Volume Based Measurement of Fabric Drape using Surfer Software and Studies on Effect of Influencing Factors

Gnanavel P1* and Ananthakrishnan T2
1Department of Textile Technology, KSR College of Technology, Tamilnadu, India
2Dept. of Textile Technology, Govt. SKSJT Institute, Kamataka, India

Abstract

The human being needs more comfort on clothing than its color, design and appearance. Drape is one of the important factors influencing the aesthetics and comfort of fabrics. In the initial days fabric drape was measured by using Cusick’s drape meter. Due to technology development and upgradation several instruments were developed by many researchers. In this research work one such latest technology was used to measure fabric drape in three dimensional way using SURFER software.

Here, the instrument used for measuring fabric drape was slightly modified from the Cusick Drape meter. The perforated circular disc was placed over the sample to measure the xyz coordinates of sample on radials range from 9.5cm to 14.5cm at each 5° intervals. The civil engineers use XYZ coordinates to measure the surface the of land profile (either hill or valley) using software. The same concept was followed to measure the profile of drape in three dimensional way using SURFER software. The xyz values are fed as input to the software and it generates contour lines, 3D view, vector lines, drape volume and drape profile area as output.

The drape coefficient was computed from the volume of drape profile and analyzed to study the effect of six different seams, seam directions and number of stitches with two different stitch densities. The seam type, number of stitches (single/double), their interaction density * number of stitches and stitch density * seam have significant effect on volume based drape coefficient.

The calculated volume (obtained from average radius and height) is compared with volume generated by SURFER software method and it was found that there is significance difference exists.

Keywords: Drape coefficient; Seam; Seam direction; Drape meter

Introduction

Clothing is one of the fundamental needs of the human being. It acts as the interface between the body and the environment and influences the comfort perceptions of the wearer.

Clothing selection is based on the needs and desires of the people. By touching one gets information such as perception of the surface, its temperature, hardness and roughness, etc. All though in some cases it is recommended to wear certain clothing and selection is not possible, for example dress of a fire fighter, military uniform, etc. Textiles differ from other technical structures in that it must have sufficient strength and at the same time it is to be flexible, elastic and easy to pleat and shape.

The clothing satisfies some aesthetic needs or fulfills any particular demand of human being. Aesthetics is a branch of philosophy dealing with the nature of beauty and taste with the creation and appreciation of beauty. It is more scientifically defined as the study of sensory or sensory-emotional values. The fabrics or garments are comfortable in aesthetic and physiological sense when we evaluate textiles in traditional use [1-5].

There are number of properties of fabric which plays a significant role in aesthetic comfort. Some are listed below;

1. Bending rigidity
2. Drape
3. Thickness
4. Grams per meter square (density)
5. Surface smoothness
6. Compressibility
7. Stretch ability
8. Shear rigidity
9. Bulkiness
10. Surface friction
11. Air permeability
12. Moisture permeability

Drape is one of the important terms to express the comfort and aesthetics of apparel products. Drape is a property which characterizes the shape of a fabric when it is hanging down of its own weight. "Drape Co-efficient (DC)" is the main parameter used to quantify fabric drape. Several physical properties have been suggested as contributors to the drape of woven fabrics. Drapability of a fabric is combined effect of several factors such as: stiffness, flexural rigidity, weight, thickness etc. It plays a significant role in providing graceful aesthetic effects in garment [6-9].

There are number of testing instruments which are used to assess
the aesthetic comfort of fabrics. One such instrument is Cusick's drape meter. The drape node number and drape coefficient are important factors to express the drape behavior of fabric, which was calculated from the shadow obtained in drape meter.

The presence of seam line influences the drape of the fabrics. The fabric has more stiff along the seam line than the remaining parts. However, fabric drape can be more realistically investigated by considering seams. The fabric is converted into garment by means of seam. The seam is a line where two or more fabrics are joined. The stitch is the configuration of the interlacing of sewing thread in a specific repeated unit [10].

This research focuses the new method to measure the third dimension of fabric drape with an attachment designed to Cusick's drape meter and to study the effect of various seams, seam directions, number of stitches (single/double) with two stitch densities on drape. The SURFER software package generates drape profiles and provides detailed information for analysis of drape in better way (Figure 1) [11-14].

Materials

To analyze the effect of various seams in different directions with two stitch densities the following yarn and fabric particulars were used (Tables 1-3).

