The Effect of Weave Density on Fabric Handle and Appearance of Men's Suit Fabrics

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Abstract

Optimum selection of materials and adequate weave structure fitted for end-uses are very important for comfortable, sensible and fashionable clothes. The optimum theoretical weave density is known and used practically depending on yarn property, however, wearing comfortability and beautiful appearance of weaves are not investigated precisely yet. Those features are considered to be made at the finishing stages of the weave manufacturing process in general, however, main part of physical properties is determined by weave structure.

In this paper, warp yarn density was changed for men's suit fabrics and the effect of weave density on fabric handle, heat and water transfer property, appearance of clothes, wrinkle resistance, and color brightness are studied precisely. It was clear that total hand value (THV) showed the highest at similar density of warp and weft yarns. Total appearance value (TAV) decreased when warp and weft yarn density was smaller. Wrinkle resistance was high in the condition of the maximum warp and weft yarn density. This paper will contributed to construction of fundamental database of designing ideal fabrics.

Keywords: Fabric density; KES properties; Comfotability; Thermal properties; Permeability; Color intensity

1. Introduction

We have examined the effects of fiber materials, yarn count, twist number, weave density in both warp and weft directions, weaving condition, dyeing method of yarns, and finishing condition of weaves (these factors are called weave structure generally) on fabric quality and showed the relationship between fabric handle and sewing ability and weave structure using KES parameters [1,2].

In this paper, warp yarn density was changed for men's suit fabrics and the effect of weave density on fabric handle, heat and water transfer property, appearance of clothes, wrinkle resistance, and color brightness are studied precisely. Theoretically optimum weave density of a fabric is decided by the method of Ashenhurst [3] for cotton and synthetic fiber weaves and by the method of Brierley [4] for wool weaves, however, comfortability and sensitivity of those fabrics made by the optimum condition is not discussed yet. In order to develop an expert system to evaluate comfortability and sensibility of fabrics objectively, this study is worth executing.

Geometrical structure of woven fabrics is shown as follows [5]. According to Peirce [6], geometrical study consists of three points such as anatomy, strain analysis, and flow. The last one is concerned with permeability and discuss "unit cell", for example, calculation of cover factor. He has considered further optical and dyeing properties of fabrics. On the hand, Wash and Snowden [7] showed that weave shrinkage depended on the ratio of weave density in warp yarn to weft yarn, that is, if the weave density of warp yarn becomes smaller, shrinkage in warp direction becomes smaller, and consequently shrinkage in weft direction becomes larger. This implies that physical property of a woven fabric in warp direction is dominated by the warp density and that in weft direction is weft density. In this study, only the weave density in warp direction was changed and other factors such as yarn count, twist number, dyeing and finishing conditions are controlled constant.

2. Experimental

2.1 Samples

Samples were made from 2/60(33.3tex) merino wool yarns (fiber diameter; 19.5 µm, average fiber length; 125 mm) and dyed into dark blue by package dyeing using chrome dyes. Twist number of the yarn was 650 t/m. Weave structure was 2/2-twill fabric. The fabrics was woven by a conventional shuttle loom with 90 rpm. The weave density in warp direction was changed as 200, 260, 310 numbers/10cm, and weft direction was 150, 200, 260, 310 numbers/10cm, and 12 samples were prepared in total. Those samples were finished in the same conditions. If Brierley's theoretical density is calculated for 2/60-2/2-twill fabric, weave density in warp direction becomes 30.8/cm, and this condition corresponds to the maximum density; 31/cm. In comparison, similar fabrics were made from 100 % cashmere 2/60 yarns and merino wool 2/80(25 tex) yarns.

Weaves were singed at first then rolled on stainless roller and crabbed in 98 ℃ water tank for 20 min, and cooled rapidly.

The weaves were dried at 110 ℃, then decatized for 6 min co-rolled with cotton satin fabrics. After leaving in the conditions of 20 ℃, 65 %RH for 24 hours, the weaves were used for experiments.

