A Novel Method for Gas-to-Particulate Mass Transfer Measurements in Fluidized Beds

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FLUIDIZATION XVI

Guilin Shangri-La Hotel, Guilin, China

Importance of Mass Transfer in FBs

Large variety of FB applications

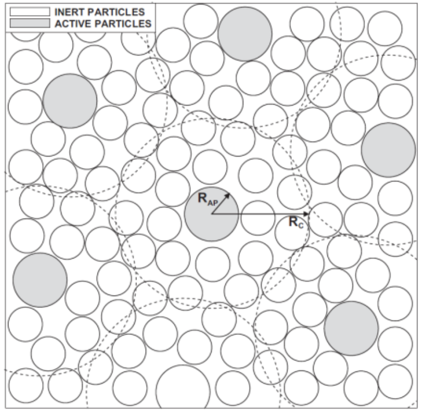
- Particle classification
- Pneumatic transport
- Drying and coating
- Catalytic processes
  - Catalytic cracking
  - Polymerization processes
- Thermal processes
  - Gasification, Combustion (CLC, OCAC)
  - Thermal cracking

Mass transfer as key mechanisms in most FB applications

Importance of Mass Transfer in FBs

Understanding mixing and mass transfer

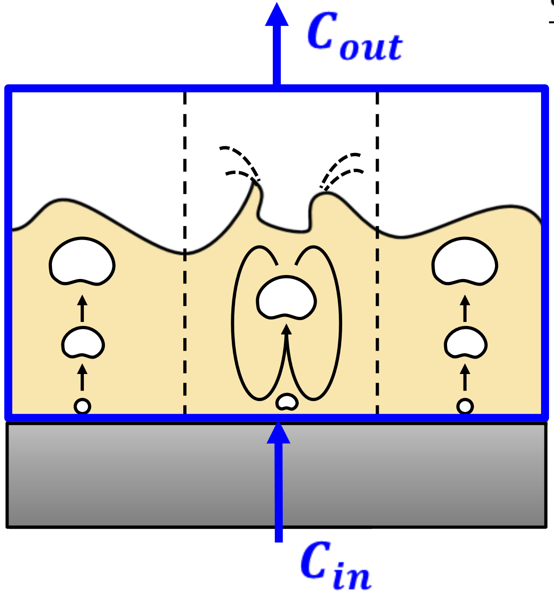
1) Gas-to-bed solids mass transfer
Mixture of inert/active bed material



Scala F. 2013. **Chemical Engineering Science.** 91, (90–101)

2) Gas-to-bed solids mass transfer
Whole bed material is active

$$\frac{dm}{dt} = kA\left(C_\infty - C_p(t)\right)$$



Macro scale

Importance of Mass Transfer in FBs

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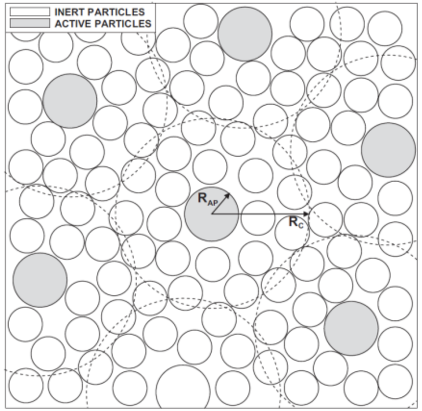

