ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

STUDIES OF DIMENSIONAL PARAMETERS AND PROPERTIES OF NEWLY DEVELOPED NONWOVEN FLOOR MATS

S. R. Bairagi[1], A. K. Singha*[2] and S. C. Ray[3]
[1]Research Scholar, Dept. of Jute and Fibre Technology, CU, Kolkata, WB, India
*[2]Associate Professor, Dept. of Jute and Fibre Technology, CU, Kolkata, WB, India
[3]Retired Professor, Dept. of Jute and Fibre Technology, CU, Kolkata, WB, India

DOI: 10.5281/zenodo.1116618

ABSTRACT

This paper describes the relationship between fabric parameters and their functional properties on development of nonwoven floor mats. The floor mats are produced with different GSM and fibre composition by using polyester, polypropylene and acrylic fibre as well as their blends. The different physical and functional properties of nonwoven fabrics produced with different GSM and fibre composition are measured experimentally. The results are analyzed to establish the relationship between fabric parameters and their functional properties. From the findings, it can be concluded that 100% polyester nonwoven fabric will have the best performance in end use application as floor mat out of the seven nonwoven fabrics produced for the study.

KEYWORDS: Fabric, Non-woven, GSM, Functional Properties

I. INTRODUCTION

Production of nonwovens was started long back for different applications, particularly in felt. The term nonwoven was not established at that time. In the past, nonwovens were often regarded as low-priced substitutes for traditional textiles and were generally made from dry laid carded webs using converted textile processing machinery. Russell [1] stated that web formation involves converting staple fibres or filaments into a two-dimensional web or a three-dimensional web assembly known as batt, which is the precursor for the final fabric. The structure and composition of the fibres strongly influence the dimensions, structure and properties of the final fabric.The nonwoven manufacturing technology that produces fibre-based nonwovens generally consists of four basic nonwoven processes namely, fibre preparation process, web formation process, web bonding process and finishing process [2]. Krcma [3] stated that the properties of nonwoven fabrics depend on many variables, out of which most important is the properties of the constituent fibre i.e. their type, staple length and fineness. Other factors which influence the final properties of the product are the effect of the fibre orientation in the plenary system. Kothari et al [4] described that the machine direction breaking load is higher than that of cross direction.
For non-swelling materials, these properties are largely controlled by the capillary absorption of fluid into the structure until saturation is reached [5]. The absorbency rate and absorbent capacity are affected by fiber mechanical and surface properties, structure of the fabric (i.e., the size and the orientation of flow channels), the nature of fluids imbibed, and the manner in which the web or the product is tested or used [6].

Midha et al. [7] studied the compression behavior of hollow polyester needle-punched fabric using the Box-Behnken experimental design wherein fabric weight, depth of penetration and punch density were considered. They reported that cross-laid structures show higher compressibility and lower recovery compared to parallel laid fabrics. Abrasion is the physical destruction of fibres, yarns, and fabrics, resulting from the rubbing of a textile surface over another surface [8]. Textile materials can be unserviceable because of several different factors and one of the most important causes is abrasion. Abrasion occurs during wearing, using, cleaning or washing process and this may distort the fabric, cause fibres or yarns to be pulled out or remove fibre ends from the surface [9&10]. Ray & Ghosh [11] have studied the fibre alignment in cross-laid needle punched nonwoven

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

made of polyester, jute and their blends, and observed that type of fibre influence the structural parameters and properties of nonwoven fabrics.

Out of many new textile products, floor mat is nowadays a very popular one and traditionally made of various natural fibres, however, manmade fibres like polyester, poly-propylene and acrylic may also be used in order to design floor mats. Floor mats are available in various sizes having a wide range of dimensional properties (GSM in the range of 200 to 900, thickness in the range of 1.5 to 6 mm etc.). The desired properties of any floor mat are higher compressibility & resilience, thermal insulation, abrasion, dimensional stability etc.

II. MATERIALS AND METHODS

Raw Materials: Three types of fibres namely polyester, polypropylene & acrylic were used for experiments of this work.