Pre-treatment

The following sequences of pre treatment were given to the fabric.

Scouring → bleaching → cold wash → neutralization → calendaring

| S.No | Particulars | Values |
|------|-------------|--------|
| 1    | Yarn Count, Tex, (Ne ) | 14.7x2,(2/40) |
|      | CV          | 2.4    |
| 2    | Twist per cm,(TPI) | 6.85, (17.4) |
|      | CV          | 3      |
| 3    | CSP         | 5298   |
|      | CV          | 3.1    |
| 4    | Blend composition, % | Polyester 65 |
|      |             | Cotton 35 |

Table 1: Yarn Particulars.

| S.No | Particulars | Values |
|------|-------------|--------|
| 1    | Warp and weft yarn Count, (Ne ) | 14.7x2,(2/40) |
| 2    | Threads per cm | |
|      | Warp (Ends per Inch) | 24.4 (62) |
|      | Weft (Picks per Inch) | 22.8 (58) |
| 3    | GSM         | 148.3  |
| 4    | Warp %      | 7.8    |
|      | Weft %      | 5.1    |
| 5    | Breaking load, kg | Warp way 74.9 |
|      |            | Weft way 63.4 |
| 6    | Bending Length (cm) | Warp way 2.36 |
|      |            | Weft way 2.18 |
| 7    | Elongation % | Warp way 101 |
|      |            | Weft way 13.2 |

Table 2: Fabric Particulars.

| S.No | Particulars | Values |
|------|-------------|--------|
| 1    | Polyester sewing thread count, Tex, Ne | 14.5x2, 19.5 |
|      | Ticket Number | 99 |
|      | CV          | 2.2    |
| 2    | Twist per cm, (TPI) | 7.2, (18.3) |
|      | CV          | 5.6    |
| 3    | Yarn Strength, kg | 1.09 |
|      | CV          | 2.32   |
| 4    | Elongation % | 10.9 |
|      | CV          | 5.2    |

Table 3: Sewing Thread Particulars.

Cutting and stitching

The fabric is cut and sewn 3 different directions (warp, weft and bias) with single & double stitches as shown below (Figure 2).

D1 sgl: Single row of stitch parallel to warp
D1 dbl: Double row of stitches parallel to warp
D2 sgl: Single row of stitch parallel to weft
D2 dbl: Double row of stitches parallel to weft
D3 sgl: Single row of stitch in bias direction
D3 dbl: Double row of stitches in bias direction.
Stitch types

Stitch is one unit of thread formation by passing the needle thread through the material and interlocking with a bottom thread.

SEAM. A seam is a joint consisting of a sequence of stitches uniting two or more pieces of fabric material. In this project, six most common types of seams are used to make samples from two groups, i.e., superimposed seam, and lapped seams.

Class SS, Superimposed Seams: The superimposed seams are formed by placing two plies of fabrics one over another and sewing it. Superimposed seams are usually made with two plies of material, although more than two plies can be used for special projects. Types of superimposed seams used are SSa, SSa-1, and SSq.

Class LS-Lapped Seams: Lapped seams are formed by overlapping the material with sufficient distance and sewing it with one or more rows. Types of lapped seams used are LSba, LSc-2, and welt. It is shown below (Figure 3).

Methodology

Surfer software method

In this method, perforated disc was placed over the sample and XYZ values were measured by at each 50 intervals on different radial diameters such as 19, 21, 23, 25, 27, and 29 using specially designed scale, which is shown below (Figure 4).

The XYZ values are fed into Surfer software, which is a grid-based mapping program that interpolates irregularly spaced XYZ data into a regularly spaced grid. The grid is used to produce different types of maps including contour, vector, image, shaded relief, 3D surface, and 3D wire frame maps (Figure 5).

The surfer generates grid file from X, Y, Z values which was used to generate contour map, 3D map, vector map, etc.

Gridding overview

A grid is a rectangular region comprised of evenly spaced rows and columns. The intersection of a row and column is called a grid node. Rows contain grid nodes with the same Y coordinate, and columns contain grid nodes with the same X coordinate. Gridding generates a Z value at each grid node by interpolating or extrapolating the data values.

Advantages of using surfer

It generates the 3D drape profile along with contour lines using the XYZ data, which is illustrated in the above figure 6).

The contour map shows lines of equal elevation (i.e., depth in this case) of the draped fabric. The lines spaced closely indicate a steeper bending, while the spaced line indicates a more flatter region.

