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# Deposition on fibrous filters in the interception region

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## INTRODUCTION

When deposit accumulates inside a fibrous filter the fluid flow through the filter, and hence the filters collection efficiency, is altered. Although this is well known, it is difficult to model the particle build up within a filter. However it is crucial that a full understanding of the process of particle deposition and its effects upon further deposition is obtained in order to understand the performances of fibrous filters. We have been developing a numerical model of fibrous filtration aimed at investigating deposition due to various mechanisms and the effect filter properties and particle characteristics have upon it (Dunnett and Clement 2006, 2009). We have shown that, for small particles where the dominant mechanism by which particles deposit is diffusion, the porosity of the deposit formed does not significantly influence further deposition. For larger particles the porosity of the deposit has been seen to have a greater influence upon the flow field, and hence upon particle behaviour. In this paper we consider particles for which interception is the main mechanism of deposition.

## NUMERICAL MODEL

In earlier work, Dunnett and Clement (2009), a numerical model has been developed which determines the flow field, and particle motion, around a single fibre which has a porous deposit made up of collected particles on its surface. Flow through the porous material is described by the Darcy equation in the model. Neighbouring fibres are taken into account by the application of boundary conditions. Further deposition of particles onto the porous surface has then been determined. It was found that the parameter $s = \kappa/\delta$ was the main factor determining the deposition mechanism. In this expression $\kappa$ is the ratio of the particle to fibre diameters also known as the interception parameter, and $\delta$ is the non-dimensional thickness of the diffusion layer. For s<1 diffusion is the dominant mechanism of deposition, for $s=O(10^0)$ interception dominates and for large values of s impaction becomes important. For small particles for s<<1 where diffusion is dominant, deposition remains mainly spherically symmetric around the fibre as the deposit builds up and the porosity does not significantly affect further deposition. However as particle size increases and s>1 then the porosity has a more significant affect. In this work deposition by interception has been considered and we will report the results obtained from our model as the deposit builds up. Initial results have shown that the shape of the deposit formed is dependent upon the flow through the initial porous deposit. As an example, the particle build up is shown in Figure 1a for the case when $\kappa$=0.05 and $\varphi$=0.9 when the numerical model has been used to build the deposit up in layers starting with a clean fibre. Here $\varphi$ is the fraction of the porous media that is occupied by void space. In Figure 1b the particle build up is shown also for $\kappa$=0.05 and $\varphi$=0.9 but in this case it has been assumed that the fibre initially has a layer of deposit on it, shown by the line in the Figure flattened at the front
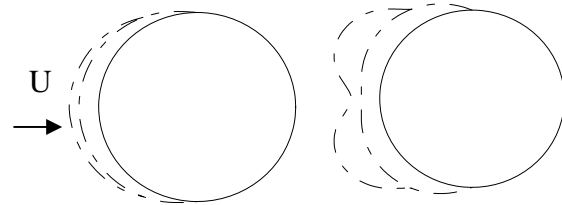


Figure 1a.          Figure 1b

As can be seen the shape of the initial deposit has a significant effect upon the subsequent deposit. The deposit shown in Figure 1b resembles that observed by Kanaoka et al (1986) and indicates that the assumptions made in the numerical model may lead to inaccuracies for the initial particle build up.

The validity of the assumptions made is being investigated. We find that Darcy's equation should ideally be replaced by the Brinkmann equation for the porous flow when the deposited layer is thin. We also investigate the effect of various parameters as the deposit builds up.

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