Suitability of Industrial Reactions for Process Intensification

Dr Jeremy M Double
Britest Ltd
jeremy.double@britest.co.uk

Introduction

- Survey of the characteristics of processes operated by Britest member companies
  - Low-tonnage processes
  - Pharmaceuticals, agrochemicals, specialty chemicals, fine chemicals and specialty colours
- Fuller details in proceedings of 2005 World Congress of Chemical Engineering, Glasgow
  - Atherton JH, Double JM, Gourlay B, 2005. Survey of PI Equipment Requirements in the Fine Chemicals and Pharmaceuticals Sector. Proceedings of the 7th World Congress of Chemical Engineering, Glasgow, UK, 11-14 July 2005

Key results — materials handling

- Nearly all processes were batch
- Over 60% of processes involved solids feed
- Two-thirds of processes surveyed involve two or more phases during reaction, and over a third involve three or more phases
  - Over 40% of processes had solids present during reaction
- Product form
  - About half liquid or solution
  - About a third solid
  - Remainder paste or slurry

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Key results — rate limiting process

- Reaction times varied from seconds to 3 days
  - Broad spread, many in hours
- Rate limiting process:
  - Nearly 50% chemical kinetics
    - In most of these, increasing T to increase rate would result in lower selectivity
  - 30% were mass transfer limited
  - Remainder heat transfer or unknown
- Half the processes had 5 or more work-up steps

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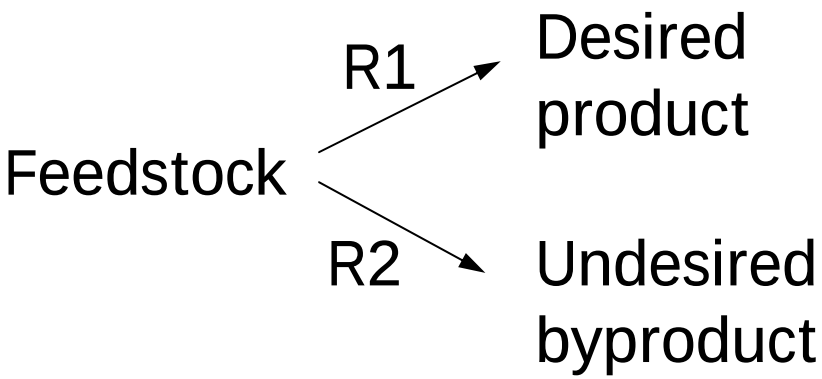
Conclusions

1. Process diversity: several reactor types needed
2. Need continuous reactors with 1-120 min residence times
3. Need for small-scale continuous equipment for feeding, processing and recovery of solid materials
4. Opportunities in work-up

Supplementary slides

Accelerating reactions

- Removing physical rate limitations will accelerate the reaction to the point where it is limited by chemical reaction rate
- Chemical reaction rates can be accelerated by raising the temperature
  - this may not give the required results:



If activation energy for R2 > activation energy for R1, then increasing T will favour R2 compared with R1, decreasing selectivity