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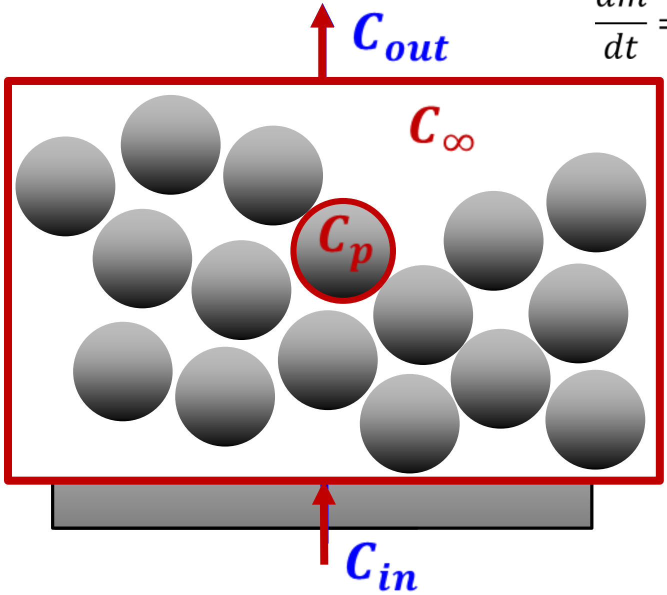
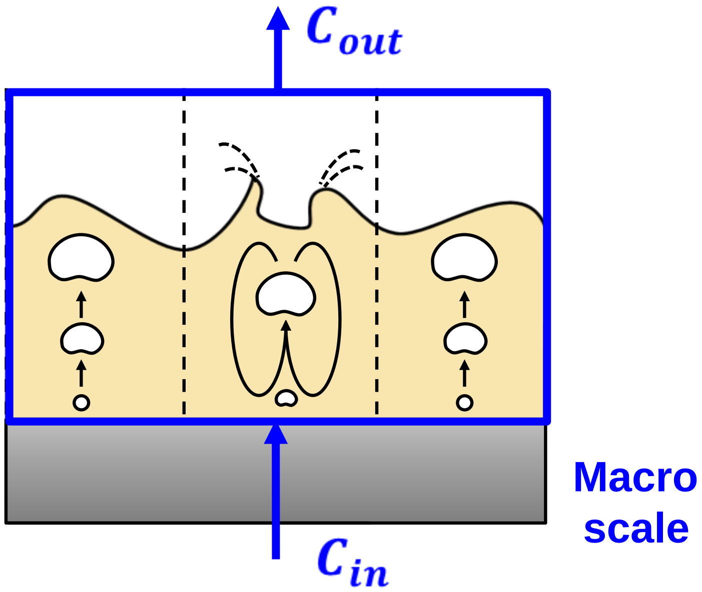


Macro scale

Micro scale

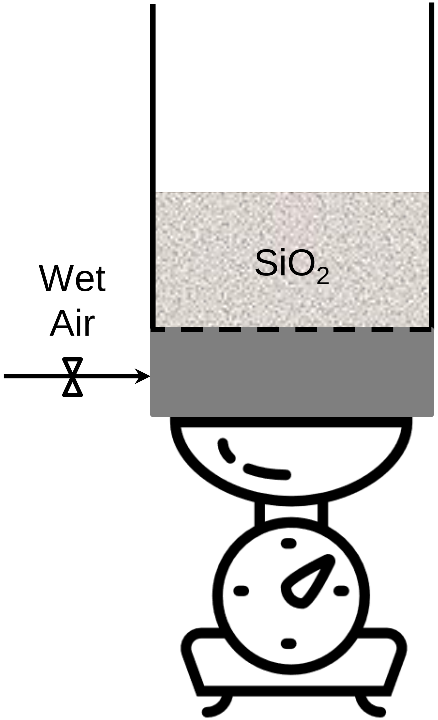
AIM

Development of a method for the measurement of macroscopic interphase mass transfer in a fluidized bed.



