Testing of Functional & Technical Textiles
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Lecture – 03
Testing of Low Stress Mechanical Properties of Textile Fabrics (contd..)

Hello everyone. So, we are discussing the FAST system.

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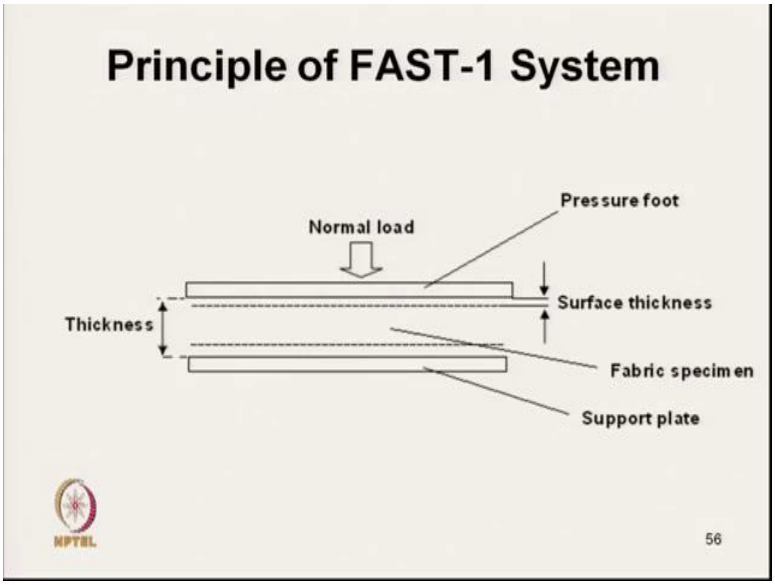

So, in last class we have discussed the FAST 1 system, which is actually compression method, compression module, where we can measure the surface thickness, and released surface thickness.

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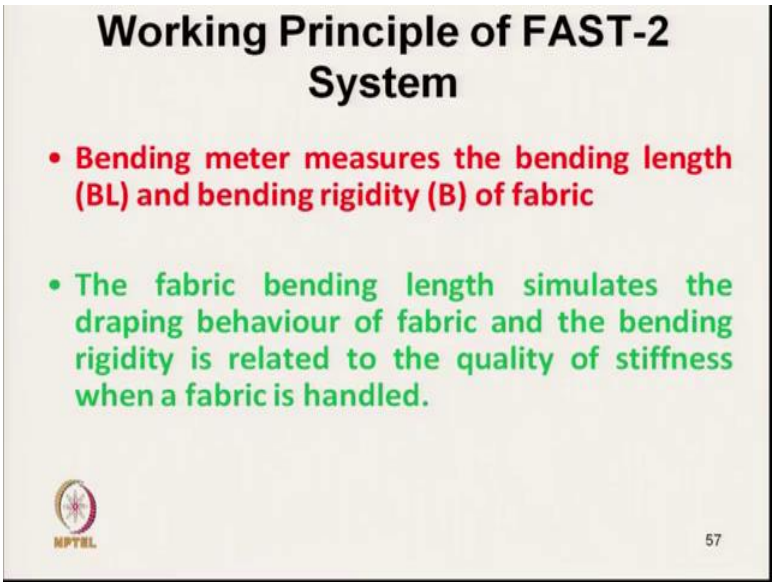

And, also we have discussed that second principle which is FAST 2 which measures the bending characteristics.

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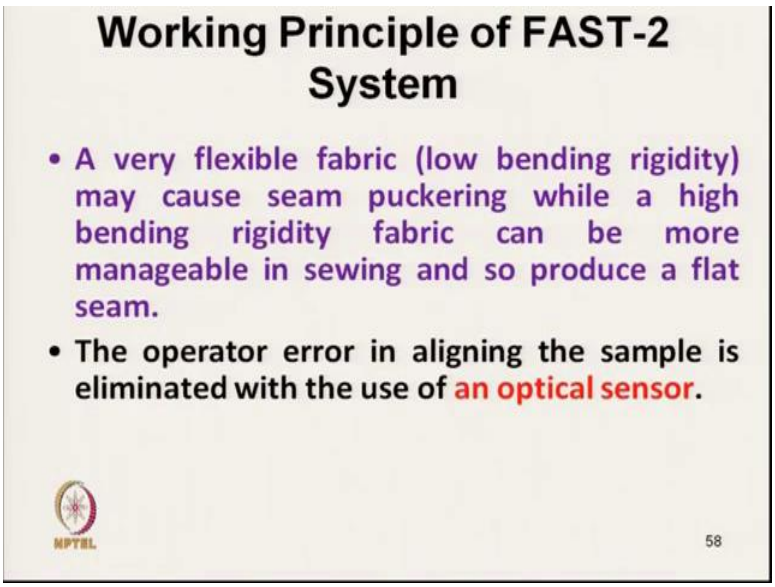

So, bending rigidity we can measure in that system.

