경편성물의 객관적인 태 평가를 위한 정신물리학적 모델 개발

윤혜신*, 박신웅, 강복춘
한국의류시험연구원, 인하대학교 섬유공학과

A Psychophysical Model for Objective Fabric Hand Evaluation of Warp Knitted Fabrics

Hye-Shin Yoon* and Shin-Woong Park, Bok-Choon Kang
Korea Apparel Testing and Research Institute, Seoul, Korea
Department of Textile Engineering, Inha University, Incheon, Korea

1. Introduction

Fabric hand is ultimately a subjective response to physical stimuli, but there are clearly practical advantage in the development and commercial trading of textile fabrics to be gained from the replacement of the traditional subjective tactile assessment by an objective measurement evaluation method. Moreover, the reliable objective measurement method for warp knitted fabrics have not developed yet, despite their increasing importance.

Therefore, we develop the objective hand measurement method for warp knitted fabrics to produce a base for the control of fabric quality and performance as a result of new process and product developments of warp knitted fabrics.

The psychophysical model for predicting the hand properties of warp knitted fabrics from mechanical and physical properties is developed. The perception of warp knitted fabric hand is estimated statistically using Steven's power law[24] through analyzing the relationship between subjective hand and mechanical and physical properties. The mechanical and physical parameters affecting on the hand properties are selected as independent variables without collinearity among variables. After the logarithmic transformation is performed on each side of the equation, the relationship between hand and mechanical and physical properties is analyzed.

2. Theory and Method

2. 1. Psychophysical model

The smallest amount of stimulus energy to produce a sensation is referred as a threshold in psychology. If a stimulus above the absolute threshold is applies to a sense organ, the intensity of this stimulus must be increased or decreased by some critical amount before a person is able to report any change in his sensation. Stevens and others described this sense feature in neural quantum theory, and it is illustrated Figure 1[1], where P=standard stimulus, the surplus energy of stimulus, which cannot excite a neural quantum; ΔQ=increment of energy needed to excite one neural quantum; and Q=stimulus intensity exciting a singular neural quantum.

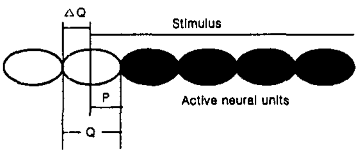

Figure 1. Neural quantum illustration[24]

Stevens proposed a form of the relationship between sensation magnitude and stimulus intensity as a power function[2], which is stated as,

$$Y = KX^{a} \quad (2)$$

where Y is a sensation magnitude on a psychological scale and X a stimulus intensity on a physical scale. When logarithmic transformation is performed on each side of the equation,

$$\log Y = \log K + a \log X, \quad (3)$$

and hence $\log Y = b + a \log X$ **(4)**

here, b = log K is a constant, a is an arbitrary constant and X for the mechanical or physical properties, and accordingly Y stands for the primary hand values judged by the experts.

In order to obtain a better agreement between objective and expert subjective results of fabric hand, we used Stevens' law in which the two sides of the equation are logarithmic.

$$\log Y = b + \sum_{i=1}^{n} a_i \log X_i \quad (5)$$

where a, b are two arbitrary constants and n $(1 \leq n \leq 29)$, the number of the parameters is closely related to hand values, which are determined by the parameter selection.

2. 2. Parameter selection

There is a common drawback in Kawabata's mechanical parameters. In other words, the measured parameters may overlap and contain duplicate information. Unnecessary parameters may become noise which makes interpretation of results difficult.

Therefore, the number of parameters should be determined before developing a predictive equation for the objective hand. Even if we assume that the sixteen parameters of the KES-FB system have completely explained all hand properties, there is some vagueness to evaluate the hand objectively. Therefore, we have to select the more significant parameters required for fully specifying a fabric hand. If not, we may then need to supplement new variables. A selection procedure is desirable so that measurements and further data processing as well as the fabric evaluation procedure can be greatly simplified.

In this paper, our process for parameter selection is as follows.

2. 2. 1. The separation and combination between wale and course parameters

The selection of measured parameters is based on the assumption that fabric hand can be completely expressed by fabric mechanical properties.

In the KES-FB system, the tensile, shear, and bending properties are averaged in the direction of the wale and course. But it is not always appropriate. Jeurissen[3] proposed to use averaged values if the warp and weft values were equal, or if there was an obvious linear relation between the mean and the difference.

In this research, we used twenty nine separated wale and course mechanical values. Since our samples are knitted fabrics which is known to have different properties in the direction of wale and course. But we think that the twenty nine parameters are too many to explain the relation with hand properties and may be highly intercorrelated between wale and course direction. Therefore, according to Jurissen, we examine the relationship between the mean and the difference in the direction of wale and course values. We use the average values if there is an obvious linear relation between the mean and the difference. From the result, the parameters are determined to use average values for 2HB, 2HG, 2HG3, SMD so that the 29 parameters are reduced to 25.

