Fluidization XVI

Flow Characteristics in the Downward FCC Feed Injection Scheme

Zihan Yan, Yiping Fan, Chunxi Lu

China University of Petroleum-Beijing






中国石油大学(北京)
China University of Petroleum (CUP)

1 INTRODUCTION

2 EXPERIMENTS

3 RESULTS & ANALYSIS

4 CONCLUSIONS

1. INTRODUCTION

Fluid catalytic cracking (FCC) is an important primary conversion process in modern oil refining industry, providing a variety of high value products such as gasoline, middle distillate and light olefins.

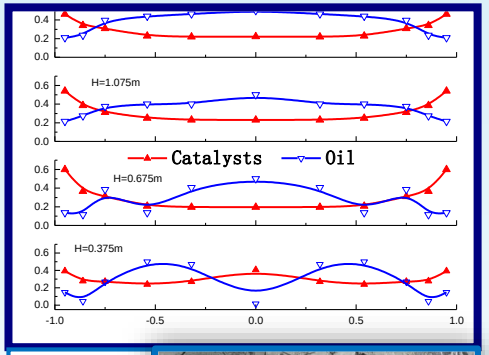
Over 50% of reaction take place

Feed injection zone

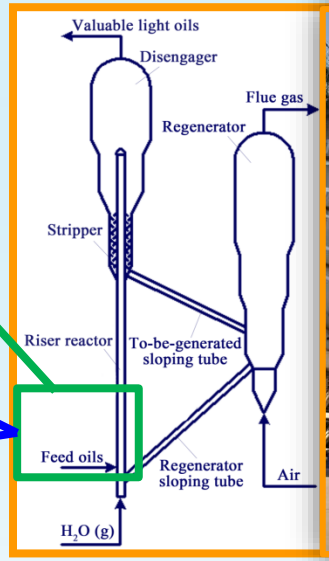
Ideal condition

Real condition

Oil and Catalysts:
Mix fully and uniformly



Oil and Catalysts:
Mismatching
Back-mixing
Coking …



FCC system

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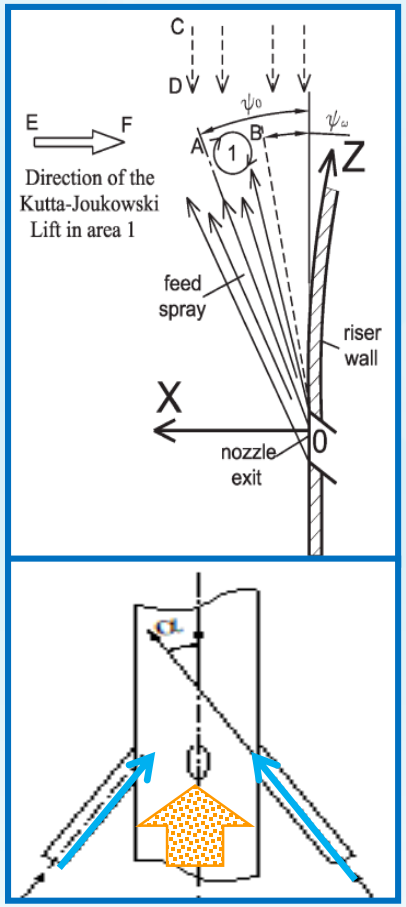
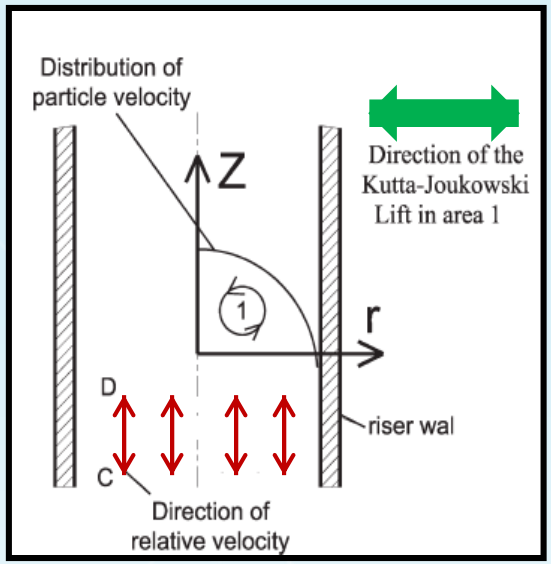
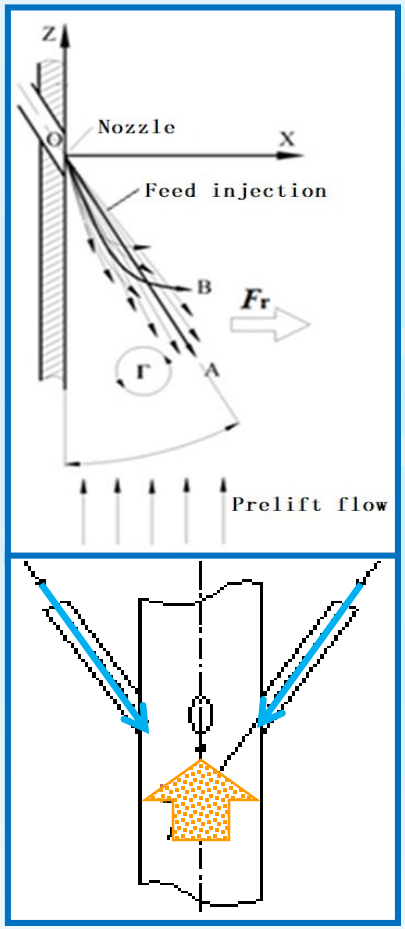
1. INTRODUCTION