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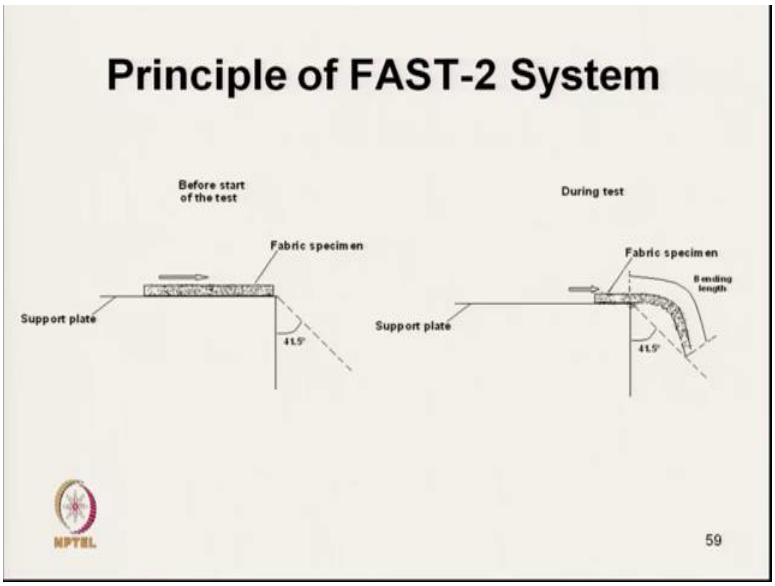

And, this system FAST 2 it is exactly same as that of Shirley stiffness tester.

Now, we will start another method, which is next module FAST-3 system.

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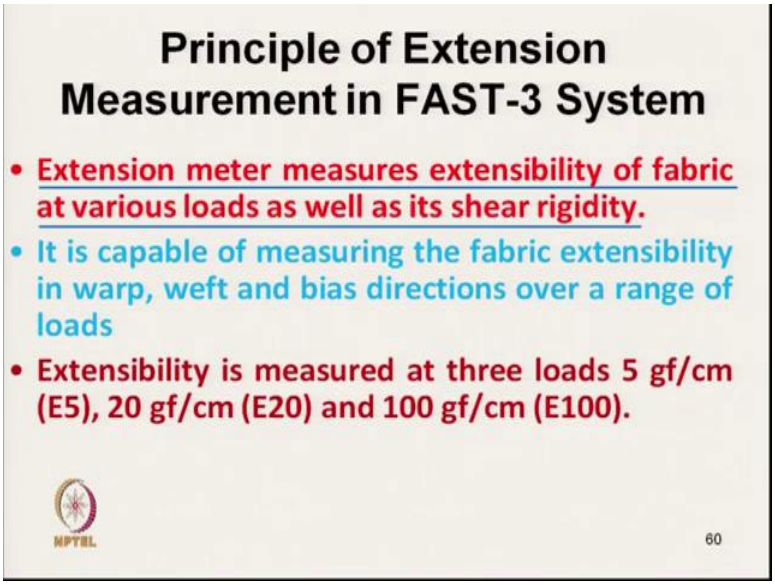

In FAST-3 system which is extension meter, which measures the extensibility of fabric, at different load condition. In addition to the extensibility it also measures the shear rigidity by biased extension. The instrument is very simple and the principle wise it is a simple. Here, we measure the extensibility by standard load. We do not measure the increasing load condition. Some fixed load condition we measure the extensibility.

It is capable of measuring the fabric extensibility, in warp direction, that is suppose this is the fabric, this is the length direction, warp direction, weft direction, and also in the bias direction. Bias direction at different biased angle we can measure the extensibility, which will indirectly show the shear characteristics of fabric. The extensibility is measured at 3 different loads at load 5 gf/cm, which is known as E 5 E 20 at 20 gf/cm and E 100, which is 100 gf/cm.

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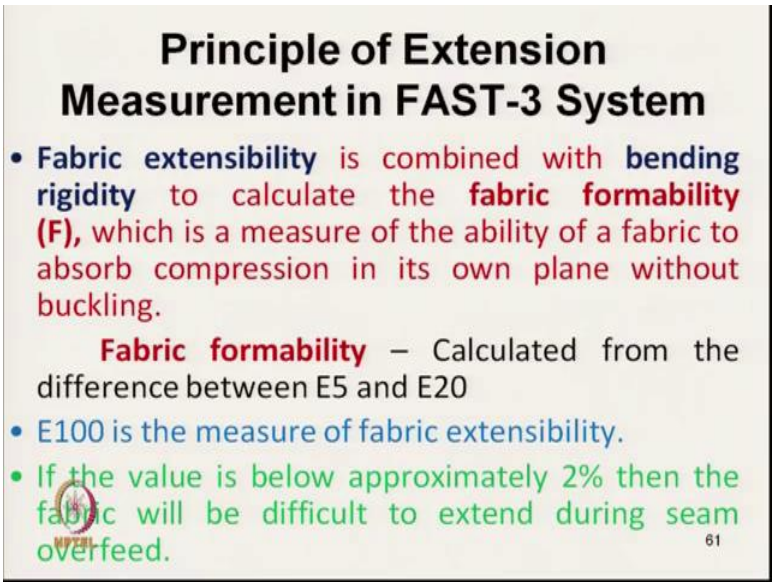

So, fabrics extensibility when it is combined with bending rigidity, which is used to calculate the formability of fabric. And, the formability is the measure of fabrics ability. Fabrics ability to absorb the compression on it is own plane without buckling. Suppose this is the fabric we want to compress the fabric on it is own plane without buckling it will not buckle, that is that quality is known as the fabric formability. And, which is calculated from the difference between E 5 and E 20. So, at the load 20 gf/cm and at the load 5 gm/cm whatever extensibility we get the difference is used to calculate the formability.

E 100 is a measure of fabric extensibility. So, that is the at 100 gf/cm load whatever value we get, that is expressed in terms of fabric extensibility. If, the value is below say approximately 2 percent then fabric will be difficult to extend during seam overfeed. So, that actually will predict the sewability of fabric and also E 100 will actually give idea about the stretchability of the fabric at lower extension.