Nonwoven Fabric Sample Preparation

The nonwoven fabric samples were produced in the Laboratory Model Nonwoven Machinery Plant of M/S. DILO Machines GmbH, Germany, installed in the departmental laboratory. The machinery set-up is comprised of - Opener, Chute feed system, Carding, Camel back lattice, Cross lapper, Feed lattice, Needle punching and Cloth winding units. The details of Needle Punching Unit are given below:

- Type of Machine: one side punching, double needle board, chute feed with worsted card & cross lapper system controlled by electronic panel board.
- Size: Working width = 70 cm, Finished Fabric Width = 60 cm (max).
- Density of needle per square inch in the needle board: 17
- Punching Parameters: a. Max punch per min.=1200
  b. Penetration of needle up to 10 mm
  c. Capacity of fibre length up to 10 cm
- Needle Parameters: a. Needle gauge = 40
  b. Needle cross-section: Triangular
  c. No. of barbs per apex: 2
- Needle board parameter: a. Length: 26.5 inch
  b. width: $7\frac{7}{8}$ inch
  c. Effective length: 24.5 inch
  d. Effective Width: 7 inch

Opening and Mixing of the fibre: In order to find the better orientation of the fibre in the web structure, all the fibres are firstly open manually and then feed to the feed table of the machine and for the blended fabrics after opening the fibres proper mixing take place according to the composition and then feed to the machine.

The manufacturing of nonwoven fabric: The required machine parameters were set through the electronic controller to make the total machinery set up for running. The partly manually opened fibres were fed at the feed lattice of the opener. After opening the fibre reaches to the hopper feeder zone of carding machine through chute feed arrangement. The carded web was taken to the camel back lattice which cross laid the web over the conveyor lattice for feeding to the needle punching system. After punching the fabric was rolled on the cloth roller. The single side punched fabric was the fed to the needle punching machine for punching the other side. Double punch takes place at one side of the fabric.

Instruments used for testing of parameters and properties of fibres and fabrics

Tensile properties of fibres and nonwoven fabrics were measured using ZWICK ROELL TENSILE TESTER Model No: ZWICK ROELL Z010, Load Cell capacity: 10 kN, Crosshead speed: 1 mm/ min – 2000 mm/ min.

Thickness, compression & recovery property of the fabric were measured by using Digital Thickness Tester (Maker's name: - AIMIL Ltd.). The thickness has been measured by means of the digital thickness meter consisting of a casted stand with pressure foot and electronic/digital display. Capacity of the thickness tester is up to 25.4mm & the least count is 0.001mm. A dead weight of 1 kPa is used to measure the thickness.

Bending length, flexural rigidity and bending modulus of the nonwoven was measured / calculated done following“Heart Loop” principles, As the available Shirley Stiffness Tester, mainly used for woven fabrics, is not suitable for nonwoven.

The Compression impact of the nonwoven fabrics under dynamic loading were measured byProlific dynamic loading machine, which simulates the compression caused by a personwalking on a carpet, was used to produce compression impacts on the needle – punched nonwovens.

The packing fraction of the fabrics was theoretically calculated from the GSM, thickness and fibre density of the respective fabrics.

III. RESULTS AND DISCUSSION

All the test results & the particulars of the nonwoven fabric samples under the study are given in this chapter in tabular form. The test results & particulars have been discussed & attempt has been made to give necessary explanation of the findings. The particulars of raw materials are given in Table 1. The polyester is stronger and less extensible compared to polypropylene and acrylic fibres.

Table 1 Particulars of raw materials

Fibre	Fineness in gm/ den	Cut length in mm	Tenacity in cN/ den	Elongation in %
Polyester	6.0	64	5.6	38.50
Polypropylene	6.0	80	3.19	54.31
Acrylic	5.0	60	3.27	58.28

Coding of the sample: The coding of fabrics has been made based on the type fibres(s) used. Total seven fabrics were produced & coded accordingly, as shown in the Table 2.

Table 2 Compositions & Coding of fabrics

SL. No.	Fibre composition	Coding
1	100% Polyester	S_1
2	100% Acrylic	S_2
3	100% Polypropylene	S_3
4	50% Polyester & 50% Acrylic	S_4
5	50%Polyester & 50% Polypropylene	S_5
6	50% Acrylic & 50% Polypropylene	S_6
7	33.3% Polyester, 33.3% Polypropylene & 33.3% Acrylic	S_7

Comparative analysis of structural property of nonwoven sample: The measured values of the nonwoven fabric parameters like areal density, thickness and packing fraction are shown in the Table 3 and Figure 1. Although attempt was made to produce all the nonwoven fabrics of same GSM, say 320, but in reality, there is some variation between the fabrics, the variation is maximum (6%) between S1/S5/S7 and S4. The thickness of the fabrics varies in the range of 3.51 – 4.22 mm, this variation is due to variation in fibre density in one hand and variation of compactness due to similar extent of needling. The variation in compactness, which varies from 0.055 to 0.088, is due to variable binding of the fibres inside fabric during needling. This variation in compactness ultimately affects the fabric properties.