Traditional feed injection scheme





Downward feed injection scheme

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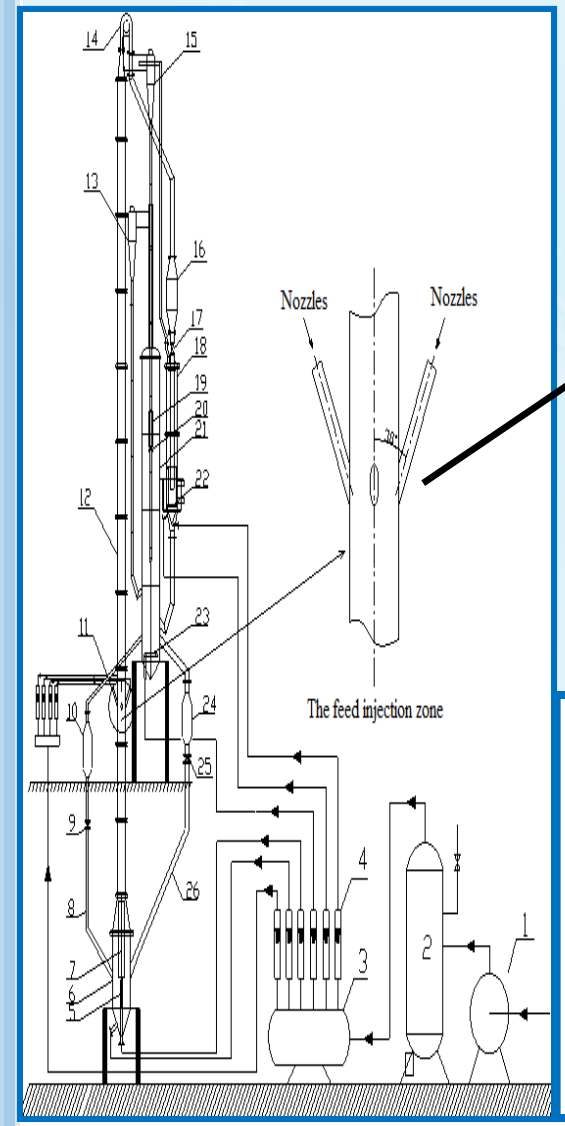
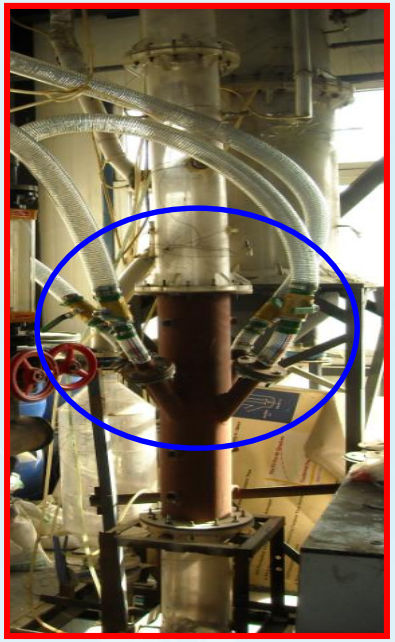
2. EXPERIMENTS



