Impact of Fluidized Bed Hydrodynamics on the Distribution of Liquid Sprayed into the Bed

Yuan Li, Cedric Briens, Franco Berruti,
Francisco J. Sanchez Careaga,

Institute for Chemicals and Fuels from Alternative Resources
The University of Western Ontario

icfar

Jennifer McMillan

Syncrude

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yli2739@uwo.ca

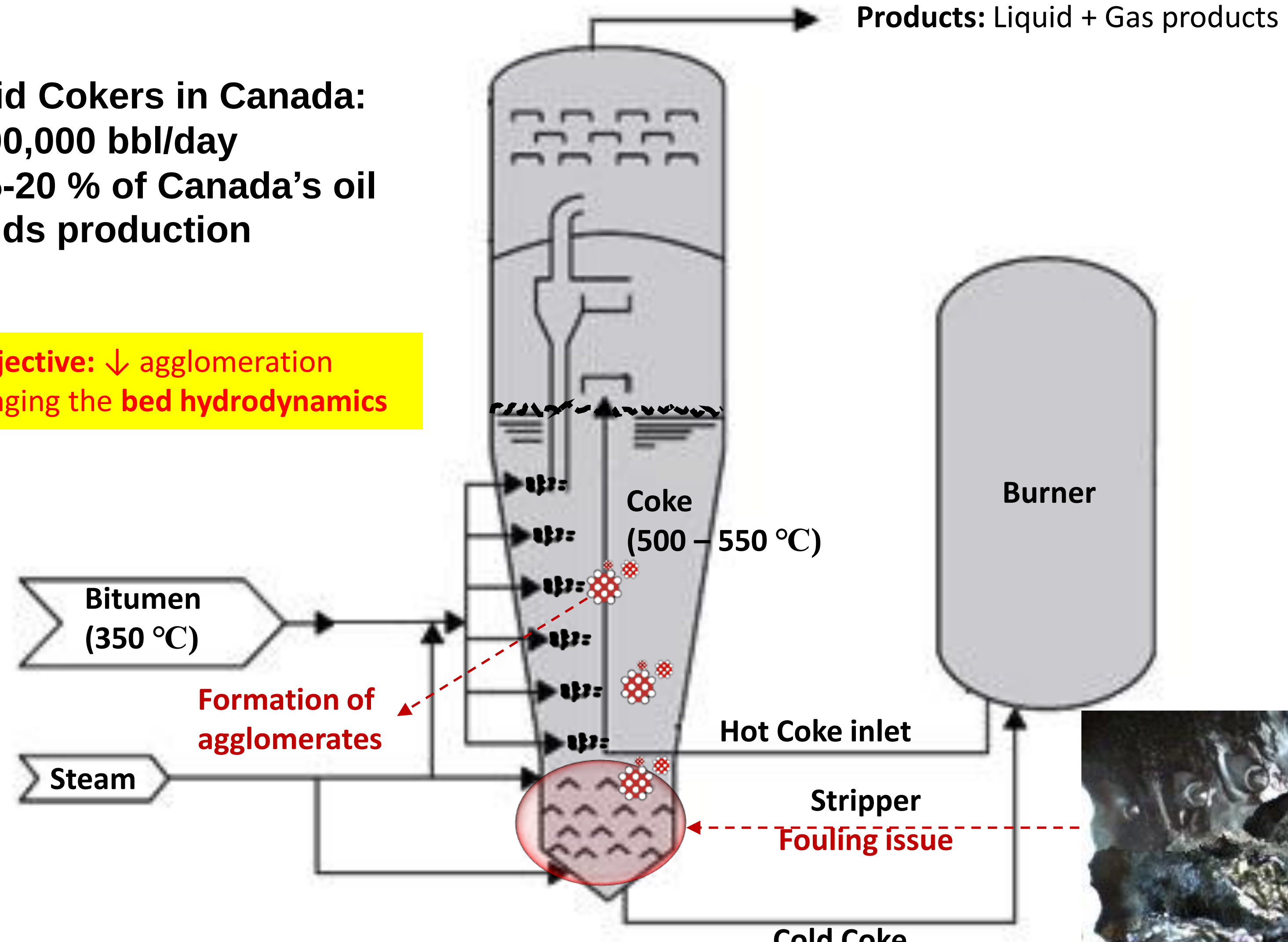
Western
UNIVERSITY · CANADA

Introduction

Fluid Coking™ technology

Fluid Cokers in Canada:
- 400,000 bbl/day
- 15-20 % of Canada's oil sands production

