Effect of High-Density Surface Structure on Filtration Performance of Needle Felt Filter

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Abstract: Filter structure is an important factor to affect the performance of bag filter. In this paper, a national standard rig is used to testing the performance of regular filter and high-density surface filter. The results show that: high-density surface filter have the advantages of low resistance, low resistance growth ratio, long filtration cycle, high dust stripping rate. Therefore, high-density surface filter is better than regular filter.

Keywords: needle felt, high-density surface filter, resistance, filtration

1 Overview

As the upgrade of national standard for dust emission, baghouse is becoming the mainly dust control technology which are widely used for smoke filtration on coal-fired power plants, steel industry, cement kiln, and nonferrous metal smelting, waste incineration[1,2]. Filter media is the core of baghouse which affect the performance of baghouse. Needle felt filter include three layers, scrim in the middle, fabric layer on upside and downside. Needle felt filter owns the advantages of high filtration efficiency, low resistance, low resistance growth and high mechanical strength, which is the most widely used filter material on site[3-5].

In the initial filtration stage for new filter, particles go into the inner layer of filter leading rapid resistance growth, which is deep filtration[6-8]. With the filtration process, particles will deposit on the filter surface, forming high-density dust layer which become the main filtration media leading to high efficiency and low resistance growth. This process is surface filtration[9,10].

To improve the performance of filter media, surface filtration theory is used to optimize the filter structure, i.e. a high-density surface layer made from thin fabric is attached on dust contact side of filter. The high-density surface layer prevents particles from entering the inner layer of filter, keeping the filter in the status of surface filtration all the time.

In this paper, experiment investigation on regular filter and high-density surface filter are implemented.

2 Experiment schema

2.1 Experiment apparatus

Filters are test with the experimental apparatus of GB6719-2009 which is compatible with VDI 3926 and ISO(drafting) standard. Experimental apparatus is shown in Figure 1.

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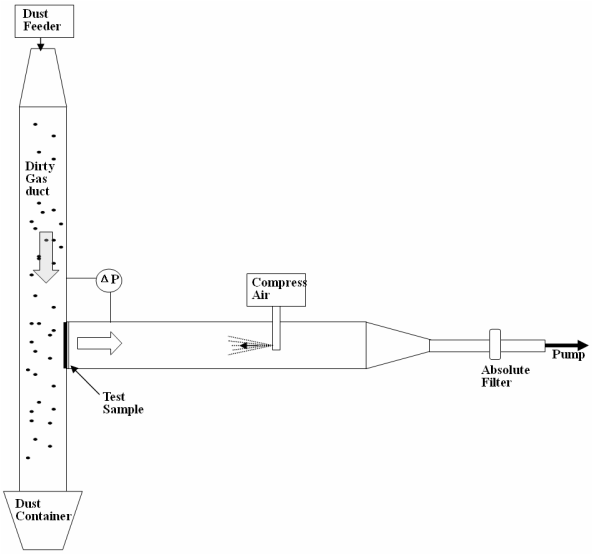

Figure 1 Experiment apparatus

Dust is fed and injected into the square tube. Filter sample is placed at the joint of vertical tube and horizontal tube. Dust is captured when air flow through the filter with suction of vacuum. Pressure drop of filter increases with the filtration process. When the pressure drop reaches predefined value, pulse jet valve is triggered and compress air eject from the clean side. Dust cake is striped from the filter. Absolute filter is used to test the filtration efficiency, computer used to record the pressure drop and to control pulse jet.

2.2 Experiment method

Experiment process include four stages:

① Stage A is the initial filtration for new filter. The resistance is low at the beginning, and increases with the filtration process. When the pressure drop reaches 1000Pa, pulse jet valve for dust cleaning will be active, dust cake stripes and resistance decreases. This process repeat for 30 times, then switch to stage B.

② Stage B is the aging process. 10,000 times of pulse jet cleaning are implemented with 5s time interval and 30ms pulse width. Then switch to stage C.

③ Stage C is recovery process. Same as stage A, only 10 cycles. In this stage, no data need to be recorded, then switch to stage D.

