2.0 Introduction

The term fabric quality as it is understood by manufacturers and consumers, generally reflects the level of manufacturing defects present in the fabric and its serviceability as defined by a selected group of properties such as strength, abrasion resistance, resistance to pilling, etc. This traditional approach to interpreting fabric quality, however, fails to take into account other important aspects associated with the total quality of apparel materials such as a fabric's tactile sensation, its three-dimensional shape-forming and shape retention ability, and the tendency of the fabric to impose a load on the human body when it is used as an under or upper garment and subjected to multidirectional stretch by the movement of the body.

These latter virtues, in fact, decide the level of comfort and satisfaction derived by the user of a particular garment, and so they are more important than the normal functional properties in deciding the suitability of fabrics for particular end-uses. Unfortunately, the current practice of judging fabric quality totally ignores these important virtues.

The first step in developing a new generation of apparel fabrics with superior comfort value and satisfactory service life therefore lies in recognizing the need for a broad based definition of fabric quality. An integrated, inclusive approach to evaluating fabric quality is certainly necessary for the success of ever-expanding research efforts to create more and more advanced yarns and fabrics. The need for such an approach becomes even more apparent when considering the special characteristics (tactile and aesthetic properties) of the products turned out by the new yarn and fabric manufacturing technologies and finishing treatments.

A re-definition of the group of properties contributing to the overall quality of apparel fabrics can also enhance consumer awareness of the importance of nontraditional properties in determining ultimate quality. All fabrics and similar, sheet-like flexible materials the most part dependent on fabric bending length and possess in varying degrees the qualities of drapeability, fabric shear resistance, flexibility, compressibility, foldability, stretchability, pliability, etc. These properties are best defined by the textile term "handle." Good handle is the subjective or qualitative characteristic given to the feel of materials as silks, nylons and bias materials. Materials having poor handle are stiff, crisp, boards or semi-rigid.

Fabric handle and nozzle extractions are two most frequently discussed topics in recent past. In the advent of most modern technological era fabric handle is one of the most widely used fabrics attributes that is measured subjectively. It is characterised by the subjective judgment of roughness, smoothness, harshness, pliability, thickness, etc. Judgments of fabric handle are used as a basis for evaluating quality, and thus for determining fabric value, both within the textile, clothing, and related industries and by the ultimate consumer. Coincidentally the same is being widely followed by both industry and the consumer in determining the acceptability of goods for their end-use.

The existing subjective method of fabric evaluation that is being referred here is pressing, rubbing, stretching, bending, shearing of fabric by hand, as shown in Fig 2.1 and rank the fabric based on the sensory feedback perception received by the evaluator. Therefore, it is obvious that it influence consumer's preferences and their perception of the usefulness of the product.

At present, the determination of fabric handle remains largely subjective. Several presently available methods or apparatus assign quantitative numbers to one or two of the flexible, material qualities comprising handle; however, none yield a single quantitative figure, representative of all the qualities comprising handle, by which the handle and attendant characteristics of one material may be compared to those of another material. With respect to handle testing, the American Society of Testing materials (ASTM) specifications refer to only two tests, both of which are directed to material stiffness through material interaction between fabric weight and fabric stiffness. A cantilever beam bending test and a loop distortion test are defined which give quantitative measures of how a fabric beam deflects under its own weight and a how a fabric loop elongates due to gravity.

Fig 2.1(a): Pressing

Fig 2.1(b): Rubbing

Fig 2.1(c): Stretching

Fig 2.1(d): Bending

Fig 2.1(e): Shearing

2.1 Handle characteristic of fabric

Studies of fabric handle may be of major commercial significance if they, for example, assist in explaining handle assessment or provide a means of its estimation based on subjective or objective measurement [13-15]**.** Subjective assessment is the traditional method of describing fabric handle based on the experience and variable sensitivity of human touch [16,17]. In subjective assessment method materials are touched, squeezed, rubbed or otherwise handled to get feel of the materials and then quantify or rank them accordingly from the sensory reaction. In the clothing industry, professional trained handle experts sort out the fabric qualities.

In objective measurement, fabric sample is tested for some specific mechanical, thermal, etc. properties. These properties are then combined suitably and a single value arrived at to express the fabrics hand characteristic. Objective evaluation of the hand of apparel fabrics was first attempted by Peirce [1] as early as 1930. Fabric hand or handle characteristics of textile fabric is a complex function of human tactile sensory response towards fabric, which involves not only physical but also physiological, perceptional and social factors as explained by various researchers [18-21].