EXPERIMENTAL SETUP

Setup at UC3 Madrid

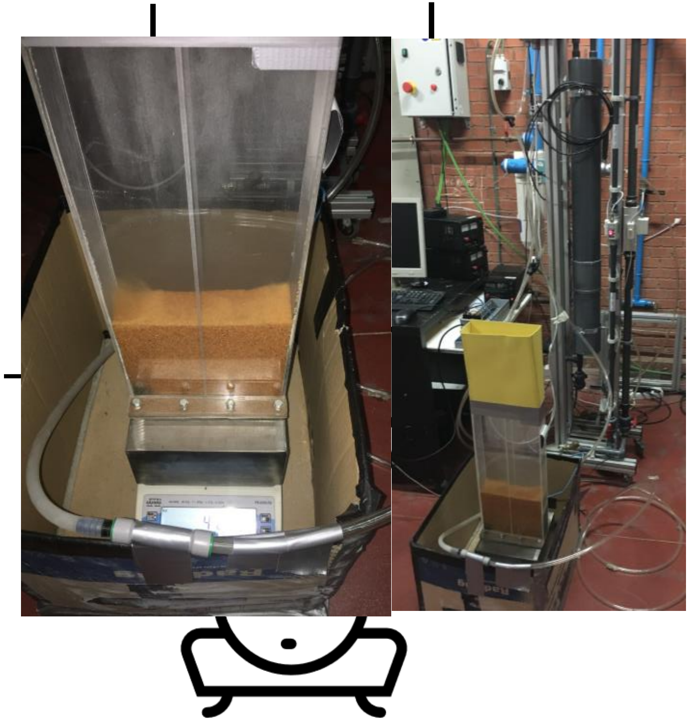


- Cross section of the bed: 5×20 cm^2
- Measurement accuracy: 0.01 g, 7 Hz
- Measurement time: ~ 45 min
- Inlet concentration: ~ 80% RH

- Varying
  - Fluidization
  - Bed height
  - Distributor pressure drop

Experimental Setup

Setup at UC3 Madrid



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  - Fluidization
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EXPERIMENTAL SETUP

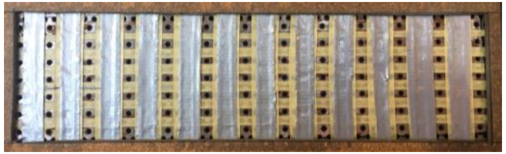
Measurement setup at UC3 Madrid

Silica gel with wet air
Particle size: ~750 µm
Bulk density: ~1320 kg/m^3
Min fluidization: 0.2 m/s

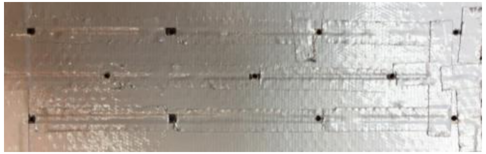
- Low bed (0.5 kg, 4 cm)
  - $1.5\times U_{mf}$
  - $2.0\times U_{mf}$
- High bed (1.0 kg, 8 cm)
  - $1.5\times U_{mf}$
  - $2.0\times U_{mf}$
  - $3.0\times U_{mf}$
    - Lo-dP
    - Mid-dP
    - Hi-dP

