5-23-2016

Experimental characterization of operational regimes in low aspect-ratio CFB risers

Tove Karlsson
Chalmers University of Technology; Dept. Energy and Environment, Sweden, tovek@chalmers.se

Xuemin Liu
Tsinghua University; Key laboratory for Thermal Science and Power engineering of Ministry of Education, China

Filip Johnsson
Chalmers University of Technology; Dept. Energy and Environment, Sweden

David Pallarès
Chalmers University of Technology; Dept. Energy and Environment, Sweden

CHALMERS
UNIVERSITY OF TECHNOLOGY

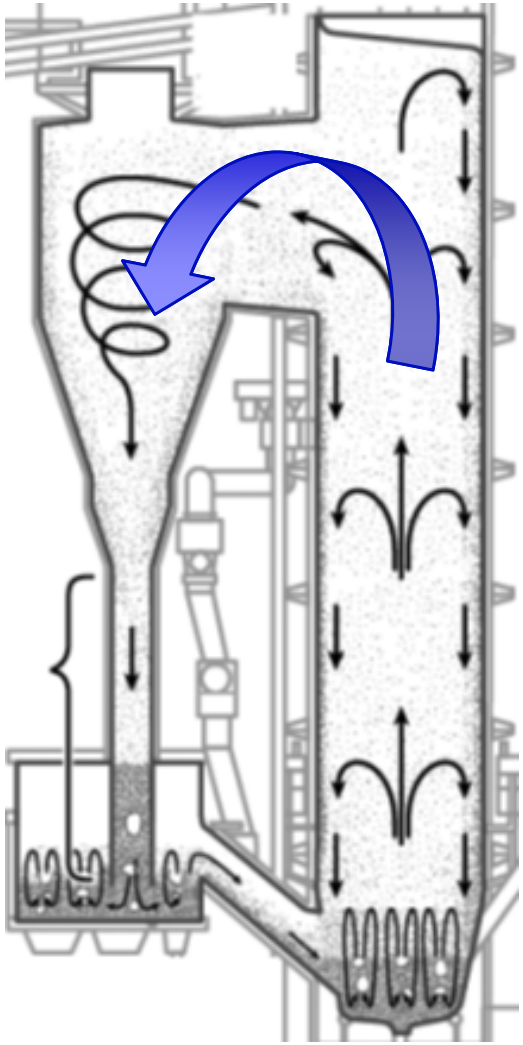
Solids circulation in CFBs with low riser aspect ratio and varying total solids inventory

Tove Karlsson, David Pallarès, Filip Johnsson
Chalmers University of Technology, Göteborg (Sweden)

Xuemin Liu
Tsinghua University, Beijing (China)

Fluidization XV – Fairmont Le Château Montebello (Québec, Canada)
May 23rd, 2016

Background – solids external circulation



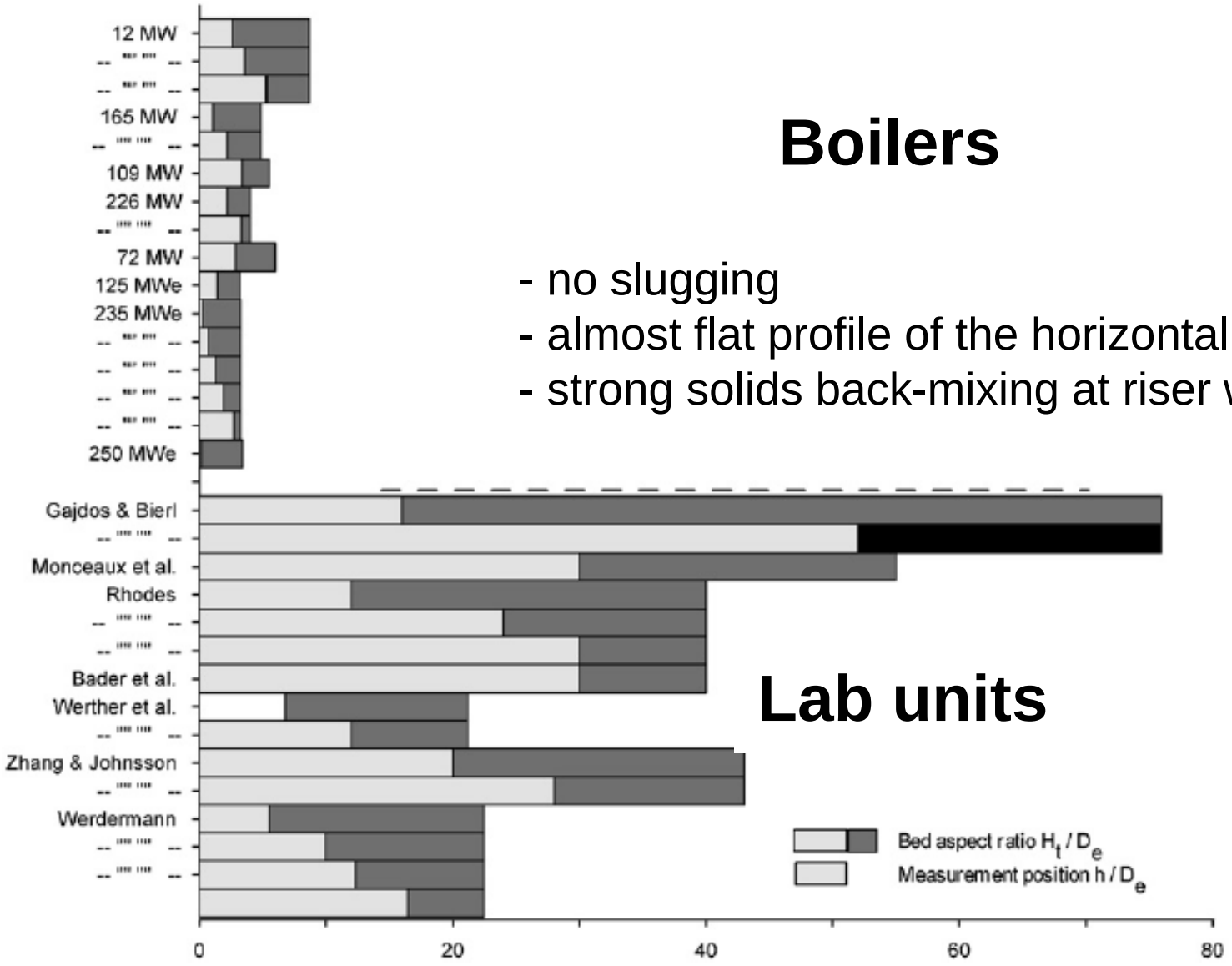
The external circulation of solids is critical for:

