5-26-2016

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

J. Sánchez-Prieto
Universidad Carlos III de Madrid, Thermal and Fluid Engineering Department, Avda. de la Universidad, Spain., jsprieto@ing.uc3m.es

A. Soria-Verdugo
Universidad Carlos III de Madrid, Thermal and Fluid Engineering Department, Avda. de la Universidad, Spain.

L.M. García-Gutiérrez
Universidad Carlos III de Madrid, Thermal and Fluid Engineering Department, Avda. de la Universidad, Spain.

F. Hernández-Jiménez
Universidad Carlos III de Madrid, Thermal and Fluid Engineering Department, Avda. de la Universidad, Spain.

F. Suárez-Gómez
Universidad Carlos III de Madrid, Thermal and Fluid Engineering Department, Avda. de la Universidad, Spain.

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

ISE RESEARCH GROUP
CARLOS III UNIVERSITY
(MADRID, SPAIN)

Energy Systems Engineering
Research group

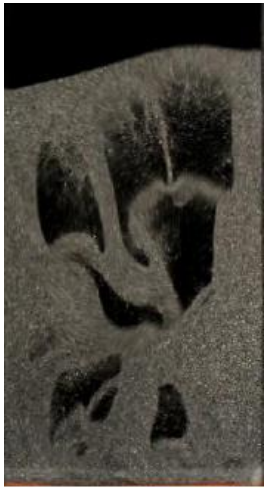
Table of contents

Table of contents

- 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

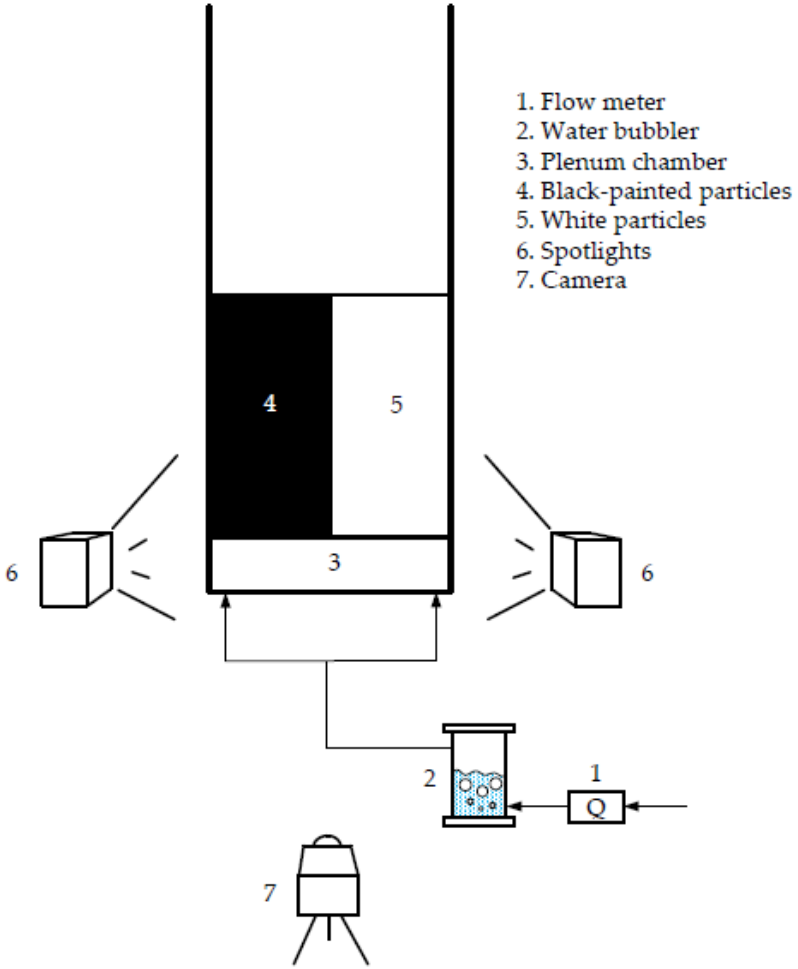
Mixing process



Randomly Mixed State

Table of contents

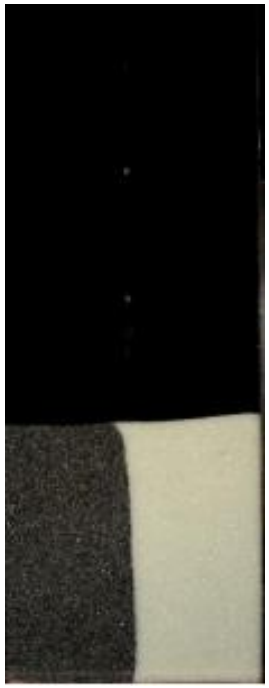
Experimental setup: pseudo-2D fluidized bed



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, ρ_s (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 process

