# CFD modelling of aerosol deposition in ventilation ducts

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In nuclear facilities, ventilation is essential for ensuring the containment of radioactive materials. Nevertheless, in accidental situations like a fire, airborne particles (radioactive and soot particles) can be transported into the exhaust ventilation network up to the High Efficiency Particulate Air filters. Assessing the deposition of aerosols into the ventilation network allows determining the amount of particles that may reach the HEPA filters. As a result, it allows a better estimate of the filter clogging and of the potential release of radioactive particles into the environment.

In order to simulate the transport and the deposition of aerosols in a duct, CFD codes can be used. ANSYS CFX code is used at IRSN since a long time. Recently, aerosol deposition and transport models (Nerisson *et al*, 2011), based on a simplified Eulerian approach, have been implemented into this computer tool. These models were validated with experimental data of the literature that concerned smooth ducts with very low diameter (around 1 cm), representative of aerosol sampling lines and hence not representative of ventilation ducts. Therefore, the aim of this study is to first validate the models implemented in ANSYS CFX from experimental data obtained in the ventilation ducts, then to take into account the roughness of the wall in the model in order to quantify the effect of roughness leads to the calculation results.

For the first part of the study, the Sippola and Nazaroff's work (2004) has been retained. These authors studied the monodispersed fluorescein aerosol (particle diameter from 1 to 16 µm) deposition in a square section duct (15.2 cm x 15.2 cm) containing two straight parts and two horizontal and vertical 90° bends. Global deposition by section and local deposition (floor, vertical walls and ceiling) have been measured on test areas of 1.5 m length by using a fluorescence analysis for different flow velocities and aerosol diameters.

These experiments have been simulated with ANSYS CFX and the results compared to the experimental ones. As an example, Figure 1 compares the evolution of the dimensionless deposition velocity as a function of the dimensionless relaxation time of the particles for a straight duct. The comparison shows a satisfactory agreement for the global deposition. Nevertheless, significant differences have been highlighted for local deposition particularly onto downward surfaces (ceiling).

For the second part of our work, a sensitivity study on the influence of the wall roughness to the deposition has been carried out. To do so, the roughness had to be taken into account in the deposition model. The El-Shobokshy's model (1980) has been chosen, implemented into ANSYS CFX and validated on El-Shobokshy's experimental results (1983).

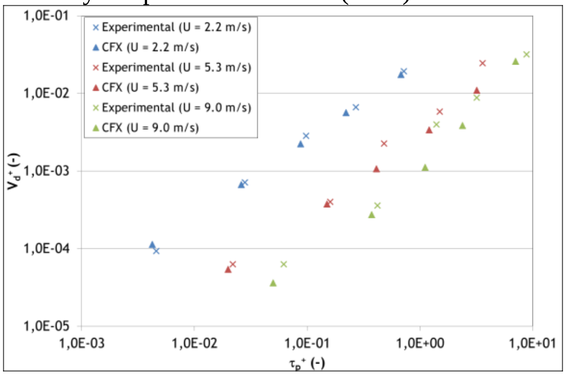


Figure 1. Comparison between numerical simulations and experimental measurements for a straight duct.

The model has then been used on the geometry of a future experimental bench representative of realistic ventilation ducts. This rectangular section (0.6 m x 0.4 m) bench is composed of several straight ducts and horizontal and vertical 90° bends. Two roughness values have been chosen, 10 µm and 100 µm, representing the roughness of stainless steel and galvanized steel respectively, and the simulation results have been compared to those of a smooth duct. It appears that for certain values of dimensionless relaxation time of particles, the deposition can be multiplied by a factor 4 for a roughness of 10 µm and by a factor 100 for a roughness of 100 µm.

In conclusion, this work has permitted to validate the deposition models implemented into ANSYS CFX as far as the global deposition is concerned, but it has highlighted some lacks for calculating the local deposition onto downward surfaces. Consequently, improvements have to be made to overcome this shortcoming. In a second part, a sensitivity study on the influence of the wall roughness has been conducted and has highlighted the need to take into account the roughness in the models even for low values (10 µm).

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