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COMPARISON OF DIFFERENT AIR GAP/SETBACK OF DIETIP ON REIFENHÄUSER BICOMPONENT MELTBLOWN LINE

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Abstract

Over five hundreds of mono- and bi-component meltblown web samples have been produced on 24-inch wide Reicofil® side-by-side bicomponent meltblown line since its installation at TANDEC in March 1999 using various thermoplastic resins such as polypropylene (PP), polyethylene (PE), poly[ethylene terephthalate] (PET), poly[butylenes terephthalate] (PBT), polyamide (PA), and their bicomponent (bico) pairs, such as PP/PE, PP/PET, PE/PET, PP/PA, PBT/PE and PBT/PP. Several dietip geometries of different air gap/setback were applied. In this research, three dietip geometries of air gap/setback as 0.5mm/0.7mm, 0.8mm/1.0mm, 2.0mm/2.0mm are compared based on available data obtained with similar processing conditions, resultant web structure and properties.

Introduction

Meltblown (MB) is a one-step process to make microfine nonwovens directly from thermoplastic polymers with the aid of high velocity of hot air to attenuate the melt filaments to microfibers. It is a complex, multi-variable process and the resultant quality of meltblown webs depends on many processing conditions. The primary process control variables for a given die geometry and resin are considered as melt temperature, air temperature, melt throughput, air flow rate, and die-to-collector distance (DCD). The die geometry is normally adjustable for air gap and setback in the range of 0.2-2.5mm. But the most used setups are between 0.5-2.0mm. Since different air gap and setback often make differences in the web quality, they have become two sensitive operational machine parameters for the meltblown process though the research publications can be hardly found particularly on this topic.

Over five hundreds of mono- and bi-component meltblown web samples have been produced on 24-inch wide Reicofil® side-by-side bicomponent meltblown line since its installation at TANDEC in March 1999. Various thermoplastic polymers were processed such as polypropylene (PP), polyethylene (PE), poly[ethylene terephthalate] (PET), poly[butylenes terephthalate] (PBT), polyamide (PA), and their bicomponent (bico) pairs, such as PP/PE, PP/PET, PE/PET, PP/PA, PBT/PE and PBT/PP. Based on available data obtained in the last three years for Reifenhäuser meltblown research program at TANDEC, three dietip geometries are selected for a comparison study according to fineness, softness and other physical properties. The air gap/setback is 0.5mm/0.7mm, 0.8mm/1.0mm, 2.0mm/2.0mm, respectively. The web structure and properties achieved with similar processing conditions are comparatively evaluated in this paper.

Experimental

30 meltblown web samples were selected, including 100% PP, 75PP/25PE, 50PP/50PE, 25PP/75PE, 75PP/25PET, 50PP/50PET, 25PP/75PET, 75PP/25PA, 650PP/50PA6, 25PP/75PA6. Each mono or bico pair was produced on 24-inch wide Reicofil® side-by-side bicomponent meltblown line with three dietip geometries with air gap/setback as 0.5/0.7, 0.8/1.0, 2.0/2.0 (mm/mm) and similar processing conditions. Table 1 gives the processing conditions, in which each ID number indicates three web samples obtained using the above three setups for the air gap/setback.

Different air flow rate was applied for ID No. 1, 5, 6, 7, 8 in Table 1 since the exactly same level could not be replicated for the dietip geometries of different air gap and setback. Taking mono PP for an example, the air flow rate 350SCFM used for the dietip of 0.8mm/1.0mm air gap/setback was unable to use for 0.5mm/0.7mm and 2.0mm/2.0mm since too many flying fibers were resulted in. Besides, lager DCD had to be used with the air gap/setback of 2.0mm/2.0mm for production of the mono PP and bico PP/PE webs to prevent the fibers from being too sticky together in the webs.

The basis weight of all the webs was targeted at 1 oz/yd^2 or 34g/m^2. They are comparatively evaluated by bulk density, fiber diameter (SEM), air permeability (ASTM D 737), tensile properties (ASTM D 1117), flexural rigidity (ASTM D 1338-64) and hydrostatic head (IST 80.4-92).

