Gas-Particle Interactions in a Microgravity Flow Cell

Michel Louge and James Jenkins
Cornell University

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Motivation:

Employ μgravity to study the essential
physics of pneumatic transport
without inertial fluid forces

Under Earth gravity:

- Particle entrainment requires large drag:

$$Re = \frac{u\rho d}{\mu} \sim 1.5 \left(\frac{\rho_s \rho g d^3}{\mu^2}\right)^{0.5} \;;$$

for 200μm plastic spheres in air, Re ~ 30.

- The suspending gas stream is inertial:

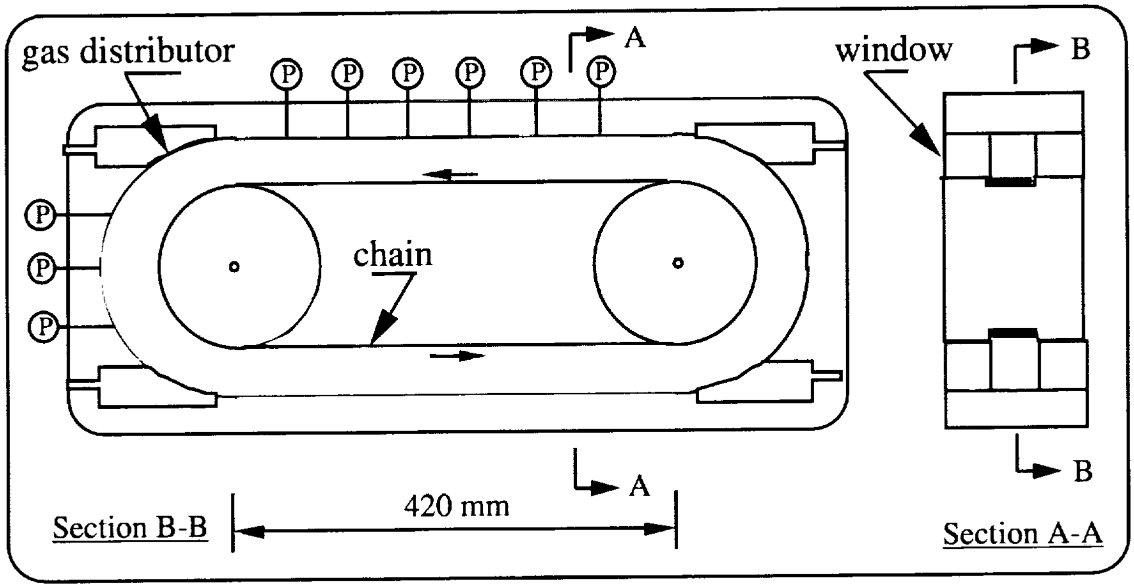
$$Re_{pipe} \bullet 100\, Re \sim 3000.$$

- Grain agitation is not set independently.

Instead, we seek:

Random viscous fluid flow
with random inertial granular flow.

Apparatus



- use metal spheres to avoid electrostatics;
- closely-spaced bumps on both boundaries to energize the grains;
- measure •p to balance gas introduction;
- grains observed through windows.
- modify the existing μgSEG design;
- use smaller 1mm spheres.

Study the role of the gas

Simulations of Sangani, Mo, Tsao and Koch, *JFM* (1996).

Simple shear, no mean relative velocity, low particle Reynolds number = $\rho \gamma d^2 / \mu$.

Effects of the gas/Stokes number St ~ $\gamma \tau$ with particle relaxation time $\tau = \rho_s d^2 / 18\mu$.
In our tests, the shear rate is $\gamma \sim U/Y$.

The gas affects the grains for
$St < St_c \sim 23$ to 45.

For steel beads of 1mm:

U (cm/sec)	Re	St
1	0.03	10
10	0.3	90

The apparatus permits us to create values of St across the critical value St_c predicted by Sangani, Mo, Tsao and Koch.

Benefits of microgravity

- Low velocities ∅ viscous fluid flow;
- control of granular agitation;
- forces ~ ρ/ρ_s in liquid suspensions are negligible in the gas (lift, added mass, history, contact lubrication).
- use of relatively large spheres.

Applications

- mining in reduced gravity;
- flows of gas-solid processes on Earth.