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Simulation of size-dependent aerosol deposition in a realistic model of the upper human airways

E.M.A. Frederix[a,*], A.K. Kuczaj[d,a], M. Nordlund[d], M. Belka[c], F. Lizal[c], J. Jedelsky[c], J. Elcner[c], M. Jicha[c], B.J. Geurts[a,b]

[a]*Multiscale Modeling and Simulation, Faculty EEMCS, University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands*
[b]*Anisotropic Turbulence, Fluid Dynamics Laboratory, Faculty of Applied Physics, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands*
[c]*Energy Institute, Faculty of Mechanical Engineering, Brno University of Technology, Technicka 2896/2 Brno 61669, Czech Republic*
[d]*Philip Morris International R&D, Philip Morris Products S.A., Quai Jeanrenaud 5, 2000 Neuchâtel, Switzerland (part of Philip Morris International group of companies)*

Abstract

An Eulerian internally mixed aerosol model is used for predictions of deposition inside a realistic cast of the human upper airways. The model, formulated in the multi-species and compressible framework, is solved using the sectional discretization of the droplet size distribution function to accurately capture size-dependent aerosol dynamics such as droplet drift, gravitational settling and diffusion. These three mechanisms are implemented in a consistent way in the model, guaranteeing that the total droplet mass as given by the droplet size distribution is always equal to the total droplet mass due to the mass concentration fields. To validate the model, we simulate monodisperse glycerol aerosol deposition inside the lung cast, for which experimental data is available. Provided that an adequate computational mesh is used and an adequate boundary treatment for the inertial deposition velocity, excellent agreement is found with the experimental data. Finally, we study the size-dependent deposition inside the lung cast for a polydisperse aerosol with droplet sizes ranging from the nanometer scale to beyond the micrometer scale. The typical 'V-shape' deposition curve is recovered. The aim of this paper is to 1) provide an overview of the Eulerian aerosol dynamics model and method, to 2) validate this method in a relevant complex lung geometry and to 3) explore the capabilities of the method by simulating polydisperse aerosol deposition.

Keywords:

*Corresponding author
Email address: e.m.a.frederix@utwente.nl (E.M.A. Frederix)