- Temperature control of the CFB loop (external heat exchanger/s, EHE)
- Solids inventory control of the CFB loop (cyclone/s)

In dual FB systems (Chemical looping, Ca-looping, indirect gasification, …):

- Mass flow of active solids between reactors
- Heat flow between reactors

Background – riser aspect ratio



Boilers

- no slugging
- almost flat profile of the horizontal solids flux
- strong solids back-mixing at riser walls

Lab units

A. Johansson, F. Johnsson, B. Leckner. ”Solids back-mixing in CFB boilers”. *Chemical Engineering Science* 62 (2007) 561–573

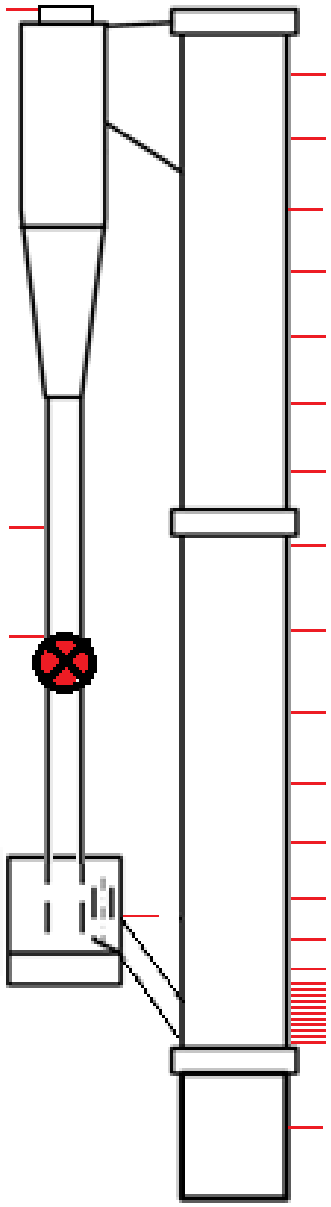
Aim

Experimentally investigate the influence of the operational parameters (u_0, Δp_{riser}) on the mechanisms underlying the solids circulation in CFB risers

Scope

Risers with an aspect ratio representative for large-scale boilers and gasifiers (*i.e.* H/L<<20)

Experimental setup and operational range



Riser cross section: 0.7 m x 0.12 m
Riser height: 8.5 m
Solids mean size: 316 µm
Solids density: 2600 kg/m^3

Pressure taps: 24 in riser (11 in the bottom region)
Solids circulation: measured with gas-permeable valve

Temperature: Ambient conditions
Fluidization velocity: 0.3 – 7 m/s
Riser pressure drop: 1.7 – 10.5 kPa
Number of runs: 146

External solids circulation, G_s = 0 – 42 kg/m^{2}s
Absence and presence of dense bottom bed

