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TAILORABILITY OF FABRICS – A REVIEW

Pravin H. Ukey [1]

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ABSTRACT

Tailorability is the ability of fabrics to be shaped, cut, and sewn to fit a particular body shape or garment style. In recent years, there has been a growing interest in developing fabrics that are highly tailorable to meet the diverse needs of consumers. This paper provides an overview of the current research on the tailorability of fabrics. The review focuses on the methods used to measure the tailorability of fabrics, factors affecting tailorability, and predicting tailorability. The paper concludes with a discussion of the challenges and opportunities for further research in this area.

1. INTRODUCTION

The main purpose of the clothing is to protect human beings or individuals from atmospheric conditions. Fabric properties are the result of fibre and yarn characteristics and the fabric geometry, which include fabric structure, number of yarns per inch and tension on yarn components. Fibres, yarns, fabrics, dyes, pre-treatments and finishesall are directed to the end use of a product. They are to be worn, used upon, and walked on. They protect the man as well as enhance his appearance and his environment (Agarwal et. al 2013).

Presently the end fabric can be manufactured by different fabric formation technologies from the fibres.One of the most common ways of fabric formation is weaving by interlacing the warp and weft yarns. The tailorability properties of the fabrics are mostly related to the conversion of the fabric into the garment with ease means without more problems with the conversion of flat fabric material into the 3D garment (Bassett et al. 1999).

2. BACKGROUND

Tailoring is the process of converting the 2-dimensional flat sheet type fabric into its intended end product which is usually a garment i.e., three-dimensional in shape when in use (Behera 2015). Tailorability is the term used synonymously to 'making - up' properties (Behera & Sharma 1998). Throughout history, it could be found that the human being is the creature who invested much time, thought and energy in dressing and adorning the human body. Tailoring is the process which by means of sewing and clothing may be made more or less to fit the human frame. The very idea of tailoring is "fit", and "well-tailored" means more fit rather than less (Bahera et al. 1997, Cardello et al. 2003). Quality is the important aspect of a tailored garment which is moulded to fit the body and can be achieved by formation of seams of supportive fabrics. These are shaped and formed by various construction techniques into the lines of the garment as they fit the body. A well-tailored garment maintains the dimensional stability of the garment on and off the body throughout the life garment. As a thumb rule to test the fabric quality and

[1] Corresponding author: Pravin H. Ukey
Email: ukeypravin@gmail.com

tailoring quality the fabric is gathered in hand and crushed, and good quality fabrics springs back into shape quickly and smoothly. A good quality tailored garment must be made of such fabric (Granberry et al. 2019).

The garment is formed by various processes like design and construction of patterns for the components of the design. The fit of the garment to the contour of the body is considered while patterning, so that the proper fit patterns can be produced. The fit of the garment related to the shape and size of the garment will be strongly influenced by the physical and mechanical properties of the fabric.This means that certain fabric properties such as the tendency of the fabric to stretch, shrink, distort and drape due to stresses induced during use under static and dynamic situations are to be taken into account while drafting patterns for a garment (Bassett et al. 1999). In the cutting and spreading process, the layers of the fabrics are superimposed on a cutting table, this permits layers to be cut simultaneously into the components for further processing. Any stretch in fabric layers produced by in-place or lateral stresses on superimposed fabric layers will affect the stress-free dimensions of garment patterns (Granberry et al. 2019). Apart from the colour and pattern the performance of the apparel fabrics is generally not specified in objective terms, though satisfactory wear performance requires certain minimum values of mechanical strength, e.g., tensile, burst and tear strength and resistance to abrasion (Kawabata & Niwa, 1989). In practice, the satisfactory performance of apparel fabrics depends on subjective characteristics such as comfort, appearance and drape. Researchers have tried to correlate the fundamental fabric properties to the subjectively assessed performance characteristics of fabrics. There are some reports on the relationship between the subjective and objective evaluation of fabrics (Kim & Slaten 1999)..

3. SEWABILITY OF THE FABRICS

Sewability is characteristic of the fabric which allows it to be seamed at the full limit of performance during a high-speed sewing machine without weakening or degrading the fabric (Lindberg et al. 1961). Seam formation is the process of joining two or more pieces of fabric material with different stitches. Seam quality is measured by the stitching quality parameters such as size, slippage and strength. It is measured in terms of a Seam Efficiency Index (SEI) (Lu & Macosko 2004). and the garment quality is depending on the quality of the fabric as well as the seams (Martin & Critchlow 1999).. The SEI could be used to optimise the sewing conditions, for various factors and needles of different types, such as type of seam, type and number of stitches per unit of length, and selection of sewing thread. The durability of a seam depends largely on its strength and its relationship with the elasticity of the material. Besides, a seam must be durable so that it will not abrade or wear easily during everyday use, including laundering (Matsuo et al. 1971.). It has been observed that the loss in breaking strength is up to 30 - 40% owing to friction and wear during the thread movement through the needle eye.

