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Objective and Subjective Analysis of Knitted Fabric Bagging

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ABSTRACT

In this study, fabric bagging tests are performed on a set of knitted fabrics that vary in design, tightness factor, and blend ratio. The relationships between residual bagging height \( R_{\text{residual}} \) obtained from the fabric bagging test and the mechanical characterization determined from the KES-FB system are presented and discussed. The work shows that it is possible to predict \( R_{\text{residual}} \) for knitted fabrics by using the standard KES-FB test and without performing fabric bagging fatigue tests.

Fabric bagging is very important to both the aesthetic appearance of apparel fabrics and to end use mechanical performance in industrial fabrics. Bagging in apparel fabric occurs during sitting or squatting down for long periods or from repeated movement. Bagging results from the lack of dimensional stability or recovery when repeated or prolonged pressure is exerted on a fabric.

Several bagging studies have been presented in the literature [4, 7, 8–13]. Most of these studies have addressed the bagging deformation of woven fabrics [8–13]. Thomas [7] showed results for a bagging test done on several knitted fabrics. He used an Instron tensile tester and exposed the samples to repeated loads, measuring the immediate recovery. In his study, the fabrics were also worn as garments, which were returned after 28 and 32 hours of wear and subjectively assessed. The results from the wear trial rankings were correlated to the immediate recovery data from the Instron loading test. Grunewald et al. [4] also reported on the results of bagging tests done on several knitted and woven fabrics. They used a device that had a motion similar to the bending of an arm. They used a wearer trial for a period of 50 days per garment, assessing the garments every five wear days. They concluded that when the degree of bagging measured in the laboratory was below 5 mm, a fabric was judged to be wearable. Both Thomas and Grunewald et al. made some useful observations, but their results could not be used to develop fundamental models of bagging in knitted fabrics, and they did not propose any relationship between mechanical properties and knitted fabric bagging.

Yokura et al. [8] analyzed the bagging behavior of woven fabric. In their study, samples were deformed under a constant load, and the bagging volume was determined with moire topography. They measured the mechanical properties of the fabrics with the KES-FB system, using a multiple linear regression analysis to predict the bagging volume of the woven fabrics from the variables obtained from the KES-FB system.

Zhang et al. [9–13] also analyzed the bagging behavior of woven fabric. In their study, samples were repeatedly loaded by an Instron tensile tester. After five load cycles, they measured relative residual bagging height. They also measured bagging resistance, which depends on the load work in the first cycle, and bagging fatigue, which depends on the change of load work between the first and last cycles. They used a multiple regression analysis to predict the bagging height of woven fabric as a function of bagging resistance and bagging fatigue. Their work also presented a subjective assessment of bagging in woven fabrics.

Both Zhang et al. and Yokura et al. provided detailed analyses of bagging in woven fabrics. Their results and predictions cannot be applied to knitted fabrics, however, since the mechanical response of knits is very different from that of woven fabrics due to structural differences. In general, a typical woven fabric is a structure of two interlaced orthogonal yarns. In many cases, the yarns are tightly held, which leads to a more stable structure compared to a knitted fabric. A knitted fabric, on the other hand, is made of yarns that are interlooped, where the yarn paths can have varying lengths and directions in the fabric.

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Thus, it is necessary to perform a detailed analysis of knitted fabric bagging and to understand how it is related to the mechanical responses of the fabric. In this study, we will analyze the relationship between bagging of knitted fabrics and their mechanical characterization parameters obtained from the KES-FB system. We will also explore predictions of both bagging height and a subjective bagging index.

**Experimental**

Fabric mechanical properties that reflect the resistance to deformation, ease of recovery, and loss of energy of fabric with use are very important to fabric bagging. Since a fabric’s mechanical properties are related to its design, tightness, material (fiber content, yarn type, etc.), and relaxation state, it is necessary to include a wide range of fabric types in this experimental study. Thus, we have produced several plain knitted fabrics in the laboratory and have purchased other fabrics (mostly double jerseys) to provide a wide range of fabric types for this study.

We will refer to two classes of knitted fabrics. One group is named the simple design fabrics, which are plain knits that have been produced in the laboratory. They have different tightness factors to investigate the effect of tightness factor on bagging. The other group is the complex design fabrics, all of which were purchased. They consist of six double knit fabrics and one single jersey fabric with tuck stitches. One plain knitted fabric was purchased to compare with those made in the laboratory. Each of the purchased fabrics contains different fiber blend ratios and different fabric designs, so we can investigate the effect of fabric design and material (fiber type). Loop diagrams of each sample can be seen in Table I. All fabrics were dry relaxed. In addition, the simple design fabrics were also relaxed with a wash-and-dry relaxation. For dry relaxation, fabrics were placed on a flat surface in a standard atmosphere (20°C at 65% RH) for one week.

