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# Experimental study of solid mixing mechanism in a 2D fluidized bed

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# EXPERIMENTAL STUDY OF SOLID MIXING MECHANISM IN A 2D FLUIDIZED BED

**J. Sánchez-Prieto, F. Suárez-Gómez, F. Hernández-Jiménez,  
L. M. Garcia-Gutierrez, A. Soria-Verdugo**



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(MADRID, SPAIN)**



**Energy Systems Engineering**  
Research group

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1. Introduction
2. Experimental setup
3. Results and discussion
4. Conclusions

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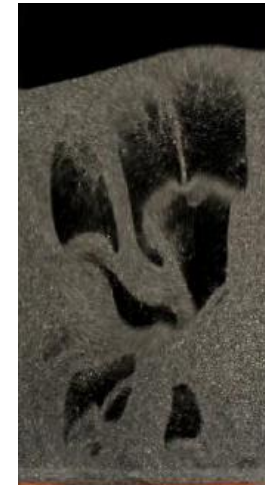
1. Introduction
  - Motivation
  - Solids mixing in fluidized beds
2. Experimental setup
3. Results and discussion
4. Conclusions

- The lateral mixing of solids influences the rates of heat and mass transfer in fluidized beds.
- The lateral mixing of solids is crucial to ensure uniform heating, reaction or drying of particles and to prevent the formation of hot spots.
- The knowledge of solids mixing rate is very useful for the design of fuel feeding ports in fluidized bed boilers and gasifiers.

Completely  
Segregated  
State



Mixing process

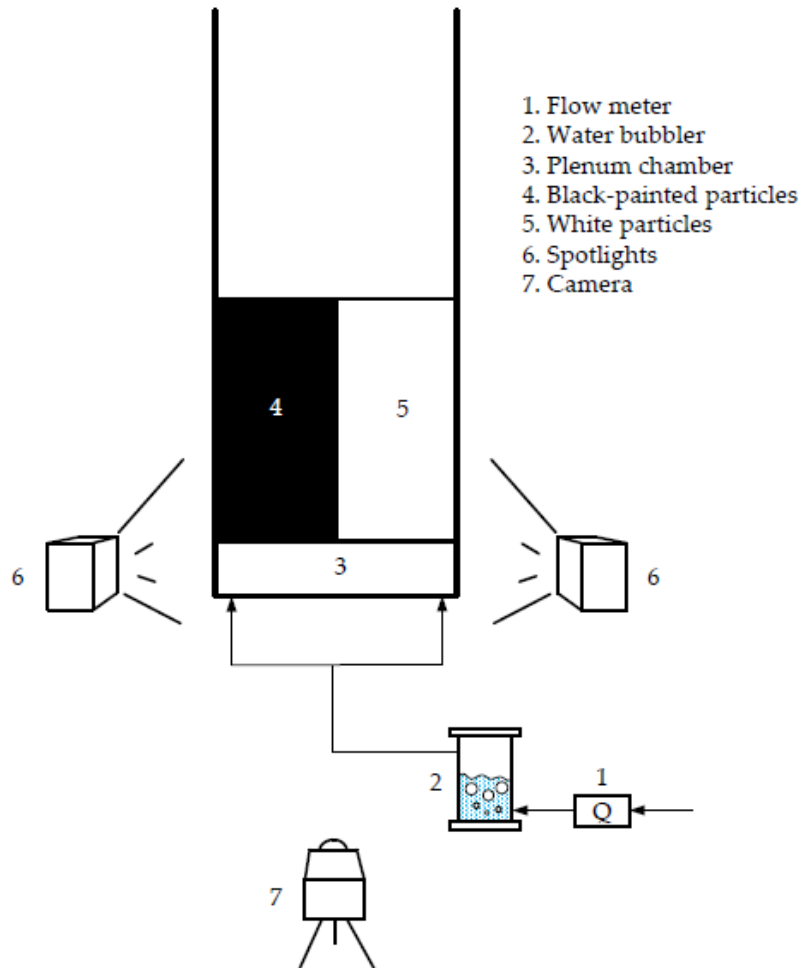


Randomly  
Mixed  
State

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1. Introduction
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  - Pseudo-2D fluidized bed
  - Painting technique description
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4. Conclusions

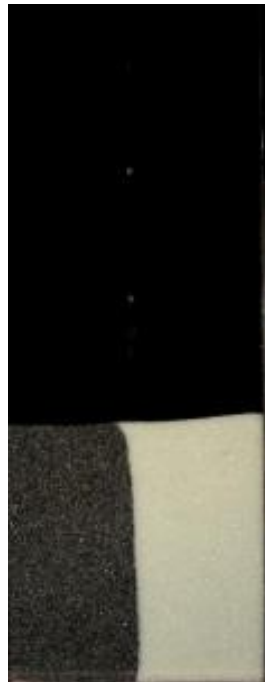
□ Experimental setup: pseudo-2D fluidized bed



Parameter		Value
Bed height, $H$ (m)		1
Bed width, $W$ (m)		0.3
Bed thickness, $Z$ (m)		0.01
Aspect ratio, $H_0/W$ (-)		1
Particle density, $\rho_s$ ( $\text{kg/m}^3$ )		2500
Small particles	$d_p$ (mm)	0.4-0.6
	$U_{mf}$ (m/s)	0.27
Medium particles	$d_p$ (mm)	0.6-0.8
	$U_{mf}$ (m/s)	0.44
Big particles	$d_p$ (mm)	1-1.3
	$U_{mf}$ (m/s)	0.67