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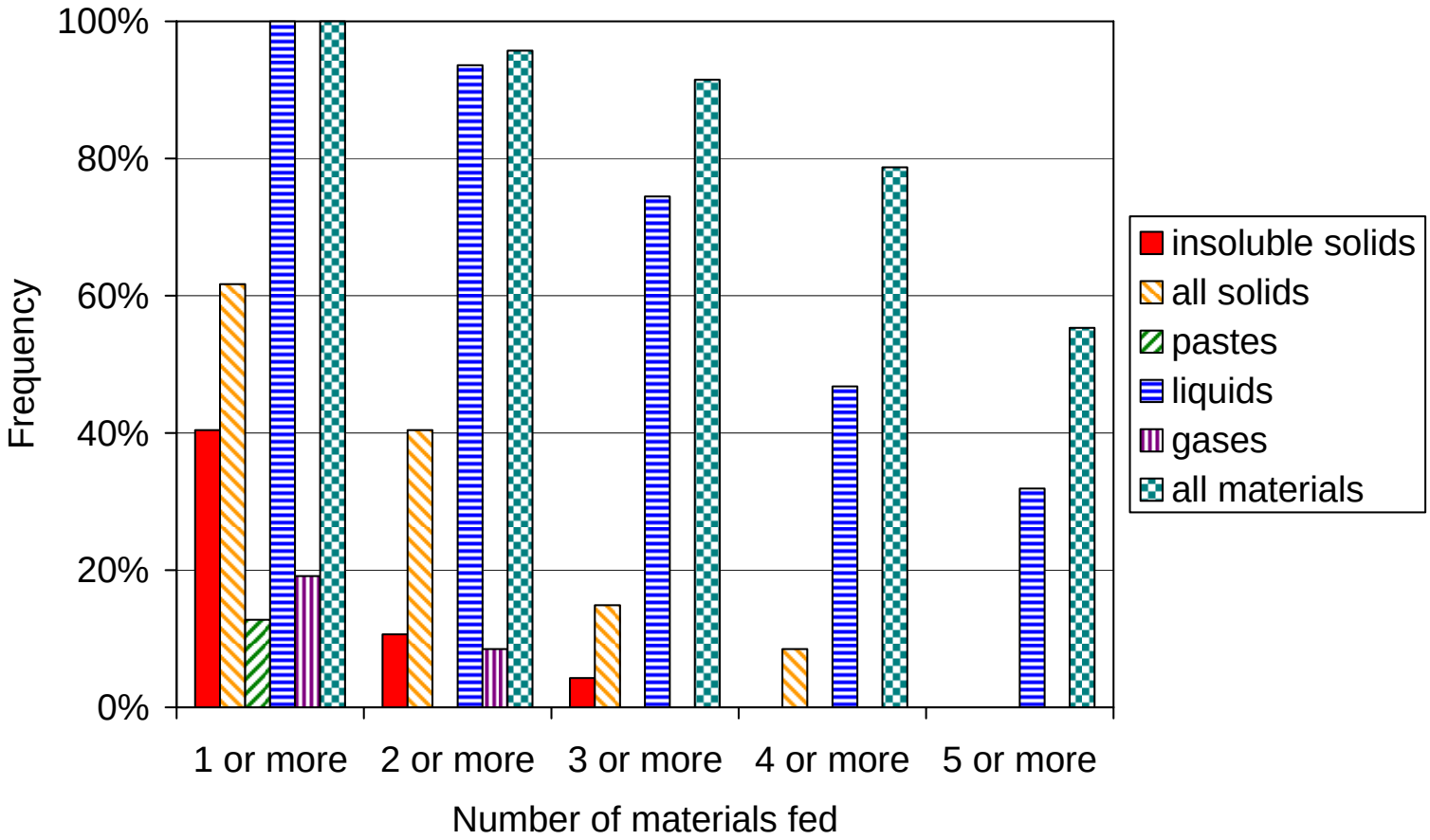
Number and type of materials fed



