Slip velocity measurement of particles inside a pleated HEPA filter

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Keywords: HEPA pleated filters, Shadow PIV, Slip velocity.

In nuclear industry, HEPA (High efficiency particulate air) filters constitute the last containment step before a potential release of hazardous matter in the environment. They ensure the collection of aerosols which are one of the main sources of contamination. Two parameters characterize a HEPA filter: on the one hand its efficiency, deeply studied in the literature, which is the filters ability to collect particles. On the other hand its airflow resistance which increases with the particle deposition on the surface of the medium along the pleat. Most of the experimental studies in the literature are focused on the medium scale or on the global pressure drop evolution; few of them are dealing with the phenomenon occurring at the pleat scale.

The prediction of this factor is essential to ensure the containment of contamination by avoiding imbalance in the ventilation networks or breaking of the filter in accidental situations especially in fire scenario. The IRSN has been conducting for many years research projects to predict the pressure drop evolution of pleated HEPA filters (Mocho and Ouf, 2011; Bourrous, 2014) in this domain.

Softwares are commonly used to simulate the different mechanisms which control the particle deposition on the medium surface along the pleats (Saleh *et al*, 2014) and then its clogging behaviour. However, they need an experimental validation to ensure the reliability of the predicted behaviour in a safety context.

To validate the numerical tools at the pleat scale, an experimental device has been developed to isolate pleats of HEPA filters used in the nuclear industry (Bourrous, 2014). The experimental study has been carried out following two steps.

Studying a clean filter has been the first step of this work. So, the flow within a pleat channel has been characterized using optical diagnostics (Shadow PIV) with flow tracer particles (DEHS particles with 0.01<St<0.03). The velocity field of flow through a clean pleat channel for different filtration velocities (figure 1) has been measured, on this basis; a comparison between these measurements and a CFD numerical simulation (ANSYS CFX) has been performed.

Measuring the particle velocity during clogging has been the second step. Using the same optical diagnostics principle, the slip velocity field of particles (alumina, 10µm, 10<St<30) against flow velocity has been measured. This should be fundamental information to predict the shape and the location of the particle deposit and may explain the formation of “bridges” at the pleats entrance which can cause surface reduction phenomenon.

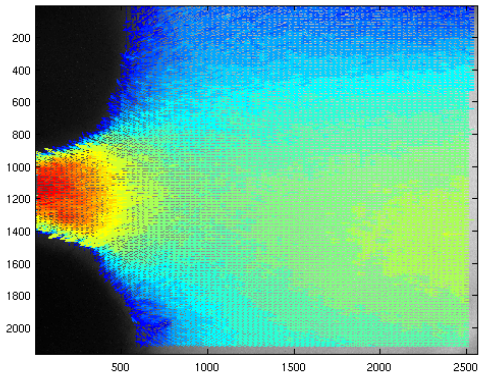

Figure 1 : Example of vector velocity field at the entrance channel of a HEPA filter pleat

These measurements will be the basis of the validation of GeoDict (software used in filtration) in terms of filters clogging with solid inertial particles. The ultimate goal is to use validated softwares to constitute sufficient data bank and to develop a predictive and phenomenological model for pressure drop taking into account all phenomena occurring in an accidental scenario at each influent scales.

This work is a part of a PhD project in collaboration with Math2Market GmbH.

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