# Frisedrum: a new mobile bed heat exchanger for cooling applications

François Rioual, Rihab Khirallah, Paule Emmanuelle Eva Gbehe

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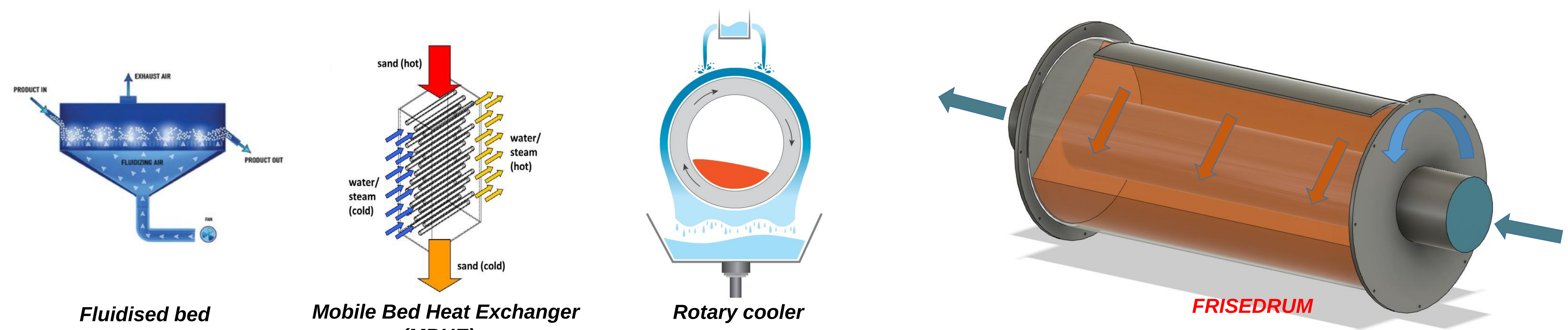
P041

# Frisedrum: a new mobile bed heat exchanger for cooling applications

**Paule Emmanuelle Eva Gbehe** (2), **Rihab Khirallah** (1), **and François Rioual** (1,*)

## INTRODUCTION

- **How to efficiently cool a granular material ?**
- This is a scientific and technological challenge in numerous fields of the agrofood and bio-energy industry where fluidised beds, gravity driven mobile bed heat exchangers and rotary coolers are commonly used.
- We propose a new kind of heat exchanger ***FRISEDRUM*** constituted by an axial pipe in a rotating drum partly filled of grains that has the advantage of being simple and compact with the aim of an improved energy efficiency.



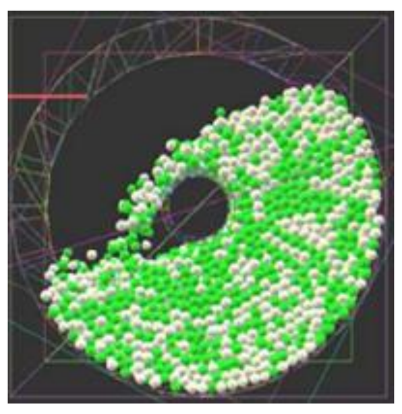
*Fluidised bed* *Mobile Bed Heat Exchanger (MBHE)* *Rotary cooler* *FRISEDRUM*

**Objectives:**

- Study the flow patterns around the pipe with respect to the main control parameters of the problem: Froude number, relative height and diameter ratio between the pipe and the drum
- Study the velocity fields and density fields around the pipe in the phase space that can lead to indirect informations on the transfer.
- Measure the average heat transfer coefficient in the phase space with respect to the flow and characterize effective transfer efficiency in our new device.

