30E09

Study on the Fabric Drape Behaviour with Image Analysis

- Measurement, Characterisation and Instability -

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1. INTRODUCTION

Colour tone, lustre, surface roughness of fabrics are very important factors in pursue of the beauty of external appearance, namely aesthetic appearance, and the dynamic functionality of fabric used to clothe the human body. Drape is one of many factors that influence the aesthetic appearance of fabric and has an outstanding effect on the formal beauty of fabric. For this reason, the measurement and understanding of drape is required to specify the performance of fabric used in clothing. Research on this topic was started first by Chu *et al*[1] and studies on the prediction of drapeability have been done to quantify the dynamic behaviour of fabric[2,3].

Instruments for measuring drapeability have been developed by Chu et al[1] and later Cusick[4,5]. Using these instruments, drape coefficient was calculated as the measure of drapeability. They defined the drape coefficient as the percentage of the total area of an annular ring of fabric with respect to the shaded area obtained by vertically projecting the shadow of the draped specimen as shown in Fig.1. This conventional method is very time consuming and requires skill, which limits the use of drape in research or quality assurance applications. The image analysis method reported in this paper was developed to overcome the problems in measuring drape coefficient.

2. PRINCIPLE OF MEASURING DRAPE COEFFICIENT WITH IMAGE ANALYSIS

The image analysis system developed for measuring drape coefficient consisted of a conventional drape-meter, computer, two monitors, a camera and image board as shown in Fig.2. In this image analysis system, the shadow projected by the fabric is quantified into a binary image after being digitised. This image is processed with a closing operation[6] to remove noise and segmentize the shadow image of draped fabric from background image. After then, the image analysis system searches the boundary between the fabric shadow and the central disk on the drape-meter(between A_d and A_1 of Fig.1) and the boundary between fabric shadow and outer region of fabric shadow(between A_2 and A_d of Fig.1). Using this boundary description, the software calculates the projected area of the central ring on the drape-meter and the projected shadow area of draped fabric. From these calculated values, drape coefficient value is calculated by the definition as shown in Fig.1.

Drape distance ratio is proposed as an alternative to the drape coefficient. Fig.3 shows the definition of this measure. As defined, the drape distance ratio increases as fabrics become more flexible and is thereby more consistent with intuition. The drape distance ratio and drape coefficient are described as "drape values" in this study.

3. TIME DEPENDENCE OF DRAPE COEFFICIENT

To observe the time dependence with our image analysis system, drape coefficients of the four fabrics were measured. Fig.4 shows a little decrease of drape coefficient of fabrics with time. It seems likely that the decrease of drape coefficient results from the relaxation of mechanical properties of the fabric. However, it is necessary to measure drape coefficient when the fabric reaches steady state. The image analysis method enables to check the steady state easily.

4. INSTABILITY OF FABRIC DRAPE

Measurement of the time dependence of the drape coefficient revealed a difference for the drape coefficients between the same fabrics, as shown Table I, II and Fig.4 for Fabric A. To study the repeatability of the drape coefficient, drape coefficients were measured 50 times for Fabric A and B per test. In addition, the number of drape nodes was counted and drape distance ratio was calculated.

Drape values were measured for Fabric A and B by using two methods. One was to measure the drape values without remounting the fabric on the drape-meter after each measurement to allow the fabric as nearly as possible to retain the same state(method I). In the other, the fabric was removed and remounted on the drape-meter between successive measurements of drape values(method II). The results for these two methods appear in Figures 5 and 6. These figures show the number of nodes according to the test sequence. Method II gives more variation in the measured number of nodes than method I. This suggests that the same drape shape would be obtained if the same initial state could be imposed on fabric before draping.

To determine if there is any relationship between drape values and the number of nodes in the fabric, the average drape values for each node of Fabric A and B were calculated. Fig.7 shows that the drape coefficient increases and the drape distance ratio decreases with the number of nodes. This is due to the fact that force balance is established early, when the number of nodes is large. This can be inferred from the decrease of drape distance ratio with the number of nodes. The results in Fig.7 show that an equivalent drape coefficient is possible for two different fabrics, depending on node values. Thus it may be better to use the distribution of the number of drape nodes with drape values to describe aesthetic appearance, since drape shape could be imagined from the distribution of nodes, whereas fabrics that differ in their aesthetic appearance can have similar drape coefficient values[7].

Coefficients of variation of drape values were also calculated for each node shape and for the entire node set as shown in Table III. The coefficient of variation within each node is smaller than that within the entire node range because the number of nodes influences the drape values as shown in Fig.7. It is thought that the variation within the same node is mainly due to the hysteresis of fabric shear and bending[3]. Since the number of nodes is influenced by the initial state of the fabric, it follows that the drape values of the fabric will change according to the initial state of fabric such as the boundary condition between the fabric and the disk of drapemeter, the draping speed, and so forth. Thus it is necessary to measure drape values many times to be able to use them as an objective measure of drapeability.

5. CONCLUSION

An image-analysis system has been developed for the measurement of drape values. With the image-analysis system, a new measure of drape, drape-distance ratio, was defined. It was found that on repeated measurements its variation was smaller than that of drape coefficient. Another perceived advantage of the drape-distance ratio is that an increase in value corresponds to an increase in drapeability, whereas an increase in drape coefficient corresponds to a reduction in drapeability.

Repeated measurements have shown that the drape shape is not constant(i.e. there is a distribution in the observed number of nodes in the drape shape), which causes the fabric to have different drape values. This instability of fabric drape makes it necessary to measure the drape values many times to allow drape values to be used as an objective index for drapeability. However, it is not easy to measure drape values many times with the conventional method. The image analysis system allows multiple measurements to be made in a reasonable time. Also, the time-dependence of fabric-drape was checked with the image analysis system. With this technique, the drape values in the steady state can be readily obtained.