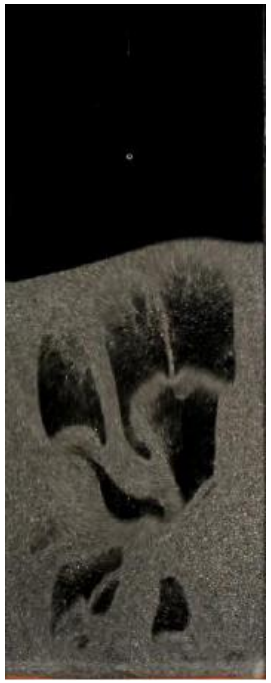
Mixing index

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

Lacey index

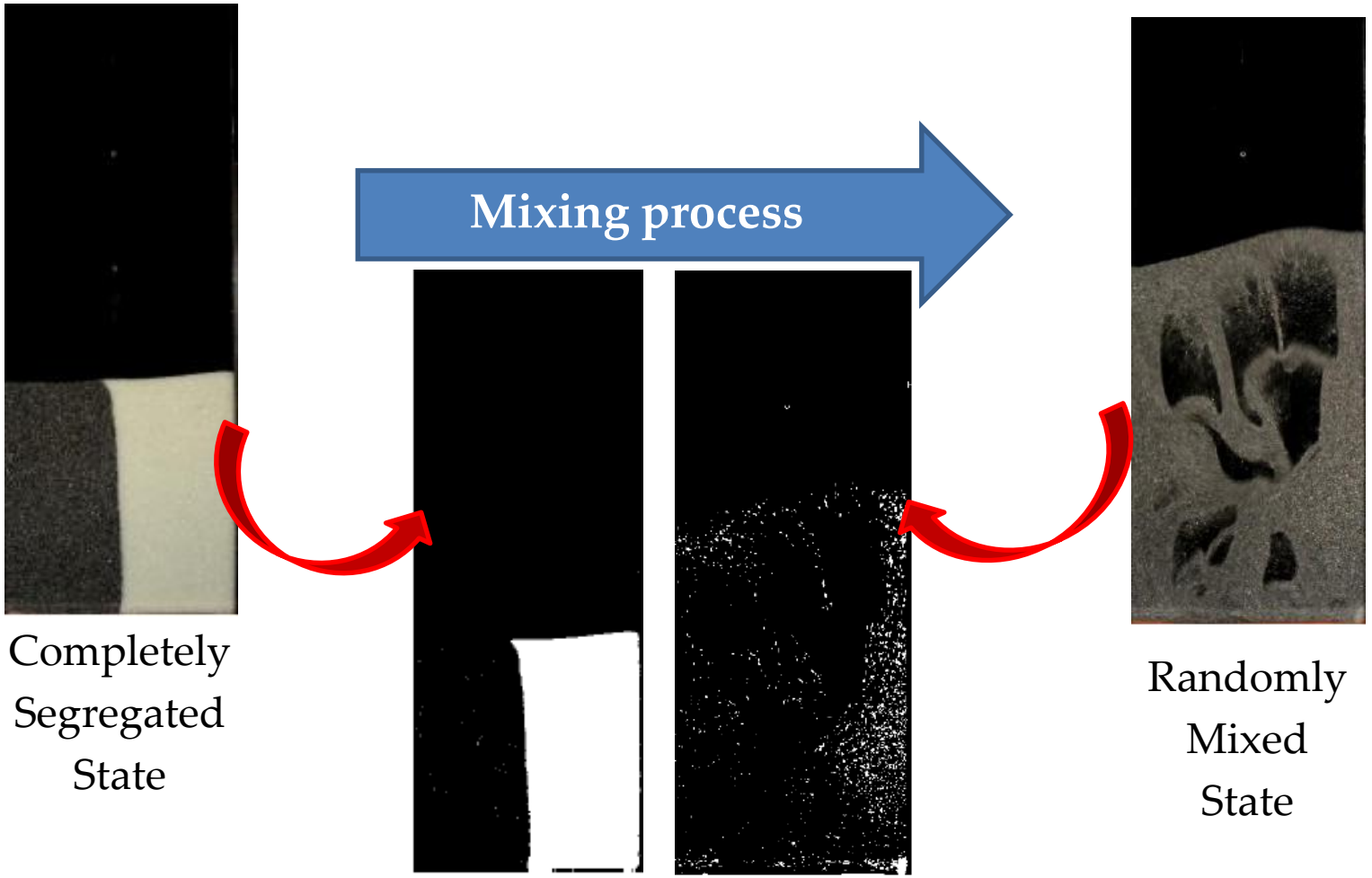
$$C^* = 1 - \frac{A_{w,i}}{A_{w,max}}$$