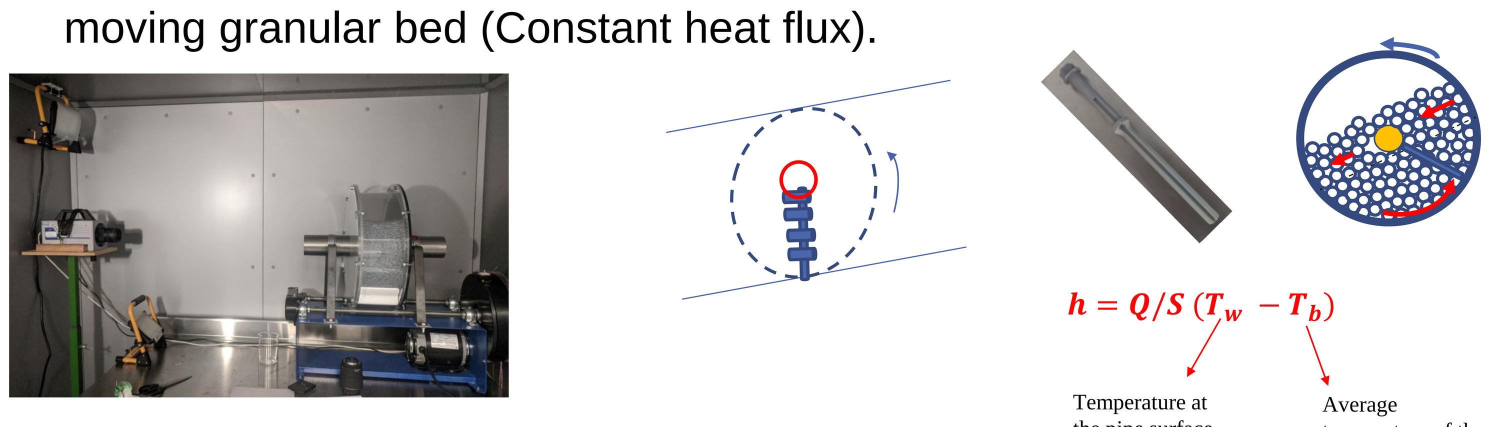
## MATERIALS AND METHODS

- Numerical simulations with the discrete element method (DEM) to model the granular flow in the original device
- Viscoelastic interaction law between particles



Analysis of the flow patterns
- Velocity field in the granular flow
- Numerical calculation of the velocity field around the pipe (20 bins, width $\pi/10$)
- Numerical calculation of the density field around the pipe (20 bins, width $\pi/10$)

- Experimental setup with glass beads, plexiglas boundaries
- Image analysis: Long exposure photography, Particle Image Velocimetry (PIV)
- Hot tube technique for heat transfer characterisation between the pipe and the moving granular bed (Constant heat flux).



$h = Q/S\ (T_w - T_b)$

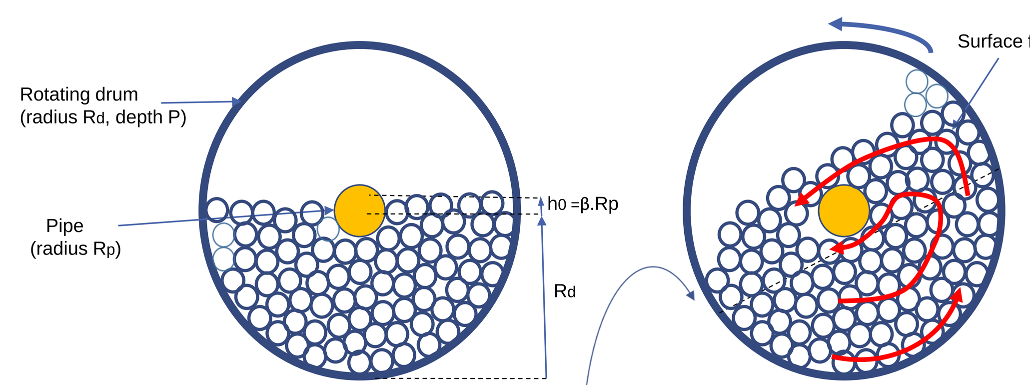
Temperature at the pipe surface — Average temperature of the beads

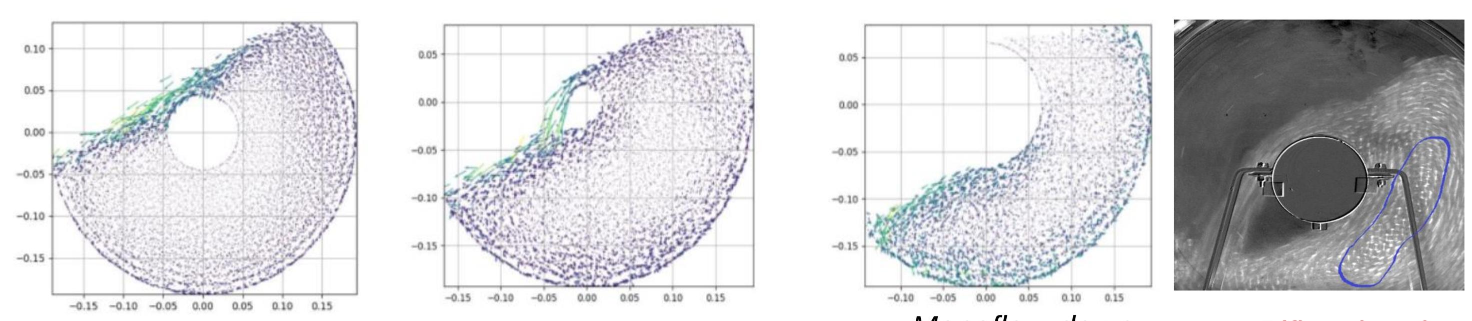
## FIRST RESULTS AND INTERPRETATION

3 control parameters:

Relative height of the packing: $\beta = h_0/R_p$;

Froude Number: $F_r = (R_d w^2)/g$ ; Diameter ratio: $\frac{R_d}{R_p}$

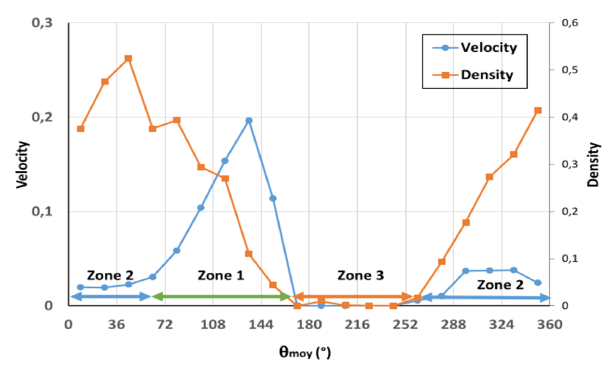


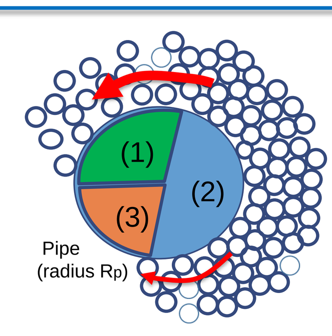



*Monoflow-up* *Biflow* *Monoflow-down* *Biflow (exp.)*

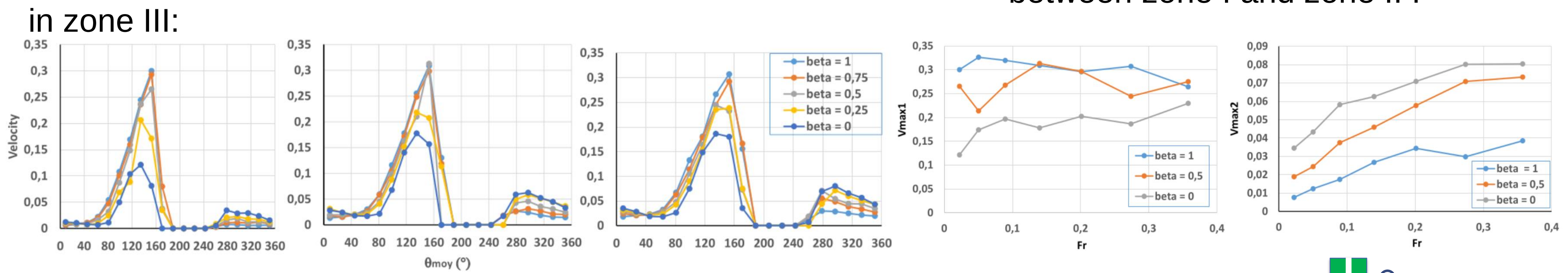
- Microstructural analysis in the *Biflow* regime

3 characteristic zones: zone I, zone II, zone III
Zone I: semi dilute, high velocity
Zone II: dense, quasistatic and low velocity
Zone III: depletion

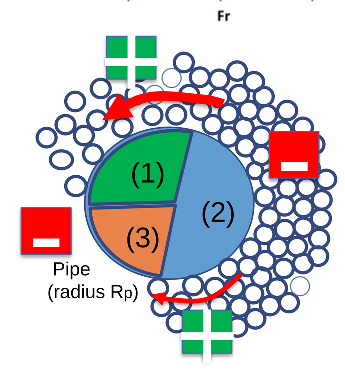



- Initial height has a crucial role in controlling the relative velocity between zone I and zone II and the width of the depletion zone in zone III:
- Two different mechanisms of transport between zone I and zone II :




- **Microstructural analysis in the «Biflow» regime**:
- Static zones are defavourable to transfers.
- Zones in depletion are defavourable to transfers.
- High velocities are favourable to transfers but local density plays also a key role >> Conclusion difficult




## PERSPECTIVES

- Next stage will be the thermal measurements of the temporal evolution of the bed temperature and the identification of the flow patterns which are associated to an improved transfer. For low conductivity ratio (particle/air) as for bio-sourced materials, transfer properties are unknown as indirect conduction properties through the air dominate direct contact heat transfer.
- Our long term aim is to propose a physical interpretation of the scenario of heat transfer mechanism around the pipe in our original device that can guide us to new paths for heat transfer enhancement.

(*) Francois Rioual (francois.rioual@inrae.fr)
(1) Unité de Recherche FRISE, 1 rue Pierre-Gilles De Gennes, 92160, Antony, France
(2) Universite Paris-Saclay, 3 rue Joliot Curie, Bâtiment Bréguet, 91190 Gif-sur-Yvette