International Journal of Chemical, Materials and Biomolecular Sciences
ISSN: 2415-6620
Vol:8, No:8, 2014

A Comparison Study of Fabric Objective Measurement (FOM) Using KES-FB and PhabrOmeter System on Warp Knitted Fabrics Handle – Smoothness, Stiffness and Softness

Ka-Yan Yim, Chi-Wai Kan

Abstract**—**This paper conducts a comparison study using KES-FB and PhabrOmeter to measure 58 selected warp knitted fabric hand properties. Fabric samples were selected and measured by both KES-FB and PhabrOmeter. Results show differences between these two measurement methods. Smoothness and stiffness values obtained by KES-FB were found significant correlated (p value = 0.003 and 0.022) to the PhabrOmeter results while softness values between two measurement methods did not show significant correlation (p value = 0.828). Disagreements among these two measurement methods imply limitations on different mechanism principles when facing warp knitted fabrics. Subjective measurement methods and further studies are suggested in order to ascertain deeper investigation on the mechanisms of fabric hand perceptions.

Keywords**—**Fabric hand, fabric objective measurement, KES-FB, PhabrOmeter.

I. Introduction

THE term "Fabric Hand" was introduced as early as 1930 when Peirce described it as customers' perception [1]. It is a comprehensive physical, psychological and social response to touching a fabric [2], [3]. Simply, fabric hand is an individual's response to touch when fabrics are held in the hand. In standard evaluation, hand is defined as the tactile sensations or impressions which arise when fabrics are touched, squeezed, rubbed or otherwise handled [4], [5].

Fabric hand assessment is often conducted by experienced judges in textile and garment production and by consumers when making buying decisions for apparel and other textile products. Peirce first proposed the evaluation of fabric handle using a series of measurable low-stress physical and mechanical properties of fabrics. Reference [6] pioneered the application of multiple factor analysis to identify the factors affecting the handle of suiting materials. According to their analysis, the handle of worsted suiting can be specified in terms of three quality attributes - fabric smoothness, stiffness and thickness.

The meaning of "fabric objective measurement" as defined by Bishop, is "the evaluation of fabric handle, quality and related fabric-performance attributes, in terms of objectively measurable properties" [7]. Such principal applies to determine, evaluate and control the properties that contribute to the fabric and garment quality perception in specific end-uses. A description preferred by Postle on the fabric objective measurement concept is "that a necessary and sufficient set of instrumental measurements be made on fabrics in order to specify and control the quality, tailor-ability and ultimate performance of apparel fabric" [8].

The most well-known objective fabric hand measurement method is KES-FB Kawabata Evaluation System for Fabrics, invented by HESC in 1980. It was developed by Dr. Sueo Kawabata and his co-worker Dr. M. Niwa to relate objective measurement of the important properties in fabric hand to subjective evaluation. This method measures numbers of fabric mechanical properties directly [9]-[11]. Hand descriptors in terms of stiffness, smoothness, fullness and softness were developed. These separate hand properties were termed as primary hand values. The system relies on the multiple linear regression technique to correlate the mechanical measurements data to subjective fabric hand evaluation, and shows clear physical interpretation of test results.

In 1990s, an alternative approach has been discussed to measure fabric smooth together with fabric hand properties [12]. The basic concept of this approach is making the sample fabric go through a flexible light circle. PhabrOmeter was then invented as a new instrument to quantity the human tactile sensory perception and the system was designed by Nu Cybertek in California, USA, based on the research by Pan and his co-workers [13], [14]. The principle of PhabrOmeter system is insertion/extraction of a piece of circular fabric through a nozzle. All the information related to fabric hand is reflected by the resulting load-displacement extraction curve. PhabrOmeter test is used to measure objectively the fabric Relatively Hand Value (RHV) between the measured fabric and a designated reference fabric. This method is found to be very useful in ranking or preference for fabric handle, to verify of a new fabric product by comparing new and old fabric fingerprints. Eight handle features are calculated based on a corresponding "feature transform matrix" which has been derived from a series of extraction curves using a pattern recognition technique [15], [16]. These 8 parameters were believed to represent

Ka-Yan Yim is with the Institute of Textiles and Clothing, the Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong (corresponding author to provide phone: +852-97508333; e-mail: yimyim910@gmail.com).

