Recycling Nonwoven Fabric and Polypropylene Selvage to Create Composite Fabric

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Abstract

Two layers of 7.0 D polyester (PET) nonwoven fabric enclosing polypropylene (PP) selvage were needle punched and thermally bonded to form a compound base cloth. This manufacturing technique not only reuses selvage, creating an environmentally friendly material, but also increases

the mechanical strength of the compound geotextile. When the base cloth weighed 150 g/m2, it displayed optimal mechanical properties, with a selvage content of 10 % and a thermal bonding temperature of 220 ℃. The linear velocity of the thermal compress roll was 0.5 m/min and its needle punch density was 400 punches/cm2. Its tensile and tear strength and geotextile application were evaluated by the ASTM D4632 and ASTM D4533 test standards.

Introduction

Rapid development in science and technology has resulted in an alarming increase in pollution, with textile waste making up 5 % of the total garbage output. Therefore, there is a critical need to develop cost-effective and eco-friendly techniques that will reduce the amount of waste produced by the textile industry.

In the past two decades, nonwoven fabrics have been widely used in a variety of fields, due to their low-cost, simple processing and effective air permeability; they can be found in bio-textiles, water filters, air conditioners, agriculture, and industrial textiles [1, 2]. Nonwoven fabrics are also commonly used in sorbent applications, such as thermoplastics and electrically conductive composites [3-7], wound dressings [8], and geogrids [9].

Nonwoven geotextiles are ideal for use in soil separation, reinforcement, filtration and drainage. Either as woven or nonwoven structures, they are frequently employed in civil engineering projects (building, bridge, dam, and highway construction) and are a main component of geosynthetics. It is essential for geotextiles to be able to fulfill more than one function, i.e. separation, drainage and filtration [10, 11].

It should also be mentioned that geotextiles enhance the service life of civil engineering constructions and minimize environmental impact [12-13]. As awareness for the need of environmental protection increases, businesses and investors are turning to environmentally friendly solutions that will form a lucrative market in the near future. The market growth rate of environmental textiles is the fastest in the textile industry [14]. Accordingly, this research focuses on creating a manufacturing technique that not only reduces fabric waste, but also increases the strength of the compound fabric.

Experimental

PP nonwoven selvage waste was collected from a textile factory that employed particular methods to produce solid and homogenous fabric. The waste was classified, smashed and cut into strips which were then cut into large, uniform pieces and superposed between two layers of PET nonwoven web (Eastlon Polyester Staple SN-3750CHB 7.0 DE × 51 mm × SD). Next, the PET web enclosing the selvage was needle punched and thermally bonded, creating a compound Geotextile whose tensile and tear strength were tested according to the ASTM D4632 and ASTM D4533 standards. The test results determined the optimal manufacturing parameters.

Results and Discussion

The Influence of the PET Nonwoven Web's Weight on the Tensile Strength

The tensile strength test assessed the influence of the PP selvage's weight percentage on the entire composite material. The test was also undertaken in order to understand the relationship between the strength of the compound geotextile and the weight of the base cloth (PET nonwoven web). Figure 1 shows the results of the fabric's tensile strength in MD and CD. When the weight of base cloth was 150 g/m2, the unit weight provided a greater tensile strength, indicating that the compound geotextile was well formed. In contrast, when the weight of base cloth was 250 g/m2, the PET nonwoven webs were thicker, resulting in a poorly made geotextile. Hence, the weight of base cloth was set at 150 g/m2 for this experiment.

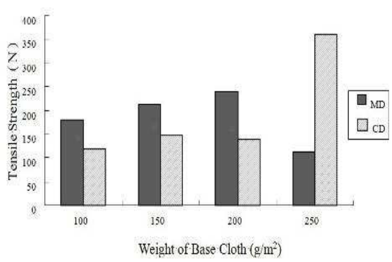
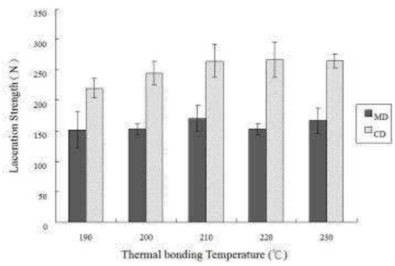


Figure 1. The influence of the base cloth's weight on the tensile strength.

