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A Method for Measurement and Evaluation of Drape of Textiles

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***Abstract*—**Drape is one of the important visual characteristics of the fabric. This paper is introducing an innovative method of measurement and evaluation of the drape shape of the fabric. The measuring principle is based on the possibility of multiple vertical strain of the fabric. This method more accurately simulates the real behavior of the fabric in the process of draping. The method is fully automated, so the sample can be measured by using any number of cycles in any time horizon. Using the present method of measurement, we are able to describe the viscoelastic behavior of the fabric.

***Keywords*—**Drape, drape shape, automated drape meter.

I. Introduction

DRAPE is defined as the ability of the fabric to deform itself in space under the action of its own weight. With regard to the above definition, it is difficult to propose an optimal measurement method, which would fully describe the behaviour of textiles in space. The first person, who tried to measure this property (drape) objectively, was Peirce [1]. He has described that drape depends on the bending stiffness of the textile which he measured on strips of a textile cut out in different directions. However, the standard for measuring drape became the method described by Cusick [2]. The principle of the method consists in comparing areas, i.e. calculate the ratio between the undeformed areas of the sample to the sample surface after deformation. This deformed area is called the drape shape of the sample. The test is performed so that a circular textile sample of 30 cm in diameter is laid on a disc diameter of 18 cm (the disc diameter can be changed according to the specific areal weight of the fabric), the sample overhanging the edges of the disc is deformed by its own weight. The resulting drapes shapes can be recorded by various methods, such as manually trace the shape of the projection pattern or to photograph it. The method of measuring according to Cusick was subsequently modified by various authors. The drape shapes were not analyzed only in terms of the area, but also the other parameters of the pattern, the formed lobes (waves), their depth, height and number were evaluated.

In 1998 Jeonga [3] in his study describes the measurement of drape using a digital camera. The work describes how to process the digital image, and there is mathematically described the drape shape of the sample or its geometry. The image analysis for objective evaluation of the drape shape is also used in the work of Robson [4]. The authors suggest that the measurement of the drape shape based on the image analysis is more accurate and reproducible. Digitalization of the drape shape has allowed us to better analyze the investigated parameters of the drape curve, such as height, depth, the symmetry of waves. Behera [5], in his work, describes a device that comprises a display unit. He processes images of drape shapes in the Matlab. In these works, however, the measured samples are laid on the disc and are therefore not strained dynamically. This measurement method appears in the works of the authors: Shyr [6], [7], Stylios [8], Lojen [9], Matsudaira [10], Yang [11], Kenkare [12], Sanad [13]. They also describe the dynamic device in combination with a display unit and computer-processed images of drape shapes.

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II. The Principle of the Newly Proposed Method

A. Standard Method

The patterns of drape shapes can now be processed automatically by using image analysis. This has opened up the possibility of evaluating a large number of drape shapes. But how do we still get most of the drape shapes? Mostly with a lot of manual work measurements are carried out so that the circular pattern is placed on the disc and consequently the drape shape is recorded (photographed). This process is repeated either with the same pattern, or a further sample of the same fabric is placed on the disc. To get, e.g. a hundred drape shapes of the fabric is time-consuming.

So how do we record a lot of drape shapes with a small proportion of manual labor, respectively, placing the sample on the disc? Can this activity be automated? These were the questions we asked when developing the new methodology for measuring drape.

B. New Method

The principle of our new solution lies in the fact that a circular sample placed on the disc is measured one hundred times without removing it from the disc. The proposed measuring device is shown in Fig. 1.

The circular disc with a diameter of 18 cm (1) is moved by a mechanism (2) vertically over a rod (3) which passes through the center of the disc and has a guiding groove thanks to which the disc does not rotate. The fabric is fixed to the disc at three points so that it could not shift at fall or revolve on the disc.

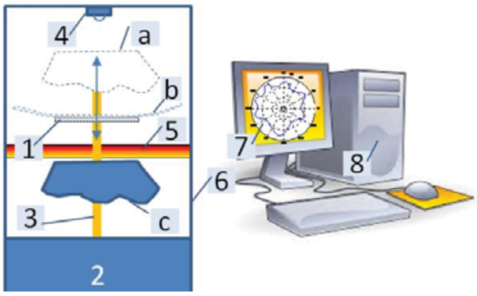


Fig. 1 Equipment for Evaluation of drape fabric

The mechanism (2) allows vertical movement of the disc with the fabric in any number of cycles. This vertical movement simulates the real dynamic behavior of cloth when in dressing the textile falls on the human body vertically.

When moving the disc of the measuring device upwards, the gravity acts on the textile and the sample of the textile is touching the disc fully (a) but during the descent (falling) of the disc, the textile sample flutters and touches the disc only at three points of fixation (b). Only after the descent of the disc, the textile is deformed by its own weight on its edge (c).

One second after the fall of the textile, a camera (4) records the drape shape of the sample. If we want to get a good picture of the drape shape, it is necessary to illuminate (5) the disk with the fabric properly. Therefore, the device was inserted into a box (6) with artificial lighting, which is evenly distributed around the circumference of the scanned sample.

