Different Techniques in Measuring Of Flexural Rigidity of Fabrics - Review

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Different Techniques in Measuring Of Flexural Rigidity of Fabrics - Review

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So many techniques to find the flexural rigidity of fabrics are already studied. In this various system of flexural rigidity of fabrics, we have also studied limitations and conditions. In this article, the various simple method of flexural rigidity, bending relaxation were studied and timely observed the useful information and determining the technique also.

Mostly the flexural rigidity and bending of fabrics is related to its own weight. In this article we explained the correlation of various methods and observations. The first person of Peirce(1J(1930) who has done the more research papers on flexural rigidity in various directions and methods, but he involved fully in pure flexural rigidity of cantilever principle of the fabric test. The other methods J.D.Owen's & R.G.Livesel (1964) involved the pure bending by simple manual cloth bending tester. The other special type of bending length of loop method by I.M.Stuart & K.Baird (1966) has done on research work of bending of woven fabrics .Likewise other researcher work done on the stress relaxation on bending by Dhingrere et.al, Behra et.al etc. Now we have discussed the new technique of Inverse stress relaxation on bending.

Properties of Flexural Rigidity of Woven Fabrics

Highly determines the flexural rigidity of the fabric is related with its shear rigidity and also correlated with drape, handle, buckling, wrinkle & crease resistance and also Formability. The determination formability is mostly in the FAST system. This will be found by multiplication of bending rigidity and fabric thickness. Normally formability is highly related with the Tailor ability. Whenever the two fabrics are seems to be joined, the seam puckering will be occurred. This will be affected the formability and tailor ability also. When fabric is thin, the formability is more, and also the puckering is less and vice versa. The flexural rigidity of the fabric is determined through the stress relaxation of fabrics by the hysteresis loop.

Measuring System of Various principles of Flexural Rigidity

Basically the flexural rigidity is classified into 2 categories, (1) Flexural rigidity of fabric by its own weight category, (2) Couple & Curvature, Moment category. Shirley stiffness tester, Stuart's bending length, Heart loop type, these are under first category. Simple bending tester like Eeg.Oleffson'stester, Livesey & Owen's tester, Isshi's tester, these are under second category. In the first category, there will not be any hysteresis loop also, because in this case the flexural rigidity maybe found non linear system, it's found by the cantilever system. Next in the second category, the flexural rigidity found by pure bending and the hysteresis loop also necessarily. The other sophisticated instruments are commercially available such as KESF instruments (Kawabata instrument), FAST system (Fabric Assurance by Simple Test), and SITRA FAST system also available.

Flexural Rigidity by Loop Method Principle

Already the master of cloth geometry, Peirce has given so many papers under the bending length measurement. In this method, the strip of fabrics is laying down on a surface by a type of "LOOP". The practical method of bending length by loop method is already described by Stuart and Baird(3) (1966).The bending length is directly proportional to the height of the loop.

Bending Length = 1.10 x Loop Height

Where loop height is determined by the distance between the neutral axes.

This method is an easy and simple method of very small instrument.

Test Requirements

1. Size of sample, Width is 1" and Length is 6".
2. A measuring scale is necessary to measure the height of the looped cloth.
3. The strip which is not adhere to the horizontal surface.
4. To Measure the thickness of the material by the thickness meter.

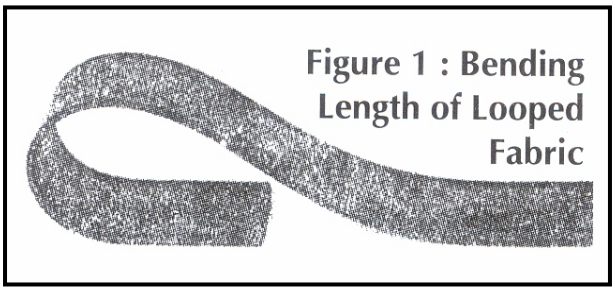

Figure 1 : Bending Length of Looped Fabric

To measure the height of loop from separation of Fabric the neutral axes at the highest and lowest portion of the loop. The fig: 1 represents the assumption of the neutral axis in the centre plan.

Loop height = Height of the loop top above supporting surface- Thickness of the material.

