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DEVELOPMENT OF NEW INSTRUMENT FOR SHEAR AND ITS APPLICATION FOR TESTING SILK FABRICS AND OTHER TEXTILE MATERIALS

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Abstract: Various races available for silk are Japanese, Chinese, Europeon and Indian races. With these differences various types of silk fabrics are made and presented to customers. To enhance sales beautiful designs woven or printed over the fabrics which can be seen in the market. Due to various deformations designs stagger and differ from original after sales of material. Various tests carried out for the defects found is not sufficient to find out design staggering. The available KES-F shear tester is very costly. A new instrument based on the KES-F shear tester is designed and it is compared with KES-F tester. This can be used for practical purposes.

Index Terms; Shear, KES-F, Silk, Fabrics, Design, Stagger, New instrument

1. Introduction

General Characteristics of the COCOON

The cocoons are classified as Japanese, Chinese, European and Indian races according to their origin.

a. **Japanese Race**
There are univoltines and bivoltines in this race. The cocoon colour is usually white and is of a peanut shape. This race has comparatively a higher proportion of double cocoons and the filament is shorter in length. The reelability is also comparatively low.

b. **Chinese Race**
There are univoltine, bivoltine and multivoltine races among Chinese races. The cocoon tint is of various colours, that is white, yellow, green and pink. They are oval, egg and nearly spherical in cocoon shape. Especially the multivoltine race is shaped like a spindle. The size of the filament is commonly fine and reelability is comparatively high.

c. **European Race**
This belongs to univoltine races. The cocoon of this race is usually bigger than the other races such as Japanese and Chinese races. The proportion of double cocoon are less than the Japanese and Chinese races and the colour is commonly white and skin colour. The filament is long and reelability is also comparatively high. These strains make oval or peanut shape cocoons.

d. **Indian Race**
They are all multivoltines and are being dispersed all over south East Asia. The cocoon is small in size and characters are not in a suitable state for international grade raw silk reeling. Since of late India has evolved some new bivoltine races.

KINDS OF SILK FABRIC

In order to let silk fabric display its characteristics such as soft feel, elegant luster etc., we must remove sericin which is contained in silk yarns (in chiffon, organdy etc. Sericin is not removed for the purpose of retaining the peculiar feel).

This removal of sericin which is the degumming process can be performed any time during the processing from the silk yarn to the finished fabric. Silk fabrics made of degummed yarns are degummed silks, while ones of raw (not degummed) silk yarns are raw silk fabrics.

A. Raw Silk Fabrics

Raw silk fabrics are woven from the warp and weft of undegummed silk, doupion silk or tussah yarns which are degummed in the state of fabrics. The following are included in this category

1. Habutae

In Japan, habutae has been an important clothing material since ancient times. At present, it is woven both in board and narrow widths and has a beautiful lustre, smooth touch and adequate elegance and particularly scroop, and is one of the representative fabrics of Japan. Uses: scarves, mufflers, linings, dresses, neckties, kimonos, obis etc.

Construction wise there are will habutae, figured habute, striped habutae, doupion habutae, shoize habutae etc. By its weight habutae is classed into light, medium and heavy habutae.

2. Crepe

This is a narrow width with crimps (Pebble effect) produced by hard-twisted silk yarn. Non-twisted yarns are used for warps, and 2 ends each of hard S twisted and Z twisted silk yarn are shot alternately. After weaving, the fabric is degummed and rubbed in lukewarm water to product crimps. Depending on the size of raw silk and the density of yarns,habutae becomes heavy or light. In addition, various crimps are produced according to the taste of clients. Uses: dyed in plain “Yuzen” dappies etc, “Kimonos”,”haoris”,”obis” and so on. There are many kinds of narrow crepes,”hitokoshi” crepe,”rinzu” crepe, “Kinsha” crepe, “Kohama “crepe, “uzura” crepe, “embroidered” crepe,”Kumoi” crepe, voiles, “kaba” crepe etc. These crepes are used for Japanese style costumes and they are transacted by tan or hiki with their weight expressed in grams.

3. Flat Crepe

This is a broad woven crepe. As the wraps are fairly dense and use silk yarns of coarse size, the crimps are fine and not very conspicuous, so appearance is flat and smooth. This constitutes the characteristic of this fabric. In white silks plain dyed or printed, it is used for dresses, blouses, linings, negliges, underwear etc.

4. Crepe de chine

The density of warps is slightly coarser than that of flat crepes so the crimps are more conspicuous, Its uses are wide, dresses, blouses, linings, mufflers, accessories etc.

5. Satin Crepe

The construction of this fabric is the regular, though the yarns used are the same as those of crepes. It appears satin with minute crimps on one side, and crepe effect like flat creeper on the other. The appearance of the surface is extremely different from that of the back. Uses: dresses, suits, linings of fur coats, Japanese style coats etc.

6. Georgette Crepe

Both the warp and weft are hard twisted raw silk. Crimps are fine and luster is relatively modest. Uses: dresses for women and children in the summer, scarves millinery, veils and trimmings.

7. Organdy

This is a plain fabric woven coarsely with the warp and weft of raw silk which is single twised and dyed without degumming and subjected to secricin fixation. Not degummed even after weaving, organdy is rather rough to touch, light and transparent. Uses are summer dresses and blouses, lingings, dolls clothing, millinery etc.

8. Kenchu

This is a comparatively light fabric hand woven with tassah silk, both in the warp and weft, degummed after weaving. In plain colours or printed, it is used for women and children’s wear, lining etc.

9. Piece-degummed shantung

Originally shantung was produced in the Shantung Province of China. It was a flat weave, made of Tassah silk both in the warp and weft. The weft yarns were especially thick and nubby. Recently however, it is made of raw silk and doupion silk instead of tussah silk. Shantung is very rustic in appearance and feel with nubs, large and small scattered on the surface but quiet and refined. Used for dresses, blouses, sportswear, curtains etc.

10. Fuji Silk

This is a plain fabric made of spun silk yarns both in the warp and filling. It is either raw silk fabric or piece degummed one. Like habutae fuji silk is soft and used as kimonos and obis for women and girls, underwear, linings etc.

