DEVELOPMENT OF NEW DEVICE FOR RAPID MEASUREMENT OF FABRIC DRAPE BASED ON FABRIC MULTIDIRECTIONAL BENDING

NGHIÊN CỨU THIẾT KẾ CHẾ TẠO DỤNG CỤ ĐO NHANH ĐỘ RỦ VẢI DỰA TRÊN ĐỘ UỐN ĐA CHIỀU CỦA VẢI

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ABSTRACT

The drape is always one of the most important properties of apparel fabrics since it is directly related to textile aesthetics. However, the measurement of fabric drape using current techniques such as F.R.L and Cusick drapemeter or 3D body scanner needs lots of time, strict conditions and preparation, long calculation and is often costly enough.

This article presents a development of new practical device for rapid measurement of fabric drape based on the fabric multidirectional bending. A new bending coefficient composed of bending angle and falling height was developped to be compared statistically with the drape coefficient obtained by Cusick drapemeter. The study conducted using 13 cotton and silk woven fabric samples demonstrates very good correlation between that new bending coefficient and the traditional drape coefficient of each fabric sample and proves the possibility to use this simple and reliable device for rapid measurement of fabric drape.

TÓM TẮT

Độ rủ luôn luôn là một trong những thông số quan trọng nhất của vải và quần áo vì nó liên quan trực tiếp tới tính thẩm mỹ của sản phẩm dệt. Tuy nhiên các phương pháp đo độ rủ có sử dụng các kỹ thuật phổ biến như F.R.L, Cusick hay quét 3D cần quá nhiều thời gian, điều kiện thí nghiệm và sự chuẩn bị mẫu khắt khe, các phép tính toán dài dòng và thường là khá tốn kém.

Bài báo trình bày sự phát triển và nghiên cứu chế tạo dụng cụ mới đo nhanh độ rủ dựa trên đặc tính uốn đa chiều của vải. Hệ số uốn mới được phát triển là tích số của góc uốn (đo bằng độ) và độ rơi uốn (tính bằng mm) được so sánh thống kê với hệ số rủ truyền thống được đo trên máy đo độ rủ Cusick của cùng mẫu vải. Nghiên cứu được thực hiện trên 13 mẫu vải bông và lụa tơ tằm dệt thoi đã cho thấy sự tương quan rất chặt chẽ giữa hệ số uốn đa chiều mới và hệ số rủ của từng mẫu vải và chứng tỏ khả năng có thể sử dụng thiết bị đo đơn giản này để đo nhanh độ rủ vải một cách tin cậy.

I. INTRODUCTION

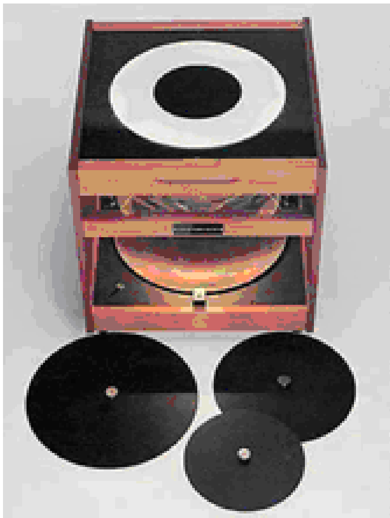
Draping of fabric and garment is a synthetic result of components (fiber content, type of yarn), fabric structures, finishing processes and the environment. It, along with color, luster, and texture is one of the most important factor affecting the aesthetics and dynamic functionality of fabrics. Drape is defined as "the extent to which a fabric will deform when it is allowed to hang under its own weight" [1]. Drape is a critical textile characteristic in determining how clothing conforms to the shape of the human silhouette. In use, this unique characteristic can provide a sense of fullness and a graceful appearance, which ultimately distinguishes fabric from other sheet materials and becomes crucial for the development and selection of materials in the apparel manufacturing. The draping behavior of fabrics reproduced by computer simulation holds great potential for the design and analysis of textiles, product development and marketing, as well as mass customization efforts in the apparel business. The simulation of a complete garment made of these fabrics could be achieved in a vitual fashion show to visualize its characteristics and/or flaws and make the fashion designer's ideas realizable.