To prepare the wash-and-dry relaxation samples, the fabrics were washed in a domestic washer at 60°C for 30 minutes with commercial detergent and tumble dried at 70°C for 15 minutes in an electrically heated dryer after they had been dry relaxed. This procedure was repeated four times. Before measurements were taken, the fabrics were conditioned for 24 hours in a standard atmosphere.

During bagging, a fabric is subjected to a complex pattern of loading. Thus we measured tensile, shear, and bending properties of fabric with the KES-FB system [5] on standard sized samples (20 × 20 cm), taking the mean value of course and wale directions. Each test was repeated five times, and data in Table II obtained from KES-FB are the mean value of these five measurements. To simulate garment bagging during wear, we developed a testing jaw similar in shape and size to that of Zhang et al. [9, 13], shown in Figure 1. The apparatus is attached to the Instron tensile tester. Each fabric sample has a diameter of 135 mm, and is placed in a circular
TABLE II. Fabric properties.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fabric material and properties</th>
<th>Weight, g/m²</th>
<th>WT, g/cm²</th>
<th>RT, %</th>
<th>B, g/cm²</th>
<th>2HB, g/cm²</th>
<th>G, g/cm²</th>
<th>2HG5, g/cm²</th>
<th>Rrec, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1d</td>
<td>100% cotton, 40 Ne x, 3.5, K 10.15</td>
<td>99.06</td>
<td>6.98</td>
<td>39.3</td>
<td>0.010</td>
<td>0.017</td>
<td>0.268</td>
<td>0.659</td>
<td>47.6</td>
</tr>
<tr>
<td>2d</td>
<td>50-50% poly-cott, 38 Ne x, 3.7, K 10.73</td>
<td>129.29</td>
<td>11.72</td>
<td>30.4</td>
<td>0.013</td>
<td>0.019</td>
<td>0.256</td>
<td>0.608</td>
<td>42.9</td>
</tr>
<tr>
<td>3d</td>
<td>30-70% poly-cott, 40 Ne x, 3.5, K 10.35</td>
<td>97.3</td>
<td>7.12</td>
<td>42.9</td>
<td>0.012</td>
<td>0.024</td>
<td>0.281</td>
<td>0.813</td>
<td>42.9</td>
</tr>
<tr>
<td>4d</td>
<td>100% cotton, 20 Ne x, 3.3, K 11.65</td>
<td>152.43</td>
<td>4.26</td>
<td>37.3</td>
<td>0.015</td>
<td>0.025</td>
<td>0.320</td>
<td>0.983</td>
<td>35.7</td>
</tr>
<tr>
<td>5d</td>
<td>100% cotton, 20 Ne x, 3.3, K 13.02</td>
<td>165.45</td>
<td>3.59</td>
<td>38.0</td>
<td>0.011</td>
<td>0.022</td>
<td>0.239</td>
<td>0.645</td>
<td>45.2</td>
</tr>
<tr>
<td>6d</td>
<td>100% cotton, 20 Ne x, 3.3, K 14.36</td>
<td>177.75</td>
<td>4.7</td>
<td>31.5</td>
<td>0.013</td>
<td>0.023</td>
<td>0.264</td>
<td>0.773</td>
<td>40.5</td>
</tr>
<tr>
<td>7d</td>
<td>100% cotton, 20 Ne x, 3.3, K 16.30</td>
<td>191.36</td>
<td>4.21</td>
<td>41.3</td>
<td>0.016</td>
<td>0.031</td>
<td>0.334</td>
<td>0.796</td>
<td>35.7</td>
</tr>
<tr>
<td>8d</td>
<td>100% cotton, 20 Ne x, 2.7, K 11.88</td>
<td>131.92</td>
<td>5.62</td>
<td>36.6</td>
<td>0.023</td>
<td>0.038</td>
<td>0.365</td>
<td>0.943</td>
<td>35.7</td>
</tr>
<tr>
<td>9d</td>
<td>100% cotton, 20 Ne x, 2.7, K 13.08</td>
<td>142.27</td>
<td>4.48</td>
<td>41.8</td>
