THE PREPARATION AND CHARACTERIZATION OF MULTI-LAYER BAG FILTER MEDIA VIA SPUNLACING PROCESS

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1 Introduction

Poly(phenylene sulfide)(PPS) fiber has the balanced thermal and chemical resistance, nonflammability and electrical properties. PPS fiber are known for its stability for a wide range of temperature and frequency vibrations, chemical resistance to acids, alkalis and organic solvents, hydrolysis resistance, flame retardant properties. Therefore, it can be widely used in many industries, especially in bag type filtration applications such as coal-fired boilers, municipal solid waste boiler, calciners/catalysts, and so on.

Bag type filtration is a device that can separate particulate contaminants in emission gases. Bag filter is generally constructed from woven or nonwoven fabrics in tube shape which gases are flowed through to remove contaminants[1]. Particulate contaminants are separated and emitted air is purified by filter media. These bag type filters are widely applied in such as cement industry, steel and nonferrous metallurgy industry, HVAC, water filtration, chemical/petrochemical processing, and food industry.

Air pulse-jet bag filters are cleansed by compressed air periodically so that the built up filter cake is discharged and the flow through the media is returned to its higher air permeability. Pulse jet bags are installed on cage and then purified the air separating the contaminants. When the pressure of the bag arrives at a certain point, the contaminants mounting at the surface of bag are discharged by back-side strong air pulse[2-3].

Many researchers in academies and companies have been studied on the low resistant, efficient bag filter medium, strong pulsing device, computer simulation technology to predict life of bag filter, the new method for bags with special properties, finishing the medium to increase of efficiency such as coating, and the large bag filter device structure to accommodate the large boiler unit and iron, steel, cement kiln flue gas purification.

In this study, multi-layer PPS bag filter media were prepared by laminating the PPS needle felted nonwoven and wet-laid nonwovens which are composed with 0.06d PPS fibers. And their mechanical and filtration properties were characterized for application into air purification industries.

2 Experimental

2.1 Preparation of PPS needle felt and wet-laid nonwoven

2de PPS staple fibers(Huvis Co., Korea) were carded and the carded web was cross-lapped on the PPS woven mesh(Young Textile Co., Korea). And two layers were physically bonded by needle punching. Another carded web was cross lapped on the other side of PPS woven mesh and needle punched again. Therefore, 3-layer needle felt with high strength woven mesh layer in the middle was prepared. The weight of felt is 310~320 g/m^2.

PPS and PET chips were spun into sea-island type fibers. The bicomponent fiber was cutted into approximately 6 mm length, that is short-cut. The short-cuts were treated in NaOH solution at high temperature. The sea component(PET) was extracted by alkali treatment and the island component(PPS) was remained. Therefore 0.06de ultra fine PPS fibers were prepared. The several wet-laid nonwovens which were distinguished by compositions and their weights were prepared from the 0.06 and/or 2de PPS fibers through mixing and dispersing them, web forming and then drying process in series.

2.2 Spunlacing process

3-layer PPS needle felt and wet-laid nonwoven were laminated by spunlacing method. The spunlacing equipment(Fleissner GmbH, Germany) has the 10 water-jet nozzles. The conditions of water jet pressures are shown in Figure 1. The final bag filter media are composed of 4 layers(Figure 2).

2.4 Characterization

The multi-layer PPS bag filter media(Table 1) were characterized with several techniques such as tensile properties, air permeability, bursting properties, pore size distribution, SEM, and filtration efficiency.

3. Results and Discussion

Figure 3 shows the tensile properties of PPS woven mesh which were used as a support layer to sustain the strength in PPS felt. PPS woven scrim has a enough high tensile strength over 800 N at machine direction and 600N at cross direction, indicating that this could effectively endure during cleaning by back pulse with air of high pressure.