Objective: ↓ agglomeration by changing the **bed hydrodynamics**



Objectives

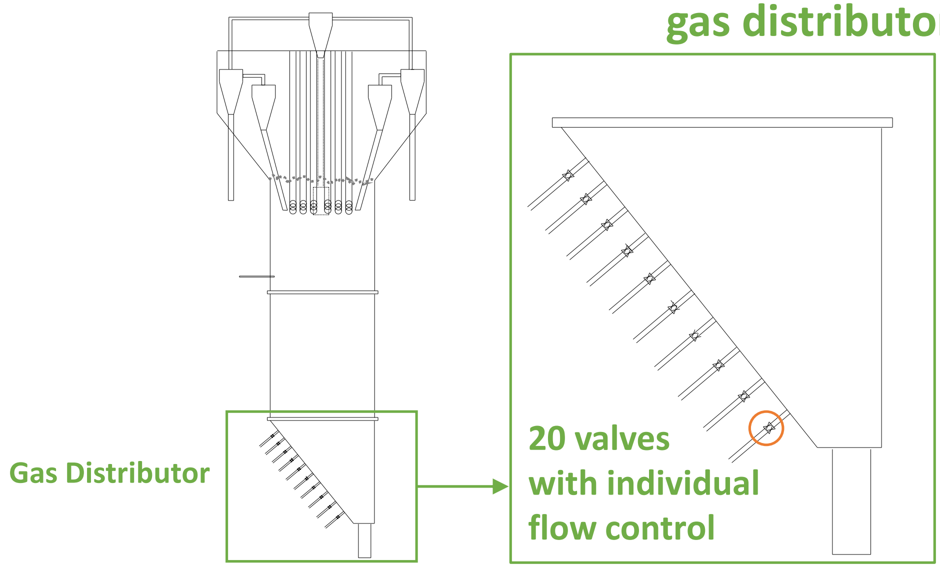
Bed Hydrodynamics

Increase superficial gas velocity

Modify gas distribution

By **changing** the **gas distributor**

By using **internals**, e.g. **baffle**



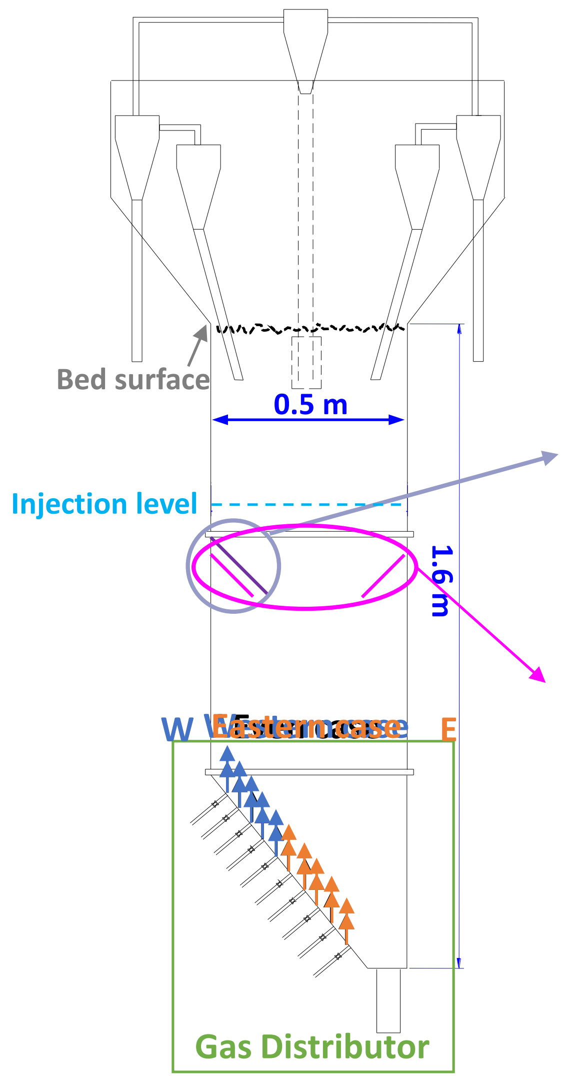
Lab-scaled Fluid Bed

Picture from: ExxonMobil, 11th International BBTC Conference

Equipment & method

Approaches to modify gas bubble distribution

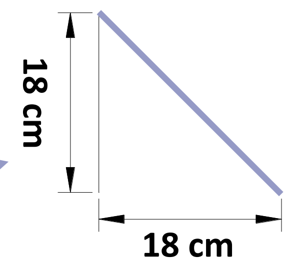
Approach 1:
Change the initial inlet gas distribution configuration