11. Sha, a kind of silk gauze

Gauze has 2 kinds of the warp, one runs in the same direction throughout but other appears on its right hand side or left hand side alternately as the filling is shot through with the result that the filling is held by 2 ends of the warp. This is a kind of leno weave. As it is light, transparent, porous and cool, it is suitable for summer wear. Uses;mid-summer kimonos , evening dresses, curtains etc.

12. Ro, a kind of silk guaze

The same as sha. It is a kind of leno weave, which is mixed with plain or twill weave. Like sha,ro is either yarn degummed or piece degummed. The uses are the same as sha.

B. Yarn-degummed Fabric

1. Taffeta

This is a plain weave with rib effects by the use of double twisted regularly degummed silk for the warp and single twisted regularly degummed thick yarns for the filling.

It has a close texture, elegance and beautiful lustre and resilience lience. Tamamushi-taffeta and chiffon taffeta belong to this group. Uses: dresses, blouses, one-piece dresses etc.

2. Degummed Silk Satin

For the warp, degummed and dyed silk yarns are used and for the filling degummed, dyed single-twisted silk yarns are used. Silk satin is soft and very lustrous and smooth but weak to friction. Used for evening dresses, gowns, cushions, linings, women’s Japanes style rain coats etc.

3. Brocade

This is a figured fabric, floating colourful patterns by the use of various coloured yarns for the filling in the stin ground. Due to many floating yarns, the face of the fabric looks different from the back. Heavy brocades are used for wall hangings, curtains etc while light ones for women’s dresses, neckties etc.

4. **Hattan**

The ground texture is the same construction as degummed silk twills of narrow width. Mostly used for bedclothes with lucky patterns such as pine trees, chriysanthemums etc for the bride.

5. **French Twill**

Comparatively thin, double twisted yarns (degummed and dyed) are used for the warp and thick single twisted yarns (degummed and dyed) for the fillings. The warp ends are close in density. This twill is a mixture of various twill constructions. Many of them are heavy (20m) and used for quality women's dresses.

6. **Faille**

The warp is degummed and dyed, double twisted silk, while the filling is lightly single twisted yarns (also degummed and dyed). In the warp yarns closely arranged, 2 or more fillings are shot to produce warp-ribs. It is very lustrous and soft. Mostly plain dyed and used for women's dresses, millinery etc.

7. **Omeshi**

Unique fabric in Japan, omeshi is a narrow silk fabric using degummed silk for the warp through which degummed S-twisted or Z-twisted yarns are shot alternately. This is a kind of crepe and used for Kimonos.

8. **Hakata Fabric**

This fabric is famous as a material for obis. In addition, it is used for under-belts, hakama or divided skirt for men's formal wear, table covers, neckties etc. Both the warp and the filling are undegummed silk. It is a plain fabric with the filling which is far thicker than the warp is strongly shot through. It is thick and firm with lustre and resilience.

9. **Meisen**

Both the warp and filling are degummed and dyed silk yarns. Before World War II, this plain fabric was popularly used for women's home wear and townwear. Recently, however it is not produced so much.

10. **Nishiki**

This is a special product of Kyoto, a figured fabric woven with ver million white, yellow and other coloured yarn. It produces gorgeous patterens in the compact, oblique-rib background by the use of various coloured yarns, gold and silver threads. To this group belong: Yamatonishiki, Ito-nishiki,Kara-nishiki, Kinran-nishiki, Tsuzure-nishiki etc.

11. **Tsumugi Hand Spun Silks**

Tsumugi is a degummed fabric of plain weave. It is woven on a handle loom with silk yarns pulled out and rounded by hand from floss silk used for the warp and filling. It is woven in splashed patterns, stripes, white etc. Originally it was produced by farmers to make use of spoiled cocoons. Though simple and rustic, it has its own peculiar elegant lustre and sobriety, it is one of the time honoured Japanese fabrics.

12. **Yarn Degummed Shantung**

In an earlier section we have referred to shuntang . Shuntang is made by degummed yarns too. Double twisted drgummed and dyed silk yarns are used for the warp and single twisted, degummed and dyed doupion silk yarns for the filling. This plain wave is used for dresses, blouses, sportswear etc.

13. **Linshang**

This is a plain fabric, relatively coarsely woven with doupion silk used both for warp and filling. With the doupion (nubby) effect appearing both in the warp and filling directions, it is very elegent. Used mostly in plain colours for women's quality dresses.

14. **Velvet**

Silk velvets is a "pile" warp fabric, which mens it contains an extra warp in addition to the ground warp. The loops of the pile warp are cut and produce a nap on the face of fabric. Silk velvet dyes in deep colours and is beautiful. Used for women's dresses and children's apparel and women's Japanese style coats.

Other uses of silk

1. **Silk Sewing Thread**

Silk thread is favoured for sewing costumes dresses.

2. **Knitted Goods**

Silk knits are used for the underwear of men and women. From recent times it is very popular as women's suits, cardigans, polo shirts etc.

3. **Bolting silk**

This is used rather as a fabric than as made-up goods. The mesh is so firmly put together by sericin that no further process is applied. Used by flour mills and pharmacies and dyeing factories for printing screens.

4. **Silk Canvas**

This is a plain fabric woven in the same manner as habutae and raw silk fabric. After weaving it conducts no degumming to let sericin remain in the material. Used mainly by calli graphers and painters.

5. **Typewriter Ribbon**

Silk ribbons are now used by the typewriters built-in the clearly. This is a Promising field.

Various tests carried out for silk are done for raw silk yarn. After woven to fabrics the silk fabrics are tested for defects like mixed warp, tight thread, mixed filling, tight filling creping defect, shining thread, nap, chika, warp floating, and shortage of the silk weight. The objective evaluation of silk fabric is done with KES-F system. The silk fabric is also tested for its colour, lustre, hands, finishing defects, skein without the diamond crossing, gummed skein, winding test, size deviation, average size, evenness, cleanliness in productivity and quality, neatness, tenacity, elongation, cohesion, scouring and exfoliation test. These were given in reference (3). The KES-F system instrument is very costly and the important tests of shear is done practically. Shear produces slanting of designs which is very serious for customers. The silk fabrics are costly and customer wants very good product for the payment made. Polyester, Cotton, Wool, Jute, Linen and other types of less cost fabric requires tests and it is not possible to test everything in KES-F system. So a new instrument is developed and its relationship with KES-F system is determined which can be used practically.