Dr. Chi-Wai Kan, is with the Department of the Institute of Textiles and Clothing, the Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong (e-mail: kan.chi.wai@polyu.edu.hk).

different aspects of fabric hand. Pan defined first three parameters as stiffness, smoothness, softness. With high correlation analyses result with Primary Hand Value (PHV) output from KES-FB, stiffness, smoothness, softness respectively.

The difference between KES-FB and PhabrOmeter is that, the former interprets clear physical and mechanical interpretation of various test results while the latter can rapidly evaluate fabric hand properties. Both measurement methods included regression or correlation analysis between tested parameter and fabric hand properties. This paper aims to present an empirical comparison study between these two fabric hand measurement methods on the properties of smoothness, stiffness and softness of warp knitted fabrics, which its uses gain popularity in recent textile markets and industries.

II. Materials and Methods

A. Fabric Preparation

Fabric samples used in this paper are 58 types of warp knitted fabrics provided by Burltexplus Knitting Industrial Ltd and Tai Tung Interlining Ltd in Hong Kong. Fabrics were cut into pieces with the approximately dimensions of 20cm x 20cm for KES-FB test and 100cm² for PhabrOmeter test. Before the fabric objective measurement, all samples were conditioned at 65% relative humidity and 21°C for at least 24 hours, following textiles condition standard ASTM D1776. Fabric weights and fabric thicknesses were calculated according to ASTM Standard D3776 and ASTM D1777 respectively. The fabric weight ranges from 58g/m² to 250.3g/m² and thickness ranges from 0.25mm to 2.26mm.

B. Fabric Objective Measurement

KES-FB test was conducted following instruments' manuals. Five 20cm x 20cm specimens of face side for each sample were tested. The quantitative component of the system was determined by a series of instruments engineered by Kawabata. These instruments measure fabric responses to low deformations such as occur in handling textiles. The KES-F system for measurement of fabric mechanical and surface properties comprises four separate instruments, namely KES-F-1 for tensile and shear testing; KES-F-2 for bending; KES-F-3 for compression and KES-F-4 for surface testing. The method of measuring fabric mechanical properties involves a complete fabric deformation-recovery cycle for tensile, shear, bending and lateral compression properties. In all cases, the deformation-recovery cycle is accompanied by a significant energy loss or hysteresis. The mechanical properties of fabrics were measured for both wale and course directions. Seventeen properties in total were tested under standard condition. The objective determination of hand is indicated as tensile, shear, bending, compression, and surface properties. Measurements were used to predict the primary hand values (PHV), such as smoothness, crispness, fullness and softness.

PhabrOmeter test is used to quantity the sensory perception in contact with human skin. Three 100cm² circular warp knitted fabric samples were inserted/ extracted through a specially designed nozzle. Additional weight of test plates was added according to the fabric linear density. Fabric deformation during extraction from the nozzle includes: compression, bending, biaxial extension and friction. Fabric samples are deformed under a very complex yet low stress state, similar to the stress state when we handle a fabric. Forces are recorded as a function of time alone the whole testing process, which only takes 22 seconds to undertake one testing. Load-displacement extraction curve is generated which contains all the information for the fabric hand, including eight fabric hands attributes (stiffness, smoothness, softness, etc.), drape, relative hand value (RHV), etc.