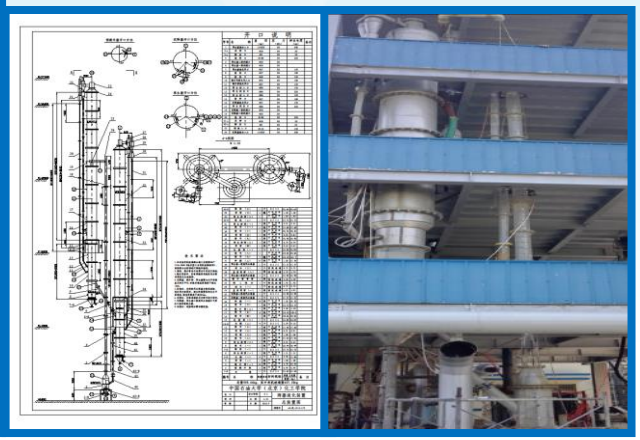


Optical fiber probe

Particle concentration and velocity

Helium-tracer

Jet concentration, Residence time distribution



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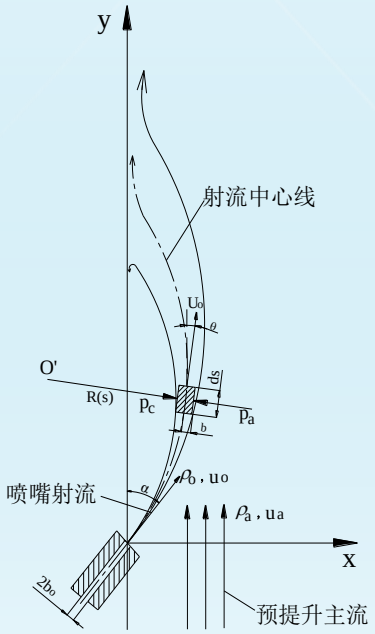
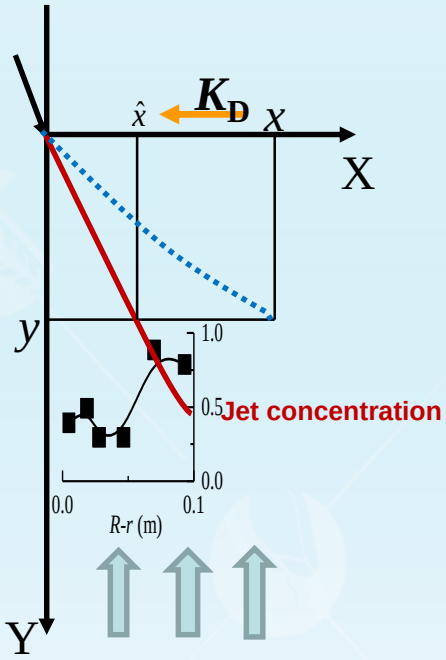
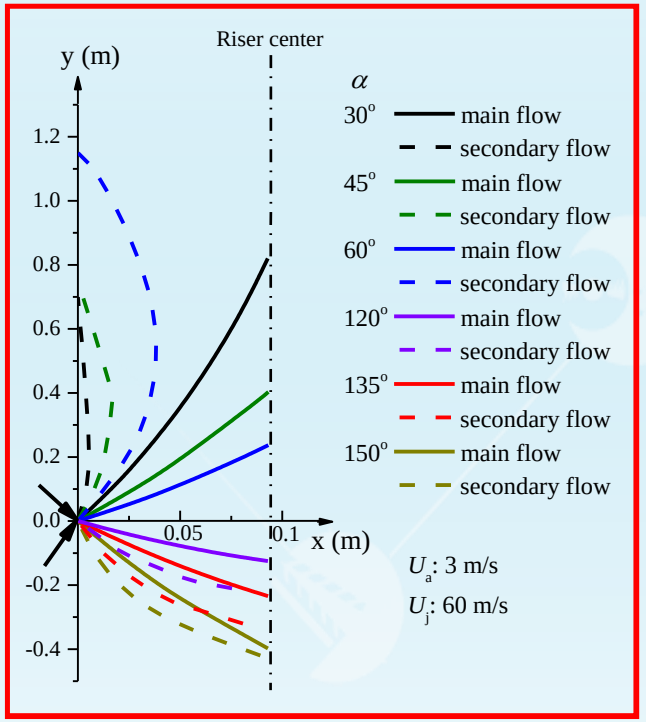
3. RESULTS & ANALYSIS

