Geophysical Research Abstracts
Vol. 17, EGU2015-12579, 2015
EGU General Assembly 2015

Study of dust re-suspension at low pressure in a dedicated wind-tunnel

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The atmosphere of several telluric planets or satellites are dusty. Such is the case of Earth, Venus, Mars and Titan, each bearing different aeolian processes linked principally to the kinematic viscosity of the near-surface atmosphere. Studies of the Martian atmosphere are particularly relevant for the understanding of the dust re-suspension phenomena at low pressure (7 mbar).
It turns out that operation of fusion reactors of the tokamak design produces significant amount of dust through the erosion of plasma-facing components. Such dust is a key issue, both regarding the performance and the safety of a fusion reactor such as ITER, under construction in Cadarache, France. Indeed, to evaluate the explosion risk in the ITER fusion reactor, it is essential to quantify the re-suspended dust fraction as a function of the dust inventory that can be potentially mobilized during a loss of vacuum accident (LOVA), with air or water vapour ingress. A complete accident sequence will encompass dust re-suspension from near-vacuum up to atmospheric pressure. Here, we present experimental results of particles re-suspension fractions measured at 1000, 600 and 300 mbar in the IRSN BISE (BlowIng facility for airborne releaSE) wind tunnel. Both dust monolayer deposits and multilayer deposits were investigated.
In order to obtain experimental re-suspension data of dust monolayer deposits, we used an optical microscope allowing to measure the re-suspended particles fraction by size intervals of 1 μm. The deposits were made up of tungsten particles on a tungsten surface (an ubiquitous plasma facing component) and alumina particles on a glass plate, as a surrogate. A comparison of the results with the so-called Rock'nRoll dust re-suspension model (Reeks and Hall, 2001) is presented and discussed.
The multilayer deposits were made in a vacuum sedimentation chamber allowing to obtain uniform deposits in terms of thickness. The re-suspension experimental data of such deposits were obtained thanks to a photovoltaic cell on which the alumina dust was deposited, taking advantage of the well-known loss of efficiency of dusty solar panels (e.g., Spirit Mars Rover before and after a "cleaning event"). The short circuit intensity of the cell being a function of the amount (mg/cm2) of dust deposited, it is possible to determine directly on-line the fraction of dust re-suspended during an experiment in the wind tunnel. Thus, we highlighted two kinds of mechanisms, with a transition region. Above a threshold and at each step increase of airflow velocity, a fraction of the deposit is quickly mobilised (in a few seconds). After a transition gap (approximately two minutes), a low linear increase of the re-suspension fraction is observed. This phenomenon is likely due to random bursts characterizing turbulent airflows. In addition, we brought to light a dust mobilisation mechanism by particle clustering, likely due to the adhesion forces between particles outmatching the adhesion forces between particles and the panel surface. These experimental data will allow to validate a re-suspension model for multi-layer deposits taking into account the effect of low pressure and of dust mobilisation by particles clustering.

Reeks, M.W. and Hall, D., 2001. Kinetic models for particle resuspension in turbulent flows: theory and measurement. J. Aerosol Sci., 32: 1-31.