Proposed mixing index

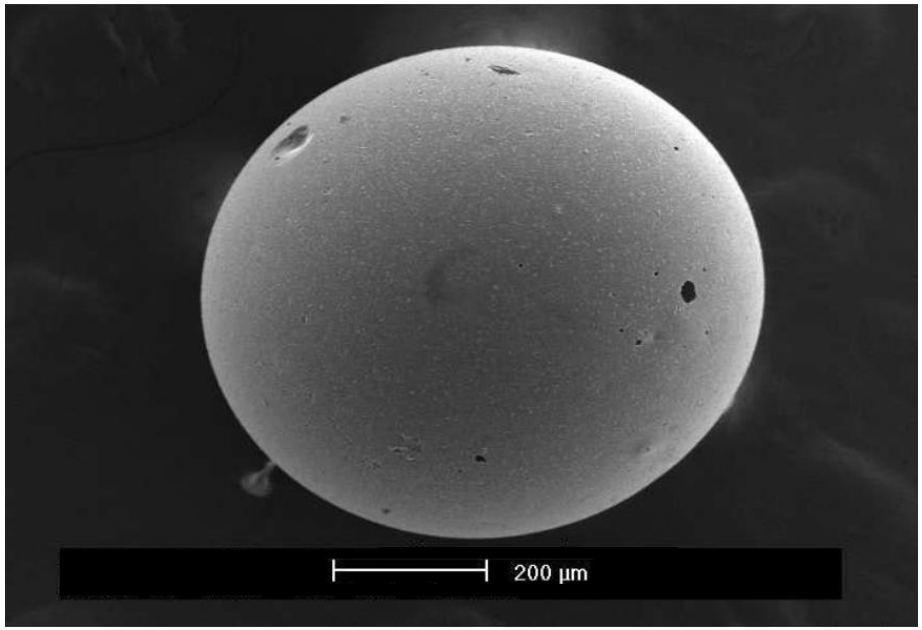


Randomly Mixed State

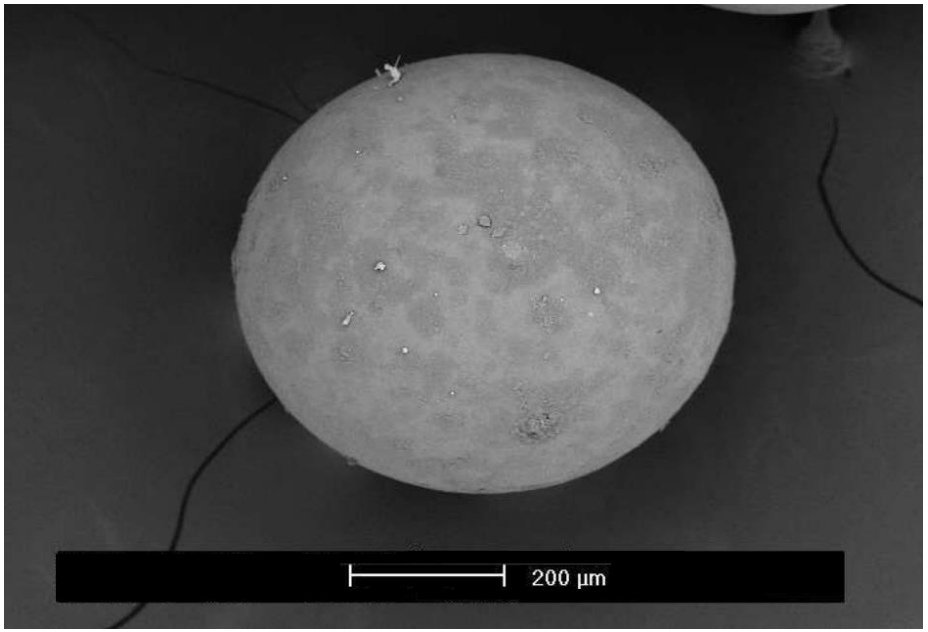
- Lateral solids mixing in fluidized beds