Warp and weft yarn density was calculated as follows:

(1) Brierley's density

This value corresponds to the maximum density and becomes 30.8 numbers/cm, however, we used 310/10cm instead and the porosity was calculated with the yarn diameter being supposed to 0.323 mm by calculation.

(2)Cover factor and porosity in a complete repeat.

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Porosity in warp direction;

$$Pa(\%)= \frac{(numbers\ of\ warp\ yarn)/10cm}{310} \times 100 \qquad (1)$$

Porosity in weft direction;

$$Pe(\%)= \frac{(numbers\ of\ weft\ yarn)/10cm}{310} \times 100 \qquad (2)$$

2.2 Measurement of Physical Properties

Physical properties of fabrics were measured by KES-system [7] in the conditions of 20 ℃, 65 %RH. Total hand value (THV) and total appearance value (TAV) of fabrics were calculated by objective equations.

THV and TAV are calculated from following equation [7,8]:

$$THV=-1.2291+0.5903Y_1-0.0441Y_1^2-0.1210Y_2+0.0517Y_2^2+0.6317Y_3-0.0506Y_3^2 \qquad (3)$$

$$TAV=1.122-0.470Z_1+0.134Z_1^2-0.304Z_2+0.166Z_2^2+0.345Z_3+0.019Z_3^2 \qquad (4)$$

Where, Y_1; primary hand value of KOSHI, Y_2; that of NUMERI, Y_3; that of FUKURAMI, Z_1; value of formability component, Z_2; that of elastic potential component, Z_3; that of drape component.

2.3 Wrinkle resistance

Wrinkle resistance of fabrics was measured by Monsanto method using Showa Juki S.J.K Crease O'meter according to JIS-L-1059-1. 1.5 mm x 4.0 mm test piece was measured for 5 times at two conditions; kept for 24 hours at 20 ℃, 65 %RH, kept for 4 hours at 40 ℃, 95 %RH. Wrinkle resistance was calculated as follows:

Crease recovery = (measured angle/180)x100 (%) (5)

2.4 Air permeability and thermal properties

Air permeability of fabrics were measured by KES-F8-AP1 [9]. A constant volume of air is passed through the fabric and the air resistance is measured with high resolution as 0.02 mm water height pressure.

Warm/cool feeling; q_{max} [10], which is considered to be related to the warm/cool feeling felt when skin layer touches objects, was measured by Thermo-labo II (KES-F7). Heat keeping property and thermal conductivity were also measured by the machine.

Heat and vapor resistance was measured by the standard thermal meter based on ISO-11092.

2.5 Dyeing deepness

Degree of dyeing deepness was measured by reflective spectrometer; Minolta-CM3600D, and evaluated by K/S value. The sample used was 5 cm square. K/S value is calculated according to Kubelka-Munk equation. L-value and Lab-value were obtained from the results.

3. Results and Discussion

3.1 KES parameters

Bending parameters; B (bending rigidity) and 2HB (hysteresis of bending property) are shown in Fig.1 versus warp density. Those value of weft density are shown in Fig. 2. It is clear that both values increase with warp and weft density.

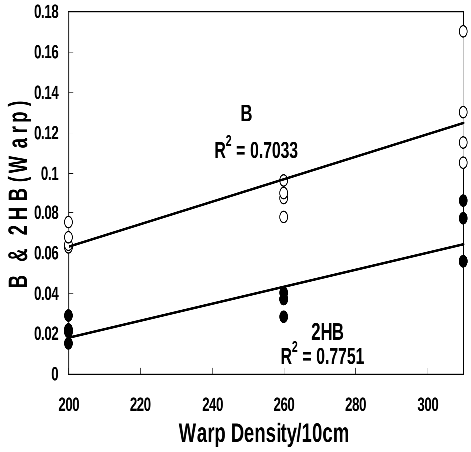

Fig.1Bending parameter versus warp density

Maximum elongation in tensile property (EMT) are plotted to fabric porosity and shown in Fig.3. It is shown that elongation in warp direction does not change with porosity, however, elongation in weft direction increases with porosity.

Relationship between shear rigidity; G, and porosity is shown in Fig.4. It is clear that shear rigidity decreases remarkably with porosity. This means that fabric becomes hard to take shearing deformation at higher weave density.

