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Spunlaced and chemically bonded nonwovens for filtration applications: Performance evaluation and comparison

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INTRODUCTION

Filter media are defined as permeable material used to separate particles passing through it. The importance of textile filter media in air filtration is to control air pollution in improving air quality and hygiene at work.

Filtration is a process of separating solid particles from liquids and gases by passing them through a porous, fibrous or granular substance.

Textile fabrics are the most important and widely acceptable groups of materials used for filter media.

The fabric filters may be woven, knitted or nonwoven. Nonwovens are the major media for air filtration and constitute almost 70% of the total filters.

Nonwovens are produced in two stages web formation and web bonding followed by web finishing. Fibres can be bonded together by different means, namely mechanically, chemically or thermally. Hydroentanglement (also referred to as spunlacing) technique, utilises high speed water jets to entangle fibres of webs. Spunlaced nonwovens offer various performance advantages compared to more traditional technologies used in air filtration. This bonding technology is illustrated by Figures 1 and 2. The turbulence of the water causes rearrangement and entanglement of the fibres with resulting consolidation of the material structure. The absence of mechanical damage prevents the passing of dust particles through the filter media and leads to the increased resistance of the fabric (Lorentz 2007).

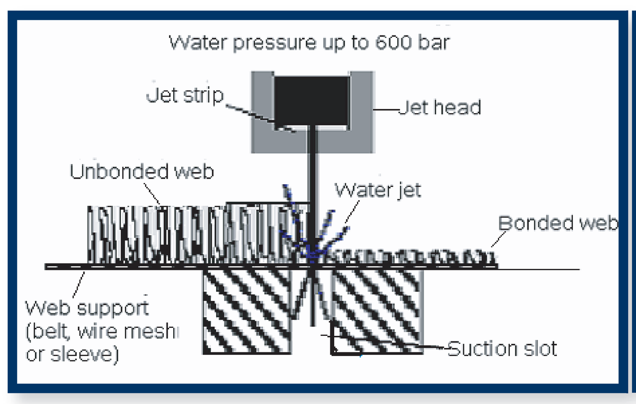


Figure 1. Hydroentanglement process Figure 2. Water jets through a manifold

EXPERIMENTAL

Polypropylene (PP) fibres of 2.2 dtex linear density, 40 mm staple length and Polyester (PET) fibres of 3.6 dtex linear density, 60 mm staple length were selected for this experiment.

Fibres were opened by carding, cross-lapped and pre-needled. The resulting batt was transported to the hydroentanglement unit containing three manifolds of water jets, where the first bonding took place. Then a chemical coating was applied on the spunlaced wet fabric by the traversing foam delivery unit. The bonded fabric was oven dryed and cured.

The sample variables are summarised in Table 1. “T2” refers to the second trial on this application.

Table1. Samples variable parameters

Sample ID	Fibre comp.	AquaJet pressure (bar)	Binder application (%)
N1-T2	PP	60	25
N2-T2	PP	120	25
N3-T2	PP	200	25
N4-T2	PET	60	25
N5-T2	PET	120	25
N6-T2	PET	200	25
N7-T2	PP	60	40
N8-T2	PP	120	40
N9-T2	PP	200	40
N10-T2	PET	60	40
N11-T2	PET	120	40
N12-T2	PET	200	40

RESULTS AND DISCUSSIONS

Samples were tested for physical, mechanical and performance properties under standard laboratory conditions.

Tensile properties

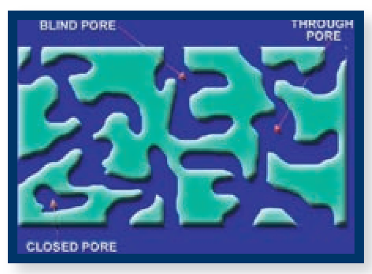
Nonwovens are anisotropic materials. The tensile properties of the material depend on the fibres alignment in the web formation.

The machine direction (MD) breaking strength increased with the increase of applied water jet pressure in all PP samples (samples N1, 2 and 3). In the PET fibre samples, the strength is higher with the 60 bar water jet pressure in MD. The same trend for PET samples in cross-direction (CD).

Pore size and its distribution

The pore size and its distribution are very important parameters in filtration application. The smallest pores contribute to higher filtration efficiency and higher dust holding capacity. The liquid extrusion technique was used for the evaluation of pore size in nonwovens. In this technique, a wetting liquid (Galwick with known surface tension parameter such as 15.9 dynes/cm) fills the pores of the sample and a pressurised gas extrudes the liquid from pores. There are three different types of pores, blind pores, through pores and closed pores (Figure 3). The through pores are the most important to this study as the diameter changes along the path of the pore’s channel (Figure 4).

The pore size and its distribution for the samples with 25% binder application are illustrated in Figure 5. It was observed that the smaller pores were created during more intense interlocking of fibres with the higher pressure water jets (200 bars) for PP and PET samples with 25% binder application.