3.1 Trajectory of feed injection



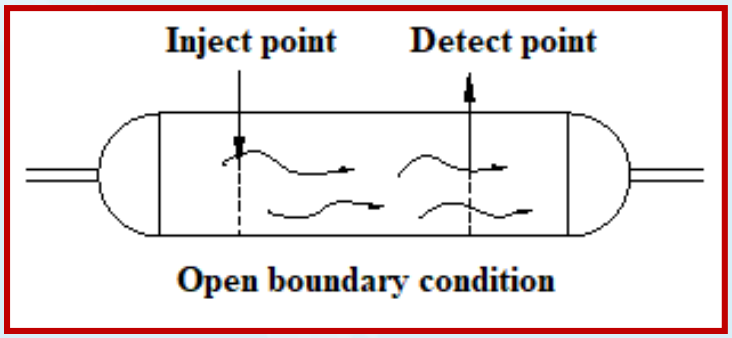




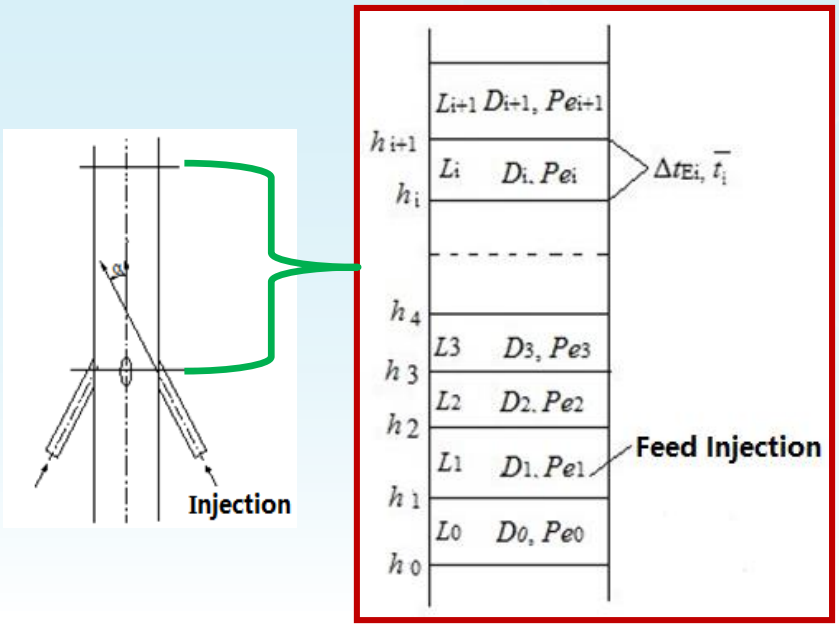
$$\hat{x} = \frac{1}{K_D} \cdot \frac{-C \pm (C^2 + 2ADy - BDy^2)^{0.5}}{D} = \frac{1}{K_D} x$$