Primary hand values; KOSH, NUMERI, FUKURAMI are plotted to porosity and shown in Fig. 5. Fabrics with higher density (lower porosity) showed higher KOSHI and lower NUMERI and FUKURAMI.

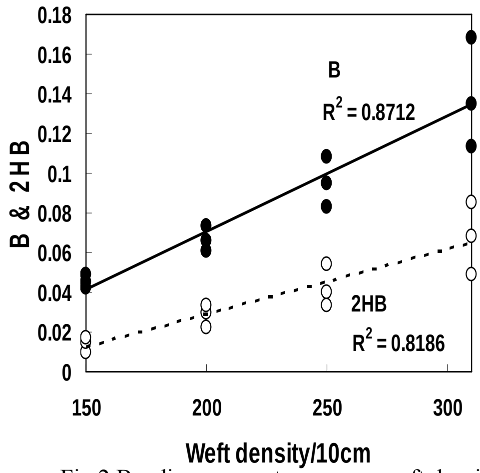

Fig.2 Bending parameters versus weft density

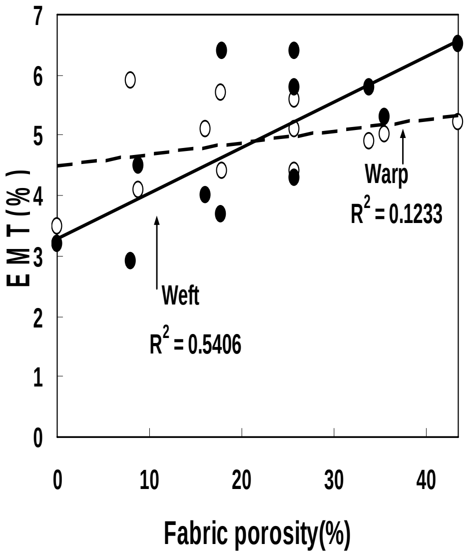

Fig.3 Maximum elongation versus porosity

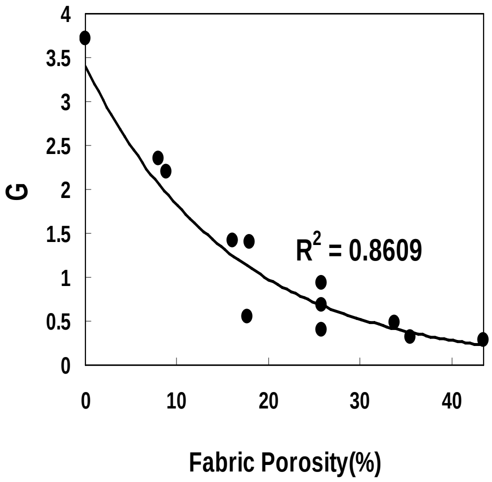

Fig.4 Relationship between G and porosity

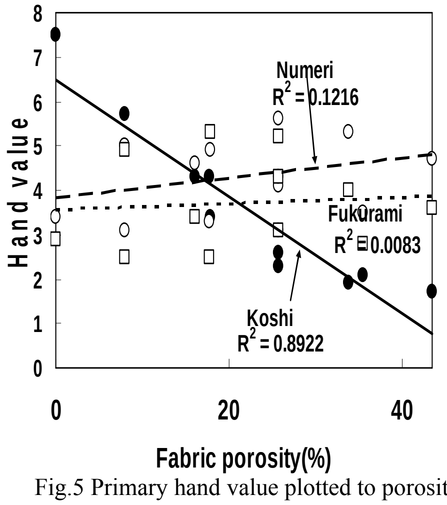

Fig.5 Primary hand value plotted to porosity

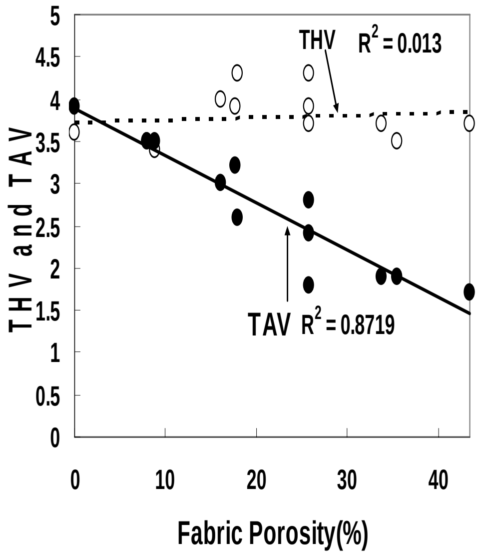

Fig.6 THV and TAV versus porosity

Total hand value (THV) and total appearance value (TAV) are shown versus porosity in Fig. 6. THV has little correlation with fabric porosity, that is, weave density. TAV showed linear correlation with fabric porosity. If porosity becomes larger, that is, density becomes smaller, TAV becomes smaller. TAV became smaller especially when both warp and weft densities were smaller. TAV increased especially with warp yarn density.