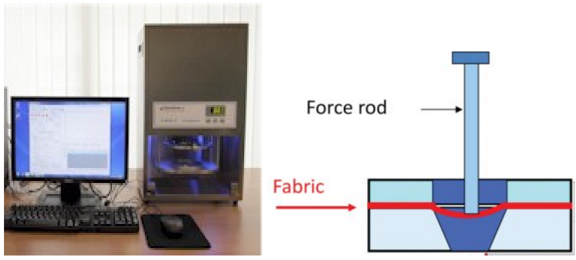

Fig. 1 PhabrOmeter system and its extraction principle

III. Results

Fabric smoothness, stiffness and softness test results obtained from KES -FB instruments shows differences within test samples. The calculated primary hand values of KES-FB test are analyzed by using the HESC translation equation for women's suiting materials, KN-201-MDY. The primary hand value for fabric stiffness ranges from 1.26 to 9.82, and the fabric smoothness and softness values range from 1.64 to 5.27 and from 0.51 to 5.64 respectively. Test results from KES-FB illustrate that differences between selected samples can be addressed. Fabric smoothness, stiffness and softness test results obtained from the PhabrOmeter System shows comparatively similar results on selected fabrics. Fabric samples show homogeneous on the properties of smoothness, stiffness and softness. Initial results express that PhabrOmeter in more degree consider selected fabric samples share similar fabric hand property. Among 58 test samples, results indicate the consistency of current fabric hand measurement methods vary from each other. Fabrics measured by different measurement instruments like KES-FB and PhabrOmeter may give different judgment on the smoothness, stiffness and softness properties. This might affect choice of fabrics when developing textile products.

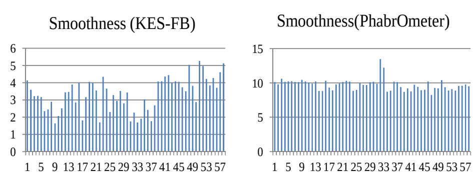

Fig. 2 Smoothness values measured by KES-FB and PhabrOmeter

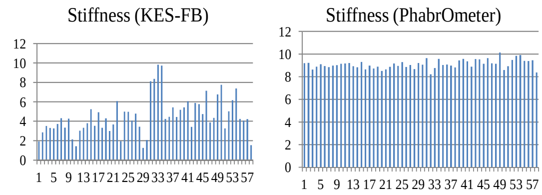

Fig. 3 Stiffness values measured by KES-FB and PhabrOmeter

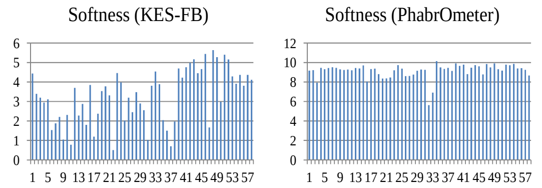

Fig. 4 Softness values measured by KES-FB and PhabrOmeter

IV. Discussion

The distinctions between two measurement methods are obvious. KES-FB system measures the surface parameters with distinct interpretation of test fabrics. PhabrOmeter in contrast performs test procedures that believed to simulate hand feeling process. Physical meanings of forces recorded are only forces that needed to push the fabrics through designed metal hole. KES-FB system subsequently calculates predicted smoothness value based on formulas obtained from regression analyses. PhabrOmeter in the other way directly calculate smoothness value from recorded data using a statistical pattern recognition formula. Therefore, their correlation analysis is performed to find whether there is relationship between these two measurements.

Correlation analysis of fabric smoothness value between KES-FB and PhabrOmeter shows significant correlation between these two measurement methods. Correlation statistics of smoothness value measured by these two instruments is shown in Table I. Correlation significant p value is 0.003<0.05, which means a significant relation is found between smoothness value measured by KES-FB and PhabrOmeter. The linear correlation between smoothness values is R=-0.386. It states that these two measurement methods gave negatively related smoothness values of the warp knitted fabrics. Fabrics with higher value obtained from KES-FB tend to show lower scores in PhabrOmeter evaluation. This relationship agrees on the definition of KES-FB smoothness value (higher the value, better the smoothness property) and the PhabrOmeter smoothness value (smaller the value, better the smoothness property).

TABLE I
CORRELATION RESULTS OF SMOOTHNESS VALUE

		Smoothness (KES-FB)
Smoothness	Pearson Correlation	-0.386
(PhabrOmeter)	Sig. (2-tailed)	0.003
	N	58