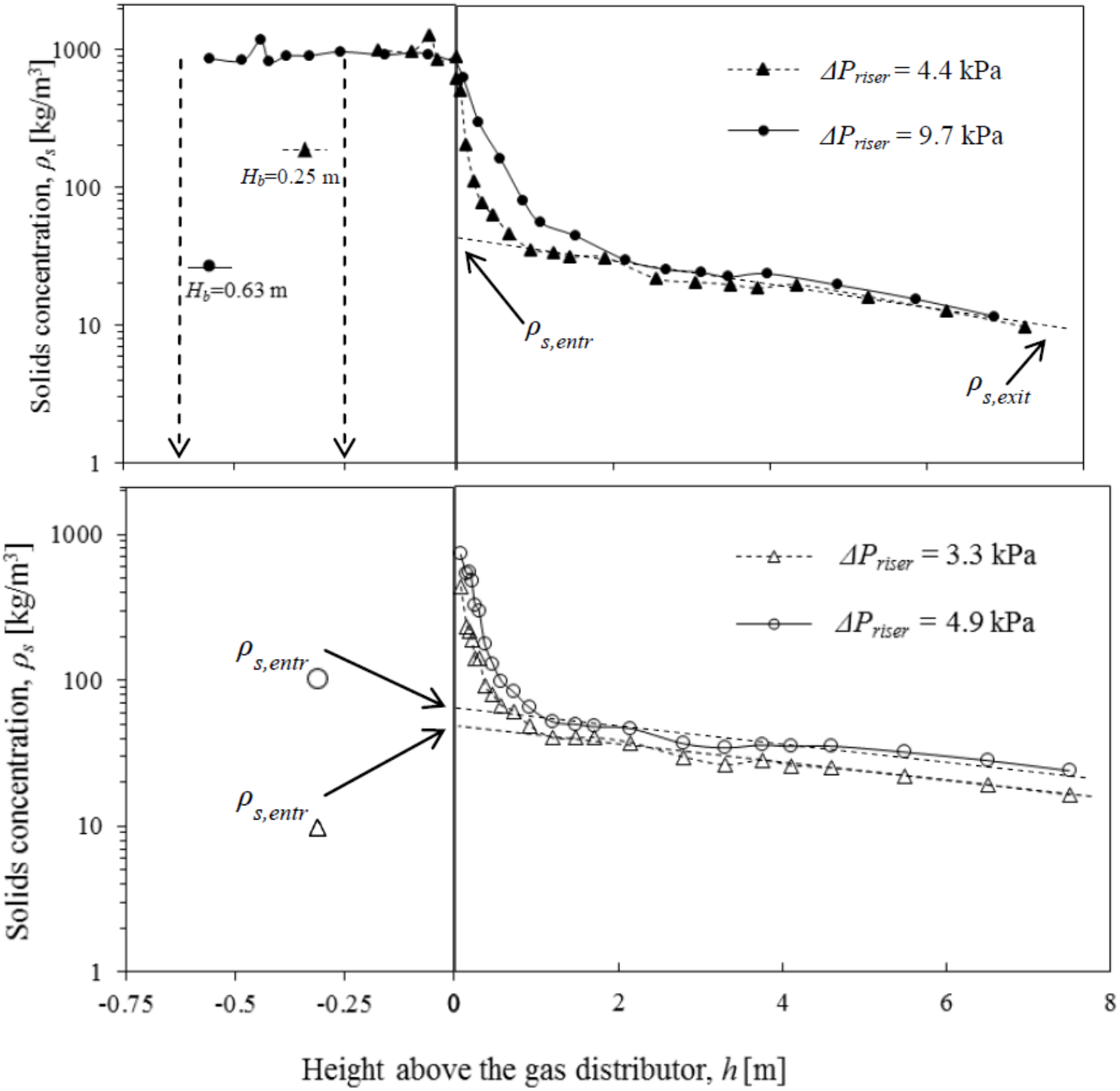
Results

u_0=4 m/s

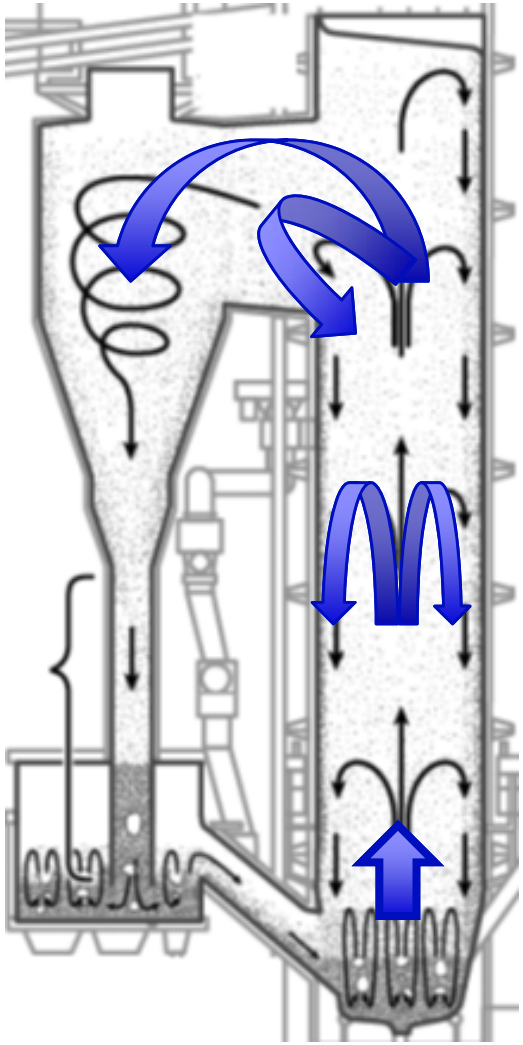
dense bed

u_0=7 m/s

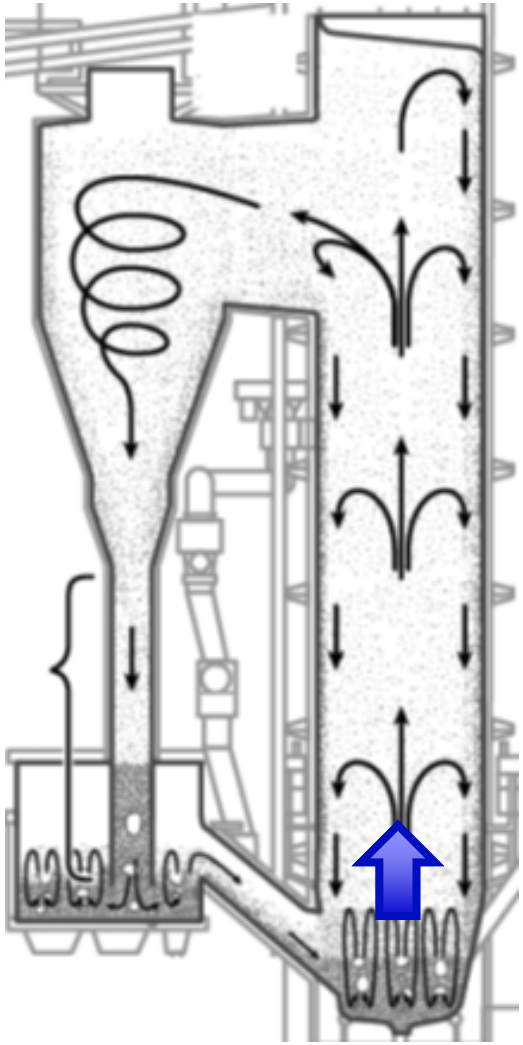
no dense bed

