Commercial and Lab Scale Reactors

Introduction

Catalytic reactors are essential tools for evaluating catalyst performance, studying reaction kinetics, and simulating commercial-scale processes. However, selecting or designing the right laboratory reactor can be a complex task. Different research goals require specific reactor types to ensure accurate and meaningful results.

This application note summarizes common laboratory reactor configurations and offers guidance on selecting the appropriate reactor design for catalyst screening, kinetic studies, or process scale-up.

Application 1: Catalyst Screening and Evaluation

Objective: Compare the activity and selectivity of multiple catalyst formulations.

Recommended Reactor Type:

- **Small Fixed-Bed Reactors**
  - Simple design and easy fabrication.
  - Requires small catalyst quantities.
  - Operable under isothermal conditions with minimal transport effects.
  - Ideal for detecting trends across a large number of catalysts.
- **Pulse Fixed-Bed Reactors**
  - Reactants pulsed periodically over the catalyst bed.
  - Allows quick screening but generates non-steady-state data—careful interpretation required.

Best Practices:

Keep overall conversions low to highlight differences in catalytic activity without masking effects from high conversions.

Application 2: Intrinsic Kinetic Studies

Objective: Obtain kinetic data free from heat and mass transfer limitations.

Recommended Reactor Types:

- **Batch Reactor**
- **Continuous Stirred-Tank Reactor (CSTR)**
- **Plug-Flow Reactor (PFR)**

Most Common Choice:

- **CSTR (Perfectly Mixed Flow Reactor)**
  - Reacting mixture has the same composition as the exit stream.

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- Designs include impeller-mixed vessels, externally recirculating systems, and internally recirculating reactors (e.g., Berty and Carberry designs).

Best Practices:

- Operate under isothermal conditions.
- Conduct transport limitation tests to confirm kinetic data accuracy.

Application 3: Process Parameter Determination and Scale-Up

Objective: Simulate large-scale reactor conditions to collect process-relevant data.

Recommended Approach:

- **Use the Same Reactor Type as the Commercial Reactor**
  - Match phase distribution, catalyst shape, and operating conditions (temperature, pressure, concentrations).
  - Maintain geometrical and operational similarity to the industrial unit.

Best Practices:

Replicate commercial conditions as closely as possible to ensure laboratory data scales accurately.

Summary Table: Reactor Types and Key Characteristics

Reactor Type	Ease of Analysis	Isothermality	Ease of Construction	Transport Effects	Quality of Data
Fixed-bed, differential	P-F	G	G	F	P-G
Fixed-bed, integral	G	P-F	G	P-F	P-F
Pulse	P-G	G	G	F	P
Batch	P	G	F	P	P-G
CSTR	G	G	P	P-F	G
External recirculating	G	G	P	P	G
Internal recirculating	G	G	P	G	G
Trickle bed	G	P	P-F	P	P
Fluidized bed	P	P	P	F	P-F
Bubble column	G	G	G	F	F

G = Good, F= Fair, P= Poor

AMI Reactor Solutions

AMI provides a full range of customizable reactor systems for catalyst screening, kinetic studies, and commercial process simulation. Whether you require small-scale fixed-bed units or sophisticated recirculating reactors, AMI's engineering team can tailor solutions to meet your specific research goals.

References

- Levenspiel, O., *Chemical Reactor Engineering*, Wiley (1972).
- Carberry, J.J., *Chemical and Catalytic Reactor Engineering*, McGraw-Hill (1976).
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- Turner, J.C.R., in *Catalysis Science and Technology*, Springer-Verlag (1981).
- Various studies by Carberry, Berty, Bennett, and Weekman (1964–1974).