4. SEWABILITY OF THREADS

Thread is the important factor while forming the seams as it holds two or more components of the fabric material, so it should work satisfactorily during the sewing process. The property of a thread to perform efficiently during the sewing operation is known as the sewability of the thread. The sewability of thread is extremely difficult to measure since it is affected by a limitless number of variables and combinations of variables. Therefore, when observing the performance of a specific sewing operation, it is impossible to determine whether one is measuring the sewability of the fabric or the performance of the sewing machine (Meinander & Varheenmaa 2002).

5. FABRIC PROPERTIES AND PERFORMANCE

Mechanical properties such as tensile, bending, shear, compression, and surface properties are considered important in deciding the utility and mechanical comfort performance of a fabric. However, analysis of the tailoring process reveals that these properties are equally important in the making-up process of the garment. For garmenting, a flat two-dimensional fabric is converted into a three-dimensional garment. The conversion requires complex mechanical deformation of the fabric at very low loads. This conversion of the fabric's formability depends on the mechanical properties as well as on the skills of the garment manufacturer (Mukhopadhyay & Midha 2013)..

Low-stress fabric mechanical properties are important in tailoring because of the following two reasons (Shishoo 1990).

- Fabrics are more extensible in the low-load region, these are more related to the tailoring process and the comfort of the wearer.
- The second reason is that fabric extensibility at low loads causes difficulty in the handling of fabrics during the cutting and sewing processes. Fabrics having high extensibility cause dimensional distortion

It can be said that the fabric's tensile and longitudinal compressive and shear properties are the main mechanical properties relevant to the tailoring performance.

5.1 Modes of Deformation

Fabric distortions are commonly the combination of two or more fundamental modes of deformation. The four main fundamental modes of fabric deformation at low levels of stress are tension/longitudinal compression, shear, bending and lateral compression. These terms may be defined as follows:

Tension/longitudinal compression

This mode of deformation represents extension or longitudinal compression in the pre-buckling region, along one of the major fabric directions (warp or weft for woven fabric). True uniaxial fabric extension is difficult to achieve for fabrics because extension in one of the major thread directions is accompanied by a contraction of fabric in the direction applied to the normal force.

1. LT, the linearity of load elongation, affects fabric extensibility in the initial strain range; low values of LT give high extensibility but fabric dimensional stability is reduced.

2. RT, the tensile resilience; high values make the fabric more elastic.

3. EM, the tensile strain; larger values of EM in warp cause many problems in tailoring due to distortion of fabric during sewing; but in the weft, they are important for comfort in wearing and easier tailoring.

Buckling

Buckling of fabrics has been considered by many research workers, as an important property in so far as it can indicate stiffness and recovery (Spivak & Treloar 1968).. The parameter longitudinal compression can be obtained from the buckling test.

Shear

For a woven fabric, a shear deformation refers to a rotation of one set of threads relative to the other at the yarn cross-over points in the weave. Many workers have determined this property.

1. G, the shear rigidity; high values cause difficulty in tailoring and discomfort in wearing.

2. 2HG5, the hysteresis of shear force at a higher shear angle (5); high values give distortion in tailoring and wrinkling during wear.

Bending

In the case of a bending deformation, a bending moment acts in one of the major thread directions of the fabric and is normal to the plane of the fabric. Pure bending occurs when the resulting fabric curvature is uniform along with a line of action of the bending moment

Bending properties influence the formability of a product of fabric bending rigidity and the longitudinal compressibility of fabric in its own plane prior to buckling. Bending rigidity is one of the basic fabric mechanical properties, and it also affects puckering and fabric cutting.

Lateral compression

This deformation is the result of opposing forces applied from the two sides of the fabric in a direction normal to the plane of the fabric. The surfaces of fabric are typically highly compressible.Fabric surface frictional properties determine the physical behaviour of fabrics which is independent of fabric tensile, shear and bending properties, and is fundamentally different from, but not independent of, fabric compressional properties (Sülar et al. 2015).

compression is measured as the degree of compressional force a fabric can sustain in a certain direction before the fabric buckling occurs. The lower the compressibility, the fabric is unable to accommodate the compressional load and the higher the chance of seam pucker. Tension is developed during sewing by the sewing thread, which tends to relax by shortening the thread path in a stitch. This is achieved by lateral and longitudinal compression. Fabric surface property, weight and thickness also influence cutting and sewing operations.