The photographed textile is protected from daylight, and so you get a better picture of the outline of the drape shape (7). In one placing the sample, it is possible to strain the textile vertically in any number of cycles. In our experiments, we strained the textile in up to five hundred cycles. The camera that captures the pictures of drape shapes is computer-controlled (8) and therefore any time of shooting can be set with the smallest time being every five seconds. In a minute then we get twelve pictures of the drape shape. We are able to measure five hundred drape shapes in forty-two minutes.

III. Analysis of Drape Shapes

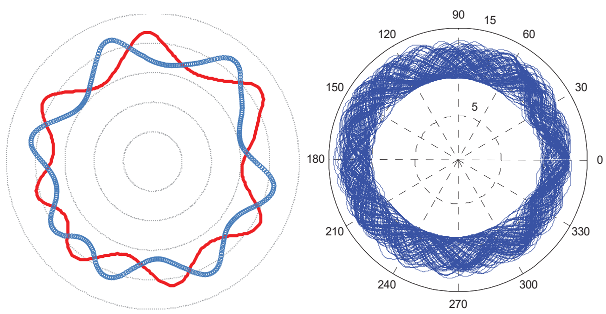
The aim of the analysis of drape shapes was to determine whether the standard methods of measuring drape shapes can be replaced by the method of vertically strained fabric with subsequent recording of the drape shape. We have compared the resulting values of two types of measurement. In the first case, the experimenter placed the fabric sample on the disc and subsequently photographed the drape shape of the sample. Thus he created a hundred pictures of drape shapes of one sample. In the second case, the sample was placed on the disc which was raised and dropped in the vertical direction with the help of a built-in mechanism. For the measurement, one hundred cycles of vertical movement were set, while the drape shapes were scanned every 5 seconds. If we evaluate the time-consuming of the experiments, then we can say that the first measuring method is at least twice more time-consuming than the second method our proposed method. Now, let us compare the parameters of drape shapes. Since the drape shapes are commonly evaluated in terms of the gained area and the shape of patterns, we have analyzed the following parameters: the content area and the number of lobes (waves) of the drape shape. Experiments were performed on fabrics whose design parameters are listed below in Table I.

TABLE I
Parameter of Fabrics

code	Material	Weave	Density [yarns/cm] warp	Density [yarns/cm] weft	Weight [g/m^2]	Thickness [mm]
KZ1	100% WO	Panama weave	22	22	184	0.356
M45	100% CO	Plain	24	20	158	0.380
M41	100% CO	Plain	24	20	166	0.356
Z20	45% WO 55% PES	Plain	28	23	159	0.300
M36	100% CO	Twill 1/4	24	24	175	0.520
M48	100% CO	Twill 1/4	24	18	153	0.550
M44	100% CO	Twill 1/4	24	20	160	0.458

IV. Discussion of Results

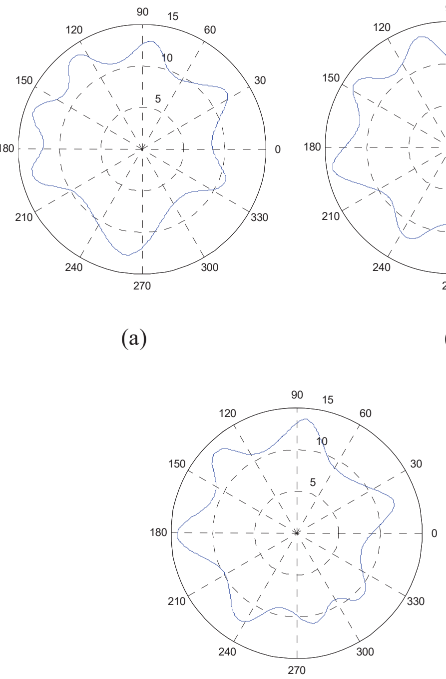
Thanks to the used measurement methodology, we have received a sufficient number of drape shapes (two thousand shapes for one type of fabric) needed for our analysis. We tested the following hypothesis: If we measure the drape shape repeatedly on one circular fabric sample, we get very close to the parameters of drape shapes that they characterize, or the content area, the number of lobes and their shape. We expected that when we perform multiple measurements of the same sample, which does not rotate during the test, there will be two to four positions at maximum, which the drape shape will have and they will repeat continuously (as shown in Fig. 2 (a)). However, this hypothesis was not confirmed.



(a) (b)

Fig. 2 Drape Shapes (a) Fiction - identical shapes which are rotated (b) One hundred different drape shapes (first experiment)

In Fig. 2 (b) individual drape shapes that we obtained from the experiment are drawn. It is evident that drape shapes behave chaotically, the prevailing dominant outline of the drape shape does not predominate (it is not projected). The pattern formed for a hundred shapes creates a continuous ring, where no shape dominates.



