Study on the Processing Technology and Mechanical Properties of Nonwoven Fabric Composited by Recycled PP Selvedges

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Abstract

Functional nonwoven products have superiority such as quick mass-production, short processing time, wide sources for raw material, low cost and high output etc. They have been widely studied and promoted in advanced countries. However, comparing with selvedge processing, they brings considerable burden to environment. So in this paper, we chose low cost polyester (LPE) and low melting point fiber (LMPE) respectively blending by 50 wt% through the process of mixing, blowing, carding, laying, and needle punching etc. to form nonwoven fabric in which the needle density was adjusted. Finally it is found that 103 needles/cm2 was optimal after mechanical testing. And then different proportions of PP selvedges were placed in the middle of two optimal nonwoven layers by sandwich structure, and mechanical properties of PET/LMPET/PP fabric produced after thermo bonding and cooling was tested. According to the optimal production evaluation for functionality, these products may apply to reinforced interlayer in general protective clothing, protective glove, reinforcement in simple building structure and stiffening geotextiles in the future.

Introduction

Nonwoven is cloth fabric not shaping by yarn in the way of traditional knitting, weaving etc, but directly producing by the web after thermo bonding, physical and chemical effect. It is forming by friction or cohesiveness among fibers, or cohesive force from bonding agent, as well as two more bonding force [1-4].

With rapid development of science and technology, industry development enters into higher production and higher consumption age. Absolutely, the wastes are also increasing. For fiber industry, since 1996 abandoned fiber and fabric products have been about 45 million tonnes each year which accounts for about 5 % of the total. But plastic wastes were only about 170 million tonnes per year which was 20 % in proportion of the total. Currently, for nonwoven industry in Taiwan, the selvedges only from manufacturing process was 3 ~ 5 % of the total. But their utility values are not high at present, and they are mostly disposed by burying and incineration etc. Yet these ways bring about not only environmental load, but also second-time pollution. If these nonwoven wastes can be recycling again, it will save material cost and increase benefits of environmental protection [5-8].

So in this study we selected low cost polyester (LPE), low melting point fiber (LMPE) as nonwoven fabric, and recycled PP selvedges as interlayer to form sandwich structure after thermo bonding. Because single material usually can not satisfy the mechanical demand in different environment and conditions, it is necessary to mix other materials to strengthening. In this way, not only the advantage of raw materials can be maintained and mechanical behavior is enhanced by reinforcement, but also the whole products cost is down via reinforcement addition.

Experimental procedure

Firstly, LPE and LMPE were bending by 50 wt%: 50 wt%. And in the process of forming multilayer web by mixing, blowing, carding, striping and laying, the needle was adjusted to 68, 103, 137 needle/cm^2. Then PE/LMPE web with optimal needle- bonded was produced, and its tensile strength and tearing strength in 0o (machine direction, MD) and 90^o (cross machine direction, CD) directions were respectively measured.

Then two PE/LMPE plies was laid with PP selvedges at the rate of 10 wt%, 20 wt%, 30 wt%, 40 wt%, 50 wt% in vertical to CD direction. And finally 2 mm thick PE/LMPE/PP fabric with sandwich structure was manufactured after hot pressing and cooling, and their tensile and tearing strength were tested by universal strength tester according to ASTMD5035-06.

Results and Discussion

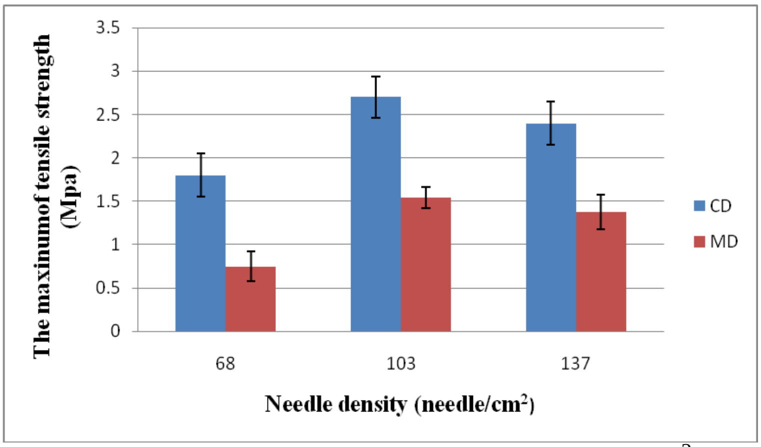

Fig.1 The relationship between needle density (68,103,137 needle/cm^2) and tensile strength of PE/LMPE nonwoven which was composed of 50 wt% PE fiber (length 64 mm, fineness 12D) and 50 wt% LMPE (length 51 mm, fineness 4D) respectively in MD and CD directions.