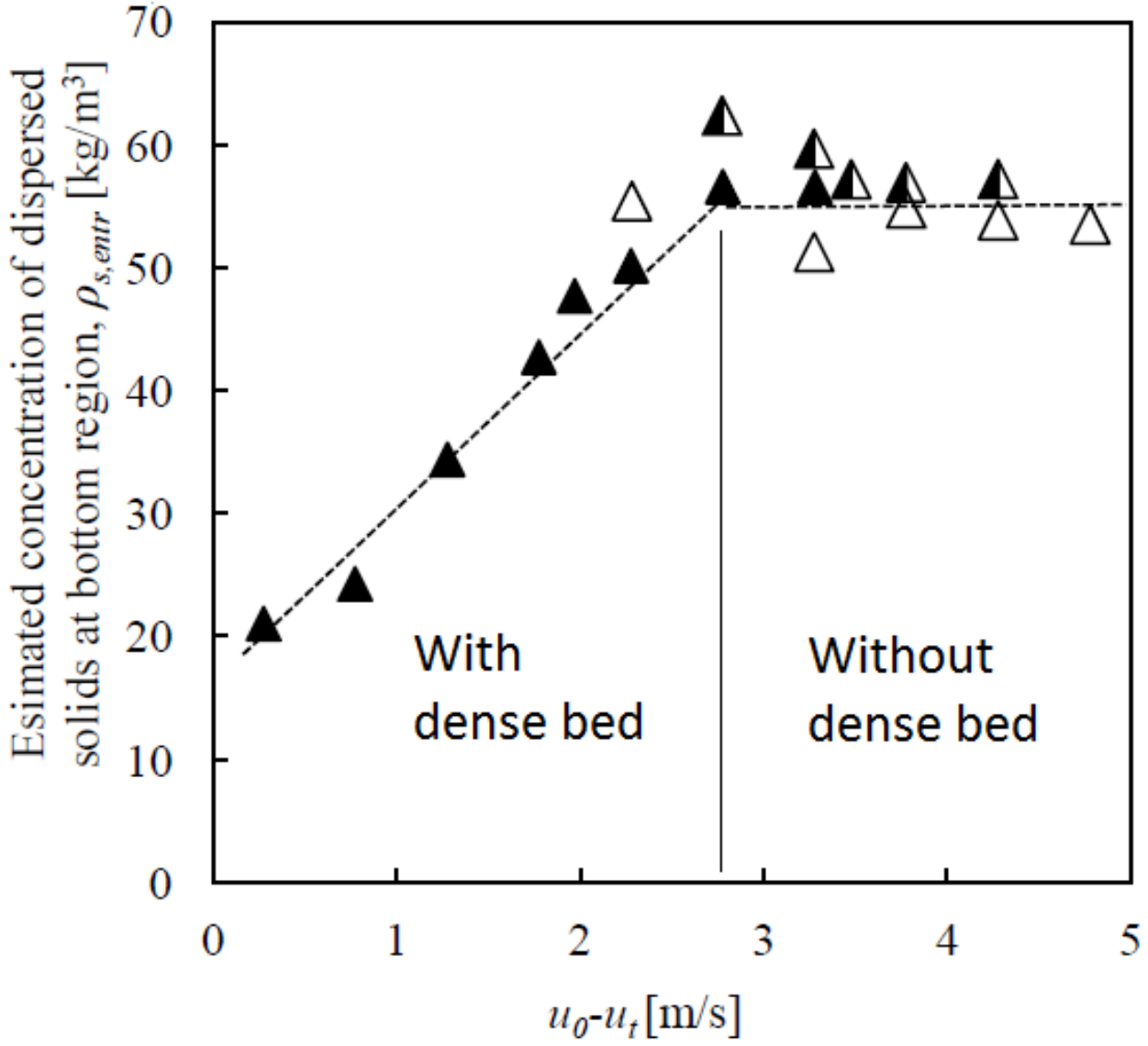


Results

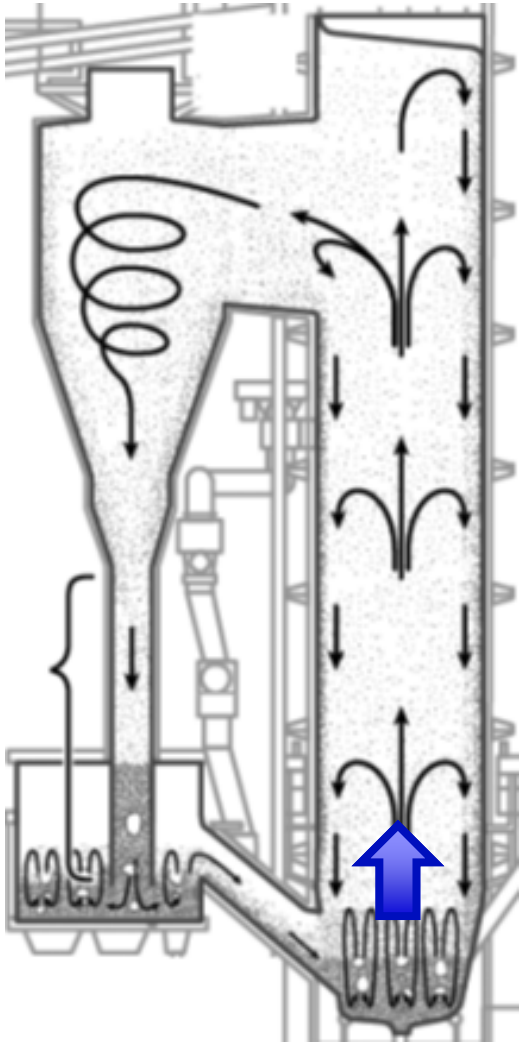


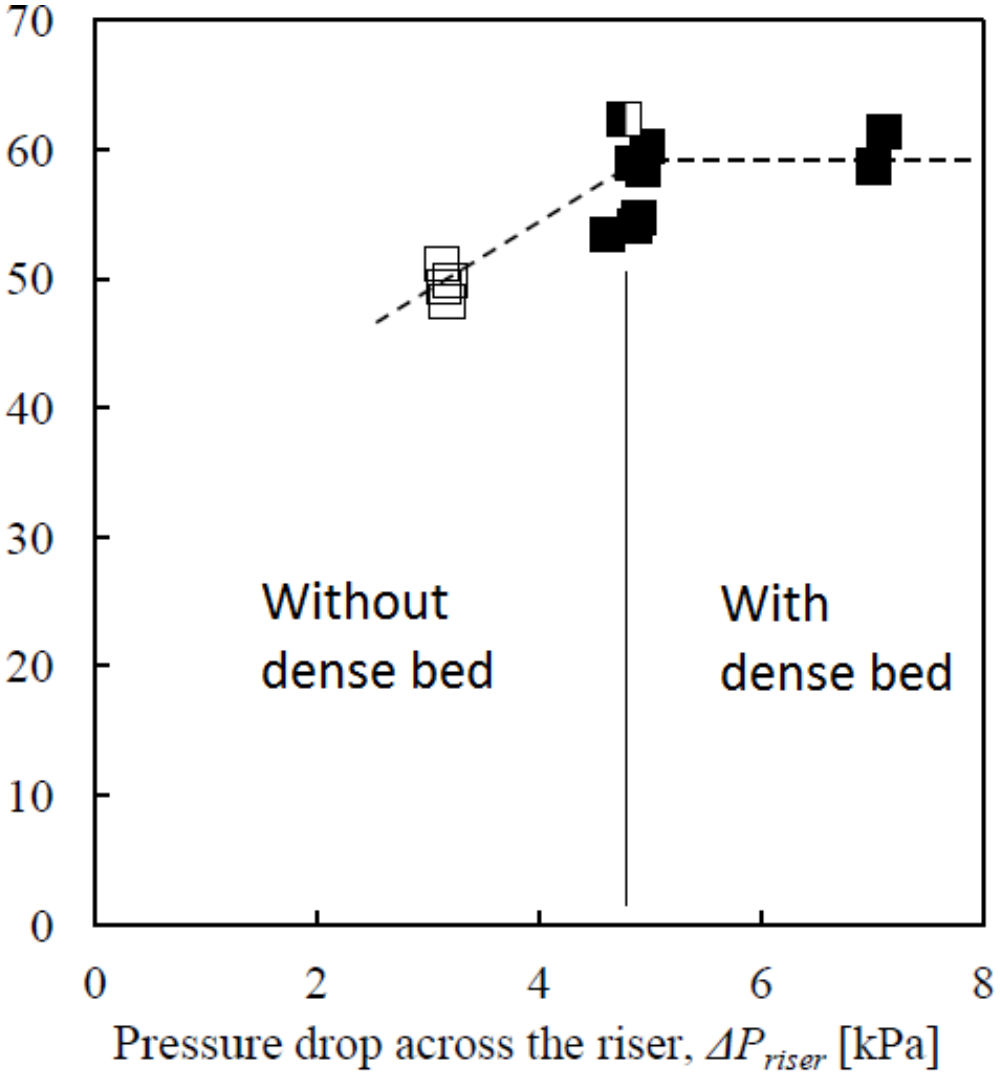
Results – solids entrained from bottom region