3. RESULTS & ANALYSIS

3.2 Diffusion of feed injection



$$\theta = \frac{t_m}{\bar{t}} = 1 + \frac{1}{Pe_a}\left(\frac{D_{a1}}{D_a} + \frac{D_{a2}}{D_a}\right)$$



$$\theta_1 = \frac{\Delta t_{m1}}{\bar{t}_1} = 1 + \frac{1}{u_1 L_1}\left(\frac{u_0 L_0}{Pe_0} + \frac{u_2 L_2}{Pe_2}\right)$$

$$\theta_2 = \frac{\Delta t_{m2}}{\bar{t}_2} = 1 + \frac{1}{u_2 L_2}\left(\frac{u_1 L_1}{Pe_1} + \frac{u_3 L_3}{Pe_3}\right)$$

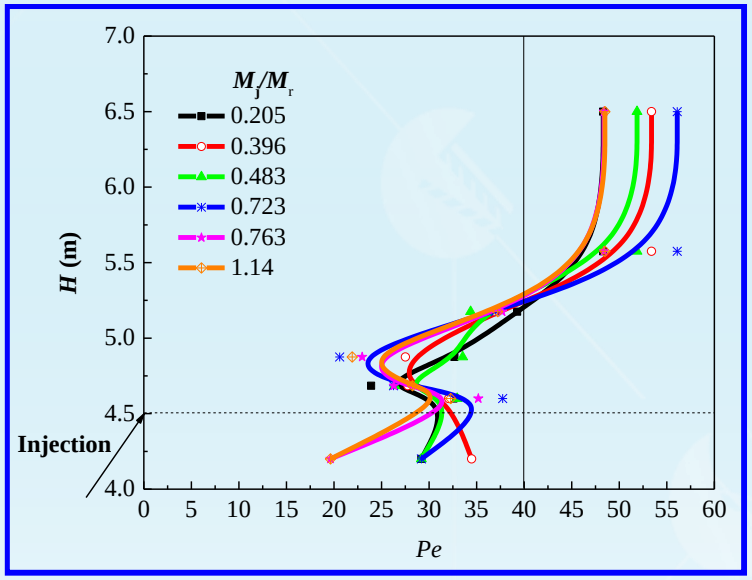
.....

$$\theta_i = \frac{\Delta t_i}{\bar{t}_i} = 1 + \frac{1}{u_i L_i}\left(\frac{u_{i-1} L_{i-1}}{Pe_{i-1}} + \frac{u_{i+1} L_{i+1}}{Pe_{i+1}}\right)$$