❑ Painting technique description



Non-painted particle

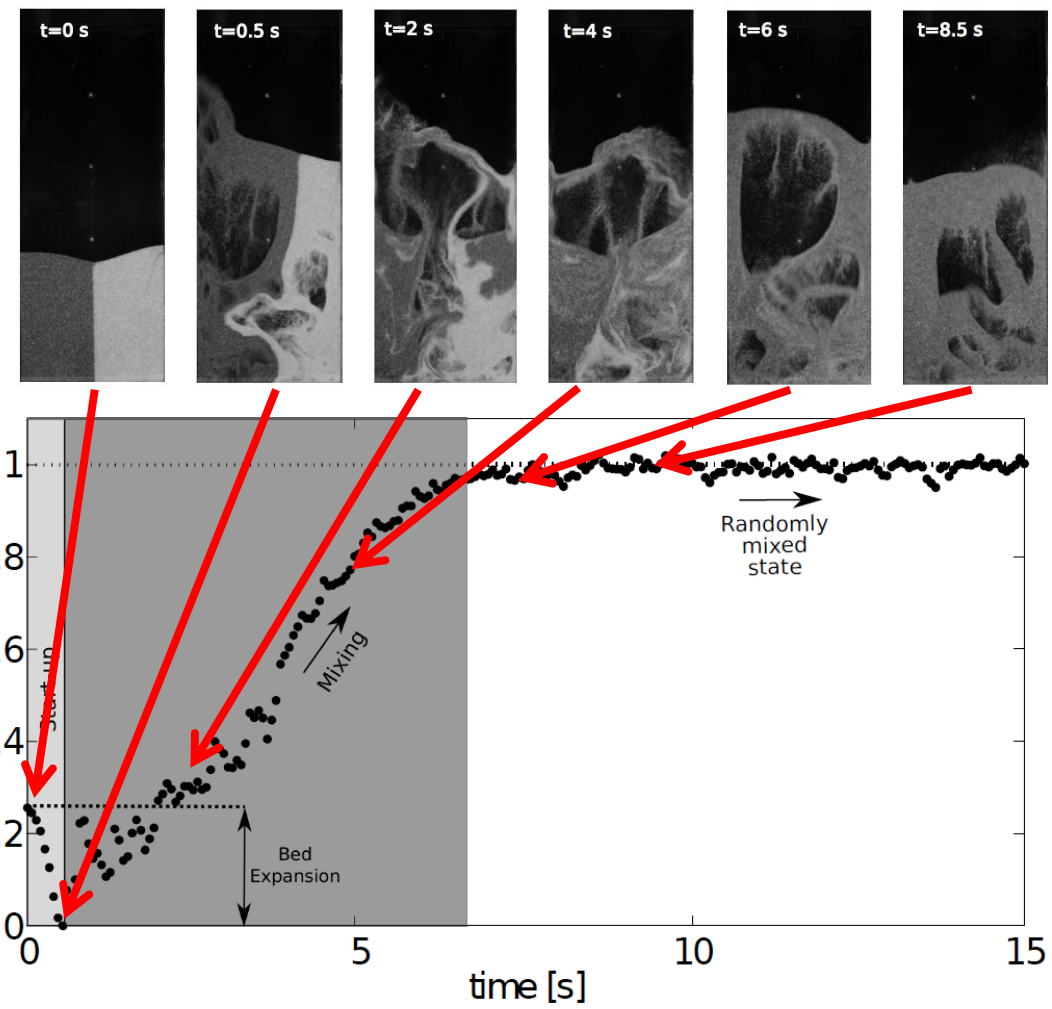


Black painted particle

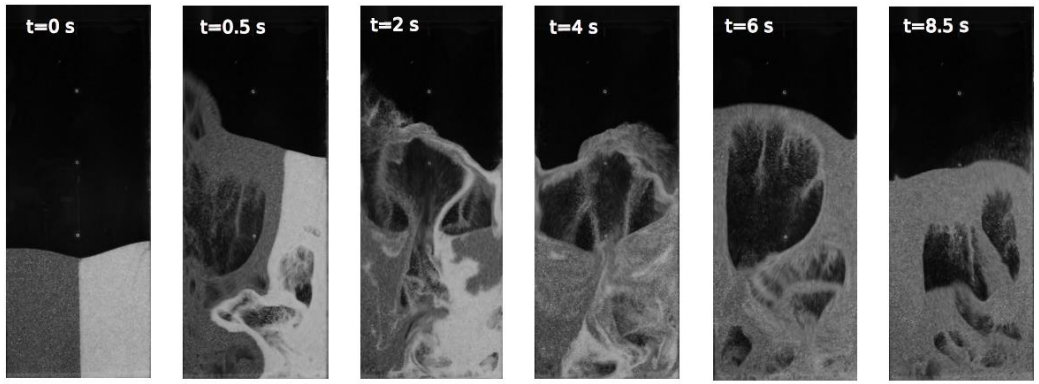
- The painting technique does not change the shape of the bed material