Fabric Tensile Test Instruments

Since it is rare for an apparel fabric to be subject to a uniaxial tensile strain either in processing or in wear, biaxial properties are more relevant to fabric performance. Several testers have been developed which apply biaxial strains to a fabric sample (Treloar 1965). The strip biaxial test can be regarded as an intermediate form of testing between the two extremes of a true biaxial tensile test and a uniaxial test. The KES-F tensile tester is suitable and is superior to the extensometer type tester in terms of the standard arrangement of the fabric gripping mechanism.

Fabric Shear Test Instruments

A wide range of laboratory-built instruments and some commercially available testers, including the KES-F shear tester have been developed which measure the shearing behaviour of a flat fabric specimen. In these testers, a specimen is clamped in two jaws and a shear force is applied in the plane of the fabric in one of the major thread directions. A small tensile load is applied in a direction initially normal to the shear force to delay the onset of fabric puckering during shear testing. In Sweden during the late 1950's and early 1960's these instruments took the form of modifications to an Instron extensometer. Several purpose-built testers have also been developed. These testers can be distinguished as follows: Testers whose clamps are not maintained parallel during testing i.e., shear, and testers whose clamps are maintained parallel during testing. It has shown that the shear stress distribution is not homogeneous for testers whose clamps are not maintained parallel during testing. But while the shear stress distribution is homogeneous for the class of parallel clamps, the tensile stresses are not homogeneous in this case, being high at the free edges of the fabric (Treloar 1965). These edge effects may be minimised by utilising an appropriate aspect ratio in the design of the tester, i.e., the use of short, wide specimens as is also recommended (Waesterberg 1965). The KES-F tester incorporates a short, wide specimen during testing, viz. nominal aspect ratio 4:1.

Bias extension

Several authors have reported the relationship between fabric shear rigidity and the fabric "tensile" modulus in the bias direction based on a simple trellis model of fabric behaviour during shear deformation. The measurement of fabric extension in the bias direction is made difficult by the relatively large ‘shearing’ contraction of the fabric in the direction normal to the applied force. The ends of the fabric clamped in fixed jaws are not able to accommodate this contraction, and so provide non-homogeneous distribution over the fabric sample of both shear and tensile stresses. It is observed levels of shear stress are higher (by over 200% in some cases) at the same levels of shear strain when calculations are based on bias extension results compared to conventional shear test results (Wallander 2019). This result and its inexplicability in terms of the trellis model, or any other model, combined with the difficulty of testing noted previously, mean that the conventional shear test is currently the most accepted method of assessing the shear behaviour of fabrics on a large scale.

6. CONTROL SYSTEM: A TAILORING CHART

Control system A tailoring control chart developed in Japan is shown in Figure 1. If all the properties of a fabric fall inside the “non-control” zone, the tailoring of this fabric is easy and it will not have defects in appearance (Mukhopadhyay & Midha 2013)..