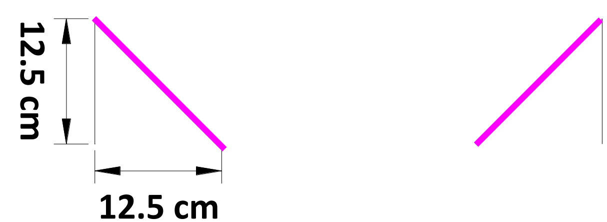
Lab-scaled Fluid Bed

Approach 2: Baffle

a. Single baffle



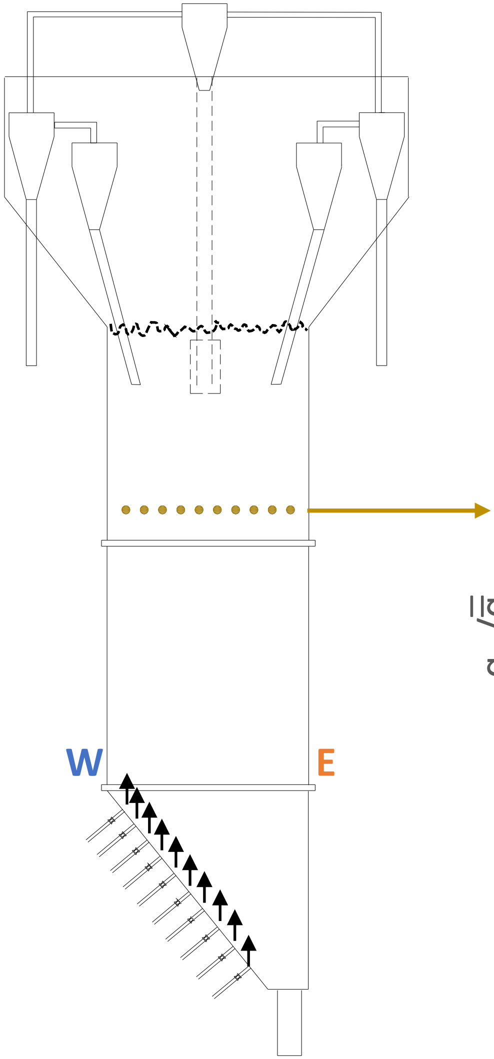
b. Symmetrical baffles



More tribo applications: Welcome to the poster session at

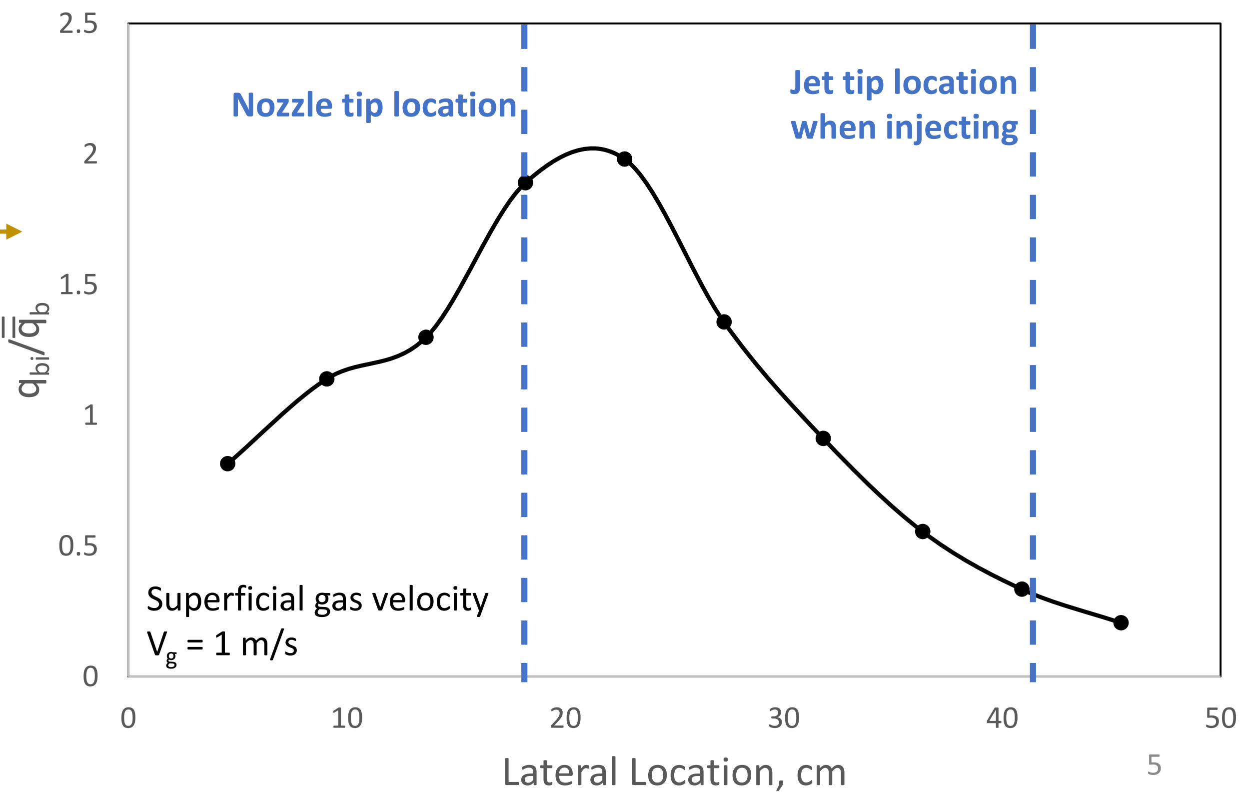
Equipment & tribo-probe method

Gas bubble distribution profile



$$\frac{\textit{Local bubble volumetric flux}}{\textit{cross} - \textit{section average bubble flux}}$$

