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Introduction

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1.1 Historical

Consumers instinctively use fabric hand to describe and assess fabric quality and its suitability for a specific end use. Fabric hand could be evaluated by mechanical and electronic devices and by human judges using psychophysical or psychological techniques. Judgments of fabric hand provide understanding of underlying fabric properties. In the measurement of fabric hand, psychological approaches use consumer judges, because sensory evaluation of fabric hand by consumers gives information about their perceptions and preferences for fabrics for specific end uses. In early studies by Schwartz[1] and Brand,[2] fabric hand was defined as a subjective property evaluated by consumers.

The need for developing means to evaluate fabric hand objectively has been recognized over many years. Several instruments have been designed, redesigned and developed for the measurement of fabric mechanical properties and have evolved through the pioneering work of Peirce[3] in 1930, which quantified the relationship between measurable fabric properties and hand.

Nowadays, several instrumentations are available and testing measurements and techniques are actually in use in the textile industry, as well as in research and development work. These are presented and discussed in Chapters 2 and 3.

1.2 Definition and concept of fabric hand

Fabric hand has been defined[4] as '… the subjective assessment of a textile obtained from the sense of touch. It is concerned with the subjective judgment of roughness, smoothness, harshness, pliability, thickness, etc.'. Judgments of fabric hand are used as a basis for evaluation quality, and thus for determining fabric value, both within the textile, clothing, and related industries and by the ultimate consumer. Studies of fabric hand may be of major commercial significance if, for example, they assist in explaining hand assessment or

provide a means of its estimation based on objective measurement. It is necessary to examine the subjective assessment of hand before examining its relationship to fabric mechanical and surface properties.

1.2.1 Review of the literature for definition of fabric hand

Peirce[3] described hand as being the judgment of the buyer, which depends on time, place, season, fashion, and personal predilections. Therefore, the intention to replace expert human assessors by numerical data from physical testing would be worthless. What human fingers sense, on the other hand, depends upon the physical properties of the cloth, so that data from physical measurements can provide a basis upon which to exercise judgment.

In a series of technical investigations of textile finishing treatments, Schwartz[1] defined hand of a fabric as a property judged as a function of the feel of the material, and explained that the sensation of stiffness or limpness, hardness or softness, and roughness or smoothness constitutes hand. He reported the desirability of physical testing which may analyze and reflect the sensations felt and which can assign numerical values to the measurements of these parameters.

Patterson[5] studied the causes of changes of hand in woolen fabrics. He defined fabric hand as a certain quality expressed by an individual reaction through the sense of touch upon examining a fabric or one or more fabrics of the same quality. He explained that a woolen fabric may be described as having a good hand, which may be further classified as soft, slick, sharp, woolly, smooth, or silky; if the hand is poor, it may be described as harsh, greasy, gummy, sticky, boardy or dry. However, he concluded that the question of hand of fabrics has been complicated because of the inability to evaluate this property of a fabric by any definite or standard method.

Hoffman and Beste,[6] in their study of fiber properties related to fabric hand, reported that fabric hand means the impressions that arise when fabrics are touched, squeezed, rubbed, or otherwise handled. The handling of a fabric may convey visual impressions as well as tactile ones; therefore, it seems proper to include luster and covering power in the properties considered.

Thorndike and Varley[7] studied the frictional property of fabrics as related to hand, and defined hand briefly as a person's estimation when feeling the cloth between fingers and thumb. Their discussion is based on the assumption that the static and/or dynamic coefficient of friction between the cloth surface and the thumb or fingers is one of the factors which influence the subjective judgment of fabric hand, although flexibility, thickness, and other properties of the material may also be involved when making such an assessment of cloth quality.