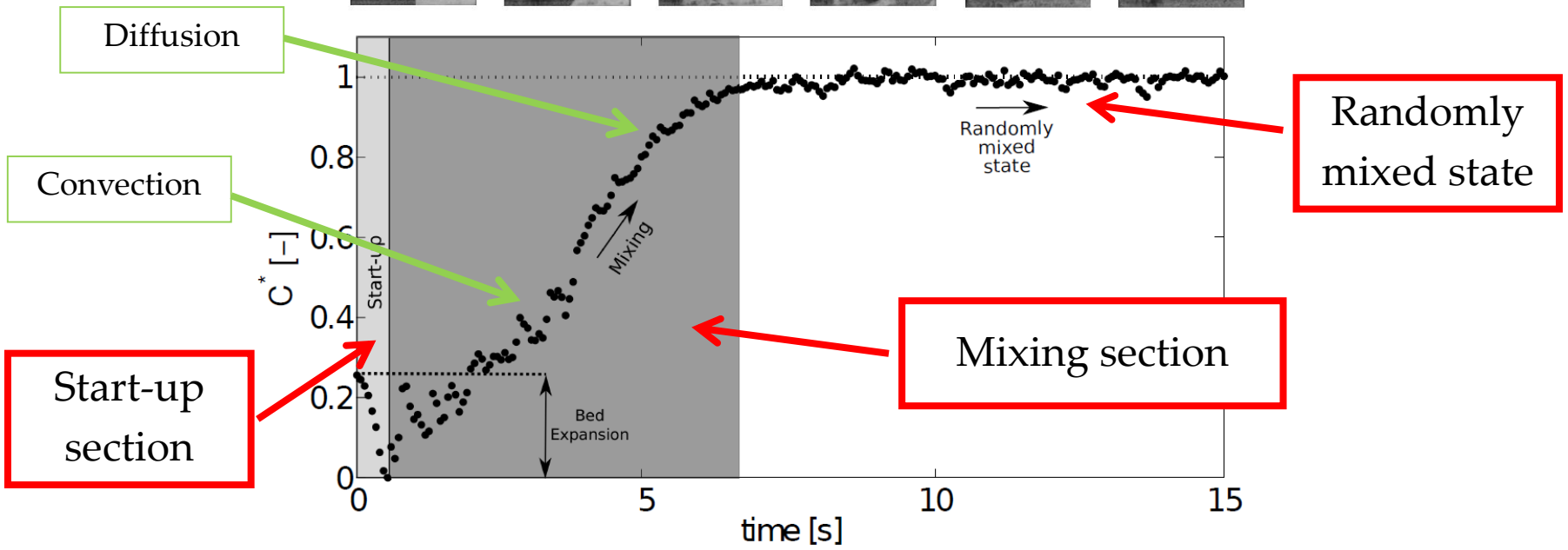
Table of contents

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

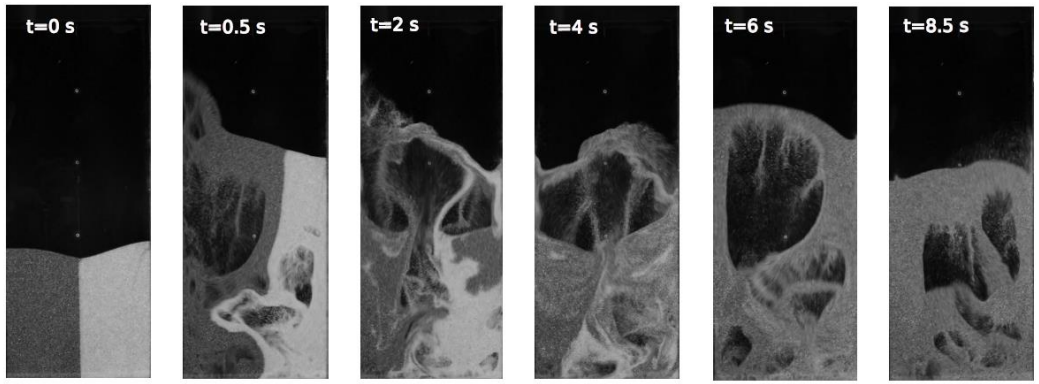


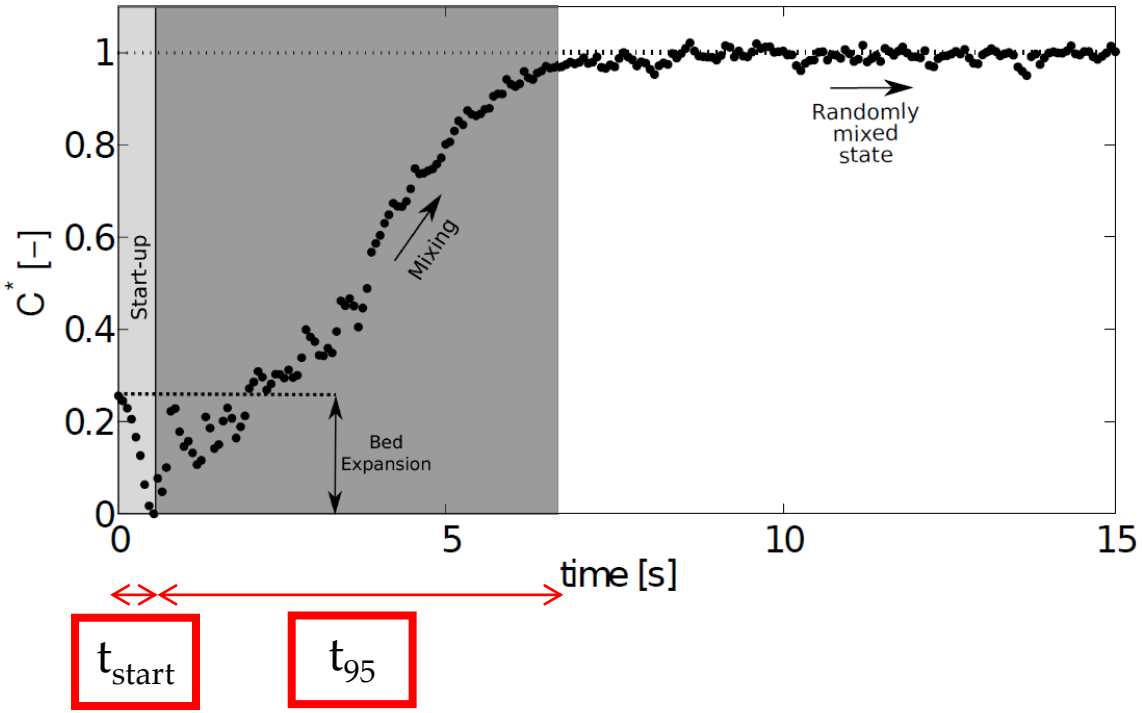
$$C^* = 1 - \frac{A_{w,i}}{A_{w,max}}$$



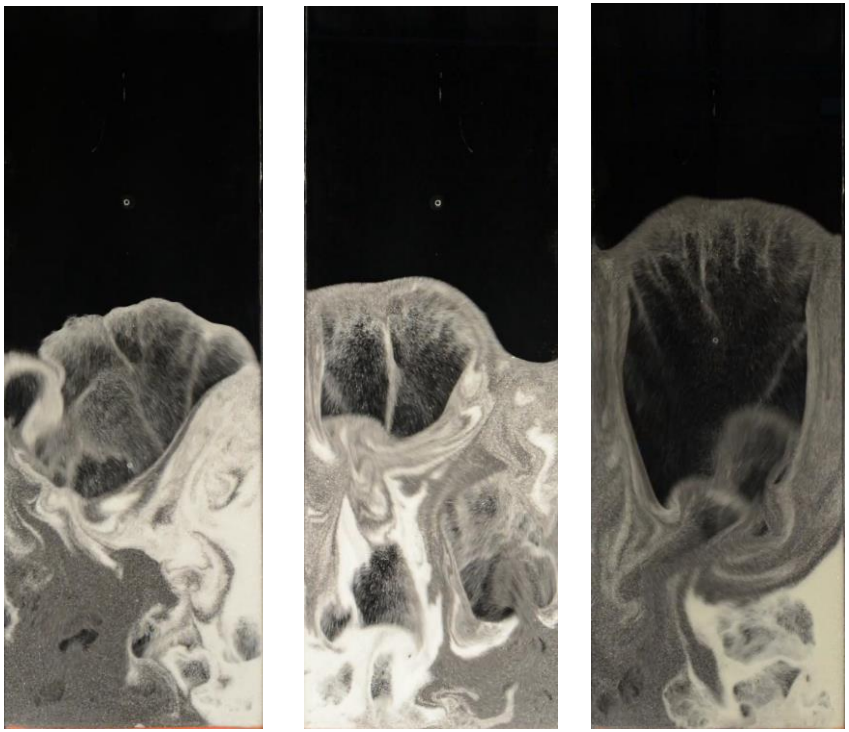