Typical profile example: even case before injection

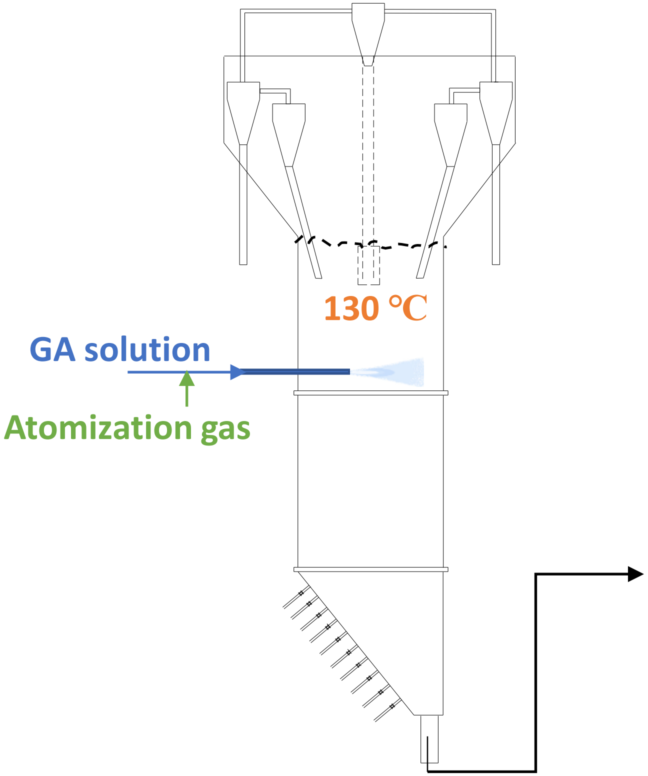


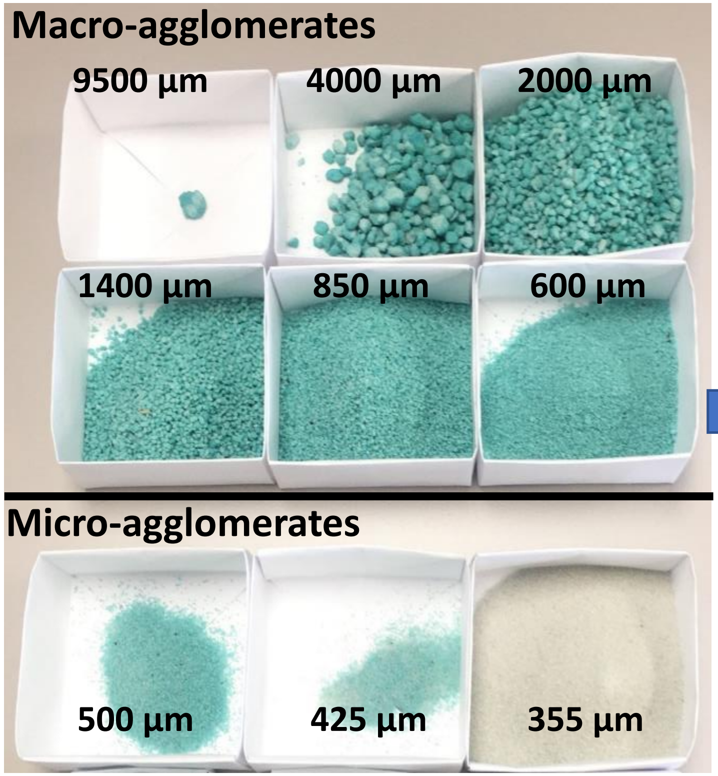
Equipment & Gum Arabic method

Simulate fluid coking agglomeration

Gum Arabic (GA) Solution: (200 g)

