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Performances Investigation of Filter Membrane Coated

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Abstract. Filtration membrane coated is a key kind of aerosol pollution control technology. The mechanism of depth filtration and surface filtration is analysed, and several SEM structure also given and basic compared. Furthermore, the efficiency of filtration e-PTFE membrane coated is tested according to the GB6719-2009 and ISO 11057-2011 used the VDI3296 experimental apparatus by the process of the standard test. The pressure is also tested in the same experimental apparatus. The investigation is useful to guide the choice of the filter membrane coated to reached the emission regulation of 10mg/m³.

1. Introduction

In recent years, fine aerosol particles pollution is played widely attention, due to serious fog and haze pollution have happen in many cities all over the world. So a serial of strict regulation has been released to restrain the fine particulate matter emission, and many new technology and new materials are utilized to removal of fine aerosol particles flowing from pollutant source. The filtration is one of these technology. Filtration technology is considered as an effective method for meeting policy stipulation, because fiber media has distinctive feature: (1) high efficiency; (2) simple application device.

Filtration is used in diverse applications, such as respiratory protection, hazardous materials [1], removal of asbestos fibers [2]. Fibrous filtration has been extensively studied experimentally and theoretically, the most population theory of filtration is that inertia impact, interception, Brown diffusion and electrostatic of single fiber, and that of the exponential power theory of the packing fiber. Ryan Mead-Hunter [3] gave a review on filter from the aerosol-mist cleaning viewpoint, and another review on the filter was reported by C.Y.Chen [4] from the overall aerosol-particulates cleaning viewpoint. Based on the single-fiber efficiency were well developed and systematically documented [1, 3, 4]. Pao-Kuan Wang [5] gave a modified efficiency definition on particles collided an infinity long single fiber, where a constant that was the geometrical volume swept out by the collector per unit time was used. K.W.Lee and B.Y.H.Liu [6] has conducted a theory study of aerosol filtration used the Kuwabara flow field. A theory review is conducted on the filtration by S.K.Friedlander [7].

Based on the fiber filtration, some new feature is added, such as Centrifugal Filter [8], filtration of fiber array [9], electrostatic enhancement of fabric filter, filter membrane filter [10]. A type membrane filter material has been developed by W. L. Gore & Associates Inc. a viewpoint is consider that membrane filter material has transformed the filter method, i.e. depth filtration to surface filtration, due to captured particles adhering the surface filter, it makes the deashing easier. Jingxian Liu [11] reported also the results of efficiency of three membrane filter, and John F. McCarthy reported [12] the results of fractional penetration of particles on GS Membrane Cartridge Filters. These study

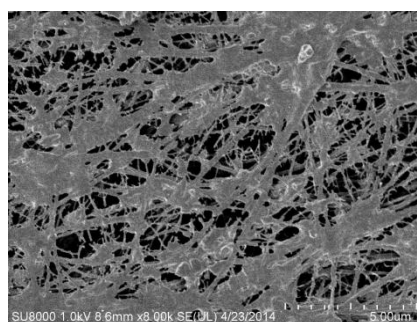
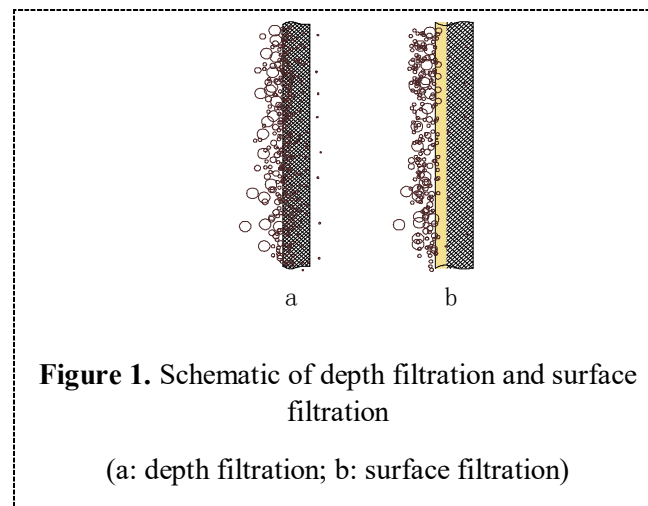


demonstrations that filter media membrane coated can meet with the emission $10\text{mg}/\text{m}^3$ regulation even lower.

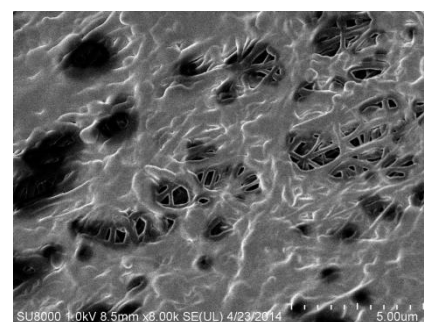
First, basic law of filtration on fiber filtration are introduced, then, several membrane microstructure and the surface filtration process are demonstrated and are compared, last the experimental performance of a e-PTFE filtration media membrane coated is reported.