④ Stage D is the stable filtration process. Same as stage A.

Experimental conditions are shown in Table 1.

Table 1 Experimental conditions and parameters

Filter	Material		Polyphenylene sulfide (PPS)
	Structure		Regular needle felt filter / High-density surface needle felt filter (HDS filter)
	Basic Weight [g/m^2]		530 / 580
Particle	Material		Al_2O_3
	Median [μm]		4.86
Test conditions	Face velocity [m/min]		3
	Pulse pressure [kPa]		500
	Stage A	Cleaning at: [Pa]	1000
		cycles	30
	Stage B	Pulse interval[s]	5
		Pulse width [ms]	30
		Pulse times	10000
	Stage C	Cleaning at: [Pa]	1000
		cycles	10
	Stage D	Cleaning at: [Pa]	1000
		cycles	30

3 Experimental results and analysis

3.1 Initial filtration stage for new filter

In the early stage of filtration, due to the different surface structure of filter media, the ratio of resistance growth is different also. Figure 2 show the first filtration cycle for the new regular needle felt filter and high-density surface needle felt filter(HDS filter). To the regular filter, because the filter surface is not compact, many dust go into the filter resulting in rapid resistance growth, shows the typical deep filtration. As contrast, HDS filter shows low resistance growth ratio.

Figure 3 shows the residual resistance for the 30 filtration cycles. The residual resistance of regular filter is much larger than HDS filter. With filtration process, the ratio of resistance growth for regular filter is larger than HDS filter. The dust stripping rate can be used to describe the effect of dust cake cleaning by pulse jet which can be calculated by formula (1).

$$b = \frac{P_d - P_r}{P_d - P_0} \quad (1)$$

Where, b -- dust stripping rate,%;

P_d -- pressure drop at which the pulse jet cleaning is triggered, here the value is 1000Pa;

P_r -- residual resistance at the end of test, Pa;

P_0 -- residual resistance at the beginning of test, Pa

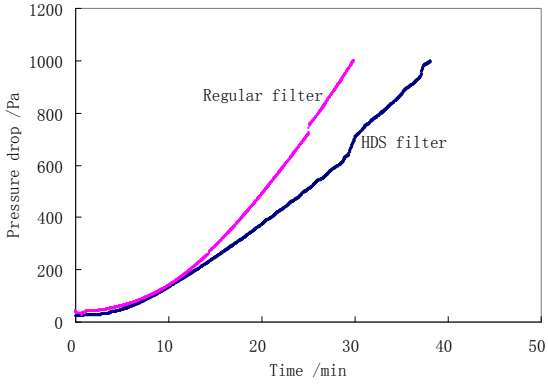

Figure 2. First filtration cycle for new filter

For HDS filter, the dust stripping ratio is 95.9%, while regular filter is 88.8% only. Which means dust cake cleaning are easy for HDS filter.

Figure 4 shows the curves of cycle time(time for pressure drop reaches 1000Pa). Comparing with HDS filter, the regular filter not only has short cycle time, but has rapid ratio of time shorten as filtration process. For the first cycle, time for regular filter is shorter than HDS filter about 26%. But for 30th cycle, the number is more than 100%.

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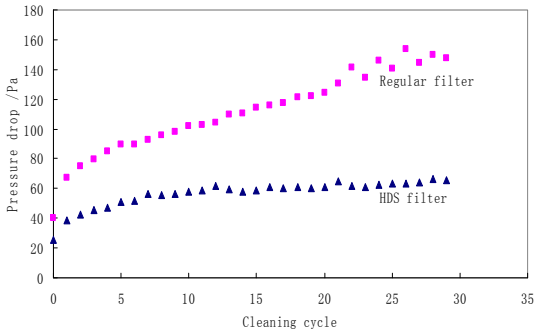

