Inverse mass convection using an experimentally identified reduced model – case of a transient pollutant source in a turbulent air flow

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Introduction

Reduction of the chemical exposure risk in occupational environments requires the estimation of sources emission rates. When the magnitude of these sources is unknown, it is possible to consider an inverse mass convection problem where the output, the measured time-varying concentrations are used to estimate the transient emission rates of one or several point sources. Instead of using a CFD code to model the unsteady transport-diffusion problem with steady state aerodynamics, a linear reduced model of low order is constructed through tracing experiments. Once the model identified, unknown inputs are retrieved through the inversion of this forced mass convection model.

Context & assumptions

A method is proposed for estimating the time-varying strength of emitting sources of a contaminant in ventilated enclosures, through the resolution of an inverse forced convection problem using Reduced Models (RMs). In [1], this approach has been numerically tested and RMs have been built from simulations. In this communication, RMs are built from in-situ concentration measurements.

Unsteady transport-diffusion of pollutant is considered, with the assumption of a stationary velocity field that remains unchanged during emission (passive contaminant). Mass transfer is therefore linear with respect to concentration. The sources location is also supposed to be known.

Experimental model identification and inversion of measured concentrations

In a first step, a RM linking up a set of control points to emission rates of sources is identified using the Modal Identification Method (MIM) [1]. This parameter estimation problem uses transient contaminant concentration measurements made at control points, corresponding to increasing and decreasing steps of emission rates. Such an experimental modeling allows first to avoid dealing with approximations specific to CFD models (boundary conditions, turbulent diffusivity models, …) and, second, to get rid of uncertainties of sensors position (an experimental RM is built from data measured at real sensors location whereas a CFD model uses theoretical locations). In a second step, the identified RM is used to solve an inverse forced convection problem: from contaminant concentration measured at the same control points, rates of sources emitting simultaneously are estimated with a sequential in time algorithm using future time steps.

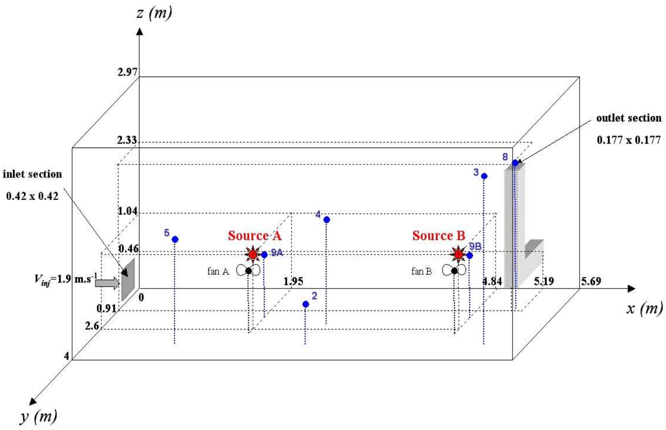

Figure 1. Tests: 2 sources and several sensors

Successful tests were run in a 70 m^3 ventilated enclosure with a 30 volume per hour air renewal rate. Inversion of two transient sources of either Helium-Argon or cyclohexane has been achieved using at least three sensors.

Future works will be devoted to the application of this method in occupational locations such as sewer networks where H_2S emissions occur.

References

[1] M. Girault, D. Maillet D, J.-R. Fontaine, R, Braconnier, F. Bonthoux, "Estimation of time-varying gaseous contaminant sources in ventilated enclosures through inversion of a reduced model", *International Journal of Ventilation* 4 (N°4), 2006, pp. 365-380.