2. Structure and mechanism of membrane filter material

Two type of filtration are usually utilized: one is depth filter media, the other is surface filter media. Depth filter media, which has high porosity and high air permeability, should be made to have high dust holding capacity, since the cartridge will not be cleaned during the operation period [13, 14]. However, surface filter media, which is that of classic fiber media surface coated a layer membrane, such as e-PTFE membrane, PPS membrane, has smooth surface and micrometer or submicron meter pore. It is obvious that the efficiency of removal of particles is more high and particles captured on surface can easily be cleaned. Surface filter media are made used meltblown, hot press methods. Usually, the meltblown technology, which is based on mechanical dispersion, is a one step process.



a. membrane



b. membrane

Figure 2. Two type surface microstructure of e-PTFE membrane.

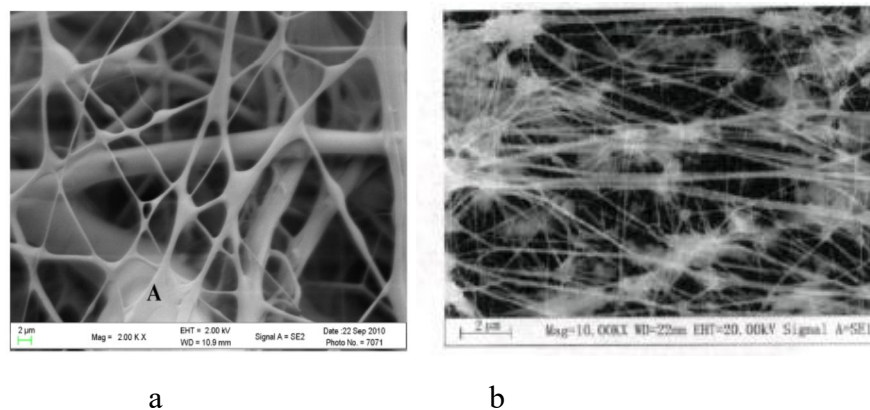


Figure 3. Membranes SEM structure by meltbrown and hot press [14]
(a meltbrown membrane SEM structure b stretch and hot press SEM membrane structure)

Particles are removed, when gas stream particle- loaded pass through depth filter media, at first stage, the depth filter media is made function, after the dust cake formed, the particle are filtrated by the dust cake [15, 16]. However, sieving becomes main mechanism removal of particles for the surface filter media, since the membrane has very small pore at surface of filter media, and the dust cake is not necessary. The differential of two can be demonstrated in figure 1. The porosity is more than 85%. Microstructure of the several membrane filter material SEM image are shown in figure 2 and figure 3, respectively.

From those SEM images, there are obvious difference the base material and the micron structure of membrane, this may bring to perfect filtration performance of the filter membrane coated, and affects the pressure drop.

3. Experimental of filtration membrane coated

The efficiency of filter membrane coated experimental apparatus is shown in figure 4. The experimental apparatus is according with ASTM D6830-02, ISO11057, VDI/DIN3926 and GB/T1264 standard. It mainly consists of a rectangular, vertical raw-gas duct, a cylinder, horizontal suction unit incorporating the sample of the fabric to be tested and cleaning-system consisting of a 2.5 liter pressure tank, a quick acting diaphragm valve and a blow-tube. Table 1 is particles distribution for the filtration efficiency tested.

Table 1. diameter distribution of particles.

Particles diameter/ μm	0~5	5~10	10~15	15~20	20~25	25~40	40~45
distribution/%	53.9	14	13.5	7.9	4.1	5.2	0.7
D50=4.2 μm		D10=0.89 μm		D90=20.7 μm			

According to the technology regulation and requirements of GB6719-2009, several experiments are conducted. Two filters membrane coated were used in this study. Their SEM image is shown in figure 2. They were made for industry application. The concentration at entrance is $5\text{g}/\text{m}^3$. The dust which made by Sasol Germany GmbH company is Pural NF. The mass of sample filter tested and absolute filter is weighed with analytical balance with resolution ratio of 0.01mg.

The pressure drop experiment is conducted in another rig made by myself.