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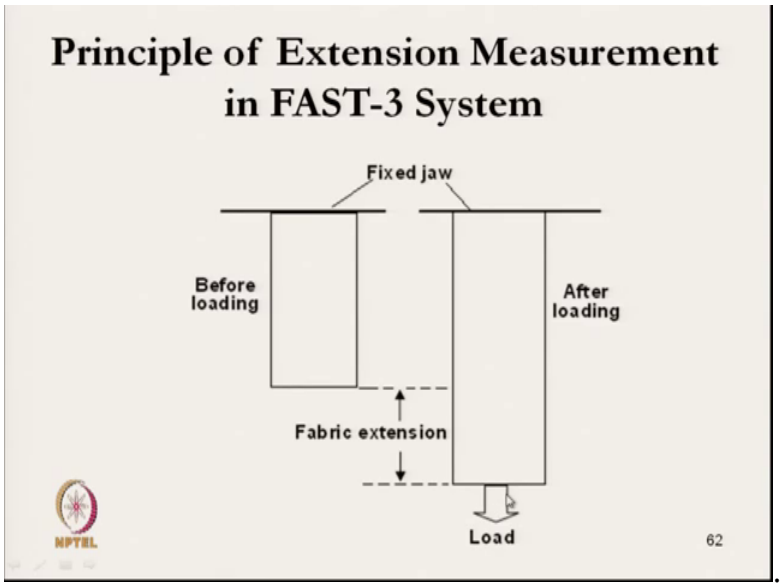

So, this is the fixed jaw before loading we have the fabric dimension and after loading is the fabric dimension, and that difference gives the fabric extension it is a simple by simple loading.

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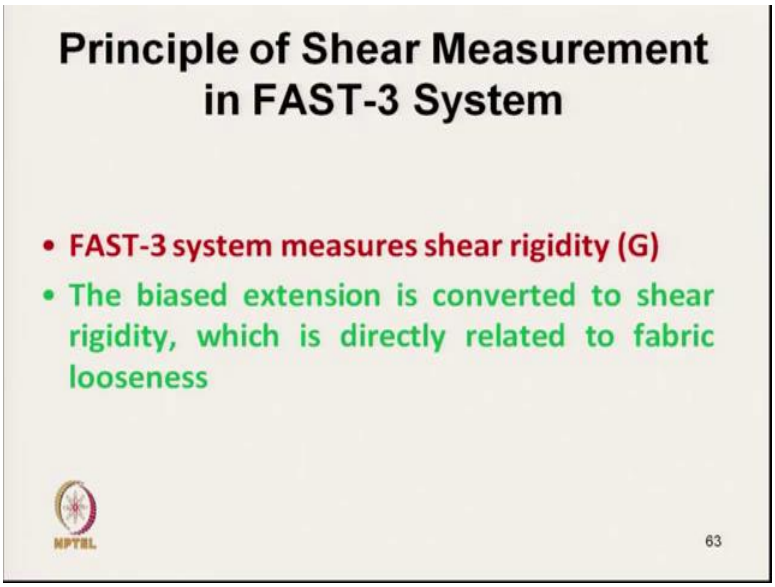

Here we are not talking about the unloading; here we are not talking about the continuous increase in load. And, FAST-3 system, measure the shear rigidity also, and biased extension is converted to shear rigidity which is directly related to the fabric looseness so; that means, if in warp and weft if they are loose enough then the shear rigidity will be low.

So; that means, they will simply there will be higher biased extension if the fabric shear rigidity is low.

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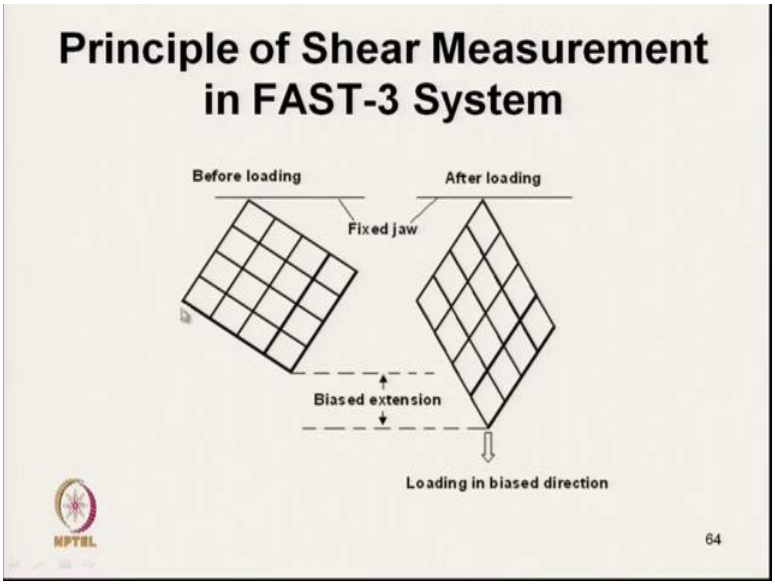

So, this is the way we express. So, this one is the, at biased direction, it is measures the warp direction or the weft direction and the after applying certain load the biased extension we can calculate.

