Impact of Column Geometry and Internals on Gas and Particle Flows in a Fluidized Bed with Downward Solids Circulation

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Introduction
Fluid Coking™ Technology

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

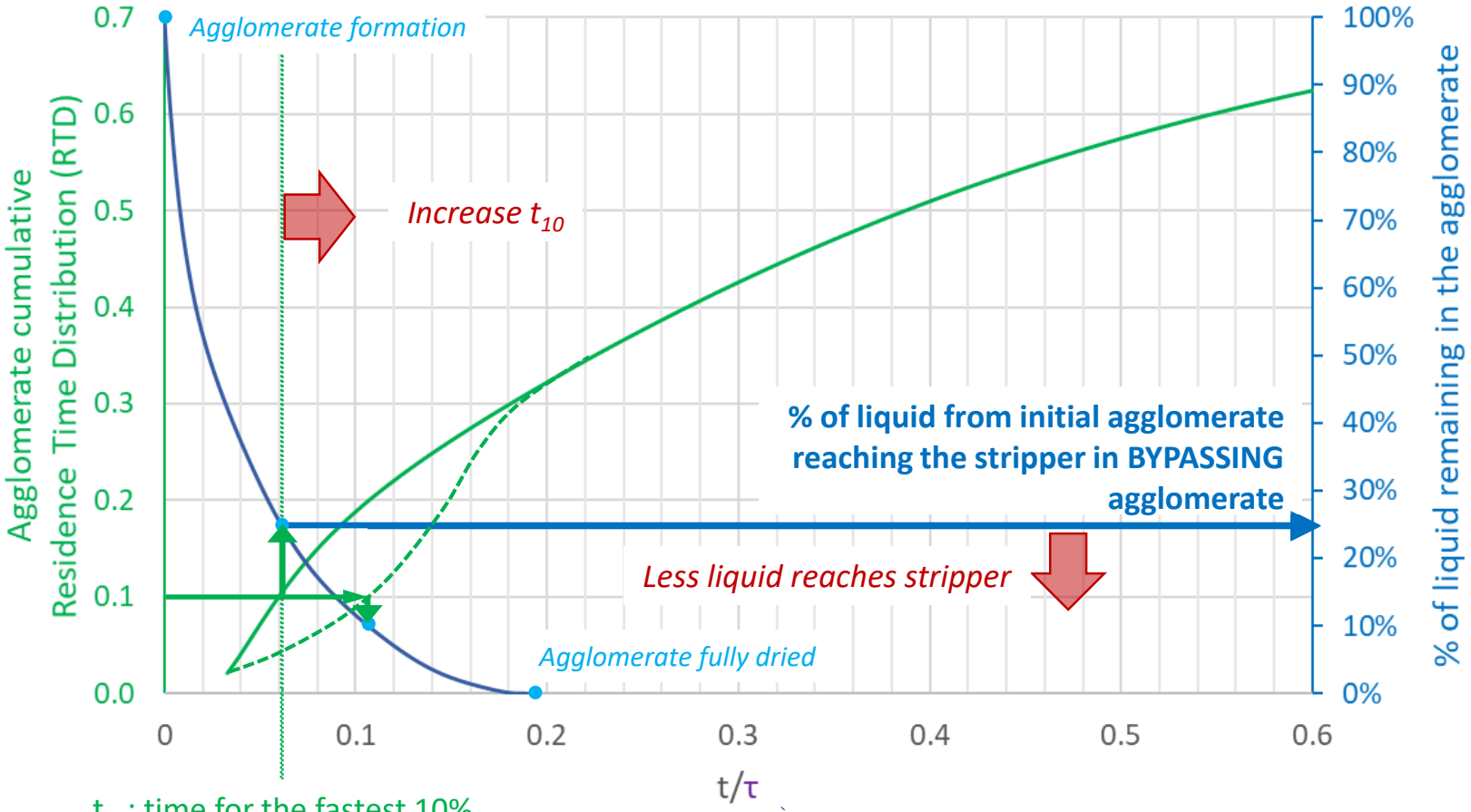
(Modified from Syncrude, 2009)

Objective: ↓ liquid losses & fouling by changing the **solids residence time distribution**

(Modified from Murray R. Gray, 2014)

Agglomerate bypassing should be reduced

Example: 1 cm agglomerate with initial liquid content of 12 wt%

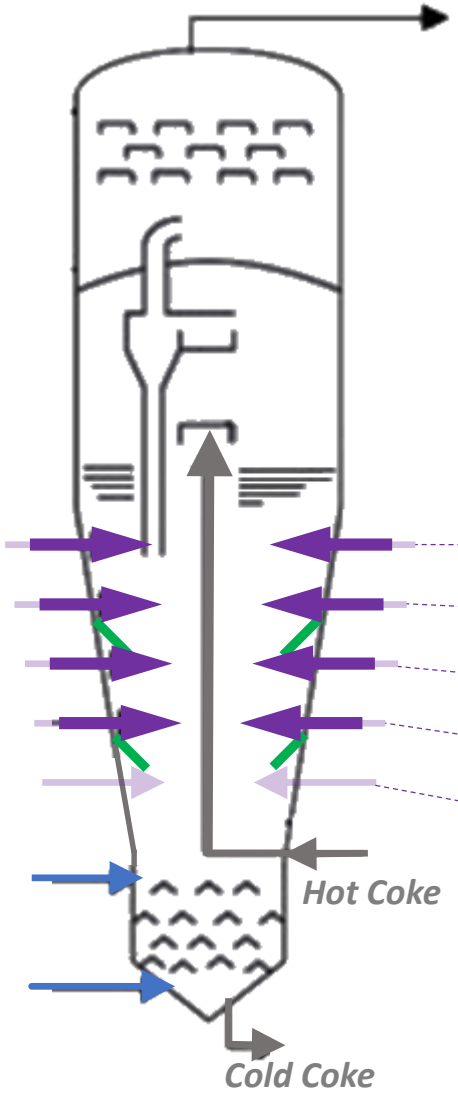


t_{10}: time for the fastest 10% of the agglomerates **BYPASSING agglomerates**

$$\tau = \frac{bed\ mass}{solid\ recirculation\ flowrate}$$

Objectives

Explore possible solutions in a pilot unit



How to reduce hydrocarbons reaching the stripper in industrial Fluid Cokers?