Figure 3. Residual resistance of 30 cycles

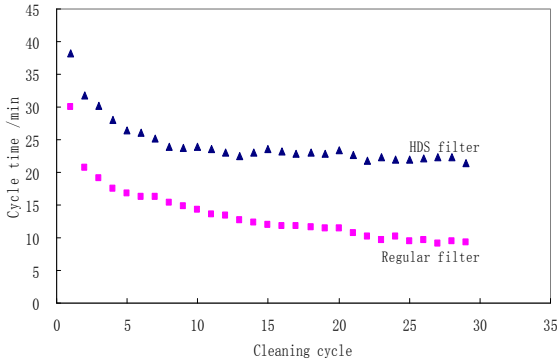

Figure 4. Time for 30 cycles

3.2 Aging stage

The aging of filter media is carried out by mandatory pulse jet dust cleaning, the aging curves of 10,000 pulse jet(nearly 14 hours) are shown in Figure 5. For the resistance value, regular filter is greater than HDS filter. For the ratio of resistance growth, at the beginning of aging, the resistance for regular and HDS filter are 100.6Pa and 64.4Pa respectively, the former is greater than the latter about 56.2%; at the end of aging, the resistance increase to 306.1Pa and 137.5Pa respectively, the former is greater than the latter about 122.6%. Resistance increase rapid for regular filter.

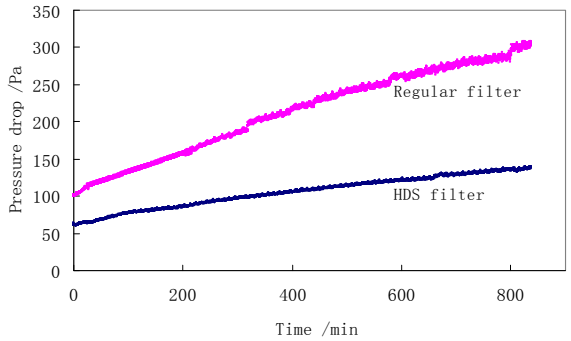

Figure 5. Aging process of filter

3.3 Stable filtration stage

In application, the filter is running in stable stage for most of the time. Figure 6 shows the first cycle for stable stage. The resistance value and resistance growth ratio for regular filter are greater than HDS filter. The time reaching 1000Pa for regular filter is far lower than for HDS filter, about 20% of HDS filter.

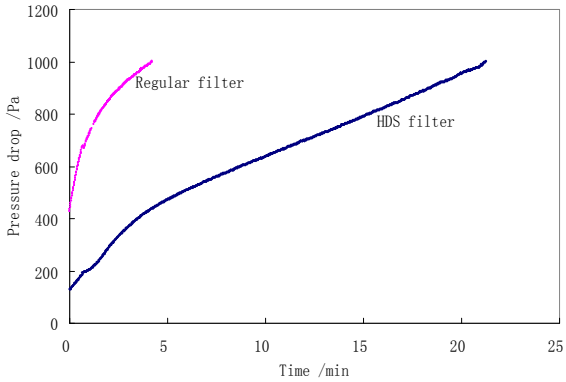

Figure 6. First filtration cycle for stable stage

Figure 7 shows the residual resistance for the stable filtration stage. The residual resistance for regular filter is far lager than HDS filter. With the increase of filtration cycle, the residual resistance is tending to stable for HDS filter, but is increasing for regular filter. The dust stripping ratio for regular filter and HDS filter re 80.6% and 99.7% respectively.

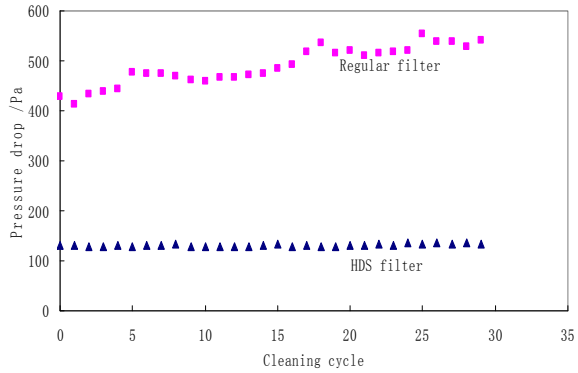

Figure 7. Residual resistance for stable filtration stage

Figure 8 shows the cycle time for stable filtration stage. The time for regular filter is far lower than HDS filter. The time of 30th cycle for regular filter is only 15.7% of HDS filter, so the pulse jet frequency for regular filter is 8 times of HDS filter, which lead to rapid mechanical damage, greatly reducing life for bag filter. In the stable stage, the cycle time is almost tending to stable.