Figure 4 shows the air permeabilities of samples prepared. Air permeability has a tendency to increase by decrease of fine fiber(0.06de) content in wet-laid nonwoven which is laminated with the felt. The media 1 which is made by laminating 100% 0.06de wet-laid nonwoven with PPS felt shows the lowest air permeability of 10.3 $cm^3/cm^2/s$. The existence of fine fiber means the formation of dense structure, indicating the small pore size of the media. Average pore diameter of the media is a range of 6~16 microns(Figure 5). As explained in Figure 4, increase of fine fiber content and weight of wet-laid nonwoven leads to a compact structure, that is, small average pore diameter.

Figure 6 shows the bursting strength of the samples which were tested by ball bursting method. Bursting strength is an important variable because bag filter media should endure the strong pressure by dust clogging and the air back pulsing during discharging the dust. The existence of wet-laid layer represents the increase of bursting strength because of the weight gain and dense structure by laminating between PPS felt and wet-laid layer through spunlacing. Particularly, The media 1 which was coupled with spunlacing between 0.06d wet-laid layer and PPS felt layer has the highest bursting strength. It represents that 0.06d fine fibers were well embedded into the felt layer through spunlacing process, indicating the strong binding strength. The bag filter media shows the similar bursting tendency with the PPS felt, indicating wet-laid layer and/or carded nonwoven layer burst first and then woven scrim later.

Figure 7 shows the SEM images of the surface of bag filter media 1~4. They shows that Media 1 has the compact surface due to an existence of all 0.06de fine fibers. Meanwhile, Wet-laid 4 which was composed with the ratio of 0.06de/2de = 25/75 by weight shows the bulky surface structure. Figure 8 shows the cross-sectional images of media 1~4. The images exhibit wet-laid layer was strongly bonded with felt layer together through spunlacing process. The fibers in wet-laid layer could be embedded in the felt layer by strong water jet, Thus, the spunlacing process is very effective for laminating the layers and improving the strength of product.

The filtration efficiency test was performed by VDI 3926 method which medium experience periodically dust loading and discharging by air pulse. Figure 9 shows the mean dust concentration which got out from the media after filtration. The lower concentrion means the higher filtration efficiency. The mean dust concentrations in clean gas of media 1~4 were 0.154, 0.182, 0.629, 0.647 mg/m^3, respectively. The higher fine fiber content in wet-laid layer, the lower dust concentration. It represents that the existence of wet-laid layer with fine fibers can achieve the higher filtration efficiency.

4. Conclusions

PPS staple fibers were melt spun for spun yarn and nonwoven. And sea-island fibers were also spun and cut into approximately 6 mm length for wet-laid nonwoven. The sea component(PET) was extracted by alkali treatment and the island component(PPS) was remained in very fine fiber. The several wet-laid nonwovens which were distinguished by compositions and their weights were prepared from the 0.06 and/or 2de PPS fibers through mixing and dispersing them, web forming and then drying process in series. PPS felt was prepared by needle punching the carded and cross-lapped web laid on the double sides of PPS woven scrim. PPS nonwoven media for bag filter with high performances was prepared in multi-layer structure from PPS woven scrim, PPS staple nonwoven and PPS wet-laid. The lamination between fine fiber wet-laid layer and the PPS needle felt through spunlacing process improved the performances the bag filter media such as mechanical properties and filtration efficiency. In further works, the preparation of light-weight media with low pressure drop and high efficiency could be performed.

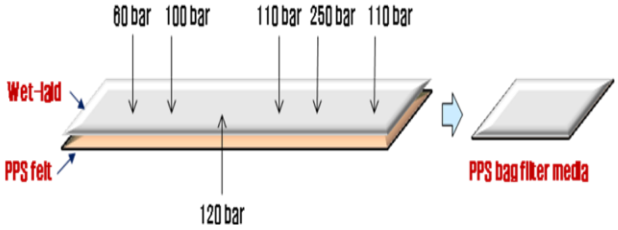

Figure 1. The water-jet pressures during spunlacing.