Table 3 Areal density (GSM), thickness and packing fraction of the sample

Sample name	Areal density (gm/m^2)	Thickness (in mm)	Packing fraction
S_1	325	4.22	0.055
S_2	317	3.73	0.072
S_3	311	3.83	0.088
S_4	306	3.51	0.068
S_5	325	3.95	0.071
S_6	322	3.75	0.082
S_7	325	3.65	0.076

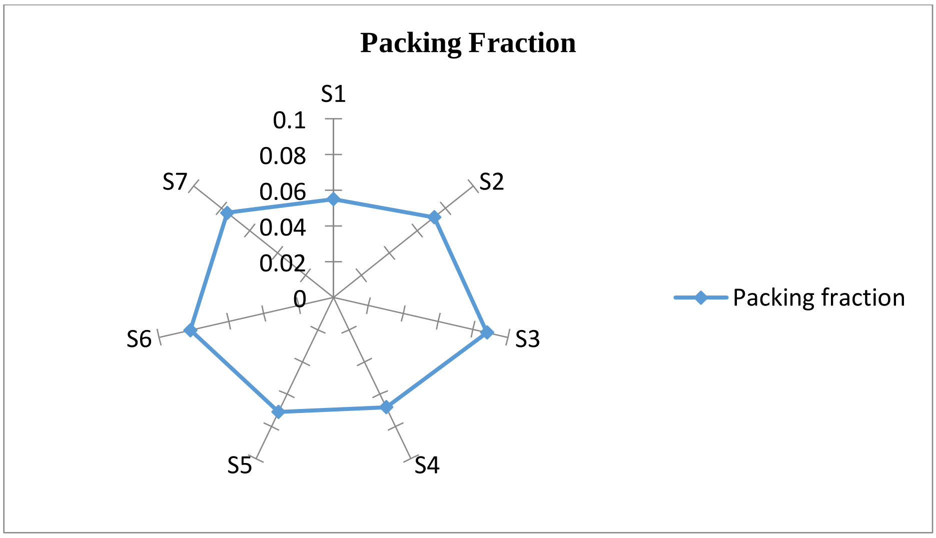

Figure 1 Packing fraction of the fabrics

Compression property of nonwoven fabric samples: The values of compression % as well as recovery % of the fabrics samples under study at two different pressures (5 kPa & 9kPa) are shown Figure 2 and Figure 3. It is observed that the compression percentage as well as recovery percentage higher for 1 kPa to 9 kPa load than the 5 kPa to 9 kPa due to the higher compactness and packing fraction after the first step loading.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