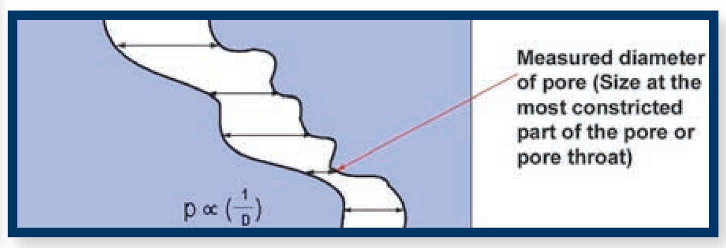
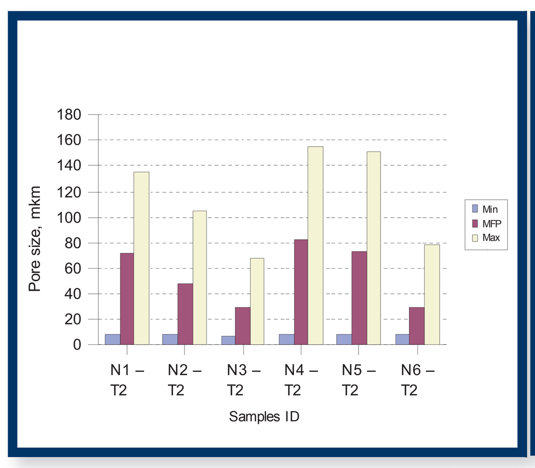


Figure 3. Different types of pores Figure 4. Pore diameter changes along the path of the channel

The pore size and its distribution for the samples with the 40% binder are illustrated in Figure 6.



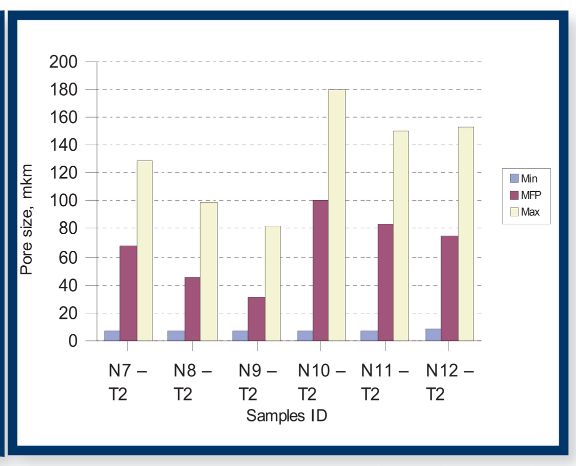


Figure 5. Pore size on spunlaced samples with 25% binder Figure 6. Pore size on spunlaced samples with 40% binder

The smallest pores were achieved for sample N9 - T2 of PP with water jet pressure of 200 bar.

Filtration properties

Samples were tested for filtration properties such as dust arrestance, dust holding capacity and resistance (pressure drop) using the dust filtration device, manufactured at the CSIR (Figure 7). The results on filtration properties for samples with 25% binder are illustrated in Table 2.

Figure 7. Dust filtration device

Table 2. Filtration properties on spunlaced samples with 25% binder

Filtration Properties	N1-T2 PP	N2-T2 PP	N3-T2 PP	N4-T2 PET	N5-T2 PET	N6-T2 PET
Water jet pressure, bar	60	120	200	60	120	200
Dust arrestance, %	90.9	93.7	99.4	95.8	94.5	96.9
Dust holding capacity, g/m^2	62.7	45.6	74.4	48.7	59.4	68.1
Pressure drop, Pa	25	37.5	25	37.5	12.5	25

In samples with 25 % binder application, sample N3-T2 (PP) showed the best performance properties in terms of all filtration parameters.

The filtration properties were evaluated on samples with 40% binder application. The results are summarised in Table 3.

Table 3. Filtration properties on spunlaced samples with 40 % binder application

Filtration Properties	N7-T2 PP	N8-T2 PP	N9 -T2 PP	N10 -T2 PET	N11-T2 PET	N12-T2 PET
Water jet pressure, bar	60	120	200	60	120	200
Dust arrestance, %	97.3	97.7	98.6	88.62	90.4	93.9
Dust holding capacity, g/m^2	75.35	52.48	72.84	49.65	64.21	37.16
Pressure drop, Pa	37.5	37.5	62.5	37.5	25	50

Within the samples with 40 % binder, sample N7-T2 (PP) showed the best performance properties for filtration parameters.

CONCLUSIONS

There was an improvement in filtration properties, such as filtration efficiency and dust holding capacity using spunlaced and chemically bonded material. Spunlacing process binds the fibres in a homogeneous way.

To help ensure improved air quality and greater hygiene in the work place, CSIR researchers are developing new generation and more efficient and effective nonwoven textile filters.

The fibres become tightly packed, making it difficult for particles to pass through the body of the fabric. With the use of finer fibres, the surface area of the filter media shows an increasing number of finer pores.

The absence of mechanical damage to the fibres leads to increased filtration performance, as dust can not penetrate the filter media. This helps create cleaner air.

It can be concluded that the optimum parameters for the manufacture of filters from PP fibres, is 200 bar pressure of water jets and 25 % binder application.

The improved surface characteristics from the finer pores of finer fibres will result in the reduction of raw material for manufacturing of lighter filtration fabric with higher filtration efficiency. Spunlaced nonwovens are a viable alternative to traditional filters.