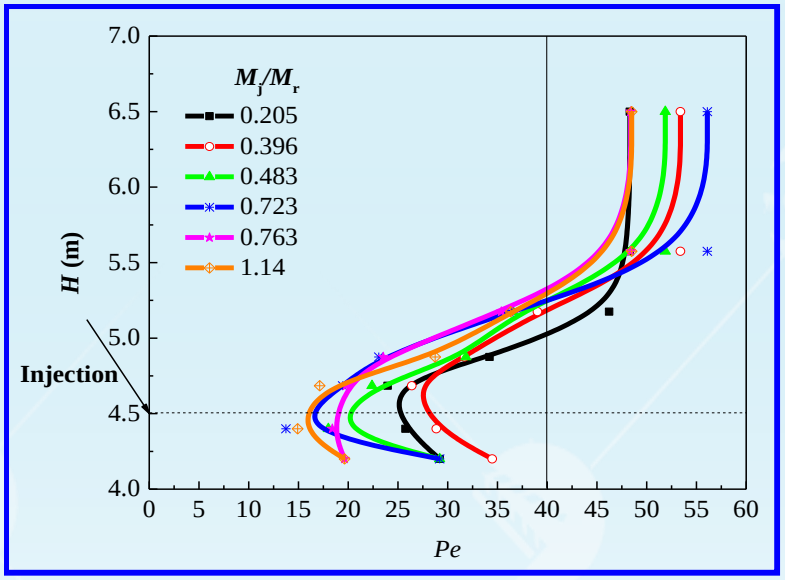
3. RESULTS & ANALYSIS

3.2 Diffusion of feed injection

Distribution of Peclet number



Upward nozzles



Downward nozzles

Pe: ↑, ↓ a little, then to plug flow

Pe: ↓ to a low value, then to plug flow

Promote to mixing between feed oil with catalysts

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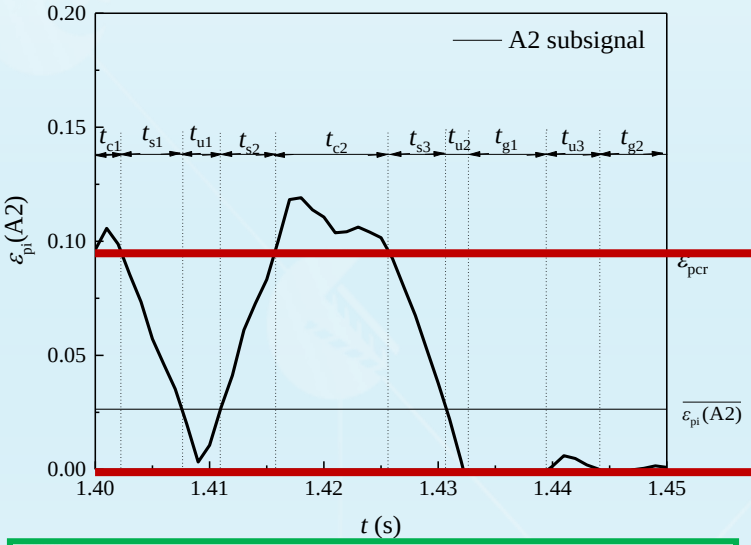
3. RESULTS & ANALYSIS

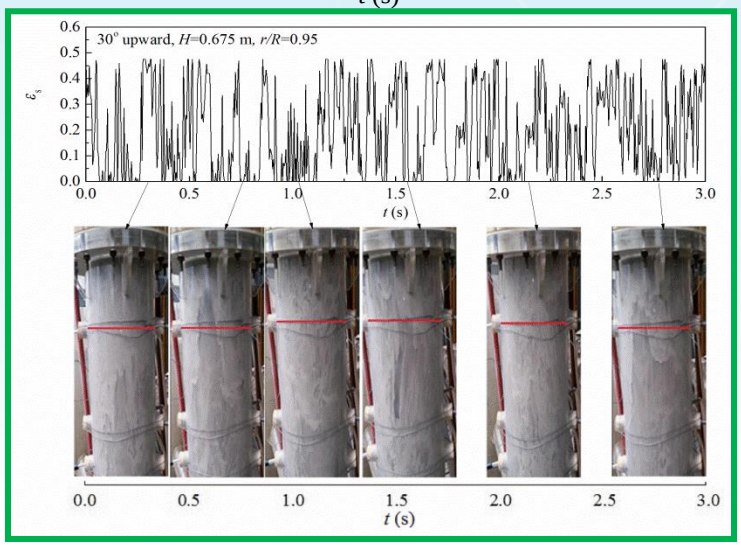
3.3 Dynamic behaviors between jet and catalysts