Particle size (mm)	$U_{mf}$ (m/s)	$U_0 - U_{mf}$ (m/s)		
		$U_0 = 2U_{mf}$	$U_0 = 2.5U_{mf}$	$U_0 = 3U_{mf}$
1-1.3	0.67	0.67	1.005	1.34
0.6-0.8	0.44	0.44	0.66	0.88
0.4-0.6	0.27	0.27	0.405	0.54

□ Lateral solids mixing in fluidized beds



Completely Segregated State



Mixing index

$$M = \frac{S_0^2 - S^2}{S_0^2 - S_R^2}$$

Lacey index

$$C^* = 1 - \frac{A_{w,i}}{A_{w,max}}$$

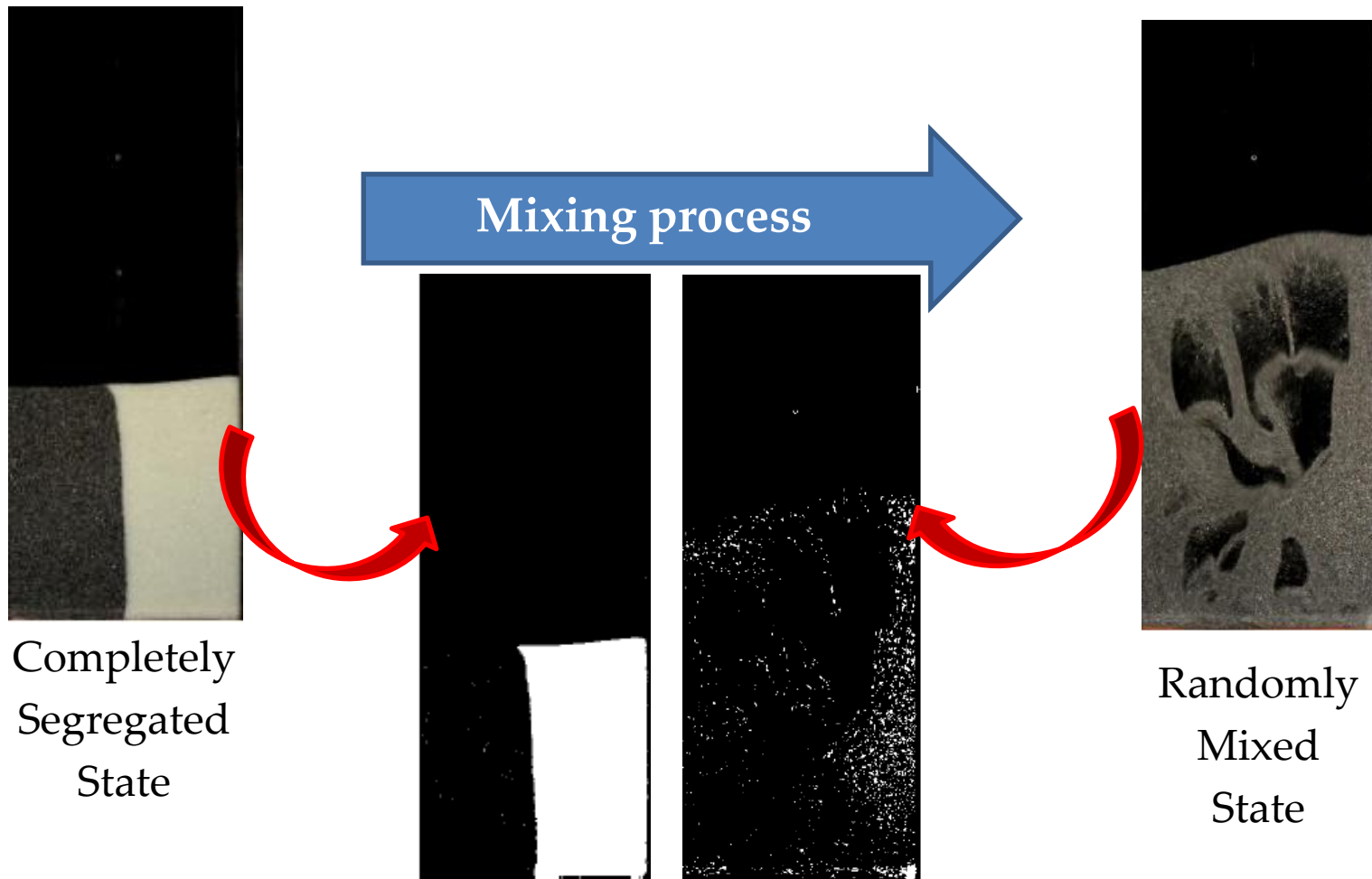
Proposed mixing index



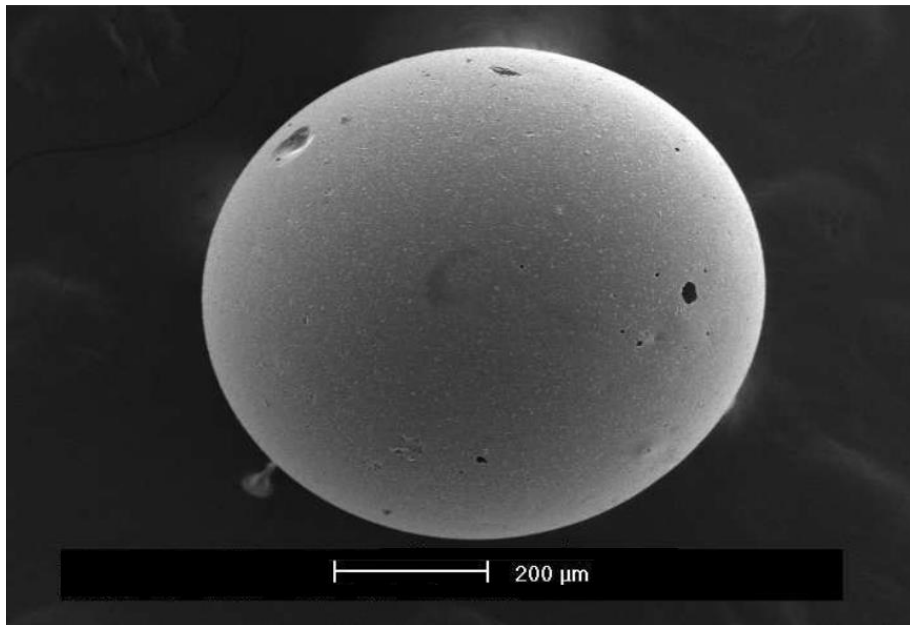
Randomly Mixed State



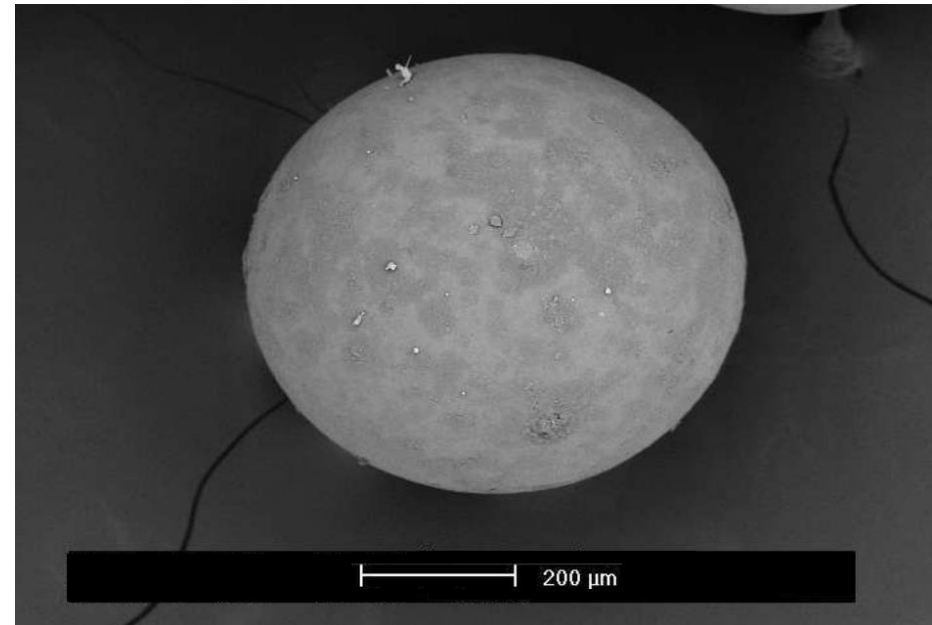
□ Lateral solids mixing in fluidized beds



□ Painting technique description



Non-painted particle



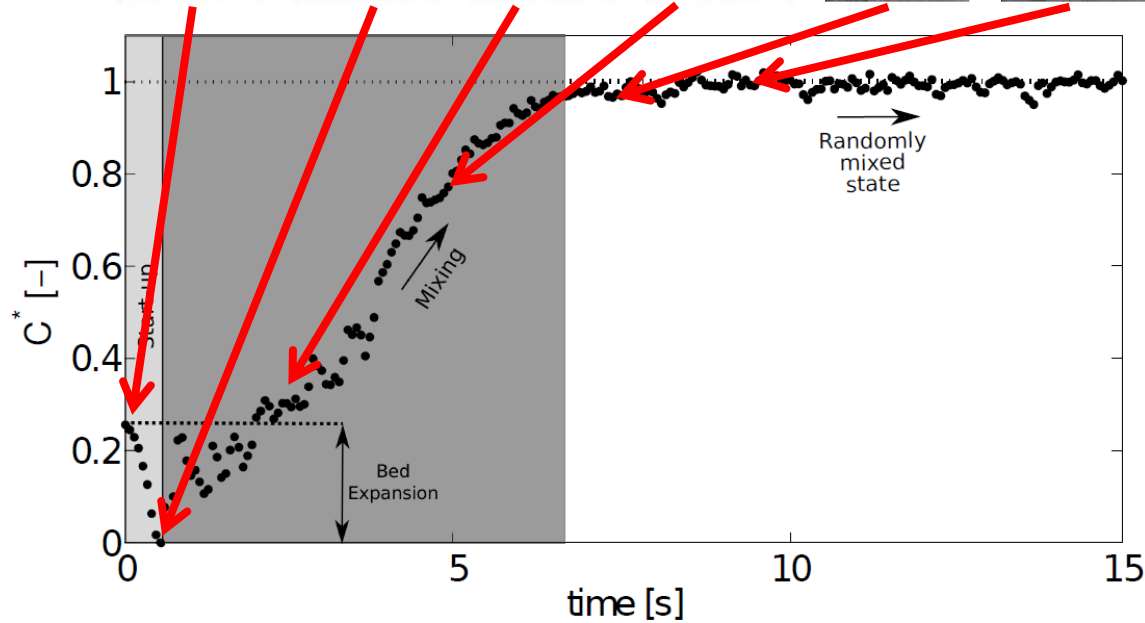
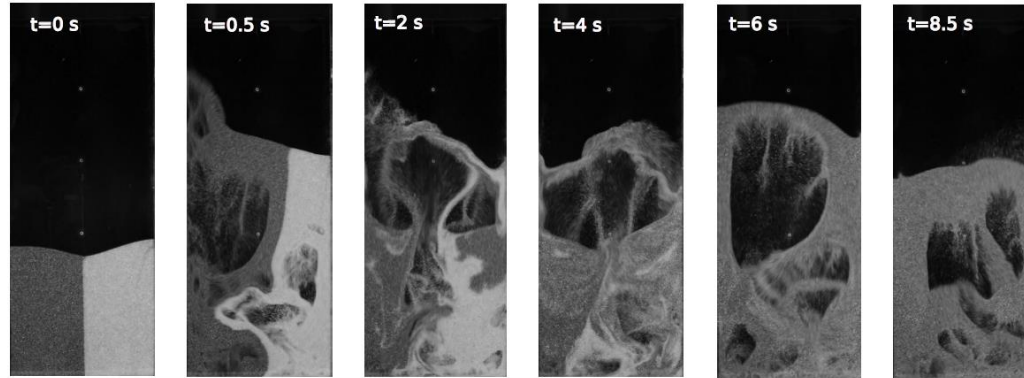
Black painted particle