Mechanical properties related to the hand of heavy fabrics were investigated

by Kita Zawa and Susami.[8] They introduced the term 'synthesized hand'. They discussed whether hand is a psychological phenomenon and whether, if hand is defined as a perceptible pattern obtained by the tactile sense of fingers, transmitted by the nervous system and assessed by the brain, explanation of the sensory pattern in a direct and objective way without clarifying the mechanisms of the sensory organs, nervous system and brain will be impossible. If so, expressing the sensory values of a fabric obtained by different assessors by use of a statistical technique becomes inappropriate. The very difference in the results of hand assessment by different assessors is an important factor in defining hand. Each assessor forms his or her own idea about the pattern of a given fabric; however, regarding such elementary sensory properties as stiffness, thickness and warmth, it is possible that communication between assessors may constitute a common idea, such as 'wool hand' or 'silky touch'. This common and qualitative idea formed by an assessor about the multiplicity of resembling samples is defined as 'synthesized hand'. A series of basic mechanical properties are assumed to govern the synthesized hand of a fabric. Then, it is possible to develop a correlation between the synthesized hand and the pattern of the mechanical properties of standard samples, provided that this standard pattern can be established.

Lundgren's[9] concept of fabric hand is that hand is considered as the summation of the 'weighed' contributions of stimuli evoked by a fabric on the major sensory centers presumably present in the human hand. Such centers can be uniquely sensitive to such physical properties as roughness, stiffness, bulk and thermal characteristics. He also stated that the term 'hand' is used to describe the tactile and muscular (kinesthetic) sensations produced by a fabric.

In a study of hand and drape of fabrics, Owen[10] defined that by hand are meant all the sensations that are felt by the fingers when the cloth is handled. He suggested the following eight physical properties as the important factors involved in hand: stiffness, smoothness, weight, thickness, compressibility, liveliness, ease of skewing or shearing, and cold feel.

Matsuo *et al*.[11] defined hand, in general terms, as what a person sensorily assesses from the mechanical properties of a fabric. In other words, human hands assess the mechanical properties of fabrics in place of sensory assessors. They classified hand terminology by defining and using new terms such as 'whole hand', 'characterized hand' and 'evaluated hand'. According to their definitions, the 'whole hand' of a fabric is what is sensorily transformed from all the mechanical properties of the fabric. And when 'whole hand' is judged in values, it is transferred to what they called 'evaluated hand'. This depends on both functional and synthetic factors. Evaluated hand may also be influenced by fashion, climate, social state, personal taste, etc. When the 'whole hand' of a fabric is compared with that of a standard fabric, attention has to be given to the differences in 'whole hand' between the two fabrics.

Therefore, the hand of the fabric which is compared with the standard must be characterized by descriptive adjectives and is classified as 'characterized hand'. The authors listed five mechanical properties – stretching, shearing, bending, compression, and surface friction – as principal parameters to define 'basic hand' as the sensibility corresponding to each of the five mechanical properties. To each property there corresponds a sensibility which people detect sensorily regardless of the extent of the sensibility. Therefore, the 'whole hand' corresponds to the assemblage of the basic mechanical properties.

Tactile properties of non-woven fabrics were investigated by Mendoza and Harrington.[12] They introduced the term 'total softness', which can be defined as a function of a composite of such physical properties as drape, hand, bulk, mass, resilience, and surface smoothness. They explained that as every human being possesses a subconscious, as well as a conscious, appeal to preferences when handling fabrics, these preferences cannot be objectively isolated, and thus total softness cannot be interpreted absolutely as a united physical response. Softness, therefore, is a relative human appeal or desirability upon handling fabrics.

Kobayashi[13] regarded hand of a fabric as a tactile evaluation judged from physical stimuli of fabric mechanical properties in his analysis of fabric hand by application of information theory. However, he further suggested that visual factors should also be taken into consideration to evaluate fabric hand on a broader scale.

From the survey of the literature on the definitions of fabric hand, it can be concluded that definitions differ considerably according to the interests of researchers. Among them, those given by Kita Zawa and Susami[8] and Matsuo *et al.*[11] seem to be the most promising in the sense that hand of a fabric can be analyzed into its mechanical property components and thus expressed by exact numerical values from objective measurements of constituent physical characteristics.

1.3 Fabric hand attributes and quality descriptors

Mahar *et al.*[14] introduced the term 'fabric hand attributes' to describe fabric characteristics such as stiffness, softness, smoothness, warmth, coolness, crispness, smooth drape, etc. Several attempts have been reported[3,11,15–19] to derive a set of hand attributes for textile materials. Despite observations that experimenters sometimes try to simplify the situation objectively and thus can fuse its subjectivity,[20] a number of authors have isolated relationships between mechanical properties and hand (for example, see references 11, 15, 18, and 19).