Change **bitumen feeding profile (e.g.)**

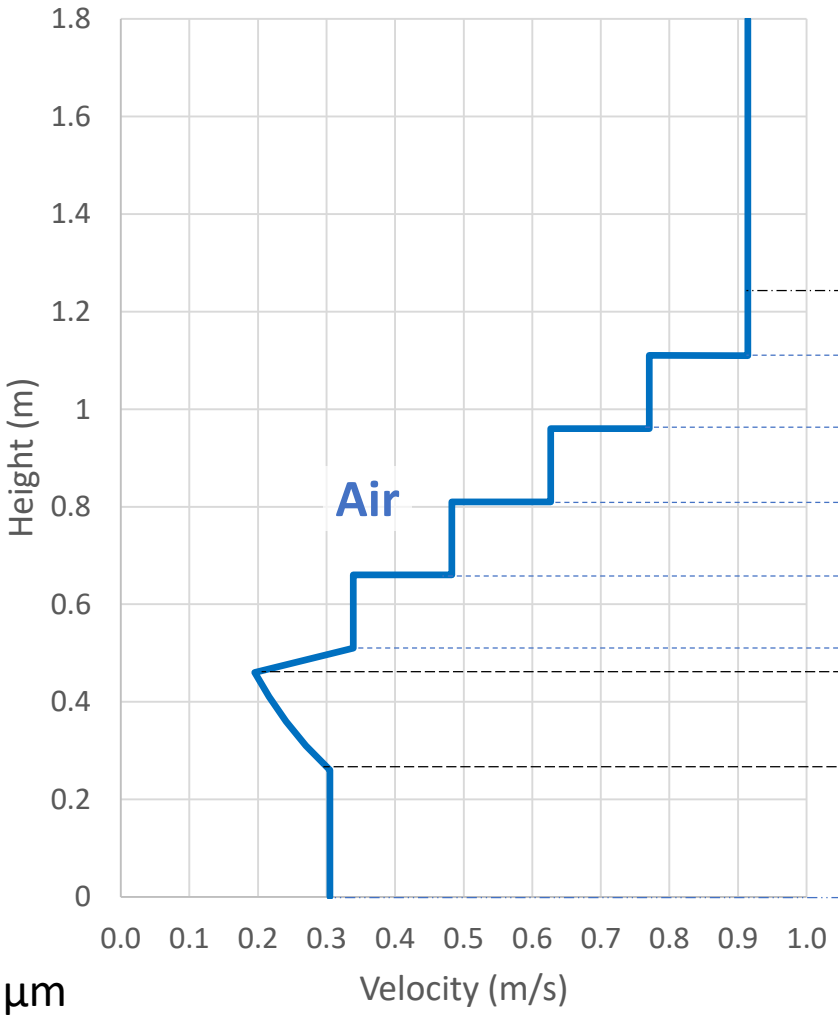
~~20%~~ **25%**
~~20%~~ **25%**
~~20%~~ **25%**
~~20%~~ **25%**
~~20%~~ 0%

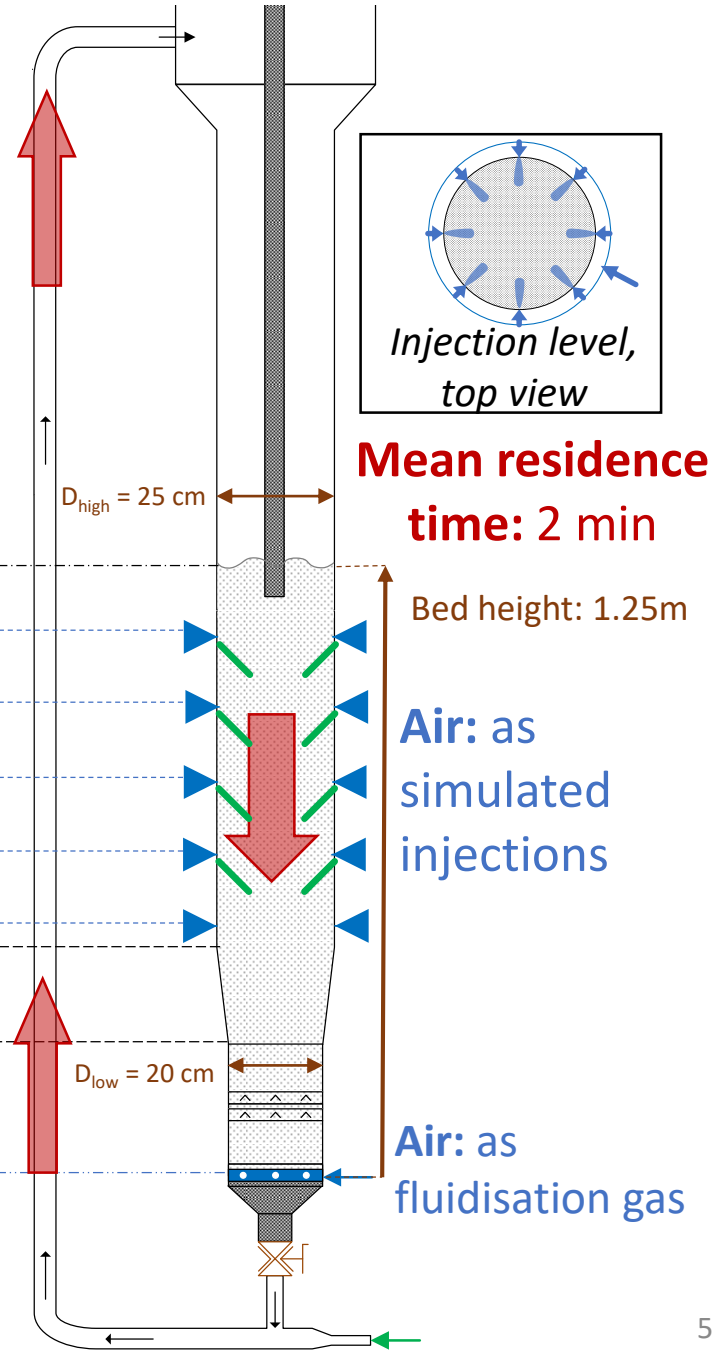
Use **ring baffle**

(ExxonMobil , 11th International BBTC Conference, 2013)

