Influence of fibrous media heterogeneity on pressure drop and filtration efficiency

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The fiber media or fibrous media are widely used in filtration: respiratory mask, dust extractor… Even if the fiber media technologies are efficient: high productivity, low cost, flexibility, the processes create heterogeneity more or less important such as nonuniform packing density, thickness or fiber size distribution. The local variations in the media alter the air flow and the particle collection and therefore modify the filtration properties. Several theoretical approaches have been done (Yeh *et al*., 1974, Shapiro, 1996, Dhaniyala *et al*., 2001) to model the heterogeneity, meanwhile few studies compare theoretical results and experimental data.

The aim of this present work is to characterise and evaluate the heterogeneity of fiber media on filtration pressure drop and efficiency. In order to compare theoretical models of pressure drop and efficiency to heterogeneous fibrous media, artificial media have been created. Two layers of the same media obtained by the same operating conditions are superimposed and holes are created in the first layer in order to create a non-uniform thickness. Therefore, artificial media with 0, 10, 20, 30 and 100% of non-uniform fraction have been created. A pressure transducer records the pressure drop of the filter. The collection efficiency of NaCl particles, (Particle size range from 0.2 to 0.5 µm) is measured with an optical counter device (Palas Welas 2100) at a face velocity of 5.3 cm/s.

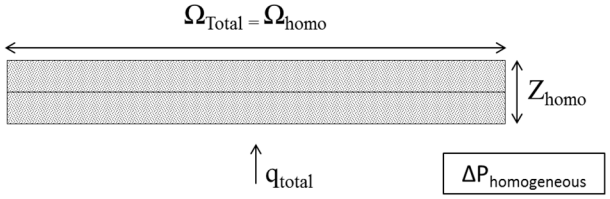

Figure 1. Model for an **homogeneous** media

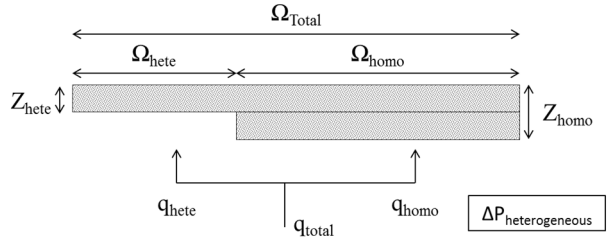

Figure 2. Model for an **heterogeneous** media

From the pressure drop of an homogeneous media ($\Delta P_{homogeneous}$) with a uniform thickness (Z_{homo}) as in figure 1, the pressure drop of the heterogeneous media ($\Delta P_{heterogeneous}$) as in figure 2 is predicted knowing the thickness of the heterogeneous surface (Z_{hete}), the fraction of non-uniformity *F*, ratio between heterogeneous surface (Ω_{hete}) and total surface (Ω_{total}), as in equation 1.

$$\Delta P_{heterogeneous} = \frac{\Delta P_{homogeneous}}{1 + (\frac{Z_{homo}}{Z_{hete}} - 1)F} \qquad (1)$$

Then, to predict the efficiency of the heterogeneous media, a model with a β correction factor using the pressure drop ratio is applied to the fiber unit efficiency (Yeh *et al.*, 1974), as in equation 2.

$$E_{heterogeneous} = 1 - \left(1 - E_{homogeneous}\right)^{\frac{1}{1+(\frac{Z_{homo}}{Z_{hete}} - 1)F}} \qquad (2)$$

The study has shown that the pressure drop model and the β correction factor of efficiency are correlated with the experimental results. For example, the figure 2 illustrates the comparison between theoretical prediction and experimental data on pressure drop.

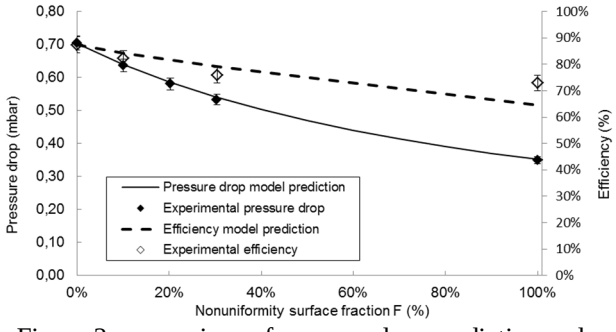

Figure 2. comparison of pressure drop prediction and experimental data

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