Another Method of Flexural Rigidity by Cantilever Principle

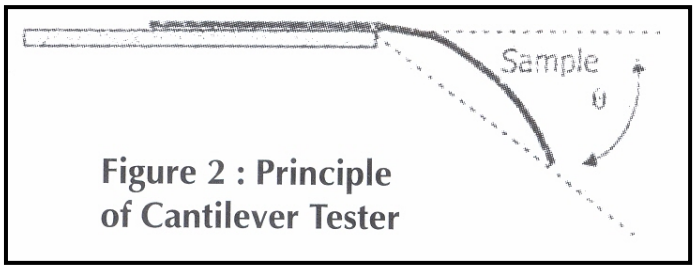

Figure 2 : Principle of Cantilever Tester

The test method of bending length is the Cantilever method represented in the fig. The first person Peirce (1) (1930) was found the flexural rigidity of the fabric by bending length of 2 cm in Heart loop method. This is only short length 2 cm sample, more than the 2 cm bending length, the Cantilever method is used. In the Cantilever Principle, the length of sample is 6" and width of a sample is 1 ", the no. sample was tested. The sample is slided over the plate form of the stiffness tester by the sliding scale and the front edge of the fabric is touches the 41.5° angle of the simple method.

The strip bending length “C” is derived from the formula

$$C = I \frac{(\cos \theta/2)^{1/3}}{8 \tan \theta}$$

The flexural rigidity (G) was calculated by the following formula

$G = 3.39\ W_1C^3$ mg.cm

$G = W_2C^3 \times 10^3$

Flexural rigidity is calculated for warp and weft ways of fabrics and over all flexural rigidity is calculated as geometric mean those two values.

Overall flexural rigidity $Go = (G_w . G_f)^{1/2}$

$$q = \frac{732\ G}{g_1^3}\ kg/SQ.cm$$

$$= \frac{12G}{g_2^3} \times 10^{-6}$$

Heart Loop and Pear's loop method

The free end of the specimen is mounted in a clamp in the apparatus, so that the is free to hand vertically. A stiff fabric is shown in the fig.3a and very limp fabric in fig. 3b

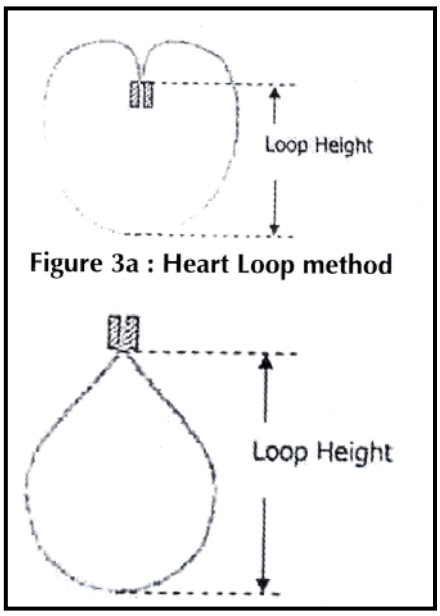

Figure 3a : Heart Loop method

After an interval of 1 mm the distance between the top edge of the clamp to the bottom of the loop, I is measured. In this test, stiffness is inversely proportional to the length I. Then the specimen is removed from the clamp, turned over and the experiment is repeated and the length I is measured again. The above procedure is repeated for all the test specimens and the average length I is called as loop length measured in cm, and the bending length is calculated using the following formula.

Bending length $C = l_0 + (\theta) / l_0$

Where $\theta = 32\text{-}85 \times d$ degrees

The Bending length of specimen (under the known length & width) which is in the form of heart shape and hanging over a horizontal bar and also the two edges are folded together. The loop height is measured in between the clamping edge of top portion and bottom portion of folding edge. Same like as for the Pear's method also, the value of the loop length is applied in the Peirce's elastic model formula and also calculated the stiffness of the fabric. The heart loop method for heavy fabrics, Pear' loop method for light fabrics.

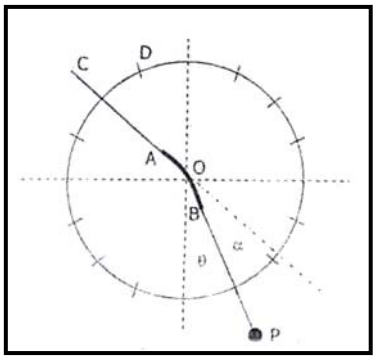

Figure 4: Simple bending Tester

Flexural Rigidity by Simple bending Tester

The flexural rigidity is very nearly related to the fabric handle,

- It's their bending resistance.
- It is depended on elastic theory, flexural rigidity, and the strip of the material.
- Bending beam means the ratio of the couple and curvature.

