1C4) Examination of Thin Fiber Bundle Filter to MVAC

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1. Introduction

In conventional filtration, dust penetration decreases with the filtration due to particle deposition. Particle penetration decreases exponentially as increasing the thickness of dust cake (Hinds, 1982), $P_f=e^{-\gamma t}$. P_f represents penetration and γ is a constant is a function of particle size, face velocity and filter porosity; t the thickness of the filter. It is hypothesized that the "effective" depth of the thin fiber bundle filter (TFBF) should also depend on particle size and filtration velocity.

$$\ln\left(\frac{1}{P_f}\right)=\gamma t^{\alpha} \quad (1)$$

Parameter α is a variable that describes the effect of the filter thickness on penetration. When α=o, penetration is independent of filter thickness and depends only on the facial area of the filter. For most conventional filters, α equals 1. Intermediate values of α between 0 and 1 provide an estimate of the filtration depth. The parameter, α, thus, could be determined by comparing the particle penetration through TFBF with different filter thickness as follows (Mermelstein et al., 2002):

$$\ln\left(\frac{1}{P_{f2}}\right)=\gamma(2t)^{\alpha} \quad \text{and} \quad \ln\left(\frac{1}{P_{f1}}\right)=\gamma t^{\alpha} \quad (2)$$

$$R=\frac{\ln\left(\frac{1}{P_{f2}}\right)}{\ln\left(\frac{1}{P_{f1}}\right)}=\left(\frac{2t}{t}\right)^{\alpha}=2^{\alpha} \quad \text{and} \quad \alpha=\frac{\ln R}{\ln 2} \quad (3)$$

2. Experimental set-up

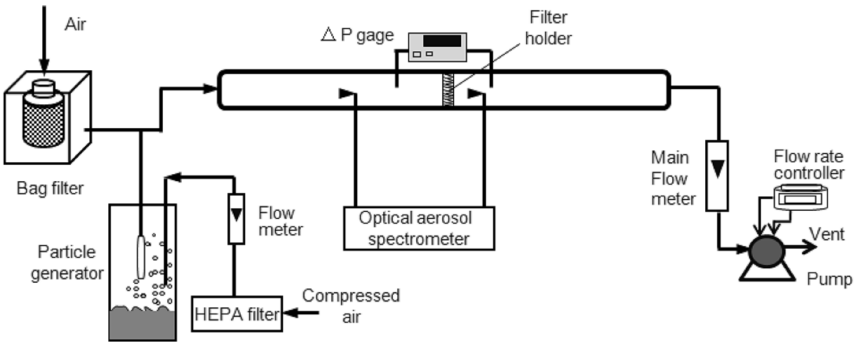
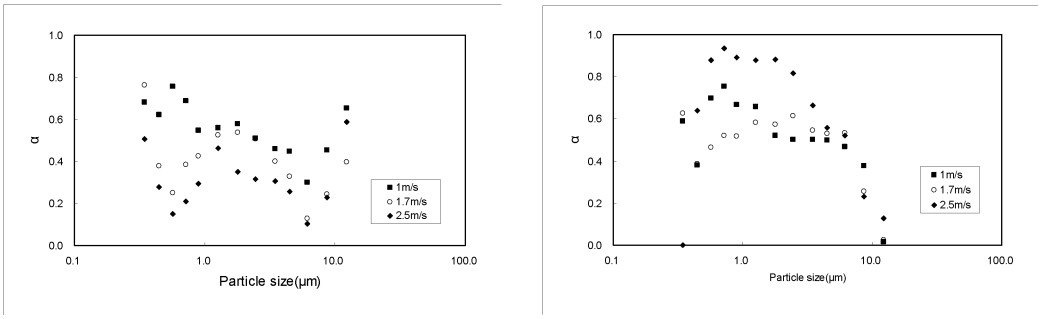


Fig. 1. Experiment set-up.

Suspensions of polydisperse ISO 12103-1 A1 ultrafine test dust were atomized by a particle generator. The generated aerosol was diluted with clean (particle-free) air and then was drawn through the test chamber, which consisted of a glass cylinder that was 4cm diameter and 80cm long.

Pressure drop across each filter was measured by pressure gauges. Particle collection efficiency of test filters was measured by means of optical aerosol spectrometer (Model 1.108, Grimm Aerosol Tech-nik, Ainring, Germany) through measuring the number concentration of particles upstream and immediately downstream of each test filter. Each filter was tested at three different face velocities, 1m/s, 1.5m/s and 2.5m/s, respectively.

3. Results and Discussion



(a) TFBF (b) subway fibrus filter

Fig. 2. Alpha values versus particle size for TFBF and subway fibrous filter.

A common feature of the data shown in Figure 2 is that α valueS are relatively independent of particle size for 0.89~4.47μm, ranging from about 0.4~0.8, at the filtration velocity of 1m/s. For particles larger than 6.12μm, α firstly decreases, and then increases to somewhat higher values. These results indicate that the particles penetrate deeper into the TFBF. The value of α will decrease with the increase of filtration velocity. The results lead to the conclusion that the high filtration velocities would weaken the effect of the filter thickness on the particles collection. It could be found that for the filtration velocities used in conventional MVAC system, fine particles and particles larger than 10μm are captured in the deeper layers of TFBF. The data show a different trend from subway fibrous filter. Particles smaller than 4.47μm penetrate deeper into the fibrous filter at test filtration velocities, especially at the higher velocity. While particles larger than 6.12μm are captured in the first few layers of subway fibrous filter with a low α value. The results also show that the high filtration velocities do not weaken the effect of the filter thickness on the particles collection.

Acknowledgements

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References

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Joshua Mermelstein, Seongheon Kim, and Constantinos Sioutas (2002) Electrostatically enhanced statinless steel filters: effect of filter structure and pore size on particle removal, Aerosol Science and technology, 36, 62-75.