- The painting technique does not change the shape of the bed material

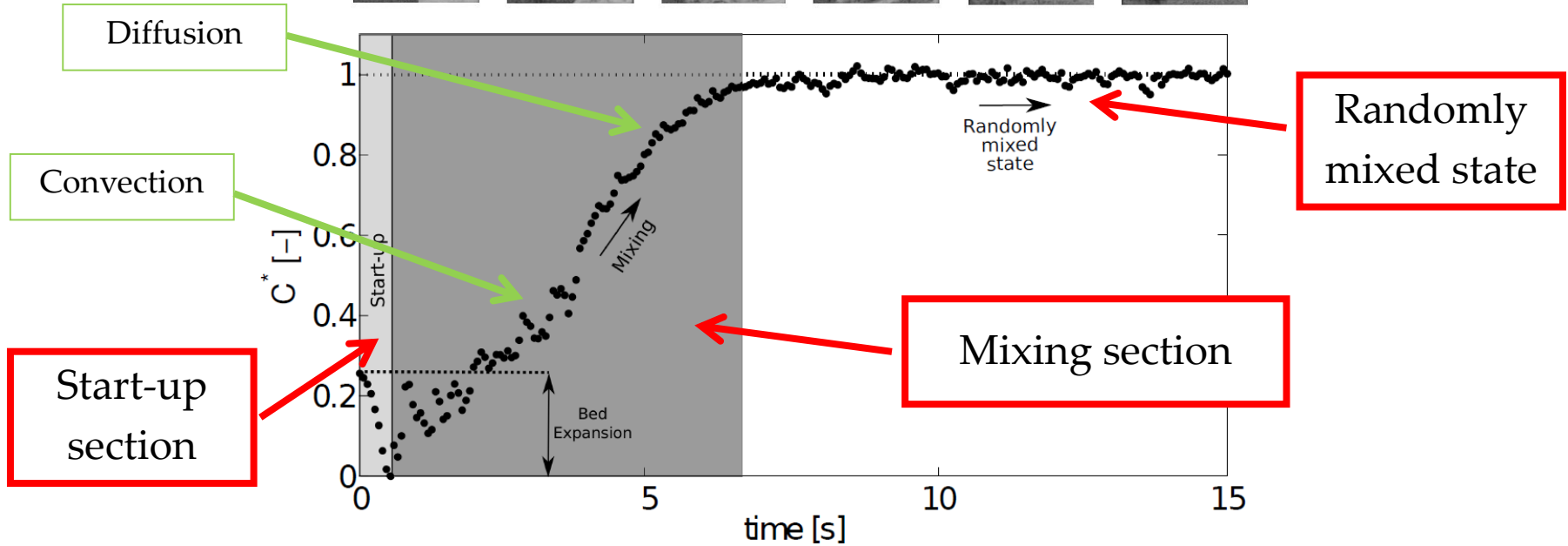
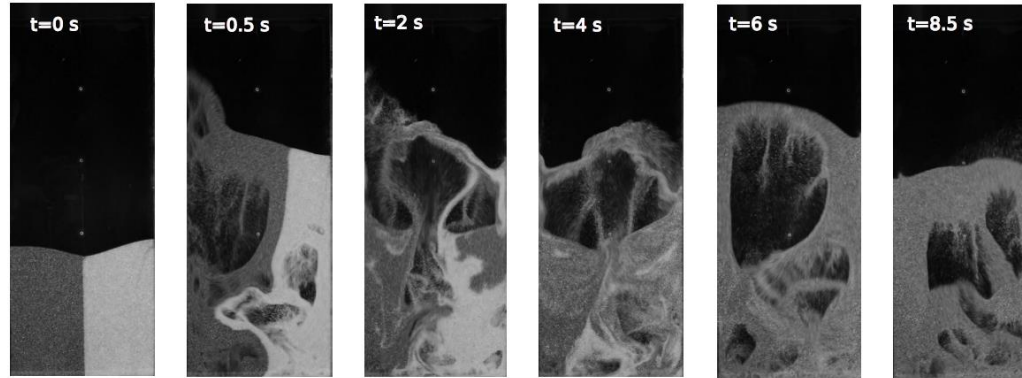
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  - Small particles
  - Medium particles
