Analysing the Properties of Needle Punched Non-Woven Fabrics by Selvedge Waste

Dr Saravanan K[1] Dr. G Karthikeyan[2] Sudharsan S[3] Saran S[4]
[1]Professor [2,3,4]B.Tech Student
[1,2,3,4]Department of Textile Technology
[1,2,3,4]K.S. Rangasamy College of Technology, Tiruchengode, India

Abstract — The recycling and the reuse of Selvedge waste are key challenges towards the sustainable disposal of waste textiles. The webs are joined using the needle punching procedure, both spun- and dry-laid. Until barbed needles are pushed through a fibrous web, certain fibres are forced through the web and remain there when the needle-punched fabrics are created and then the Needles are removed. The web can become a fabric if enough fibres are sufficiently displaced, thanks to the consolidating effect of these fibre plugs or tufts. The motion of pounding a needle happens about 2000 times each minute. Mechanical techniques can be used to convert selvedge wastes into short fibres. In the course of research to more or less completely recycle fibres from end-of-life textiles, a number of techniques have been carried out. First, grinding equipment is used to crush selvedge waste. Comparing recycled cotton and polyester nonwoven to traditional thermal insulators has various benefits, including lower product costs, easier handling, and environmental protection. A needle-punched nonwoven is a material composed of webs or batts of fibres, some of which have had their ends forced upward or downward by barbed needles. Only low gramme weight nonwovens can be produced with the original needling machines because of their basic structure. The needle-punched nonwovens, however, that weigh more than 200g/m2 have a more compact construction, improved performance, and broader application. This type of cloth has the promising market potential [4]. Therefore, it is crucial to ensure the functionality of the needling machine while generating high gramme weight nonwovens, particularly by managing the bending deformation of the supporting bed, which is a vital part of the needling machine. The structure is kept together by frictional contact and fibres interlocking caused by the needling process. Polypropylene and polyester are the two most often used man-made fibres in nonwovens. Due to the challenges that natural fibres, like cotton, encounter during manufacturing, like the low carding rate of cotton fabric that has been dyed, their availability is constrained. Cotton fibre has several benefits while being used far less frequently than other synthetic fibres. Cotton fibre is suitable for use in nonwoven materials because it is biodegradable, very absorbent, simple to blend, has good strength, andis dyeable. Cotton offers a higher level of absorbency and is more aesthetically pleasing to consumers.

Keywords: Eco-Friendly, Selvedge, Needle Punching, Non-Woven Fabric

I. Introduction

The first technique for creating nonwoven products is needle punching. Since the 1870s, the industry has employed the needle-punching process. Currently, 150 million tonnes of waste textiles are produced annually worldwide, with roughly 20 million tonnes produced in China.[1] The number of waste textiles is also rising along with the increase in clothing consumption as people's living standards rise. By 2050, it is predicted that there will be 875 million tonnes of textile waste generated worldwide. We recycle at least 50% of the textiles we discard. Therefore, it is urgently important to enhance the proportion of textile wastes that are reused or recycled in order to create a sustainable ecology.[2] Understanding fabric characteristics, such as their physical and thermal properties, is essential for developing fabrics. Consequently, the focus of this study will be on nonwoven fabrics made of various fibres (cotton and polyester). Nonwoven samples were made using a needle-punched nonwoven machine with varied stacking layer counts. The effect of cotton and polyester blend proportions on the comfort characteristics of nonwoven materials as well as properties including heat conductivity, wicking ability, and penetrability, was investigated. The findings show that the blend proportion significantly influences the comfort characteristics of the non-woven materials. The non-woven material has demonstrated greater air permeability, the capacity to wick moisture, reduced thermal conductivity, and lower bursting strength.