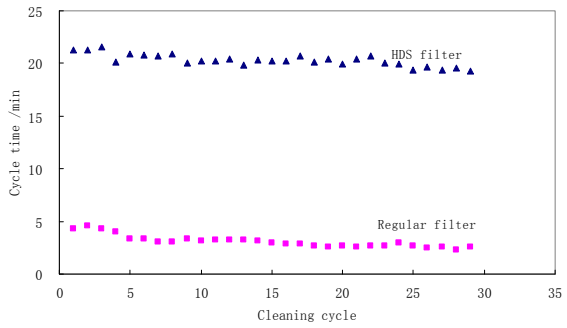

Figure 8. Cycle time for stable filtration stage

For the total test stages, the dust stripping ratio for regular filter and HDS filter are 47.9% and 88.9% respectively.

4 Conclusion

From the experimental research on regular and HDS filter, the following conclusions are achieved:

(1) In the initial filtration stage for new filter, HDS filter shows the feature of surface filtration, also gives advantages on resistance growth, residual resistance, cycle time;

(2) In the aging stage, the high-density surface layer partly plays a role of the dust layer, slows the growth of resistance;

(3) In the stable filtration stage, the high-density surface layer shows more obvious advantages, not only slows growth of resistance, reduces residual resistance, but the cycle time is 8 times of regular filter, which greatly reduces energy consumption at pulse jet dust cleaning and mechanical damage for the bag filter;

(4) No matter in initial stage and in stable filtration stage, the dust stripping ratio for HDS filter is larger than for regular filter, which means the excellent dust cleaning performance for HDS filter.

References

[1] XIAO Rong-xu, Baghose Precipitator with Broad Dev elopment Prospects[J], China Environmental Protection Industry, 2003, 3, P16-17(Ch).

[2] Wang Shaoquan, Development of fabric filter used on disposing tailing smoke of garbage incinerator[J], Electric Power Environmental Protection, 2003, 3, P31-33(Ch).

[3] J. Binnig,J. Meyera and G. Kaspera, Origin and mechanisms of dust emission from pulse-jet cleaned filter media[J], Powder Technology, 2009, 189(1), P108-114.

[4] Chih-Chieh Chen, Wei-Yu Chen, *et al*.,Experimental Study on the Loading Characteristics of Needlefelt Filters with Micrometer-Sized Monodisperse Aerosols[J],Aerosol Science and Technology, 2001, 34(3), pp. 262-273.

[5] Mahmood Saleema, Gernot Krammera, Effect of filtration velocity and dust concentration on cake formation and filter operation in a pilot scale jet pulsed bag filter[J], Journal of Hazardous Materials,2007,144,P677-681

[6] Xavier Simona, Denis Bémera, *et al*. Consequences of high transitory airflows generated by segmented pulse-jet cleaning of dust collector filter bags [J], Powder Technology, 2010, 201, pp. 37-48.

[7] Yi-Shun Chen and Shu-San Hsiau,Cake formation and growth in cake filtration[J], Powder Technology, 2009, 192, pp. 217-224.

[8] Huachang CHI, Zhongli JI, *et al*, Experimental Investigation of Dust Deposit within Ceramic Filter Medium during Filtration-Cleaning Cycles[J].Chinese Journal of Chemical Engineering, 2009, 17(2), pp. 219-225.

[9] Tobias D. Elmøea, Antonio Tricolia, *et al*. Filtration of nanoparticles: Evolution of cake structure and pressure-drop[J], Journal of Aerosol Science, 2009, 40(11), pp. 965-981

[10] K.J. Jeon and Y.W. Jung, A simulation study on the compression behavior of dust cakes[J], Powder Technology, 2004, 141,P1-11.

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