Combine **ring baffles** & **bitumen feeding profile**

Equipment
Cold pilot-scale unit



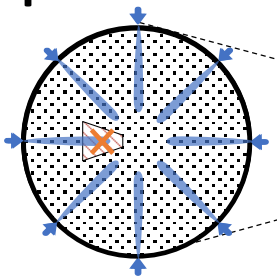


<u>Fluid Coke:</u>

- d_{pm} = 140 µm
- ρ_{part} = 1480 kg/m^3

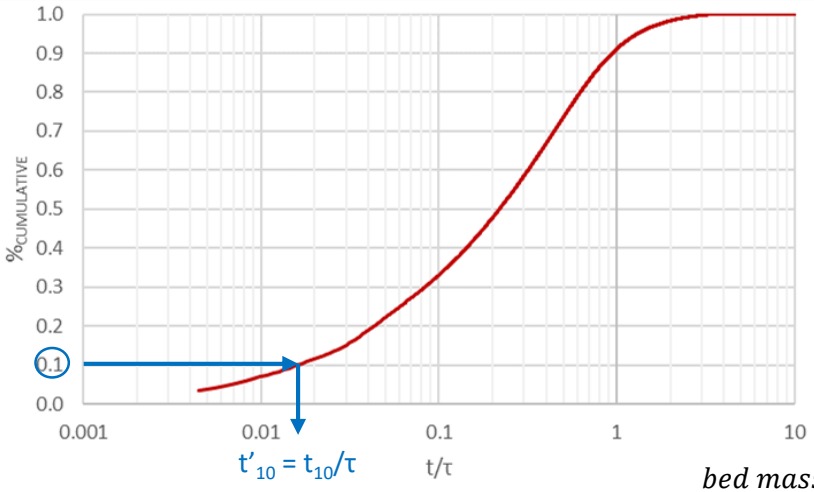
Formation-to-stripper time

- Measured using **Radioactive Particle Tracking** (single ^{46}Sc tracer & 12 scintillation detectors) with CARPT method
- One time distribution for each agglomerates formation zone

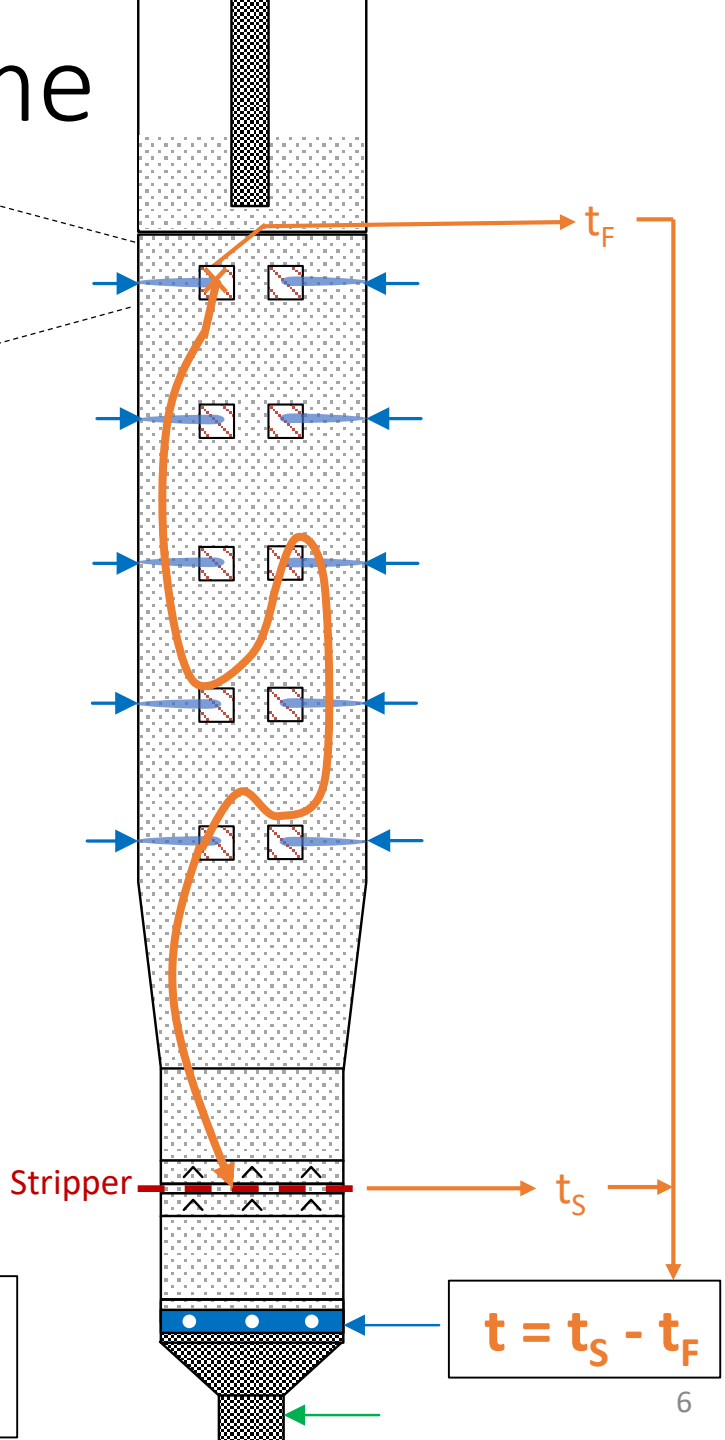


Agglomerates Formation zones

Overall bed



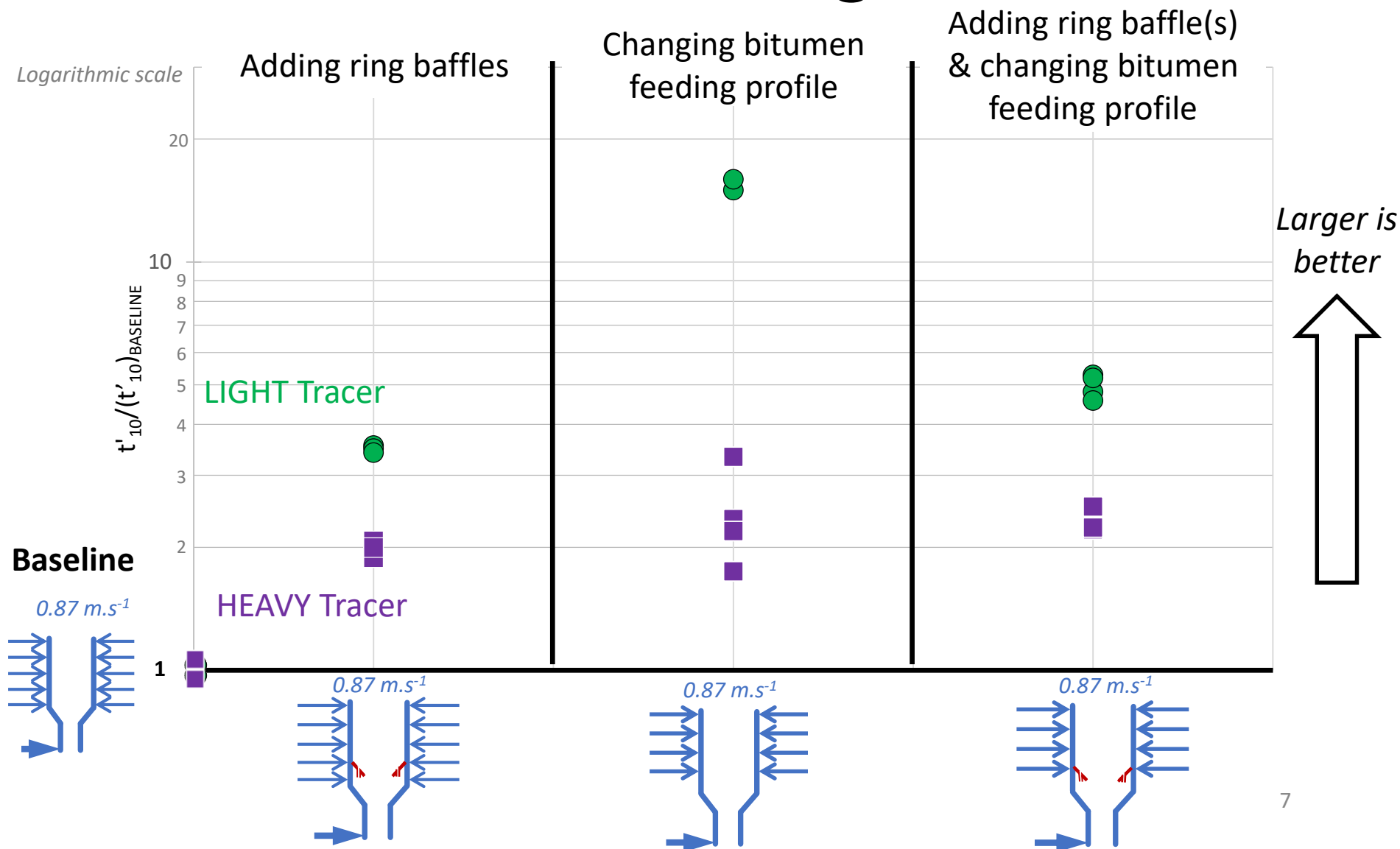
$$\tau = \frac{bed\ mass}{solid\ recirculation\ flowrate}$$