The credit for providing a feasible instrumental technique to evaluate fabric hand value goes to Kawabata [6]. The system of fabric evaluation provided by Kawabata better known as Kawabata Evaluation System (KES) comprises of a series of instruments to measure textile material properties that enable predictions of the sensory qualities perceived by human touch. Thus KES is the first of its kind to provide objective measurement of fabric hand. The principle of this system is to combine 16 mechanical properties measured by the instrument of a fabric directly to its Japanese hand preference through multivariate statistical regression analysis.

Due to some serious drawbacks like Japanese hand preference and cost involved, the instrument failed to offer an adequate solution for fabric hand assessment in countries other than Japan, and there are still many other problems associated with this system as described in the papers [5]. The Fabric Assurance by Simple Testing (FAST) method by Australian scientist also came up for evaluating handle characteristic of fabric. Both KES and FAST systems measure similar parameters using different instrumental methods.

However, although objective assessments are precise from a mechanical point of view, these methods have not been commonly used in the textile and clothing industry because of its complex nature, time and cost involved. Even today, many companies still use subjective evaluation to assess fabric properties. The main reason for this situation is the repetitive and lengthy process of measurement, the lack of knowledge for a good interpretation of the test results and the cost of the instrument.

In recent past various researcher have attempted to overcome above mentioned limitations and developed a simple method which can easily measure the fabric handle value better known as 'Nozzle Extraction' method [3,5] of fabric evaluation. In this method, a specimen of fabric is extracted through a nozzle and the force generated while withdrawing a fabric specimen through the nozzle is measured.

The nozzle extraction method of testing was further simplified by many researchers. In this new approach, the extraction force generated due to multidirectional deformation of the fabric with respect to bending, shear, tensile, compression, etc are studied in nozzle extraction method for measuring by way of axial and radial force. This new approach is based on the concept of tensile testing machine and measures the force generated while extracting a circular fabric specimen through a nozzle [22-24]. It has been reported that different testing variables, like presence of supporting plate, extraction speed and shape of the specimen, have significant effect on peak extraction force, whereas the number of pass does not have any specific effect on the extraction behaviour of fabric.

At present there are few instruments available for evaluating fabric handle value objectively and the Kawabata evaluation system for fabric is the most used among them. The main disadvantages of this instrument of this instrument are high cost, complexity, and time consuming procedure that restrict its industrial applications, especially for small scale apparel and textile manufactures, processers and merchandisers.

2.2 Evaluation of handle characteristics of fabric

The fabric hand characteristic is a complex phenomenon of textile material. Some of the commonly understood attributes are type of fibre / raw material, yarn structure, fabric structure, finish application etc.. Properties of yarns and fabrics have a high degree of influence on the fabric hand. On top it evaluation of handle characteristics of fabric is a matter of challenge to all. As mentioned traditionally it used to be evaluated subjectively[14].

In recent time lot of thrust is being given by many researchers to develop some method and evaluate the same objectively. Objective assessment it is to predict fabric hand by testing the fabric in the instrument as devised may be and established relationships between sensory reactions and instrumental data. Till few years back also very few instruments were available to evaluate the fabric objectively. The well known method or instrument that is available in industry are Kawabata Evaluation System for Fabrics (KES-F) and the Fabric Assurance by Simple Testing (FAST) method. The measurement techniques of these two instruments might be different, but both systems measure similar parameters using different instrumental methods. Over a period of time another technique was developed which consist of the ring or slot tester.

The level of accuracy of evaluating handle characteristic of fabric is always at stake – whether subjective or objective method. But in general it has been observed that objective assessments are more consistent and precise. However, these methods have not been widely adopted in the textile and clothing industry. Even today, many companies still use subjective evaluation to assess fabric properties. The main reason for this, as opined by many, might be due complexity and lengthy process of measurement and the lack of knowledge for a good interpretation of the test results [25].

2.2.1 Subjective evaluation of fabric handle

The subjective assessments to evaluate the handle characteristic of fabric, the fabrics are subjectively judged by way of touching, pressing, rubbing or stretching. Hence, fabric hand value is understood subjectively as result of a psychological reaction through the sense of touch. Therefore, the subjectivity of the results of evaluation plays a vital role. The word subjective does not have perfect boundary. The number of factors involved in subjective assessment adds more complication and variability in results. therefore, one has to be very careful about the subjective assessment parameters.

