



FlexReactor

BHR*Solutions*

Flexible Reactors and Plant for Process Intensification

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Contents

Introduction to PI

Static Mixers and HEX Reactors

FlexReactor

***FlexReactor* Performance**

FlexPlant

Conclusions



Process Intensification - An Introduction

PI - What's it about?

- Reduction in plant size by at least factor of 100
 - Prof. C Ramshaw (1970s)
- Step change in product, process and *business* performance through in-depth understanding of the fluid dynamics and process chemistry
 - BHR (1990s)



Process Intensification - An Introduction

PI Philosophy

PI is a design philosophy where the fluid dynamics in a process are matched to the chemical, biological and/or physical requirements...

~~Process time~~  ~~Reaction time~~
... enabling the process to proceed safely at its optimum chemical kinetic rate with minimal byproduct formation

A vertical strip on the left side of the slide shows a satellite view of Earth, focusing on the Western European coastline and surrounding oceans. The image is in shades of blue and white, showing cloud patterns and landmasses.

The Big Issue for PI

UK/Western European industry focusing on lower tonnage, higher added value products (fine, speciality, pharmaceuticals..)

Key issues in manufacturing are *flexibility* and *responsiveness* to address changing market demands

Major plus point of traditional batch stirred reactors are their flexibility - they can do anything..... Badly!

PI invariably improves performance - but how can it be made flexible?



Static Mixers

High energy dissipation rate, ε

- ◆ 100s W/kg

Uniform energy dissipation

Narrow residence time distribution

- ◆ plug flow

Rapid dispersion

- ◆ radial mixing

High mass transfer rates

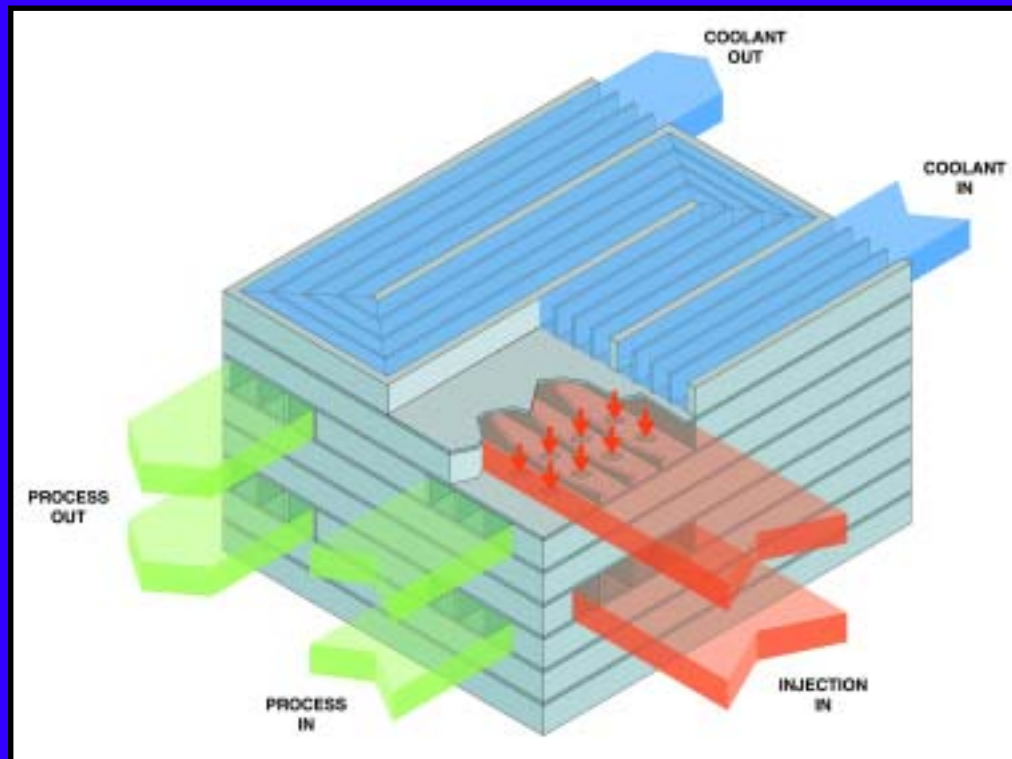
- ◆ 10 - 100 x stirred tank $k_L a$

High gas flow rate

HEX Reactors

If reaction is highly exothermic must get heat out as it is produced

Combine mixing, reaction and heat transfer in one unit, eg Marbond:



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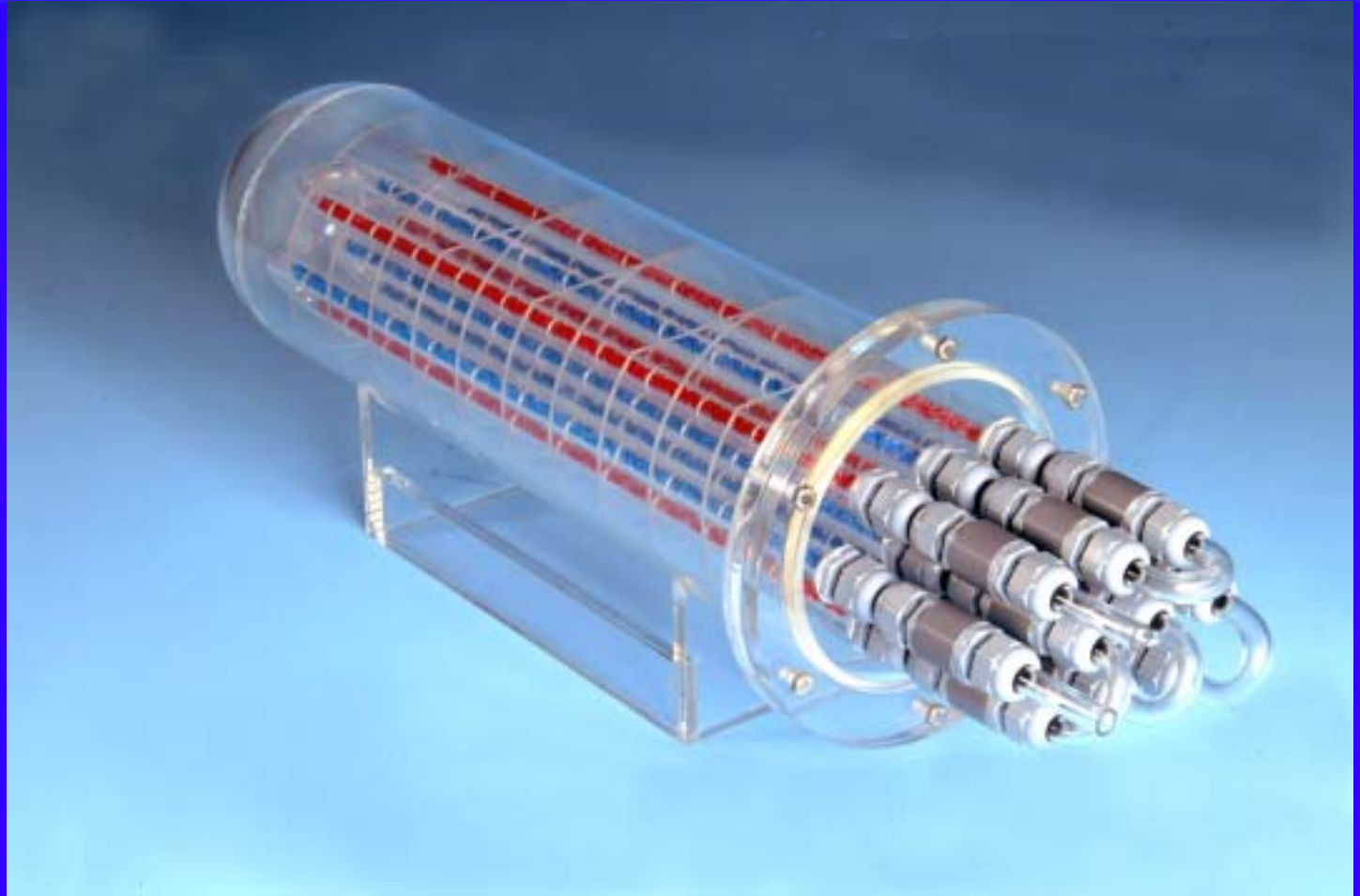
Flexible Reactors

PI - match reactor to requirements of chemistry

Tailored solution - how can it then be flexible?