Results and Discussion

Figure 1 shows the actual basis weight of 30 mono or bico webs, which are around 1 oz/yd^2 or 34g/m^2 as designed Figure 2 gives bulk density of the webs. Most of the webs achieved their lowest bulk density with the air gap/setback of 0.8mm/1.0mm.

Figure 3 are fiber diameter of the meltblown webs. In terms of producing smallest fiber diameter, air gap/setback of 0.8mm/1.0mm was the most favorable choice for mono PP and 0.5mm/0.7mm was the best choice for bico PP/PE, PP/PET, PP/PA6 webs.

Figure 4 demonstrated the flexural rigidity of the webs. The smaller the flexural rigidity, the softer the web. It was interestingly found that the air gap/setback of 0.8mm/1.0mm produced the softest hand among the mono PP and PP/PE, PP/PET, PP/PA6 webs under the conditions studied, even though larger DCD used for the air gap/setback of 2.0mm/2.0mm was favorable to produce the softer webs for Samples marked as ID 1-4 in Table 1. The softness and fineness of the web in the meltblown process depends on many factors after the filaments are extruded out of the dietip orifices, including temperature distribution and flow dynamics of the high-velocity hot air, melt elongational behavior, and DCD. Assuming all the processing conditions are the same except the air gap/setback, the larger air gap/set back should results in slower air jet in the filament attenuation field, that means smaller air drag force for the filament attenuation and less impulsive force or momentum exerted on the web once colleted on the collector. The effect on the resultant web is larger fiber size and softer hand. But on the other hand, the larger air gap/set back also results in relatively higher filament temperature since the wider and slower air jet reduce heat transfer rate from the hot filament to the environment. The higher temperature on the filaments during the attenuation tends to produce the finer fibers. Since the cooling rate is not as fast as smaller air gap and setback, the fibers may be more thermal-bonded to each other, reducing the web softness. That is the reason why larger DCD (10in, 11in) had to be used for production samples from Id No. 1-4 in Table 1. Therefore, there exists an optimized air gap/setback between the small and large setups to achieved the best desired properties. In terms of web softness, the air gap/setback as 0.8mm/1.0mm appeared to be the best choice among three dietips studied for production of the mono PP, PP/PE, PP/PET, PP/PA6 bico webs.

Figure 5 and Figure 6 are tensile properties of the meltblown webs. The mono PP, bico PP/PE produced with the air gap/setback of 0.8mm/1.0mm exhibited the weakest web strength, and those produced the air gap/setback of with 0.5mm/0.7mm exhibited the best strength and greatest web breaking elongation. For PP/PET and PP/PA6 bico webs, the webs produced with the air gap/setback of 2.0mm/2.0mm overall achieved the strongest web strength. No consistent trend could be observed for the breaking elongation.

Figure 7 shows the air peameability. The webs produced with the air gap/setback of 0.5mm/0.7mm and 0.8mm/1.0mm exhibited the highest values (best breathability) among three dietips tested in this research. The web produced with the air gap/setback 2.0mm/2.0mm showed the worst air breathability.

Figure 7 gives the test results for static hydrohead. The mono PP web produced with the air gap/setback of 0.8mm/1.0mm demonstrated the highest hydrohead (water resistance) among all the webs in this study. It also achieved the finest fiber diameter (Figure 3). For the bico PP/PE, PP/PET, PP/PA6 webs, the air gap/setback of 2.0mm/2.0mm produced the webs of the highest hydrohead, but the values appeared at the cost of the web breathability as shown in Figure 6.

Conclusion

Three dietip geometries with the air gap/setback as 0.5mm/0.7mm, 0.8mm/1.0mm, 2.0mm/2.0mm were comparatively studied on Reifenhäuser bico MB line at TANDEC. Based on the tested samples including mono PP, bico PP/PE, PP/PET, PP/PA6, the air gap/setback of 0.8mm/1.0mm produced the softest webs and fine web structure. The obtained mono PP achieved the finest fiber and highest hydrohead among all the webs studied.

The air gap/setback of 0.5mm/0.7mm appeared favorable to create the smallest fiber diameter for the bico webs. The webs produced with the air gap/setback of 2.0mm/2.0mm exhibited the best web strength and the worst air breathability.

It should be noted that the comparison conducted in this study is directly related to the processing conditions since meltblowing is a nonlinear, multi-variable and dynamic-correlated process.