Tracer encapsulated to adjust density, to match:

- Wet agglomerates (1080-1240 kg/m^3)
- Solids & micro-agglomerates (880-970 kg/m^3)

Results
Best alternative configurations



Adding ring baffle(s)

1 baffle (flux tubes)

1 baffle (no flux tubes)

4 baffles (no flux tubes)

Not industrially suitable

LIGHT Tracer

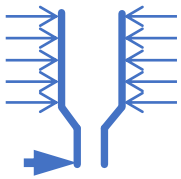
HEAVY Tracer

$t'_{10}/(t'_{10})_{BASELINE}$

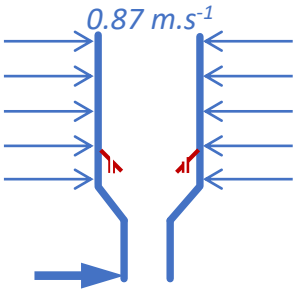
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1
0.75
0.50

Baseline

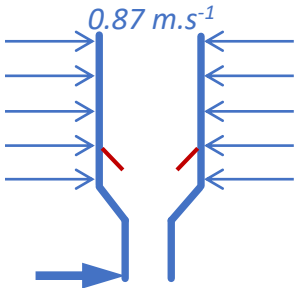
0.87 m.s^{-1}



0.87 m.s^{-1}



0.87 m.s^{-1}



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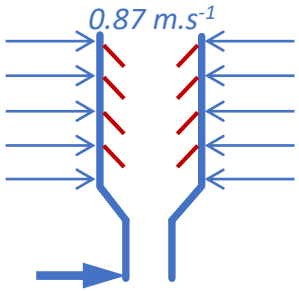
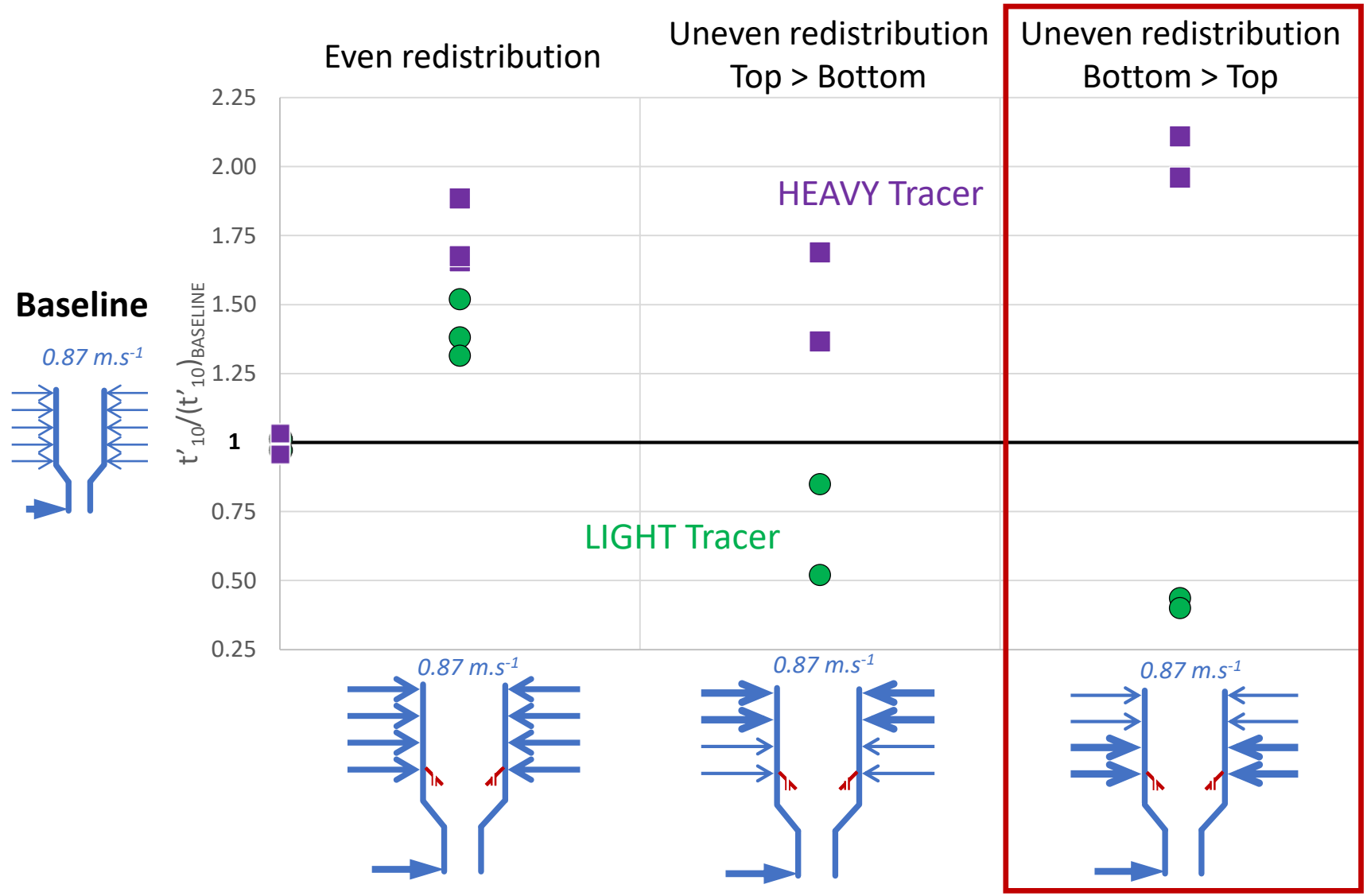
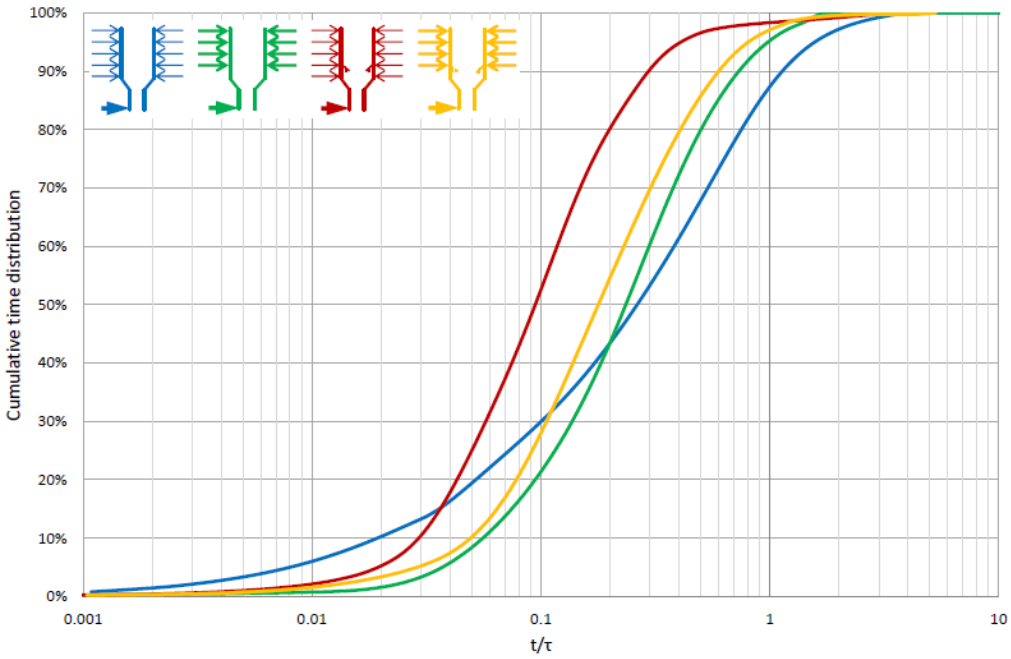