  - Big particles
  - Mixing time and start-up time
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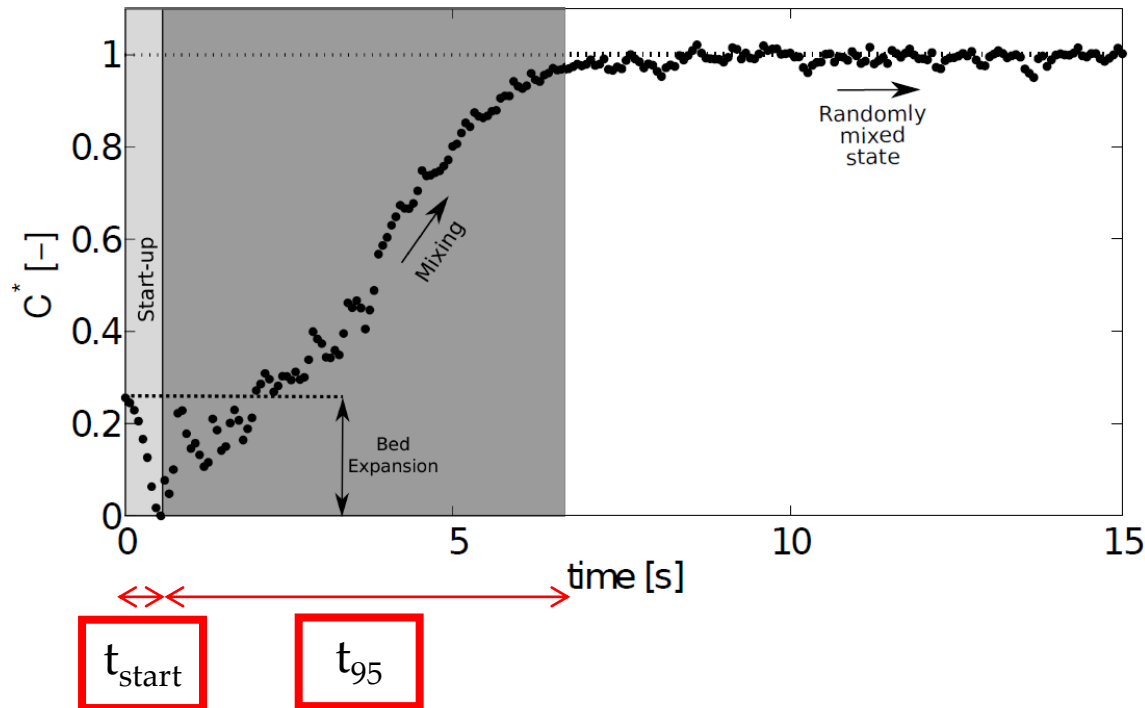
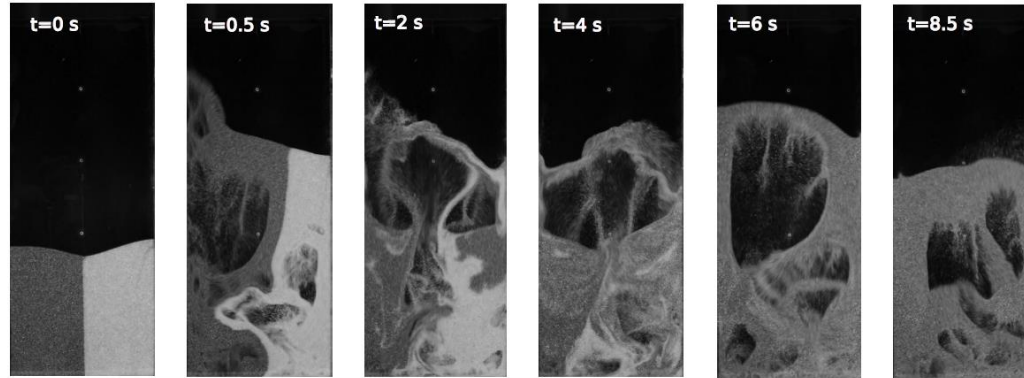
$$C^* = 1 - \frac{A_{w,i}}{A_{w,max}}$$