At the moment, chemical and mechanical technologies are primarily used to recycle textile waste. The textile wastes could be converted into recyclable new parts using chemical recovery. However, there are dyes on textile wastes that require to have the pollution in their breakdown taken into consideration. Needle Punching is the mechanical method to convert waste into useful non-woven fabrics for commercial usage. The selvedge waste is collected and processed into new fibres and used for needle punching.[3]

II. Review on Materials

A. Selvedge waste:

The creation of a false selvedge results in waste production in the warp and weft threads. To avoid wastes, the length of the weft thread should be slightly longer than the breadth of the woven fabric. This additional weft yarn could be 8-9 cm long on either side and up to 9–10% of it would be waste. Because it directly affects the price of fabric, selvedge waste is always a serious issue for weavers. It has become increasingly important because profit margins are getting smaller, especially when weaving expensive weft yarns. Four types of selvedge can be formed: 1)Tucked-in selvedge 2)Chain stitch selvedge 3)Leno selvedge 4)Fused selvedge.[4]

B. Cotton Selvedge:

Cotton selvedges were collected, segregated, and manually cleaned to eliminate non-cotton and colourful materials from the cotton selvedge waste made from cotton threads. These wastes were received from the shuttle-less weaving loom.[5]

A grinding machine was used to open the selvedge into a fibrous shape. Threads that have been washed and the leftover selvedge

Fig. 1: Selvedge Waste

C. Polyester Selvedge Waste:

Selvedge wastes were manually gathered, segregated, and cleaned to remove any remaining polyester and coloured components. They were obtained from the shuttle-less weaving loom. The cleaned polyester wastes were processed through a grinding machine to become fibrous. Photographs of cleaned polyester selvedge waste and polyester selvedge waste that had been discarded.[6]

III. REVIEW ON METHODS:

A. Grinding Machines:

Grinding Machine provides incredibly precise opening and mixing equipment that makes recycling the waste materials used to make technical fabrics incredibly simple. Building construction uses thermal insulation, much like the automotive sector. Additionally, textiles are used in a variety of items, including agriculture textiles, large bags, carpets, apparel, furniture, nets, tarps and other uses.[7]

B. Blending Fibres:

Using a small laboratory carding machine, cotton and polyester were mixed in different ratios. Samples of the different ratios of recycled cotton and polyester fibres used in the creation of nonwoven fabrics were provided. The fibre mixture was carded four times to increase the homogeneity of the web, and all measurements were made using an electrical balance in grams.[8]

C. Web Formation:

To obtain the carded web, 100% recycled cotton, 100% polyester, and a combination of cotton and polyester fibres are fed into a small laboratory carding machine. The fibre blend was additionally opened into separate fibres during the carding process and combed to be relatively parallel. The web homogeneity was improved by the four-carding of the fibre blend. Layers made of various webs are stacked one on top of the other to give the finished nonwoven fabric the necessary thickness.[9]

D. Needle Punching:

The needle-punched nonwoven is a fabric developed from fibre webs or batts in which part of the fibres has been propelled by a hooked needle thrust forward or below. By locking fibres together through friction, this needling action holds the structure together.[10] The type of fabric included in the study is needle-punched nonwoven. By adjusting the type of fibre, porosity, and amount of air inside the structure, nonwoven assemblies' thermal characteristics can be improved. Since air may be trapped by nonwovens' porous structure and has a low thermal conductivity of 0.025 Wm1K1, nonwovens' porosity is essential in the formation of thermal barriers. The objective of the current work is to create needle-punched nonwoven fabrics from cotton and polyester fibres with various stacking layers.

In needle punching, the web is punched vertically with barbed needles to hook and entangle fibre tufts. Although needle-punched non-woven have a look similar to felt, they are usually constructed of materials other than wool. They come in weights ranging from 50 to 275 grams and thicknesses ranging from 15 to 150 mils, and they are characterised by high density along with some bulk.

Two basic steps are involved in the construction of needle-punching non-woven.

- A machine with specifically made needles receives the fibre web, or butt, that has been prepared by carding, garnering, or air-laying procedures.
- The needles penetrate the plates and the fibre web as the fibre web travels on a substrate sandwiched between a metal bedplate and a stripper plate. This reorientation of the fibres causes mechanical interlocking or bonding between the individual fibres. Figure 1 will show the schematic diagram of the needle-punching machine.