Uneven bitumen feeding redistribution using baffle with flux tubes and 4 banks

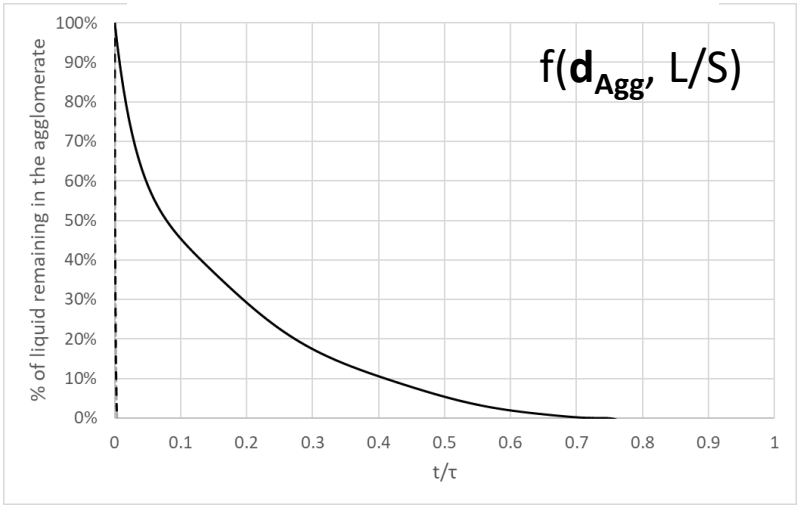


Liquid content reaching the stripper (1)