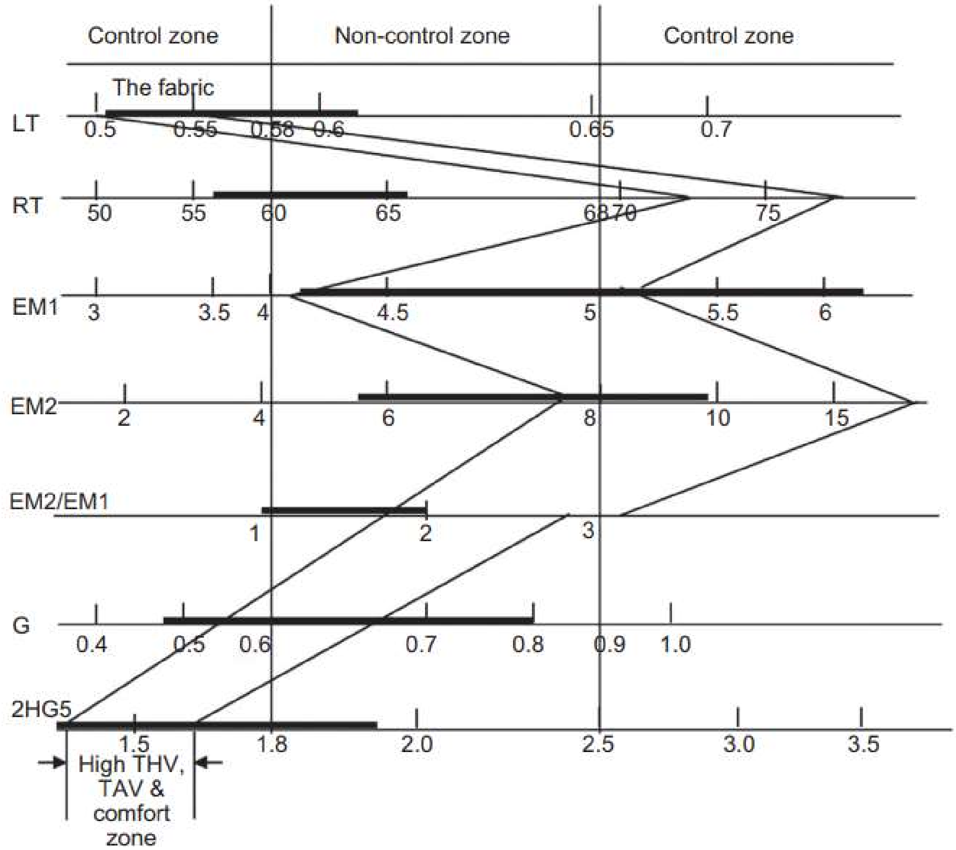

Figure 1. Interrelation between fabric mechanical parameters and tailoring processability

However, if it was found that the properties of the fabrics having good handles are not necessarily in the “non-control” zone, the fabric might not be suitable for tailoring. This means good suiting cannot be processed in tailoring. The dots and horizontal lines show the mean value and the range of distribution of the fabric properties. The control chart has been introduced for tailoring higher-grade fabrics, with special instructions for the tailoring process based on those mechanical properties that fall outside of the “non-control” zone. The difference in the smoothness of the seam line comes from the mechanical properties of the constituent fabrics. The mechanical property related to this problem is mainly the bending property in the weft direction.

Another important property of fabrics for processing is fabric shrinkage caused by the steam-pressing process in the production-line system of suits. Inspection of fabric properties before tailoring is done to determine the fabric's acceptance.

7. EXPERIMENTAL STUDIES ON FABRIC TAILORABILITY

In the late 1950's and early 1960's the first large-scale investigations of fabric tailorability were undertaken at the Swedish Institute for Textile Research (TEFO), and continued at the. Later work in this area has concentrated in Japan and at the University of New South Wales, much of this work has been directed at measuring fabric mechanical properties, notably fabric shear properties (Wang et al. 2003). Other fabricproperties investigated in relation to fabric tailorability include: fabric extensibility, fabric bending rigidity, fabric longitudinal compressibility; and fabric thickness and weight. The Japanese workers have included tailorability as an essential parameter in that it has relevance to the Garment industry. FAST, developed by CSIRO, Division of Wool Technology also gives a measure of formability. In addition, a measure of total appearance value (TAV) is also provided by the KES-F system as an adjunct to the clothing industry. Many authors related fabric mechanical properties to subjectively assessed "making up properties". Waesterberg concluded that fabric "adaptiveness" was correlated with fabric formability. Fabric tensile, bending and shear properties are related to the appearance of men's summer suits (Wang et al. 2008).

8. PREDICTING TAILORABILITY

The production of high efficiency suits the Kawabata Evaluation system (KES-F) is a tool to that decide the fabric will be acceptability and, in some firms, a quality control system has been introduced on this basis. Fabric puckering and bubbling either during garment assembly or during the first month of wear can be predicted. The warp and weft extension under 500 g/cm load should preferably be 4% or above – otherwise, problems will be experienced on wool fabrics. In many countries, KES-F instruments are being used for quality control and product development in the textile industry. The behaviour of the fabrics during the garment construction can be predicted by the mechanical properties of fabrics.

9. CONCLUSION

The tailorability of fabrics is an essential factor in the fashion and textile industry. The ability to modify fabrics to fit specific body shapes or designs is crucial for creating customized clothing that meets individual preferences. Factors such as fibre content, weave, weight, and stretchability influence the tailorability of fabrics. Tailors use various techniques such as cutting, sewing, and draping to modify fabrics. Advancements in technology have also revolutionized the process of altering fabrics, making them easier and more efficient. The future of tailorability looks promising, with continued advancements in technology that will improve the process of creating customized clothing.

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Pravin H. Ukey
Ministry of Education,
Government of India
Mumbai,
India
ukeypravin@gmail.com
ORCID: 0000-0001-9028-3953