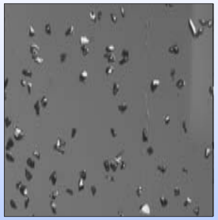
EXPERIMENTAL INVESTIGATION OF PARTICLE VELOCITY AND DRAG WITH SPHERICAL AND NON-SPHERICAL PARTICLES THROUGH A BACKWARD FACING STEP

Kyle Larsen, Dr. Dale Tree

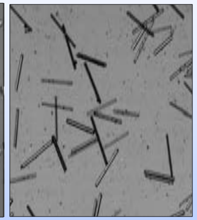
Background

Numerous investigations have been conducted to determine the gas phase velocity in a backward facing step for both laminar and turbulent flows. Furthermore, some studies have also been conducted to determine the velocity of various sizes of spherical particles in a backward facing step compared with their corresponding gas phase velocities. Few if any velocity measurements have been made for non-spherical particles.

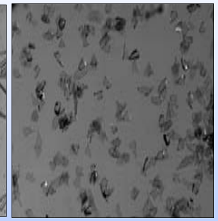
Understanding the slip and drag for spherical and non-spherical particles in a turbulent flow such as that in a backward facing step can provide valuable information on how to properly model these particles in various flow situations.



Gravel Shaped Particles



Cylindrical Shaped Particles

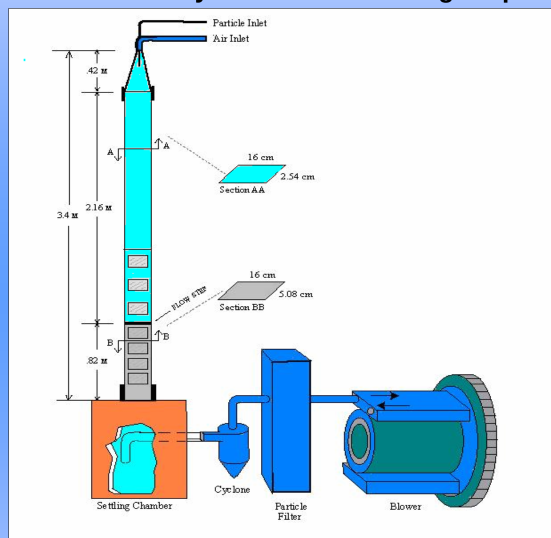


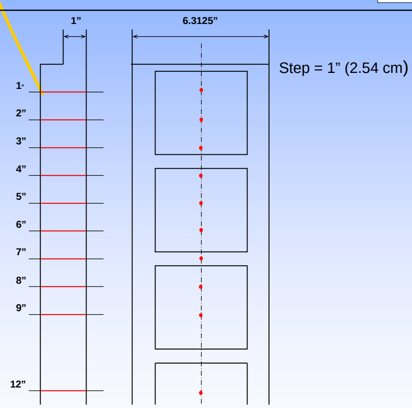
Flake Shaped Particles

Objectives

1. Measure the velocity and slip of various sizes and shapes of particles in a backward facing step using laser techniques.
2. Estimate the coefficient of drag for various sizes and shapes of particles in a turbulent flow through a backward facing step and compare these values to those in quiescent air with the same relative Reynolds number.

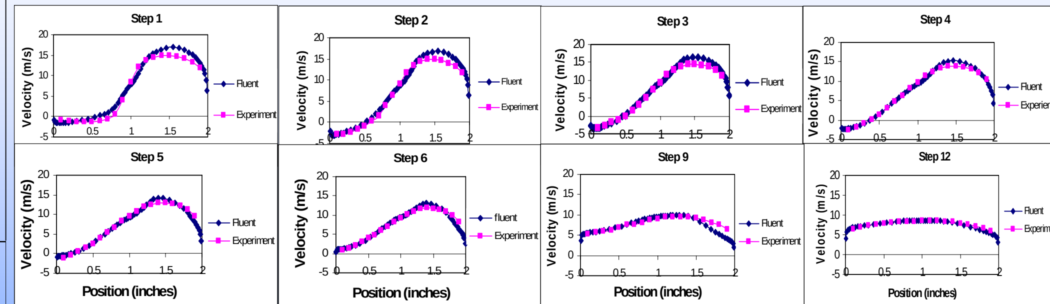
Research Facility – Backward Facing Step