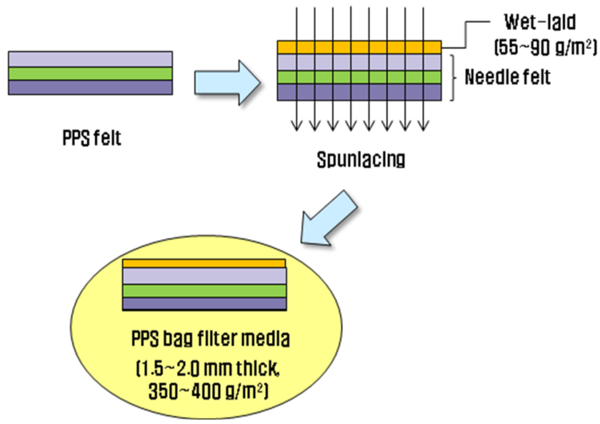

Figure 2. Multi-layered PPS bag filter media.

Table 1. The samples prepared in this study

Sample	Composition (weight ratio)	Weight (g/m^2)
PPS felt	-	310
Wet-laid 1	0.06d 100%	55
Wet-laid 2	0.06d/2d (50/50)	90
Wet-laid 3	0.06d/2d (50/50)	65
Wet-laid 4	0.06d/2d (25/75)	65
Media 1	PPS felt + wet laid 1	365
Media 2	PPS felt + wet laid 2	400
Media 3	PPS felt + wet laid 3	375
Media 4	PPS felt + wet laid 4	375

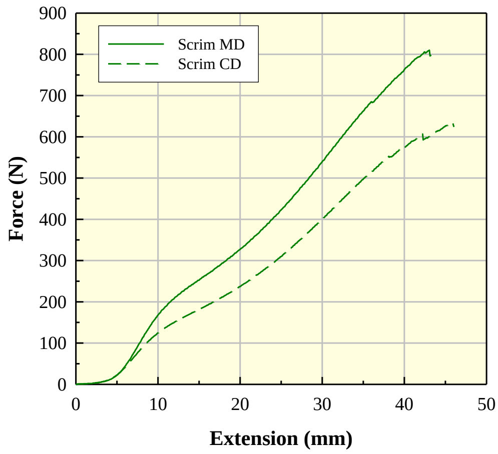

Figure 3. Tensile properties of PPS woven mesh.

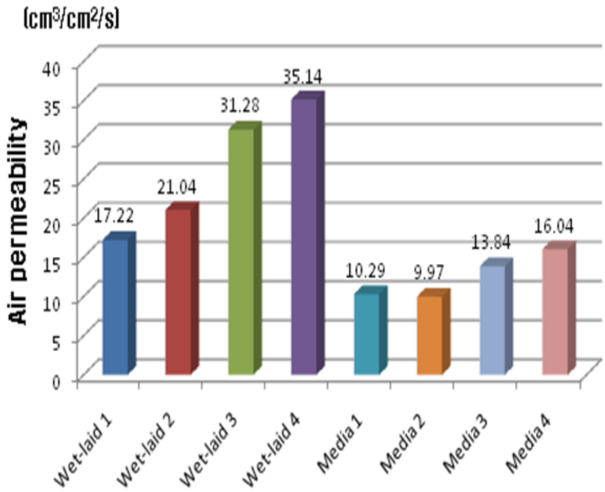

Figure 4. Air permeabilities of samples prepared

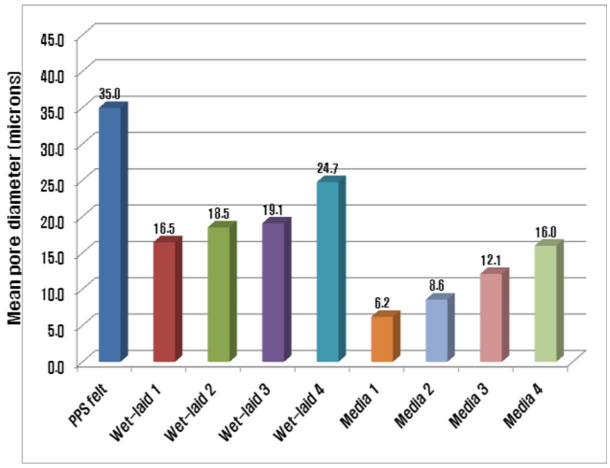

Figure 5. Average pore diameters of samples prepared.