2. Design staggering by shear in silk and other fabrics

The design which is different in colour from the base or group of yarns should be perfectly visible. It should not be slanting and deviate from the original desired methods. The design may be short in height or flat in width. This is done to shrinkage in warp side and increase in width. The design may be elongated and thin which is due to extension in warp and elongation in weft. This can also be applied for printed design. These are not shear property. The design can be analysed for shear property. The design can be slanting to left or right. This is due to the shear of the warp and weft yarns in the fabric. This can be analysed with shear tester. Kawabata evaluation system for fabrics (KES-F) uses electronic method in determining the shear parameter of fabric.

The typical shear curve is shown in figure (4). The stress and strain diagram shows the hysteresis of the shear curve. The shear curve obtained may be of different types for different fabrics. the shear curve may be slanting towards y-axis, x-axis have bulged width, thinner width, have more area on second quadrant, more area on third quadrant, stress and strain large values, stress-strain small values. Different curve represents different meaning and they can be used for determining the design correctness in fabric. For slanting towards y-axis the design is stiff and there is less variations. If slanting towards x-axis happens then design staggering occurs and design changes after heatset and shrinkage, bulged or thinner width design is due to shrinkage. Have more area on second or third quadrant means imbalance design and it have already shear parameter in fabric. Large values of stress and shear values means bulky fabric and design is stable. Smaller stress or strain values means unstable design. These interpretations can be used for stable design in silk and other types of fabrics and customer will be satisfied for good design.

3. Breakage of fabric due to shear in silk and other types of fabrics

When fabric is stretched along warp or weft exactly opposite to each other tensile force is acting and fabric breaks after overcoming combined strength of gripped yarns. When fabric is gripped at 45^0 angle to each other shear force is acting and fabric breaks after overcoming the forces of yarns that are resisting the force. Other angle forces tend to make fabric tear and tear strength accounts for fabric breakage. Silks fabrics are costly and breakage of fabrics means whole saree, dhothi or garment becomes waste. So it is essential to know the shear strength which is lesser than tensile strength and higher than tear strength. Other types of shirtings, suitings, blouse, petticoat, children dresses etc. also requires testing so that the life can be increased. By determining suitable standards of shear strength, the life of the fabric and garment can be prolonged and less work can be done in manufacture of new products.

4. Work done on shear property in silk fabrics

In order to investigate the soft handle of woven silk fabrics, their basic tensile, bending, shearing, compressional, and surface properties were measured on the KESF system. Fabric shear, compressional, and tensile properties distinguish continuous-filament silk fabrics from fabrics of other fibres. Shear stiffness and hysteresis in shear force are very small, and these fabrics are very deformable in their compressional and tensile properties at small strain levels. High values of FUKURAMI are a characteristic of continuous-filament woven silk fabrics. These were reported in reference (4).

The gap between the warp and weft threads at their crossover points in woven silk fabrics is responsible for the very low values of shear stiffness and hysteresis of shear force in these fabrics. The existence of this gap is proved by using shear–deformation theory and making experiments on silk fabric. A quantitative determination of the gap is obtained by using strip–biaxial–extension experiments and measuring the retardation strain. The gap observed for woven silk fabrics is 6–7 μm. Since microscopical observation of the cross–section of silk fabrics does not show the gap, the gap measured by mechanical methods is called an "effective gap". The gap has a strong effect on the mechanical properties of silk fabrics, especially their shear properties. It also emphasizes the good handle of silk fabrics. These were given in reference (5).

Applications of silk

Because of the unique characteristics such as handle, drape, appearance, lustre and comfort properties, silk is used in both apparels such as saris, dress, shirts, suits, pants, socks, etc. and home furnishings such as upholstery fabrics, blankets, bed sheets etc. Moreover, as silk proteins amino acid composition is close to that of the human skin, it is also used in biomedical applications such as medical sutures, prosthetic arteries, etc.

Properties of Woven Silk Fabrics:

Silk, the strongest natural fibre is comfortable and has good absorbency with excellent drape. In order to judge the suitability of a fibre for different end-uses such as clothing and industrial uses; it should have certain desirable properties. The study was carried out to know the physical and comfort properties of white and red eri spun silk fabrics compared with mulberry spun silk fabrics.

High fullness and softness are distinguishing properties of silk fabrics and related to high compression deformability and tensile extensibility, which arise due to fibre crimp bulkiness. In order to clarify the effect of gap on fabric handle, the primary hands of polyester weaves having different degrees of weight reduction were evaluated objectively, and is shown that the gap leads to higher Fukurami and Shinayakasa and lower Koshi and Hari handles of the weaves.

The study of the objective evaluation of the woven silk fabric has found that both shear stiffness and hysteresis in shear force of woven silk fabrics are extremely small in the region of relatively small strain. However, these properties become larger with increased shear strain. In the small strain region of compression and tensile properties, silk fabrics are very readily deformed as compared with fabrics made from other fibres. Analysis of the shearing properties shows that the gap between the warp and weft threads at their cross-over points in woven silk fabrics is responsible for the very low values of shear stiffness and hysteresis of shear force in these fabrics. Using shear-deformation theory and making experiments on silk fabrics prove the existence of this gap. Using strip - biaxial extension experiments and measuring the retardation strain obtain a quantitative determination of the gap. The gap observed for woven silk fabrics is 6 to 7 mm. Since microscopical observation of the cross-section of silk fabrics does not show the gap, the gap measured by mechanical methods is called an "effective" gap. The gap has a strong effect on the mechanical properties of silk fabrics, especially their shear properties; it also emphasizes the good handle of silk fabrics.