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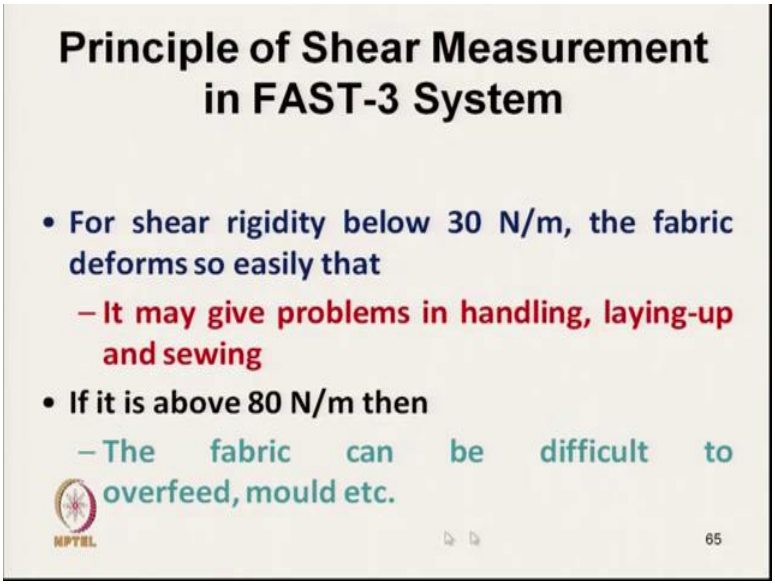

The shear rigidity below 30 N/m the fabric deforms. So, easily it create some problem. The problems will be it may give problem in handling the problem, laying up during the

stitching or during cutting operation, and sewing operation, if it is above it is very high, above 80 N/me, then the fabric can be difficult to overfeed ok. So, during the stitching operation this gives idea of the shear characteristics.

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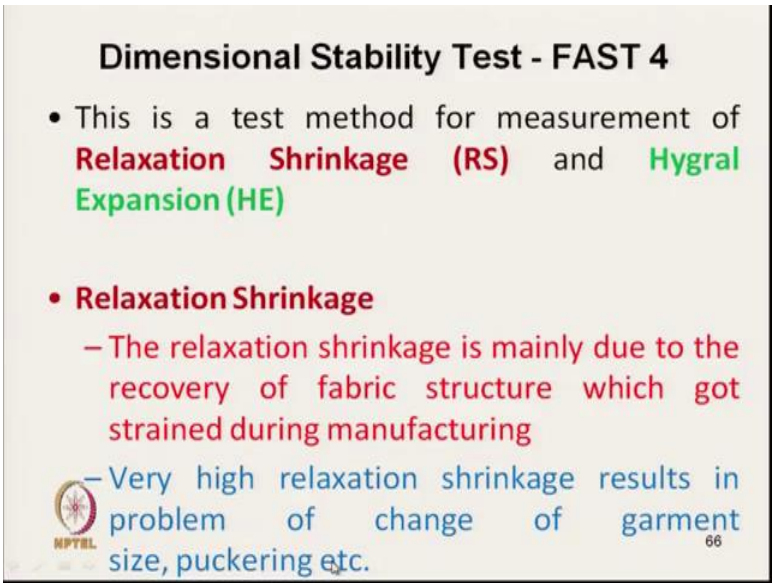

And, last method is that FAST 4 which measures the Relaxation Shrinkage and Hygral Expansion RS and Hygral expansion HE.

So, here the relaxation shrinkage is mainly due to the recovery of fabric structure which got strained during manufacturing. So, when the fabric is relaxed the type of actual relaxation, type of shrinkage, it gives idea about the relaxation shrinkage ok. And, very high relaxation shrinkage results in problem of the size of the garment ok, changes the garments dimension and puckering. Like a fabric warp and weft when we stitch together, in such an certain stitching point. If, the warp relaxation shrinkage is higher than the weft then it will actually show as seam puckering. So, that is, that creates problem we must measure the relaxation shrinkage.

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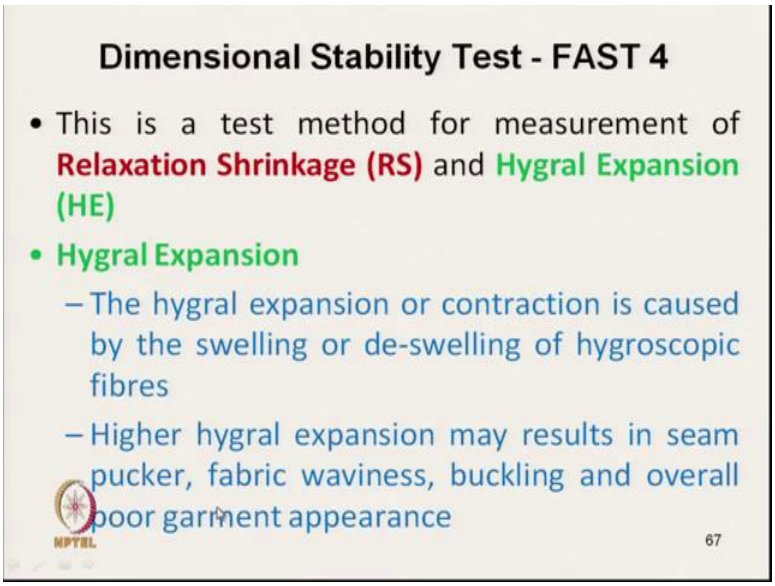

So, this is the test method for measurement of Relaxation shrinkage and Hygral expansion.

So, the hygral expansion it gives idea about the expansion or contraction of the fabric due to swelling or de swelling of hygroscopic fibres. The hygral expansion may result in seam puckering, fabric waviness, buckling and overall poor garment appearance. So, we must measure the hygral expansion also.