Acknowledgements

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Table 1. Processing Conditions of 30 Meltblown Webs Produced with Air gap/Setback as 2.0mm/2.0mm, 0.8mm/1.0mm, 0.5mm/0.7 mm.

IDNo.	Bico Ratio (%)	Melt Temperature (˚F)	Melt throughput (g/hole/min)	Air temperature (˚F)	Air flow rate (SCFM) 2.0/2.0, 0.8/1.0, 0.5/0.7	DCD (in) 2.0/2.0, 0.8/1.0, 0.5/0.7
1	100PP	520	0.6	520	250, 350, 250	10/8/8
2	75PP/25PE	500/500	0.6	500	350	11/8/8
3	50PP/50PE	500/500	0.6	500	350	11/8/8
4	25PP/75PE	500/500	0.6	500	350	11/8/8
5	75PP/25PET	590/590	0.6	600	550, 550, 500	10
6	50PP/50PET	590/590	0.6	600	550, 550, 500	10
7	25PP/75PET	590/590	0.6	600	550, 550, 500	10
8	75PP/25PA6	580/590	0.6	600	500	8
9	50PP/50PA6	580/590	0.6	600	600, 600, 500	8
10	25PP/75PA6	580/590	0.6	600	500	8

The resin grade was Exxon 3546G for No. 1, Exxon 3546G/Dow6808 for N0. 2-4, Note: Exxon 3155/Wellman for No. 5-7, Exxon 3155/BASF B3 for No. 8-10.

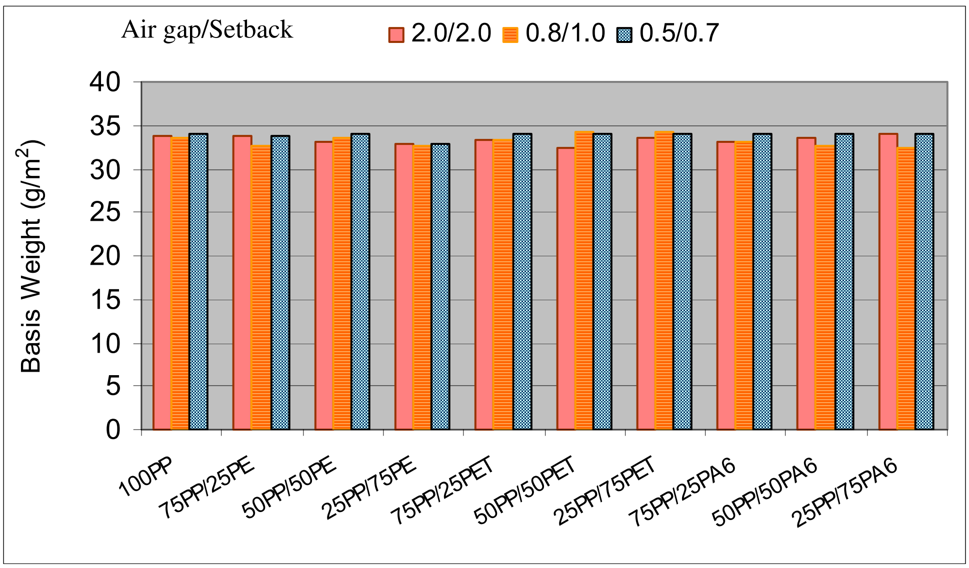

Figure 1. Basis weight of the meltblown webs.