Drape of fabrics was evaluated subjectively by a panel of judges in the early days of evaluating fabric aesthetic characteristics. Peirce (1930) developed the "cantilever method" to measure fabric bending properties and then used the two dimensional bending characteristic as a measure of fabric drape. Characterizing drape using a two-dimensional measure imposed many limitations in describing the complex anisotropic behavior of fabrics. To overcome the limitations of estimating fabric drape via two dimensional measurement of stiffness, researchers in Fabric Research Laboratories developed the F.R.L Drapemeter [2]. Later Cusick [5], developed a drapemeter (see figure 1) based on a similar principle. By developing drapemeters, Chu and all., [2] and Cusick [3, 4, 5] made significant contribution to the practical determination of this fabric property by measuring drape in three-dimensions. However, these methods are tedious, slow, prone to operator error and often very costly.

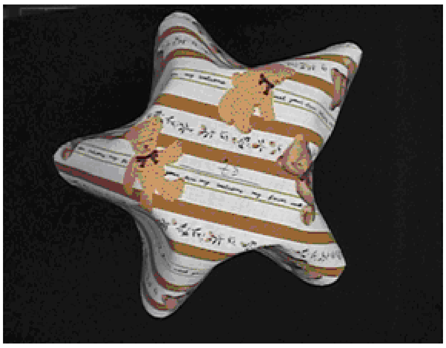
In this paper, we present simple, practical and quite reliable device for rapid measurement of fabric drape by using new multidirectional bending coefficient. The study conducted using 13 woven fabric samples demonstrates very good correlation between that new bending coefficient and the traditional drape coefficient of each fabric sample.

II. CONVENTIONAL METHOD FOR MEASUREMENT OF DRAPE USING CUSICK DRAPEMETER

Conventionally, drape is measured using a Cusick drapemeter resulting in a drape coefficient. Figure 1(a) shows the front view of the Cusick Drapemeter.



(a) Cusick drapemeter



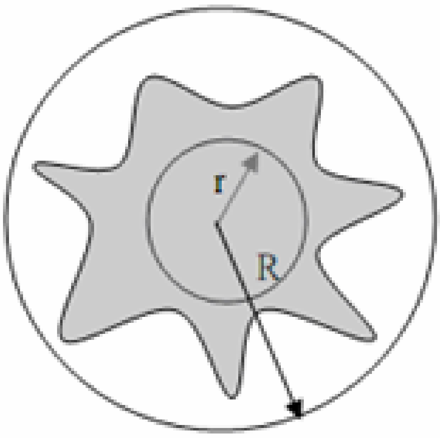
(b) Configuration of draped image on Cusic drapemeter

Fig. 1

The Cusick Drapemeter is widely used to measure drape of the fabrics in the textile and apparel industries. The instrument is capable of testing fabric samples of 24 centimeters, 30 centimeters, and 36 centimeters in diameter supported on a disk 18 centimeters in diameter.

In evaluating drape, the unsupported area of a sample drapes over the edges of the support disk forming the drape configuration of the fabric speciment. The drape configuration of the fabric can be quantified using the "Drape Coefficient" (DC).

The drape coefficient is defined as a ratio of the area of the portion of the annular ring obtained by vertically projecting the shadow of a draped speciment to the total area of the annular ring, expressed in percentage (Figure 2).



$$\mathbf{DC} = \frac{\text{Area Under the Draped Sample} - \text{Area of Support Disk}}{\text{Area of the Speciment} - \text{Area of Support Disk}}$$

Fig. 2 Definition of drape coefficient

To measure this drape coefficient, a circular fabric sample is supported horozontally by an inner circular disc and an outer annular disc. During the drape test, cloth is placed over the two discs and the outer annular disc is lowered gradually while the inner disc is held stationary allowing only an annular ring of the fabric to drape. This results in deformation of fabrics into a series of folds supported by the circular disc.

Even though drape is not completely parameterized by the drape coefficient, most of the research related to fabric drape consider drape coefficient as one of the primary attributes explaining drape in fabrics. However, the drape coefficient is unsufficient to completely describe fabric drape. Two fabrics sharing the same drape coefficient may have different drape shapes. Hence along with drape coefficient, other parameters such as number of nodes (folds) and node dimensions were measured (Figure 3) in the current investigation [6].