$$C^* = 1 - \frac{A_{w,i}}{A_{w,max}}$$

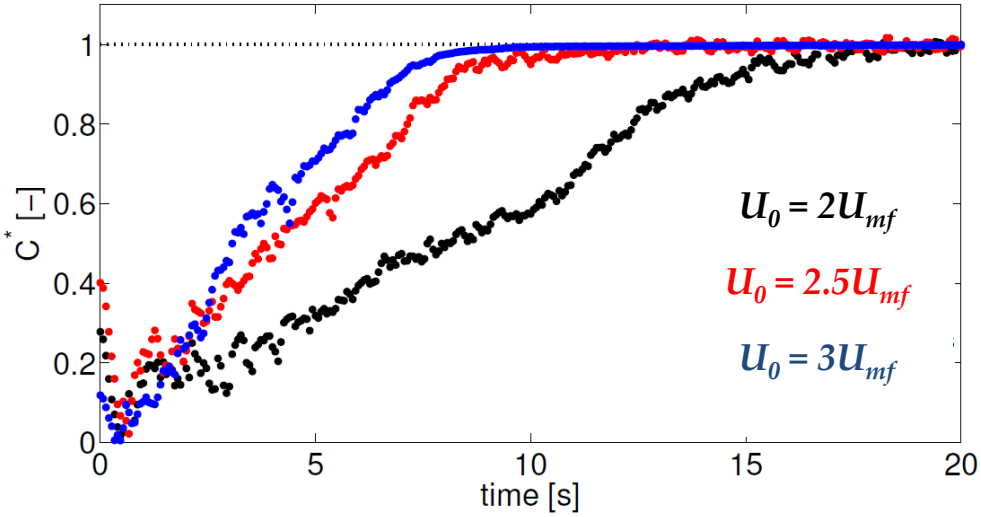




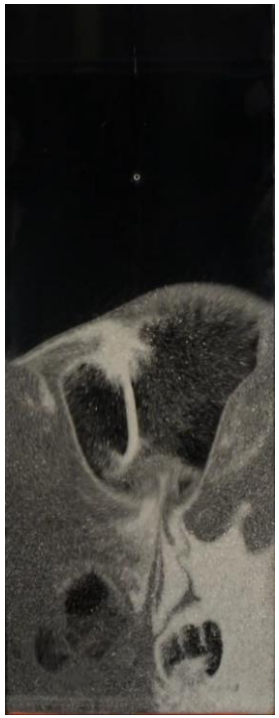
- Small particles (d_p = 0.4-0.6 mm)

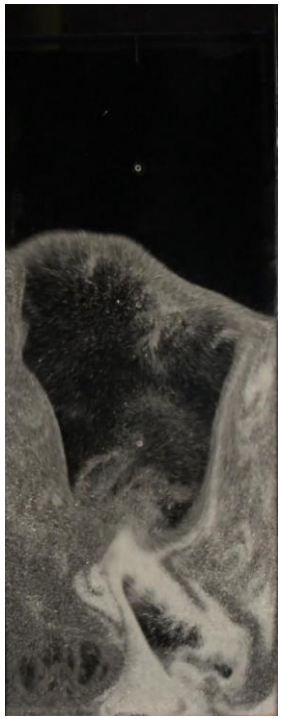


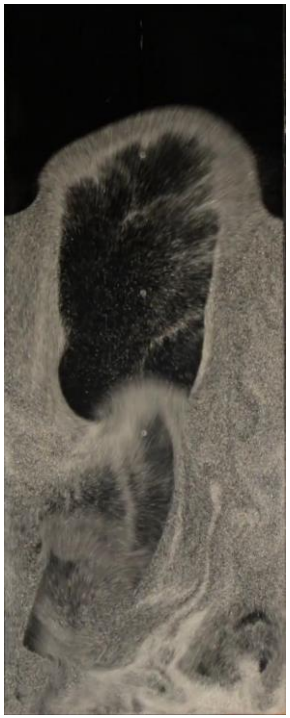
$U_0 = 2U_{mf}$ $U_0 = 2.5U_{mf}$ $U_0 = 3U_{mf}$