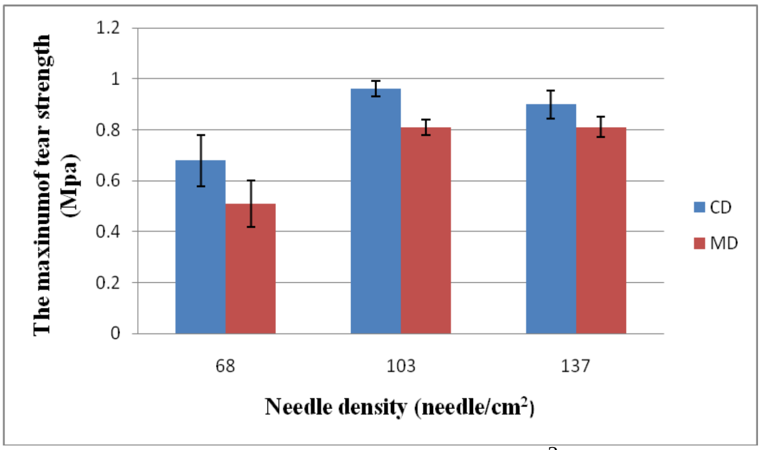

Fig.2 The relations of needle density(68,103,137 needle/cm^2) to tearing strength of PE/LMPE nonwoven which was prepared from 50 % PE (length 64 mm, fineness12D) and 50 % LMPE (length 51 mm, fineness 4 D) respectively in CD and MD directions.

As shown in fig.1 and fig.2, the tensile strength and tearing strength of PE/LMPE fabric were increasing when the needle density was between 68 and 103 needle/cm^2. And they presented gradually decreasing when needle density was increasing from 103 to 137 needle/cm2. In the needle-bonded process, the needlehook made the web moving up and down fast at short time to reinforcement, so the needle density had considerable influence on their physical performance.

From the above two figures, the physical property tend to improve when needle density was increasing from 68 needle/cm^2 to 103 needle/cm^2.That was beacause denser needles makes the amount of fibers below needlehook moving up multiple and fiber gap narrow. But when rising needle density from 103 up to137 needle/cm2, the mechanical properties instead tend to drop. That was because too dense needles conversely causes tangling fiber boundles ruined, which will bring negative impact on nonwoven structure when needle density was increased to a certain degree. It is concluded that the maximum tensile and tearing strength in CD and MD directions were respectively 2.696 MPa, 0.943 MPa (CD) and 1.54 MPa,0.813 M Pa (MD) when the needle density was 103 needle/cm^2.

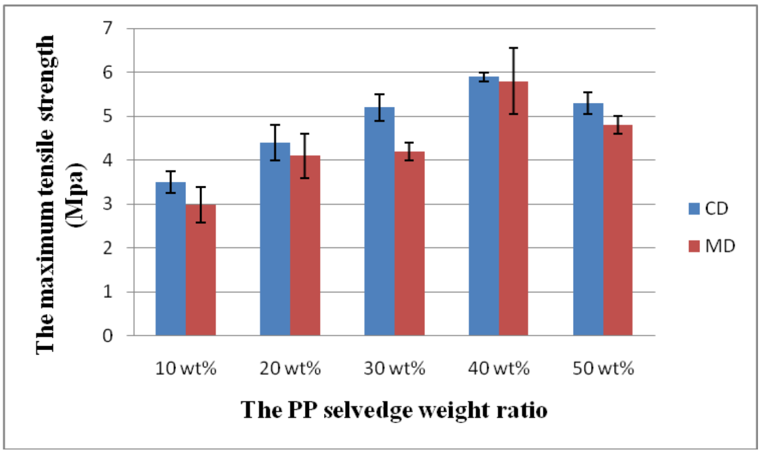

Fig.3 The relations of PP selvedges wt% (10 %, 20 %, 30 %, 40 %, 50 %) to maximum tensile strength of PE/LMPE/PP nonwoven after hot-pressing (0.5 m/min speed,180 ℃ temperature, 2 mm gap between up and down) respectively in CD and MD directions .