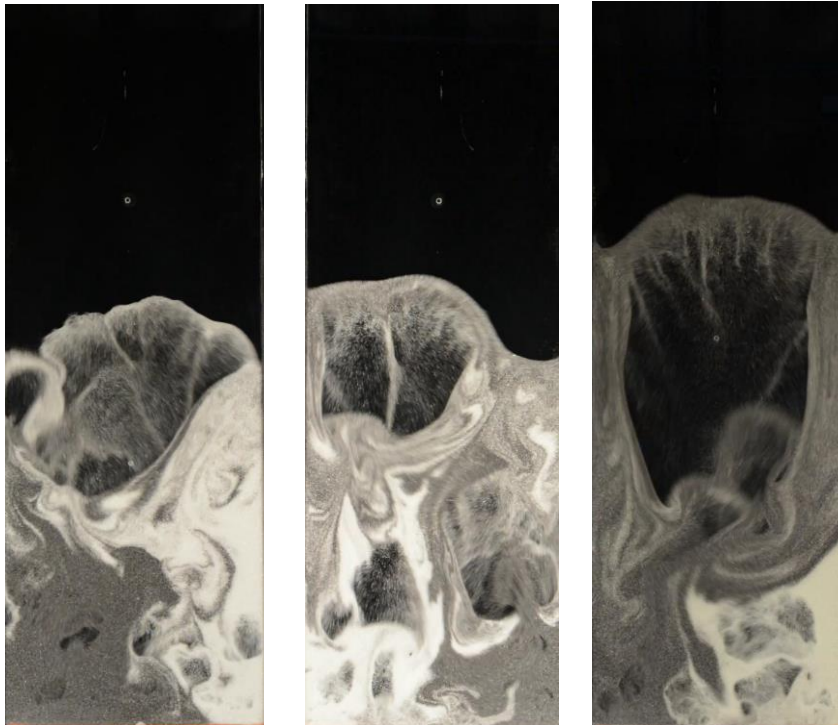
$$C^* = 1 - \frac{A_{w,i}}{A_{w,max}}$$



$$C^* = 1 - \frac{A_{w,i}}{A_{w,max}}$$



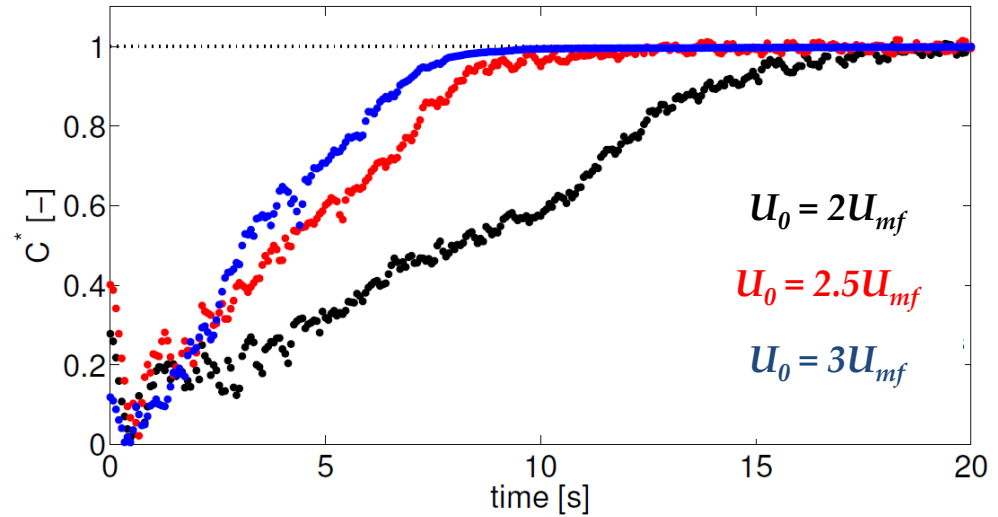
□ Small particles ( $d_p = 0.4-0.6$  mm)



