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The Making of Geotextiles from Raw Waste of Wool Merino and Plastic using the Thermal Bonding Method

Agung Setia Budi [1], Asril Senoaji Soekoco [2]

[1] agungs.asb@gmail.com, Politeknik STTT Bandung
[2] asrilsenoaji@gmail.com, Politeknik STTT Bandung

* Correspondence: agungs.asb@gmail.com; Tel.: -

Abstract : Merino Sheep is a type of sheep that can produce two main products in the form of meat and fleece (wool). Lamb fur is still considered by breeders as stool-like waste, so its utilization is still lacking. in recent years there have been innovations in wool products to be applied to technical needs such as nonwoven fabric used for thermal and acoustic insulating materials in construction and the automotive or geotextile industries. This geotextile for wool fiber is made using the thermal bonding method, where wool fibers are mixed with thermoplastic fibers. To minimize the using of energy, the adhesive used is plastic polyethylene waste with a content variation 50%, 45%, and 40% of plastics and aims to get weight per meter square, moisture content and moisture regain, tensile strength, and bursting strength from the fabric. The test results obtained have been compared with the standard. The nonwoven fabric from a raw waste of wool merino and plastic can be made with the thermal bonding method and can be used geotextiles for erosion control, but not for construction scale.

Keywords : wool; geotextiles; thermal bonding

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1. Introduction

Sheep livestock is one of the most developed farms in Indonesia. Many sheep are kept in rural and suburban areas. In Figure 1 below is the population according to the Directorate General of Livestock and Health Data until August 2018.



Description: *) Temporary numbers
Source: Directorate General of Livestock and Health

Figure 1. Sheep population in Indonesia

Sheep are generally kept for meat production purposes and a small portion is for savings or for hobbies such as fighting art. There are so many types that exist in sheep populations in Indonesia, including Garut Sheep, Priangan Sheep, Fat Tail Sheep, Merino Breeds Sheep, and Merino Sheep. Can be seen in Figure 1.1, the number of sheep populations in Indonesia in 2018 was 17,397,696, of which 13.77% were spread in Central Java Province.

One area that has sheep is in the Wonosobo Regency area. According to the Central Java Province Animal Husbandry and Animal Health Service data until September 24, 2018, the population of sheep in Wonosobo reaches 105,534. Where one type of sheep in cattle is the Merino Sheep. Merino sheep is a type of dual-function sheep, namely sheep which can produce two main products in the form of meat and fleece (wool) (Huda, Nasich, & Nuryadi, 2015).

Wool is still considered by breeders as stool-like waste, so its utilization is still lacking. The use of wool has not been done much because of the limited knowledge of farmers. The breeders tend to throw away their wool after shaving the sheep so that the wool becomes waste on the ground or burned. Incorrect wool disposal creates ecological problems and contributes significantly to soil and air pollution (Roman Niznikowski, 2006).

Wool is produced by shearing fleece activities that are carried out 1-2 times a year for females while males are carried out every 2-4 months. Where each local sheep is able to produce 1 kg of wool/tail in a single shear, so that the potential of sheep hair which is considered to be waste can be utilized at 105,534 kg in one shave which if used as a product, will produce high economic value so that farmers can increase their income.

Wool is a natural fiber so that the fiber can decompose naturally in the soil in a matter of years, and will slowly release valuable nutrients back to earth. Wool has anti-tangle properties, can absorb large amounts of water vapor, can store temperature, is fire resistant and resistant to UV light (Jumaeri, 1977).

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So far, fleece has been used for the production of carpets and other interior textiles. In the last few years, there have been innovations in some products from fleece which have not a good quality to be applied to the needs of techniques that have commercial value (Russel, Swan, Trebowicz, & Ireland, 2016). The product is woven weaving cloth which is used for thermal and acoustic insulating materials in construction and the automotive or geotextile industry(Patnaik, Mvubu, Muniyasamy, Botha, & Anandjiwala, 2015).

Nonwoven fabric is a product that is made by spreading fibers in parallel, crossing or randomly formed into a sheet of fabric using adhesive, or thermoplastic fibers that are conditioned with a certain temperature and pressure (Patel & Bhrambhatt, 2011). Thermoplastic fibers or commonly used adhesives are polyvinyl chlorides, polyamide, polyester, polypropylene, and polyethylene. The adhesive used for making nonwoven fabrics must be adjusted to the basic material of the fabric used, the melting point of the adhesive must be lower than the fiber to be made of cloth (P. K. Roy, 2011). The adhesive used is plastic made from high- density polyethylene. High-density polyethylene plastic is used because it has a low melting point compared to other adhesive materials which are equal to 135^{0}C. Based on that, the study was taken about "The Making of Geotextiles From Raw Waste of Wool Merino and Plastic Using The Thermal Bonding Method".

2. Experimental

2.1. Materials

The material used is wool from merino sheep and polyethylene 2 plastic sheets which differ in weight per one square meter. Where the fiber goes through the scouring process first by soaking it for 4 days and soaking it with kitchen salt for one day and then drying it to dry in the sun.