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Table I Comparison drape coefficients(%) using conventional method(BS5058: 1973) with image analysis(paired *t-test* value is 0.86).

	Fabric	A	B	C	D	E	F	G	H	I	J	K
Drape coefficient	Conventional	39.44	40.72	39.84	40.18	51.62	57.67	32.25	58.24	71.65	61.45	26.54
	Image analysis	39.37	40.86	39.66	40.27	51.57	57.70	34.67	58.11	71.00	60.70	25.11

Table II Verification of repeatability of image analysis method(Fabric A).

	Average	Standard deviation	Coefficient of variation
Drape coefficient(%)	37.72	0.024	0.063

* Average differs from Table I - see text

Table III Coefficient of variation of drape values according to the number of nodes with remounting every measurement(method II).

		The number of nodes					
		5	6	7	8	9	All nodes
Fabric A	Drape coefficient	-	1.34	1.46	1.28	-	2.53
	Drape distance ratio	-	1.68	1.47	1.62	-	1.89
Fabric B	Drape coefficient	1.61	2.35	2.46	1.94	0.6	4.63
	Drape distance ratio	1.56	2.33	2.37	2.16	0.96	3.61

-: the count of the number of node is one.

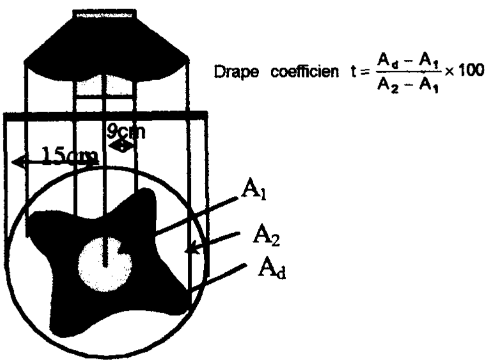

Fig. 1 Principle of calculation of the drape coefficient

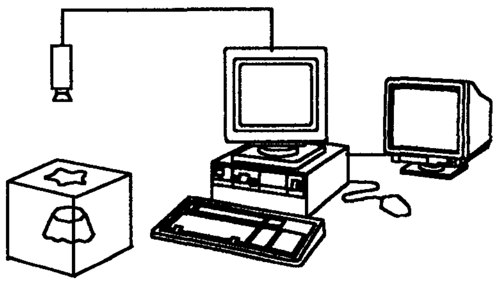

Fig.2 Diagram of image-analysis system for the measurement of fabric drapability

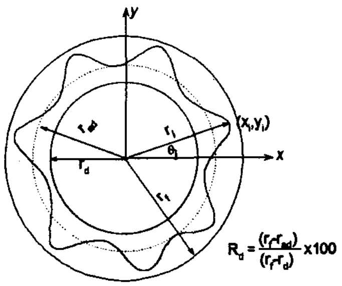

Fig.3 Definition of drape distance: r_f =radius of fabric before being draped; r_d : radius of disk of drape meter; r_{ad} : average distance to edge of draped fabric; r_i, θ_i : radius and angle at ith point; R_d = drape distance ratio

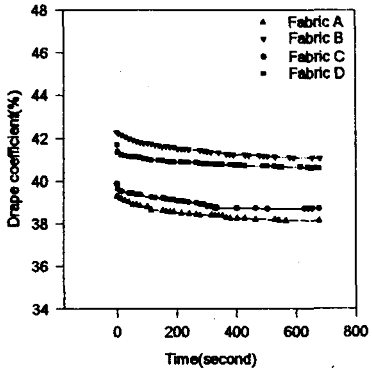

Fig. 4 The change in drape coefficient with time

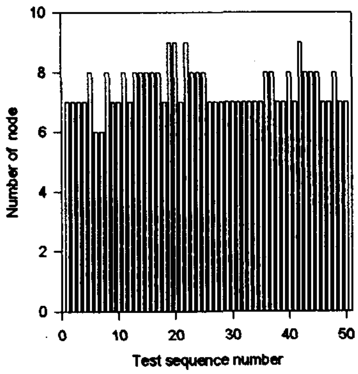

Fig.5 The effect of repeated measurement on the number of drape nodes for Fabric A; each measurement was conducted by using method I ,i.e. without remounting of the sample between tests.

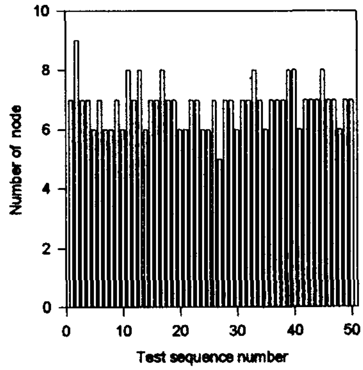

Fig.6 The effect of repeated measurement on the number of drape nodes for Fabric A; the drape was measured by using method II ,ie, the fabric was removed and remounted on the drape-meter between successive measurements.

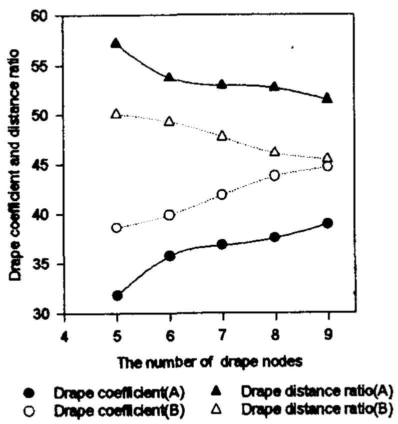

Fig.7 The change of drape values according to the number of drape nodes(method II)