2.2.1.1 Factors effecting on subjective evaluation

The first and foremost important factor of the subjective assessment of fabric handle characteristic is the evaluator itself. Characteristics of individuals such as physiological, sociological, climatic conditions, cultural preferences, gender, age, educational background, etc. are some of the important factors which influence a lot in the process of evaluation of fabric subjectively.

Sensory reactions of skin of different individuals are invariably going to be different as the case may be. For example, female individuals in general respond more delicately and sensitively than male individuals and therefore have a finer assessment of a specific parameter [16]. Different skin hydrations of individuals affect notably the feel of a textile. A higher moisture level on the skin makes it more sensitive to the sense of touch.

In subjective assessment mainly softness of the fabric judged. Therefore, physical and mechanical parameters like fiber, yarn, finishing treatments etc. plays a vital role in subjective assessment results[26,27].

2.2.1.2 Drawback of subjective evaluation

All people do not have the same sensory perception mainly due to biological as well as psychological phenomenon. Age, gender, profession, religion, cultural etc. are the some of the parameters that contribute the sensory reaction of the subjective evaluation. If you look at the biological point of view different professional background people will invariably have different skin condition and so as the sensory reaction of the skin. Age and gender also results similar differences in sensory reactions due to the biological phenomenon. Climatic condition like tropical region and cold countries will invariably react differently in the same subjective evaluation. Religion and cultural issues also plays a vital role in subjective evaluation.

The above mentioned phenomenon is due to multi–modal sensitivity of skin over the surface of touch. A set of 5 million skin receptors are available to differentiate touch events. Skin’s ability to perceive touch sensations gives our brain wealth of information [28,29]. The sense of touch by skin is resultant feedback of huge network of nerve endings and touch receptors in the skin known as the somatosensory system and responsible for all the sensation we feel like cold, smooth, soft, etc. Somatosensory system consist four main types of receptors: mechano receptors, thermo receptors, pain receptors and proprioceptors. Mechano receptors perceive sensations such as pressure, vibration, and texture etc. There are four types of mechano receptors whose only function is to perceive indentions and vibrations of the skin: merkel's disks, meissner's corpuscles, ruffini's corpuscles and pacinian corpuscles.

For fabric handle evaluation the receptors which are found on palm or fingertips are more important. The merkel's disks and Meissner's corpuscles are found in the very top layers of the dermis and the epidermis and generally found above mention area. Merkel's disks are rapidly adapting receptors and Meissner's corpuscles are slowly adapting receptors so skin can receive both i.e. touching something and how long the object is touching [28,30].

The somatosensory system would not make any difference if the sensation does not reach to the brain. Therefore, a sensation is a subjective experience, experienced by a person, correlated with the receptor, and measurable only to the extent that the incident energy falling on the receptors, and the response of the receptor to that incident energy is measurable. Regardless of origin, touch sensations create experiences and memories that lead to judgment. The analysis of descriptors for early touch experience of both US and Chinese respondents revealed that "soft" and "smooth" were the most commonly recalled traits of tactility [30]. Thus subjective feeling of the experimenters is totally understood as result of a psychological reaction through the sense of touch of the experimenters. There are variations in how individuals actually feel textiles because people do not have the same sensory perception of identical occurrences as stated above. [31,32].

The subjective assessment is also governed by the subconscious bias which results in variations in evaluation output. Therefore, there are variations in how individuals actually feel textiles because people do not have the same sensory perception of identical occurrences. As the classic sayings, ‘something is better than nothing’, probably the traditional method for assessing fabric handle is the tactile sensory technique is probably reasonable. Researcher Brand [33] mentioned that the aesthetic concepts of fabrics are basically people's preferences and should be evaluated subjectively by people. This apparent common-sense approach immediately raises difficulties, however, such as finding the most appropriate judges-experts or untrained consumers? There is difficulty with the communication between judges, the low assessment sensitivity, and above all the time consuming nature of the whole assessment procedure. The conclusion is that a reliable subjective evaluation of fabric handle is possible, but obviously the method does not facilitate rapid development of textile products [3].