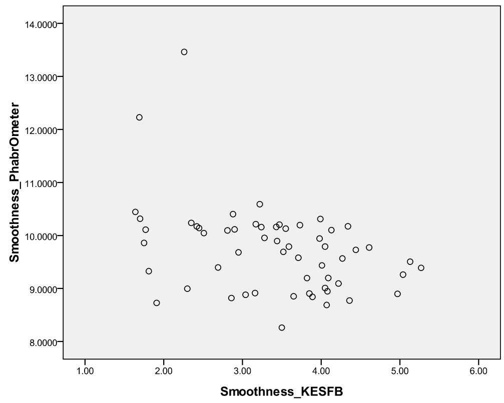

Fig. 5 Scatter plot of smoothness from KES-FB and PhabrOmeter

Fabric stiffness value between KES-FB and PhabrOmeter also shows significant correlation between these two measurement methods. As shown in Table II, correlation coefficient between two methods is 0.303, significant p value is 0.022<0.05. It can be explained that these two evaluation methods have positive relationship on smoothness values of the warp knitted fabrics. Both measurements indicates fabric stiffness as the higher the stiffness value – the harder the fabric.

TABLE II
CORRELATION RESULTS OF STIFFNESS VALUE

		Stiffness (KES-FB)
Stiffness	Pearson Correlation	0.303
(PhabrOmeter)	Sig. (2-tailed)	0.022
	N	58

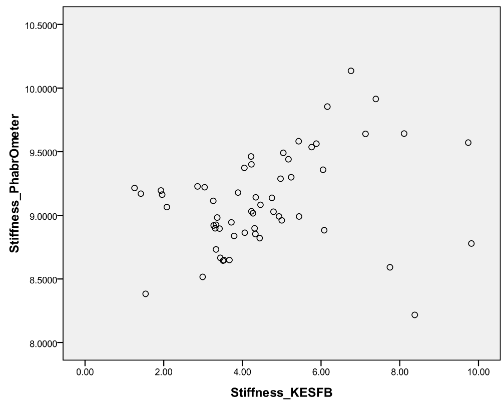

Fig. 6 Scatter plot of stiffness from KES-FB and PhabrOmeter

Unlike the smoothness and stiffness value, softness value between KES-FB and PhabrOmeter System shows no significant correlation. The correlation significant p value is 0.828, which represents that no significant relation is found between the KES-FB and PhabrOmeter System. The different instruments used in these two evaluations may affect the softness hand value.

TABLE III
CORRELATION RESULTS OF SOFTNESS VALUE

		Softness (KES-FB)
Softness	Pearson Correlation	-0.029
(PhabrOmeter)	Sig. (2-tailed)	0.828

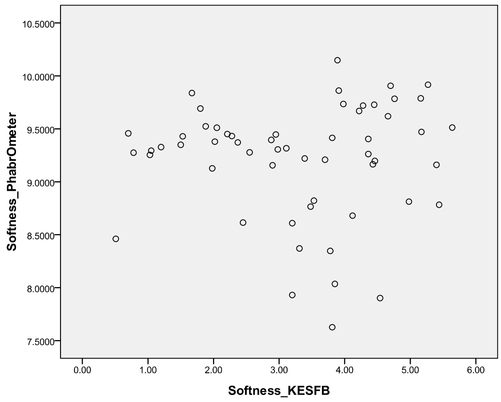

Fig. 7 Scatter plot of softness from KES-FB and PhabrOmeter

In the above finding, agreements from two measurement methods are found in fabric smoothness and stiffness properties, but not found in softness value. Results indicate that consistency of fabric hand measurement methods is not reliable enough. Fabrics measured by different measurement instruments from KES-FB and PhabrOmeter may give different judgment on the hand feel properties.

V. CONCLUSION

Having a sample size of 58 warp knitted fabrics, the data set is large enough to evaluate fabric objective measurements. Using a traditional fabric hand evaluation of KES-FB System and a newer approach of fabric hand measurement by PhabrOmeter system, different fabric attributes can be obtained from the system in terms of stiffness, softness and smoothness, which provide quantitative methods to measure fabric hands objectively.

An objective measurement method to quantitatively describe fabric hand properties of fabrics samples are always one direction in the study of fabric hand. By combining different instrumentations that used to measure various warp knitted fabrics, distinct measurement methods were developed on the basis of different measurement principles. This article investigates the correlation between fabric hand properties and the results suggest that mechanisms of hand perception process should be considered when developing new measurement instruments. So far, generalization abilities of both measurement methods show inadequacy facing new group of fabric samples using warp knitted fabrics. Limitations on current fabric hand properties measurement methods were found in this paper. Subjective measurement on fabric hand will be conducted to ascertain more findings and further studies in the perception principle fabric smoothness, stiffness and softness sensations are suggested to consider in future study.