2. 2. 2. The relationship between subjective and objective parameters

We analyzed the correlation between 4 subjective hand features and 25 KES-FB parameters in order to investigate the effects of KES-FB parameters on subjective hand features. The correlation analyses were performed with 90% statistical confidence (p value=0.1).

Based on the correlation coefficient and the significance, the parameters affecting on the hand properties are selected for independent variables. This method has the advantage of taking the human factor into consideration and reducing the unnecessary parameters to simplify the objective evaluation procedure.

Table 1. The selected parameters affecting on the four subjective hand features

Handproperties	The selected parameters
Surface property	EMTⓒ, WTⓒ, Bⓒ, Gⓦ, Gⓒ, 2HG3ⓜ, MIUⓦ, SMDⓜ, LC, WC, T
Bulkiness	LTⓦ, LTⓒ, WTⓒ, RTⓦ, RTⓒ, Bⓦ, Bⓒ, 2HBⓜ, Gⓒ, MIUⓦ, MMDⓦ, MMDⓒ WC, RC, T, W
Drapability	EMTⓦ, EMTⓒ, WTⓦ, WTⓒ, Bⓦ, Bⓒ, 2HBⓜ, Gⓦ, Gⓒ, 2HG3, MIUⓦ, LC, WC
Elasticity	EMTⓦ, EMTⓒ, LTⓒ, WTⓦ, WTⓒ, Bⓦ, Bⓒ, 2HBⓜ, Gⓦ, Gⓒ, W

2. 2. 3. Diagnotics checking for the collinearity and regression for model selection

When explanatory variables are dependent each other in the model, the affected estimates are unstable and have high standard errors. This problem is called collinearity. Therefore, we intend to find out surplus variables among the above selected Kawabata parameters in Table 1. The collinearity is checked on the basis of variance inflation factors(VIF) and tolerance values(TOL). And we used forward, backward and stepwise method for model selection.

2. 2. 4. Final selection

By combining the results from 2.2.1. to 2.2.3, the selection of necessary parameters proceed. And we determined the parameters which would be used to establish the subjective hand prediction model. Our final selection is shown Table 2. For the convenience of further data manipulation, all the selected parameters are recorded.

Table 2. Selected parameters.

Subjective hand properties	Selected parameters	Discarded parameters
Surface properties	G©, MIU(w), SMD(m), T	EMT©, WT©, B©, G(w) 2HG3(m), LC, WC,
Bulkiness	LT(w), RT(w), MMD(w) T, W	LT©, WT©, RT©, B(w), B©, 2HB(m), G©, MIU(w), MMD©, WC, RC
Drapability	WT©. MIU(w)	EMT(w), EMT©, WT(w), B(w), B© 2HB(m), G(w), G©, 2HG3, MIU(w) LC, WC
Elasticity	WT©, B(w), G(w)	EMT(w), EMT©, LT©, WT©, B©, 2HB(m), G©, W

(w) : The mechanical value for wales.
© : The mechanical value for courses.
(m) : The mean of mechanical value from wale and course

3. Result and Discussion

After selecting Steven's law, a stepwise, backward and forward regression methods are used to obtain the best-fit equations containing only significant variables to predict primary hand values. As a result of the regression analysis, subjective hand properties of warp knitted fabrics were predicted from selected mechanical and physical parameters using the multiple regression model as follows.

Surface properties	Y1 = -1.14161 + 0.50338 G© - 0.87831 MIU(w) +0.35620 SMD(m)- 2.50423 T	R^2= 0.8475
Bulkiness	Y2 = -0.666 + 1.59630 LT(w) + 0.44379 RT(w) - 0.25001 MMD(w) + 1.91401 T + 1.27864 W.	R^2= 0.9734
Drapability	Y3 = 0.61495 + 0.59778 WT© + 0.42904 MIU(w)	R^2= 0.8949
Elasticity	Y4 = 1.26839 - 0.39936 WT© + 0.13068 B(w) - 0.38481 G(w)	R^2= 0.7340

where the factor score from subjective hand evaluation as a dependent variable is re-scaled 0 to 10 and all variables must be transformed into logarithm on each side of the equation before calculation. R square is the proportion of the total variance in the dependent variable that can be explained by the independent variables. As a result, the subjective hand properties of warp knitted fabrics are predicted well from selected mechanical and physical parameters by the multiple regression model. And the predictability of models are high enough.

4. Literature Cited

1. Hu, J., Chen, W. and Newton, A., A Psychophysical Model for Objective Fabric Hand Evaluation : An Application of Steven's Law, J. Text, Inst., 84(3), 354-363 (1993).
2. Gescheider, G. A., "Psychophysics, Stevens' Power Law", Lawrence Erlbaum Associates, Hillsdale, N. J., U. S. A., 126, 1976.
3. Jeurissen, P. C. J., "Looking for a Relation between Sensory and Instrumental Data" in final report of the postgraduate programme "Mathematics for Industry", Technische Universiteit Eindhoven, the Netherlands, ISBN 90-5282-118-6 bound, 1991.