2.2.2 Objective evaluation

The meaning objective evaluation of fabric for its handle characteristic is to test the fabric in an instrument and the instrument will quantitatively generate on single hand value. The same is supposed to be reproducible. Therefore, it is definitely imperative that quantitative methods are needed to measure the handle characteristics of fabric objectively, quickly and accurately. For example in order to confer a variety of looks and effects on fabrics there are many fabric parameters provided by the manufacturer viz. different weaves, yarns, fibres, finishes etc. and manufacturer claim for its improved handle character of fabric from one combination to other. It is, therefore, required to have some instrument test data to support the claim made by the manufacturer like other properties of fabric ranging from tensile, tear, burst, pilling, crease recovery, drape, etc.

Therefore, a simple and quick objective evaluation of fabric for handle characteristic techniques would be useful for quality control. At present there are few instruments available for evaluating fabric handle/softness objectively such as Kawabata Evaluation System for Fabric (KESF), Fabric Assurance by Simple Testing (FAST), etc. The main disadvantages of these instruments are high cost, complexity and time consuming procedure as well as data interpretation from the discrete results that is a tough job; restrict its industrial applications, especially for small scale apparel and textile manufactures, finishers and merchandisers.

2.2.2.1 Kawabata fabric evaluation system

The Kawabata Evaluation System for Fabric (KES-F) has established by Professor Kawabata and his team way back in 1972 in Japan. He developed on this instrument to measure the low stress mechanical properties of fabric namely shearing, bending, extension, compression and surface property. He constituted a group of expert committee called Hand Evaluation and Standardization Committee (HESC). The role of the HESC was to evaluate the fabric subjectively. Empirical equations for calculating primary hand values and total hand values were put forward by Kawabata and Niwa [6,7].

The Kawabata Evaluation System for Fabric (KES-F) is used to judge the handle characteristics of fabric objectively. The KES instruments measure low stress mechanical properties that correspond to the basics of hand evaluation of fabric subjectively[34].

The Kawabata Evaluation System for Fabric (KES-F) includes four highly sensitive modules namely **KES-FB1, KES-FB2, KES-FB3 and KES-FB4.**

KES-FB1 : Shearing

In this module of the instrument shear force is measured for specific shear deformation and the shear strain.

KES-FB2 : Bending

Bending length characteristics is measured in this module of the instrument.

KES-FB3: Compression

Compressional properties of fabric viz. linearity of the compression, compressional energy, compressional resilience etc. are measured in the module of the instrument.

KES-FB4 : Surface friction and variations

This module measures the surface frictional property of the fabric

2.2.2.2 Fabric Assurance by Simple Testing (FAST) System:

Fabric Assurance by Simple Testing (FAST) has been developed by CSIRO, Australia Purpose of this instrument was to predict the properties of wool and wool blended fabrics that affect their tailoring performance and the appearance of the tailored garments in wear[34]. This system instruments also give information which can be related to the fabric handle. Unlike KES-F system, FAST measures the resistance of fabric to deformation and not the recovery of the fabric from deformation. However, many are in the opinion that the FAST system is simpler and more robust than the KES-F system, as well as cheaper.

FAST system consists of four module:

FAST – 1 : Compression Meter

FAST – 2 : Bending Meter

FAST – 3 : Extension Meter

FAST – 4 : Dimensional Stability Test

Test results from FAST – 1, 2 and 3 recorded automatically, but results of FAST – 4 need to be recorded manually. The results are plotted on a control chart to provide a Fabric Fingerprint, which indicates weather the tested fabric will be suitable for the intended end use.

Some values of produced by FAST are not measured directly but are calculated using a combination of values from different FAST instruments and in some cases using Mathematical Constants. These properties are known as Derived properties because they are not directly measured by any one instrument. Bending Rigidity is a derived property because in addition to the Bending Length, fabric weight is brought into the calculation. The measurements obtained from FAST-3 are important in calculating two further derived values, Formability and Shear Rigidity. The parameters measured and calculated on FAST system is given in Table No. 1.1