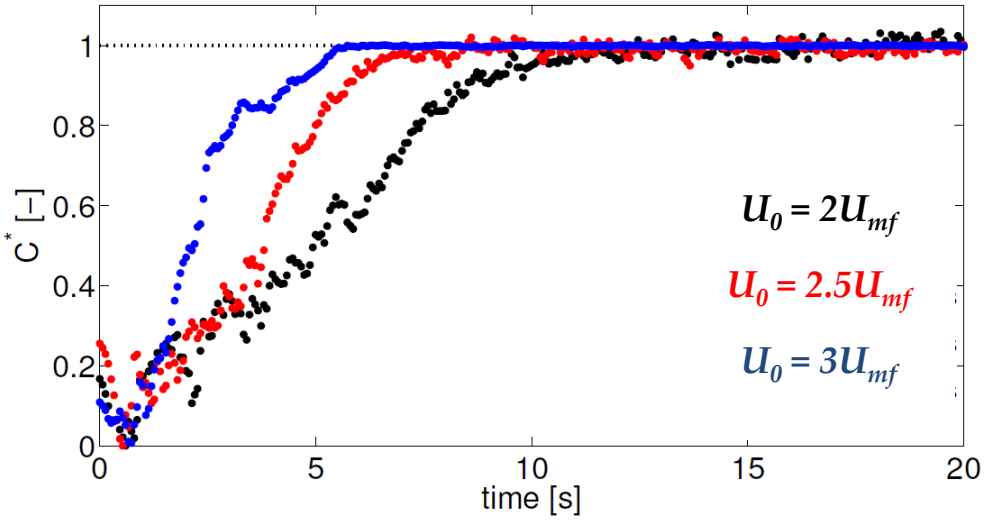


❑ Medium particles (d_p = 0.6-0.8 mm)