Livesey and owen and Abbott and Grosberg have researched more new trended tests on flexural rigidity of plain woven fabrics. In this system the specimen was bent by revolving one end about a horizontal plane and the couple developed by the defluxion from the vertical of a small weighted arm connected to the other end, the curvature was obtained from the variation between angular defluxion of the two ends. In this way 2 values of couple and curvature were calculated, and then plotted the bending hysteresis.

The flexural rigidity of all samples were studied on this type of pure simple bending tester. The sample size is 0.5X2.54 Cm was used for the test.

Bending Hysteresis Curve

The curvature is proportional to angle α and couple to sin θ and the distance from the specimen to the pointer centre of gravity. If W is the mass in gms of pointer and L the distance in em of the centre of gravity from the end B of the specimen, (Livesey & Owen's Principle) the mean couple in the specimen over the practical range of values of a and 8 is given by,

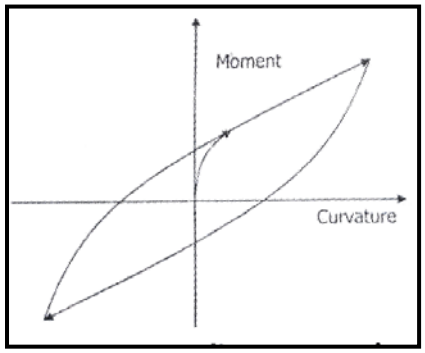

Figure 5: Bending Hysteresis Curve

Wg (L+0.35) Sin θ, dyne. cm

The fabric flexural rigidity is defined as the ratio of couple curvature for a strip of unit width .It is measured in dyne .cm. So the unit of flexural rigidity is dynes em/em. the curvature amplitude used in all the test in fabrics were 3cm". The parameters of hysteresis curve can be calculated by the following formula,

Coersive Couple= LM/2 dyne cm/cm

Initial flexural rigidity = Ratio of couple to curvature at Adyne
Final flexural rigidity = Mean slope of BC and FG dyne cm^2 / cm
Bending recovery = 100 X (JK-HD)/ JK % dyne cm^2 / cm

Eeg- Olofeson's pure bending tester

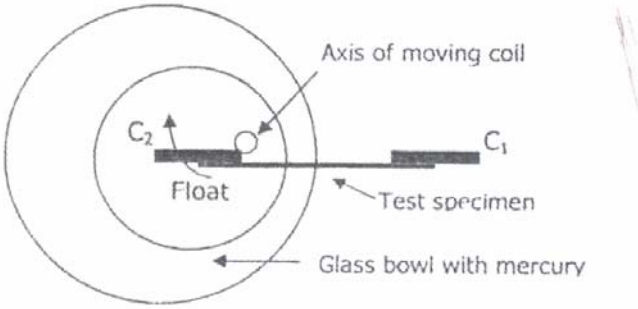

Figure 6 : Principle of Eeg- olofssion's tester

In this system, the moment and curvature curve was obtained by the 2 vertical clamp (C1,C2), one is fixed and another is floated as indicated in the fig 6.

The floated clamp C2 floates on mercury. It carries an electrical coil, which can rotate about a vertical axis in a magnetic field. When current flows, the coil rotates and moment is applied to the fabric by C2. In order to apply only bending moment to the sample, the float with clamp C2 must be able to move side ways. The radius of curvature of the sample depends on the current through the coil. As the moment is proportional to the current, it is easily determined by means of a multi meter. The curvature is indicated by the angle of

deflection of the coil. A complete curve of the moment of bending curvature relationship was obtained.

Isshi's pure bending tester

In this tester, the fabric sample was clamped at two ends and positively controlled. The total sample could be bent in an arc of constant curvature C, simultaneously the curvature was changed continuously. The tester represents in the fig; the sample is fixed in clamp at A and the other end B is driven to execute the uniform rotation of circular arc. The curvature is obtained from the angle of the pointer fixed on the moving clamp. A start which is prevented from rotation by the torsion spring, then the fixed clamp is mounted on the shaft. When the sample is bent, the fixed clamp causes a slight rotation of the torsion spring. Then the rotation is reversed back another spring, through the link system is nullified. The deflection of the nullified second spring can be recorded and is related to the bending moment on the clamp.