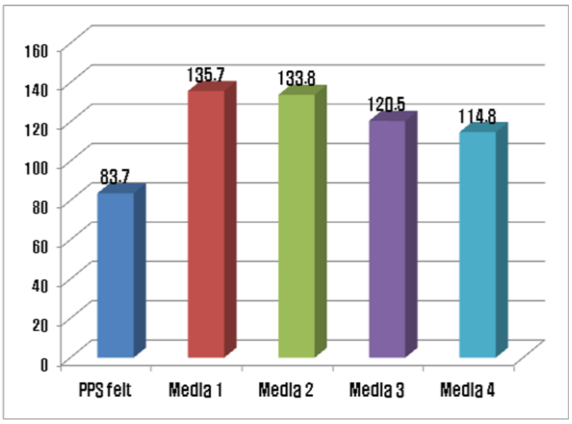

Figure 6. Bursting strengths of the media prepared

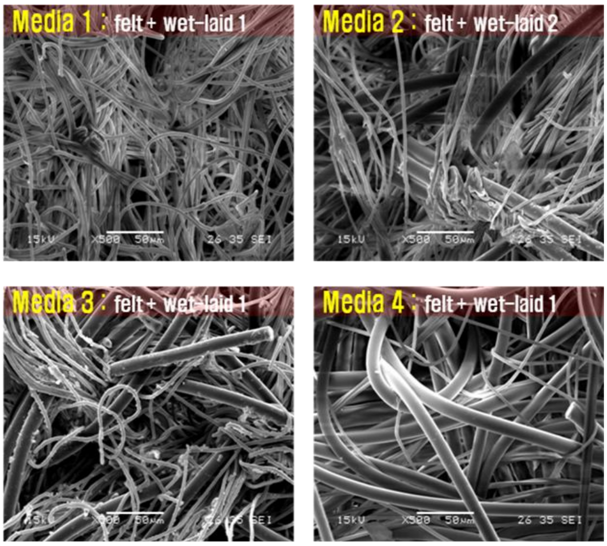

Figure 7. SEM images of the surface of media 1~4

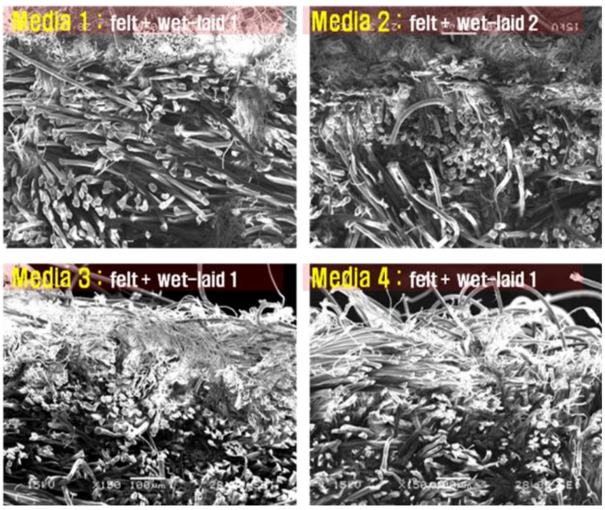

Figure. 8. Cross sectional SEM image of the media 1~4

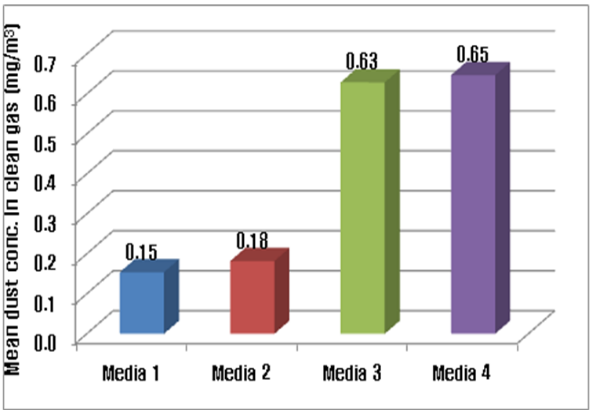

Figure 9. Mean dust concentration in clean gas

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