2.2. Method

This geotextile for wool fiber is made using the thermal bonding method, where wool fibers are mixed with thermoplastic fibers. The adhesive used is plastic polyethylene with a content variation of:

- 50% wool: 50% plastic HDPE
- 55% wool: 45% plastic HDPE
- and 60% wool: 40% plastic HDPE.

The process of making the nonwoven fabric is carried out at the STTT Polytechnic Spinning Laboratory in Bandung. The making of nonwoven fabric uses a prototype machine for making nonwoven fabric with a thermal bonding method with hot rollers. Then the roller temperature is set to 150^{0}C because the adhesive material used has a melting point of 135^{0}C. Then set the roller rotation according to the specified parameters, which is set at a speed of 0.25 or 0.0028 m/s.

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3. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

3.1. Weight per unit area

This test uses a standard SNI 3801: 2010 (Textiles - The method for testing for fabric weight per unit length and weight per unit area). Based on the test, the results are presented in Table 3.1 which can be seen below.

Table 1. Data of weight per unit area

Fabric Variation	Weight per unit area
50 % wool, 50% HDPE	105.13 g/m2
55 % wool, 45% HDPE	116.78 g/m2
60 % wool, 40% HDPE	130.68 g/m2

It can be seen that the more wool content in the fabric, the higher the weight per unit area. Regarding the content of a material in an object, Raymond Chang suggests that the more material, the higher the mass will be (Chang, 2005). This can be seen in the nonwoven fabric that has been made. As can be seen in the table, where it shows an increase which means that any difference in the weight of the wool content on the fabric affects the weight per unit area of the fabric.

3.2. Moisture content and moisture regain

This test uses a standard SNI 8100: 2015 Textiles - Test method for moisture content (moisture content or moisture regain). Based on the test, the results are presented in Table 3.2 which can be seen below.

Table 2. Data of Moisture Content and Moisture Regain

Fabric Variation	Moisture Content	Moisture Regain
50 % wool, 50% HDPE	6.96%	7.48%
55 % wool, 45% HDPE	7.09%	7.63%
60 % wool, 40% HDPE	7.69%	8.33%

Moisture content shows how much the fabric's ability to store vapor, the higher the value of the moisture content, the higher the absorption capacity. The difference in the content of wool and plastic in the fabric affects the moisture content of the fabric. As seen in the table, the more wool content in the fabric, the higher the ability of the fabric to absorb water. As we know that wool fiber has a moisture regain up to 14.4%(Soeprijono, 1973) and according to Vuni (2018) all types of polyethylene

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have hydrophobic properties (Setyowati, Ayu, Widodo, & Restu) which mean it cannot absorb water, which with such properties can affect the absorbency of the fabric. Seeing when a wool fiber has become a fabric with a plastic mixture, moisture regains on the fabric decreases by almost half. This is because of the mixing done in heterogeneous mixing. Where according to Hardjono (2008) that heterogenous mixtures are between two kinds of substances or more which constituent particles can still be distinguished from each other. So that the properties and mixtures can be distinguished (Hardjono, 2008). The properties obtained in the fabric are a combination of the two properties of raw materials. So that when the content of wool is more than the plastic, then the resulting properties will be more is the wool and vice versa.

3.3. Thickness

This test uses a standard SNI ISO 5084:2010 (Textiles – methods for testing the thickness of textiles and textile products. Based on the test, the results are presented in Table 3.3 which can be seen below.

Table 3. Data of thickness

Fabric Variation	Thickness
50 % wool, 50% HDPE	62 mm
55 % wool, 45% HDPE	73 mm
60 % wool, 40% HDPE	81 mm

It can be seen that the more wool content or the less plastic content in the fabric will produce a thicker fabric, as stated P.K. Roy (2011) that if the binding content is 10% of the total mixing, the fabric structure is bulky, porous and flexible (Roy, Malik, & Sinha, 2011). Because the fabric produced is bulkier, it will have a more thick effect on fabrics with only 10% plastic content.

3.4. Tensile strength

This test uses a standard SNI 0276:2009 (How to test the tensile strength and elongation of woven fabric). Based on the test, the results are presented in Table 3.4 which can be seen below.

Table 4. Data of tensile strength

Fabric Variation	Tensile Strength (Length)	Tensile Strength (Width)
50 % wool, 50% HDPE	28.62 N	19.31 N
55 % wool, 45% HDPE	20.68 N	18.68 N
60 % wool, 40% HDPE	19.70 N	17.60 N

As seen in the table above shows that the more content of HDPE plastic on the fabric will produce higher fabric strength. Wool fiber has a strength of 1.2-1.27 g/denier (Soeprijono, 1973) and

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according to Bally Ribbon Mills (2019), fiber polyethylene has a strength of 2.6-4.2 g/denier. It can be seen that HDPE has higher strength than wool fiber, so when fabrics with HDPE plastic content, the strength generated will be stronger. It can be proven that according to P.K. Roy (2011) the binding content has a significant role in determining the properties of the fabric. If the binding content more than 50% of the total mixing, the resulting fabric is like reinforced by plastic, whereas if the binding content 10% of the total mixing, the fabric structure produced is hollow, porous and flexible with relatively low strength (Roy, Malik, & Sinha, 2011).