$U_0 = 2U_{mf}$

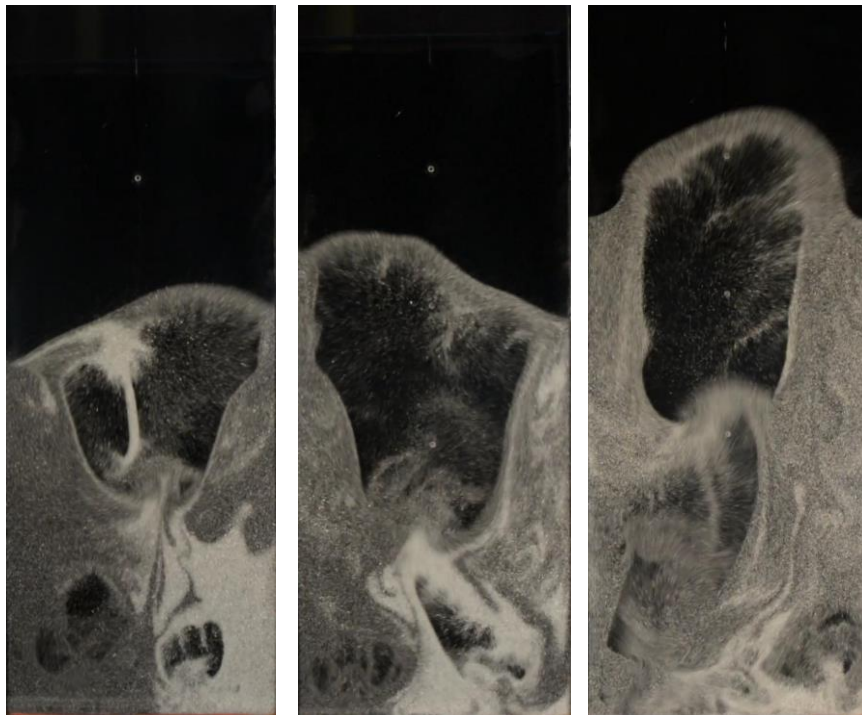
$U_0 = 2.5U_{mf}$

$U_0 = 3U_{mf}$





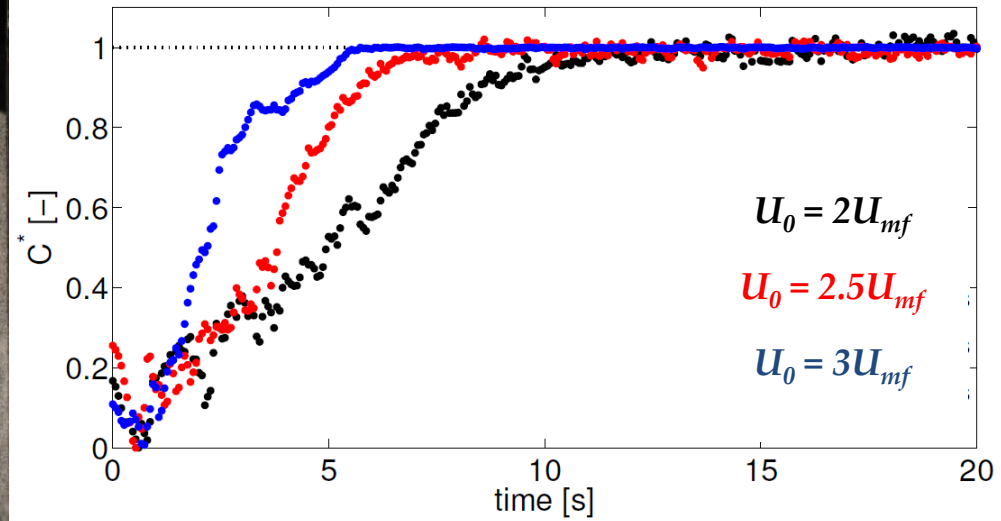
□ Medium particles ( $d_p = 0.6-0.8$  mm)



$$U_0 = 2U_{mf}$$

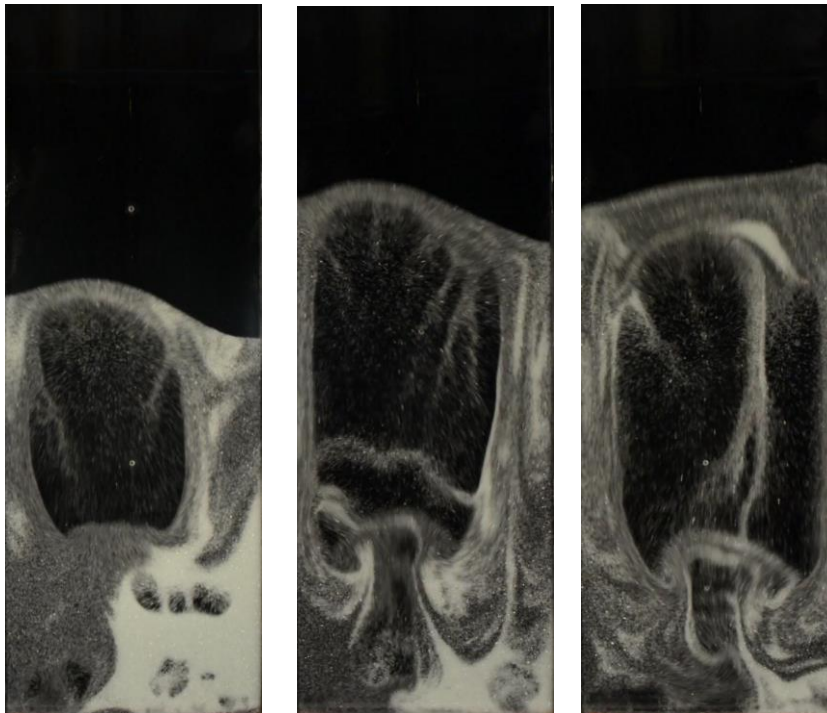
$$U_0 = 2.5U_{mf}$$

$$U_0 = 3U_{mf}$$





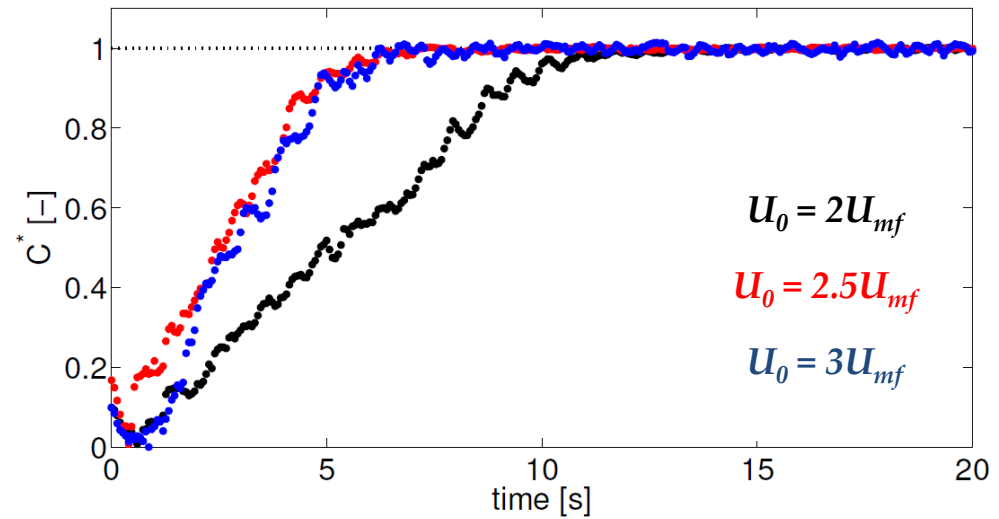
□ Big particles ( $d_p = 1-1.3$  mm)