From the same map a 3D Surface can be generated which gives the visual appearance of draped sample. The Vector map shows the direction and magnitude of flow that is curvatures and also we can visualize top and front view of drape profile using this software (Figure 7).

Drape profile volume measurement

The SURFER software also measures volume of drape profile. This volume data is used as an additional parameter along with drape coefficient to quantify fabric drape. The normalized volume of drape is defined as follows

\[
\text{Normalized Drape volume} = \frac{\text{Volume of drape profile}}{\text{(Max. Volume - Min. Volume)}}
\]
=Volume of drape profile / 2715 (3.14*15*15*6) – (3.14*9*9*6)

The low value of Normalized volume indicates the material is more stiff as it increases the material bends easily [15,16].

**Result and Discussion**

**Effect of stitch densities, seams, and seam direction on volume based drape**

(Nominalized volume) (Table 4)

Dependent variable: Normalized drape volume

Independent variables: Stitch density (2), Seam (6), Direction (3), Number of Stitch (2)

Null hypotheses: There is no effect of stitch density on Normalized drape volume.

There is no effect of seam on Normalized drape volume.

There is no effect of direction on Normalized drape volume.

There is no effect of number of stitches on Normalized drape volume.

There is no interaction effect of various factors on Normalized drape volume.

Alternative hypotheses: Stitch density has a significant effect on Normalized drape volume.

Density has a significant effect on Normalized drape volume.

Seam has a significant effect on Normalized drape volume.

Direction has a significant effect on Normalized drape volume.

Number of Stitches has a significant effect on Normalized drape volume.

There is a significant interaction effect of various factors on Normalized drape volume (Table 5) [17-20].

It can be seen from the above table that a high value of $F_{,37}$ (4.274) and p-value of 0.004 for the factor Seam verify that the corresponding null hypothesis is rejected at 5% level of significance.

The $F_{,37}$ value of 16.956 with a p-value of 0.000 for the factor Number of stitches (single/double) verify that the corresponding null hypothesis is significant at 5% level of significance and hence rejected.

It can also be seen from the above table that the value of $F$ for the other main effect such as Density and Direction do not have any significant effect on Normalized drape volume.

The value of $F_{,10}$ (3.264) with a p-value of 0.079 for the interaction between Density* Number of stitches verify that the null hypothesis is marginally rejected at 10% level of significance.

The $F_{,10}$ value of (8.517) with p-value of 0.000 for the interaction between Density*Seam verify that the corresponding null hypothesis is rejected at 5% level of significance. The other interactions do not have any significant impact on Normalized drape volume.

Also it can be noted from the table that R-Square value is 0.737, which means that the model can explain about 73.7% per cent of variability in Normalized drape volume. This is higher than that of drape coefficient (71.5 percent), thus is more discriminative measure to characterize drape.
Influencing Factors.

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Table 4: Normalized volume values of samples in SURFER software method.