Lo-dP

Mid-dP

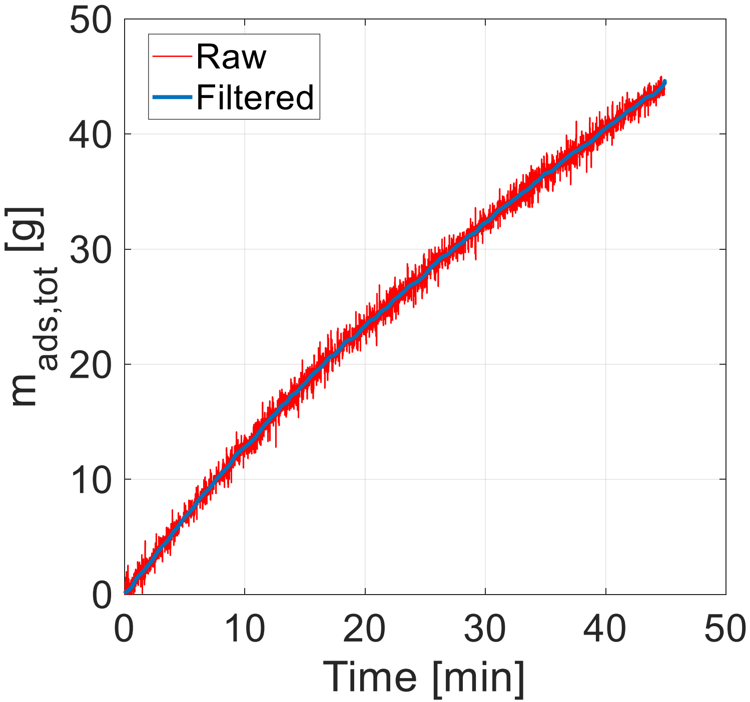


Hi-dP



METHOD

Measurement of mass of FB unit



$$\frac{dm}{dt} = kA\left(C_\infty - C_p(t)\right)$$

$$C_p(t) = \frac{m_{ads} \cdot C_{in}}{m_{ads,tot}} \qquad C_{out} = \frac{\dot{m}_{in} - \dot{m}_{ads}}{\dot{V}_{out}}$$