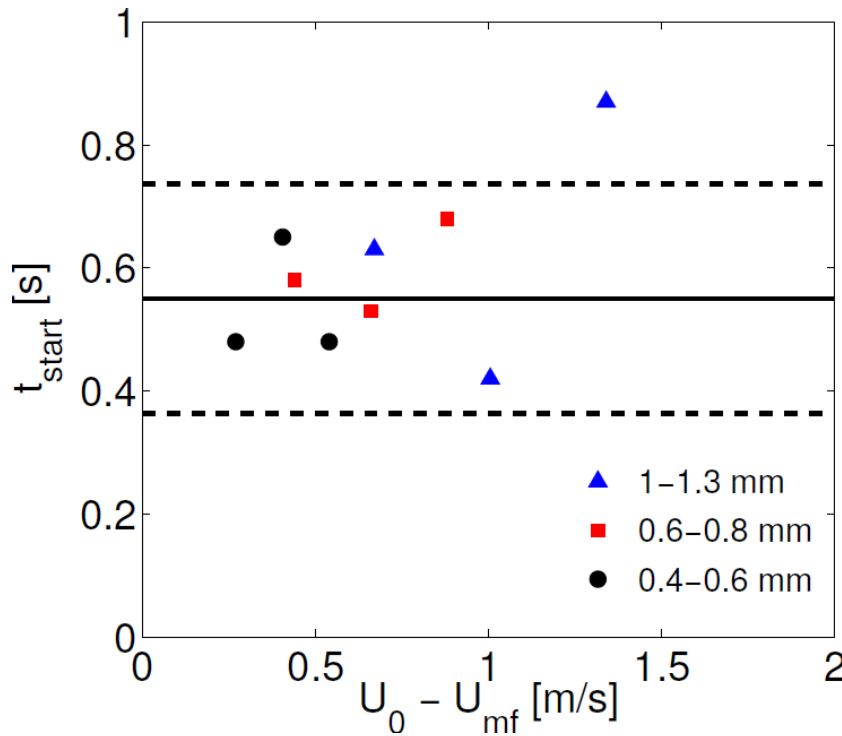
$U_0 = 2U_{mf}$

$U_0 = 2.5U_{mf}$

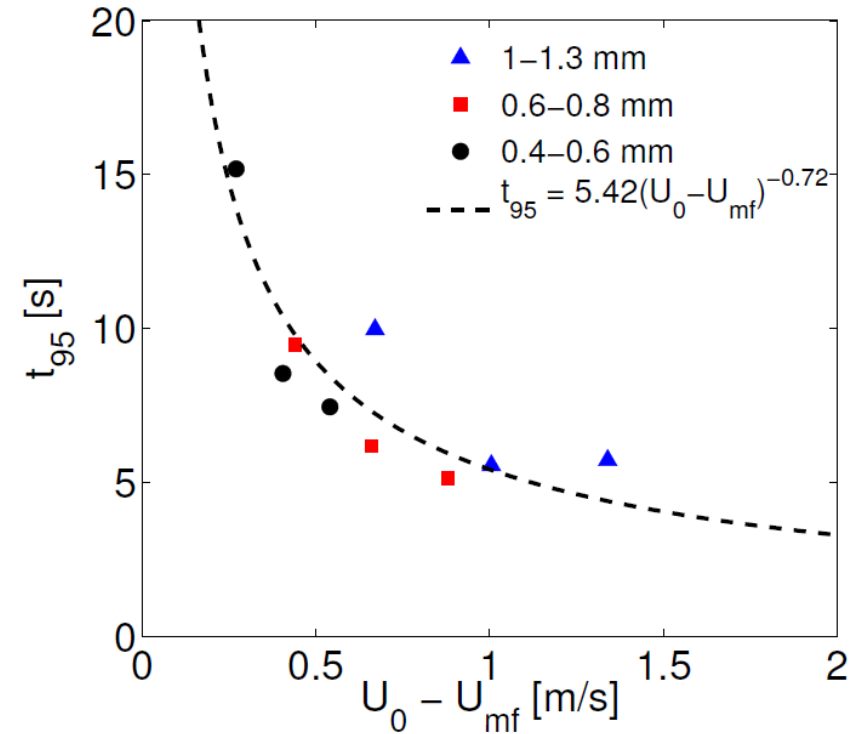
$U_0 = 3U_{mf}$



□ Start-up time ( $t_{start}$ ) and Mixing time ( $t_{95}$ )



Start-up time constant



Potential relation for the mixing time

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4. **Conclusions**

- The painting technique of the particles showed no changes in shape, therefore, the two solids phases are just differentiated by its colour.
- Two different sections were found in the mixing experiments:
  - The start-up section is independent of the excess gas velocity and the particle size. The start-up time is only influenced by the way the experiments were carried out.
  - The mixing section can be divided into two subsections:
    - convective mixing mechanism (fast ascending bubbles)
    - diffusive mixing mechanism (small cluster mixing).
  - The mixing time has a potential relation with the excess gas velocity and is independent of the particle size.



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**Thank you for your attention**