<td>0.018</td>
<td>0.038</td>
<td>0.424</td>
<td>1.039</td>
<td>33.3</td>
</tr>
<tr>
<td>1w</td>
<td>100% cotton, 40 Ne x, 3.5, K 10.15</td>
<td>102.61</td>
<td>6.46</td>
<td>36.0</td>
<td>0.025</td>
<td>0.063</td>
<td>0.448</td>
<td>1.081</td>
<td>31.0</td>
</tr>
<tr>
<td>2w</td>
<td>50-50% pes-cott, 38 Ne x, 3.7, K 10.73</td>
<td>136.01</td>
<td>4.37</td>
<td>43.9</td>
<td>0.024</td>
<td>0.044</td>
<td>0.463</td>
<td>1.073</td>
<td>33.3</td>
</tr>
<tr>
<td>3w</td>
<td>30-70% pes-cott, 40 Ne x, 3.5, K 10.35</td>
<td>108.5</td>
<td>6.04</td>
<td>41.5</td>
<td>0.026</td>
<td>0.069</td>
<td>0.522</td>
<td>1.280</td>
<td>31.0</td>
</tr>
<tr>
<td>4w</td>
<td>100% cotton, 20 Ne x, 3.3, K 11.65</td>
<td>166.25</td>
<td>4.35</td>
<td>48.4</td>
<td>0.029</td>
<td>0.068</td>
<td>0.655</td>
<td>1.441</td>
<td>26.2</td>
</tr>
<tr>
<td>5w</td>
<td>100% cotton, 20 Ne x, 3.3, K 13.02</td>
<td>176.3</td>
<td>6.26</td>
<td>40.8</td>
<td>0.043</td>
<td>0.072</td>
<td>0.696</td>
<td>1.664</td>
<td>23.8</td>
</tr>
<tr>
<td>6w</td>
<td>100% cotton, 20 Ne x, 3.3, K 14.36</td>
<td>193.3</td>
<td>4.99</td>
<td>39.1</td>
<td>0.021</td>
<td>0.031</td>
<td>0.375</td>
<td>0.854</td>
<td>35.7</td>
</tr>
<tr>
<td>7w</td>
<td>100% cotton, 20 Ne x, 3.3, K 16.30</td>
<td>211.57</td>
<td>5.6</td>
<td>35.4</td>
<td>0.031</td>
<td>0.047</td>
<td>0.439</td>
<td>1.243</td>
<td>31.0</td>
</tr>
<tr>
<td>8w</td>
<td>100% cotton, 20 Ne x, 2.7, K 11.88</td>
<td>168.87</td>
<td>3.88</td>
<td>45.0</td>
<td>0.023</td>
<td>0.033</td>
<td>0.433</td>
<td>0.979</td>
<td>35.7</td>
</tr>
<tr>
<td>9w</td>
<td>100% cotton, 20 Ne x, 2.7, K 13.08</td>
<td>175.17</td>
<td>5.89</td>
<td>38.6</td>
<td>0.037</td>
<td>0.049</td>
<td>0.520</td>
<td>1.374</td>
<td>31.0</td>
</tr>
<tr>
<td>10</td>
<td>100% polyester</td>
<td>200.22</td>
<td>0.89</td>
<td>41.5</td>
<td>0.088</td>
<td>0.059</td>
<td>0.943</td>
<td>2.125</td>
<td>38.1</td>
</tr>
<tr>
<td>11</td>
<td>20-80% pes-cott</td>
<td>254.72</td>
<td>1.97</td>
<td>35.5</td>
<td>0.135</td>
<td>0.235</td>
<td>1.147</td>
<td>3.518</td>
<td>42.9</td>
</tr>
<tr>
<td>12</td>
<td>100% polyester</td>
<td>227.03</td>
<td>1.13</td>
<td>58.9</td>
<td>0.050</td>
<td>0.022</td>
<td>0.643</td>
<td>1.058</td>
<td>26.2</td>
</tr>
<tr>
<td>13</td>
<td>50-50% pes-cott</td>
<td>210.3</td>
<td>3.99</td>
<td>38.0</td>
<td>0.058</td>
<td>0.078</td>
<td>0.456</td>
<td>1.246</td>
<td>38.1</td>
</tr>
<tr>
<td>14</td>
<td>10-90% pes-acryl</td>
<td>206.73</td>
<td>1.83</td>
<td>40.8</td>
<td>0.072</td>
<td>0.071</td>
<td>0.681</td>
<td>1.837</td>
<td>35.7</td>
</tr>
<tr>
<td>15</td>
<td>45-55% acrylic-pes-cott</td>
<td>215.75</td>
<td>2.74</td>
<td>45.2</td>
<td>0.063</td>
<td>0.073</td>
<td>0.609</td>
<td>1.511</td>
<td>35.7</td>
</tr>
<tr>
<td>16</td>
<td>50-50% pes-cott</td>
<td>262.25</td>
<td>3.2</td>
<td>30.2</td>
<td>0.127</td>
<td>0.183</td>
<td>0.434</td>
<td>1.005</td>
<td>40.5</td>
</tr>
</tbody>
</table>