(a) (b) (c)

Fig. 3 Drape shapes with the same number of lobes - seven (a, b, c)

In Figs. 3 (a)-(c) drape shapes containing seven waves are shown. The shapes are not similar, they agree only in the number waves. The shapes of waves and surfaces of patterns (the surfaces range between 367 and 389 cm^2) are different. There is no correlation between the number of wave patterns and their area. The areas of patterns with five waves are ranging from 373 to 379 cm^2 and the surface of patterns with nine waves is ranging from 382 to 391 cm^2. Drape shapes most frequently occurred with seven waves. The minimum number of waves of was five, the maximum nine waves. We analyzed the results of both experiments (lying the sample, vertical falling off the sample). The results are evident from Fig. 4.

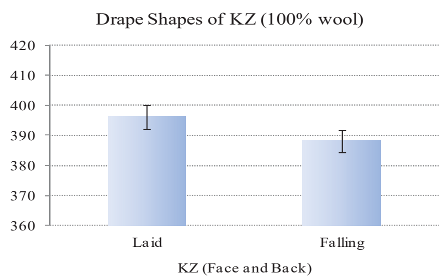


Fig. 4 Drape shapes of 100% wool

The average values of the surface of patterns between the first and the second type of experiment differed only by 3% (from 396.1 to 388.1 cm^2). Data variances ranged from 395.4 to 396.9 cm^2 (laid) and 387.9 to 388.3 cm^2 (falling). We compared the average of the area from two experimenters. Fig. 5 presents the results which are different only by 0,67 %.

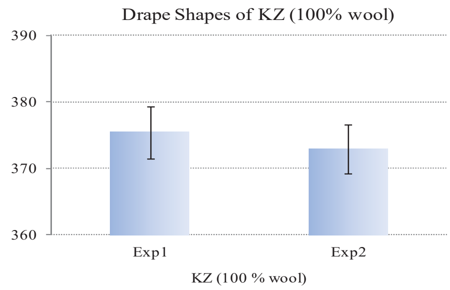


Fig. 5 Repeatability (two different experimenters)

Fig. 6 presents the histograms of the distribution of the number of lobes (fabrics code-KZ). As we can see in the picture, the number of waves is in the range of five to ten waves for both experiments (laid, falling). If we had only twenty measured samples (Fig. 7), then we would hesitate between the numbers of groups seven and eight. From the above, it is clear that multiple measurements on one sample refine the result without the need to measure a large number of samples.

We hypothesized that from a small number of samples cyclically and vertically strained; we would obtain parameters of assessment of drapability comparable to values obtained by measurements on a big number of samples by the standard static method.

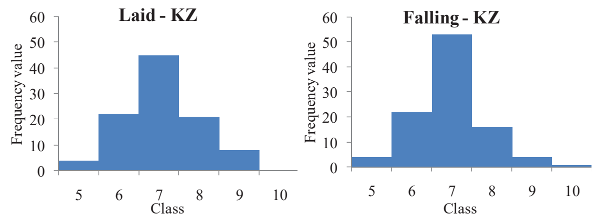


Fig. 6 Histogram of distribution of lobe for laid and falling

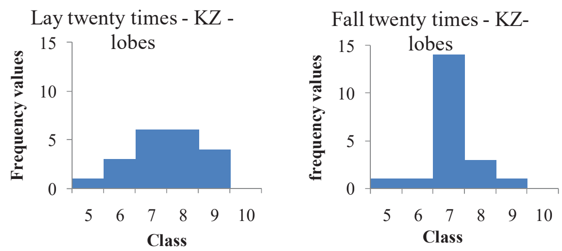


Fig. 7 Histogram of distribution of lobe for twenty measuring

We examined the hypothesis using analysis of variance and conformity of averages (areas of drape shapes for experiment 1 and 2). The analysis has shown that the hypothesis is true and both files have the averages and also the variances identical.

V. Conclusion

Multiple falls of the textile (a hundred falls) can be described as the solution of an unstable task. Each fall of the textile on the disc is a new variant of deformation of the textile over the edge of the disc, resulting in a large number of diverse patterns (which showed the patterns of drape shapes in Fig. 2). The calculated area of drape shapes does not change much, and the numbers of waves are found in a certain interval. At each fall of the textile on the disc edge, there is a reorganization of yarns and binding points, which come into contact with the edge of the disc. Already in the process of falling the textile is variously deformed, bent, the yarns, and the attachment points interact; the textile never falls on the disc in the same form of grouping.

The proposed device, whose vertical movement simulates the real strain when wearing the textile, enabled us to analyze and describe the drape behavior (properties) of the textile. Experiments and statistical analysis have shown that with our proposed method of measuring drape we obtain comparable results to the standard method. This means that it is possible to measure drape shapes on a small number of cut out samples (e.g. five pieces) with a large amount of cyclic strain of one sample (one hundred cycles), and thus the obtained resulting values are comparable (similar) to the standard measurement values of drape, i.e. a large number of samples (one hundred) are successively placed on the disc and the drape shape is recorded.

The diversity of drape shapes obtained by a cyclic strain of one sample, therefore, can identify and describe the drape behavior of the textile in the same way as when we measure a large number of samples placed once on the disc. Our proposed method then will enable to describe the drape behavior of the textile using fewer samples and with significant time savings of the laboratory technician because the measurement of drape shapes is automated.

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