Table No. 2.1 : Parameters measured and calculated on FAST system

Instrument	Measurement	Parameters	Symbol	Units
FAST 1	Compression	Fabric Thickness	T	mm
		Fabric Surface Thickness	ST	mm
		Released Surface Thickness	STR	mm
FAST2	Bending	Warp Bending Length	W1	mm
		Weft Bending Length	W2	mm
		Warp Bending Rigidity	B1	uNm
		Weft Bending Rigidity	B2	uNm
		Formability	F	mm2
FAST3	Tensile Extension	Warp Extensibility	E100-1	%
		Weft Extensibility	E100-2	%
		Shear Rigidity	G	N/m
FAST4	Fabric Dimensions	Warp Relaxation Shrinkage	RS-1	%
		Weft Relaxation Shrinkage	RS-2	%
		Warp Hygral Expansion	HE-1	%
		Weft Hygral Expansion	HE-2	%
Chemical Balance	Weight	Fabric Weight/Unit Area	W	g/m2

2.2.2.3 Fabric evaluations by dynamic drape testing method

In the present context, the drape and its associated fabric properties have paramount importance. Therefore, the same is elaborated in little details here. There are subjective and objective methods to evaluate drape. The method of objective measurement of drape is basically fabric fall by itself in specific shape according to its properties, when part of it is supported and rest is unsupported. Studies of drape were discussed long ago by Hearle et. al., Chu et. al. and Cusick et. al.[36-38]. The most widely accepted method of drape test is IS 8357:1977. In this test, a circular fabric sample whose diameter is 25.0 cm is placed on a circular disk of 12.5 cm. The cloth drapes and compresses internally owing to gravity, finally resulting in a flared shape. Then the drape coefficient is described as the ratio of vertical projection area to the entire sample area. A diagrammatic representation of the same is given in the following figure 2.2 & 2.3.

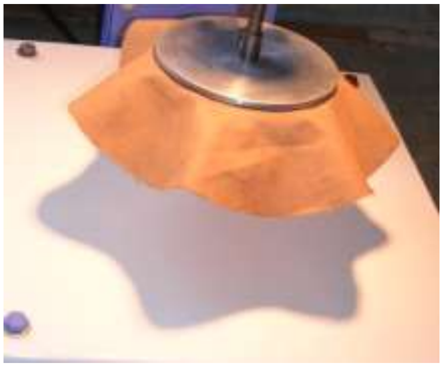

Fig. 2.2: Actual Projection of Drape Shadow

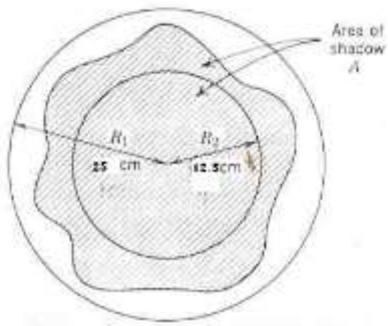

Fig. 2.3: Based on drape projections, various areas.

$$Drape\ Coefficient\ (D) = \frac{A - \pi R_2^2}{\pi (R_1^2 - R_2^2)} \times 100\ \%$$

where, A = Area within the projected outline of the draped specimen

R_1= Radii of the fabric sample, R_2= Radii of the disk

The drape coefficient alone does not give a complete description of drape behaviour. There are many other aspects of the detailed form of draping. One other parameter which can easily be measured is the number of nodes formed as the fabric drapes. The following Fig 2.4 illustrates how the number of nodes formed when the fabric bends symmetrically at the edge of the disc without double curvature depends on the relative values of disc and fabric diameter. Flexible fabric will drape down by buckling in to more folds than are shown in the Fig. 2.4

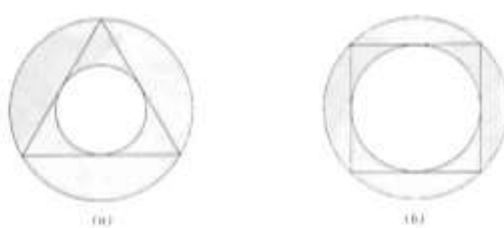

Fig. 2.4: Influence of relative values of disc and fabric diameter on probable minimum number of nodes. (a) Specimen diameter 30 cm; disc diameter 15 cm – three nodes. (b) Specimen diameter 30 cm; disc diameter 21.3 cm – three nodes.

Cusick confirmed this experimentally and the following Fig 2.5 is based on his schematic representation of how the number of nodes depends on fabric stiffness and disc diameter. Very stiff fabric merely sag slightly without forming any definite nodes: this gives the area designated as zero nodes. The number of nodes increases as the disc diameter decreases and the fabric stiffness decreases.