In the silk fabrics, there may be a small gap between the warp and weft threads at their cross - over points because of the sericin removing treatment that is applied after weaving. The tensile behavior of a fabric with such a gap is considered to consist of two stages. In the first stage, the bent yarn alone is stretched, since the bending rigidity of silk yarns is small, and gap is relatively large, the tensile modulus of silk fabric becomes very low in the initial tensile region. After the contact of the warp and weft threads, the soft lateral compressional property of the silk threads leads to extensibility of the silk fabric.

This stage is called here the second stage, in which the tensile and the lateral compressional deformation proportion are mainly concerned with the tensile behavior of the fabric in this region. Silk - fibroin fibre has a small fibre crimp, and this crimp also makes the silk yarn compressible. The crimp enables the silk fabric to maintain the effective gap and a stable weave structure where slight contact of fibres between the two threads supports the structure. Secondly, the crimp causes greater yarn compressibility, which leads to the higher extensibility of the weave. These were given in reference (1).

Properties of Woven Silk Union Fabrics

The deformation behaviour of silk and polyester fabrics was determined. The fabrics tested were silk habutae, consisting of twist less continuous filament yarns in both the warp and the weft; silk dechine, consisting of continuous high twist filament weft yarns and twist less continuous warp yarns; silk georgette, consisting of high twist filament weft yarns in both the warp and the weft; and polyester fabrics of both the habutae and dechine types. A Kawabata Evaluation System measured tensile, bending, shearing and compression properties. The fabric properties were combined with information about fabric thickness, crimp and wave shape to determine the effective void volume of the fabric.

Spun silk polyester was used for developing products for home interiors as a creative endeavor to design and produce novel home interior products. A survey was conducted to gather varied respondents from the field of commercial art, textile, fashion and interior designers and homemakers. The most preferred product was the lampshade followed by the table runner. Respondents gave positive response with a high level of acceptance and the products seemed to have commercial value.

Considering the properties of eri silk and the cost of viscose rayon, a study was conducted by interweaving viscose rayon with different counts of eri silk to explore its properties so that even a common person can enjoy the unique richness of silk with excellent softness of viscose rayon. An effort has been made to emerge the richness of silk with the brilliancy of viscose rayon that offers cost effective, yet attractive fabrics in various combinations. In case of subjective evaluation most of the respondents opined that all the union fabrics were slightly stiff to handle. In general, majority of the respondents preferred union fabrics whose cost of production was lower.

Silk Blends

In an effort to discover a lower cost alternative to silk, researchers studied the performance of silk, polyester and nylon in filament form and in blended fabrics. Several blends and weaves were tested. Nylon multifilament covered yarn fabric with a satin weave gave a silk-like hand and appearance.

Silk Union fabrics

There was a study on the low stress mechanical properties of woven silk union fabrics with mulberry silk warp and mulberry silk, cotton, linen. Viscose, modal, excel (lyocell) and polyester weft yarns as weft using KES F and has also studied the cluster analysis and discriminant analysis these fabrics.

Fabric Handle and Review of Previous Work done

After the performance of clothing found to be in use has been satisfactory to some extent, consumers seek better quality, that is, more comfortable fabric. With the introduction of various types of 'Shingosen' fabrics, which are silk like fabrics made from new man-made synthetic fibres, there has been an increasing interest in the objective evaluation of the fabric handle. This is being effectively used as a quality control tool in the manufacture of the silk fabrics on a mass scale. Thus, consumers and textile exporters are likely to use hand as the first attribute of fabric quality for apparel or home furnishings.

The theoretical primary hand values of the spun bonded silk fabrics were computed from the mechanical properties determined with the KES-FB and compared to that of a comparable spun bonded polyester fabric. The differences in handle characteristic of the silk and polyester fabrics are explained in terms of inherent fibre properties, the distribution of fiber orientation and the bonding characteristics of the fabrics.

The KESF was demonstrated to be capable of bringing out the unique handle characteristics of the silk fabric, which is related to fibre property, freedom of fibre mobility, fibre distribution, fibre geometry and bonding characteristics.

The new trend in textile technology

We are now entering the second generation of textile technology. The second generation is the engineered design of textiles based on more advanced technology. The textile industry is still experience preceding industry from technical viewpoint. The precise design of engineered manufacturing of textile products is difficult even today. We are now moving towards the engineered

Design of textiles focusing the design of ideal suiting. The goal is the engineered design of the ideal quality of suiting on the basis of fibre science, textile mechanics and the objective measurement technology. We are now proceeding to create a guideline for producing ideal fabrics. Ideal fabrics are those, which satisfy the following three conditions:

Good hand (high THV)

Good appearance of suit (high TAV)

Mechanical comfort conditions. These were given in reference (2).

The technology of objective fabric measurement has been applied to pure silk fabrics of different qualities, such as paz, habotai, georgette, crepe de chine, crepe satin and silk twill, in nominal weights ranging from 21 to 82 g/m^2. The instrumentally measured properties of the finished silk fabrics are discussed in terms of fabric weight, thickness, tensile properties, shear, bending, compression surface friction and surface geometry. The mean values and the range of these low-stress mechanical and surface properties for finished pure silk fabrics are reported. Using this data the quality characteristics of finished silk fabrics have been evaluated objectively and compared with those of other textile materials. The measurement initiate what could become an important database for the objective evaluation of finished pure silk fabrics.

Using the fabric low-stress mechanical property measurements reported, it has been possible to evaluate objectively and to compare the quality characteristics of the finished silk fabrics tested. Furthermore, these measurements initiate what could become an important database for the objective evaluation of finished pure silk fabrics. Such a database could be used in the future, for example, to evaluate quantitatively the effects of silk finishing treatments, such as degumming, bleaching, dyeing and drying, on the quality attributes of the final fabric. It is also possible that a database of finished silk fabric mechanical properties could be used to engineer new characteristics or attributes into finished silk fabrics and also to provide a basis for the control of fabric making-up operations during apparel manufacture. These were given in reference (6).

5. Instrument developed and its problems

Kawabata evaluation system for fabrics (KES-F) was developed to determine the various properties of fabrics. The system of evaluation is globally accepted and it is used in many research purposes. It is very costly and its use on commercial purposes is not there. The database generated were not known to industry people. The customers are not aware of the various development happened. So it is responsible for the researchers and academician to give suitable consultancy services and provide necessary instruments at affordable price.