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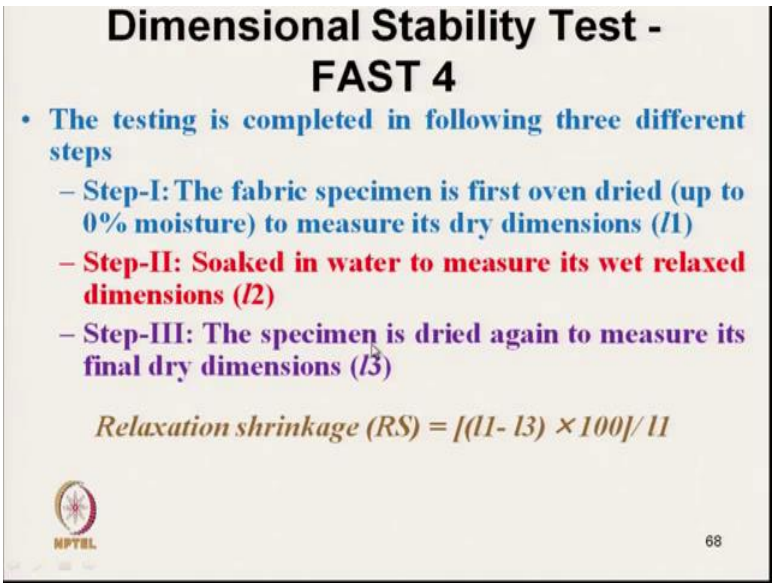

So, test here it has got 3 distinct steps to complete the test. The protocol is that in step 1 the fabric specimen is first oven dried up to 0 percent moisture to measure it is dry

dimension l1. So, first it has been oven dried brought up to 0 percent moisture and dry dimension is measured.

And, in step II, the fabric is soaked in water. And depending on the swelling and de swelling condition the fabric may get expanded or contracted. So, the dimension here it is l2. And, third is that the specimen is dried again to measure the final dimension, which is dry dimension, it is l3. From these 3 parameters l1, l2, l3 that maybe warp wise direction or maybe weft wise direction. We can measure both warp and weft wise direction l1, l2, l3.

And, from there we can measure 2 parameters 1 is relaxation shrinkage,

$$\textit{Relaxation shrinkage (RS)} = [(l1 - l3) \times 100]/ l1$$

that means, the initial dry condition and final dry condition, the difference between that divided by initial dry condition. So, that shows the relaxation shrinkage and hygral expansion is nothing, but that the difference

$$\textit{Hygral expansion (HE)} = [(l2 - l3) \times 100]/ l3$$

So, that gives the hygral expansion.

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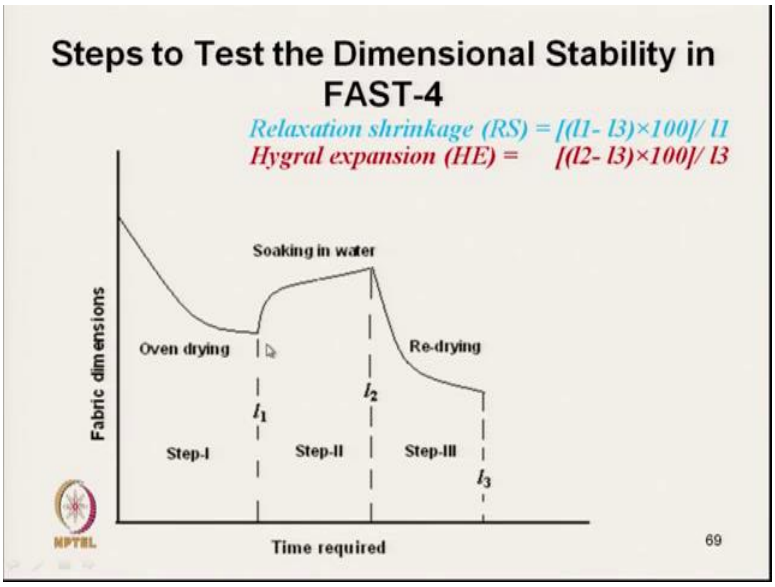

And, this is the diagram which shows here the fabric is initial stage. And, once it is dried oven drying and this is the stage 1 step, after step 1 we get the value l1. And, once it soaked it gets expanded it always it may not expand for this example it is expand it may contract ok.

Here it is after soaking it has become dimension has become l2 due to the swelling of the structure, and then after drying Re-drying it has come back to l3. So, this l1 and, l3 this difference gives idea about the relaxation shrinkage once it is relaxed. So, after soaking and Re-drying it has been relaxed and it gives the, whatever the shrinkage it is l3, l1- l3 that is actual shrinkage. So, it gives the idea about the relaxation shrinkage. And, hygral expansion it is l2 and l3 this difference it is a hygral expansion. So, from these 2 parameters we can get idea about the shape of the fabric and appearance of the fabric after stitching.

So, as we have seen the FAST the principles the 4 method this gives a very simple approach of measurement. Unlike the Kawabata system which is relatively complex system ok, complex measurement system and complex interpretation system, and FAST although it is has simple system, but it is interpretation gives us very nice information.