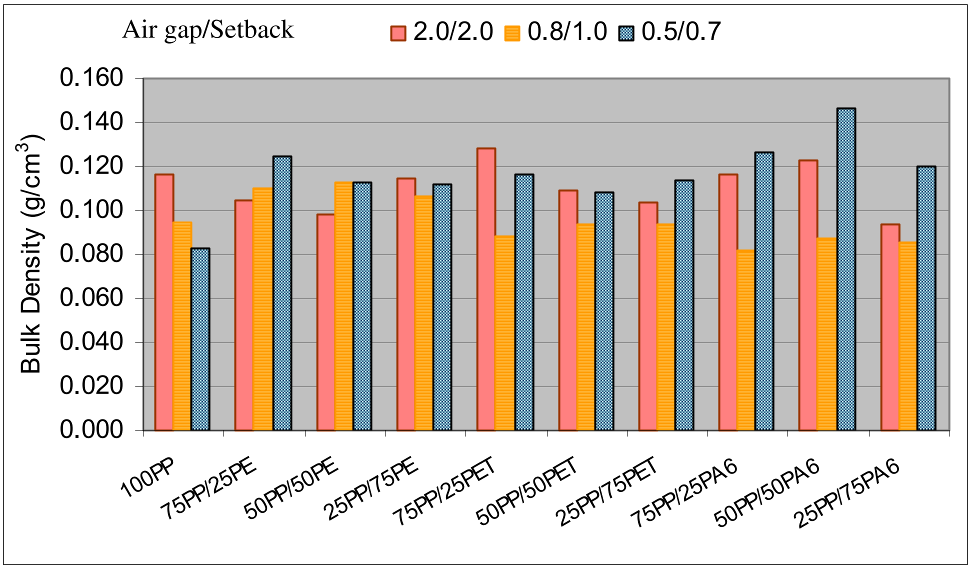

Figure 2. Bulk Density of the meltblown webs.

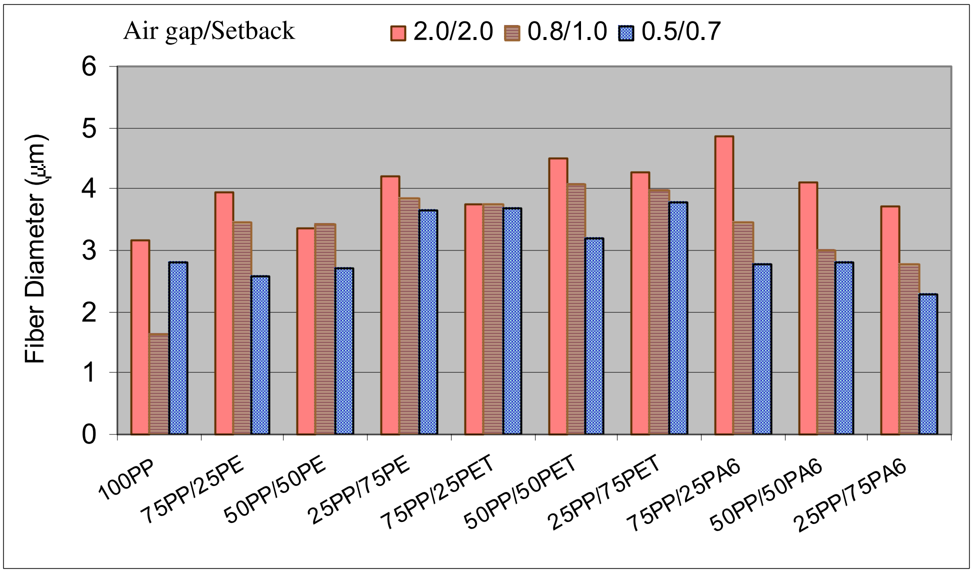

Figure 3. Fiber diameter of the meltblown webs.