a d stands for dry relaxation, w stands for wet & dry relaxation. b K = tightness factor (tex/cm). f = twist factor of yarn. WT = percentage tensile extensibility. RT = tensile resilience. B = bending rigidity. 2HB = hysteresis of bending moment. G = shear rigidity. 2HG5 = hysteresis of shear force at 5 degrees, as measured by the KES-FB instrument. Rrec is Rresidual measured from the bagging test.

clamp with an inner diameter of 56 mm. It is then deformed by a steel ball with a diameter of 48 mm. The ball displaces the fabric by 21 mm at a cross-head speed of 20 mm/min and returns to its original position. This process is repeated five times. After a recovery time of 2 minutes under zero load, the nonrecovered bagging height is measured. Most of the testing parameters are the same as the test method presented by Zhang et al. [9, 13]. An exception is the predetermined bagging height. Zhang used 12 mm as the predetermined bagging height and we use 21 mm in this study. The 12 mm deformation corresponds to approximately 10% elongation [13]. Although this is sufficient for the woven fabrics, knitted fabrics are subjected to much higher deformations during use. Kirk et al. [6] pointed out that when performance is the primary requirement, the available stretch level should be 20 to 30%, but when comfort is the primary requirement, the stretch level should be 25 to 40%. For these reasons, we use a deformed bagging height of 21 mm, corresponding to approximately 25% elongation. The relative residual bagging height (Rrec) at the end of the last cycle, after a recovery time of 2 minutes, was modeled by Zhang et al. [9, 10] with Equation 1 (Rresidual) values are shown in Table II).
where $R_{\text{residual}}$ is the residual bagging height ($\%$), $H_{\text{nonreb}}$ is the nonrecovered bagging height (mm), and $H_b$ is the predetermined bagging height (mm).

Results and Discussion

Relative Residual Bagging Height and Fabric Mechanical Properties

To determine the relationship between relative residual bagging height ($R_{\text{residual}}$) and fabric mechanical properties ($G$, $2HG5$, $B$, $2HB$, $WT$, $RT$) we conducted a bivariate correlation analysis. The relationship between $R_{\text{residual}}$ and fabric mechanical properties for the simple design and complex design fabrics is summarized in Table III.

Simple Design Fabrics

For simple design fabrics (plain knit), there is a negative relationship between $R_{\text{residual}}$ and $G$, $2HG5$, $B$, and $2HB$ (with a significance level of 0.01 for a two-tailed distribution). This means that as the elastic restraint and frictional resistance (fabric rigidity) of a simple design fabric against deformation increases, $R_{\text{residual}}$ decreases. This is explained by noting that we use a variety of simple design fabrics with varying tightness factors (Tables I and II). As we know, an increased tightness factor in a plain knit increases fabric rigidity ($G$, $2HG5$, $B$, $2HB$) due to the inner pressure. This increased tightness factor in the plain knit fabrics increases loop curvature in three dimensions, and increased loop curvature (increased tightness factor) causes the structure to behave more like a spring. Thus, such a fabric recovers more easily than a more slack structure. Several researchers have observed this same phenomenon. For example, Alimaa et al. [1] pointed out that with an increased of tightness factor, the response of the structure to bending deformation is like that of a spring. Zurek et al. [14] also showed that an increased tightness factor increases fabric recovery from tensile deformation. As we mentioned above, an increased tightness factor increases fabric rigidity against deformation due to inner pressure. However, an increased tightness factor also increases fabric recovery after deformation due to its spring-like behavior, which leads to a decrease in $R_{\text{residual}}$. This explains the negative relationship between the fabric rigidity parameters and $R_{\text{residual}}$ that we observed. Increased fabric rigidity (tightness factor) decreases $R_{\text{residual}}$.

