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Optimal non-woven filter media using multiscale simulations

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Filtration of contaminants out of air is vital for many industrial applications. In particular, we are interested in the technology of air filtration used in vacuum cleaners produced by Dyson Ltd. In this study, we focus on predicting and improving the efficiency of the filter media used in vacuum cleaners. Filter media are usually characterized by different criteria. The first one is energy consumption. The small pressure drop or large permeability of filter media ensures economic use of energy. The second criterion is how efficient the filter media is at trapping the contaminants. The third criterion that we consider in this study is the dirt holding capacity, which characterizes how much contaminants the filter media can store over time and, therefore, how long it can be used. Using a multiscale model for filter efficiency simulations, we perform a parametric study to determine the characteristics of the filter medium with the best performance based on these criteria. The advantage of the multiscale method is that the coupled micro- and macroscale behaviour is captured without the computational expense of globally resolving the microscale filtration problem. We account for: single-phase fluid flow through the filter medium, contaminant transport with convection, diffusion and adsorption and the evolution of the filter medium microstructure due to the contaminant adsorption. We begin by comparing two given filter media to understand the differences in their behaviour. Then, we focus on the optimization of filter media by investigating the parameter space of different media characteristics, for example, porosity and fibre diameter.

References

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Primary authors: Dr BRUNA, M. (University of Oxford); Dr GRIFFITHS, I.M. (University of Oxford); Dr GRIMBLE, T. (Dyson Ltd.); Dr HOVELL, B. (Dyson Ltd.); Dr MORRIS, G. (Dyson Ltd.); Dr PRINTSYPAR, G. (University of Oxford)

Presenter: Dr PRINTSYPAR, G. (University of Oxford)

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