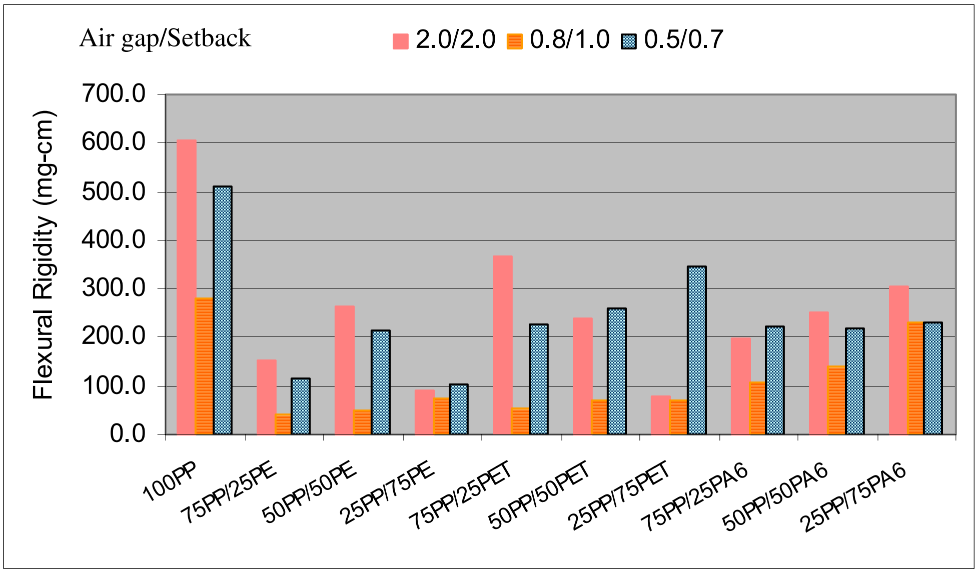

Figure 4. Flexural rigidity of the meltblown webs.

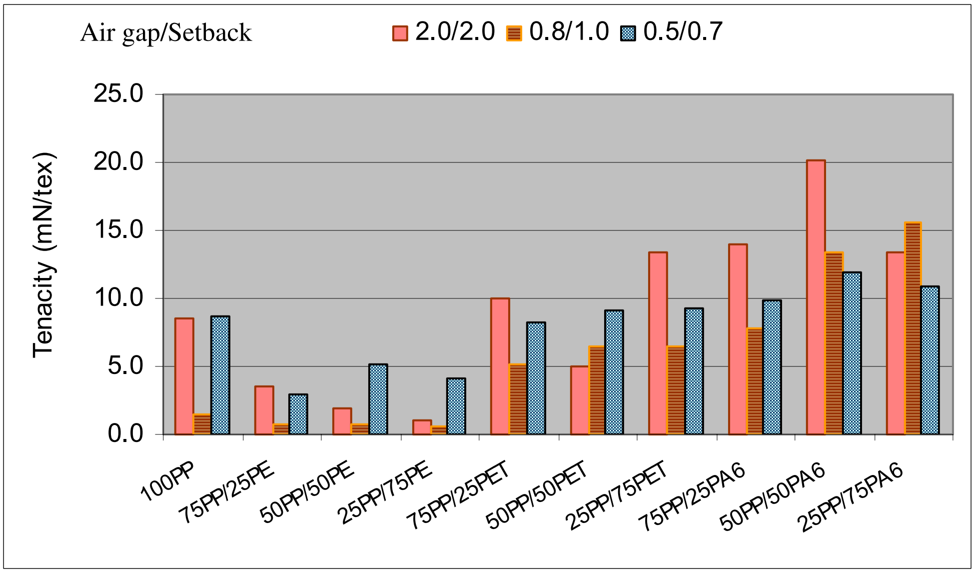

Figure 5. Tenacity of the meltblown webs.

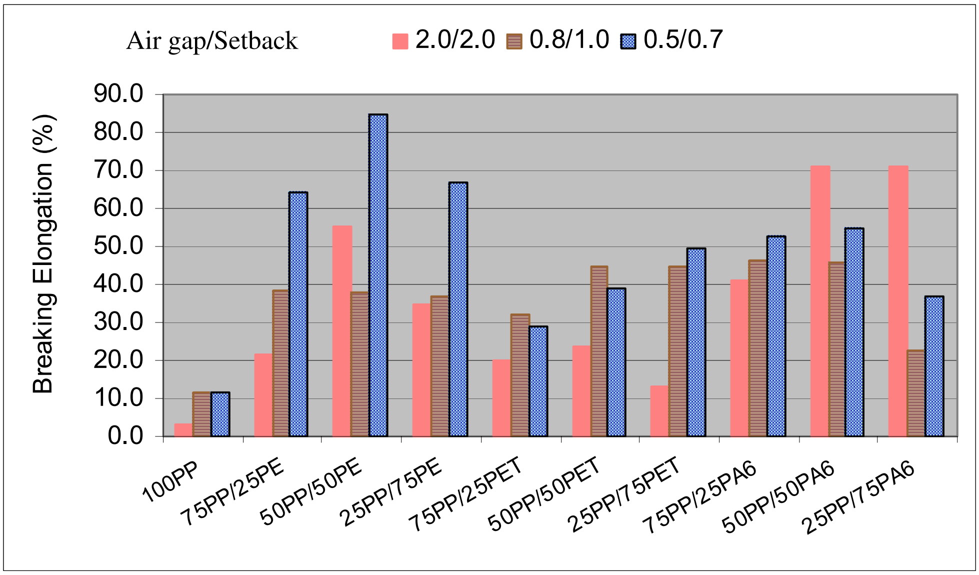

Figure 6. Breaking elongation of the meltblown webs.