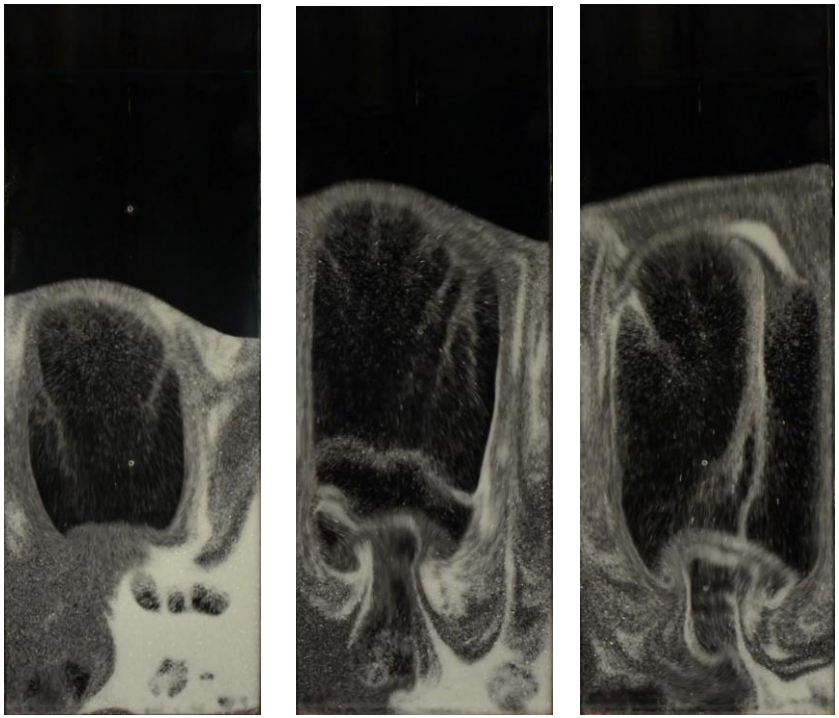




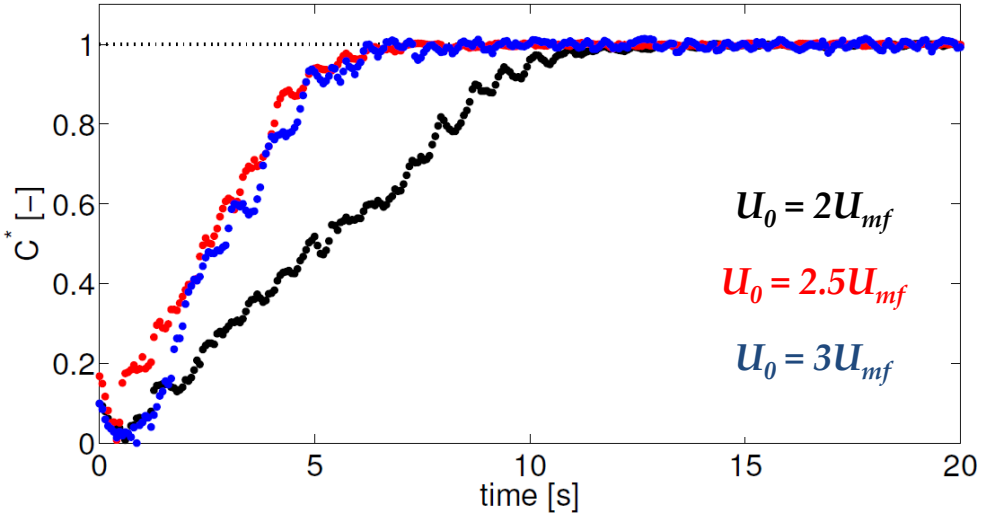


$U_0 = 2U_{mf}$ $U_0 = 2.5U_{mf}$ $U_0 = 3U_{mf}$

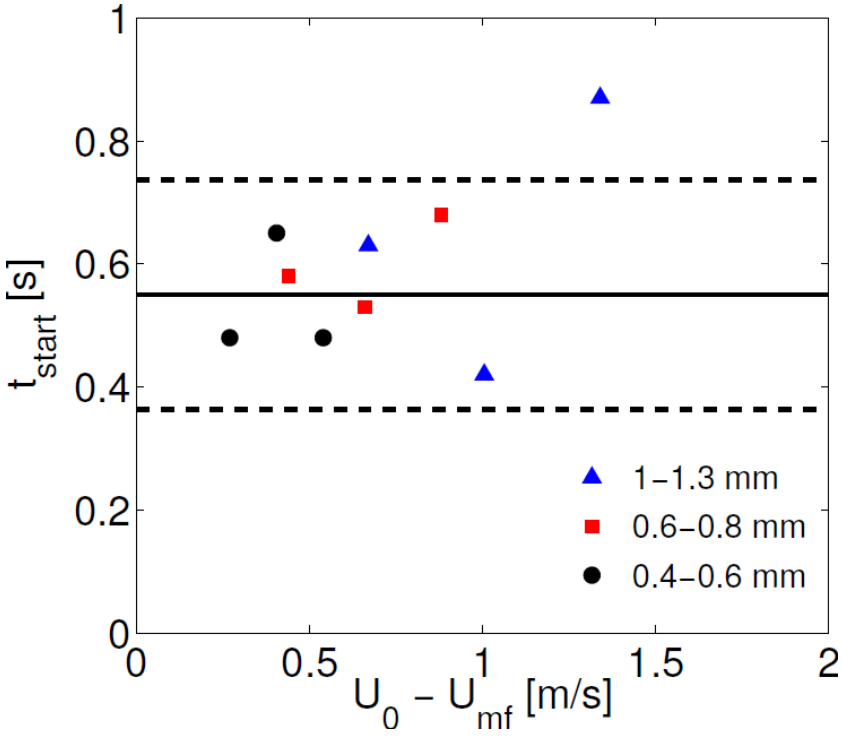
- Big particles (d_p = 1-1.3 mm)



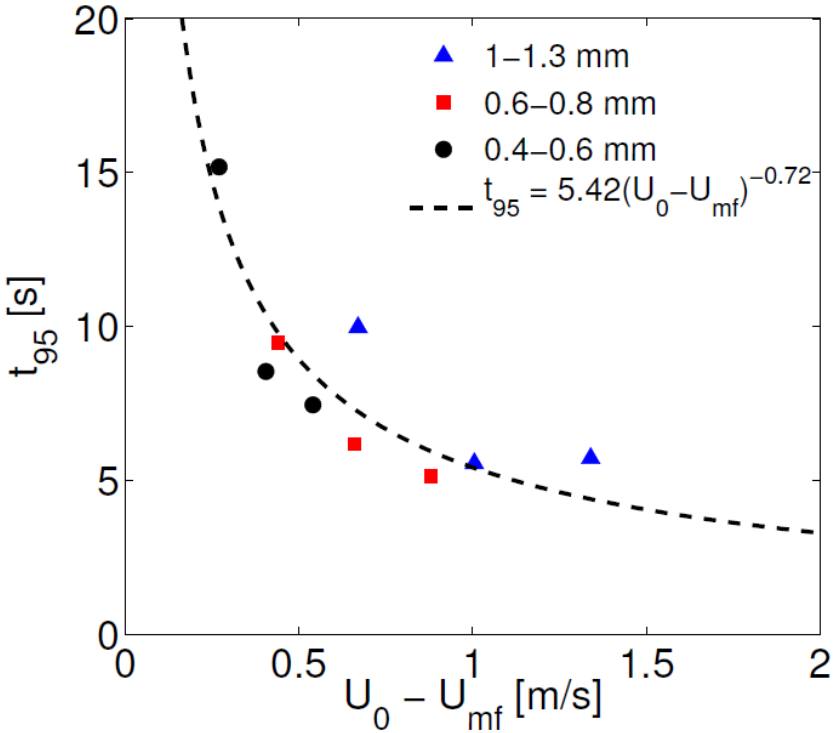
$U_0 = 2U_{mf}$ $U_0 = 2.5U_{mf}$ $U_0 = 3U_{mf}$



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



Start-up time constant



Potential relation for the mixing time

Table of contents

- 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.

Energy Systems Engineering
Research group

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

Thank you for your attention