92 wt% water + 6 wt% gum Arabic + 2 wt% blue dye; pH: 3.0



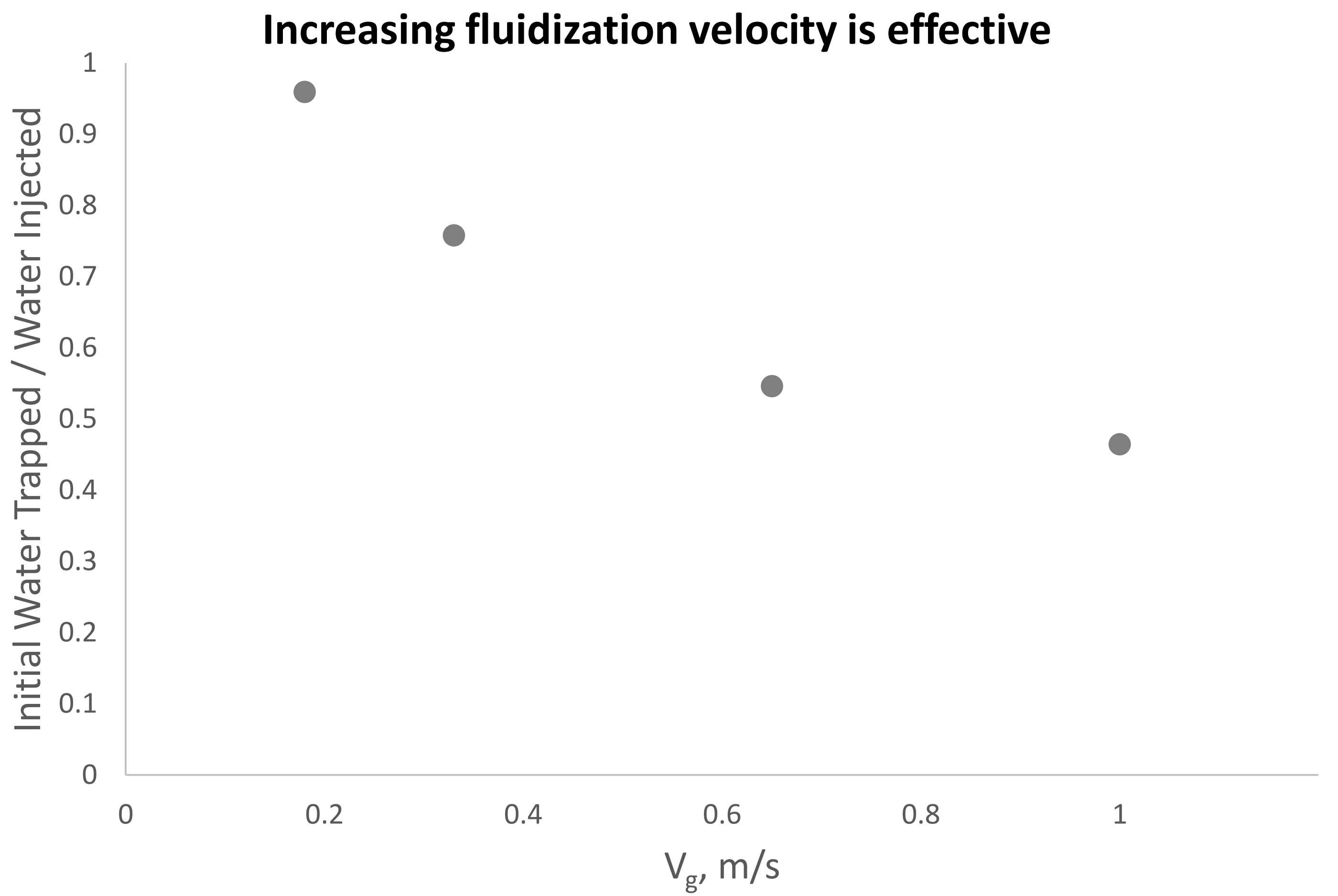


Fraction of injected water that is trapped in agglomerates

Increase of V_g in the Coker

↓ agglomeration

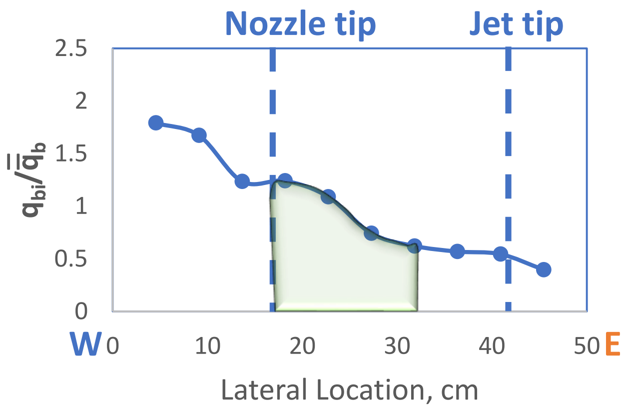
Even Gas Distribution, No Baffle, Slumped after injection



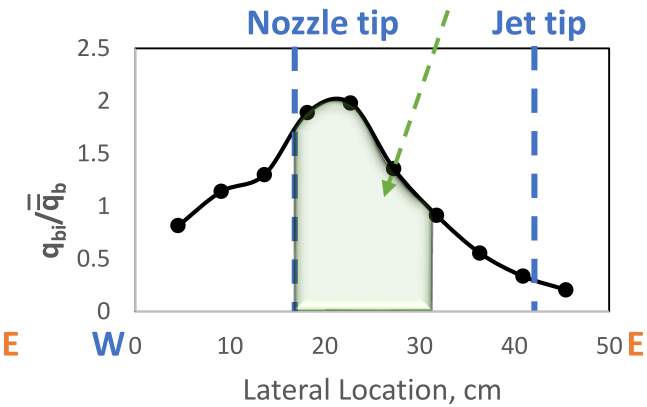
Impact of gas distribution

3 gas distributions

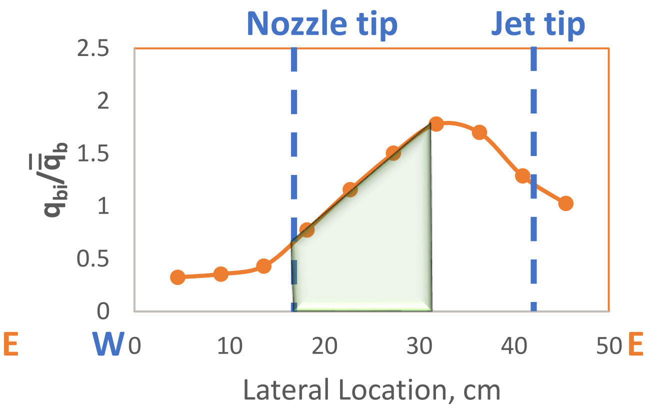
$$\frac{1}{(29.5-18)}\int_{18\,cm}^{29.5\,cm} \frac{q_{bi}}{\overline{q_b}}$$