Figure 2. The tensile strength of the compound Geotextile based on varying thermal bonding temperatures.



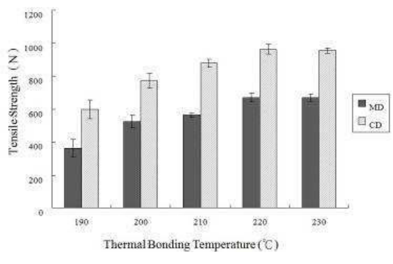


Figure 3. The tear strength of the compound Geotextile based on varying thermal bonding temperatures.

The Influence of Thermal Bonding Temperature on the Tensile Strength

In previous studies by this laboratory, it was discovered that when the proportion of PP selvage in a composite textile was 10 %, the compound geotextile possessed optimal MD and CD tensile strength. The thermal bonding temperature was varied in order to observe whether the PP selvage and PET nonwoven webs bonded effectively. The tensile and tear strengths were also tested to determine their relationship to the temperature. Various temperatures of 190 ℃, 200 ℃, 210 ℃, 220 ℃, and 230 ℃ were used during the thermal bonding.

Figures 2 and 3 illustrate the tensile and tear strength of the compound geotextile based on the thermal bonding temperature. Both the tensile and tear strengths were greater as the thermal bonding temperature increased from 190 ℃ to 220 ℃. At 220 ℃, the geotextile achieved optimal strength in both categories, possibly due to the fact that a higher temperature ensures better geotextile performance.

The Influence of the Thermal Compress Roller's Linear Velocity on the Tensile and Tear Strength

The parameters of linear velocity for thermal pressing were: 0.5 m/min, 1.5 m/min, 2.5 m/min, 3.5 m/min, and 4.5 m/min. Figure 4 gives the results of the tensile strength test. When the linear velocity was 0.5 m/min, the tensile strength of the geotextile was greater. The shorter the amount of contact time between the textile and the two rollers during thermal bonding, the greater the increase in the linear velocity. As a result, the heat was incapable of completely melting the PP selvage.

Figure 5 indicates that when the linear velocity was 0.5 m/min, the geotextile had better tensile and tear strength. This may be attributed to the lower linear velocity, which gave the nonwoven more time to come in contact with the rollers during pressing, ensuring that the PP selvage was thoroughly melted.

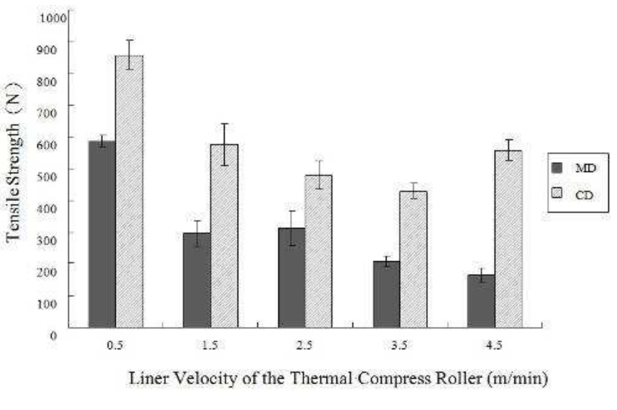


Figure 4. The tensile strength of the compound geotextile based on different linear velocities of the roller.