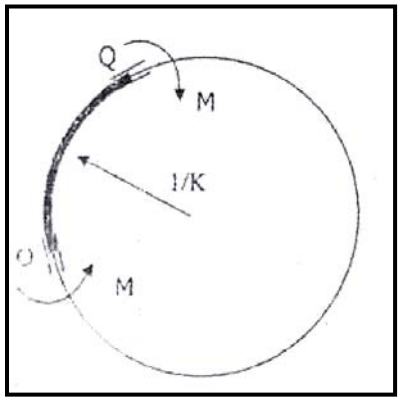

Figure 7: Principle of Isshi's Tester

KESF & FAST system

The KESF and FAST systems are all modified and modern technological sophisticated instrument, which is a costly one. The testing cost is too high, but the accuracy is very much higher. In this KESF pure bending instrument developed by the Kawabata by the consideration of the modification of Isshi's and Popper and Backer's work also.

The FAST system developed by the Common wealth scientific and Industrial research Organization (CSIRO) in Australia. It is also having a bending module. It is the basic principle of Pierce cantilever principle by using Optical device to the deflection angle.

Cloth bending and recovery by Compression of loop method

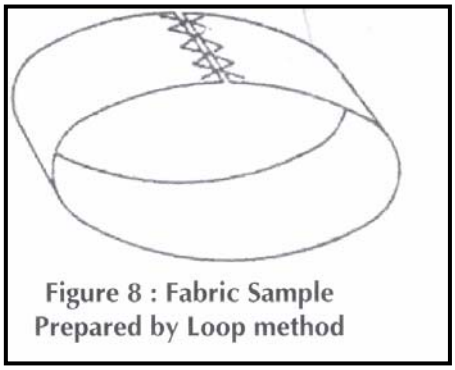

Figure 8 : Fabric Sample Prepared by Loop method

In this method, the et.als I.M. Stuart,P. Hetherington, and K.Balrd have been found the measuring of bending and recovery by using Instron tester. In this test, there are 2 loads are used to support and loop can be separated. One of the load is that arranged in between the fabric bends, this measure the in between fabric bends when compression starts, and also the remaining loads are carried by the bends. The sample sizes are 6x 2"; 4 X 2"; 3 X 2". The two ends of the stripe is stitched by the nylon filament as in the fig. 8.

Then the sample loop is placed in between the two plates of the Instron tester. The bottom portion of the sample was placed on the compression cell, and the top portion of Perspex plate (approximately 2.5 cm thick) was touches the sample, which is fixed on the movable cross head as in the fig. 9.

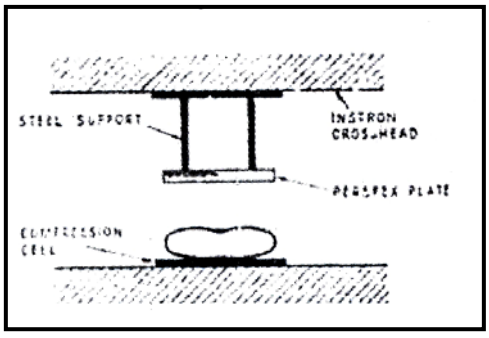

Figure 9: Sample fixed in the Instron Tester

Prof D.A.Gilla et.al was investigated on the bending behavior of the nylon & cotton fabrics on bios mode. In this case he discussed the bending recovery in the bios manner and found in relation between the residual elastic energy and bending recovery. That is the residual elastic energy also various that affects bending recovery also.

Conclusion

In this paper, we discussed so many types and method of bending property, The selection mode of the test is depended upon the depth of fabric & type of fabric used also. The testing property will be according to the customer usage and taste also. Suppose they wants to test the accuracy of bending, we goes to the pure bending instrument of automated simple bending tester and the advance instrument of KAWABATA system, which is a non linear one. That is the curvature principle. If they test for linear type of test means, we goes to test the other principles of cantilever, heart loop method, Pear's loop method, Stuart's Bend loop method etc.

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