Flexibility through reconfigurability

Flexible Reactors



FlexReactor

Reactors: *FlexReactor*



Features

- ◆ Simple but effective static mixer technology
- ◆ Highly flexible package
- ◆ Wide range of materials of construction

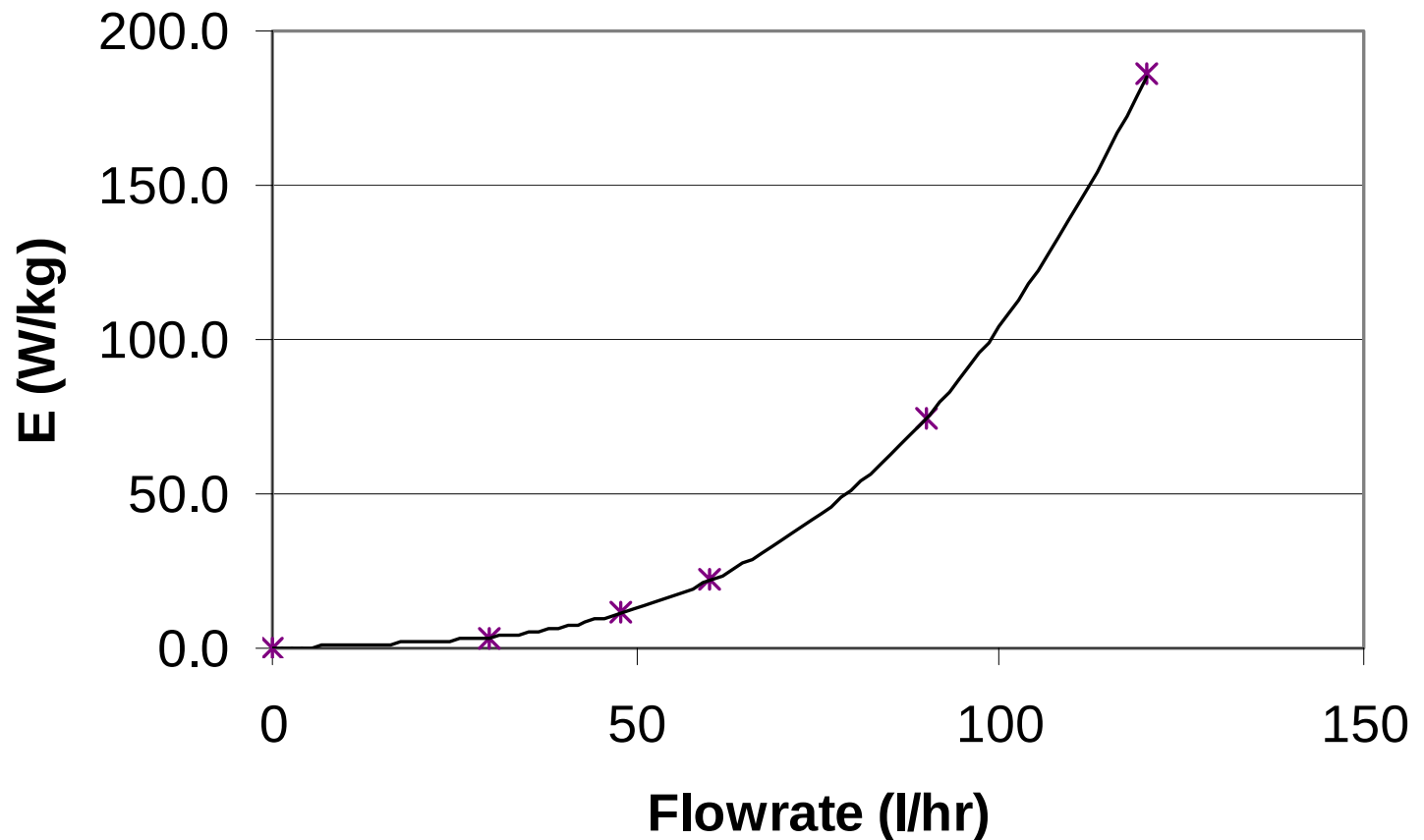
Benefits

- ◆ Use for wide range of processes
- ◆ Flexibility to cope with undefined chemistry

