Experimental data on particles re-suspension and adhesion forces for refining a re-suspension model – Application to the dust issue in ITER fusion tokamak

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During normal operating conditions of the future ITER tokamak, a massive production of dust coming from the erosion of the plasma facing components is anticipated. For safety reasons, it is essential to assess dust mobilization during a loss of vacuum accident (LOVA) in the vessel. In ITER, there will be principally polydispersed tungsten and beryllium particles deposited on surfaces. The aim of our study is to provide reliable data on particles re-suspension in well defined experimental conditions to assess reliability of the Rock'n Roll (R'nR) re-suspension model (Reeks & Hall, 2001), with polydispersed particles size distribution and low pressure airflow.

Here, we focus on the re-suspension of tungsten particle monolayer deposits by an airflow at 1000 and 300 mbar in the IRSN BISE (*BlowIng facility for airborne releaSE*) wind tunnel. The size distribution of the tungsten powder used is between 0.1 and 45 µm, as anticipated in ITER (see Rondeau *et al.*, 2015a). The monolayer deposits were made on a 16 cm^2 tungsten surface area by using a dry powder disperser. The particles size and number on the surface are measured with an optical microscope (Morphologi 3G, Malvern) before and after a ten-minute exposure of the deposit to the airflow in BISE. The re-suspended particle fractions are measured by microscope analysis on an area corresponding to a 10 mm diameter disc.

For each experiment in our wind tunnel, we controlled the parameters entering the re-suspension mechanism, namely the pressure P, the airflow velocity U and the friction (shear) velocity $u*$. In addition, the normal distribution of airflow fluctuations (f_{rms}), inherent consequence of a turbulent regime, were measured in BISE to fine-tune the airflow forces in the R'nR model ($f_{rms} = 0.07$ is found in BISE instead of the usual 0.2 for a fully developed turbulent air stream).

In figure 1, an average of three experimental results of particle re-suspension in BISE at 280 mbar ($Kn < 1$) is presented, since low pressure is to be considered in the re-suspension mechanism (Rondeau *et al.*, 2015b). The error bars on data represent one standard deviation of the measurements. To achieve comparison with R'nR model calculations, we used Biasi *et al.* (2001) adhesion forces correlation extrapolated with the surface energy of tungsten (4.4 $J.m^{-2}$). Otherwise, we directly measured by AFM (Atomic Force Microscopy) the distributions of adhesion forces of our system of interest (tungsten particles as involved in re-suspension experiments, on tungsten surface). Measurements yielded log-normal distributions with medians, as a function of particles diameter, lower than those of the Biasi *et al.* (2001) correlation. In figure 1, the experimental data are compared with the predictions of the R'nR model, either with the correlation of Biasi *et al.* (2001) or with our AFM measurements.

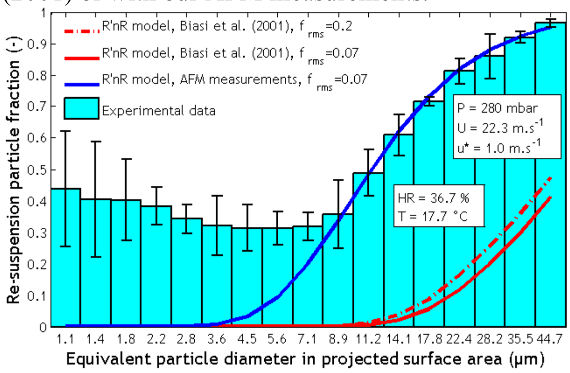

Figure 1. Comparison between experimental data of the re-suspended particle fractions (by size bin) and the R'nR model predictions.

The predictions of the R'nR model, as correlated by Biasi *et al.* (2001), are not in agreement with our experimental data. Indeed, the experimental fractions are higher than the predictions of the model. By running the R'nR model with actual adhesion forces, as measured by AFM, and the airflow forces fluctuation (f_{rms}), we obtain a good agreement with re-suspension data for the largest particles (diameter from 8.9 to 44.7 µm). However, re-suspension of smaller particles is not well described by the R'nR model, highlighting a limitation for polydispersed particle deposits. Their mobilization is probably due to collision with the bigger particles when the latter, detached from the surface, slip or roll.

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