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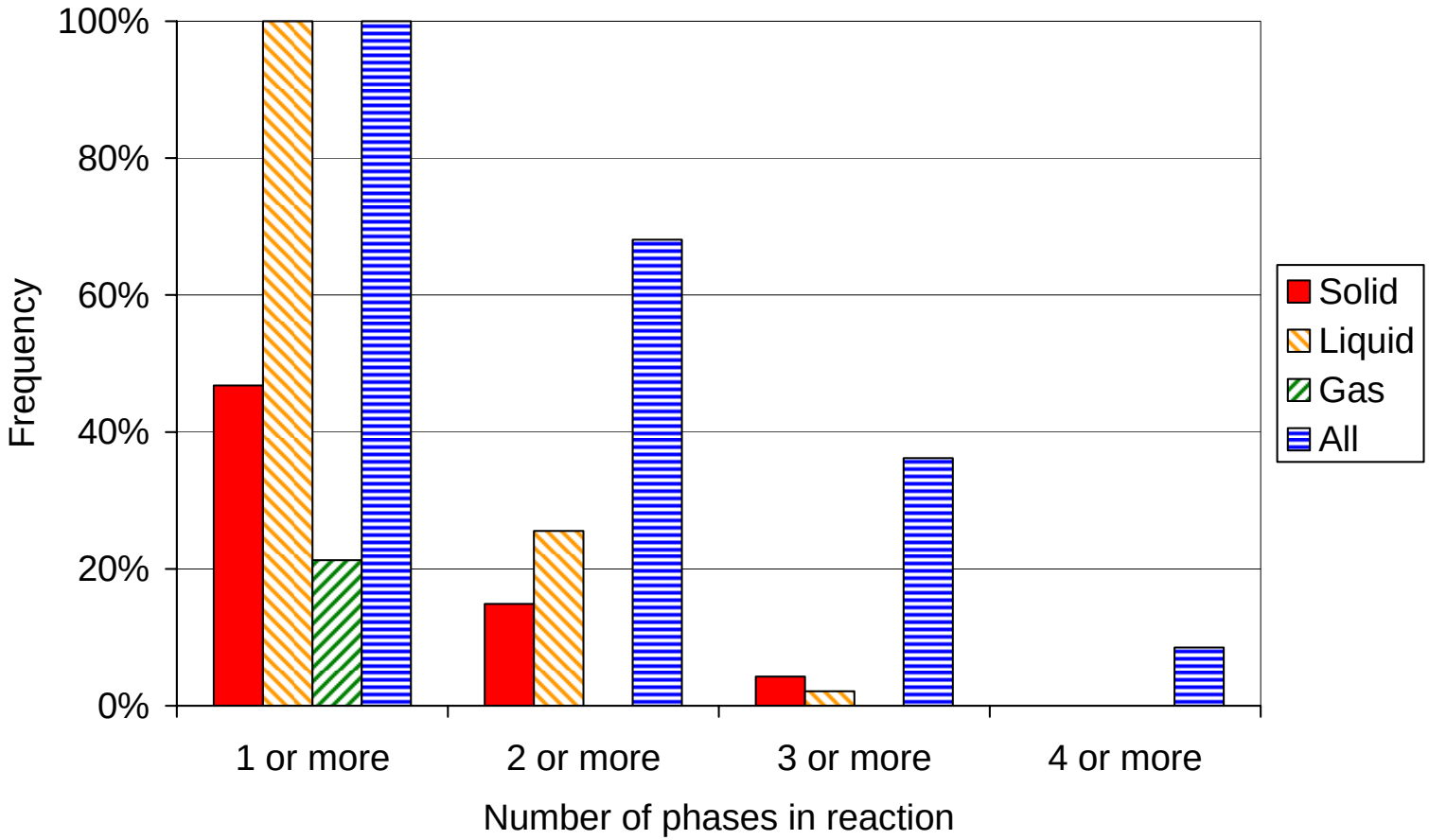
