International Research Journal of Multidisciplinary Science & Technology
www.irjmrs.com ISSN : 2455-930X

PHYSICAL AND MECHANICAL PROPERTIES OF JUTE NEEDLE-PUNCHED NONWOVEN

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Abstract - *It has been seen that needle-punching process is mostly used for manufacturing nonwoven structure from jute fiber. Various physical, mechanical and functional properties of needle-punched jute-nonwovens have been discussed here. The influence of various factors on various properties of jute -nonwoven such as Thermal Insulation, Air Permeability, Compressibility, Water Absorbency and Acoustic Insulation has been reported.*

Key Words: Nonwovens, Needle-Punching, Physical and Mechanical properties.

1.INTRODUCTION

Jute is an important natural fiber occupying second place in economic importance only after cotton. It is one of the most important fibers used for industrial applications. More importantly it is a commodity on which millions of households in some of the countries depend for their cash earnings. India, Bangladesh, China, Nepal and Thailand are the major producers of jute accounting for over 95% of the global output[1]. The main traditional use of jute has been for the packaging market. Cloth, sacks and bags made of woven jute fabrics are widely used for transportation and storage of agricultural products, fertilizers, cement and some chemical products. With the advent of bulk handling and cheap synthetic packaging materials, the market for these traditional jute materials have been seriously affected. Recently jute fibers are used in manufacturing nonwoven materials with superior functionality for diversified technical applications. Different non -woven manufacturing techniques like stitch bonding, hot calendaring, needle punching, hot-air thermal bonding, oven bonding, hydro entanglement etc. were successfully used and assessed for manufacturing jute-nonwovens [2-3]. The prime reasons of growing market of jute-nonwovens in technical applications are as following [4]. it need to mention here that the natural fibers like jute and others might enjoy more favorable market conditions in the future on account of increasing concern with environmental issues all over the world. It was found in study that jute is more environmentally sound and less costly to society than its competing synthetic material. Even in the life-cycle, the disposal stage of synthetic material is most harmful to the environment causing highest direct economic and social costs.

2.PHYSICAL PROPERTIES OF JUTE NEEDLE-PUNCHED NONWOVEN

Density and thickness play important role for different potential applications. Ultimately these two characteristics govern many functional properties of nonwovens such as thermal and noise insulation, water absorbency, resiliency, compressibility etc. So, we should have knowledge of the process parameters which may influence density and thickness of nonwovens. Study has been conducted to find out influential process parameters which govern density of needle-punched nonwoven [5]. The contour diagrams present the effect of punch density, depth of needle penetration and oil per cent on bulk density of needle-punched nonwoven. When batching oil is not applied, with the increase in punch density, the bulk density decreases continuously at low depth of needle penetration. But at high depth of needle penetration, bulk density initially increases and then decreases. With the increase in depth of needle penetration, bulk density decreases for low range of punch density, but increases at high punch density. Application of oil per cent has very little effect on bulk density for a given punch density of fabric. For a fixed oil percentage, bulk density increases with the increase in punch density initially and then decreases. For a given depth of needle penetration, bulk density increases with the increase in per cent oil applied and for a given oil per cent, it decreases with the increase in depth of needle penetration.

3.MECHANICAL PROPERTIES OF JUTE NEEDLE-PUNCHED NONWOVEN

Different needle-punched nonwoven fabric properties, such as tensile strength, bursting strength, compressibility, bending modulus, air permeability, etc have great importance in different fields of application. Most often the isotropic properties of nonwoven material are a must for technical applications. There is a good scope to improve the quality of carded web which would help produce isotropic nonwoven fabrics. More over the required characteristic for a specific application can be achieved by alterations in the fiber composition, the needling process parameters etc. which have been discussed here [2,6].