6. New instrument developed and its testing

Description of the instrument

The instrument consists of bottom plate, back plate, top clamps, bottom clamps, frictionless guide pulley, scale, nylon yarn, pans and an indicator wire. The bottom plate and back plate are connected by screws. The back plate stands vertically and the setup is sturdy. Two slots are made on the back plate for fixing guide pulleys. The top clamps are fixed to the back plate with screw rods. The top clamps are immovable. Emery sheets are pasted over the top and bottom clamps to have grip over the fabric. The bottom clamps are connected to the pan with nylon yarn which runs over the frictionless pulley. The bottom clamps are movable to the left and right by the addition of weights over the pan. The indicator wire is fixed to the bottom clamp. Scale is fixed at the bottom between two frictionless pulleys. The indicator wire shows the reading of the movement of bottom clamps in millimeter. The scale constitutes the additional item which was not existing in the method developed by Treloar (1965). Hence this represents a novel feature of the instrument.

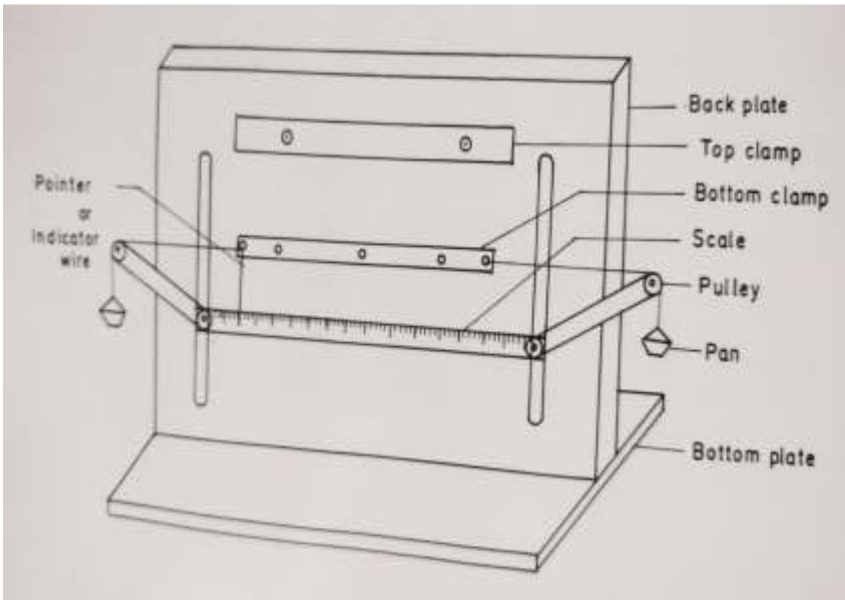

Figure1. Setup of shear apparatus

Working method

Fabric sample of 20 cm x 5cm was mounted between top and bottom clamps of the instrument. The edges of the fabric samples were unraveled to have parallel threads over the edges. Vertical weight of 200 gms including clamps weight was added and the force becomes 10 gf/cm. The readings on the scale were noted down initially. Constant weight of 6 gms were added to the right pan and the readings on the scale were noted down. The readings were noted down for seven millimeters of right pan movement. The readings were taken 30 seconds after the loading is over. The time factor was fixed in order to avoid any error due to Viscoelasticity. The weights were then taken out and loaded to left pan and the corresponding indicator readings upto 7mm were noted down. Again the weights were taken out and loaded to right pan and the indicator wire readings were noted down. An example of the readings taken is given in table 1.

Table 1
Example of reading taken in new instrument

Load gms	Reading on scale				
	A	B	C	D	E
0	7.7	8.1	8.1	7.3	7.3
12	7.7	8.3	8.0	7.1	7.3
24	7.7	8.4	7.8	7.0	7.4
36	7.8	8.5	7.7	6.9	7.6
48	7.8	8.6	7.6	6.9	7.7
60	7.8	8.6	7.5	6.9	7.8
72	7.9	8.7	7.4	6.9	7.9
84	8.0	8.7	7.3	6.9	8.0
96	8.1	8.7	7.2	6.9	8.1
108	8.2	8.7	7.2	6.9	8.1
120	8.3	8.7	7.1	6.9	8.2
132	8.4	8.7	6.9	6.8	8.3

144	8.5	8.7	6.9	6.8	8.4
156	8.5	8.7	6.8	6.8	8.5
168	8.6	8.7	6.8	6.7	8.6
180	8.7	8.7	6.7	6.7	8.6

A- Right side displacement
B- Recovery from right side
C- Left side displacement
D- Recovery from left side
E- Right side displacement

Calculation

Shear Angle $\Theta = \tan^{-1}(5/X)$

X = 0.1 to 0.7 in steps of 0.1 cm … (1)

Shear Force = F-W $\tan\Theta$ … (2)

Shear Force = Load – 200 x $\tan\Theta$ … (3)

By reducing the specimen size to 20 x 1.6 cm the shear strain becomes 24^0 as against 8^0 in a specimen of 20 x 5 cm as given below.

For 20 x 5cm $\tan\Theta = X/5 = 0.7/5 = 0.14$ … (4)

$\therefore \Theta = 8^0$

For 20 x 1.6cm $\tan\Theta = X/1.6 = 0.7/1.6 = 0.43$ … (5)

$\therefore \Theta = 24^0$

The distance moved X is 0.7 cm for both the sample sizes namely 20 x 5 cm and 20 x 1.6 cm.

Materials and methods

The samples used for testing are given. Group A samples and Group B samples were used for testing.