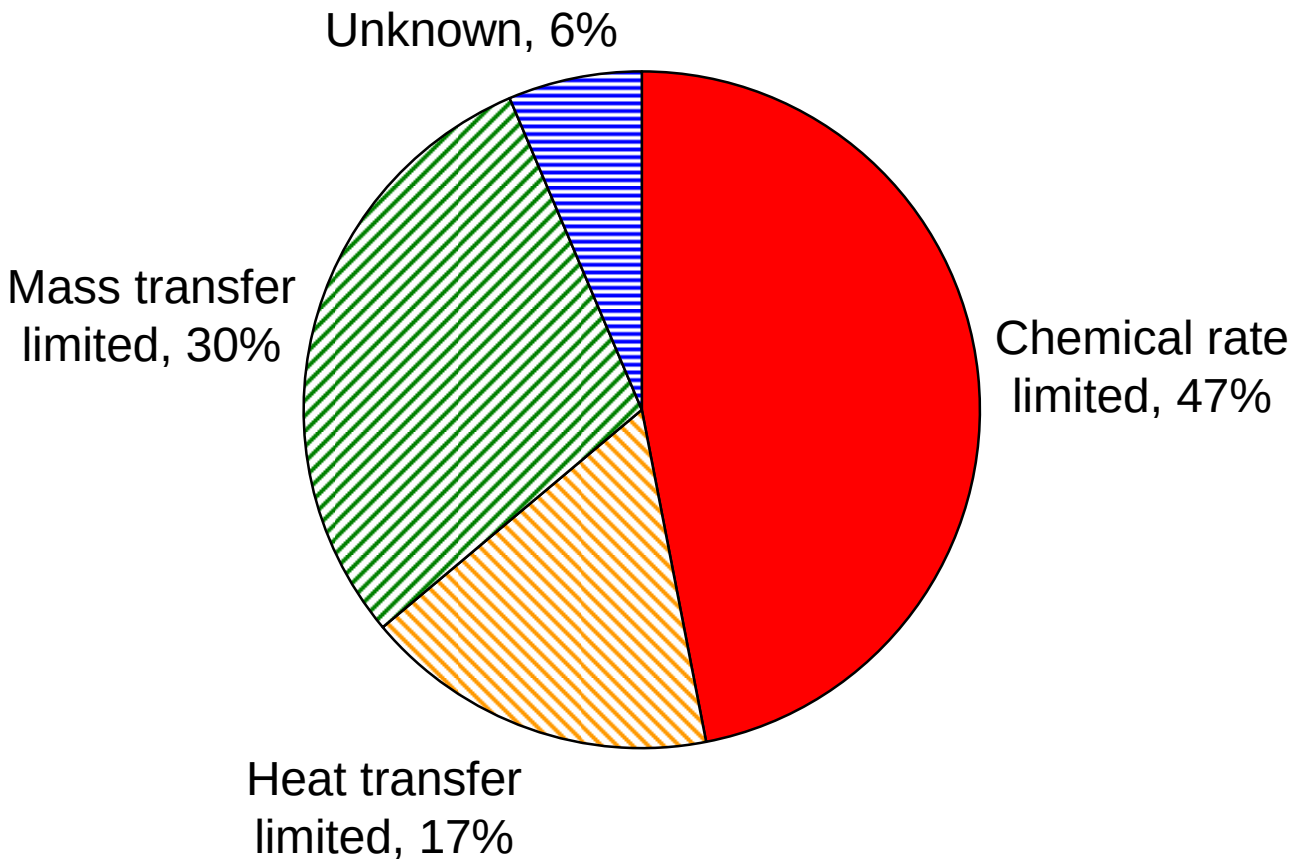
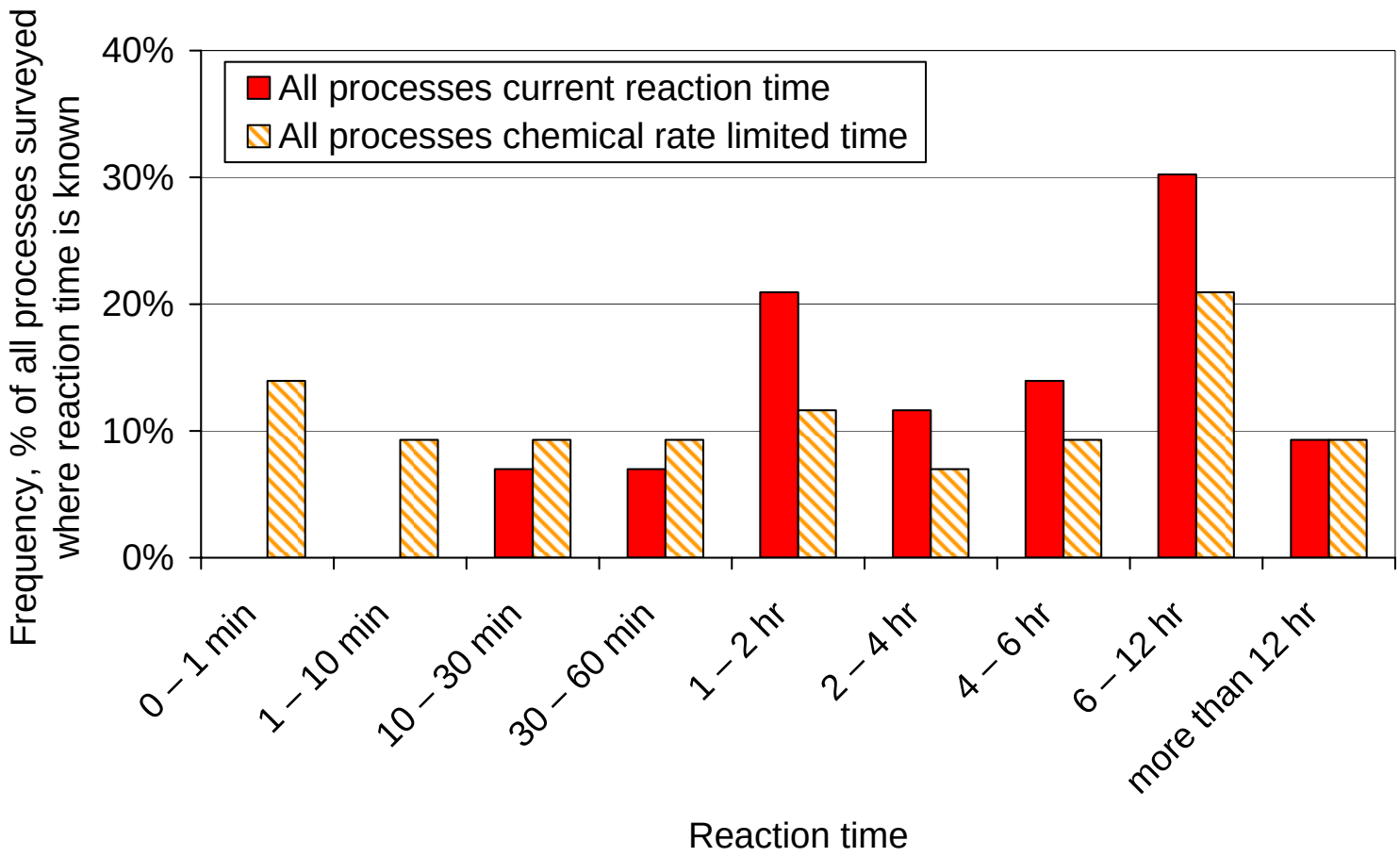
Phases present during reaction