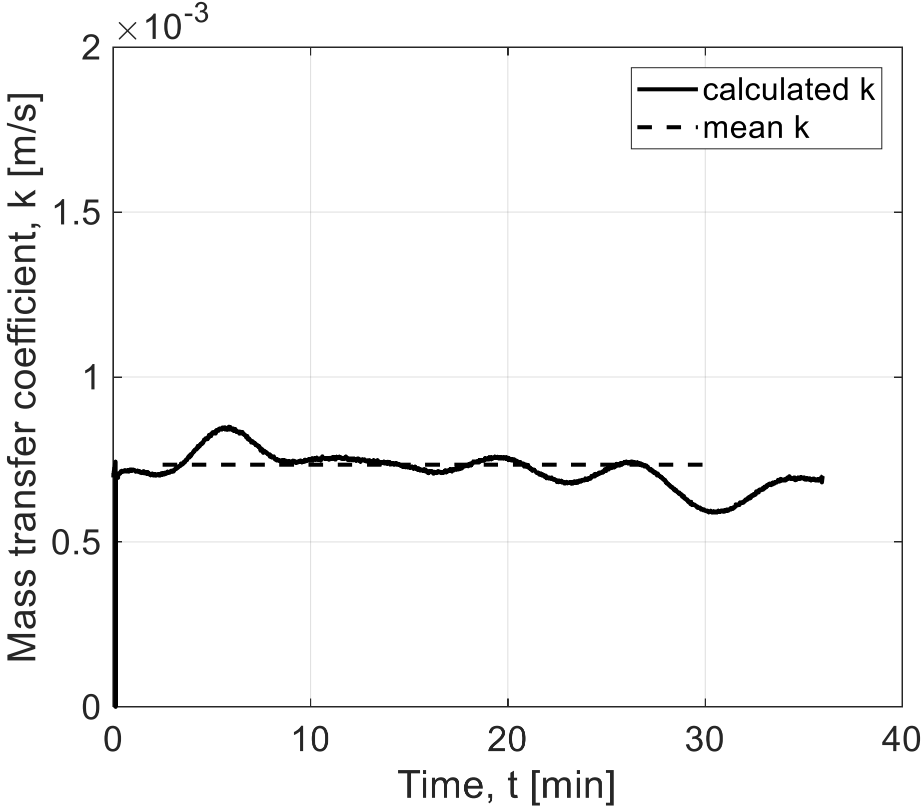
Different models for calculating C_∞

CSTR $$C_\infty = C_{out}$$

PFR $$C_\infty = \frac{(C_{in} - C_{out})}{\log(C_{in}) - \log(C_{out})}$$

METHOD

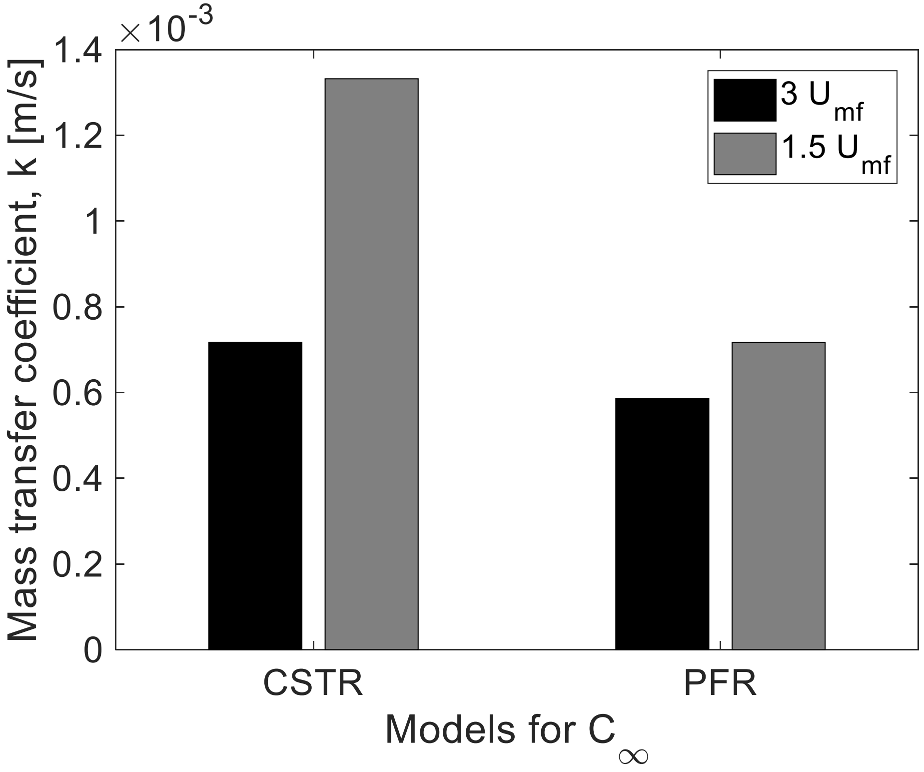
High bed
$3.0 \times U_{mf}$
PFR



- Finding time interval, where transport is mass transfer dependent
- Mean over time interval