More information about the quality of a fabric may be conveyed by considering the separate fabric characteristics or attributes that, taken together, constitute the complex notion of hand, rather than by considering the overall concept of hand.

1.3.1 Evaluation of fabric hand

The Hand Evaluation and Standardization Committee (HESC) of Japan's Textile Machinery Society has published standards (Appendix A) incorporating samples of appropriate fabrics for overall fabric hand, or Total Hand Value (THV), for men's winter suitings[16,17]. The Committee has also published similar types of standards for fabric hand attributes or Primary Hand Value (PHV), considered important in the fabric hand evaluation of both men's winter and summer suiting fabrics and ladies' thin dress materials.[16,17] The PHVs nominated by the HESC for men's winter suitings are Koshi, Numeri, and Fukurami. Similarly, the PHVs for men's summer suitings are Koshi, Shari, Hari, and Fukurami (Appendix A).

The work of the HESC in establishing and subsequently publishing standards for overall fabric hand (THV) and fabric quality attributes (PHVs) has resulted in much improved communication of the aesthetic qualities of fabrics, both within and between the Japanese textile and clothing industries. These standards for fabric hand and quality attributes, with their associated descriptions and terminology, will also be used on an international scale to initiate a similar improvement in communication on fabric aesthetics. However, the speed, and ultimately the scale, of international acceptance of Japanese fabric hand standards will be hindered by the deficiencies inherent in language translation. This will be discussed and presented in Chapter 5.

1.3.2 Instrumentation

To evaluate fabric hand objectively, the need to use instrumentation was imperative in order to measure physical and mechanical properties of the fabric. Calculations of objective hand value were then made by various interpretations of the different properties measured. The different methods by which objective hand value are calculated are discussed in Chapter 5.

1.4 Development of fabric hand evaluation

Chapter 3 discusses the developments in measurement and evaluation of fabric hand. A survey of the different earlier method is discussed together with the latest developments and a newly patented system.

1.5 Elements relating to fabric hand

The basic elements that can fundamentally affect fabric hand are as follows:

- Fiber characteristics: fineness, length, friction property, resilience, compressibility
- Yarn type: staple fiber, continuous filament, textured, count and twist, etc.

- Fabric construction: woven, knit, non-woven, weight, thickness, surface, roughness, etc.
- Method and type of dyeing and finishing processes.

These elements are discussed in Chapters 6 to 10.

1.6 Application of statistical methods in assessing fabric hand

Due to the nature of variations and elements involved in assessing fabric hand, particularly subjective hand value and the objective assessments, statistical methods and approaches have been adopted widely in the field. Chapter 4 presents all the statistical methods used in assessing fabric hand.

1.7 Comparison of fabric hand assessments in different cultures

Comparative studies of the different ways of assessing fabric hand as a result of differing cultures and other human factors are necessary for the following reasons:

- The effects of culture, customs and tradition vary from one country to another.
- The ability of different languages to describe the feel and the hand of the fabric with similar terms or single words has made it difficult to communicate this fabric property, which is an essential feature in global trade and business.
- Men and women differ in their assessment of fabric hand; this has been studied in the USA and Korea.
- The effect of evaluating objective as well as subjective hand values using different methods was proven to give different results and conclusions.

Special attention has been given to the two major methods applied in the industry nowadays, namely the Kawabata (KES) system (Japan) and the FAST system developed by the AWTOMEC (Australia).

Some other methods based on an engineering approach have been compared with the Kawabata (KES) system. Also, subjective hand evaluations by judging panels from different countries have been directed towards fabric produced commercially from different countries: the USA, Japan, Australia, and Korea. The results have shown more agreements than disagreements to warrant negative effects on the outcome of the judgment.

1.8 Effect of performance and refurbishing on fabric hand

A critical property of fabric in its end use is its performance and how it withstands washing and/or dry cleaning to maintain its hand. Results of studies addressing this important phenomenon are presented in Chapter 11.

1.9 References

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