하이드로 인탱글드 부직포의 역학특성에 관한 연구

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Studies on Mechanical Performance in Hydro-entangled Nonwovens

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1. INTRODUCTION

Hydroentanglement describes a versatile process for manufacturing nonwoven fabrics using fine, closely speed, high-velocity jets of water and entangles loose arrays of fibers. The resultant fabrics rely primarily on fiber-to-fiber friction to achieve physical integrity and are characterized by relatively high strength, flexibility, and conformability. These technologies can use efficiently the majority of all types of fibers and produce fabrics that could achieve properties equivalent to wovens.

An important inference from this work would be the recognition that the mechanical properties of hydroentangled non-woven structures can be described quantitatively through a theoretical model based on the mechanics. Rational design of nonwoven products, as well as minimization of failure-related disruptions of their fabrication processes, would be facilitated by effective models for prediction of the properties of these materials.

2. OBJECTIVES

Our research objective is to develop a method for predicting critical mechanical properties of hydroentangled nonwovens. In doing so, we will gain a better understanding of the behavior of hydroentangled nonwovens as a function of the structural variables. Our goal in developing such a model is to facilitate improvements in processing conditions that will enhance performance characteristics of hydroentangled nonwovens

3. MATERIALS

Two sets composed of a total of 10 fabrics were prepared with the following processing parameters from nylon and polyester fibers. Webs were prepared by carding and cross-lapping. All web characteristics were kept constant.

Series 1: Treated on two sides with eight treatments
top & bottom @ 100,100, 300, 300, 300, 600, 600, 600 PSI
Series 2: Series 1 treated alternate sides;

top @ 1200 PSI and bottom @ 1200 PSI

Series 3: Series 2 treated alternate sides;
top @ 1600 PSI and bottom @ 3000 PSI

Series 4: Series 3 treated alternate sides;
top @ 1000 PSI and bottom @ 3600 PSI

Series 5: Series 4 treated alternate sides;
top @ 1000 PSI and bottom @ 3600 PSI

All other processing conditions were kept constant. The fabrics are referred to as P1-P5 for polyester and N1-N5 for nylon.

4. PLANAR ODF

The planar ODF (fiber orientation distribution function (ODF) in xy) were determined for each fabric by using the optical image analysis system developed by the authors. For each fabric, 5 images were captured and analyzed. The analysis method chosen is one based on the Fast Fourier Transform of the image. We have shown previously that this method is quite robust even in the presence of noise and that the result correlated well with mechanical and physical properties of the samples.

The ODF results are shown for both sets below in Figure 1.

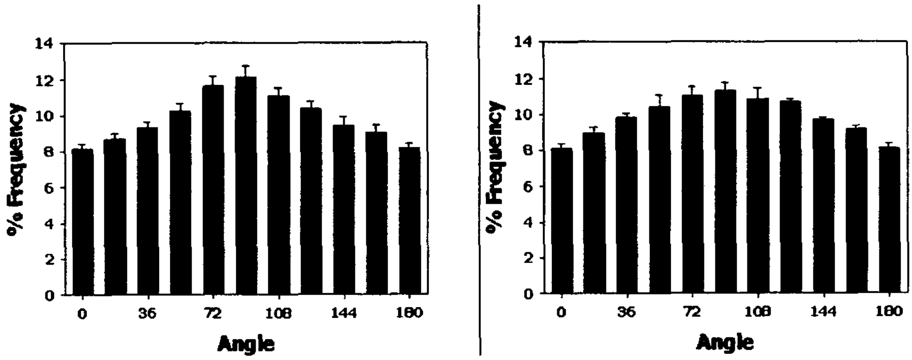

Figure 1. Planar ODF for polyester (left) and nylon (right) samples

As may be noted, both ODFs are quite similar and in fact, are not significantly different. Note also that there is a machine direction dependency in both. For carded webs, these are typical.

4. ANGULAR MECHANICAL PROPERTIES

Mechanical properties were investigated for by conducting bending and tensile tests on samples cut at different azimuthal intervals (18 degree intervals). Bending was performed by the Cantilever method and tensile tests were performed on an Instron tensile testing machine.

The bending results as function of energy are summarized below.

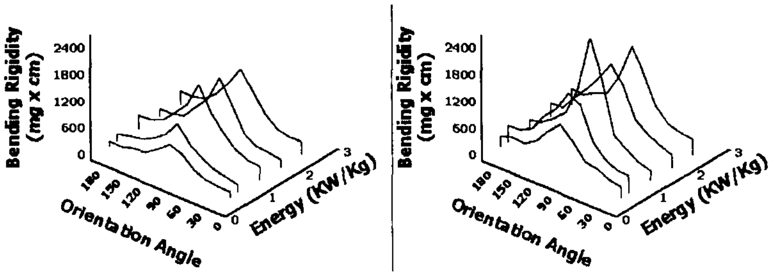

Figure 2. Bending for polyester (left) and nylon (right) samples at different energies

It may be noted that bending rigidity follows the planar ODF trend regardless of the hydroentangling energy level. Also note that both P3 polyester and N3 nylon samples show the highest bending rigidity values respectively followed by a decline. This is better summarized in another Figure where the average and standard deviations for bending rigidity for the machine direction which shows the highest peaks.

5. FUTURE PLANS

1 We have developed the experimental protocol required for acquiring images and determining the entanglement of the fabrics.

2 We will test the system by comparing different fabrics and establishing a knowledge base to help with the modeling aspects of the study, and begin the development of the model framework and compare the model generated results with those of the experimental data.

3 We will finalize the model and establish the necessary correlation between fiber properties, process conditions and the fabric properties.