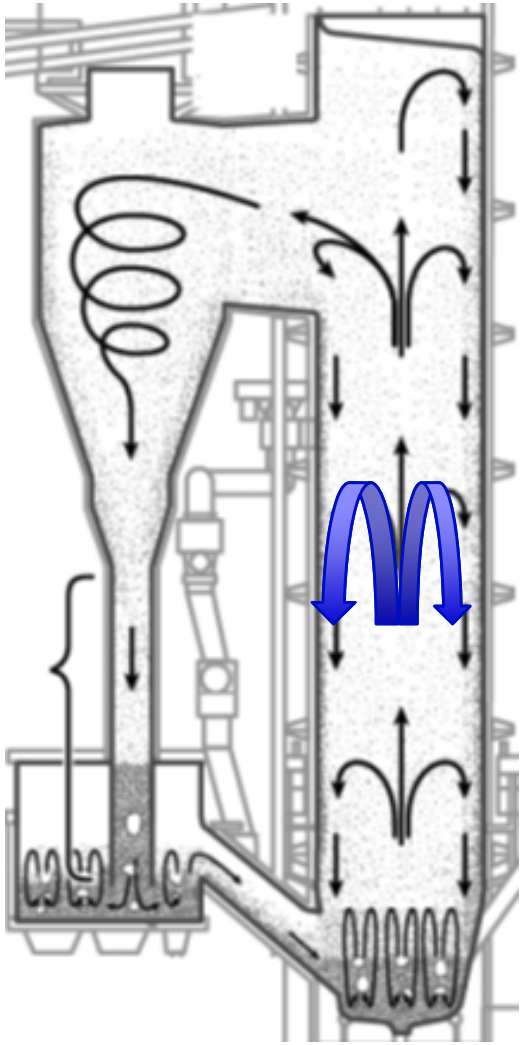


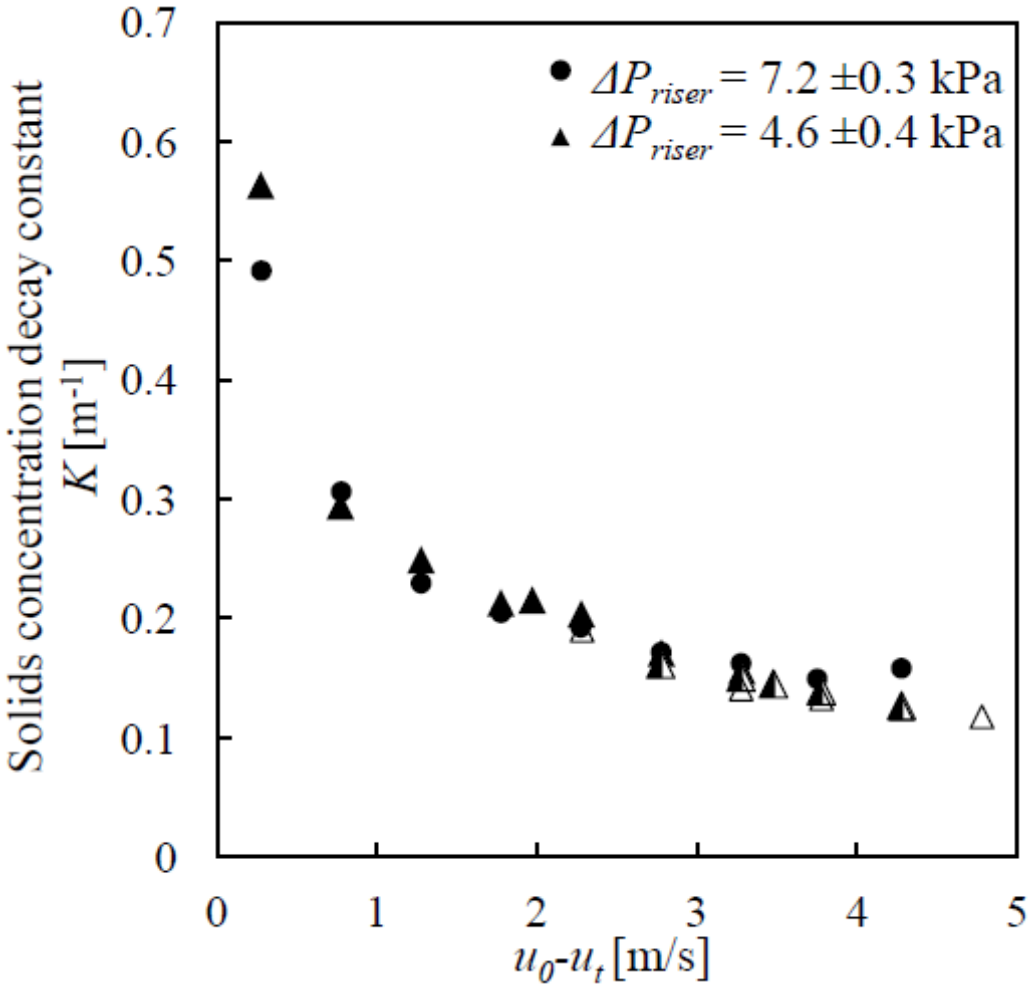
Results – solids entrained from bottom region