Table 2
Group A Fabrics

Sample No.	Code	Description Of Material	Details Of treatment
1	a	100% PET dress material	Control
2	a_1	Effect of both ratio	1:3
3	a_2	Effect of both ratio	1:20
4	a_3	Effect of both ratio	1:40
5	b	Control	Control
6	b_1	Effect of both ratio	1:3
7	b_2	Effect of both ratio	1:20
8	b_3	Effect of both ratio	1:40
9	c	Weight reduction + Heat set 170^0 C	
10	c_1	Heat set 170^0 C	
11	d	Heat set 180^0 C repeated weight reduction	
12	d_1	Heat set 200^0 C repeated weight reduction	

Table 3
Group B Fabrics

S.No.	Fibre Content	Weave	Threads/cm		Linear density (Tex)		Weight g/m^2
			Warp	Weft	Warp	Weft	
1	P/C 67/33	Plain	25	20	42	42	206
2	P/C 67/33	Plain	28	22	30	35	198
3	P/C 67/33	Plain	26	20	33	31	159
4	P/C 67/33	Plain	25	20	39	39	213
5	P/C 67/33	Plain	24	20	39	39	197
6	P/C 67/33	Plain	26	19	39	39	212
7	P/C 67/33	Plain	28	21	33	31	178
8	P/C 67/33	Plain	28	20	30	30	166
9	P/C 67/33	Plain	25	20	42	39	221
10	P/C 67/33	Plain	26	20	42	45	213
11	P/C 67/33	Plain	25	18	39	39	192
12	P/C 67/33	Plain	25	20	37	39	201
13	P/C 67/33	Plain	25	20	37	39	196
14	P/C 67/33	Plain	46	28	14	13	112
15	P/C 67/33	Plain	43	35	12	11	128
16	P/C 67/33	Plain	42	35	12	12	106
17	P/C 67/33	Plain	37	37	12	11	95
18	P/C 67/33	Plain	41	29	15	17	111
19	P/C 67/33	Plain	43	34	12	12	103
20	P/C 67/33	Plain	28	20	31	31	192
21	P/C 67/33	Plain	28	22	33	35	183

Results

Calculations of shear force and shear angle are given in Table 4. From the shear force and shear angle values for different loads, shear hysteresis curve was drawn. The experiment was repeated five Times, and the average of the shear parameters was found out. These readings were then compared with KES-F values, (sample tested also in KES-F instrument) and the correlation between the values was calculated.

The experiments were repeated for different treated samples differing in construction particulars, and the shear parameters namely shear rigidity and coercive shear stress were measured. Since the recovery was not good, shear hysteresis values 2HG and 2HG5 were not taken. The readings of the shear parameters and KES-F values are given in Table 5 and 6.

Table 4

Calculation of shear stress and shear angle from new instrument

A		B		C		D		E	
Shear Stress (g/cm)	Shear Angle (deg)	Shear Stress (g/cm)	Shear Angle (deg)	Shear Stress (g/cm)	Shear Angle (deg)	Shear Stress (g/cm)	Shear Angle (deg)	Shear Stress (g/cm)	Shear Angle (deg)
0	0	-0.28	4.58	-0.28	4.58	-0.28	-4.58	-0.28	-4.58
0.6	0	0.18	6.88	-0.69	3.44	-0.18	-6.88	-0.32	-4.58
1.2	0	0.705	7.45	-1.43	1.44	-0.71	-7.45	-0.99	-3.44
1.73	1.14	1.235	8.02	-1.8	0	-1.24	-8.02	1.73	-1.14
2.33	1.14	1.765	8.59	-2.33	-1.44	-1.84	-8.02	2.4	0
2.93	1.14	2.365	9.17	-2.86	-2.29	-2.44	-8.02	2.93	1.14
3.46	2.29	2.89	9.17	-3.39	-3.44	-3.04	-8.02	3.46	2.29
3.99	3.44	3.49	9.17	-3.92	-4.58	-3.64	-8.02	3.99	3.44
4.52	4.58	4.09	9.17	-4.45	-5.73	-4.24	-8.02	4.52	4.58
5.05	5.73	4.69	9.17	-5.05	-5.73	-4.84	-8.02	5.12	4.58
5.58	6.88	5.29	9.17	-5.58	-6.88	-5.44	-8.02	5.65	5.73
6.105	7.45	5.89	9.17	-6.105	-7.45	-5.97	-8.59	6.18	6.88
6.635	8.02	6.49	9.17	-6.635	-8.02	-6.57	-8.59	6.71	7.45
7.235	8.02	7.09	9.17	-7.165	-8.59	-7.17	-8.59	7.24	8.03
7.765	8.59	7.69	9.17	-7.765	-8.59	-7.77	-8.59	7.77	8.59
8.29	9.17	8.29	9.17	-8.29	-9.17	-8.29	-9.17	8.37	8.59

Table 5

Shear parameters for polyester determined by KES-F and new instrument

S. No.	Shear Rigidity (g/cm.deg) Polyester Fabrics								
	Kawabata			Instrument developed in the present work					
				20 x 5			20 x 1.6		
	Warp	Weft	Mean	Warp	Weft	Mean	Warp	Weft	Mean
1	0.23	0.25	0.24	0.142	0.134	0.138	0.3135	0.325	0.3192
2	0.21	0.21	0.21	0.17	0.14	0.155	0.164	0.168	0.166
3	0.2	0.2	0.2	0.11	0.19	0.15	0.1315	0.1995	0.1655
4	0.21	0.21	0.21	0.21	0.13	0.17	0.1805	0.1785	0.1795
5	0.22	0.21	0.215	0.193	0.171	0.182	0.172	0.1635	0.1678
6	0.22	0.22	0.22	0.14	0.17	0.155	0.1925	0.2225	0.2075
7	0.22	0.21	0.215	0.23	0.27	0.25	0.2775	0.2605	0.2690
8	0.21	0.2	0.205	0.21	0.18	0.195	0.1738	0.1585	0.1662
9	0.25	0.26	0.255	0.23	0.22	0.225	0.161	0.117	0.139
10	0.23	0.23	0.23	0.19	0.19	0.19	0.1865	0.2070	0.1968
11	0.21	0.21	0.21	0.127	0.202	0.1645	0.196	0.12	0.158
12	0.22	0.21	0.215	0.144	0.176	0.16	0.124	0.194	0.159