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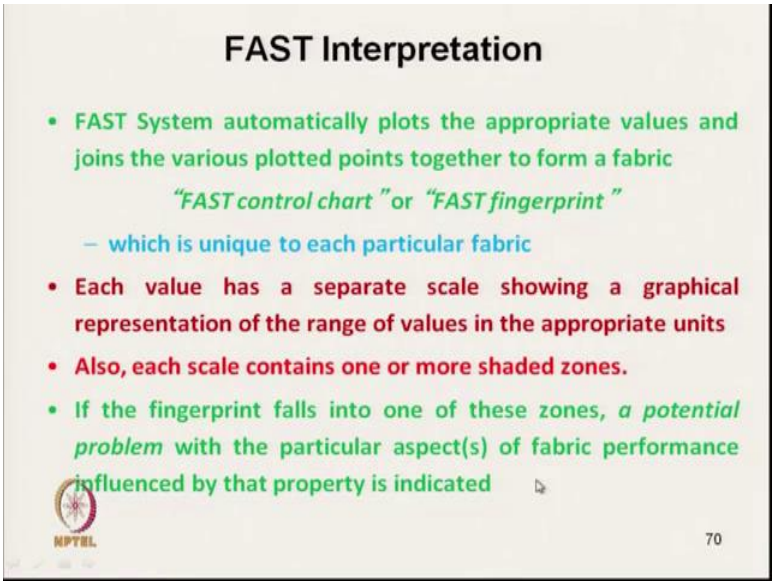

The FAST system automatically plots the appropriate values and joins the various plotted points together to form a fabric ok.

So, “FAST control chart” or fabric “FAST fingerprint”. So, fabric FAST control chart and or fabric FAST fingerprint they are same so, which is unique to each particular fabric. So, every fabric will get different fingerprints, we have different fingerprints, each value in the fingerprint has separate scale showing a graphical representation of the range of value in the appropriate unit.

So, for different hygral expansion, extensibility, formability so, this they have the different units in 1 fingerprint or 1 FAST control chart, we get all the parameter together. Also, each scale contains one or more shaded zone. This shaded zones actually shows the extreme point, defect point. If, the fingerprint falls into one of this shaded zone, a potential problem with the particular aspects of fabric actually fabric performance influenced by the property is indicated.

So, that actually if the fingerprint comes within that shaded zone, that will give us the indication that that there will be some problem in the fabric characteristics.

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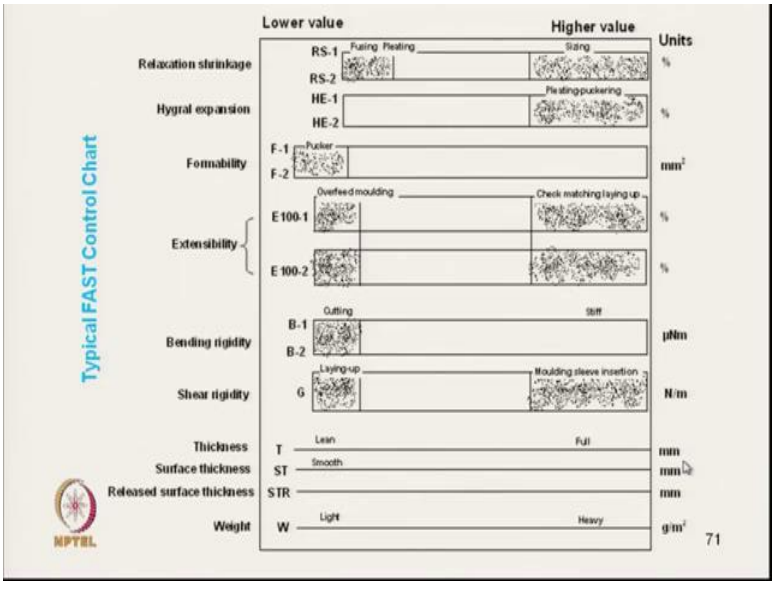

This is the typical fingerprint. Here FAST it is showing the relaxation shrinkage. RS RS-1 and RS-2, 1 indicates the warp direction and 2 indicates the weft direction.

Similarly, hygral expansion, HE1, HE2 and this shaded zone means there is some problem. If the relaxation shrinkage is very low, that we will create a fusing or pleating problem and sizing problem will be there if it is very high.

So, that if the value is in between; that means, the fabric will not have that much problem; that means, higher relaxation shrinkage will create sizing problem; that means, after the fabric is made after the garment is made, that will change the total size of the fabric. Similarly, formability F-1 F-2 warp direction, weft direction, extensibility it is E 100-1 and E 100-2; that means, warp direction extensibility and weft direction extensibility.

So, if the extensibility is very low; that means, overfeed there will be problem overfeed moulding there will be problem and if the extensibility is very high, then there will be check matching problem during laying up. So, for automatic laying up process, where the large number of layers are being laid of a fabric. And, if the fabric is single coloured then there is no problem, but if the fabric is check type fabric, then check matching problem will be there due to the higher extensibility.

So, that depending on the extensibility value we can predict the problem of check matching also. Similarly, bending rigidity if the fabric bending rigidity is very low ok, then we will have a problem of cutting related, problem will be there. And, B-1 means bending rigidity of warp and B-2 is bending rigidity of weft.

Shear rigidity you will have problem, if the shear rigidity, is low then there will be laying up problem, and then if the shear rigidity is very high, then moulding problem will be there ok. So, but shear rigidity as it is clear that there is no warp and weft because it is a measured by in biased direction. It is not measured like a extensibility in a warp and weft direction here it is measured in biased direction that is why shear rigidity it is a only 1 direction.