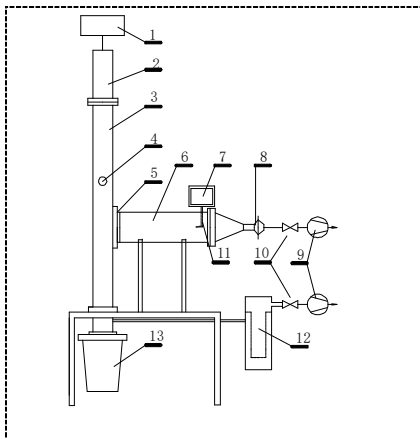


Figure 4. Schematic diagram of experimental apparatus

1. dust feeder 2. inlet mixing tube 3. vertical dirty-gas tube 4. photometric measuring pore 5. holder for filter sample 6. horizontal clean-gas dust 7. Compressed air tank 8. absolute filter 9. pump 10. mass-flow-meter 11. blow tube 12. dirty-gas back-up filter 13. dust container

3.1. Fraction efficiency

Two kinds of filtration membrane coated efficiency are acquired: number fraction efficiency and dust-laden mass fraction efficiency. Under the filter velocity 1.2m/min condition, the number fraction efficiency is conducted, and the result is shown in figure 5. Under the face velocity 2m/min condition, the mass fraction efficiency is conducted, figure 6 shows the experimental curve. As figure 5 shown, the number efficiency is more than 94 percent even through the diameter of particles is less than 0.5 μm , and shows than there is remarkable different between two kinds of filter membrane media. Contrast to the SEM image two kinds of filter e-PTFE membrane media, it is easily found that the pore quality of A filter membrane media is superior to B filter membrane. A filter membrane media can be applying to filtering PM2.5. This can be proved by the pressure loss of two kinds of the membrane.

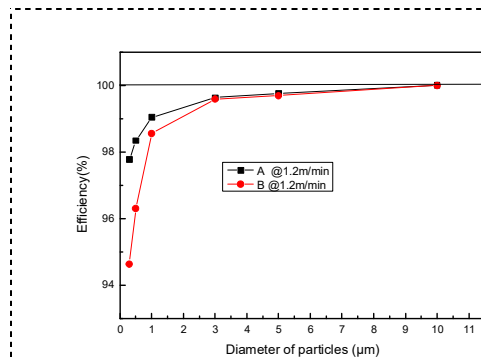


Figure 5. Counter fractional efficiency of A and B filter membrane coated.

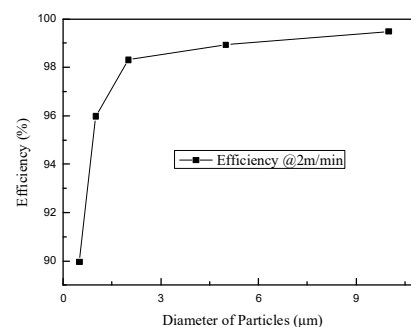


Figure 6. Mass fractional efficiency.

Figure 6 shows that the simulated dust-laden mass efficiency is more than 90 percent, this results of dust-laden simulated experiment is different from that of number efficiency, the cause may be the velocity is larger than that of the number efficiency measuring.

3.2. Pressure drop and ageing

To evaluate the performance of the filter membrane coated, it is necessary not only on the filtration efficiency but also on the pressure drop and ageing.

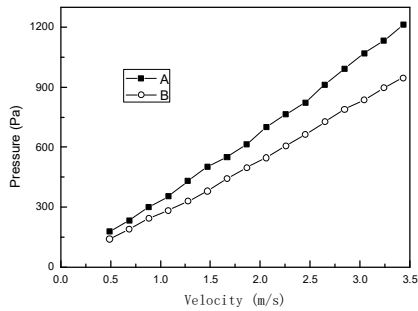


Figure 7. The pressure drop versus velocity for filter.

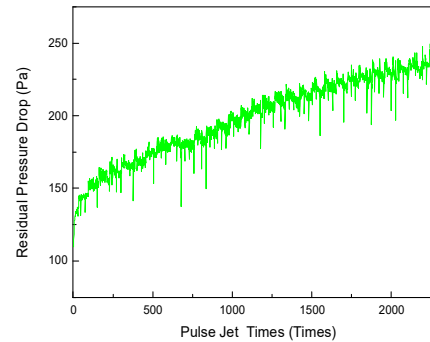


Figure 8. Residual Pressure Drop changing Curve cleaning with Pulse Jet.

Figure 7 shows that the relationship of pressure drop versus face velocity under cleanable gas flow. The pressure drop increase with the face velocity increase for two filter, but the pressure drop of B filter is less than that of A filter. This is consistent with the efficiency curve, the pressure drop data and SEM structure.

Figure 8 shows that the change of Residual pressure drop is with pulse jet in first 2300 cycles. The data is under the condition that Cleaning pressure is 1000pa, the face velocity is 2m/min, and the pulse jet pressure is 5 bar. The residual pressure drop is increase at first 2300 cycles. The residual pressure drop is less than 250 Pa, it is good for the peel performance of the filter membrane coated.

To evaluate the life of filter, the aging experiment also are conducted, the result is shown in figure 9 under the constant pressure pulse jet 10000 condition with dust- laden gas. There are different about two filter. The pressure drop has a decrease for A membrane the last fifteen jet, it might be that the pore become large result to the pressure drop small.

