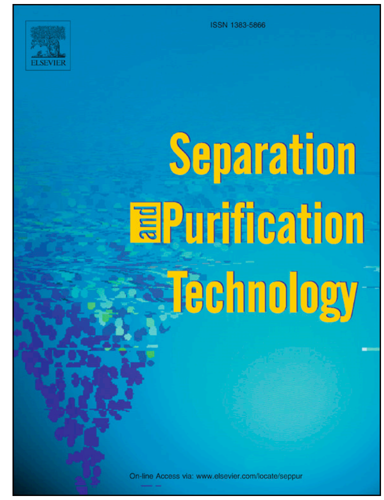

Representative Domain Size for the Simulation of Coalescence Filtration in Nonwoven and Foam Media

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Representative Domain Size for the Simulation of Coalescence Filtration in Nonwoven and Foam Media

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Abstract

Pore-scale filtration simulations require high spatio-temporal resolutions and significant computational effort, hence, keeping the domain size to a minimum is desirable. Previous studies have considered domains based on Brinkman length, or are limited by computing power, and little information is available for conditions involving high fluid saturation – typical of steady state mist filtration. In this study, simulations are performed to characterize the effect of domain size on pressure drop, residual saturation, liquid film thickness and interfacial area concentration, using virtual nonwoven and foam filters with similar micro-structural properties. Further, experiments using micro-CT are performed to validate the present computational simulations. It is found that two phase flow through filters are more sensitive to local geometric variations or mesh resolution in the porous media than single phase flow. Statistical uncertainties in the steady state quantities of less than ± 10 % can be expected to cope with the increase in computing power required for practical mesh sizes. A computational domain size of about 50-100 $\times d$ (where d is the strut or fibre diameter) was found to be required for CFD for the operating conditions considered.

Keywords : saturation, filtration, foam, fibre, CFD, domain size

Nomenclature

A_f	specific filter surface area, m^{-1}
A_ic	interfacial area concentration, m^{-1}
C_Br	multiplication factor, –
d	diameter of the filter elements, m
Eu	Euler number, –
l	filter thickness (or depth), m
p	pressure, Pa
Re	Reynolds number, –
S	oil saturation, –
u	velocity, m/s
w	width (cross-section) of the filter, m
x, y, z	lengths along the coordinate axes, m

	Symbols
α	packing density, –
β	fibre orientation angle, °
ε	liquid volume fraction, –
κ	permeability, m^2
λ	oil film thickness, m
μ	dynamic viscosity, Pa-s
ξ	oil centre of mass in the filter, m
ρ	density, $\mathrm{kg/m}^3$
θ	contact angle, °
ψ_p	polydispersity foam, –

1 Introduction

Several natural and anthropogenic processes including industrial gas compression, oil and gas production and distribution, lubricated manufacturing and in engine crank-cases produce liquid mists that are either valuable products or undesirable byproducts which may need to be recovered. Recovery of such mists for reuse or treatment is typically accomplished through coalescence filtration, employing highly porous fibrous (nonwoven) [1], knitted stainless steel [2] or foam [3] filter media, which are regarded to provide high filtration efficiencies and low pressure