Results of THV for all the samples examined here are shown in Fig.7 with the data of porosity. In this figure, black bar shows the results of objective evaluation and grey bar shows the results of subjective evaluation carried out by one of the authors (M. Mori). High THV were obtained in the case of warp; 200/10cm, weft; 260/10cm (porosity; 25.8%), and warp 310/10cm, weft; 260/10cm (porosity; 17.9. It is concluded that THV becomes the highest at similar density of warp and weft yarns.

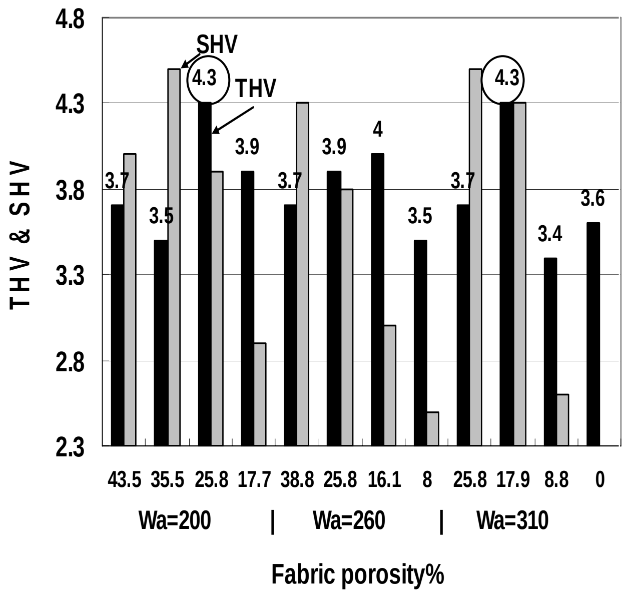

Fig.7 Results of THV and fabric porosity

3.2 Results of wrinkle resistance

Crease recovery of fabrics were shown in Figures 8 and 9 for warp and weft density, respectively. It is clear that crease recovery increased with weave density for both warp and weft. The tendency is especially strong in the case of wet state (40 ℃, 95 %RH; water regain; 24%) compared to dry state (20 ℃, 65 %RH, water regain; 15%).

As the absolute value of crease recovery was about 70 % for the smallest wet condition, it is concluded that these samples examined here had high wrinkle resistance. The wrinkle resistance becomes larger at higher warp and weft densities.

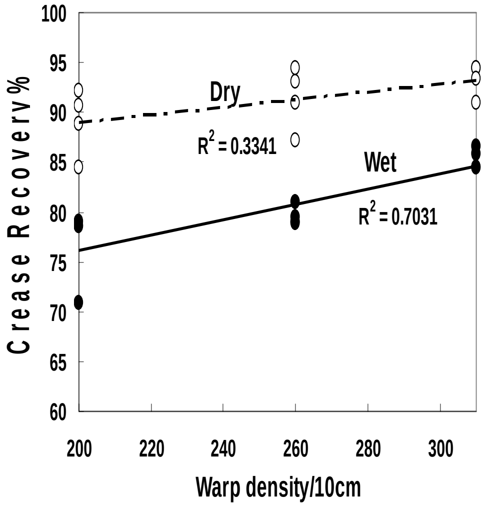

Fig.8 Crease recovery versus warp density.