Measured formation-to-stripper time distribution

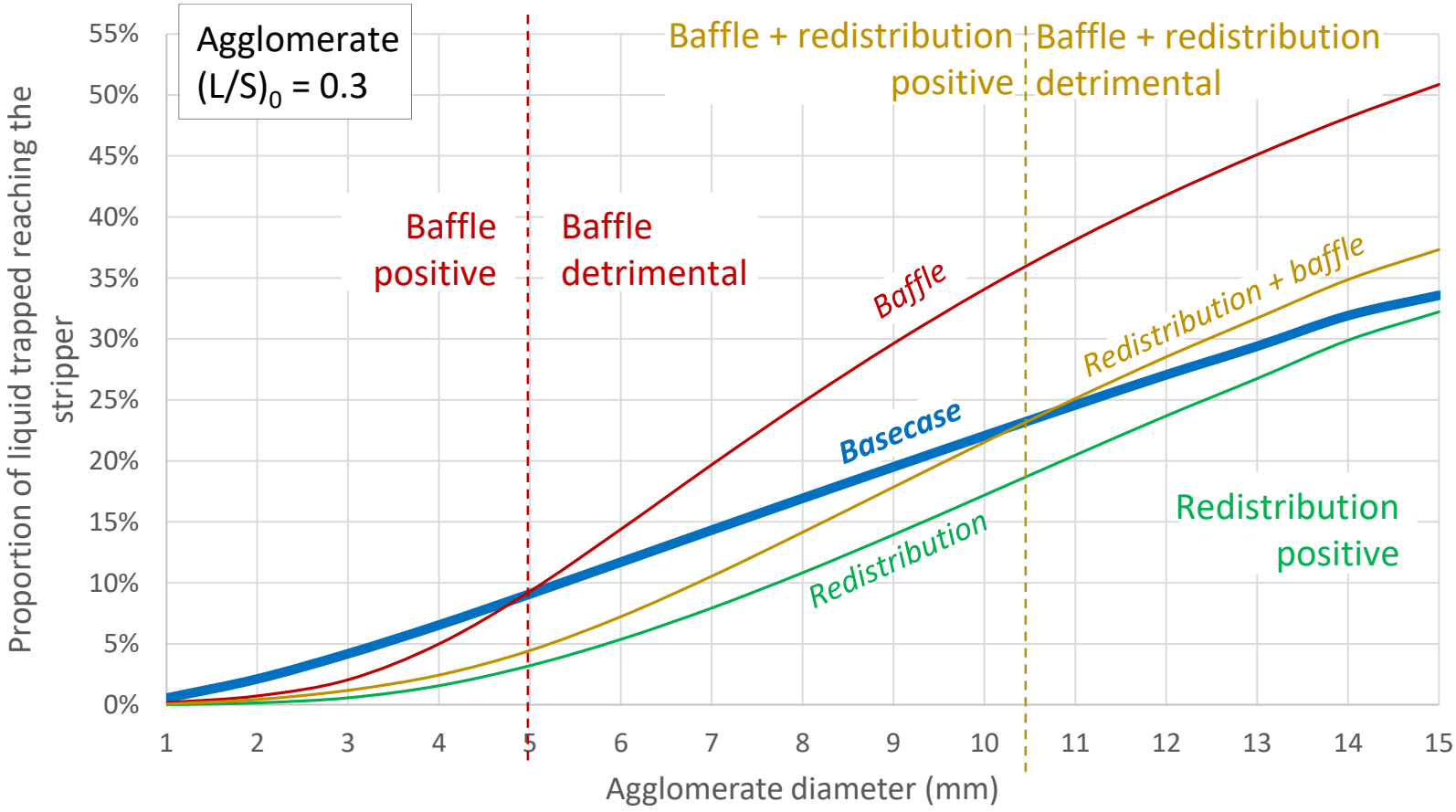


Heat & Mass transfer model (shrinking core)

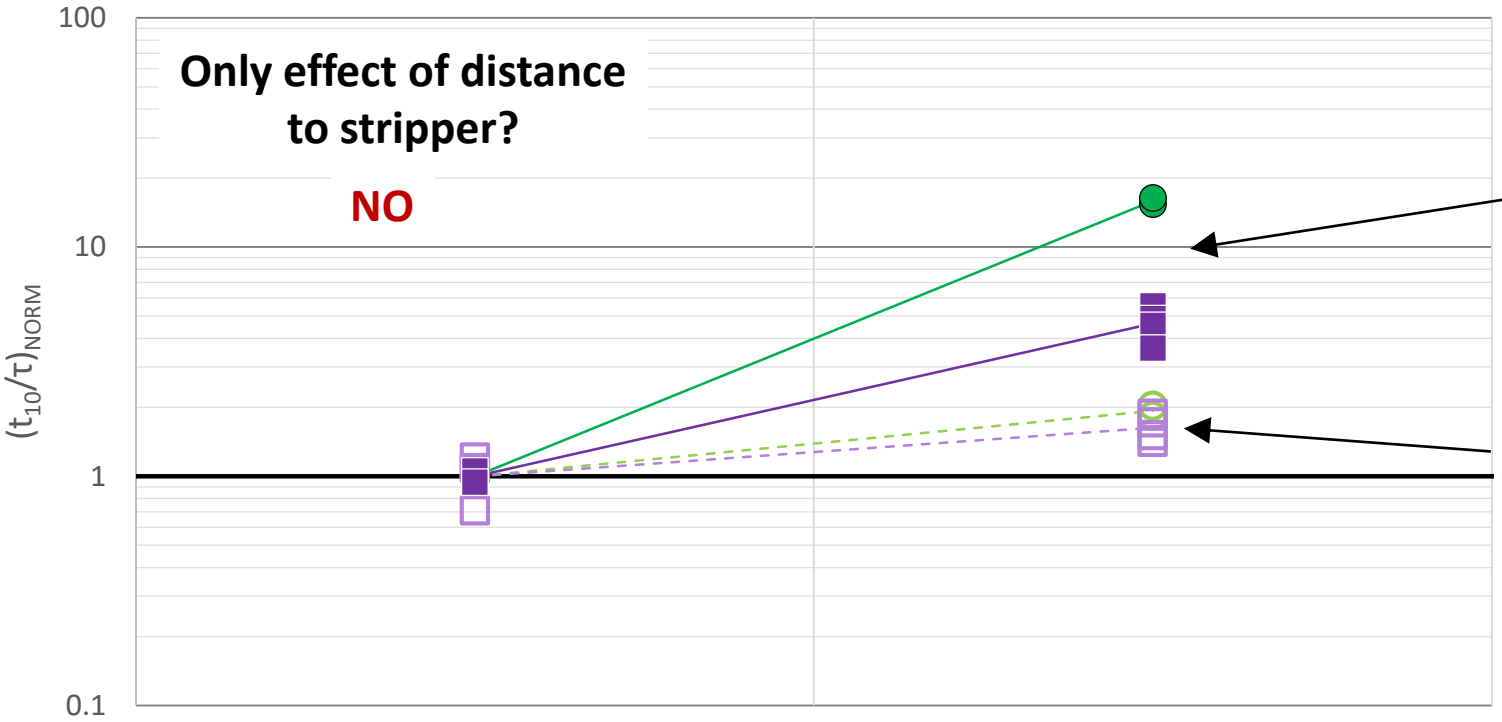


Liquid content reaching the stripper (2)

By combing the 2 previous charts

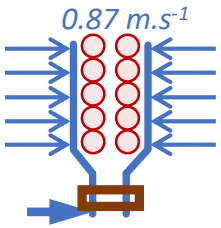


Change of bitumen feeding profile
Distance vs. hydrodynamics

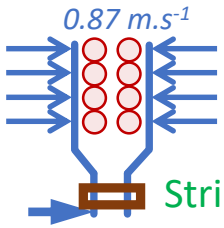


***All** active agglomerate formation zones*

***Only common** active agglomerate formation zones*



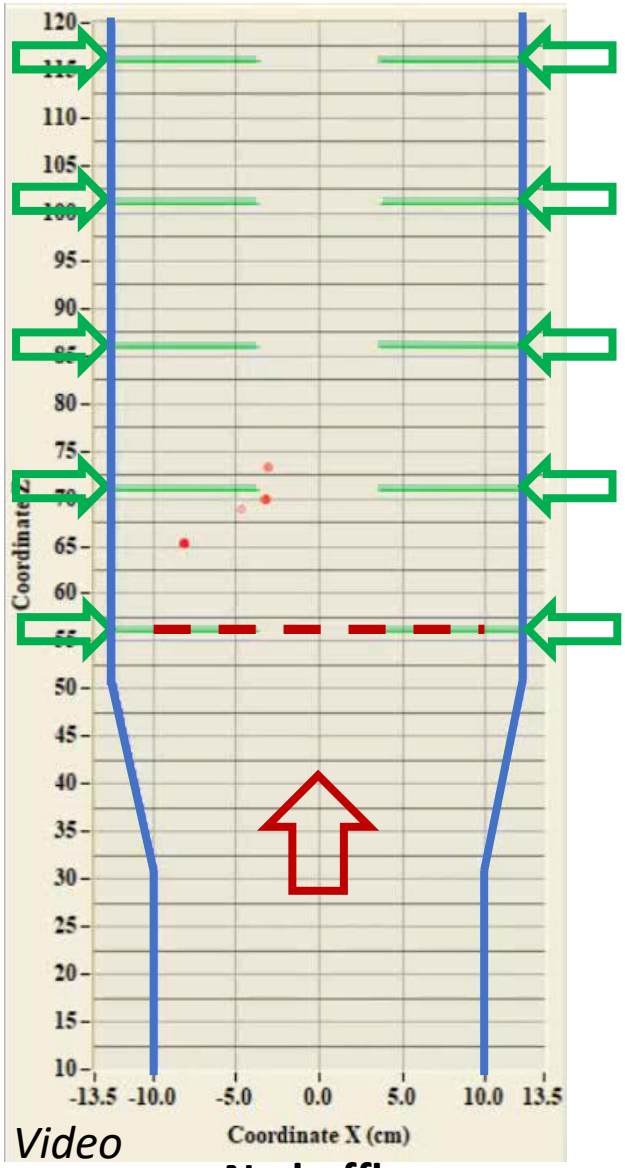
*Consider **only common** active agglomerate formation zones*



