PhD position

Study of the resuspension phenomenon of realistic microparticles under accelerated airflow in HVAC systems: combined numerical – experimental approach

Research area: Aerosol Physics / Multiphase flows

Domain and scientific/technical context

For several years, and especially since the SARS-CoV-2 pandemic, Indoor Air Quality has become a major concern for populations due to sanitary and environmental reasons. The importance of exposure to airborne particles has clearly become a main concern for public opinion and scientists. It is also crucial for certain manufacturing industries, where airborne pollution can damage products (micro/nanotechnology, food and pharmaceutical industries…). Among the sources of indoor air contamination by particles are the Heating, Ventilating and Air Conditioning (HVAC) systems. The transport of particles (dusts, bacteria, industrial pulverulent products…) in those systems leads to particle deposition in duct walls, and the exposure of those deposits to airflows yields a possible particle resuspension phenomenon. In this context, understanding the resuspension constitutes a major challenge for reducing indoor pollution.

Targeted scientific and technical problems

The present topic addresses the study of particle resuspension induced by airflow in HVAC systems, focusing on fan start situations, i.e. accelerated airflow, as resuspension mainly occurs during such transient events. The French team has developed a time-resolved experimental methodology to depict the temporal evolution of resuspension through simultaneous measurements of fraction of particles remaining on the duct wall and airflow velocity close to the duct wall, by using deposits made from spherical particles. The Argentinian team has developed various Monte Carlo models for particle resuspension, including spherical particles under transient airflow and, more recently, irregular particles under constant airflow. The goal is to adapt these models to new particle deposits used in experiments and validate the assumptions with more complex morphologies, aiming to achieve more accurate and realistic models of the resuspension phenomenon.

Considered methods, targeted results and impacts

This research will involve experimental and numerical tasks. The experimental protocol developed by the French team to capture the temporal evolution of resuspension during accelerated airflow will be applied to new types of deposits. The challenge lies in generating deposits made from irregular microparticles, which have not been studied in previous resuspension experiments under transient airflow. Additionally, the focus will be on characterizing their morphological properties and the adhesion forces between particles and duct walls to determine accurate parameters for the Monte Carlo model. On the numerical side, the existing codes will be modified to account for particle shape and analyze how shape factors influence forces and lever arms, which differ significantly from spherical particles. This updated code will help validate theoretical assumptions by comparing them with experimental data, enabling a deeper understanding of how irregular particles interact with surfaces and air.

Environment
The PhD student will be supervised by IMT Atlantique (DSEE department) and San Luis University (Argentina). The experiments will take place at IMT Atlantique, where a wind tunnel facility is available and dedicated to resuspension experiments. This facility is also equipped with a Hot Wire Anemometry device to realize air velocity measurements. For physical and chemical characterization of deposits, adhesion forces measurements will be performed using Atomic Force Microscopy and, morphological parameters of particles (diameter, aspect ratio…) will be determined by Scanning Electron Microscopy at the IMN laboratory in Nantes. The Monte Carlo simulations will be conducted at San Luis University. The numerical algorithm will be written in C, allowing it to be compiled on standard computers without special requirements. Once the code is developed in San Luis, simulations can be executed at IMT Atlantique, incorporating any new experimental data obtained after the stay in Argentina.

This Phd position is a doctoral program part of the Marie Skłodowska-Curie Actions, a COFUND program co-financed by IMT Atlantique and the EU.

Profile required

The proposed topic involves both experimental and numerical approaches, and is at the interplay between Applied mathematics (Monte Carlo method), Physics of aerosol, Fluid dynamics, and Image analysis.
The pre-required skills and abilities are thus:
- Process engineering or Fluid Mechanics
- Some skills on aerosol physics would be a plus
- Numerical modelling, proficiency in C or similar programming languages
- Interest in experimental measurements

Eligibility conditions:
- not having resided or carried out their main activity in France for the last 36 months (from November 10th, 2021).
- being graduated of a M2 or equivalent diploma at the time of the enrollment (Spring 2025), not have been awarded a doctoral degree before and be an early-stage researcher (be in the first four years of a research career).

Information on the SEED program and conditions to apply
https://www.imt-atlantique.fr/en/research-innovation/phd/seed/application

Starting date: April 2025 (Spring)
Deadline to apply : 10th of November 2024
Application: only via the platform https://seed-apply.imt-atlantique.fr/

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