Similarly, thickness is we are we get thickness surface thickness we get released surface thickness we get. So, if the there is a difference between surface thickness and release surface thickness. We can get the idea from that idea from this plot and weight mass per unit weight. And in right side we get the unit like relaxation shrinkage, the unit is in %, hygral expansion in %, formability in unit mm^2 the extensibility in %, shear rigidity in N/m, bending rigidity μm. So, in right side we will get all the related units of the parameters, which is shown in the left side of this chart.

Now, I will show you typical fingerprint.

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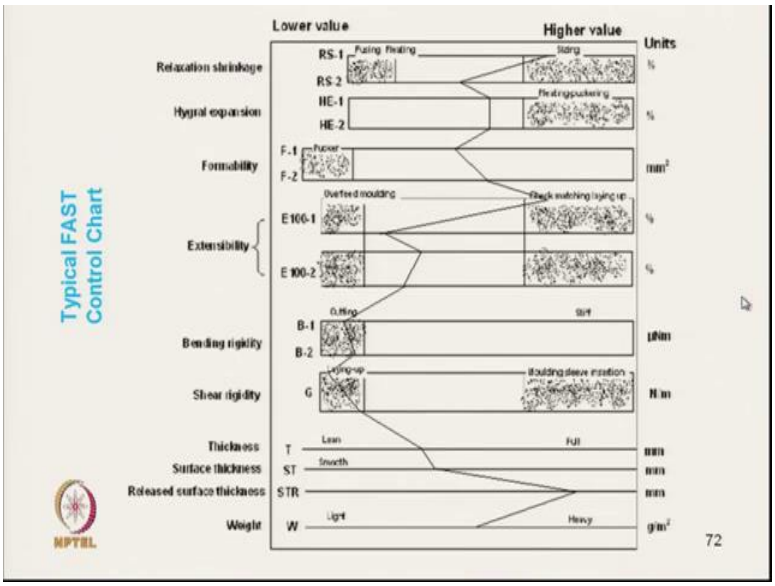

So, this is the typical fingerprint. From here we will we can get some idea we can get idea looking at the fingerprint, what type of problem this fabric will have? So, we will have the problem of sizing problem we will have, check matching problem this fabric will have, will have different cutting problem. So, this in at a glance from this fingerprint, we can get idea about what type of problem this fabric will have in further processing. So, this give idea we can take precautionary action on that.

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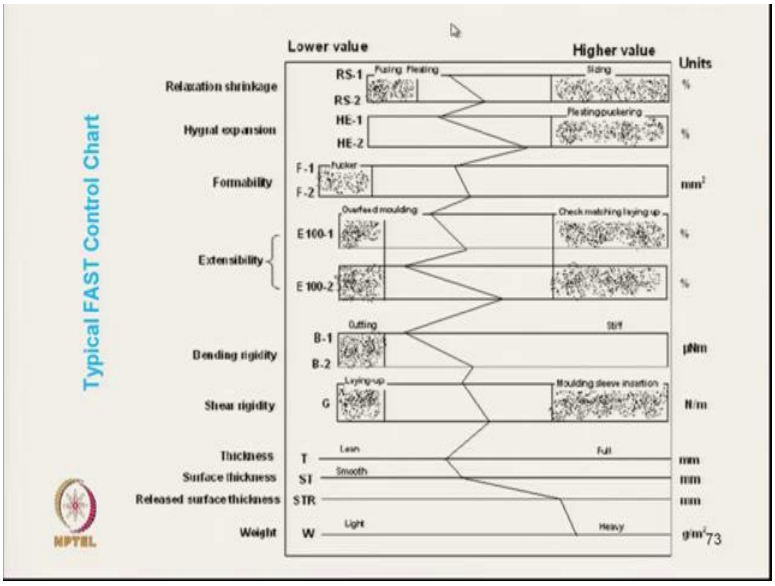

So, another plot this is the plot, which shows that fabric it is perfect, which will not give any problem during the process. So, our this is ideal fabric we should get, but here if we see the thickness and this there is a 1 problem. Here, it shows a surface thickness you will see it is a lower value. As compared to release surface thickness STR, which is very high, what does it show? It shows this fabric it is the whatever finishes were there this actually finishes went off during washing treatment.

So, the finish this gives idea although the fabric is perfect in all the sense, but the finish which has been applied it is not perfect ok. So, from there we can get. So, we will see if we see earlier fabric here also there is a problem of this release surface thickness.

Now, we will start another process of measurement of fabric handle characteristics, which is the principle of fabric extraction and by nozzle extraction principle.

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So, fabric extraction principle, here it has been common practice for many years it is not new principle ok. The useful technique in judgement of fabric handle, it is qualitative methods, old technique among ladies, where the fabric particularly scarf it is pulling out scarf through a the ring and judging the overall quality based on the resistance during the pulling out process. So, the fabric is being pulled through the ring and the resistance the force required to pull is being judged ok. And, that gives the idea about the fabric handle characteristics.