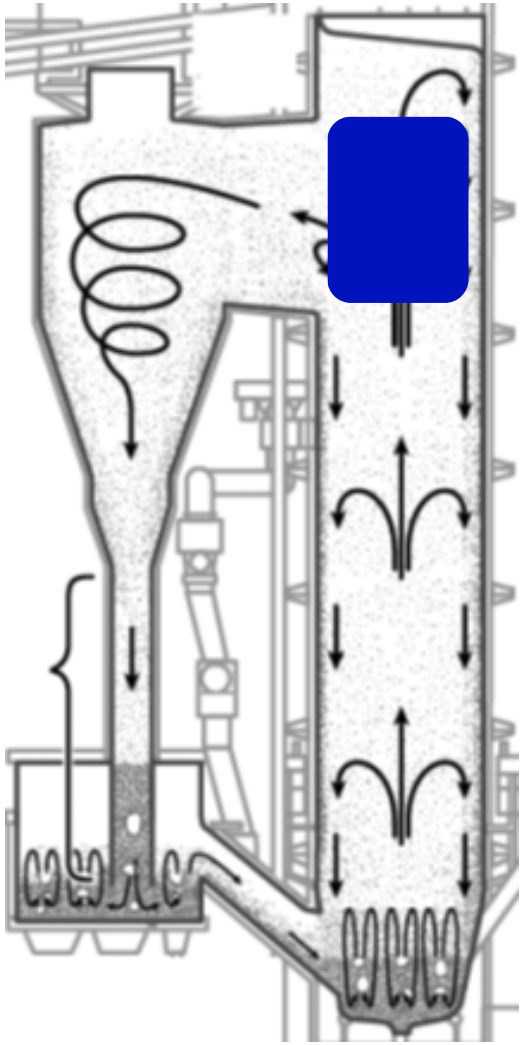


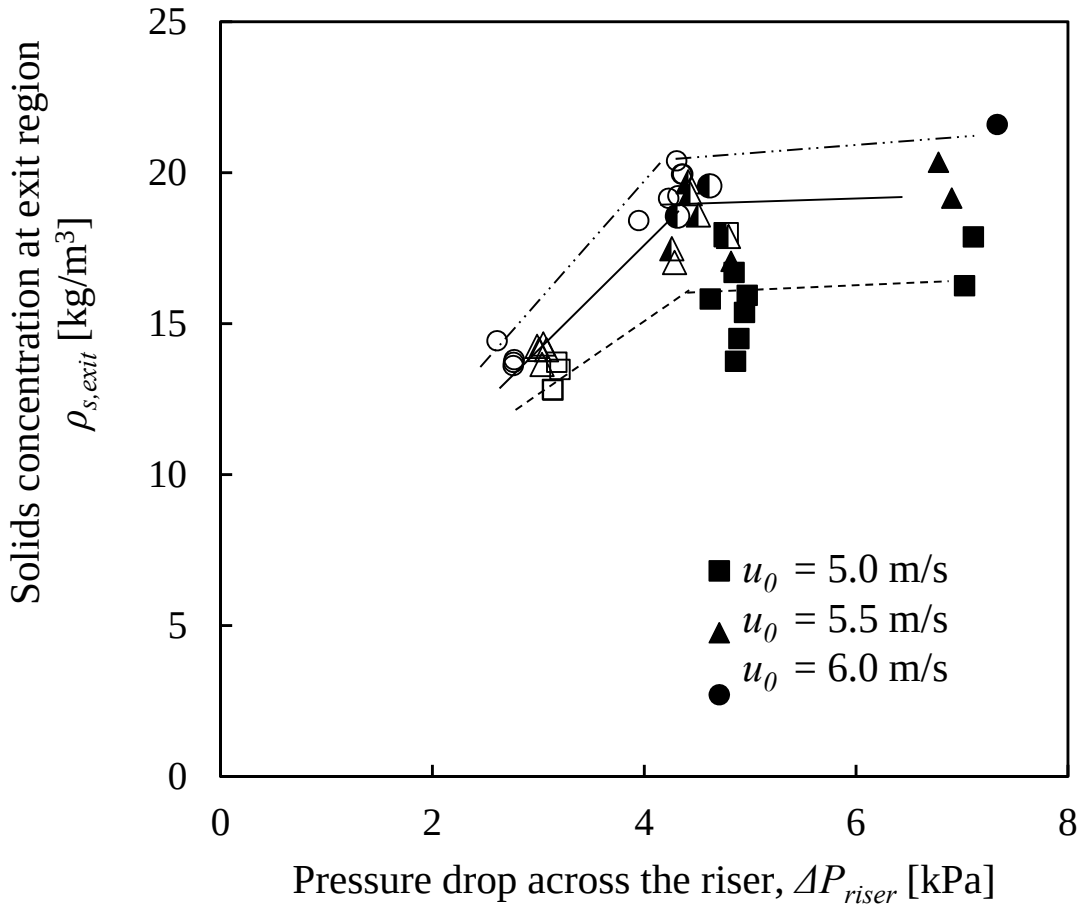
Results – solids back-mixing to the walls



