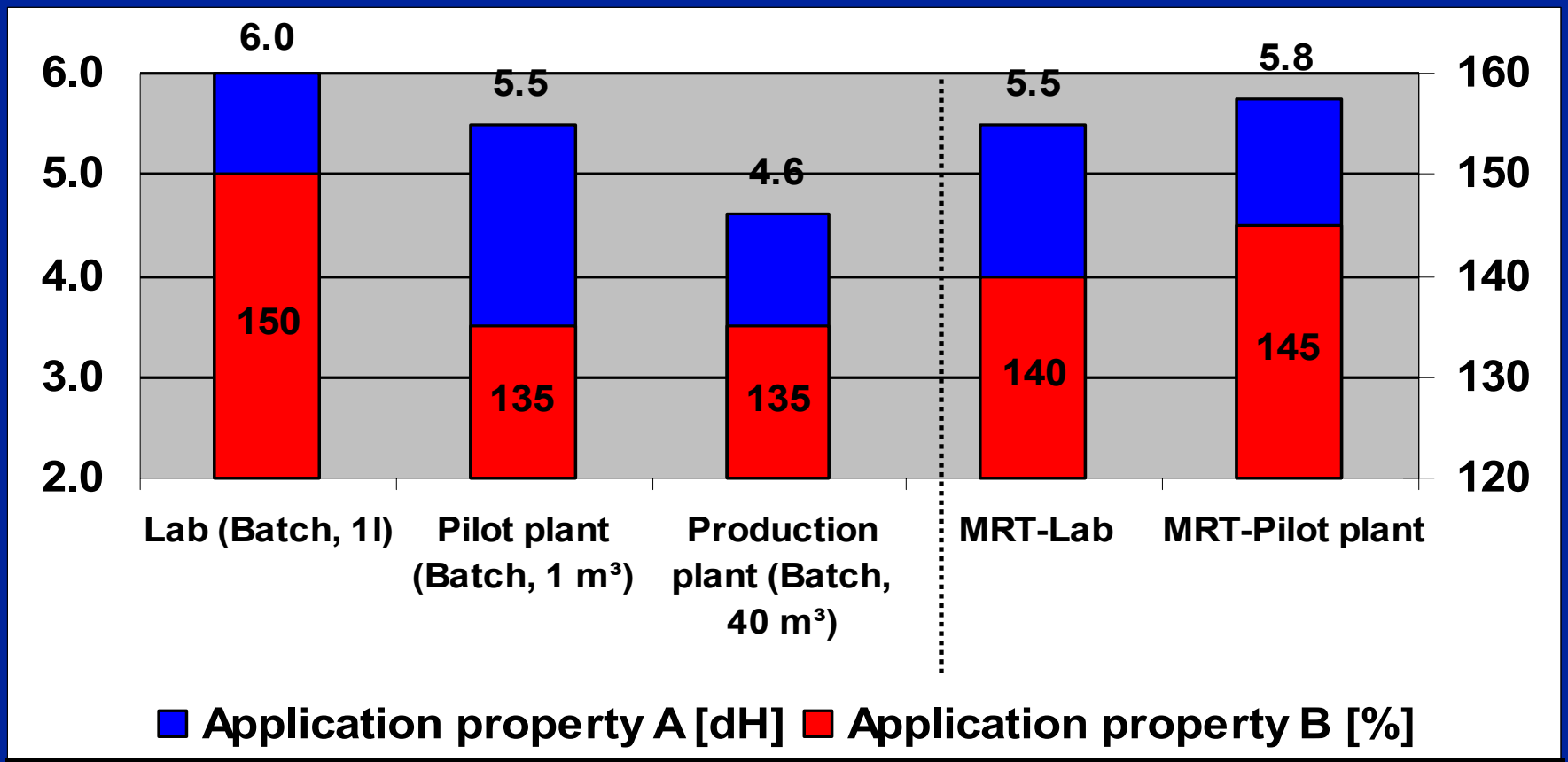




Barriers to Adoption

- Lack of user understanding
- Perceived need for design tools
- Impact on plant reliability, flexibility
- Scale-up

Scale-up



Classic scale-up phenomenon | 1:1 reproducibility

Courtesy of Clariant GmbH

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Barriers to Adoption

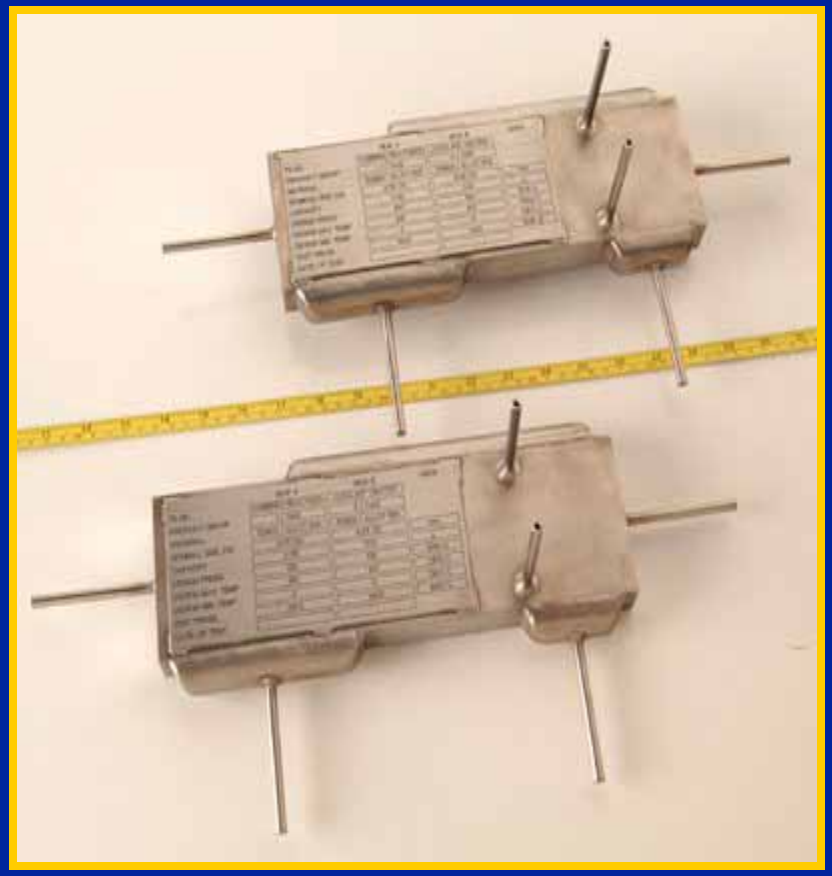
- Lack of user understanding
- Perceived need for design tools
- Impact on plant reliability, flexibility
- Scale-up
- Cost, payback time

Cost, Payback Time

- Equipment costs ~20% of total plant cost
- Engineering may outweigh hardware costs

But

- Beware cost justification for new technology



The Way Forward

The Way Forward

- Educate, Educate, Educate!
- Focus on Chemistry Needs; seek bespoke solutions, not Unit Operations
- Forget marginal justification, focus on Project-Enabling opportunities

Info@heatric.com

www.heatric.com