**Recipient of UK Government
Smart Award**

FlexReactor: Specifications

FlexReactor Energy Dissipation Rate





FlexPlant - Features

Able to rapidly screen suitability of reactions for PI

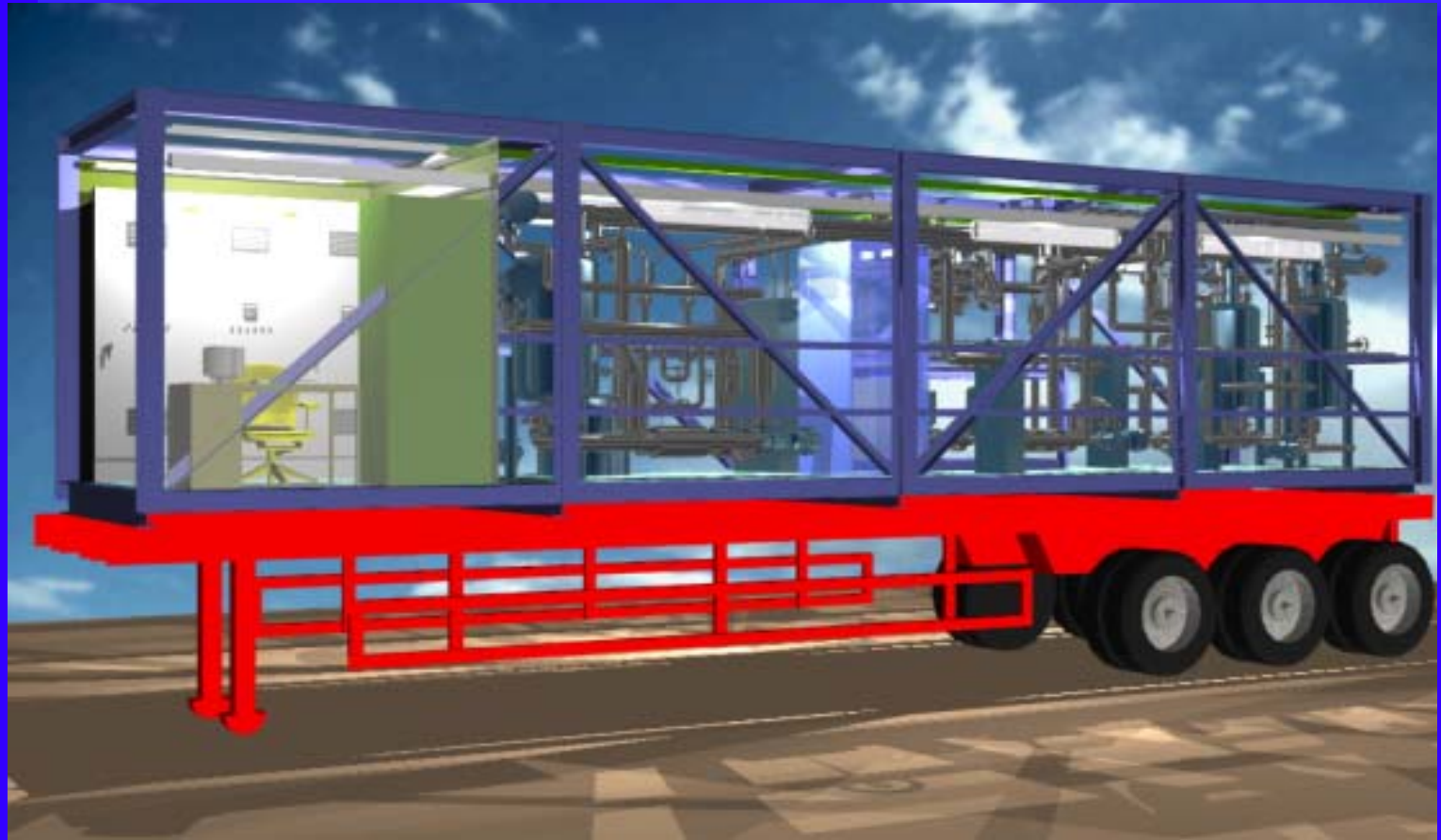
Wide range of flow, temperature and pressure conditions

Readily reconfigurable for wide range of reactions (incorporates *FlexReactor*)

Can be operated to GMP

Scale up well understood

Flexible Plant - Where Next?





Flexible Plant - Where Next?

Scale down?

FlexPlant is 'Lab-sized' but 'Pilot Scale' in terms of throughput (needs 10's litres)

Difficult to construct at much smaller scales - and flow regime likely to change (turbulent to laminar)

How do you design a small scale equivalent of Flexplant to work with 10's or 100's mls? - and scale between the two?

Watch this space!

A vertical strip on the left side of the slide shows a satellite view of Earth, displaying blue oceans, white clouds, and brown landmasses.

Conclusions

PI offers many benefits for the higher added value chemical sectors

Must build in flexibility through reconfigurability

***FlexReactor* and *FlexPlant* provide this opportunity - and allow companies to 'try out' PI at low risk and investment**

Plant available now (purchase or rental), but future developments planned in 'scale up' and 'scale down'