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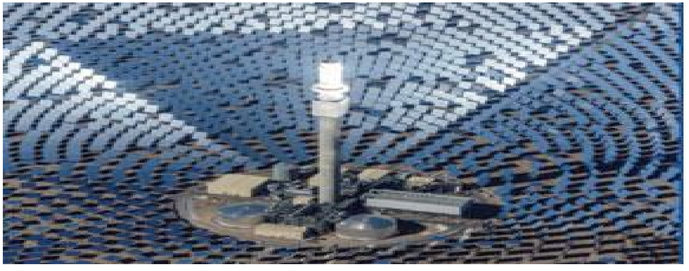

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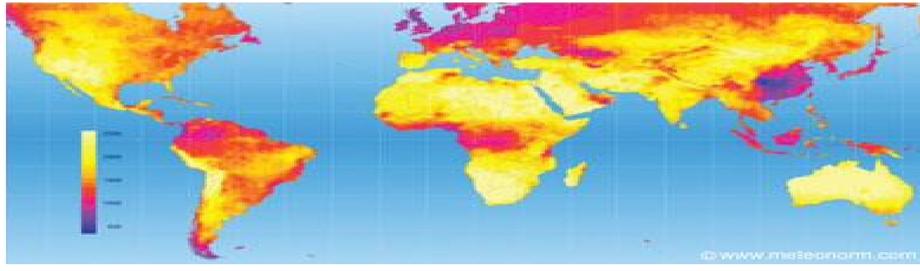

Particle Flow Heterogeneity in Fluidized-Particles Multitube Solar Receiver

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Context

- **Molten salt** is the commonly used heat transfer fluid in solar towers [1], but **has limited operating temperatures** (220-565 °C) that limit the efficiency of the power block to 42% [2].
- **To overcome this issue and reduce costs**, new particle receivers are under development worldwide as the **fluidized particle-in-tube** of the french National Center for Scientific Research.
- Tests at large scale of the Next-CSP H2020 project [3] with forty 3 m-long tubes (Fig.1) under concentrated solar flux revealed the existence of **heterogeneity in particle mass fluxes between the tubes**.
- One of the possible explanation is a difference in the air velocity due to **temperature heterogeneity** and the existence of an **interaction between the tubes**. A small cold mock-up was constructed to study the hydrodynamics and behavior of the particle suspension flow at PROMES laboratory.
- **Objective:** Represent this phenomenom at ambient temperature by injecting different air velocities inside a 2-tubes mock-up.

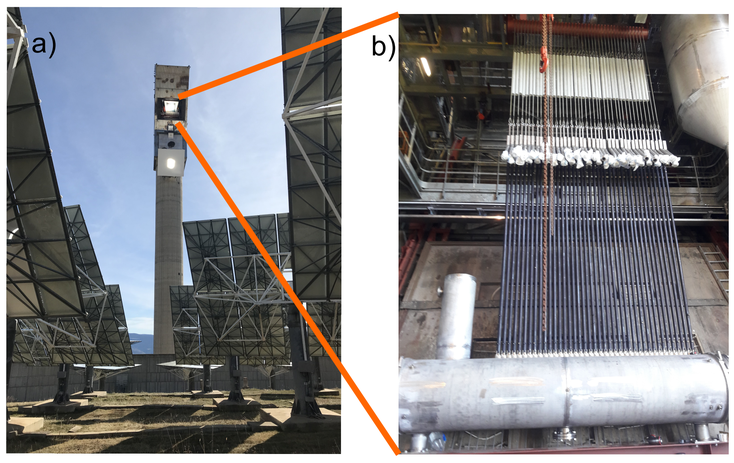

Fig.1: a) Thémis solar tower (Targasonne, France) with **b)** the Next-CSP fluidized bed 40-tubes solar receiver.

Methodology and Experimental Setup

- **Material**: olivine with a Sauter diameter of 61 µm (group A of the Geldart Classification)
- **Fluidization** in a dispenser thanks to a homogeneously distributed air flow rate. By applying an **overpressure**, the fluidized bed passes into two 3.70 m-long transparent glass tubes of 4.5 cm internal diameter and is collected onto two weighting devices to measure each **particle mass flux G_P**.
- A **secondary air flow rate q_{ae}** is applied at an injection nozzle of 1.5 mm diameter at the bottom of each tube. The particle volume fraction and the fluidization regime of the mixture in the tube is directly dependent on the air velocity in the tube [4].

- **Analysis method:** Particle mass fluxes G_P (in kg/(m².s)) of each tube are studied and compared for homogeneous and heterogeneous air flow rates injected q_{ae} (in sm³/h).