| S.No | Stitch density | Seam type | Direction | Number of stitch | Volume | Normalized volume |
|------|----------------|-----------|-----------|------------------|--------|-------------------|
| 1    | warp           | single    | single    | 641              | 0.2362 |
| 2    |               | double    | double    | 651              | 0.2397 |
| 3    | weft           | single    | single    | 659              | 0.2427 |
| 4    |               | double    | double    | 689              | 0.2539 |
| 5    | bias           | single    | single    | 624              | 0.23    |
| 6    |               | double    | double    | 634              | 0.2335 |
| 7    | warp           | single    | single    | 622              | 0.229  |
| 8    |               | double    | double    | 617              | 0.2272 |
| 9    | weft           | single    | single    | 575              | 0.2117 |
| 10   |               | double    | double    | 647              | 0.2384 |
| 11   | bias           | single    | single    | 563              | 0.2073 |
| 12   |               | double    | double    | 590              | 0.2173 |
| 13   | warp           | single    | single    | 620              | 0.2283 |
| 14   |               | double    | double    | 611              | 0.2252 |
| 15   | weft           | single    | single    | 641              | 0.2362 |
| 16   |               | double    | double    | 555              | 0.2044 |
| 17   | bias           | single    | double    | 658              | 0.2423 |
| 18   |               | double    | single    | 593              | 0.2186 |
| 19   | warp           | single    | single    | 617              | 0.2272 |
| 20   |               | double    | double    | 588              | 0.2167 |
| 21   | weft           | single    | single    | 598              | 0.2202 |
| 22   |               | double    | double    | 618              | 0.2276 |
| 23   | bias           | single    | single    | 638              | 0.2349 |
| 24   |               | double    | double    | 553              | 0.2038 |
| 25   | warp           | single    | single    | 599              | 0.2206 |
| 26   |               | double    | double    | 553              | 0.2036 |
| 27   | weft           | single    | single    | 590              | 0.2173 |
| 28   |               | double    | double    | 599              | 0.2206 |
| 29   | bias           | single    | single    | 592              | 0.2182 |
| 30   |               | double    | double    | 543              | 0.2    |
| 31   | warp           | single    | single    | 634              | 0.2337 |
| 32   |               | double    | double    | 551              | 0.2029 |
| 33   | weft           | single    | single    | 558              | 0.2055 |
| 34   |               | double    | double    | 543              | 0.2001 |
| 35   | bias           | single    | single    | 552              | 0.2033 |
| 36   |               | double    | double    | 552              | 0.2034 |
| 37   | warp           | single    | double    | 643              | 0.2476 |
| 38   |               | double    | single    | 569              | 0.2095 |
| 39   | weft           | single    | single    | 606              | 0.2232 |
| 40   |               | double    | double    | 614              | 0.2261 |
| 41   | bias           | single    | single    | 628              | 0.2313 |
| 42   |               | double    | double    | 606              | 0.2232 |
| 43   | warp           | single    | single    | 636              | 0.2342 |
| 44   |               | double    | double    | 573              | 0.211  |
| 45   | weft           | single    | single    | 636              | 0.2342 |
| 46   |               | double    | double    | 564              | 0.2077 |
| 47   | bias           | single    | single    | 643              | 0.2368 |
| 48   |               | double    | double    | 510              | 0.1878 |
| 49   | warp           | single    | single    | 566              | 0.2084 |
| 50   |               | double    | double    | 552              | 0.2033 |
| 51   | weft           | single    | single    | 610              | 0.2246 |
| 52   |               | double    | double    | 479              | 0.1764 |
| 53   | bias           | single    | single    | 566              | 0.2084 |
| 54   |               | double    | double    | 483              | 0.1779 |

Table 5: Anova results of samples- Volume (Surfer method).

| S.No | Stitch Density | Seams type | Direction | No. of Stitches | Calculated volume | Volume by SURFER |
|------|----------------|------------|-----------|-----------------|-------------------|------------------|
| 1    |                | S1         | Warp      |                 |                   |                  |
| 2    |                |            |           |                 |                   |                  |
| 3    |                |            | Weft      |                 |                   |                  |
| 4    |                |            | Bias      |                 |                   |                  |
| 5    |                |            |           |                 |                   |                  |

Table 6: comparison of computed volume and SURFER volume for seam type 1.

Comparison of volume generated by SURFER software and calculated volume

The volume of drape profile to be computed from average radius and height values and it is compared with the volume generated by SURFER software method (Table 6 and 7).

From the results there is significant difference exists between computed volume and volume by SURFER. The volume computed by average height and radius gives only the volume of frustum. It doesn't include irregularities on drape profile, but SURFER volume gives...
Conclusions

Measurement of depth and analysis by SURFER software has opened up a new drape parameter namely Normalized volume based drape to be defined. The seam type, number of stitches (single/double), their interaction density * number of stitches and stitch density * seam drape to be defined. The seam type, number of stitches (single/double), opened up a new drape parameter namely Normalized volume based drape. The other main factors and interactions do not have significant effect on volume based drape.

The image processing method and other old techniques gives information about the 2D image of drape profile and drape profile area. Measuring the depth and use of SURFER software provides the detailed information about drape profile area, drape profile volume, 3D image of drape profile in 360° with rotation, vector image, contour image and variogram. Further one can easily identify the seam line on the image. It is a new tool to quantify the drape in better way.

Table 7: Anova results of sample (computed volume and SURFER volume).

| Source of Variation | SS    | df | MS   | F-value | F crit |
|---------------------|-------|----|------|---------|--------|
| Between Groups      | 26878.7| 1  | 26879 | 28      | 0.0004 | 4.9    |
| Within Groups       | 9730.1| 10 | 973   |         |        |        |
| Total               | 36608.9|11  |       |         |        |        |

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