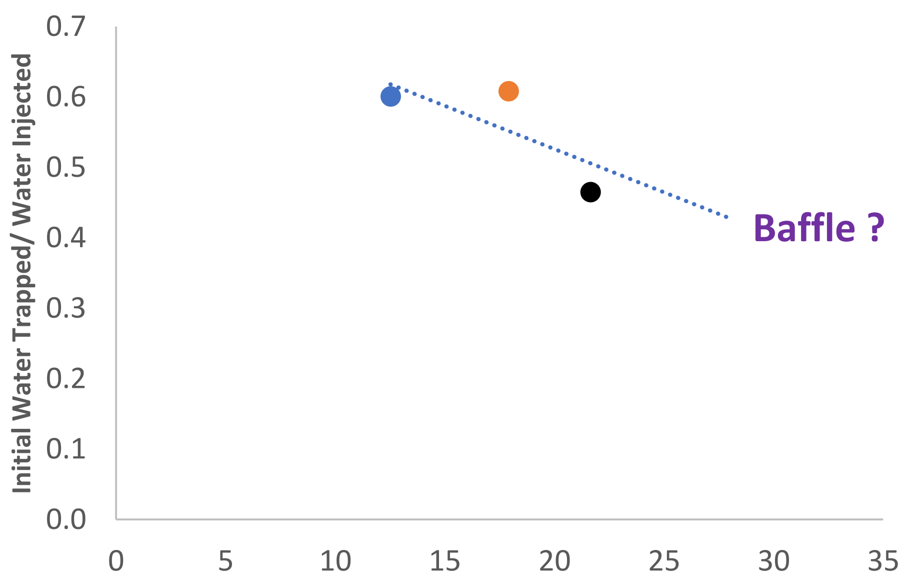
Western case



Even case



Eastern case

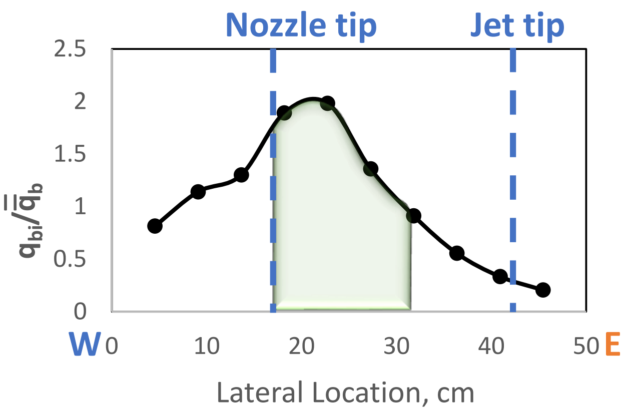


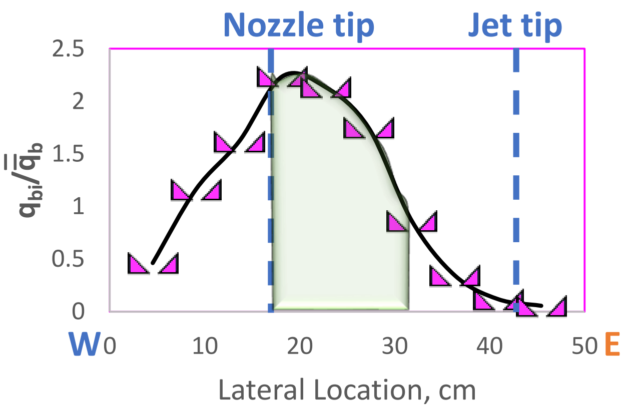
$$\frac{1}{(29.5-18)}\int_{18\,cm}^{29.5\,cm} \frac{q_{bi}}{\overline{q_b}}\,dx$$

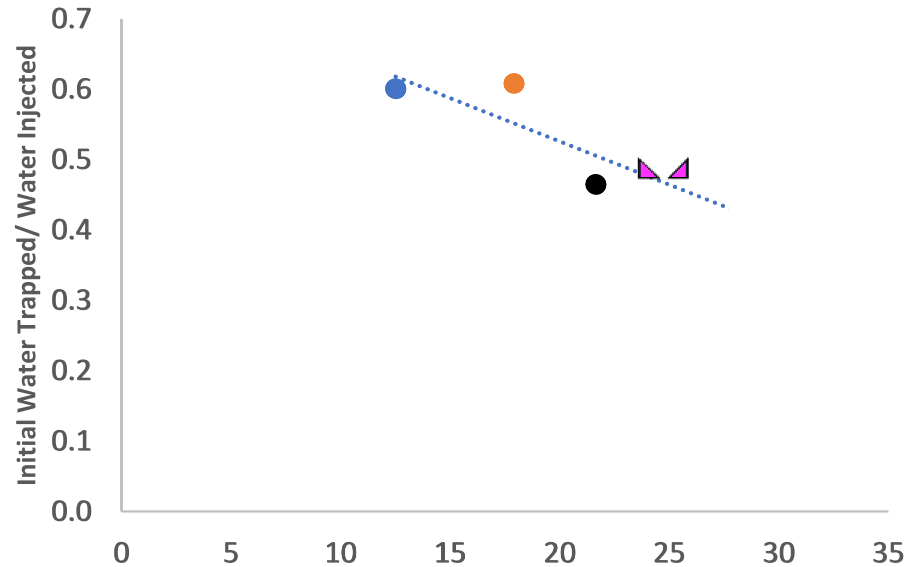
V_g = 1 m/s, slumped after injection

Impact of gas distribution

Symmetrical baffles (even case)