Complex Design Fabrics

On the other hand, for the complex design fabrics, consisting mostly of double knits, there is a positive relationship between $R_{\text{residual}}$ and $B$ and $2HB$ (with a significance level of 0.05 for a two-tailed distribution) and a negative relationship between $R_{\text{residual}}$ and $RT$ (with a significance level of 0.01 for a two-tailed distribution). This means that as the elastic restraint and frictional resistance of the simple design fabric against deformation (fabric rigidity) increase, $R_{\text{residual}}$ increases. This can be explained as follows:

The complex fabrics vary in both design and fiber material. Each fabric in the complex design group has a different yarn path and a different fiber type (Tables I and II) so as to include a wide range of fabric geometries (yarn path) and fiber components in the bagging analysis. As shown in the stitch diagrams of Table I, the yarn paths for these fabrics are complex compared to the plain knit fabrics. There are many long contact areas and complex linkages between the stitches. Most linkages cross each other at every successive course, so this structure makes the fabric more rigid against deformation. Also, fabrics with more intricate and longer linkages between stitches will tend to recover less deformation due to more fric-

\[
R_{\text{residual}} = \left(\frac{H_{\text{nonreb}}}{H_b}\right) \times 100.
\]

### Table III. Correlation analysis for simple design and complex design fabrics.

<table>
<thead>
<tr>
<th>Fabric group</th>
<th>$G$</th>
<th>$2HG5$</th>
<th>$B$</th>
<th>$2HB$</th>
<th>$WT$</th>
<th>$RT$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{\text{residual}}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>simple design</td>
<td>-0.926**</td>
<td>-0.929**</td>
<td>-0.885**</td>
<td>-0.898**</td>
<td>0.248</td>
<td>-0.373</td>
</tr>
<tr>
<td>complex design</td>
<td>0.300</td>
<td>0.550</td>
<td>0.778*</td>
<td>0.798*</td>
<td>0.395</td>
<td>-0.938**</td>
</tr>
</tbody>
</table>

***Correlation is significant at 0.01 level (two-sided). * correlation is significant at 0.05 level (two-sided).
tional resistance, thus increasing $R_{\text{residual}}$. Therefore, there is a positive relationship between fabric rigidity parameters and $R_{\text{residual}}$. Increased fabric rigidity (increased complexity in linkages) increases $R_{\text{residual}}$.

To predict $R_{\text{residual}}$, we performed a multiple regression analysis using twenty-five samples and two proposed models. The first model involves six variables ($G$, $2HG5$, $B$, $2HB$, $WT$, $RT$). The coefficients of $RT$ and $WT$ in the model equation are not statistically significant ($t$-statistic), so the second model for predicting $R_{\text{residual}}$ does not include the $WT$ and $RT$ variables. We obtained Equation 2 using four variables with a reasonable correlation coefficient ($r = 0.72$). The $F$ value is also higher than the $F$ critical value at 95% for a one-sided distribution ($F = 5.36$). Both these results show that Equation 2 can be used to predict $R_{\text{residual}}$ reliably:

$$R_{\text{residual}} = 43.11 - 67.8(G) + 18.8(2HG5) + 203.8(B) - 91.5(2HB).$$

### SUBJECTIVE ASSESSMENT

The bagging performance of knitted fabrics is described in different ways for different applications. For applications where the subjective view of the consumer (knitted garment appearance) is of primary importance, the rated performance measure is the most appropriate. For those applications where the objective, mechanical performance is of primary interest (for example, medical textiles such as compression wear), a measure such as residual bagging is more informative. The KES-FB system yields data that can be used to predict both kinds of measures of bagging behavior for fabrics, which vary in fiber type, fabric structure, and yarn size.

Subjective assessments were determined by rating photographs taken of the fabrics after the bagging tests. Since $R_{\text{residual}}$ is a function of time, all of the photographs were taken after 1 minute relaxation time (recovery time of 2 minutes) on the bagging apparatus. All fabrics were placed on a table and photographed under the same conditions, i.e., light, angle, etc. The sixteen photographs of the knitted fabrics in wet and dry treatment were presented to five people for ranking and rating. First, the sixteen fabric samples were ranked according to the relative severity of bagging from 1 (no bagging to all) to 16 (fabric showing the most severe bagging), then they were rated on a scale of 1 to 10, where 1 indicates no bagging. After the ranking and rating process was complete, each panelist’s ranking and rating results were compared and the panelists discussed the reasons for their ranking and rating values. As a result of this discussion, we obtained a common conformity for ranking and rating. A rating over 2 is considered as “failing” (high bagging). Rating results ($R$) can be seen in Table IV.