Cluster phase

Particulate phase (denser & diluter)

Gas phase (ε≈0)



Fluctuation of solid holdup

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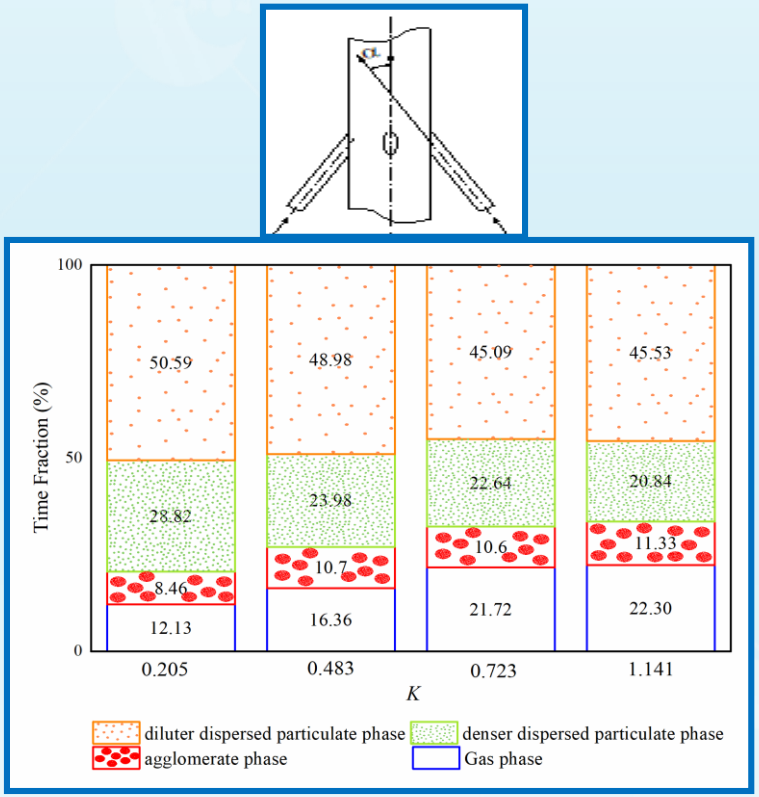
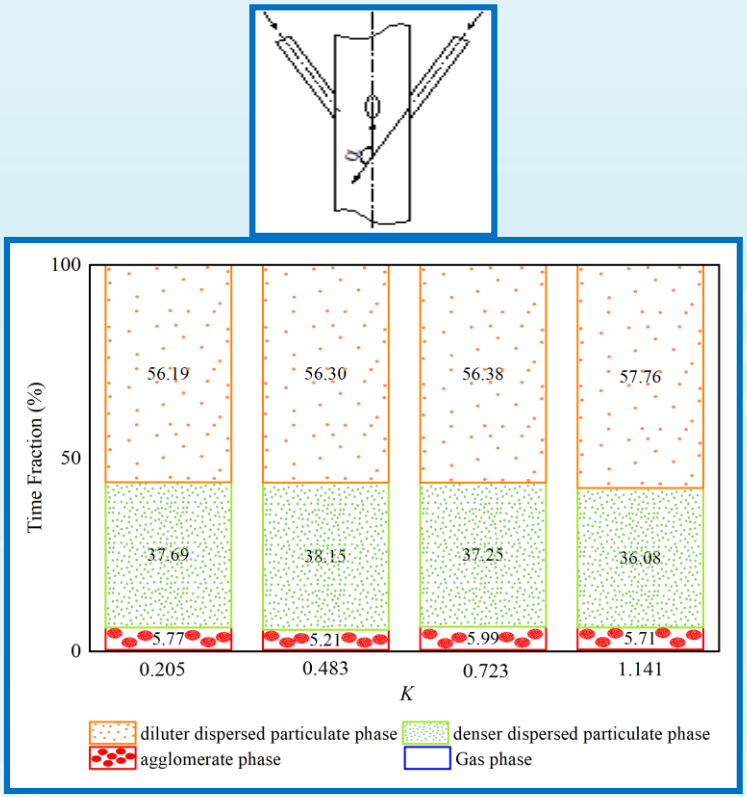
3. RESULTS & ANALYSIS

