STUDY OF THE FRICTIONAL PROPERTIES OF NEEDLEPUNCHED NONWOVEN FABRICS

S. S. Ramkumar and Nichole A. Hester
Texas Tech University, International Textile Center
Lubbock, TX
A. P. S. Sawhney
Southern Regional Research Center, USDA
New Orleans, LA

Abstract

Nonwoven fabrics have several high-tech and specialty applications. The friction and hand-related properties of nonwoven fabrics play very important roles in day-to-day applications. Frictional properties of a set of nonwoven fabrics were evaluated using a simple apparatus. Results presented in this paper indicate that the sliding friction apparatus is a very reliable and useful tool for the evaluation of the frictional properties of nonwoven fabrics.

Introduction

Nonwoven fabrics have a wide variety of applications such as automotive fabrics, medical textiles, clean room textiles, protective clothing substrates, floor and wall coverings, etc. In all the aforementioned applications, friction and hand-related properties are important from the applications point of view. Hand of textiles is a very nebulous quantity and its evaluation has heretofore remained an ostensibly unsolved enigma. Recent research activities by the principal author (1-4) have thrown some light in this field and the results have shown that for all practical purposes, the evaluation of the frictional properties is sufficient. In addition, the evaluation of the frictional properties of fabrics is a simpler procedure compared to the testing of hand properties by subjective methods. In this paper, results from a most recent study of the surface mechanical properties of a set of needlepunched nonwoven fabrics are presented.

Experimental Method and Materials

Experimental Procedure

Friction is measured as the force of interaction between two bodies. Normally, the frictional properties of solid materials are characterized using the coefficient of friction "μ." The coefficient of friction "μ" is derived from the classical Amontons' law of friction that states that the relationship between the friction force (F) and normal load (N) is linear, i.e., $F/N = \mu$. However, in the case of polymeric materials such as textiles, the above relationship is not valid since the frictional force depends on:

1) the normal load,
2) the area of testing,
3) the speed of testing, etc.

Ramkumar et al. (1), have recently derived a new friction parameter that can be conveniently derived and used to characterize the friction and hand-related properties of textiles. The method is based on the sliding of two substrates against each other and calculating the frictional resistance over a range of normal loads. This can be achieved using the simple apparatus as shown in Figure 1.

The principle behind the measurement is based on the sliding motion of a bovine leather friction sledge (standard in all the experiments) of 22.5 cm^2 in area and weighing 36.56 gms over experimental fabrics. Experimental fabrics were attached to the aluminum platform of the friction apparatus. The standard friction substrate was pulled at 50 mm/min by means of a string attached to the movable crosshead of the tensile tester. Experiments were conducted at 6 different normal loads. The minimum and the maximum loads used were 36.56 and 86.56 gms respectively. The loads were incremented in steps of 10 gms. The frictional interactions were recorded by the tester and were transferred to a microprocessor for further analysis and storage.

The details of nonwoven fabrics used in the study are in given in Table I.

Experimental Results

As discussed in the previous section, frictional properties were characterized using the friction parameter "C" and the material/friction index "n." The method that has been used to derive the two frictional parameters is clearly delineated in the literature (1, 2). Frictional parameter and index values for nonwoven fabrics tested in this study are given in Table II.

As is evident from Table II, in majority of the fabrics studied, the friction index values were less than 1. Even in fabrics that have friction indices more than 1, the increase is very marginal. This indicates that the simple Amontons' law of friction is not valid for polymeric and textile materials. Therefore it is appropriate to use the frictional parameter values to compare and characterize the frictional properties of textiles. The lower is the value of "C," the lower is the friction and the higher is the quality of fabrics.

Inferences from the Study

The main purpose the study reported in this paper is to establish the usefulness and the reliability of the sliding friction apparatus to evaluate the friction and hand-related properties of nonwoven textiles. Ramkumar has recently shown that the results obtained from the sliding friction apparatus were able to reflect the variations in hand of differently finished fabrics (3). Another study on the evaluation of hand of cellulase enzyme treated fabrics has also proven the usefulness of the sliding friction apparatus (4).