RESULTS

High bed
Mean k



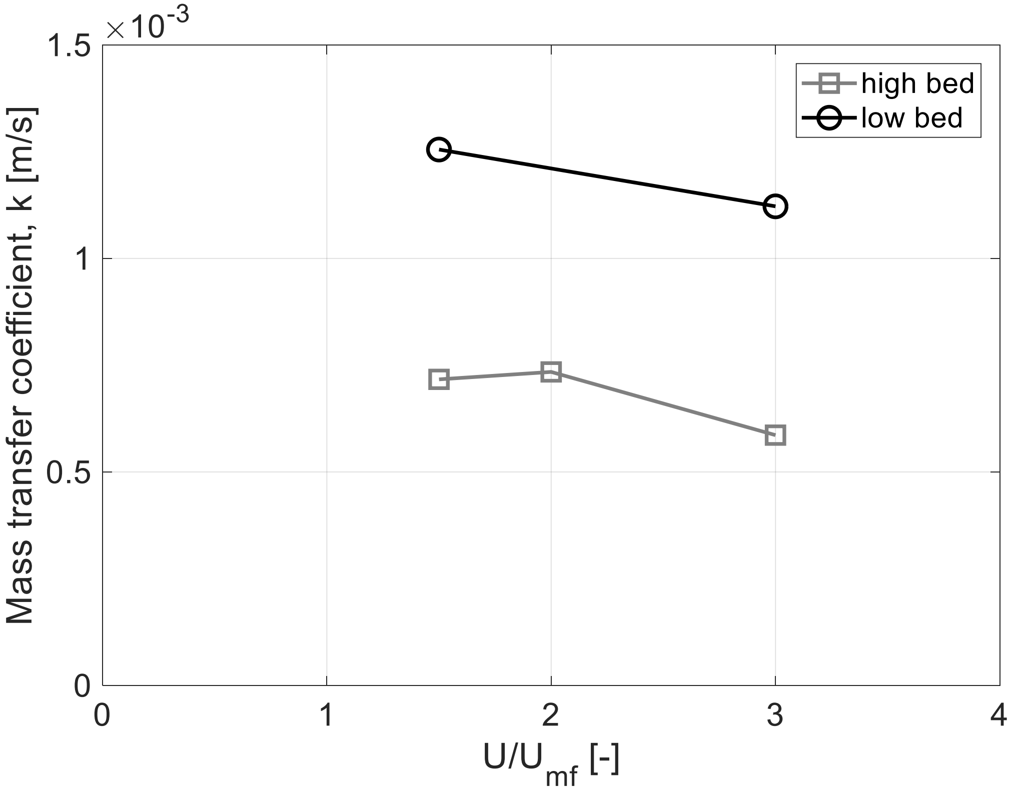
- Influence of the model used for C_{∞}

→ use of PFR approach

RESULTS

Low bed (0.5 kg, 4 cm)

High bed (1.0 kg, 8 cm)

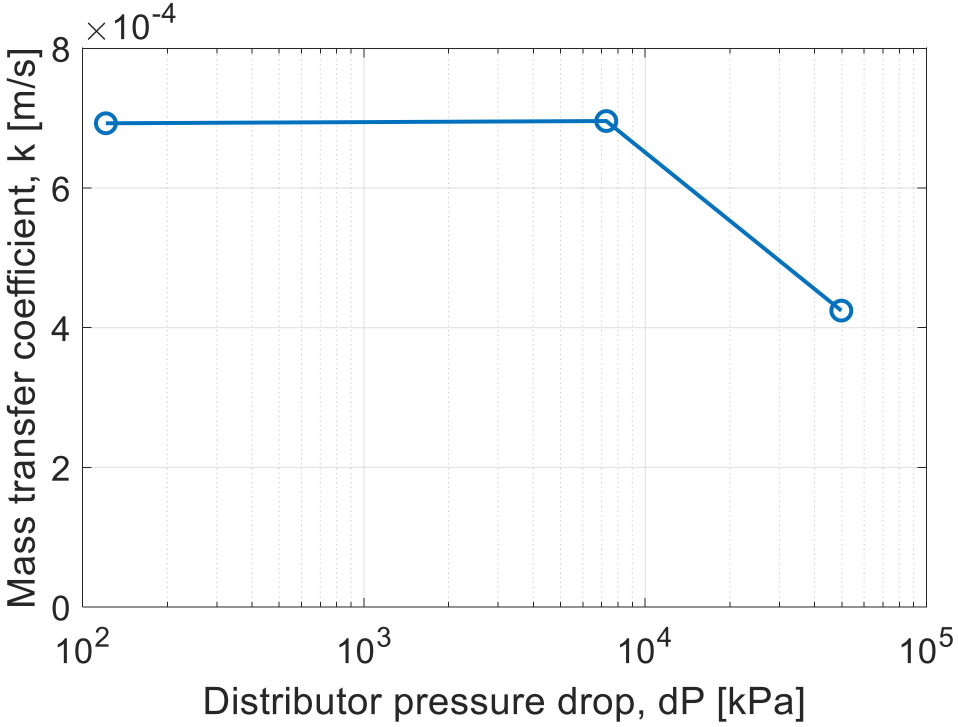


Influence of the

- fluidization ratio
- bed mass/bed height

RESULTS

High bed
$3.0 \times U_{mf}$



Influence of pressure drop over distributor

CONCLUSIONS

- A method to measure the macroscopic mass transfer coefficient in a BFB was developed.
- Trends observed when changing experimental parameters
  - Fluidization: U_0↑ → k↓
  - Bed height: H_0↑ → k↓
  - Pressure drop: ΔP↑↑ → k↓

FUTURE WORK

- Approach to calculate micro scale mass transfer coefficient with help of CFD modelling
- Measurements with mixture of inert/active bed material
- Use of fluid-dynamically down-scaled material coated with silica gel particles

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