However, the pressure drop does not decrease, it demonstrates that the pore of B membrane hasn't changed basically, and performance is better for tolerating gas flush. So the life period is more long for B membrane, and the efficiency is stable.

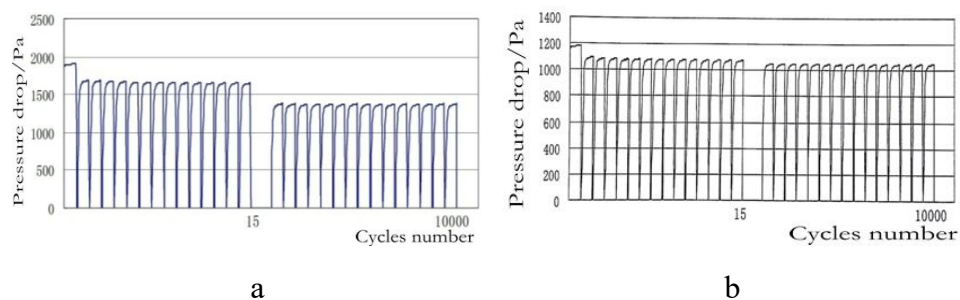


Figure 9. Constant pressure pulse jet ageing (first fifteen and last fifteen).

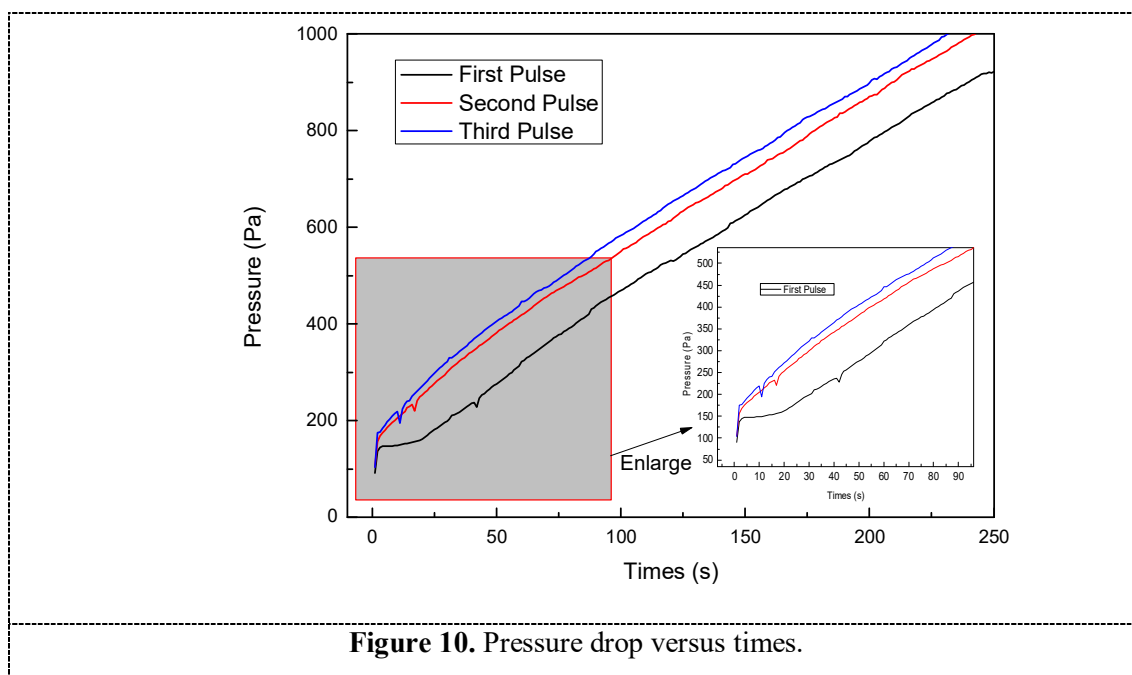


Figure 10. Pressure drop versus times.

The Curve of pressure drop excursion versus the filtering times is shown in figure 10 under first three pulse jet. As figure 10 shown, the pressure drop excursion curve versus specific aerosol loading is slow increase at initial short time span, following it is linear increase. This may be the transition from the dust cake form to dust accumulate. There are a distinct different among first three times pulse jet under 0.5bar constant pressure, this may be cause that the dust cake doesn't form for cleanable filter firstly used.

4. Conclusions

Several membrane microstructures are given out, and the collection efficiency of two e-PTFE membrane filter media may reach 99 percent for 1 μ m, and 98 percent for 0.5 μ m.

Filtration coated membrane is a high collection efficiency, and pressure drop increase with increasing face velocity.

B filter is more life period than A filter according to pressure drop experiment.

Acknowledgments

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