3.3 Dynamic behaviors between jet and catalysts



Upward nozzles



Downward nozzles

Cluster phase: high
Gas phase: quite high

Cluster and gas phases: low
Particulate phase: high

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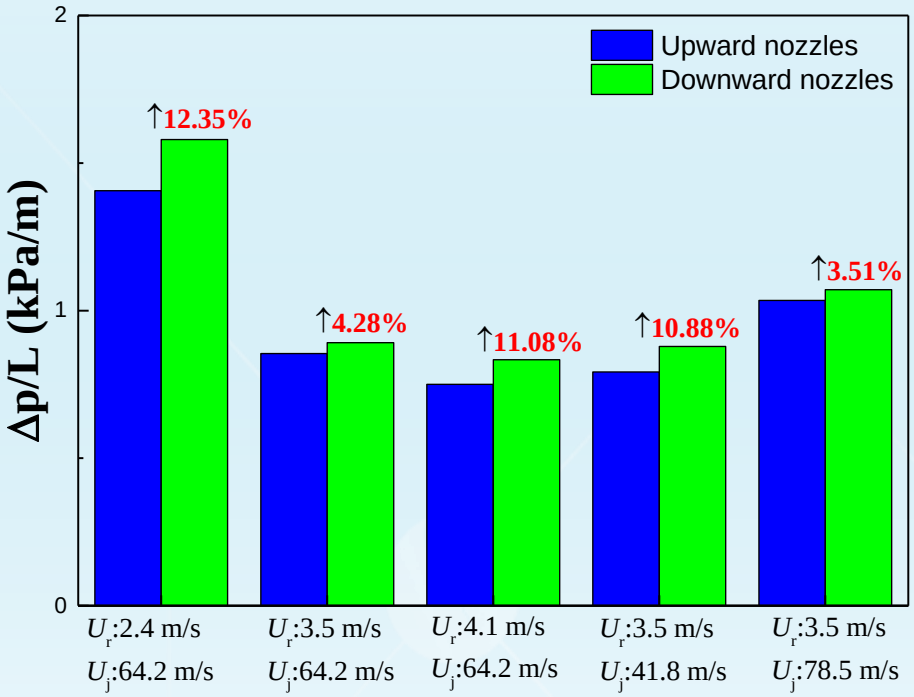
3.4 Pressure drop



Downward nozzles:
No significant increase in pressure drop is seen!

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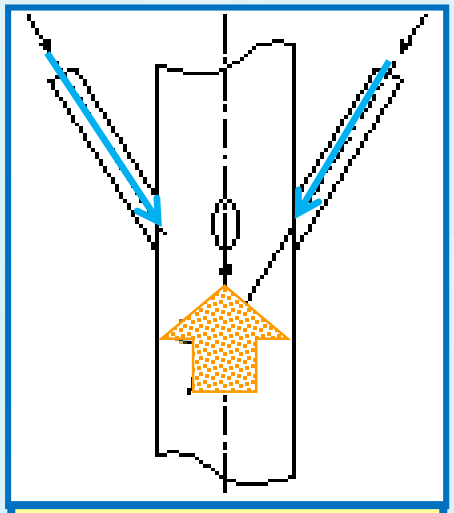

Downward feed injection scheme

- Reduce back-mixing near the riser wall
- Flow pattern:
  complete mixed flow → plug flow, quickly
- Dynamic mixing :
  Reduce cluster and gas phases
  Increase particulate phase
- Pressure drop:
  No significant increase

Great potential of application

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Thank you!






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