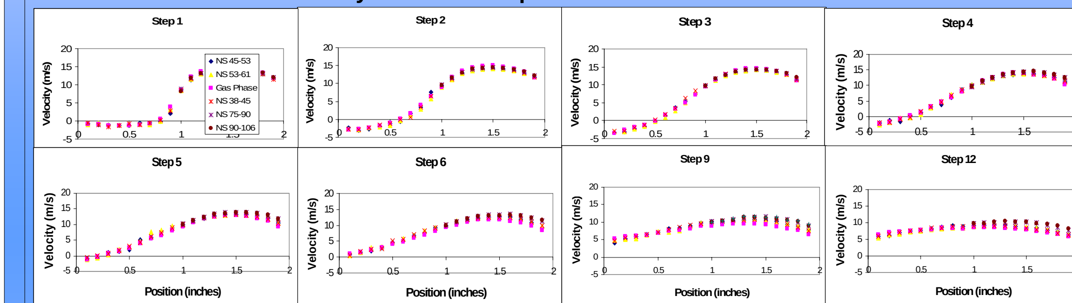


Step = 1" (2.54 cm)

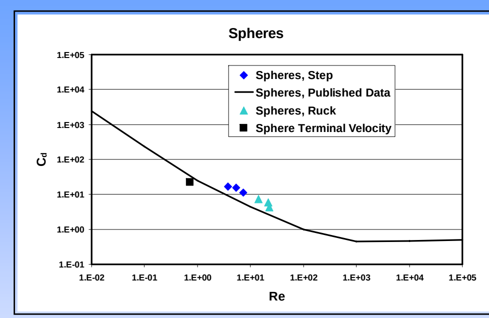
Gas Phase Velocity through a Backward Facing Step - Experimental versus Fluent Results

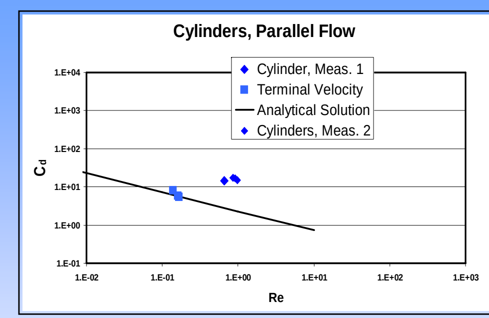


Velocity of Gravel Shaped Particles versus Gas Phase



Coefficient of Drag Results for Spheres, Flakes and Cylinders





Particle Momentum Equation used to Estimate the Coefficient of Drag C_d

$$m\frac{du_p}{dt} = \frac{1}{2}\rho(u_p - u_g)^2 C_d A$$

$$C_d = \frac{2m\frac{du_p}{dt}}{\rho(u_p - u_g)^2 A}$$

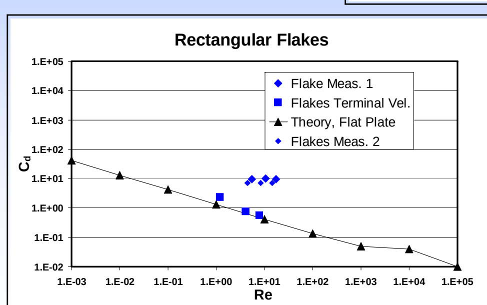
With:

$$du_p \approx \Delta u_p = u_{p2} - u_{p1}$$

$$dt \approx \Delta t \approx \frac{\Delta x}{\frac{u_{p2} + u_{p1}}{2}}$$

And:

$$\mathrm{Re}_p = \frac{\rho d_p |u_p - u_g|}{\mu}$$



Conclusion

Results from the graphs show that there is strong evidence that the drag coefficient of a particle is significantly larger in a turbulent flow than in quiescent air even though their relative Reynolds numbers are approximately the same. Consequently, current published values based on just Reynolds number significantly under-estimate the coefficient of drag for particles flowing in a turbulent medium.

Acknowledgements

The Brigham Young University, Department of Mechanical Engineering

Dr. Mardson McQuay

Dissertation Defense Committee: Daniel Maynes, Jeffrey Bons, Deryl Snyder, Brent Webb