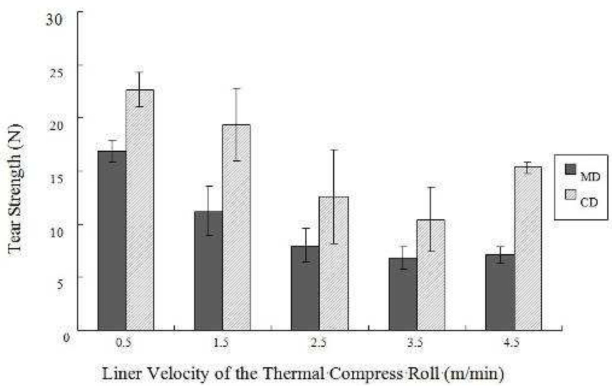


Figure 5. The tensile strength of the compound geotextile based on different linear velocities of the roller.

The Influence of the Needle Punching Density on the Mechanical Properties of the Compound Geotextile

The upper and lower layers of the fiber web entangled and intertwined during needle punching, reducing the geotextile’s thickness and preventing the two layers from coming apart under external force. The parameters for the needle punch density during this experiment varied from 200 punches/cm2, 300 punches/cm2, 400 punches/cm2, and 500 punches/cm2. Figure 6 provides the results of the tensile strength test and Figure 7 displays the results of the tear strength test. When the needle density was between 200 punches/cm2 and 400 punches/cm2, there was a significant improvement in the tensile strength and tear strength. Because a denser needle punching reinforced the connection between the upper and lower layer in the fiber web, increasing the tensile strength and tear strength. However, when the needle punch density was of excess of 400 punches/cm2, the over punching damaged the fibers’ structure, decreasing the tensile and tear strength of the geotextile. In particular, the geotextile exhibited optimal mechanical properties when its needle punching density was 400 punches/cm2.

The Influence of the Thermal Bonding Temperature on the Water Permeability of the Compound Geotextile

The water permeability of the geotextile was decided by its pore size. When the temperature used for thermal pressing increased, there was more thermal bonding in the PP selvage, creating a more compact PET web. Figure 8 gives the results of the water permeability test. As obviously indicated, the water permeability decreased with a rise in the temperature during thermal pressing; a hotter temperature caused the PP selvage to have a closer knit bond.

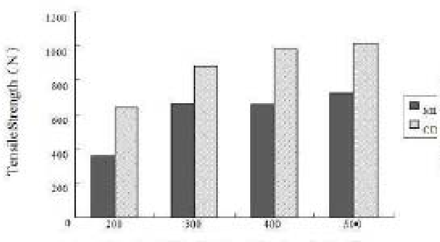


Figure 6. The tensile strength based on different needle punching densities.

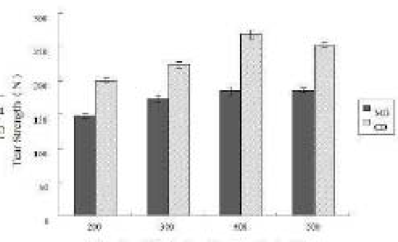


Figure 7. The tear strength based on different needle punching densities.

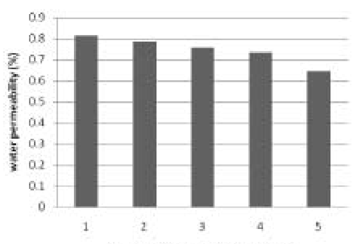


Figure 8. The influence of the temperature during thermal pressing.

Conclusion

The manufacturing process employed in this study creates an alternative material which is more environmentally friendly, yet just as efficeint as its commercial equivalents. Geotextiles were produced from recycled thermalplastic nonwoven selvages and reinforced with needle punching, creating a durable nonwoven structure. According to the experimental results, the compound geotextile reached an optimal tensile and tear strength of 982.25 N and 272.56 N, respectively, when manufactured under parameters of: a 150 g/m2 base cloth weight; a 10 wt% PP selvage weight percentage; a thermal bonding temperature of 220 ℃; a 0.5 m/min linear velocity for the thermal compress roller; and a needle punching density of 400 punches/cm2.

Acknowledgement

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