Table 6

Comparison of Shear parameters for some commercial fabrics

S.No.	Sample	Shear Rigidity (g/cm.deg) Commercial Fabrics					
		Kawabata Value			Instrument developed in the present work 20 x 5 cm		
		Warp	Weft	Mean	Warp	Weft	Mean
1	A	1.367	1.228	1.298	1.560	1.550	1.555
2	B	1.448	1.255	1.352	1.490	1.340	1.415
3	D	2.125	1.804	1.965	1.958	1.540	1.749
4	E	1.131	1.030	1.081	1.375	1.210	1.293
5	F	1.480	1.480	1.480	1.850	1.150	1.500
6	G	1.325	1.216	1.271	1.295	1.090	1.193

7	H	1.258	1.174	1.216	1.150	1.240	1.195
8	K	1.489	1.352	1.421	1.950	1.260	1.605

Table 7
Correlation Co-Efficients between Kawabat (G) and New Instrument (G) Values For Low Weight Fabrics

Kawabata	New Instrument G (N/m)					
	20 x 5 cm sample size (8^0)			20 x 1.6 cm sample size (24^0)		
	Warp	Weft	Mean	Warp	Weft	Mean
Warp (8^0)	0.435	0.2362	0.4147	0.2472	0.1619	0.1633
Weft (8^0)	#	0.2363	0.1287	#	0.1939	0.3014
Mean (8^0)	#	#	0.2513	#	#	0.2507

Table 8
Mean and Standard Deviation of G Values for Low Weight Fabrics

S.No.	Particulars	Mean (N/m)	Standard Deviation (N/M)
1	Kawabata Warp 8^0	0.2192	0.0131
2	Kawabata Weft 8^0	0.2183	0.0190
3	Kawabata Mean 8^0	0.2188	0.0157
4	New instrument 20 x 5 Warp 8^0	0.1747	0.0414
5	New instrument 20 x 5 Weft 8^0	0.1811	0.0391
6	New instrument 20 x 5 Mean 8^0	0.1779	0.0328
7	New instrument 20 x 1.6 Warp 24^0	0.1894	0.0547
8	New instrument 20 x 1.6 Weft 24^0	0.1928	0.0581
9	New instrument 20 x 1.6 Mean 24^0	0.1911	0.0524

Table 9
Correlation C0-Efficient of Kawabata G and New Instrument G Values for Medium weight Fabrics

	New Instrument 20 x 5 cm sample size 8^0
Kawabata Warp 8^0	0.7195
Kawabata Weft 8^0	0.7350
Kawabata Mean 8^0	0.7956

Table 10
Mean and Standard Deviation of Kawabata G and New Instrument G Values for Medium weight Fabrics

S.No.	Particulars	Mean	Standard Deviation
1	Kawabata Warp 8^0	1.4529	0.2974
2	Kawabata Weft 8^0	1.3174	0.2360
3	Kawabata Mean 8^0	1.3855	0.2644
4	New Instrument 20 x 5 cm Warp 8^0	1.5785	0.3092
5	New Instrument 20 x 5 cm Weft 8^0	1.2975	0.1697
6	New Instrument 20 x 5 cm Mean 8^0	1.4381	0.2010

Table 11
Corrective Shear Stress Values Obtained From New Instrument for Low Weight Fabrics

S.No.	Corrective Shear Stress (g/cm) Polyester Samples					
	20 x 5 cm			20 x 1.6 cm		
	Warp	Weft	Mean	Warp	Weft	Mean
1	1.0	1.0	1.0	2.05	1.0	1.525
2	1.6	1.15	1.375	0.95	1.45	1.200
3	0.85	1.0	0.925	0.65	1.15	0.9
4	1.0	1.3	1.15	1.2	1.05	1.125
5	1.3	1.15	1.225	1.7	1.65	1.675
6	1.1	1.0	1.05	1.1	0.9	1.0
7	0.9	0.92	0.91	0.45	1.0	0.725

8	0.7	0.8	0.75	1.35	1.25	1.3
9	1.2	1.45	1.325	1.67	1.7	1.685
10	0.8	0.9	0.85	0.95	1.05	1.0
11	1.05	0.65	0.85	1.55	1.1	1.325
12	1.15	0.95	1.05	1.05	1.6	1.325

Table 12
Corrective Shear Stress (N/M) Values Obtained From New Instrument for Medium Weight Fabrics

S.No.	20 x 5 cm Sample Size Commercial Samples		
	Warp	Weft	Mean
1	1.8	1.9	1.85
2	1.95	2.0	1.975
3	2.15	2.4	2.275
4	1.45	1.5	1.475
5	2.3	1.35	1.825
6	2.0	2.1	2.05
7	1.8	1.9	1.85
8	2.0	1.95	1.975

The correlation co-efficient, mean and standard deviation between KES-F values and method developed are given in Tables 7, 8, 9 and 10. The experiments were repeated for sample size of 20 x 1.6 cm and the readings were presented. Coercive shear stress values (Half of Y-intercept) are given in Tables 11 and 12.

Figure 2 illustrates the set up of shear apparatus. Figure 3 and 4 show the shear stress strain curves.

Figure2. Setup of shear apparatus (Treloar's method)

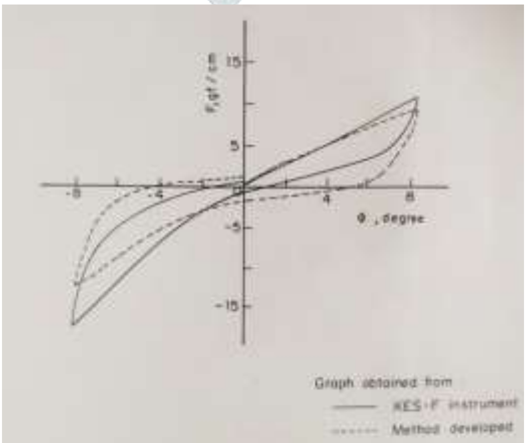

Figure3. Shear Stress Strain Curves obtained by both methods

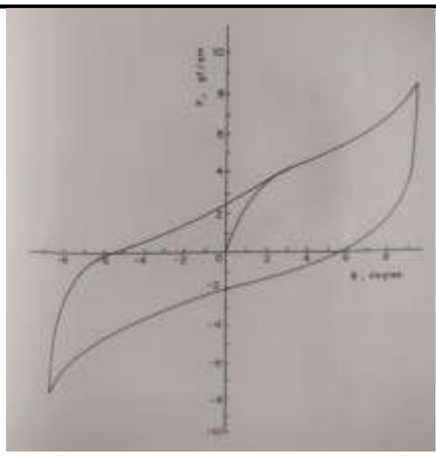

Figure4. Shear Stress Strain Curves

It is concluded that the same shear parameters could be obtained in an inexpensive manually operated instrument. The other parameters can be found out if the manual setup is suitably altered.

