Nanoparticle Filtration by Virtual Spunbonded Nonwoven Media

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The most common method of filtration is via fibrous nonwoven media. Fibrous filters are generally characterized by their collection efficiency and pressure drop. Traditional studies in this area are typically based on unrealistic 2-D geometries with the fibers simply placed in a lattice perpendicular to the flow. In this study, a virtual 3-D web is generated based on the fiber orientation information obtained from analyzing microscopic images of lightweight spun-bonded filter media.

We generated a series of 0.5 mm × 0.5 mm spun-bonded virtual fiber-webs having a SVF close to 3.1% and with a fiber diameter of 17 micrometer. A steady state laminar flow model has been adopted for the flow regime inside the filter. The governing equations: continuity and conservation momentum, written in vectorial below, are solved simultaneously using Fluent code. In Figure 1 the velocity field is shown by the velocity vectors in one of the abovementioned structures.

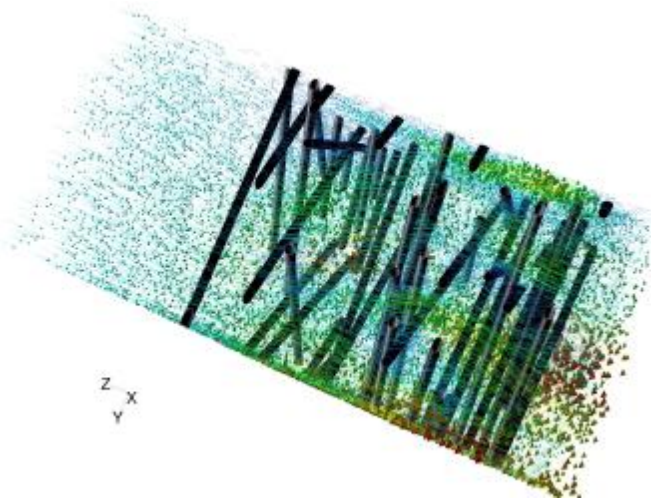

Figure 1: Velocity vectors showing the flow field.

Pressure drop of our virtual filters are simulated and compared with the previous 2-D analytical and numerical models as well as the experiment. Our pressure drop calculation, unlike the previous models, showed a perfect agreement with experimental data (see Figure 2).

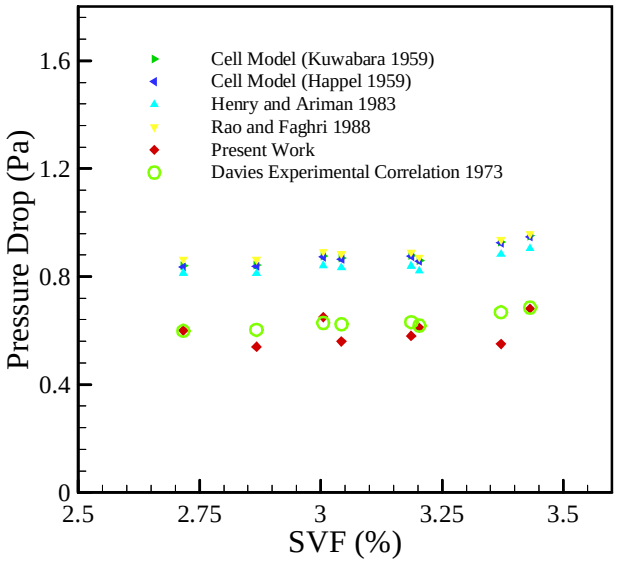

Figure 2: Pressure drop compared with experimental data.

Multi-disperse aerosols having a particle size ranging from 50 nm to 500 nm have been introduced to the filter with a face velocity of 0.05 m/s. It can be seen that the filter collection efficiency decreases by increasing the particle size in the above range.

The collection efficiencies predicted by our simulations follow a trend very similar to that of the Kuwabara's cell model as can be seen in Figure 3.

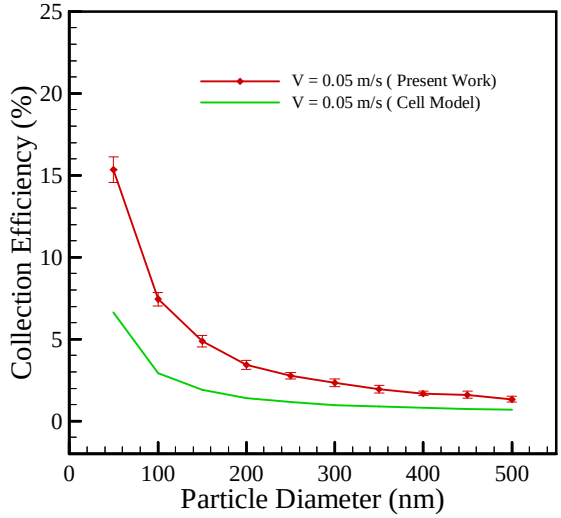

Figure 3: A comparison between collection efficiencies from CFD and cell model

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