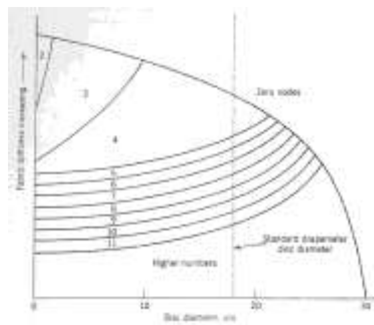

Fig. 2.5: Schematic representation of variation of number of nodes with disc diameter and fabric stiffness. Fabric diameter = 30 cm.

2.2.2.3.1 Various Fabric Properties and Drape of Fabric:

From the above mentioned discussions so far it can be seen that drape of fabric is a complex phenomena of various fabric properties like bending and buckling behaviour of fabric, shear properties, tensile properties, etc. Substantial amount of work has been done by various researchers and established lots of relationship between these parameters. Cusick[39-40] and Treloar[41] have done lots of work in this field and have investigated the dependence of drape of the fabric on bending and shear stiffness.

Sharma[42] *et* al have studied on low-stress mechanical properties of fabric and its relationship with drapeability characteristics of a fabric. In their work, they have observed that the drape coefficient has a strong correlation with bending properties, good to strong correlation with shearing properties and poor correlation with tensile properties.

Substantial amount of work has been done by various researchers on preparing models and prediction of fabric drape. Work done by Okur[43] *et* al gives the prediction of fabric drape coefficient from FAST data. In their work, relationship between fabric drape coefficient obtained from Cusick's drape meter and mechanical properties ascertained on the FAST system for women's woven suiting fabrics were examined and a multiple linear regression model was proposed.

Lai Sang-Song[44] had worked for establishing discriminant models of fabric characteristics. In the work four fabric groups, woven from cotton, linen, wool and silk were used. Discriminant analysis were used to characterized and discriminate between different fabric groups and 14 drape forms were able to classify the four groups of fabrics with a 98.3% classification accuracy rate.

In another interesting work by Lo[45] *et al,* have presented a model for predicting fabric drape profiles using polar coordinates. It is claimed that with the help of their developed model, the drape coefficient, node locations, node numbers and node shape in the fabric drape profile can be predicted. In this work polar coordinate fitting is used to determine the constants and a good agreement were observed between the theoretical and experimental drape profiles and drape coefficient.

2.2.2.3.2 Various Issues Related to Drape :

Earlier researches in textile mechanics were mainly focused on the understanding of relationship between the mechanical properties of fabrics and those of the yarns as well as fabric structures. Thereafter, shape of a draped fabric were explained by using various theories viz. plate theory, non-linear finite-element theory, large deformation shell theory, etc [46-48].

For many decades, much of the textile literature has been devoted to finding linear relation to explain the natural way in which fabrics deform or drape. However, linear concept do not apply for essentially nonlinear phenomena which occur in the dynamic interactive processes involved in textile and apparel manufacture and technology[49-51]

An early publication of Morooka and Niwa provides the basis for determining a drape coefficient from bending rigidity and the weight of the fabric. In her work with Izumi and indirectly with Fujimoto Mamiya and Murakami Kanayama, the researcher offered further observations on the measurement of mechanical properties in static and dynamic drape. Stroboscopic measurement and continuous photography using camera motor drive, have facilitate the correlation of subjective evaluation of dynamic drape, mechanical parameters, primary hand values and dynamic bending properties (or dynamic shear properties) with high correlation found with an instability parameter delivered from 'heavy elastica' theory[52]. To evaluate dynamic drape behavior of fabrics, a testing device was designed by Yang *et al*[53] and new adequate parameters which can represent dynamic drapeability were defined and the stability of those parameters were discussed. In another work on conventional static and new dynamic drape by Matsudaira & Yang[54], on Silk Fabrics finds that dynamic drape property is very useful for categorizing the fabric. In this work, conventional static and new dynamic drape coefficients of silk woven fabrics were examined precisely to distinguish those features of each classified fabric by its yarn structure using our regression equations. Today there are many design programs with various software tools and a wide choice of designing functions are available. These are worked on a sketching model that can produce a visual presentation on how colours, motifs and materials look scanned model. Production preparation steps such as pattern construction, grading system, pattern planning and optimization and automated cutting are realized with computer assistance. However, CAD systems available in the market have two weak spots: the system work only two-dimensionally, and the material behaviour and parameters are not taken in to account[55].