4.TENSILE PROPERTY

In the cross-laid nonwoven majority of fibers is oriented in an angle with cross direction of fabric. Hence, for the tensile test in cross direction of fabric, the fibers can easily be reoriented much closer to the test direction (in the direction of application of load during tensile testing); but if the testing is carried out in machine direction the majority of fibers cannot be oriented in the test direction. Hence, the contribution of fibers towards the load bearing is much higher in the testing of cross direction than in machine direction. The stress development during extension is always higher in cross direction than in machine direction. Moreover, the rupture of fabric in the cross direction shows higher step breaks which is the evidence of breakage of taut fibers and subsequent increase in stress due to other fibers. The same fabric in wet condition shows improved tensile properties due to increased cohesion between the fibers and more compact structure in swelling and shrinkage [7]. In another study it was reported that the tensile strength of the fabric, made with multiple numbers of passages of the web through the needle loom, is found greater than that of the fabric made with its one passage only. The fabric made with a low protrusion, finer gauge, needle of closer barb spacing showed higher values of both stress and strain. The value of tenacity of the fabric made by needling on one surface only was higher than that of the fabric made by needling on both top and bottom surfaces [8].

It was also reported that if jute batching emulsion is applied on the web before needing then the tensile strength of the needled fabric is increased. The tenacity value increased with an increase in the batching emulsion percentage or binning period up to a certain level. Afterwards there found no improvements [9].

With the increase in fabric weight, tenacity, initial modulus, and work of rupture initially increase, but at greater fabric weight, though the tenacity becomes steady, initial modulus and work of rupture show a declining trend. Elongation at break is reduced with an increase in fabric weight, punch density, and depth of penetration [9-10].

4.1.Bursting Strength

The effects of various factors on the bursting strength of jute needle-punched nonwoven were studied.It was observed that bursting strength of fabric increases with the increase in fabric weight, needle punch density and depth of needle penetration, but beyond some optimum punch density and depth of needle penetration bursting strength of fabric shows a declining trend[9,11].

4.2.Bending Rigidity

Bending modulus of fabric increases with the increase in fabric weight, whereas fabric -bending modulus after attaining a maximum value starts declining with the increase in punch density and depth of needle penetration [10]. Another study on bending rigidity of jute/viscose blended needle-punched nonwoven using statistical experimental designing technique has been reported. This study also says that bending modulus of fabric increased with the increase in fabric weight. But as the proportion of viscose fiber was increased in the blend proportion, the bending modulus decreased [12].

4.3.Thermal Insulation

Jute fiber is a good insulator of heat. Pure jute-nonwoven and various blends of jute-nonwovens were assessed for thermal insulation property. Blending of woollenised jute improved the thermal insulation property when it was used with pineapple leaf and ramie fiber in blends. Needle-punched nonwovens made of woollenised jute and wool blend showed better thermal insulation than those made of woollenised jute and polypropylene or woollenised jute and acrylic blend Needle -punched nonwoven from jute caddies can also be used as thermal insulator [13-14].

In another study [15] the effect of fabric weight and needling density on thermal resistance at jute-polypropylene blend needle-punched nonwoven was examined by employing experimental design. It was reported that the thermal resistance increased with the increase in fabric weight. With the increase in fabric weight thermal resistance increases more prominently at lower needling density, but its effect is negligible at higher needling density. With the increase in fabric weight, the number of fibers unit area of the fabric increases. This causes increases in fabric thickness and also amount of pores in fabric structure, causing increase in thermal resistance. However, with the increase in needling density, thermal resistance decreases because the fabric structure tends towards higher degree of consolidation and hence reduces amount of pores in the structure.