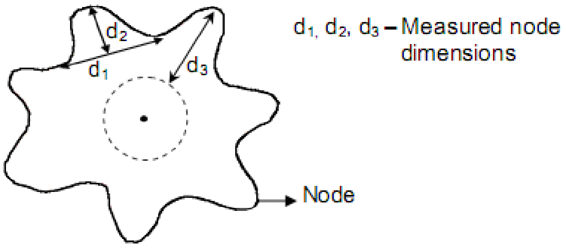


Fig. 3 Measurement of nodes and node dimensions

III. DESCRIPTION OF NEW DEVICE FOR RAPID MEASUREMENT OF FABRIC DRAPE

New device for rapid measurement of fabric drape consists of three main componets: (1) Horizotal platform made of very polished alumium with a minimum area of 38 x 200 mm and having a smooth low-friction, flat surface. A leveling bubble was incorporated in the platform. (2) Speciment Feed Unit, motorized by AC step motor with smooth timing belt drive (Figure 4) set to the speed of 120 mm/min ± 5%. (3) Scale and reference point, to measure the new multidirectional bending coefficient as a multiple of bending angle [^{o}] and falling height [mm]. (4) Movable slide, consisting of a metal bar of 25 x 200 mm by 3 mm thick and having mass of 250 g ± 5 g.

The lot and laboratory sample preparation as well as the number of test speciments and speciment dimension should be according to the standard ASTM D 1388 – 08. The test speciments of 25 x 200mm ± 1mm dimension should be cut on the warp, weft, 45^o and 135^o to the machine direction. After preparation of test apparatus, calibration and conditioning, the speciment should be placed between the horizontal platform and the movable slide at the initial left position (see Figure 4). By turning the switch on, the moving slide will move the fabric speciment to the right by the overhang length of 30, 40 or 50 mm. The new multidirectional bending coefficient should be carefully read on the Angle x Height Scale.

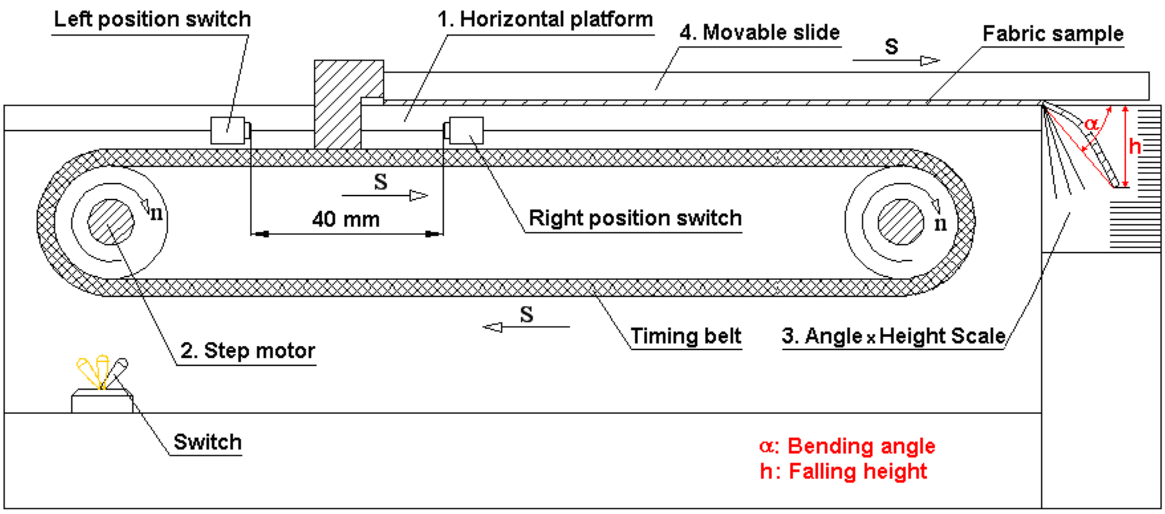


Fig. 4 New device for rapid measurement of fabric drape

IV. DISCUSSION ON EXPERIMENTAL RESULTS AND COMPARISON BETWEEN THE NEW MULTIDIRECTIONAL BENDING COEFFICIENT AND THE DRAPE COEFFICIENT

The study conducted was using 13 different cotton woven fabrics. Technical parameters of those 13 cotton woven fabrics are shown on the table 1.