Change of bitumen feeding profile
Heavy agglomerate motion pattern

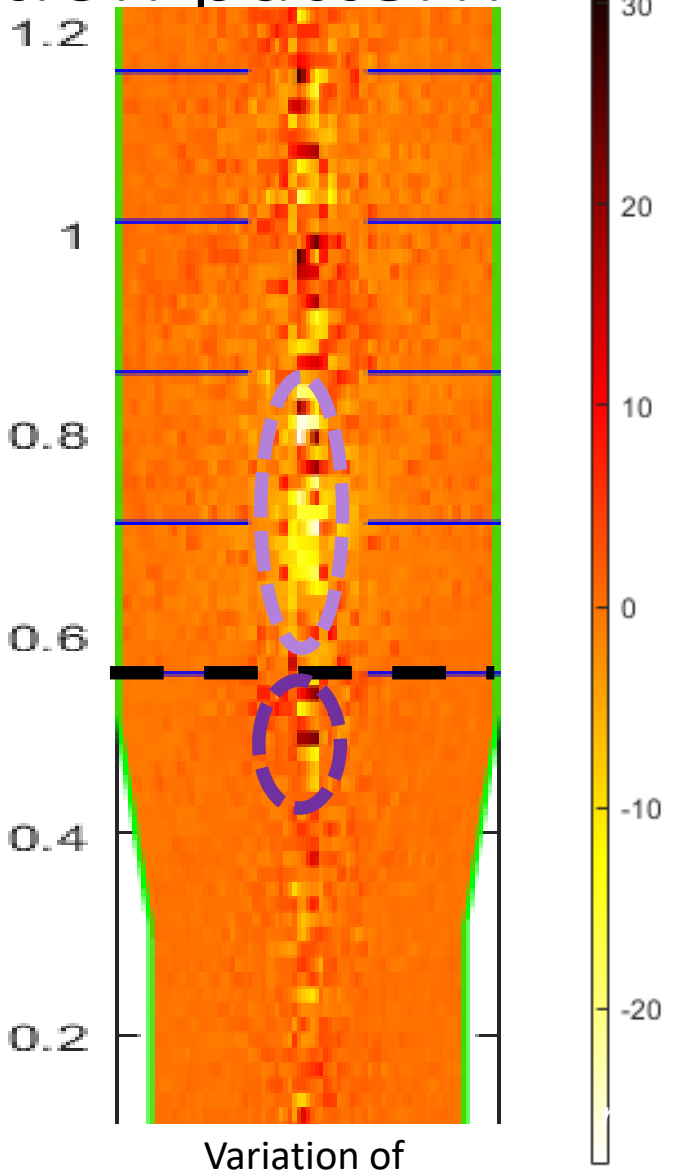
From RPT

5 banks of injection



Video

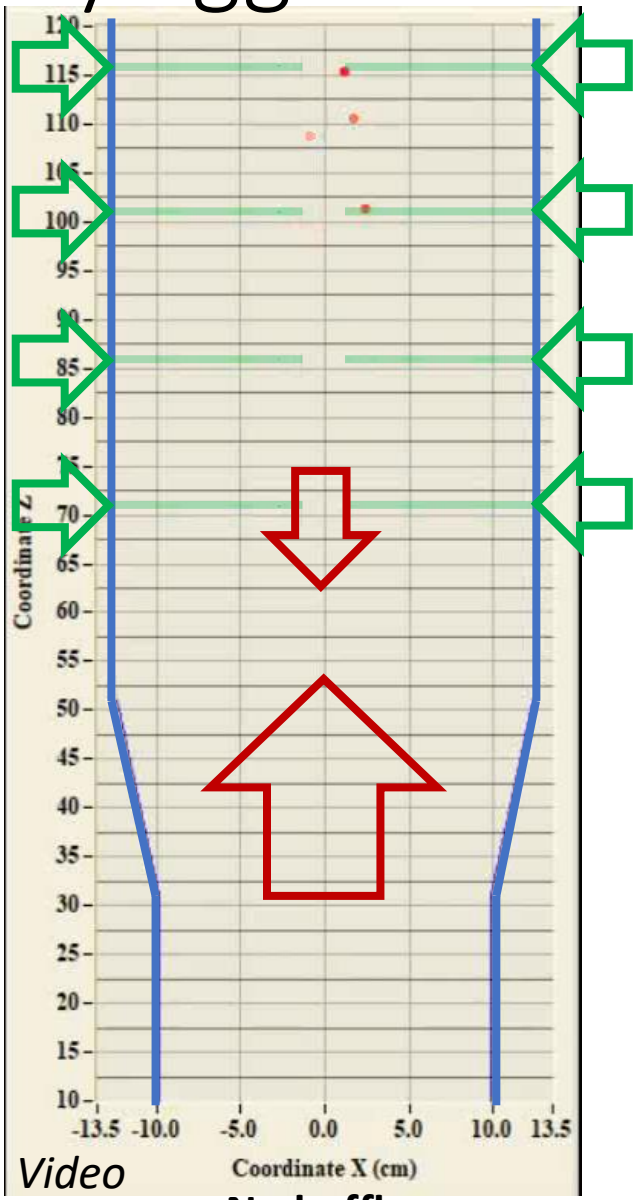
No baffle



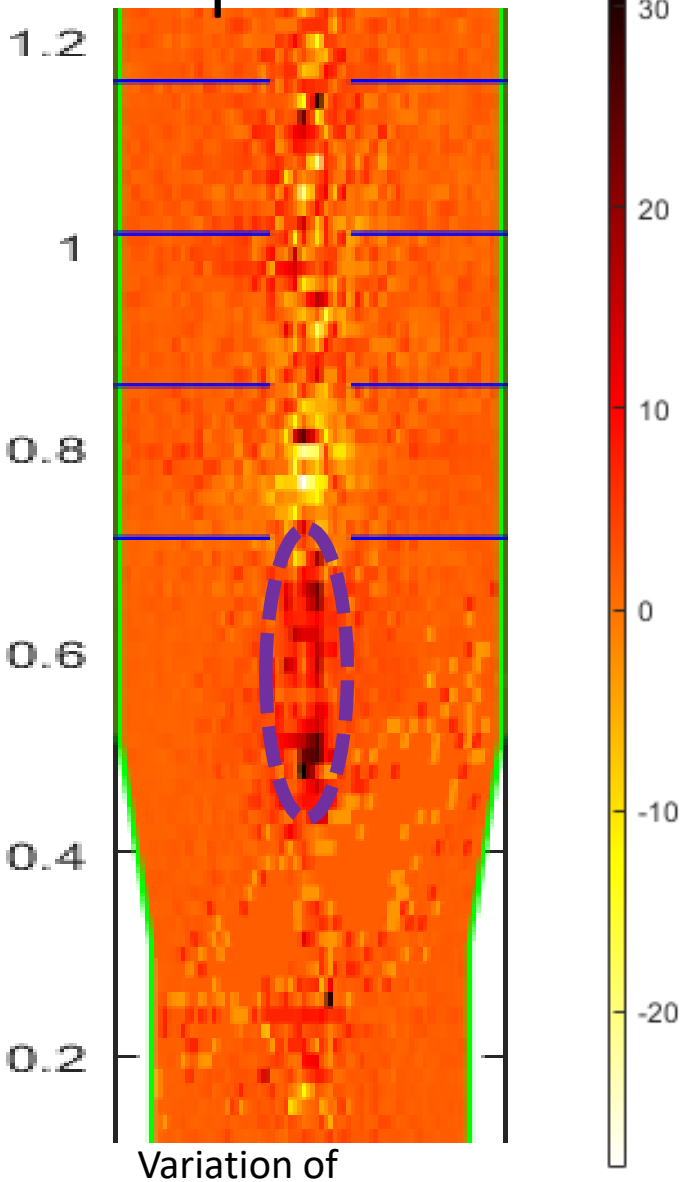
Variation of axial velocity

Change of bitumen feeding profile
Heavy agglomerate motion pattern

4 banks of injection (same total gas flowrate)



No baffle

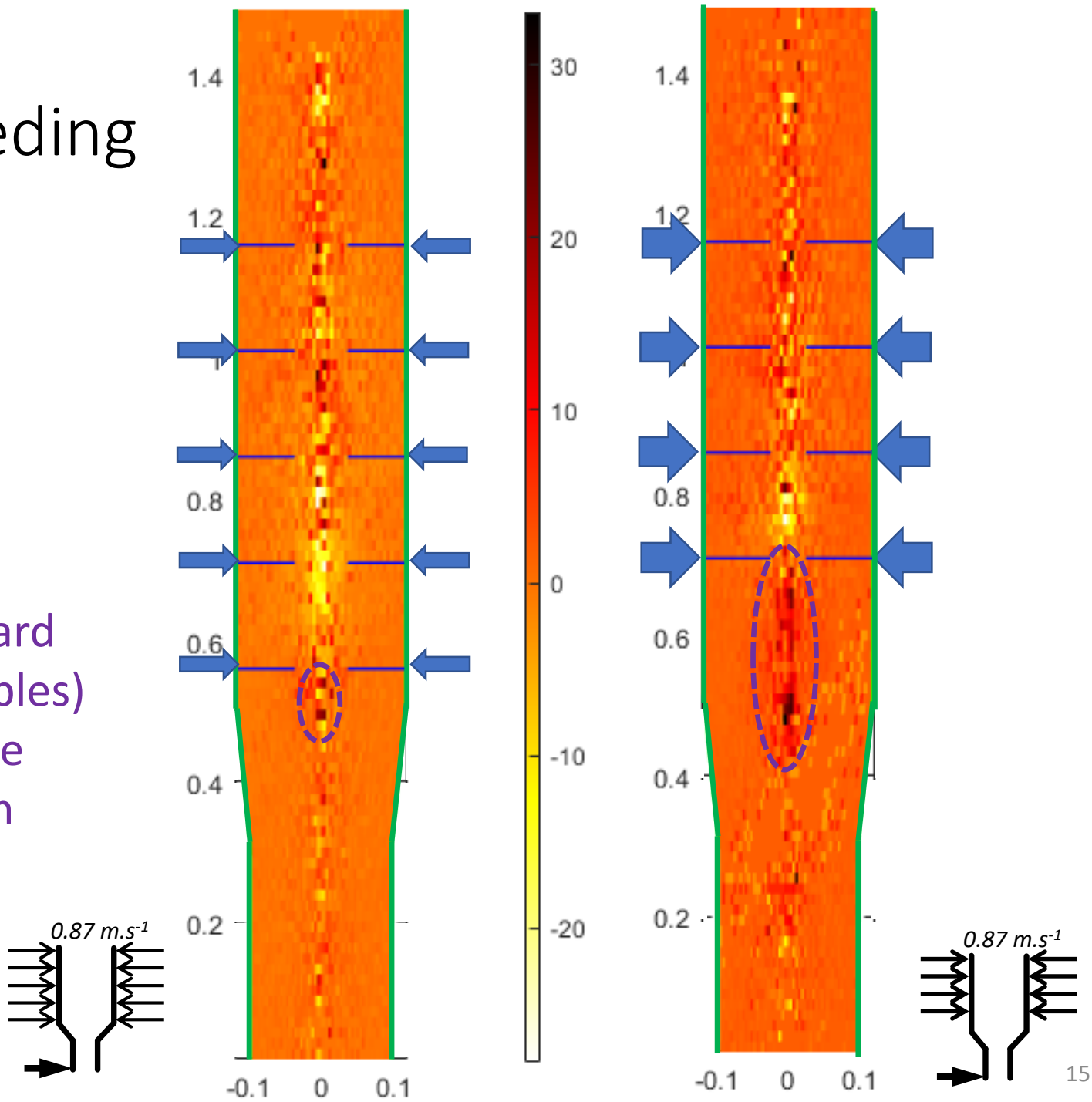


Variation of axial velocity

Change of bitumen feeding profile - Comparison

Variation of <u>axial</u> velocity

Stronger upward (related to bubbles) flow after the modification



Conclusion

Two possible solutions to reduce liquid reaching the stripper:

1. Redirect bitumen feed from lowest injection bank to higher banks – For any agglomerate size

Or,

2. Add ring baffle with flux tube – Only for small agglomerates (< 5 mm)

The combination of both is in-between

Improvements connected to hydrodynamics changes

Acknowledgments

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Industrial Research Chair

in Fluid Coking Technologies