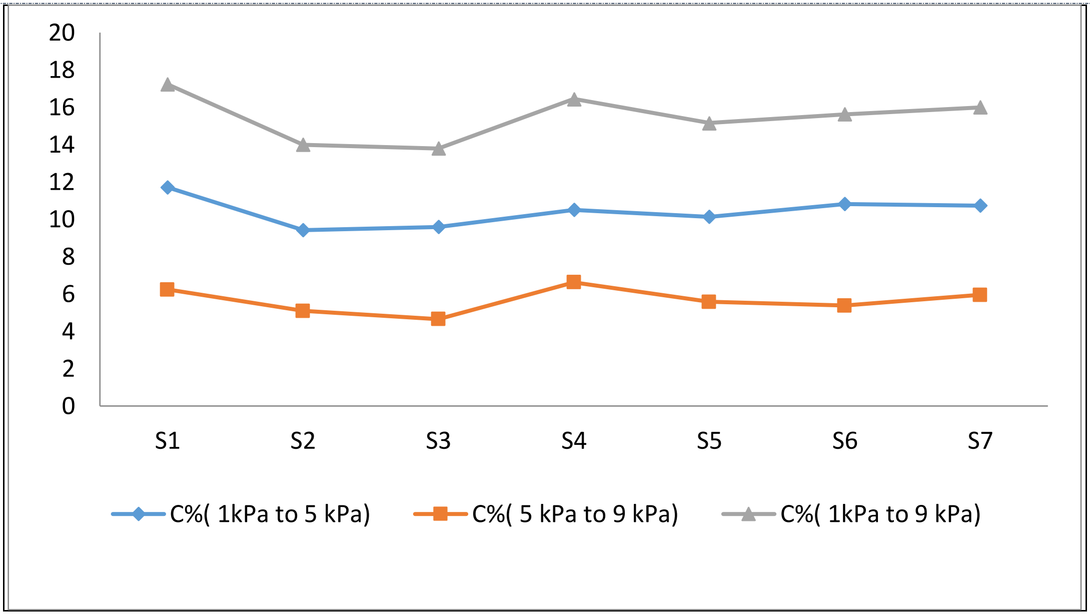

Figure 2 Compression % of different nonwoven fabrics at different pressures

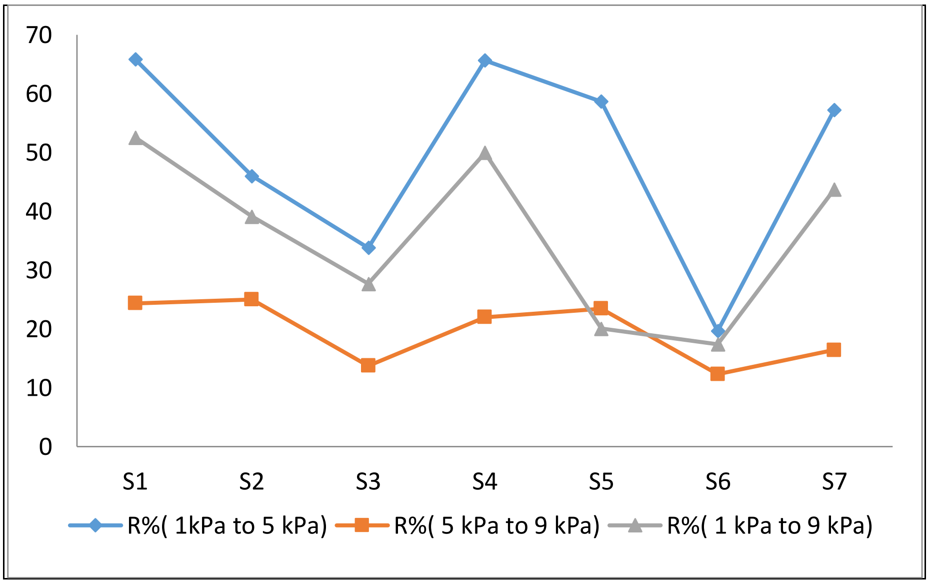

Figure 3 Recovery % of different nonwoven

Bending properties of nonwoven fabric samples: Figure 4 and Figure 5 show the bending properties of the nonwoven fabrics produced for the study. The bending values of S_1 & S_5 are closer to S_7. As we know the bending length depends on the type of fibre used and length varies in the range of 2.69 to 2.90 cm fromfabric to fabric. Although S_7 has the maximum value, the structure of the fabric. So, it is due to the presence of polyester