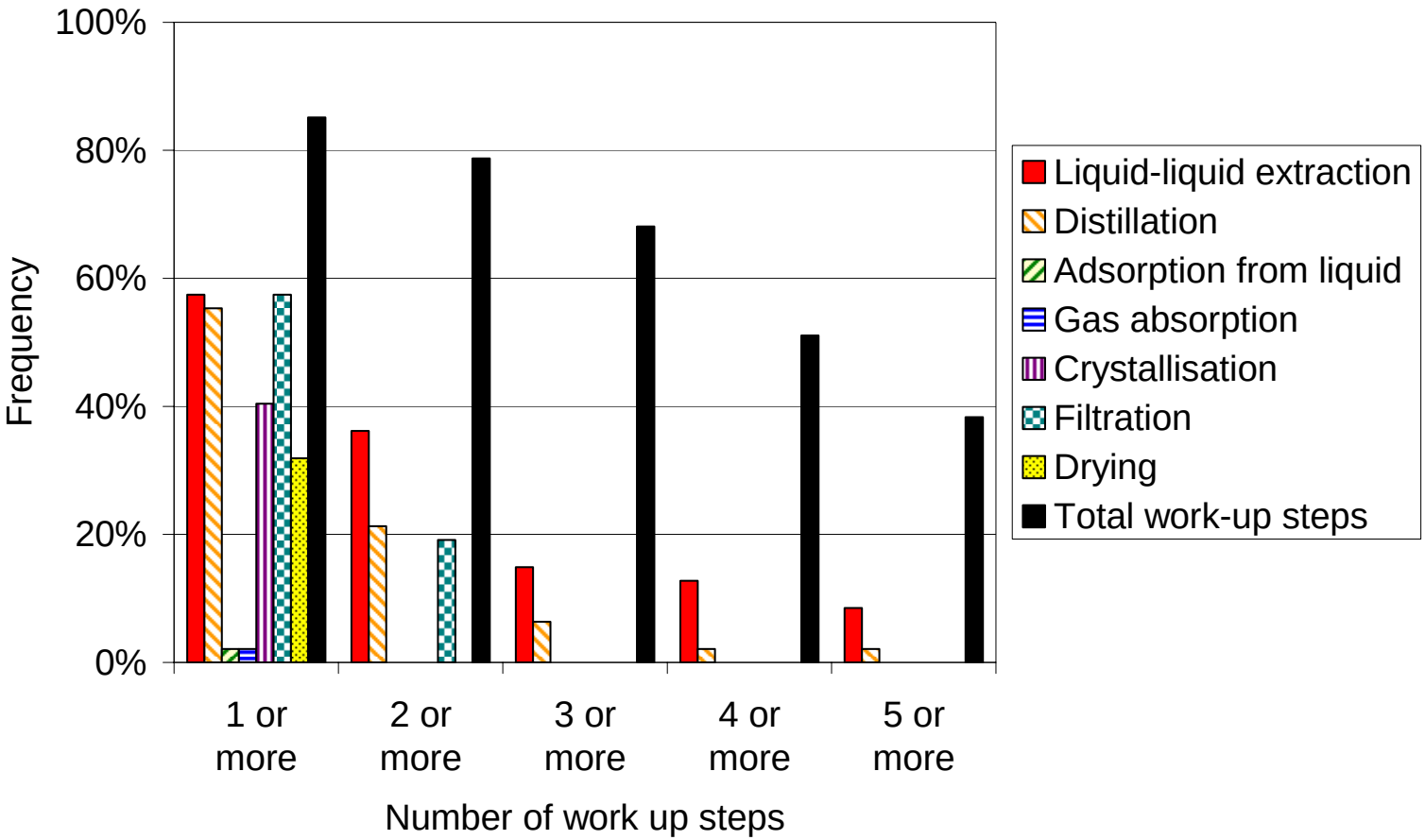
Rate limiting process for reaction



Reaction time



Number of work up steps



Product physical form