Unsteady discharge rate of granular materials out of a pressurized tank

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Abstract

The discharge rate of fragmented fuel materials out of a hypothetically failed nuclear fuel rod during a reactivity initiated accident determines the possible violent interaction between these fuel fragments and the surrounding coolant. This motivates the need for a deeper understanding of the driving force for discharge rate of gas and granular materials out of a tank. The current understanding of such discharge flow is still restricted to quasi-steady conditions. This problem is modelled by an experimental facility were the nuclear fuel fragments are replaced by spherical glass beads and the internal gases are replaced by air. The flow is induced from a pressurized cylindrical tank after the sudden rupture of an aluminum foil.

Experimental Results
The instantaneous flow rate of both gas and granular medium can be estimated from high-speed video camera and pressure sensors measurements. The comparison with a quasi-steady model for such discharge rate validated on former experiments shows that at the first times the inertial effects play an important role in the dynamics.
The granular jet at the outlet has successive instabilities. The analysis of their frequency and conditions of appearance allows us to propose a mechanism for their origin.
Numerical Model
The coupling of gas and granular flows plays an important role in such a discharge rate. The numerical simulation of this two-phase flow is still a challenge and we present the results obtained thanks to a continuous approach. Using the free software Basilisk [Popinet], we consider the transient time evolution of the gas pressure field through the silo to act as an additional drag force on the granular medium. The latter is described thanks to the so-called visco-plastic μ(I) rheology that already successfully modeled some steady discharge flows of gas and grains [Zhou].

Conclusions
This study proposes the analysis of the governing mechanisms for the sudden discharge of initially confined granular materials within a pressurized tank. Using experimental device and numerical simulation, one evaluates the relative role of inertia, gas-grain coupling in the instantaneous flow rate. We identify also an instability mechanism that can lead to spreading

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of the granular jet. Modeling of those processes will be extended to the nuclear safety related case of the ejection of fuel particles toward coolant.

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