3.5. Bursting Strength

This test uses a standard SNI 08-0617-1989 (how to test bursting strength knit fabric (diaphragm method)). Based on the test, the results are presented in Table 3.4 which can be seen below.

Table 5. Data of bursting strength

Fabric Variation	Bursting Strength
50 % wool, 50% HDPE	25.36 N
55 % wool, 45% HDPE	24.10 N
60 % wool, 40% HDPE	23.84 N

It can be seen in the table above that the plastic content will produce a strong fabric to break down. This is because if more and more plastic content in the fabric, the fabric Struktur will be denser and more solid compared to fabric with more wool content. According to P.K. Roy (2011), the binding content has an important role in determining the properties of the fabric. If the binding content is more than 50% of the total mixing, the fabric produced is like a fabric reinforced by plastic, whereas if the binding content is 10% of the total mixing then the fabric structure produced is hollow, porous and flexible with relatively low strength (Roy, Malik, & Sinha, 2011) Fabrics that are more hollow and porous will be easier to be compared to fabrics with fewer capacities and pores.

4. Discussion

Non-woven fabric for geotextiles made from Merino Sheep wool and HDPE plastic can be divided into 3 variations. Variations used are by distinguishing the content of plastic by varying the plastic content by 50% (V1), 45% (V2), and 40% (V3). In preparation for making this fabric, the weight of the plastic becomes a fixed variable so that the total amount of weight in each variation is not the same, because the fabric made is likened to the size of a plastic that is 60 x 30 cm. So that there are difficulties if the total weight of the overall variation must be the same, to overcome this thing the amount of weight that can be adjusted is wool fiber so that each variation has a different weight of wool.

When the production process takes place, some problems cannot be dealt with, the problem is that there are variations in temperature on each roller. The rollers are set at 150^{0}C, but the actual temperature varies up to ± 30^{0}C so that the heating of HDPE plastic on the fabric does not occur evenly. Based on the results of correspondence with the lecturer, the factors that influence the uneven temperature of the machine are due to the dirty elements for heating on the engine or the malfunction of the heating elements contained in the rollers. After cleaning the heating element on the machine it

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did not affect the problem so that it could be concluded that there was a heating element inside the rollers that did not work.

According to Roy et al. (2011) temperature is one of the factors that can affect the nature of the products produced (Roy, Malik, & Sinha, 2011). Proven in the fabric there is a part of HDPE plastic that melts perfectly and the part that has not melted is perfect. Both of these parts when the evaluation was given the style produced far different results. The following is a comparison of results data and quality standards for geotextile fabrics used for erosion protection.

Table 6. Comparison of test results with standard

Testing	Unit	V1	V2	V3	Class A	Class B	Explanation
Tensile Strength (Length)	N	28.62	20.68	19.70	200	90	X
Tensile Strength (Width)	N	19.31	18.68	17.60	200	90	X
Bursting Strength	N	25.38	24.10	23.84	320	140	X

It can be seen that the test results from fabric are made, none of them reached quality standards for geotextiles that are applied to erosion protection on an industrial scale, this is due to the different raw materials used, because the characteristics of the raw materials and the amount of composition can also affect the results of fabric made.

Previously, research on the production of non-woven fabric for geotextiles from the wool fiber was applied for erosion protection by Jan Broda (2017). It was found that the tensile strength of the non-woven fabric was 0.67 kN / m2 (Broda et al., 2017) The following is a comparison of test results with the results of previous studies.

Table 7. Comparison of test results with previous research

Testing	Unit	V 1	V 2	V 3	Previous Research	Explanation
Tensile Strength (Length)	kN / m^2	2.72	1.77	1.51	0.67	**X**
Tensile Strength (Width)	kN / m^2	1.84	1.60	1.35	0.67	**X**

It can be seen that the results of the fabric made have greater tensile strength than the previous research, so it can be said that the results of the non-woven fabric made can be used as erosion protection geotextiles.

5. Discussion

Based on the results of the tests that have been obtained, the test results that have been compared with the standard can be concluded that waste of wool Merino and plastic can be made of non-woven fabric with a prototype thermal bonding with hot calendaring method and can be used for erosion-resistant geotextiles, but not for scale construction. The properties of the fabric are influenced by the content of wool and HDPE plastic. Research needs to process holes in plastic sheets so that it can be

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made perfectly the porosity in the fabric, or use another adhesive like thermoplastic fiber and needs to be done at a higher weight per unit area so that the test results can reach geotextile standards for construction scale. The last one is the test that is done by all aspects of geotextiles.

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