2.2.2.4 Multiple properties through a single test

2.2.2.4.1 Nozzle extraction method

This is a revolutionary invention and a beginning of a new dimension of fabric evaluation for quantitatively measurement the handle of fabrics and other flexible materials by a single test. In this method the handle characteristic of fabric or a flexible material is quantified by measuring the force required to draw the sample through an orifice and expressing the resultant extractive force as a function of test apparatus geometry and the amount of sample drawn through the orifice to arrive at quantitative measure.

The design of nozzle extraction method that was done by employees of United State Government and patented has been described by Alley [56]. The patent comprises a nozzle composed of a truncated cone section and annulus section. The fabric sample or the flexible material that is to be tested is drawn through the truncated cone and annulus section of said nozzle and determine the force necessary to draw the said material with respect to said nozzle in order to determining a compaction ratio of said sample. The schematic diagram of the patented device is shown in Fig 2.6

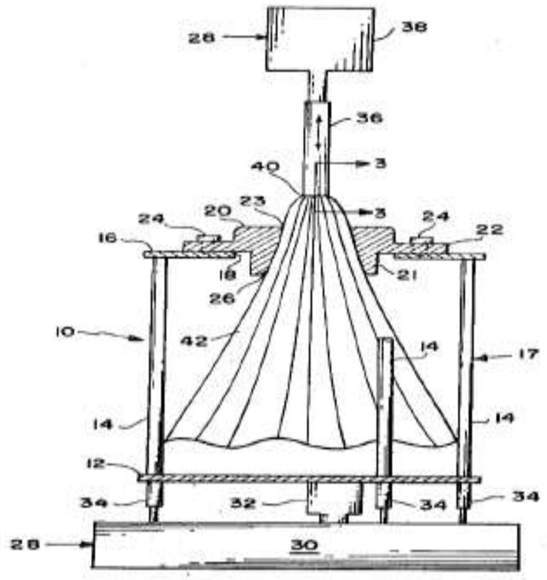

Fig 2.6: Handle meter designed and patented by United States

There are many issues related nozzle extraction method described above. It can be seen that a simple nozzle extraction method for measuring objectively the fabric handle has been used. This method is based on the use of a simple attachment fitted to a tensile testing machine and measures the force generated while extracting a circular fabric specimen through a nozzle. Different variables, like nozzle shape, nozzle material, fabric holding support plate, extraction speed, shape of the specimen etc. have significant effect on average as well as peak extraction force in both the directional forces i.e. axial as well as redial.

2.2.2.4.2 CHES – FY system of fabric evaluation

A comprehensive handle evaluation system for fabric and yarn (CHES-FY) is another type of instrument capable of measuring mass, bending, friction and tensile behaviour just through one pulling out test and is able to characterize the handle of fabric as described by Zhaoqun et al [57]. The schematic structure of CHES-FY system is illustrated in Fig. 2.7. The CHES-FY system is consists of bi-U shaped pin and a apir of jaws as well as a moving pin that is controlled by a motor and the force data sensed by the sensor are fed in to a computer by an A/D converter and the hung shape of the fabric can be captured by a digital camera.

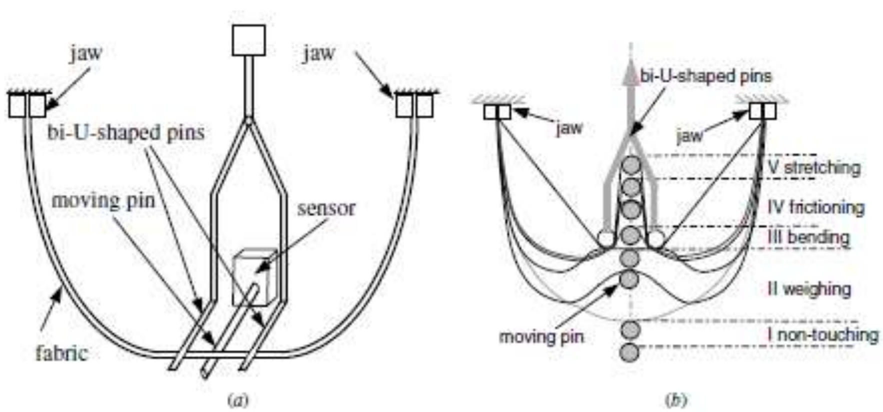

Fig. 2.7: A schematic structure (a) and separated extraction steps (b) of the CHES-FY

Geometric and mechanical deformation analysis of CHES-FY system is shown in Fig 2.7(b). The entire pulling out process of pin is described as five distinct zone viz. non-touching, weighing, bending, frictioning and stretching. It is, therefore, important to understand that whether nozzle extraction or pulling out process using pin, the entire duration of testing procedure need to study carefully and draw inference according to the phenomenon observed.

