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Evaluation of mechanical properties of uniform fabrics in garment manufacturing

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Abstract

Kawabata Evaluation System (KES) is the first advanced and unique solution of user friendly testing of fabric mechanical properties. The information provided by this system can enable remedial/preventive action to be taken in garment manufacturing so as to guarantee production efficiency and product performance since the mechanical properties of fabrics not only govern the performance of fabric products but also influence garment making operations. In the present research, this system was adopted to investigate the mechanical properties of uniform fabrics currently in use on the basis of 12 different commercial types of uniform materials obtained from different sources. All determination of the 16 parameters describing fabric mechanical properties was undertaken according to the prescribed procedure and required condition. The obtained results will surely help to identify the design criteria for uniform clothing so as to produce high-quality career uniforms.

Keywords: Uniform; Kawabata Evaluation System

1. Introduction

The Kawabata Evaluation System (KES) is the first advanced and unique solution of user friendly testing of fabric mechanical properties and has acquired great popularity in many countries due to their high precision and reproducibility in measurement. This commercially very successful solution is basically a weighted-regression analysis combining 16 factors, as shown in Table 1, measuring in five separate tests, including compression, shear, tensile, bending, and surface tests, and Fig. 1 illustrating the measuring principle of KES system.

With the information provided by this system, it is possible to realize effective communications and cooperation among various sectors (e.g. researchers, industry sectors, and traders) of the textile and clothing industries through specifying the performance requirements and transactions based on fabric properties data. Apart from this, this system also provides an approach for production control, an example of which is given in Table 2, marketing strategy, like what indicated in Table 3, quality assurance, and new product development.

The authors selected 12 different commercial types of uniform materials with various fiber content, blend composition, fabric weave, color, and end uses for the present study. Results generated will sure help understand the uniform performance and monitor the manufacture process so as to produce high-quality career uniforms.

2. Experiments

Twelve currently used uniform fabrics were selected for the present study with their details listed in Table 4. The samples were collected from different sources, including airline, bank, department store, and government departments, involved a wide range of end uses like skirt, jacket, trousers, blouses, etc., and thus differed a lot in color, fiber content, blend composition, density, thickness, weight, and fabric weave, as shown in Table 5. To ease the comparison of fabric handle, the samples were further subcategorized into three groups according their different end uses, including all-year-round outerwear clothing, summer light clothing, and winter outerwear clothing, as shown in Table 6.

Kawabata Evaluation System was the main testing apparatus used in the present research due to its unique ability to examine fabric physical and surface properties as well as automatically integrate these properties into a data to express the total hand value of the fabric. All determination of the 16 parameters describing fabric mechanical properties was undertaken according to prescribed procedure and required condition.

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Table 1
The parameters measured on KES–F system

Property	Symbol	Parameter measured	Unit
Tensile	EM	Extensibility, the strain at 500 gf/cm	[%]
	LT	Linearity of tensile load–extension curve	[–]
	WT	Tensile energy per unit area	[gf cm/cm^2]
	RT	Tensile resilience, the ability of recovering from tensile deformation	[%]
Bend	*B*	Bending rigidity, the average slope of the linear regions of the bending hysteresis curve to $\pm 1.5\,cm^{-1}$ curvature	[gf cm^2/cm]
	2HB	Bending hysteresis, the average width of the bending hysteresis loop at $\pm 0.5\,cm^{-1}$ curvature	[gf cm/cm]
Shear	*G*	Shear rigidity, the average slope of the linear region of the shear hysteresis curve to $\pm 2.5^\circ$ shear angle	[gf/cm degree]
	2HG	Shearing hysteresis, the average widths of the shear hysteresis loop at $\pm 0.5^\circ$ shear angle	[gf/cm]
	2HG5	Shearing hysteresis, the average widths of the shear hysteresis loop at $\pm 5^\circ$ shear angle	[gf/cm]
Surface	MIU	Coefficient of fabric surface friction	[–]
	MMD	Mean deviation of MIU	[–]
	SMD	Geometrical roughness	[μm]
Compression	LC	Linearity of compression–thickness curve	[–]
	WC	Compressional energy per unit area	[gf cm/cm^2]
	RC	Compressional resilience, the ability of recovering from compressional deformation	[%]
Thickness	*T*	Fabric thickness at 50 N/m^2	[mm]
Weight	*W*	Fabric weight per unit area	[mg/cm^2]

Table 2
Instructions for process control according to each parameter [2]

Extensibility <1.84%	Overfeed operations	Guide fabric carefully, confirm the length of seams being sewn
Extensibility in warp >2.53% and/or weft >4.07%	Spreading, sewing operations	Avoid excess tension during spreading, spread fabric a bit longer than it required, push fabric to avoid excess extension, confirm the length of seams
Bending rigidity in warp <7.67 and/or weft <4.06 μN m	Cutting, handling	Use very sharp cutting knife, reduce cutting speed
Bending rigidity >12.35 μN m	Stiff, cutting operations	Reduce number of plies in a lay, guide fabric carefully during cutting, use very sharp cutting knife
Shear rigidity <33.9 N/m	Spreading, sewing operations, handling	Take care not to stretch fabric and repeat adjustment for each ply, reduce sewing thread tension, reduce presser foot pressure, reduce machine speed, push fabric to avoid excess distortion
Shear rigidity >55.3 N/m	Shaping and moulding operations	Push fabric during sewing

Table 3
Data about fabric mechanical property classified into three different "acceptability" categories used in the buying control system employed by a Japanese clothing factory [2]

KES value	Judgment A	Judgment B	Judgment C
(1) EM1 [%]	3.5–7.0	3.00–3.49 and 7.01–9.00	If any one of items falls out of "A" and "B" region
(2) EM2 [%]	4.0–9.0	3.50–3.99 and 9.01–12.0	
(3) LT	0.55–0.70	0.70–0.75	
(4) RT [%]	60.0–75.0	55.0–59.9 and 75.1–80.0	
(5) αT	0.9–1.5	0.80–0.89 and 1.51–2.00	
(6) *G* [N/m]	33.7–53.4	25.3–33.6 and 53.5–67.4	
(7) 2HG, N/m	0.50–0.90	0.30–0.499 and 0.91–1.10	Any one or more of items fall out of the region of "A" and "B"
(8) 2HG5 [N/m]	1.50–3.0	1.00–1.49 and 3.1–3.5	
(9) B1 [μN m]	4.9–9.8		
(10) B2 [μN m]	5.9–14.7	The same range as "A"	
(11) 2HB [mN]	0.15–0.34		
(12) αB	0.9–1.5		

If any one or more than one items fall into out of the region indicated, the fabric grade is shifted to lower grade. αT = EM2/EM1; αB = B2/B1.