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

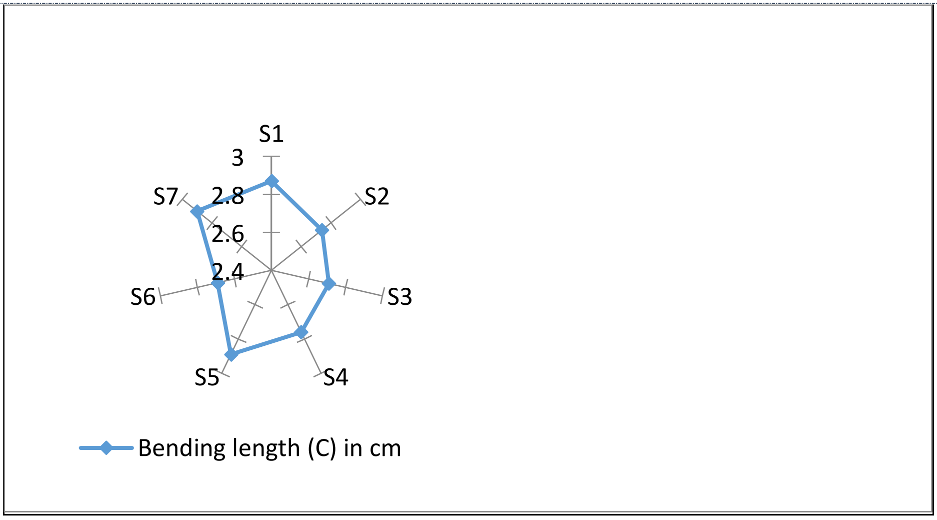

Figure 4 Bending length of the sample

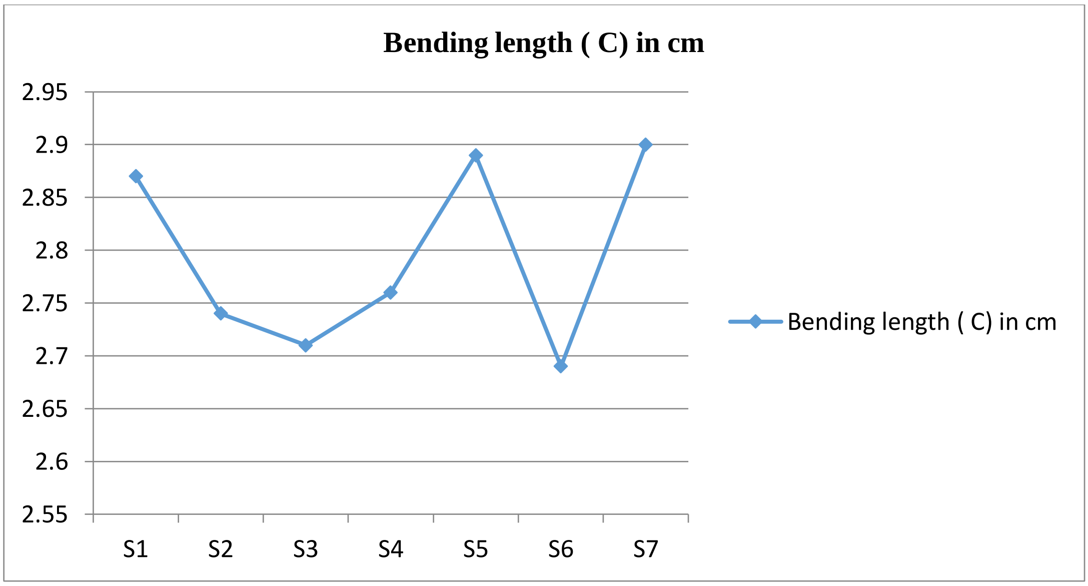

Figure 5 Bending length of the sample

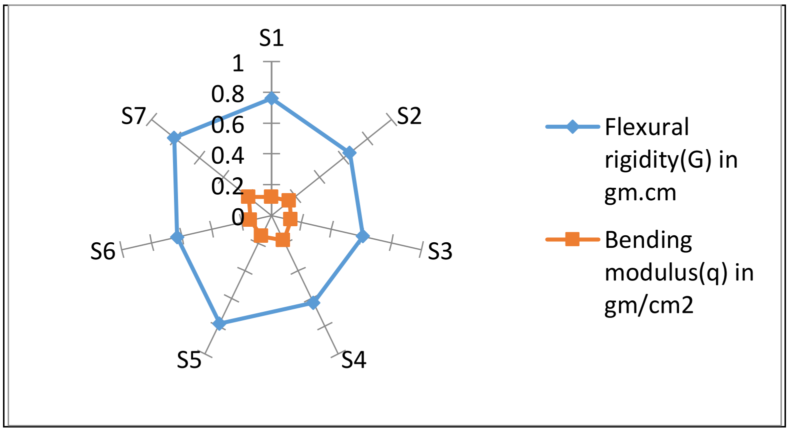

Figure 6 Flexural rigidity (G) and Bending modulus (q) of the samples

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

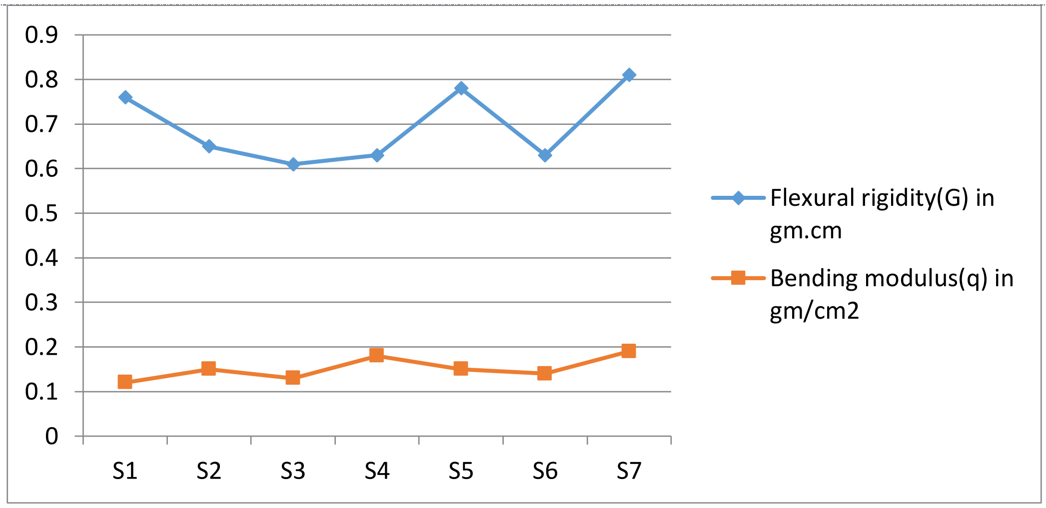

Figure 7 Flexural rigidity (G) and Bending modulus (q) of the samples

fibre only which is more rigid than other fibres. From the literature review it is known that the flexural rigidity and the bending modulus is directly dependent on the bending length. The flexural rigidity of the fabrics also varies from fabric to fabric in the range of 0.61 to 0.81, Figure 6 & Figure 7. It is gathered that flexural rigidity depends upon the bending length and the weight of the fabric sample in grams per sq. cm. As the bending length of the samples $S1$, S_5 & S_7 are higher than the other samples (S_2, S_3, S_4 & S_6), the flexural rigidity of those fabrics are higher for those samples.

IV. CONCLUSION

(i) 100% Polyester and 100% polypropylene nonwoven fabrics have resulted minimum and maximum packing fraction respectively.
(ii) 100% Polyester nonwoven fabricshows maximum Compression and Recovery percentage compared to the other fabrics.
(iii) The bending parameters like bending length, flexure rigidity and bending modulus are maximum for blended fabrics in which polyester is one of the component.