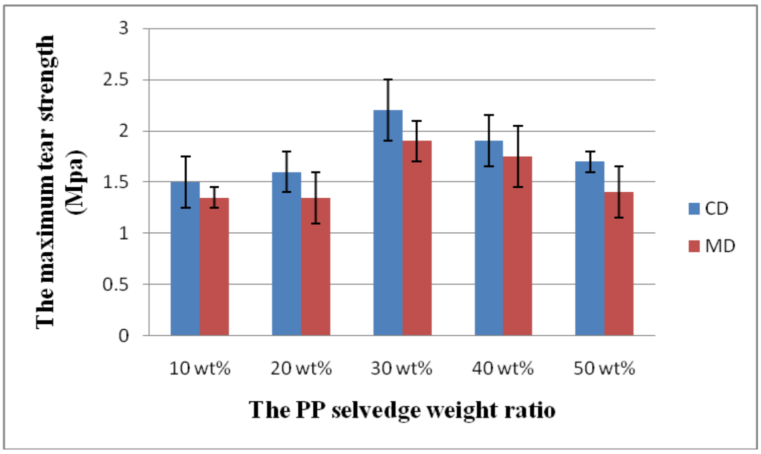

Fig. 4 The influence of PP selvedges wt% (10 %, 20 %, 30 %, 40 %, 50 %) on maximum tearing strength of PE/LMPE/PP fabric respectively in CD and MD directions which was hot-pressed in velocity of 0.5 m/min at 180 ℃with 2 mm gap between up and down rollers..

With nonwoven as main body and PP selvedge as reinforcement, the mechanical properties were elevated to a certain extent after thermo bonding and cooling. When PE/LMPE/PP fabric passing by the hot-press rollers, the molecular chain of LMPE and PP selvedges happens to soften due to molecular slipping, leading to filling the fibers interspaces and increasing adhesiveness among fiber bundles. And after cooling, the original melting macromolecular chain will be fixed on final cooling position. According to this way, composites achieve reinforcing effect.

From fig. 3 and fig. 4, the mechanical properties tend to enhance as the ratio of PP selvedges was increasing. When PP selvedges wt% was 40 %, the fabric reached maximum tensile strength of 5.855 MPa (CD) and 5.78 MPa (MD). And the maximum tearing strength of PE/LMPE/PP including 30 wt% PP selvedges was 2.224 MPa in CD direction and 1.898 MPa in MD direction.

Conclusion

Appropriate material match and process design can save production cost, as well as solving effectively environmental issues where the current global paid attention. In this study we design a type of nonwoven using low-cost polyester and low melting point of polyester fiber to make sandwiche structure blending with recycled PP selvedges as interlayer after hot-pressing. In Experiment, we founded that needle-bounded density with 103 needles/cm^2 was optimal. If density exceeds 103 needles/cm^2, the mechanical properties was declined because of destroyed fiber. Finally optimal tensile strength was 2.696 MPa in CD, and 1.54 MPa in MD. Optimal maximum tear strength was 0.934 MPa in CD and 0.813 MPa in MD direction.

PP selvedges after melting can fill interspaces between fibers, causing the mechanical properties elevation. In our study, it is demonstrated that maximum tensile fracture strength occurs to 5.855 MPa in CD and 5.78 MPa in MD when PP selvedges contains 40 wt %. But maximum tear strength of fabric containing 30 wt % PP selvedges achieves to 2.224 MPa in CD and 1.898 MPa in MD .

This research had successfully developed the processing technology of nowoven fabric using recycling PP selvedges, and discussed their mechanical properties. According to study, it is not except for reducing pressure from fiber waste to environment, and promoting application of fibers products with diversified functionality, such as bulletproof interlining, reinforcing materials of general work soles, stiffener grid fabric and reinforcement materials of general stereoscopic structure fabric for etc.

Acknowledgement

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