A PRELIMINARY STUDY ON THE STABILITY OF PARTICLE LADEN JETS THROUGH A FULLY COUPLED CFD-DEM SOLVER

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Introduction

Jets are widely used in engineering applications. In material machinery, hydro-transportation systems as well as in chemical industry it is common to deal with a dispersed solid phase interacting with the jet, and therefore creating a so-called slurry jet or particle-laden jet. The stability of a jet is a key issue for many of these processes, still the underlying physics of this turbulent multiphase flow is highly complicated. Conventional CFD approaches have been proven satisfying for the study of the stability of two-phase jets. When a solid dispersed phase is present in the system, the stability problem gets more complicated and dependent on the solid phase dynamic.

Objective

A possible solution for the problem is to extend the CFD solver capability through a correct coupling with a DEM solver. In this work a preliminary investigation on the potentialities of this kind of approach is presented. In particular the effect of the presence of differently sized particles in the jet is outlined and the influence of particle properties and concentration is investigated.

The fluid phases are solved through an Eulerian finite volume (FV) multiphase solver based on the OpenFoam® libraries, and coupled with the XDEM code in order to treat the dispersed phase in a Lagrangian way.

Methodology: Fully coupled Multiscale Approach

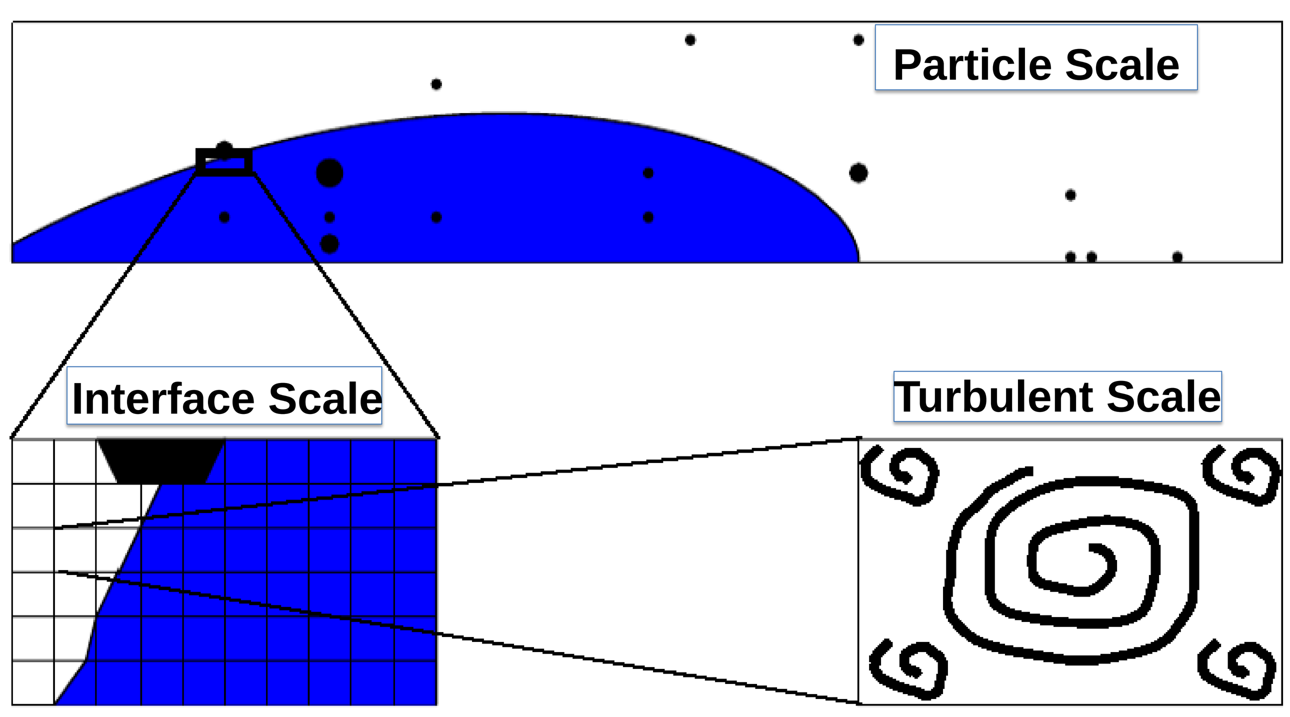
The physic of particle laden jets is dominated by three main phenomena:

- Particle Flow interaction
- Liquid interface dynamic
- Turbulent behavior of the fluid

Fluid-Particle Interaction

$$F_{sf} = \int_S \sigma_f \cdot n\, ds = \int_s \tau_f \cdot n\, ds - \int_S p \cdot n\, ds$$

A multiscale approach to the problem can represent a promising solution in terms of accuracy and computational costs. Three length scales are defined as: **The Particle, The Interface, and The Turbulent** scale respectively



Fluid filtered equations Solution

$$\phi_i = <\phi_i>_A + \phi'$$

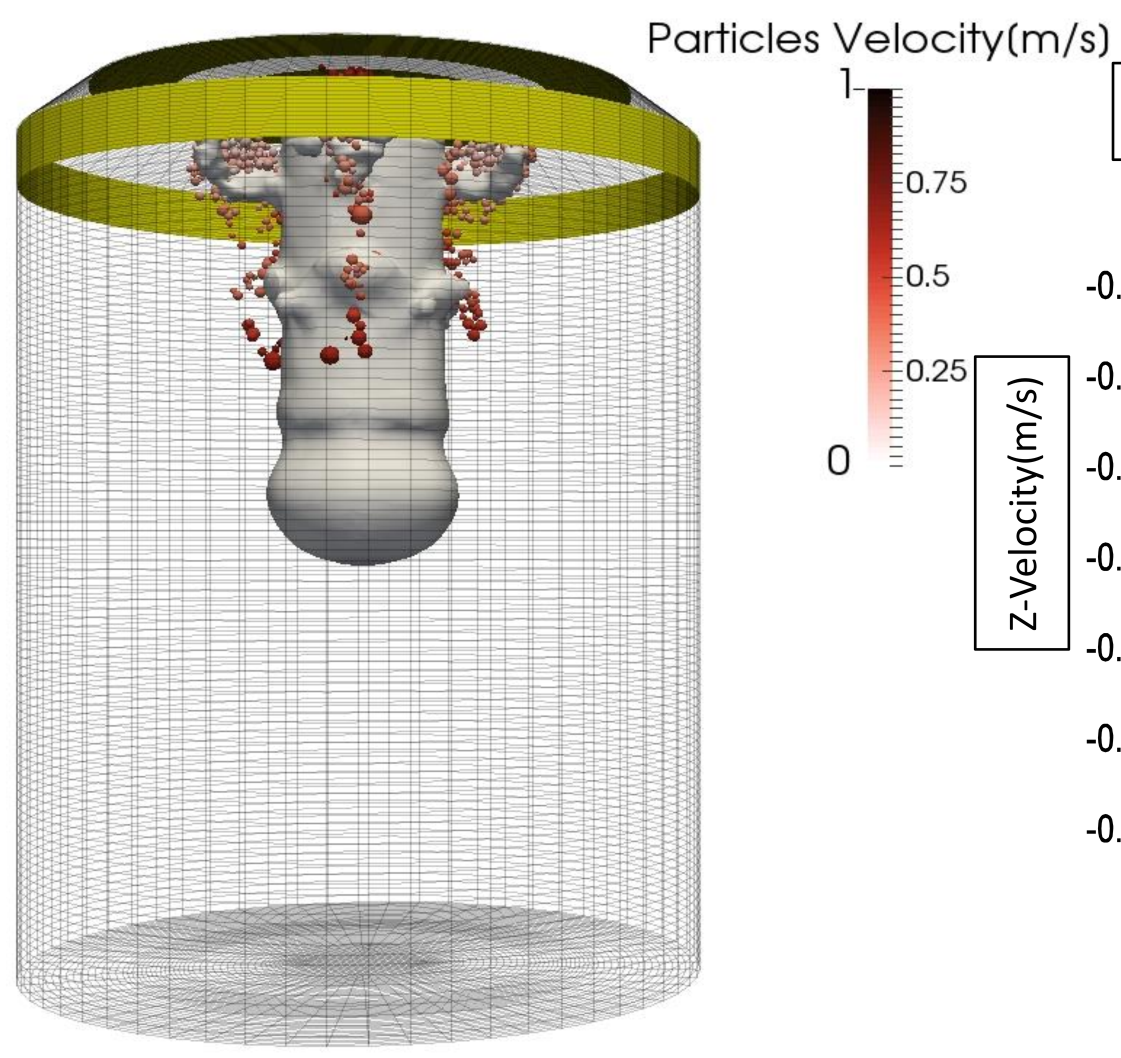
$$<\phi_i(x)>_A = \int_D \phi_i(x - x')G(x')dx'$$