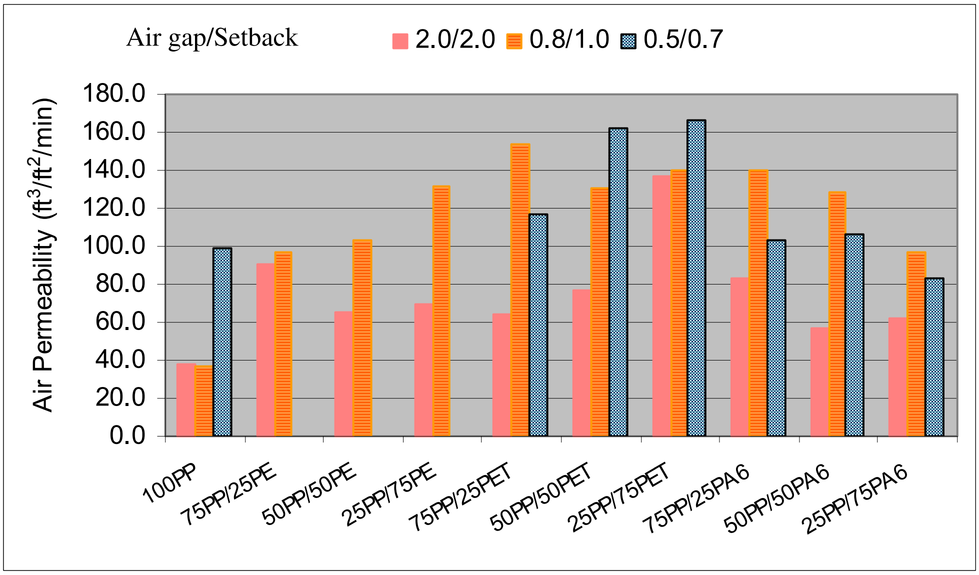

Figure 7. Air permeability of the meltblown webs.

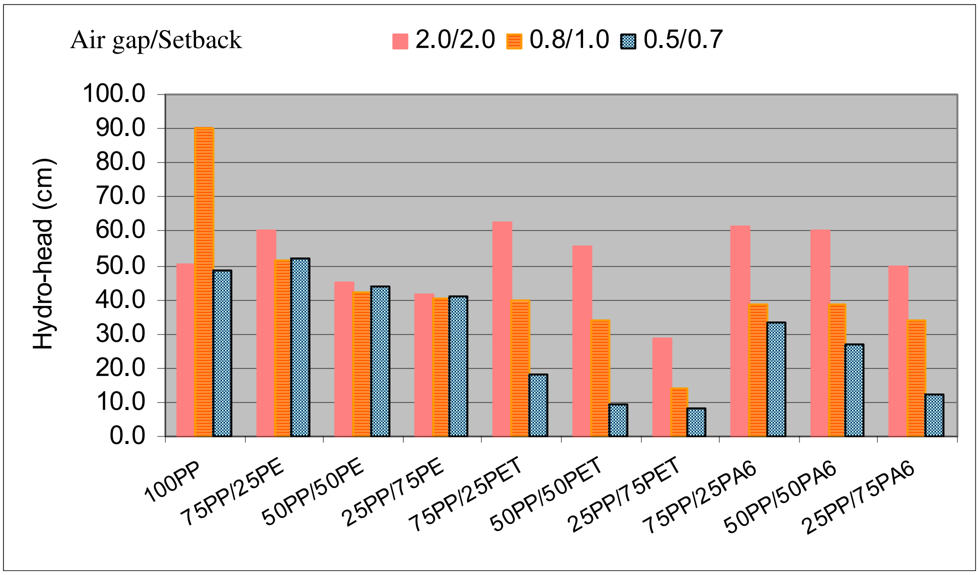

Figure 8. Hydro-head of the meltblown web.