The weighing principle and the structure of CHES-FY system is given in Fig 2.8. A sample is mounted between a pair of jaws and the sample is lifted up by moving pin and the forces required to lift the pin is recorded by a sensor.

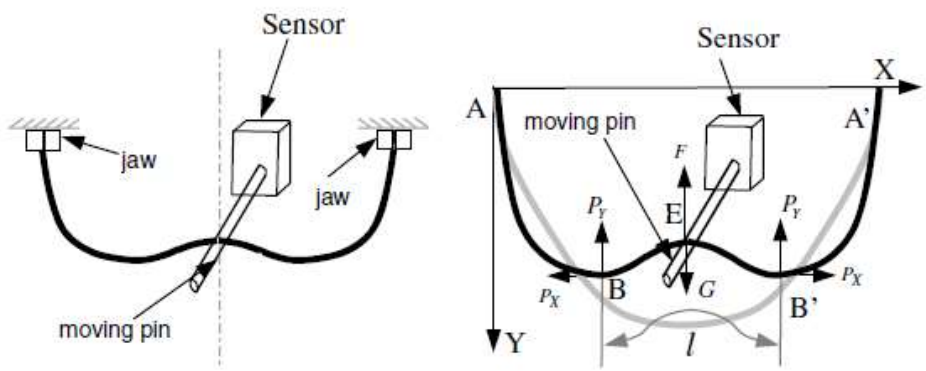

Fig 2.8: The weighing principle and the theoretical model of a fabric in CHES-FY

The detailed study of CHES-FY and the comparison of the same with KES-FB2 and FAST-2 have been done as reported by Zhaoqun et al [57]. It is claimed that CHES-FY is feasible and accurate in measuring mass and bending rigidity of fabric and suitable in characterizing mass and bending behaviour of fabric.

2.3 Drawback of the existing fabric evaluation system

Study of handle characteristic of fabric is not a new concept – whether it is subjective evaluation or objective evaluation. Subjective evaluation has its own drawbacks. Since last 2-3 decades, therefore, focus shifted towards objective evaluation. To study the handle characteristics of fabric many fabric evaluation systems have been developed over these years viz. KES-F, FAST, Nozzle Extraction System, CHES-FY, etc. But most of the systems have some drawback of its application universally either from intricacy and complexity point of view or cost parameters of the instrument or some preferences to its application.

For example, Kawabata fabric evaluation system which has its presence or edge over other fabric evaluation system consists of a set of instruments known as the KES-F or FB for measuring fabric mechanical properties. An empirical formula derived by the team is embedded in the system to get direct output of hand value of the fabric from the set of tests. Without any doubt, definitely this is a new era of fabric evaluation system and new dimension of research in this area. The system uses multivariate regression to relate the subjective assessment results assessed by the Japanese experts to the objectively measured data on the KES-F instruments and to formulate the equations for handle value calculation. Because the system is based on the preferences of Japanese judges, the unsuitability of the results to markets other than Japan.

Similarly, FAST system seems to another most promising instrument in this area. Cost of the FAST instrument is comparatively less compared to KES-F. As claimed, the instrument can provide a comprehensive guide to the garment manufacturer. But, no claim has been made so far regarding handle characteristics of fabric in the line of KES-F total hand value (THV). Interestingly, hand value as one of the important guideline is looking for by many warehouse and made-ups segment.

As far as nozzle extraction is concerned, substantial amount of work has been done in different dimensions like analysis of various forces acting in different directions, their interactions, nature and so on. No doubt academic interests of these dimensions are sky high. But lack of convergence is clearly seen resulting no commercially available instrument to study the handle characteristics are available in the market using the nozzle extraction technique.

CHES-FY has its own dimension of study. No further progress is reported in this direction of the fabric evaluation system so far.