Analytical Modeling of Turbulent Scale

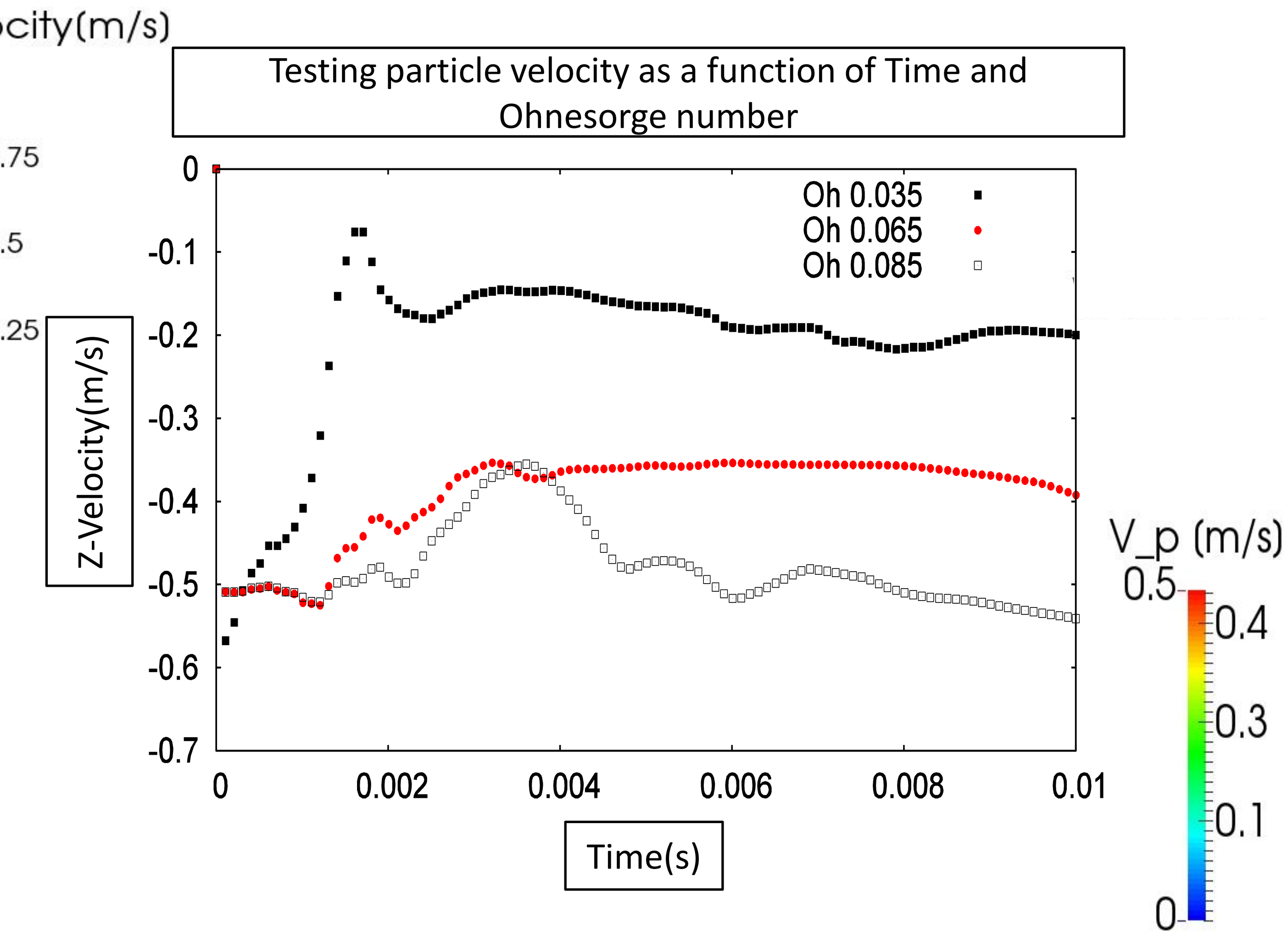
$$<\phi_i>_A = f(\phi')$$

$$\nu_t = \Gamma_v K_t^{\frac{1}{2}} \Delta$$

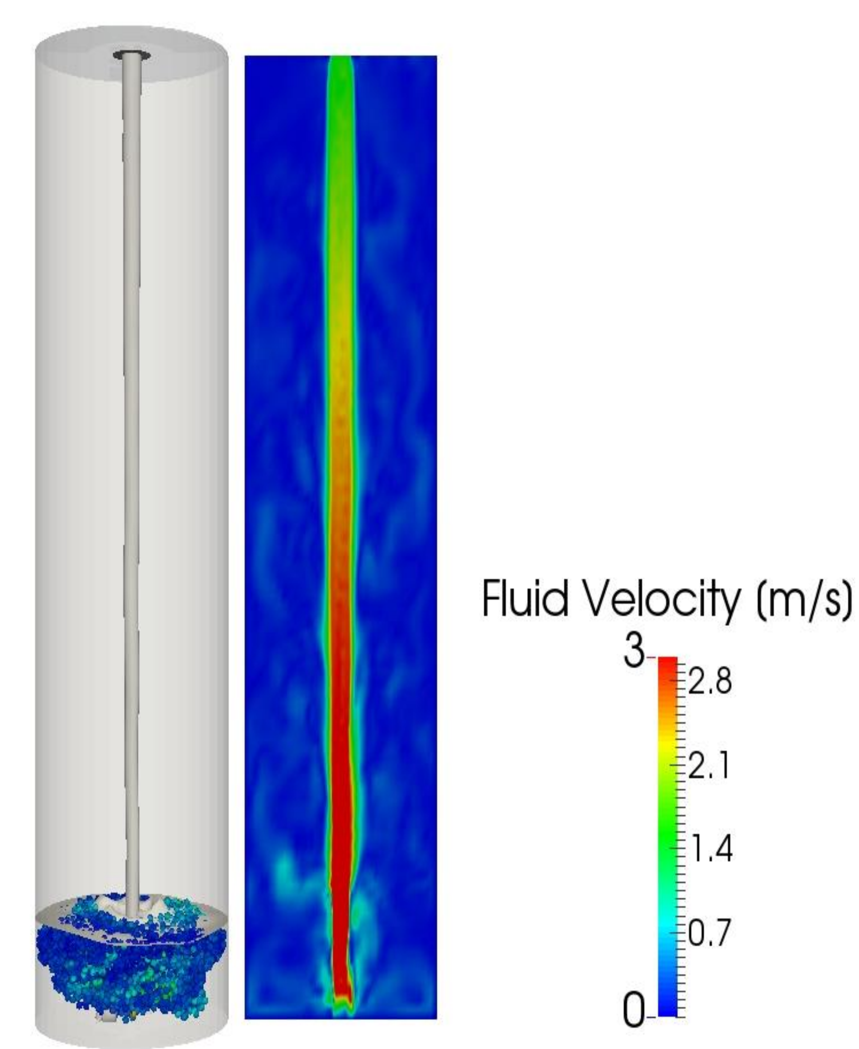
Numerical Results



Particles and Jet Concurrent injection



Influence of the Ohnesorge number on a particle Dynamic



Jet bumping into a particle Bed

Conclusions

- The fully coupled multiscale approach enables to take into account the influence of differently sizes of particles and to study secondary jet rupture phenomena as a function of particles concentration
- Separation and clustering phenomena can be captured and solutions can be provided for a wide range of Reynolds numbers.
- Mesh convergence of the fluid-dynamic problem can be ensured within the CFD-DEM coupling.

References

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