As with the Zhang et al. study of woven fabrics [9], we developed a model for predicting the rating values. Zhang’s study [9] predicted the rating using only the residual bagging height as the independent variable, but this was not possible for the knitted fabrics of our study. We had to include bending and shear parameters in our prediction study for two reasons. First, knitted fabrics, especially plain knits (simple design), have a lower resistance to deformation ($G$, $2HG5$, $B$, $2HB$) than most woven fabrics. Thus, knitted fabrics, especially the plain knits, will flatten easily with gravity when the bagged fabric is placed on a flat surface. Another reason is that the response of the simple design group (plain knit) and complex design group are different from each other. For example, as we mentioned previously, for the plain knitted fabrics, $R_{\text{residual}}$ increases with the decreased resistance of the fabric. The opposite is true for complex design fabrics, i.e., $R_{\text{residual}}$ increases with increased resistance of the fabric. Thus, any one of the simple design group fabrics, which has a similar $R_{\text{residual}}$ but lower resistance than any one of the complex design group, flattens more with gravity than the complex design fabrics during the relaxation time before the photograph is taken. This observation can be seen in Figure 2, and the situation can be explained more easily by looking at the drape properties of weft knitted fabrics. As we know, bending and shear properties are very important factors to the drape of weft knits. When the rigidity decreases, the drape of the fabric increases [2, 3]. Therefore, if two fabrics have the same residual bagging height but different rigidities due to their design, the fabric with lower rigidity will be ranked lower (more acceptable) than the fabric with higher rigidity. Thus, in the first model for predicting rating values, we used $G$, $2HG5$, $B$, $2HB$ along with $R_{\text{residual}}$ predicted from Equation 2. The coefficients of $R_{\text{residual}}$, $G$, and $2HG5$ are statistically insignificant ($t$-statistic). Thus, for the second model, we used only $B$ and $2HB$ to predict the rating values. We obtained Equation 3 with a correlation coefficient of

### Table IV. Rating values for fabric samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>1w</th>
<th>2w</th>
<th>3w</th>
<th>4w</th>
<th>5w</th>
<th>6w</th>
<th>7w</th>
<th>8w</th>
<th>9w</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
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<tbody>
<tr>
<td>Rating</td>
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<td>4</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>10</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>8</td>
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</tr>
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</table>
0.87. F values are also higher than the $F_{critical}$ value ($F = 20.3$) at 95% for a one-sided distribution. This shows that it is possible to predict the rating value ($R$) with our model:

$$R = 2.05 + 110(B) - 33.8(2HB) \quad (3)$$

![Figure 2](image-url) Photographs of two samples that were placed on a flat surface after the bagging test; these samples had similar $R_{residual}$ values: (a) sample $1w$ (simple design) and (b) sample $11$ (complex design).

Conclusions

The bagging performance of knitted fabrics is important to both appearance and mechanical performance. Thus, for those applications where the mechanical performance is of primary interest, for example, medical textiles, a measure such as residual bagging ($R_{residual}$) can be more informative. For applications where the subjective view of the consumer is of primary importance, the rated performance measure ($R$) can be most appropriate. The KES-FB system yields data that can be used predict both measures of bagging behavior for fabrics that vary in fiber type, fabric structure, and yarn size. KES-FB systems are also used for evaluating fabric properties such as handle and sewability. This study shows that by measuring shear and bending parameters of fabrics, it is possible to evaluate bagging properties by Equations 2 and 3 with correlation coefficients of 0.72 and 0.87, respectively. Using KES-FB tests involves less effort than setting up a bagging residual device, since KES-FB is a readily available, standard set of tests.

For simple design fabrics (plain knits), there is a negative relationship between $R_{residual}$ and $G$, $2HG5$, $B$, and $2HB$ with a significance level of 0.01 for a two-tailed distribution. This means that for simple design fabrics, as the elastic restraint and frictional resistance against deformation (fabric rigidity) increase, $R_{residual}$ decreases. However, for complex design fabrics, consisting mostly of double knits, there is a positive relationship between $R_{residual}$ and $B$ and $2HB$ (with a significance level of 0.05 for a two-tailed distribution) and a negative relationship between $R_{residual}$ and $RT$ (with a significance level of 0.01 for a two-tailed distribution). This means that as the elastic restraint and frictional resistance of complex design fabrics increase against deformation (fabric rigidity), $R_{residual}$ increases. Subjective rating values show that as fabric rigidity increases, the impact of bagging on appearance will be more severe.

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Literature Cited


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