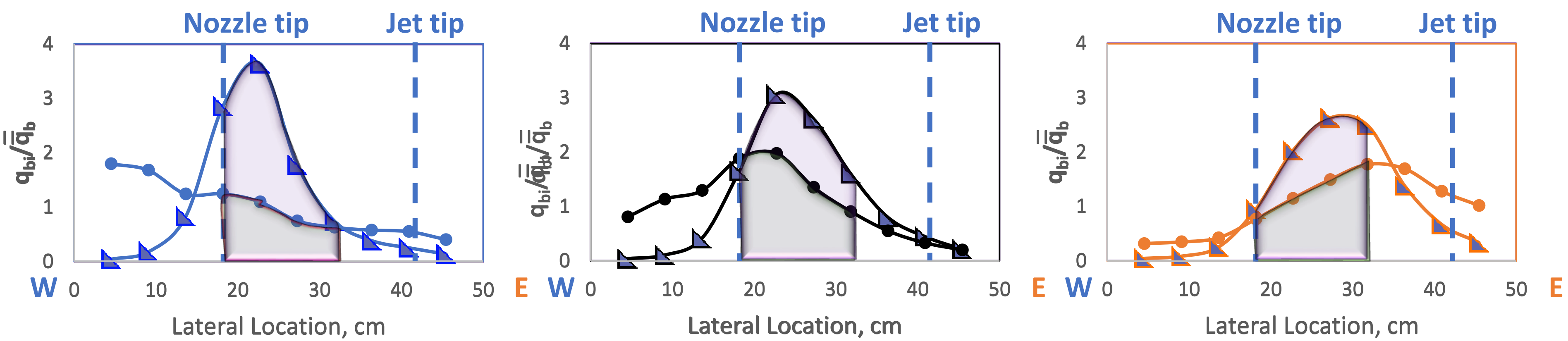


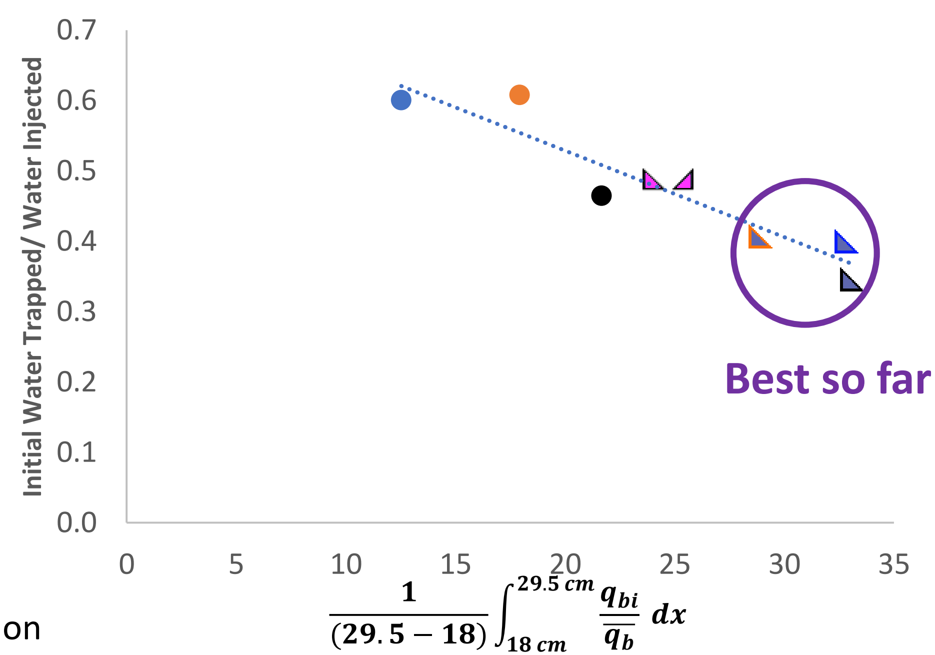
$$\frac{1}{(29.5-18)}\int_{18\,cm}^{29.5\,cm}\frac{q_{bi}}{\overline{q_b}}\,dx$$

V_g = 1 m/s, slumped after injection

Impact of gas distribution

3 gas distributions + single baffle





V_g = 1 m/s, slumped after injection

Conclusion

To reduce agglomeration:

1) Increase fluidization gas velocity

2) More efficient:

- **Move the nozzle**, so 1^{st} half of jet cavity exposed to high bubble flow
- **Move the gas** to 1^{st} half of jet cavity, with internals

Acknowledgments

NSERC/Syncrude/ExxonMobil

Industrial Research Chair

in Fluid Coking Technologies

References

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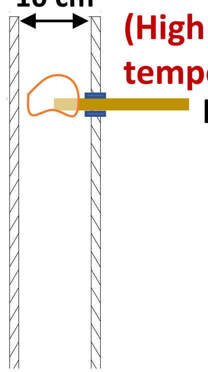
Jahanmiri, Majid, “Effect of a baffle on gas bubbles flow patterns and the distribution of liquid injected into gas-solid fluidized beds” (in press).

Ariyapadi, S., Berruti, F., Briens, C., Griffith, P., & Hulet, C. (2003). Modeling the Injection of Gas Liquid Jets into Fluidized Beds of Fine Particles, 81(August), 891–899.

Appendices

Equipment & Tribo-Probe Method

Gas Bubble Distribution Map

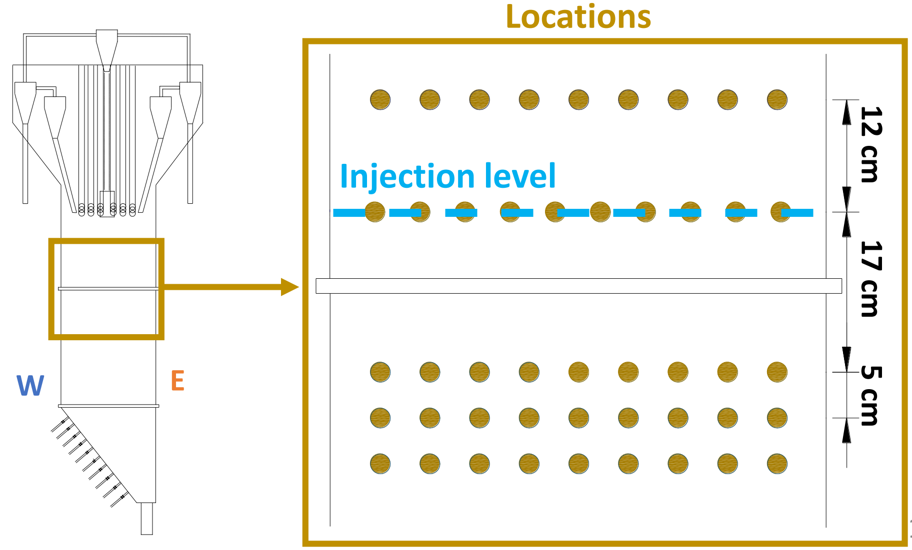


Principle:

Triboelectric current produced by **collisions** with fluidized **particles in bubble** wakes

Cycle amplitude is applied to calculate **local volumetric flux (**q_{local}**)**

$\frac{q_{local}}{q_{average}}$ shows the **bubble profile**



Poster session at

More about Tribo-probe Applications:

- Bubble profile
- Slugging check
- Bubble velocity
- Bubble evolution pattern
- Jet penetration
- …

Tribo-electric Method

Principle:

The triboelectric current is produced by the collisions with fluidized particles in bubble wakes

Correlation:

$$q_{bi} = \alpha Amplitude_{cycle}^{\beta}$$

where the q_{bi} **is the volumetric flux**, Cycle amplitude is applied for calibration

To get the bubble profile along the bed length:

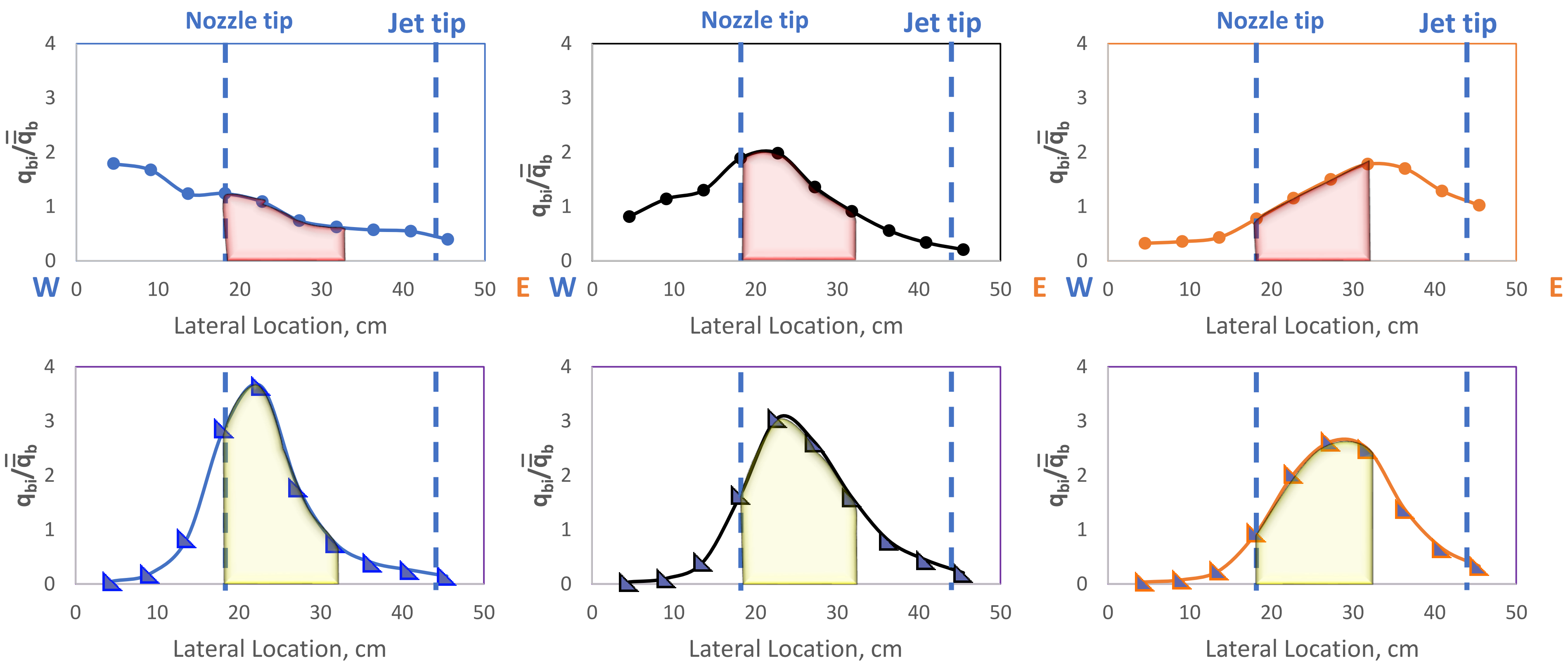
$$\frac{q_{bi}}{\overline{q_b}} = \frac{Amplitude_{cycle}^{\beta}}{\frac{1}{\sum \lambda_i}\left[\sum \lambda_i \, Amplitude_{cycle}^{\beta}\right]}$$

where λ_i = cross-sectional area associated with position

(Yuan & Jahanmiri et al., 2019)

Impact of gas distribution

3 gas distributions + baffle



Baffle successfully concentrate gas bubbles to 1st half of jet cavity