4.4.Air Permeability

Some studies have been reported on air permeability of jute needle-punched nonwovens. It was reported that with the increase in fabric weight, punch density, and depth of penetration, air permeability of the fabric is first reduced due to better consolidation of fibers in the fabric and then shows an upward trend due to channel or near-hole formation in the fabric[12]. Air permeability of nonwoven fabric made from woollenised jute and its blends was reported much lower compared to the fabrics made from jute and its blends. As punch density increases air permeability of jute-nonwoven made out of woollenised jute and its blends decreases. But air permeability of fabrics made from jute and its blends having low polypropylene content increased with the increase in punch density. As the polypropylene content was increased the trend was reversed. With the increase in needle penetration and jute fiber cut length, the air permeability was decreased [14,16]. The air permeability decreases prominently with the increase in fabric weight at all levels of jute contents. With the increase in needling density the air permeability decreases at higher fabric but its influence is negligible at lower level of fabric weight.

4.5.Compressibility

Needling density, depth of needle penetration and fabric area density are found three most important parameters which affect compression behavior of jute needle-punched nonwoven [10,17-18]. The compressibility of fabric in terms of thickness loss is initially reduced with the increase in fabric weight, punch density, and depth of penetration, and after attaining a minimum value it starts increasing if the increase in these variables is continued further [18]. The compression behavior of jute/polypropylene blend needle punched nonwoven showed increase of thickness with increase of fabric weight. This study also said that fabric thickness reduced with the increase in the needing density and the percentage compression resilience of the fabric increases with the increase in polypropylene content in the blend.

4.6.Water Absorbency

Wettability of jute fiber is good among all the long vegetable fibers. The porous nonwoven structure is expected to improve the water holding capacity of the fabric. A study [5] reported that for a particular depth of needle penetration or for particular oil percentage, with the increase in punch density extrinsic rate of sorption increases initially and then decreases. Initial increase of rate of sorption is due to better entanglement of fiber but afterwards when fiber breaks the rate decreases. For a particular punch density and depth of needle penetration, or with the increase in depth of needle penetration, the increase in oil percent will increase the extrinsic rate of absorption. The increase of oil percentage ensures the less breakage of fibers which ultimately resulted low bulk density and high rate of absorption.

4.7.Acoustic Insulation

Jute needle-punched nonwovens exhibit superior sound insulation characteristics. The studies [10,19-20, 22] reported that there is significant sound transmission loss when sound energy passes through the jute needle-punched nonwoven. Punch density, depth of needle penetration and mass per unit area of needle- punched nonwoven significantly affect the sound transmission loss when the nonwoven acts as sound barrier. With the increase in needle penetration, sound loss increases initially and after achieving the maximum it decreases. Increase in needle penetration means more number of barbs penetrates into the web, resulting in more fiber orientation in the vertical position. This may create bigger hole due to side-wise shifting of web and more compact structure, thus forming a denser fabric. This is the reason for increase in sound loss with the increase in needle penetration. When the penetration is very high it may create fiber breakage this is very much prone in jute like non-extensible fiber, which, in turn, increases the bulk and deteriorates the structure. Hence, sound loss decreases with high penetration. The increase in punch density, sound loss decreases initially, reaches to minimum and then increases. The initial decrease in sound loss is probably due to higher number of holes in compact structure through which sound can penetrate. At the higher punch density, these holes are not clearly formed due to breakage of fibers which is responsible for increase in sound loss. As area density increases there is initial decrease in sound loss and after attaining minimum it increases. This is because in this range of needle penetration, a change over takes place from major fiber consolidation to major fiber breakage and it affects the structure.

5.CONCLUSIONS

Nonwovens from jute fibers can be manufactured from different techniques such as stitch-bonding, thermal bonding, needle punching, adhesive bonding, hydro entanglement etc. Among them needle-punched nonwoven technology is considered to be a forward technology very much suited to the jute industry. Jute nonwovens have superior mechanical properties and functional properties. Lots of research and development are going on jute made nonwovens for diversified applications and there is also lot scope of further improvement. Jute nonwovens are used nowadays in almost all sectors of technical textile such as home textiles, geotextile, agricultural textile, filter media, clothing, automobiles, industrial textiles etc due to its superior mechanical and functional properties, ease of availability, ease of processability, environmental compatibility, recyclability and biodegradability.

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