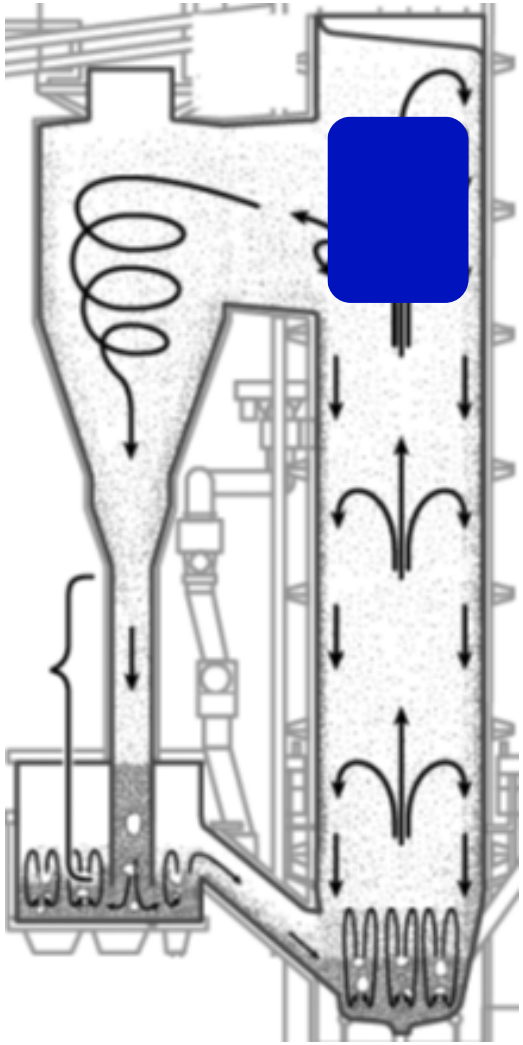


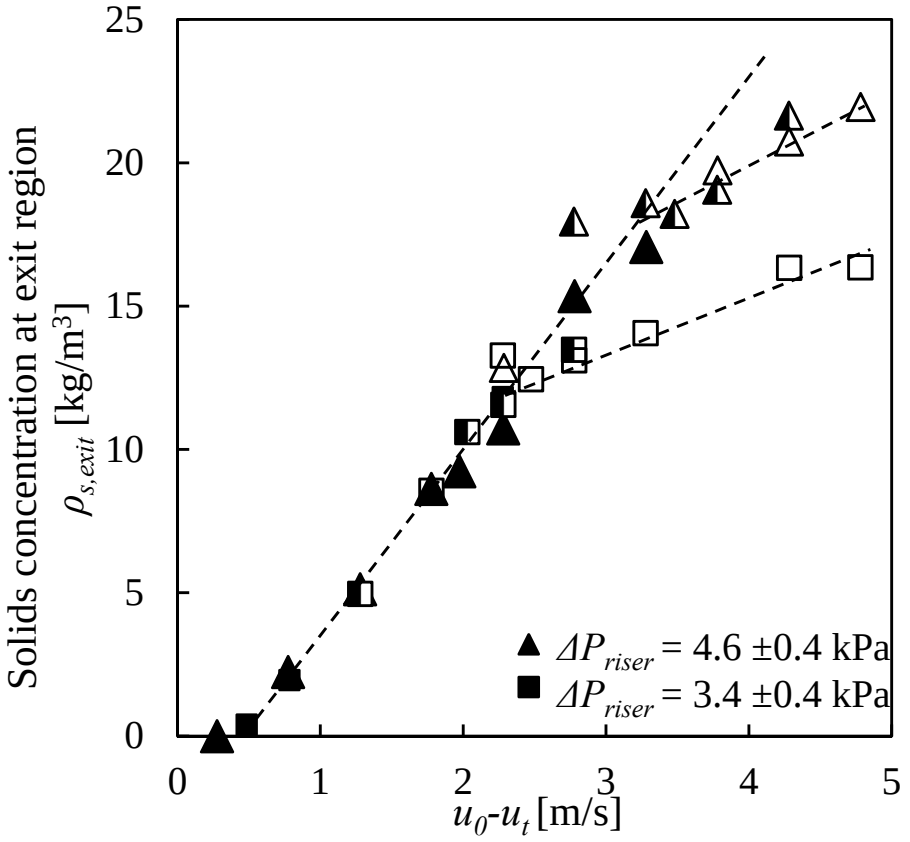
Results – solids concentration at the riser top



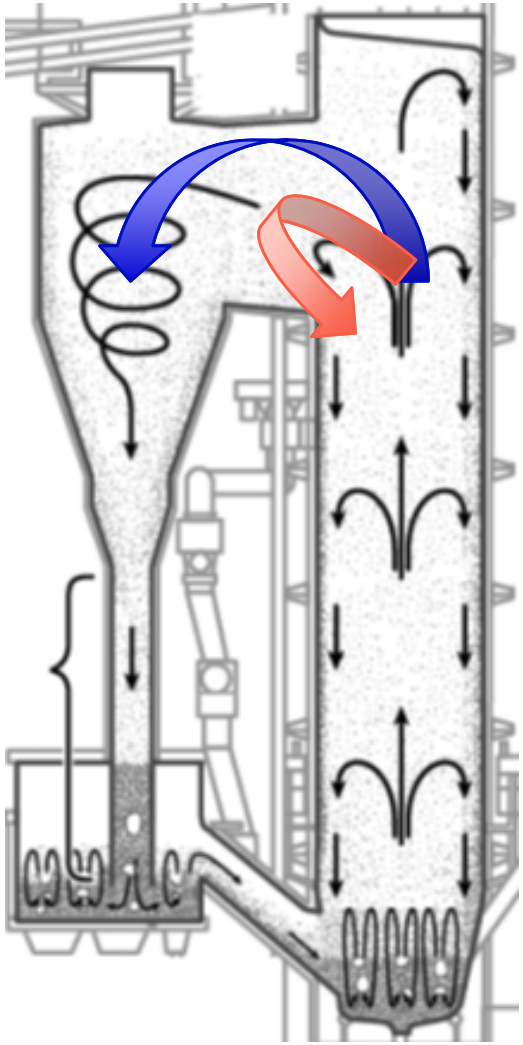


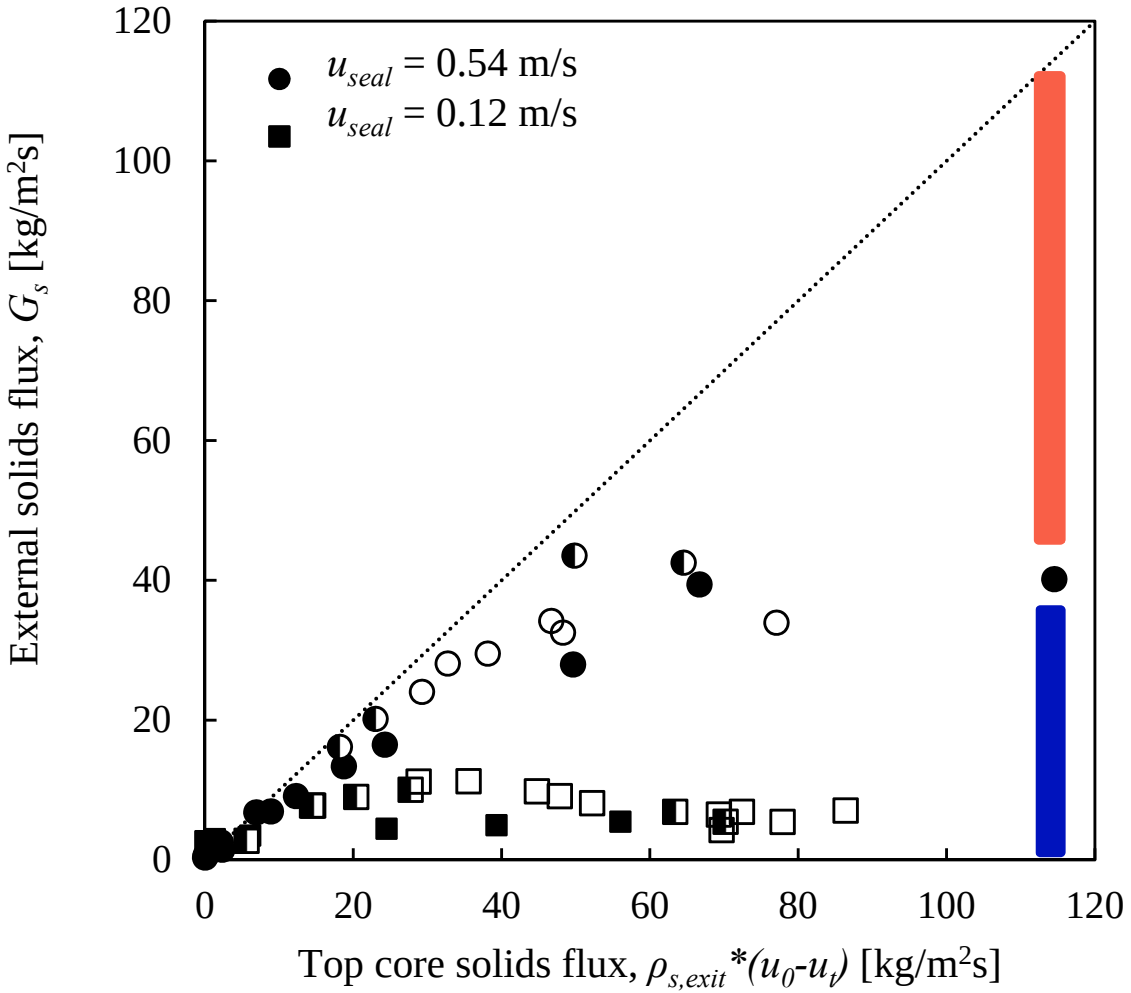
Results – solids concentration at the riser top