Crease recovery was plotted to total density, that is, cover factor and shown in Fig.10. Crease recovery increased with total density (cover factor) in the case of both dry and wet conditions. It is concluded that wrinkle resistance depends much on cover factor and increase with cover factor.

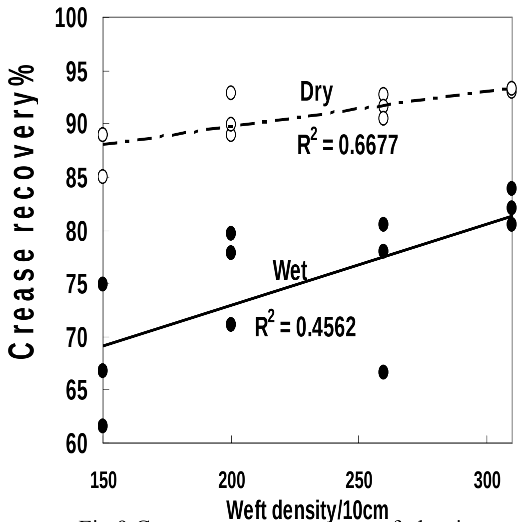

Fig.9 Crease recovery versus weft density.

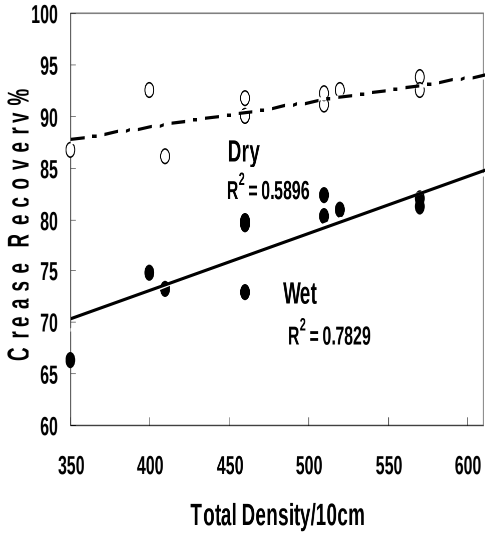

Fig.10 Crease recovery versus total weave density.

3.3 Air permeability

Air resistance of fabrics measured by KES-F8-AP1 were plotted to the fabric porosity and shown in Fig.11. Air resistance depends on quadratic function of porosity very well. The coefficient of determination was R^2=0.939. We cannot explain why air resistance depends on quadratic function of porosity, however, it should become zero at very large value of porosity.

3.4 Warm/cool feeling

Warm/cool feeling of fabrics; q_{max}, were measured by KES-F7; Thermo-labo II. The results were shown in Table 1 with other thermal property, KES parameters, etc.

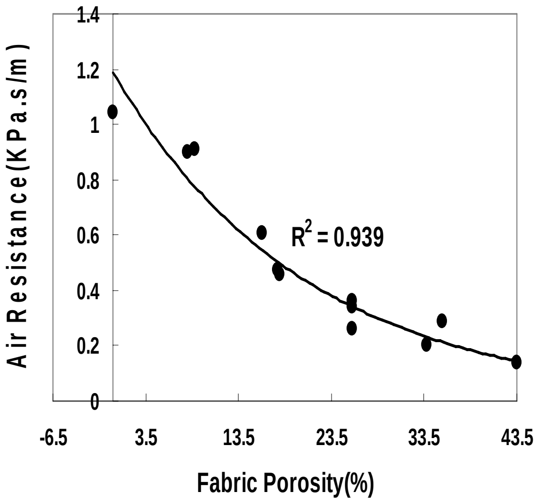

Fig.11 Relationship between air resistance and porosity.

Heat keeping property was also measured by KES-F7 and the results were shown in Fig.11 with qmax.