Table 1. Technical parameters of 13 fabric samples

Properties / Sample	Material	Structure Rapport	Thickness (mm)	Surface mass (g/mm^2)	Warp density (yarn/10cm)	Weft density (yarn/10cm)	Warp yarn count (Ne)	Weft yarn count (Ne)
Sample 1	Cotton	Plain	0.487	124.1	57	29	60	60
Sample 2	Cotton	Twill 4/4	0.373	66.7	84	74	60	60
Sample 3	Cotton	Twill 2/1	0.648	148.5	136	104	40	40
Sample 4	Cotton	Twill 2/1	0.601	155.1	48	42	40	72
Sample 5	Cotton	Plain	0.459	120.7	48	36	40	40
Sample 6	Cotton	Twill 2/1	0.519	128.2	71	55	40	40
Sample 7	Cotton	Plain	0.565	67.4	38	32	40	40
Sample 8	Cotton	Plain	0.340	107.1	128	68.3	50	37
Sample 9	Cotton	Plain	0.680	144.1	67.3	55.4	22	21
Sample 10	Cotton	Plain	0.350	113.6	134.4	69.9	43	42
Sample 11	Silk	Plain	0.130	41.8	66/2	40	80/2	97
Sample 12	Silk	Twill 2/1	0.150	45.3	68/3	36	70/3	55
Sample 13	Silk	Plain	0.110	49.4	67/2	40	78/2	93

The new bending coefficient was defined as a multiple of a bending angle (degree, ^{o}) and a falling height (mm) of a 40 mm overhang length fabric sample. This new bending coefficient was calculated as an average of 4 testing results from each sample.

The measurement of the new multidirectional bending coefficient was done for warp, weft, 45^{o} and 135^{o} to the machine direction and defined as a mean of those 4 new bending coefficients obtained from 4 aboved direction samples. The testing results for new multidirectional bending coefficient of each from those 13 fabric samples have been calculated and shown on the table 2.

The same 13 fabric samples have been prepared for drape measurement on the Cusick Drapemeter to measure drape coefficient according to the British standard BS 5058-1973 and the results were shown on the table 3.

Table 2. New multidirectional bending coefficient of 13 fabric samples

Sample No.	New Multidirectional Bending Coefficient (BC)	Sample No.	New Multidirectional Bending Coefficient (BC)
1	2331.5	8	2491.2
2	2606.0	9	1692.5
3	2459.8	10	2251.0
4	1553.7	11	3002.5
5	2400.7	12	2892.0
6	2439.0	13	2923.7
7	2470.3		

Table 3. Drape coefficient of 13 fabric samples

Sample No	New Multidirectional Bending Coefficient (^{o}.mm)	Drape Coefficient (%)
1	2331.5	67.92
2	2606.0	61.40
3	2459.8	64.65
4	1553.7	83.75
5	2400.7	70.24
6	2439.0	69.76
7	2470.3	63.76
8	2491.2	66.36
9	1692.5	79.06
10	2251.0	66.05
11	3002.5	38.83
12	2892.0	39.98
13	2923.7	39.82

The study results show very good relationship between the new multidirectional bending coefficient and the drape coefficient with the coefficient of correlation $R^2 = 0.9478$. The regression equation between those two coefficients was hyperbolic (see Figure 5).

$$Y = -2E\text{-}05\ X^2 + 0.0782\ X - 5.4215$$

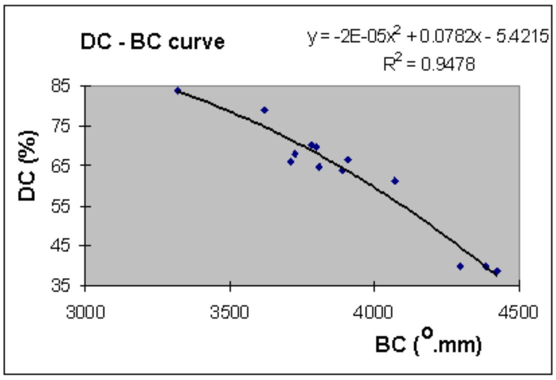


Fig. 5 Relationship between the new multidirectional bending and the drape coefficients using Cusick drapemeter

The comparison between drape coefficient calculated from our new measurement device and traditional drape coefficient measured on Cusick drapemeter at Hanoi Textile Research Institute for 5 different fabric samples shows negligeable errors around 0.1% and the analysis of variance proves that those two drape coefficients are considered similar with no significant differences.

V. CONCLUSIONS

A new simple, quite reliable and practical device for rapid measurement of fabric drape based on new multidirectional bending properties of the fabric has been developed. Using this new device we can obtain the calculated results similar to the drape coefficient measured on traditional Cusick drapemeter with very good correlation. The best regression was hyperbollic equation.

This new device can be used to determine drape characteristics of selected fabrics and to achieve the simulation of a complete garment made of these fabrics in a vitual fashion show to visualize its characteristics and/or flaws.

We hope that our device could contribute to the design and analysis of textiles, product development and marketing as well as customization efforts in the clothing industry.

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