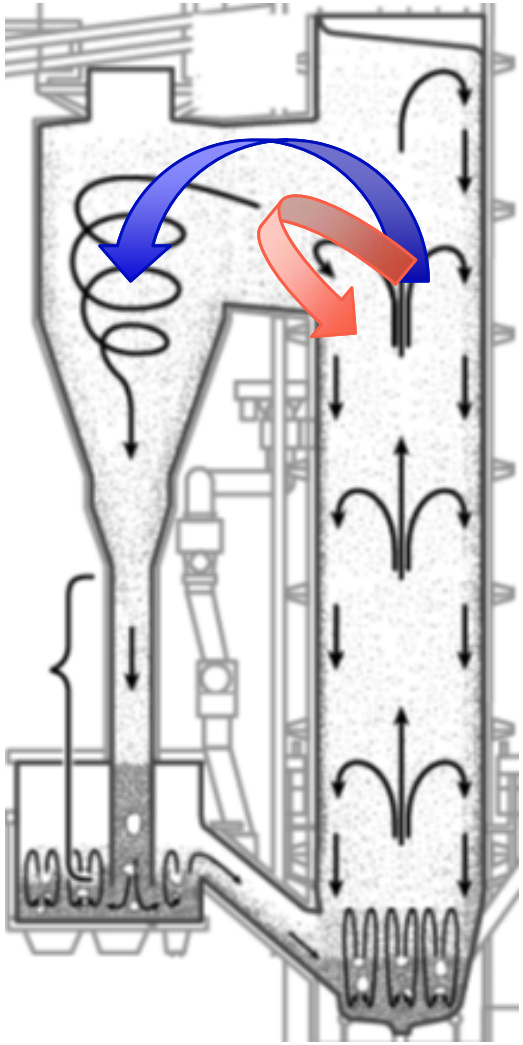


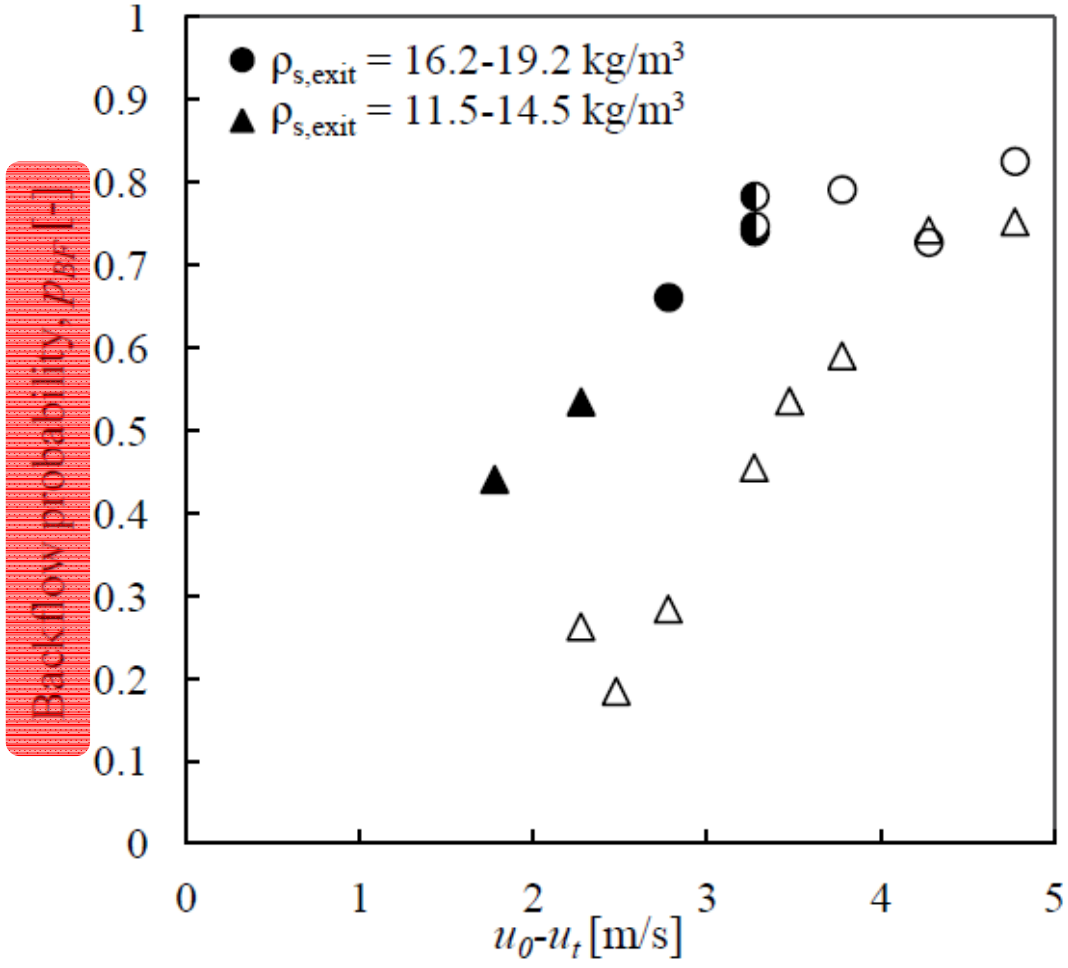
Results – solids backflow at exit duct





Results – solids backflow at exit duct





Conclusions

The entrainment of solids from the bottom region

in presence of a dense bed,	increases with fluidization velocity is not influenced by the riser pressure drop
in absence of a dense bed,	increases with riser pressure drop is not influenced by the fluidization velocity

The back-mixing of solids to the riser walls

regardless of the bottom region,	decreases with gas velocity is not influenced by the riser pressure drop

The backflow of solids in the exit region

regardless of the bottom region,	increases with gas velocity increases with solids concentration (decreases with seal fluidization velocity)

Further work

Analogous investigation in a fluid-dynamically down-scaled model of a utility scale CFB boiler

(first runs planned for June 2016)

Length scale factor: 13

Height: 35 m → 2.7 m

Acknowledgements

Valmet Technologies Oy

Swedish Energy Agency