The present study was conducted mainly to concur with the earlier results obtained on the reliability and the usefulness of the friction method using nonwoven fabrics. As the structure of nonwoven fabrics is quite different from that of conventional fabrics, repeatability of friction results on nonwoven fabrics would lead to the establishment of the sliding friction apparatus as a useful and simple quality evaluation tool. As is evident from the friction results (Table II), it is possible to obtain sensible and useful conclusions. In addition, the results have shown that it is possible to objectively evaluate the hand-related properties of nonwoven fabrics using the friction values.

Furthermore, the sliding friction apparatus used in this study can be conveniently fitted to any universal tensile tester. The set-up allows the testing of frictional forces at different normal loads to enable the calculation of the frictional parameter "C."

The frictional properties of nonwoven fabrics are influenced by a number of variables such as weight, surface finish, material type, etc. In the present study it was not possible to know the characteristics of the fibers used, needling density, surface finish applied, etc. It should be understood that the overall objective of the study was to examine the suitability and the repeatability of the friction results on the friction adaptation. The observations from the study were interesting and useful. The results indicate that the relationship between the friction parameter "C" and weight does not follow any particular trend. This suggests that in case of nonwoven fabrics, weight is not the only factor that influences the friction and hand-related properties. There are a number of other factors that collectively influence the evaluation of the friction and hand-related properties. It would be very desirable and will be an useful exercise to undertake studies on a

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wide variety of nonwoven fabrics and understand the relationship between the friction of fabrics and influencing factors such as the type and the characteristics of fibers used, amount of needling given, surface finishes applied, etc.

Conclusions

A small study has been undertaken to examine the suitability of the sliding friction apparatus to evaluate the frictional properties of nonwoven fabrics. The results obtained have shown that it is possible to obtain reliable results using the simple sliding friction apparatus. The study was conducted over a range of normal loads and the frictional properties were characterized using the frictional parameter "C." The "n" values indicate that the simple Amontons' law is not valid for nonwoven fabrics and therefore it is not logical to characterize the frictional properties using "μ." The research activity is currently being extended and conducted on a set of medical bandages and wipes. It is hoped that the results from the nonwoven fabrics' friction study would help to establish a standard method to evaluate the friction and hand of fabrics. Although results on cotton nonwoven fabrics are not presented in the report, efforts are underway to study the friction and hand properties of cotton nonwoven textiles.

References

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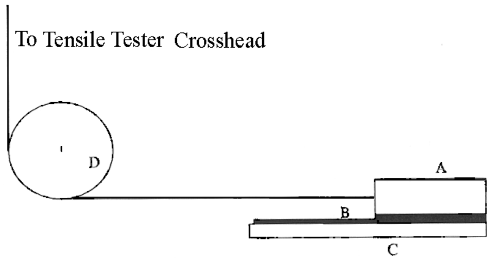
Table I. Details of Nonwoven Fabrics

S. No.	Fabric Type	Weight (gms/m^2)
1	Filtration Media Fabrics	500
2	Automotive Head Lining (Polyester)	240
3	Blanket (Acrylic)	220
4	Blanket (Acrylic)	230
5	Air Filter (PP/Mod Acrylic)	70
6	Air Filter (Viscose/PP)	220
7	Ball Felt (Acrylic)	540
8	Filtration Media	500
9	Roofing Felt (Polyester)	220
10	Geotextile (PP/Polyester)	300
11	Automotive Trunk Lining (Polyester)	300
12	Floor Covering (PP)	650

Table II. Frictional Parameter Values

S. No	Frictional Parameter "C" (Pa^{1-n})	Values "n" Index
1	0.883	0.943
2	0.521	0.997
3	2.639	0.746
4	2.230	0.765
5	4.332	0.642
6	0.815	0.906
7	0.495	0.995
8	0.439	1.026
9	0.299	1.062
10	0.366	1.014
11	0.270	1.106
12	0.634	0.906



A: Bovine leather friction sledge, B: nonwoven fabric, C: aluminum platform and D: frictionless pulley

Figure 1. Sliding Friction Apparatus.