Tightness factor of weft knitted fabrics has a significant effect on the shear parameters. Also, pick density in the case of woven fabrics influences shear parameters. An analysis of shear parameters within the knitted and woven fabrics has been made.

7. Results

The hand values are very important in determining the quality of fabric. It is given in table 13, 14 and 15.

Table 13
Primary Hand Expressions and their definitions

HAND		Definition
Japanese	**English**	
Men's Winter Suit Fabric		
KOSHI	Stiffness	A feeling related with bending stiffness. Springy property promotes this feeling. The fabric having compact weaving density and woven by springy and elastic yarn makes this feeling strong.
NUMERI	Smoothness	A mixed feeling come from smooth, limber and soft feeling. The fabric woven from cashimere fiber gives this feeling strongly.
FUKURAMI	Fullness and Softness	A feeling come from bulky, rich and well formed feeling. Springy property in compression and thickness accompanied with warm feeling are closely related with this feeling. (FUKURAMI means "swelling".
Men's Summer Suit Fabric		
KOSHI	Stiffness	A stiff felling from bending property and springy property promotes its feeling. High density fabrics made by springy and elastic yarn usually possess this feeling strongly.
SHARI	Crispness	A feeling come from crisp and rough surface of fabric. This feeling is brought by hard and strongly twisted yarn. This feeling brings us a cool feeling. (This word means a crisp, dry and sharp sound arisen by that the fabric is rubbed with itself).
HARI*	Anti-drape stiffness	Anti-drape stiffness, no matter whether the fabric is springy or not. (This means "spreading").
FUKURAMI*	Fullness and softness	Feeling come from a bulky, rich and well formed feeling. Springy property in compression and thickness accompanied with warm feeling.
* These are recently added to the primary hand group for the summer men's suit fabric		

Table 14
Primary Hand Expressions and their definitions for women's medium-thick fabrics

HAND		Definition
Japanese	**English**	
KOSHI	Stiffness	A feeling related with bending stiffness. Springy property promotes this feeling. The fabric having compact weaving density and woven by springy and elastic yarn makes this feeling strong.
NUMERI	Smoothness	A mixed feeling come from smooth, limber and soft feeling. The fabric woven from cashimere fiber gives this feeling strongly.

FUKURAMI	Fullness and Softness	A feeling come from bulky, rich and well formed feeling. Springy property in compression and thickness accompanied with warm feeling are closely related with this feeling. (FUKURAMI means “swelling”.
SOFUTOSA*	Soft feeling	Soft feeling, a mixed feeling of bulky, flexible and smooth feelings.
* These is not a primary hand. This expression was added as a semi-primary hand because that this feeling was important for ladies dress fabric.		

Table 15
Primary Hand Expressions and their definitions for women’s medium-thin dress fabrics

HAND		Definition
Japanese	English	
KOSHI	Stiffness	A stiff felling from bending property and springy property promotes its feeling. High density fabrics made by springy and elastic yarn usually possess this feeling strongly.
HARI	Anti-drape stiffness	Anti-drape stiffness, no matter whether the fabric is springy or not. (This means “spreading”).
SHARI	Crispness	A feeling come from crisp and rough surface of fabric. This feeling is brought by hard and strongly twisted yarn. This feeling brings us a cool feeling. (This word means a crisp, dry and sharp sound arisen by that the fabric is rubbed with itself).
FUKURAMI	Fullness and Softness	Soft feeling, a mixed feeling of bulky, flexible and smooth feelings.
KISHIMI	Scrooping feeling	Scrooping feeling. A kind of silk fabric possesses this feeling strongly.
SHINAYAKASA*	Flexibility with soft feeling	Soft, flexible and smooth feeling.
* These is not a primary hand but semi-primary hand. This hand is added because of its importance at the evaluation of the ladies thin fabric.		

The total handle value is determined by using the expression values by experts.
5 is excellent 4 – good 3-average 2-below average 1-poor 0-out of use.

These were given reference (7). The results obtained can be summarized. The types of silk fabrics, races, various tests are given here. The problem of design staggering is severe and hence investigation is done to tackle the problem, Breakage of fabric due to shear is also explained. Work done by various authors were given. The research purpose instrument and its problems were explained. The new instrument developed & its testing is explained. With this knowledge it is possible to use the new instrument for avoiding design staggering. For better feel the various hand expressions were given which could be used for practical purposes.

8. Discussion

The voftine means year univoltine means once in a year, bivoltine means thrice in a year, multivoltine means two or more times in a year. Japanese race Chinese, European and Indian races have different lengths of silk yarns. The different kinds of silk fabrics shows different characteristics. Designs embedded on fabrics shows varied shaped after washing and prolonged wearing of clothes. Silk fabric is different from other types of fibre fabric. Matsudaira and Postle have already done work on shear property of fabric. The mechanism of deformation should be understood. During shear the fibres in the yarn dislocates and when load is removed, fibres tend to eject out and appear as protruding fibres which is also called as hairiness. After removing the load and sheared in opposite direction the fibres produces more hairiness. So the bulky shear curve is produced for other fabrics. In silk fabric since the filament is very long hairiness is very less and hence thin shear curve appears on testing as reported by Matsudaira. Hence the deformation once made is permanent for silk fabrics. All types of silk fabrics can be tested for shear property and the fabrics with good recovery can be used for design purposes. This will avoid design staggering and customer will be satisfied once design is in good shape after using for long duration.

9. Conclusions

The new instrument developed shows good result. The instrument can be used for determining fabric which has poor shear property. Those fabrics can be avoided in sales and customer can be supplied with good fabric. For silk fabric, the shear property must be used for objective evaluation purposes and shear curve can be found out easily.

10. Acknowledgement

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