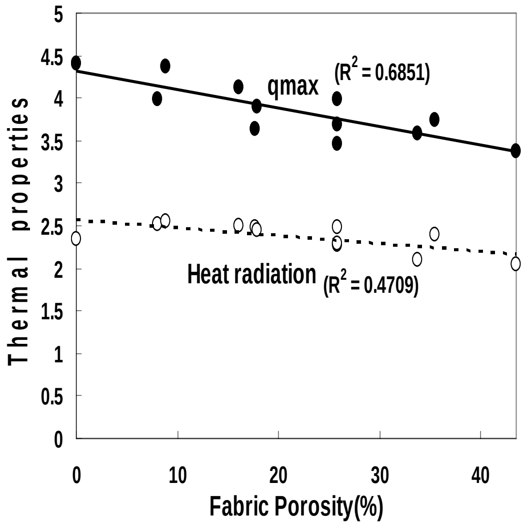

Fig.12 q_{max} and heat keeping property versus porosity.

It is shown that there is no linear correlation between heat keeping property and porosity. q_{max} did not changed a lot within the porosity examined here. However, both q_{max} and heat keeping property increased a little with weave density.

3.5 Dyeing deepness

L^*-value and subjective color intensity measured by ten experts on finishing technology were shown in Fig. 13. Subjective value was obtained by 1 – 5 scale, where 5 means the highest dyeing deepness and 1 is the lowest dyeing deepness. It is clear that color deepness by subjective evaluation decreased with weave density. Fabrics with smaller density was judged to be deep by subjective evaluation.

All the data measured in this experiments were shown in Table 1. Items having high correlation (R^2>0.8) are shown in bold letters.

4. Conclusions

Optimum selection of materials and adequate weave structure fitted for end-uses are very important for comfortable, sensible and fashionable clothes, and main part of physical properties is determined by weave structure. In this paper, warp yarn density was changed for men's suit fabrics and the effect of weave density on fabric handle, heat and water transfer property, appearance of clothes, wrinkle resistance, and color brightness are studied precisely. It was clear that total hand value (THV) showed the highest at similar density of warp and weft yarns. Total appearance value (TAV) decreased when warp and weft yarn density was smaller. Wrinkle resistance was high in the condition of the maximum warp and weft yarn density. This paper will contributed to construction of fundamental database of designing ideal fabrics.

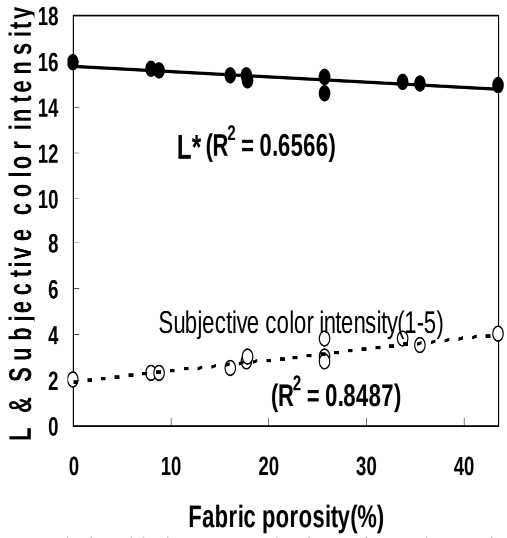

Fig.13 Relationship between color intensity and porosity.

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Table 1 Relationship between Various Parameters Concerning Comfortable, Sensible and Fashionable Clothes.

Property	Item		Fabric structure			
			Porosity	Density		
				Warp	Weft	Total
KES property	B			0.7033	**0.8712**	
	2HB			0.7751	**0.8186**	
	EMT	Warp	0.1233			
		Weft	0.5406			
	G		**0.8609**			
	THV		0.0130			
	TAV		**0.8719**			
	Koshi		**0.8922**			
	Numeri		0.1216			
	Fukurami		0.0083			
Easy care function	Crease Recovery	Dry		0.3341	0.6677	0.5896
		Wet		0.7031	0.4562	0.7829
Thermal property	Air permeability		**0.939**			
	q max		0.6851			
	Heat radiation		0.4709			
Color	L*		0.6566			
	Subjective color intensity		**0.8487**			