ACKNOWLEDGMENT

This is a research project of HKRITA funded by Innovation and Technology Fund (ITF) with title “Technological Aspects for Designing Warp Knitted Fabrics" (ITP/043/12TP). Author would like to thank the financial support by ITF. Any opinions, findings, conclusions or recommendations expressed in this material/event (or by members of the project team) do not reflect the views of the Government of the Hong Kong Special Administrative Region, the Innovation and Technology Commission or the Panel of Assessors for the Innovation and Technology Support Programme of the Innovation and Technology Fund and the Hong Kong Research Institute of Textiles and Apparel. Also, we would like to thank the support and sponsorship from Hong Kong Burltexplus Knitting Industrial Ltd. And Tai Hung Interlining Ltd.

REFERENCES

[1] F.T. Peirce, “The handle of cloth as a measurable quantity,” Journal of the Textile Institute Transactions, vol. 21, issue 9, pp. 377-416, 1930.
[2] J. Dargahi and S. Najarian, “Human tactile perception as a standard for artificial tactile sensing – a review,” International Journal of Medical Robotics and Computer Assisted Surgery, vol. 1, issue 1, pp. 23-35, 2004.
[3] T.J. Mahar and R. Postle, “International fabric handle survey,” in *Proc. 2nd Australia-Japan Symposium on Objective Measurement*, Australia, 1983.
[4] AATCC 202-2012 Relative Hand Value of Textiles: Instrumental Method, AATCC Technical Manual, pp. 404-406, 2013.
[5] AATCC Evaluation Procedure 5-2011 Fabric Hand: Guidelines for the Subjective Evaluation of Fabrics, AATCC Technical Manual, pp. 388-390, 2012.
[6] W.S. Howorth and P.H. Oliver, “The application of multiple factor analysis to the assessment of fabric handle,” Journal of the Textile Institute Transactions, vol. 49, issue 11, pp. 540-553, 1958.
[7] D.P. Bishop, “Fabrics: sensory and mechanical properties,” Textile Progress, vol. 26, issue 3, pp. 1-62, 1996.
[8] R. Postle, “Fabric objective measurement technology, present status and future potential,” International Journal of Clothing Science and Technology, vol. 2, issue 3, pp. 7-17, 1990.
[9] S. Kawabata, The Standardization and Analysis of Hand Evaluation, Textile Machinery Society of Japan. Osaka, Japan, 1980.
[10] S. Kawabata, The Development of the Objective Measurement of Fabric Handle, Objective Specification of Fabric Quality, Mechanical Properties and Performance, Osaka, Japan, 1982.
[11] S. Kawabata and M. Niwa, “Fabric performance in clothing and clothing manufacture,” Journal of the Textile Institute, vol. 80, issue 1, pp. 19-50, 1989.
[12] N. Pan, K.C. Yen, S.J. Zhao and S.R. Yang, “A new approach to the objective evaluation of fabric handle from mechanical properties - Part I: Objective measure for total handle,” Textile Research Journal, vol. 58, issue 8, pp. 438-444, 1988.
[13] N. Pan, S.H. Zeronian and H.S. Ryu, “An alternative approach to the objective measurement of fabrics,” Textile Research Journal, vol. 63, issue 1, pp. 33-43, 1993.
[14] N. Pan, “Quantification and evaluation of human tactile sense towards fabrics,” International Journal of Design and Nature, vol. 1, issue 1, pp. 48-60, 2006.
[15] H. Wang, T. Mahar, N. Pan and R. Postle, “Objective handle evaluation of next-to-skin knitted fabrics from merino wool,” in The Textile Institute 86th World Conf. – Fashion and Textiles: Heading towards New Horizons, 2008.
[16] S.M. Ishtiaque, A. Das, V. Sharma and A.K. Jain, “Evaluation of fabric hand by extraction method,” Indian Journal of Fibre and Textile Research, vol. 28, no. 2, pp. 197-201, 2003.