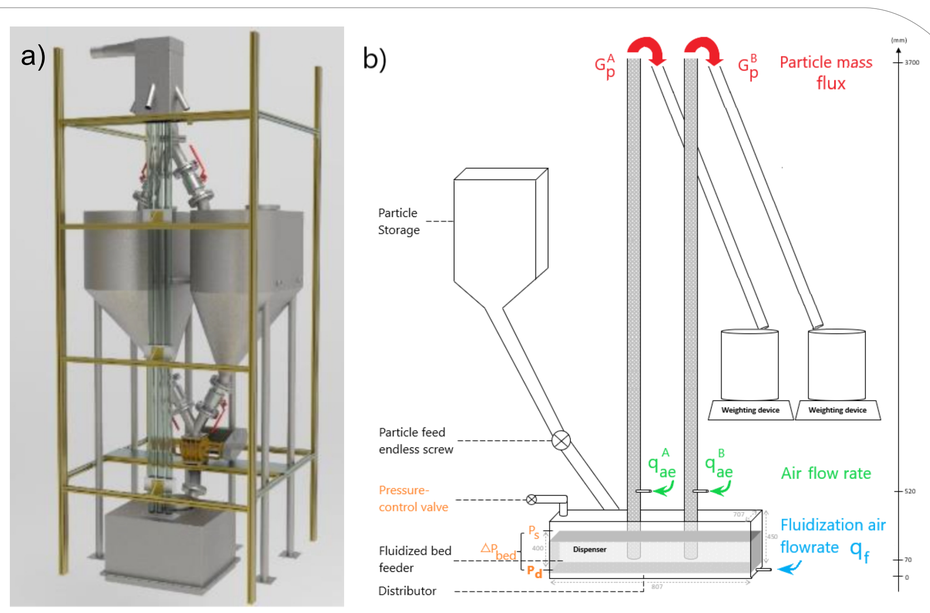

Fig.2: a) 3D and **b)** schematic of the two tubes cold mock-up.

Results

- Experimental tests were conducted as follows:
  - Same air flow rates q_{ae} for both tubes **A** and **B** (Fig.3.a) until the mixture flows (intervals 1-3).
    → **Same particle mass fluxes G_P** in the tubes (Fig.3.b).
    → The **pressure in the dispenser decreases** (Fig.3.c).
  - Then only the air flow rate of **tube A** is increased (intervals 4 and 5)
    → **G_P^A increases** while the **pressure in the dispenser decreases** and thus **G_P^B too**

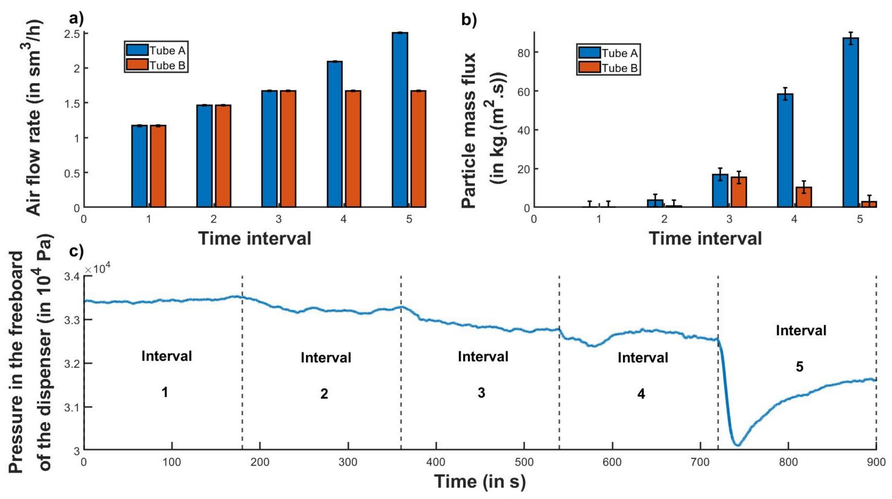

Fig.3 : Test 1 – a) Air flow rate (in sm³/h) and **b)** particle mass flux (in kg/(m².s)) for tube A (in blue) and B (in orange) for different time intervals. **c)** Pressure in the dispenser (in Pa) through time (in s).

→ Existence of an **interaction between the tubes**, through the pressure of the dispenser.

- An **increase of the total particle mass flux** leads to a **decrease of the pressure in the dispenser**, with a linear correlation as shown in Fig.4 for all conducted experiments.

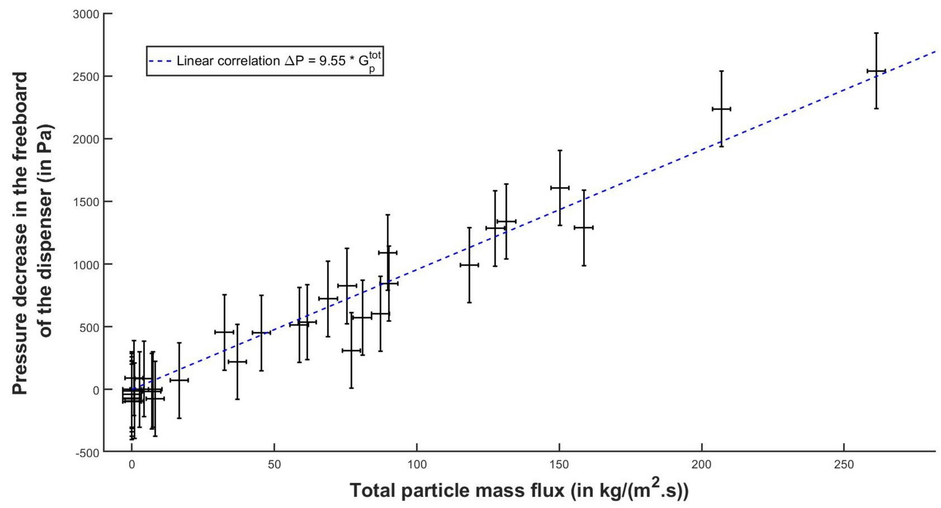

Fig.4 : Decrease of the pressure in the dispenser (in Pa) as a function of the total particle mass flux (in kg/(m².s)).

Conclusion

- **Different air velocities** in fluidized-particles multitube receiver lead to **heterogeneous particle mass fluxes.**
- An increase of air velocity in one tube increases the total particle mass flux that reduces the pressure in the dispenser with a linear correlation.
- The **other tube is impacted by this diminution of pressure** and its particle mass flux decreases.
- This interaction can create a **circulation stop** in some cases, that has to be taken into account to prevent risks for an industrial application.

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