(iv) Keeping in view the abovementioned points, it is obvious that polyester is the best out of the three fibres for using in floor matt.

V. REFERENCES

[1] S.J. Russell, “Handbook of Nonwovens”,Woodhead Publishing Limited, 2007.
[2] A. N. Roy, P. Roy, “Manmade Textiles India(48/10)”, 2005, P-39.
[3] R. Krcma, “Manual of Nonwoven, Textiles Trade Press,” Manchester, England,1971.
[4] V.K. Kothari, A. Das, A. Sarkar, “Effect of processing parameters on properties of layered composite needle-punched nonwoven air filters,” I.J.F. Textile Research,(32) June, 2007.
[5] L. F. Fryer, B. S. Gupta, “Determination of Pore Size Distribution in Fibrous Webs and Its Impact on Absorbency,” Proceedings of 1996 Nonwovens Conference," 1996, pp. 321-327.
[6] B.S.Gupta, D.K. Smith, “Nonwovens in Absorbent Materials,” Textile Sci. and Technol. 13, 349-388, 2002.
[7] V.K. Midha, R. Alagirusamy, V.K. Kothari, “Studies on properties of hollow polyester Needle-punched fabrics,”I. J. F. Text. Res., vol. 29, pp. 391-399, 2005.
[8] I. Abdullah, R.S. Blackburn, S.J. Russell,“Abrasion Phenomena in TwillTencel Fabric”, Journal of Applied Polymer Science, Vol. 102, pp.1391–1398, 2006.
[9] J. Hu, “Fabric testing”, Woodhead Publishing Series in Textiles: Number 76. 2008.
[10] S. J. Kadolph, “Quality Assurance for Textiles and Apparel”, ISBN:156367-144-1, Fairchild Publication,2007.
[11] S. C. Ray and P. Ghosh, “Studies on nature of anisotropy of tensile properties and fibre orientation in cross laid needle punched nonwoven fabrics”, *Indian Journal of Fibre and Textile Research, June, 2017.*