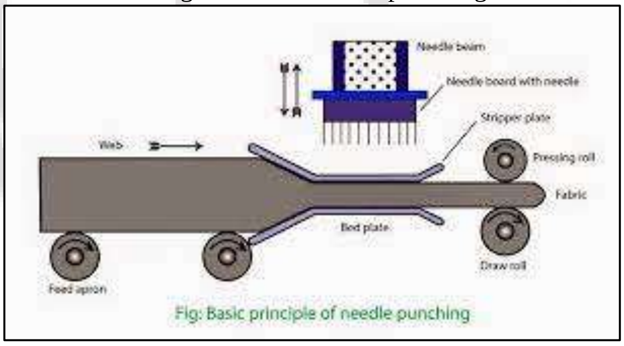

Fig. 1: Schematic diagram of needle punching machine

E. Mechanical Property & Structure:

The application and structure of nonwoven fabrics depend on anisotropy. The distribution of fibre orientations and the way they are arranged on the web have an impact on its mechanical structure. A nonwoven fabric is a web structure created by attaching or by mechanically, thermally, chemically or solvent-based methods of interconnecting fibres or filaments. Nonwoven fabrics may experience bond failure, fibre breakage, and fibre slippage. Typically, the web's fibres are oriented in a variety of ways according to a known or random statistical distribution.

The mechanical characteristics of nonwoven fabrics are influenced by the raw ingredients, the fineness, length, and arrangement of the fibres, as well as structural variations brought on by various manufacturing processes. In order to determine how these fibre configurations, affect the nonwoven fabrics' tensile, tearing, and bursting strengths, tests have been carried out.

IV. Testing of Non-Woven Fabrics:

1) Air permeability ASTM D737-96
2) Bursting strength ASTM-D-3786-2013
3) Tearing strength ASTM - D5587
4) Tensile strength ISO 9073-3:1989

A. Air Permeability:

That the nonwoven air permeability decreases when the nonwoven's weight rises, possibly mostly due to an increase in the nonwoven's density. Increasing the weight also increases the nonwovens' compactness, providing additional airflow resistance.[11]

B. Bursting Strength:

It demonstrates that as the weight of the needle-punched nonwovens increases so does the bursting strength. This might be mostly explained by the fact that fabrics with greater g/m2 have more fibres, which helps to create a compact and durable fabric structure. The fabric can support higher weight and withstand high application bursting resistance due to the increase in fibre entanglement and compactness.[12]

C. Tearing Strength:

It should be noted that the impact of shear force via the function of the nonwovens' g/m^2, the interlocking of the fibres, fabric density, and needle-punch density were all studied. High levels of interlocking cause fibres to resist sliding under shear stress, increasing grip strength. The needle punch density of nonwoven textiles is high, ranging from 550 g/m^2 to 90, as indicated which causes a drop in tearing strength.[19]

D. Tensile Strength:

The tensile strength of the nonwoven material is significantly influenced by the fibre orientation. Tensile strength was greatest in the vertical direction because the fibres were organised in a machine direction (vertical direction) by the traditional way of producing nonwoven fabrics. With increasing angle of specimen cut for strength assessment, the tensile strength of the random or parallel web decreased. In the horizontal or cross directions, elongation was greater. For tensile strength, the parallel web's coefficient of variation was less than 10%. The random webs' variance factor was greater than 10% due to the uneven thickness; the random arrangement had more fibres pointing horizontally than pointing vertically.

V. Conclusion

According to the study, the weight of needle-punched nonwovens increases with a corresponding decrease in air permeability. With an increase in the weight of needle-punched nonwovens, the bursting strength and tearing strength were also seen to rise. The tensile strength of a parallel web or random web decreases as the specimen's angle of cut direction increases. Elongation is uneven and better in the horizontal or cross-direction. The horizontal ripping strength of both parallel and random webs is greater than the vertical tearing strength for both methods. The bursting strength of parallel webs is greater than that of cross webs. When tortuosity decreases, air permeability increases. As the number of barbs in needle-punched nonwoven grows from three to six. The tensile strength of nonwovens in the horizontal direction (CD) decreased as weight values increased. On the other hand, when the weight of the nonwoven grew in the vertical direction, their tensile strength increased (MD). As the length of penetration lengthens, the nonwovens' weight reduces. The initial modulus of the nonwovens increases as a function of the length of the needle's penetration in the machine direction, suggesting that the needle penetration modifies by increasing the amount of crossing fibres impregnated in the interstitial spaces of the structure of the nonwoven. The idea that the increase in crisscross fibre density in the non-woven matrix was caused by a rise in the length of penetrating fibres is supported by changes in initial modulus, tenacity, and elongation (%).

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