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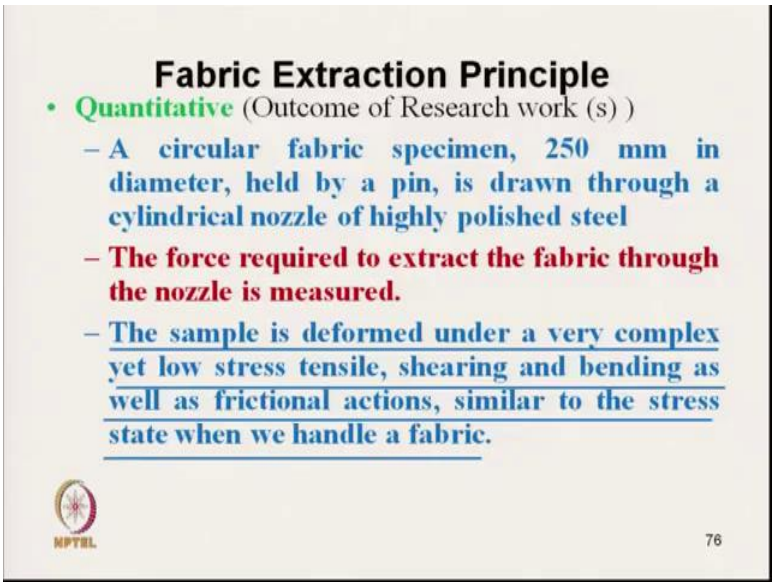

And, this principle is used it is a fabric extraction principle, it is Qualitative ok. Outcome of the Research Work is . A circular fabric specimen, which is 250 mm, 25 cm diameter fabric, it is centre point is held by a pin, which is drawn through a cylindrical nozzle ok, circular nozzle of highly polished steel. So once it is a drawn through the nozzle the load the force required to pull is measured. The force required to extract the fabric through the nozzle is measured. The sample is deformed under very complex at low stress, tensile shear and bending as well as the frictional characteristics ok.

So, the fabric is deformed during all during the extraction due to all this type of complex force, which is actually done during the handle of the fabric. While handling the fabric, we actually exert all these forces all these type of forces.

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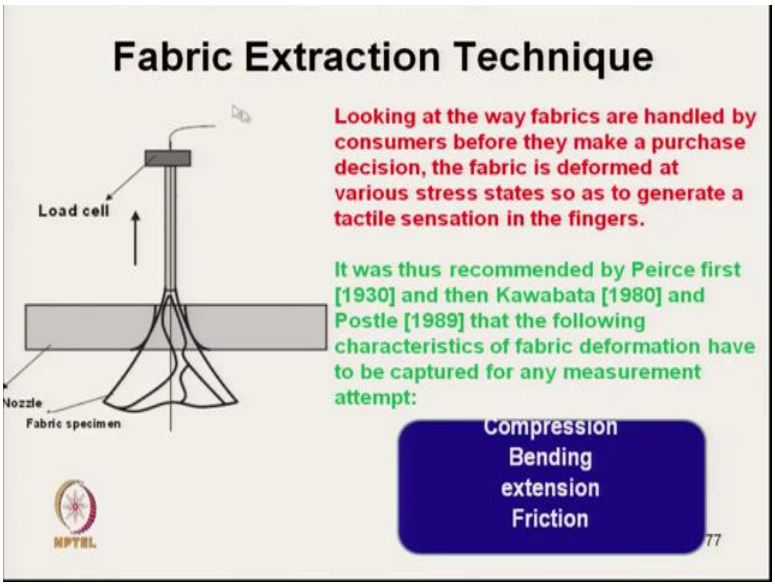

So, this is the technique here it is used. So, looking at the way fabrics are handled by consumer before they make a purchase decision, the fabric is deformed at various stress ok. It was actually first used by Peirce, then Kawabata and Postle different groups they have attempted to measure the extraction force, and correlate with the fabric handle characteristics. And, this during this extraction the fabric is undergoing compression, bending, extension, friction all this forces are actually coming into play.

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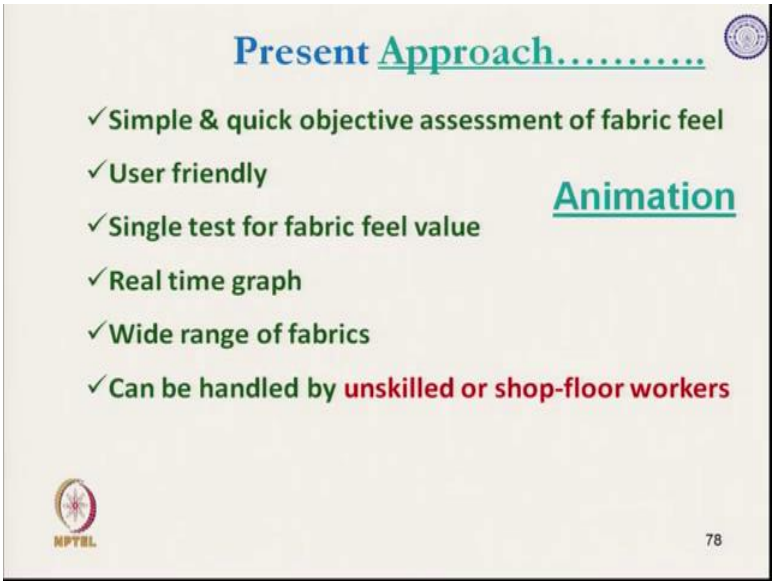

And, this present approach which is simple and quick objective assessment of fabric feel, which is user friendly anyone can handle, single test for a fabric feel value, we can get the fabric entire fabric feel value by single test unlike Kawabata or FAST where we have to test a large number of testing like in Kawabata 4 different modules and all these things.

Here using a single test we can get idea about the fabric feel, real time plotting we can get, and wide range of fabrics can be tested here ok. And, the simple the approach is so, simple the instrument is so, simple. Even, now unskilled shop floor level worker can handle. Now, let us see the animation here.

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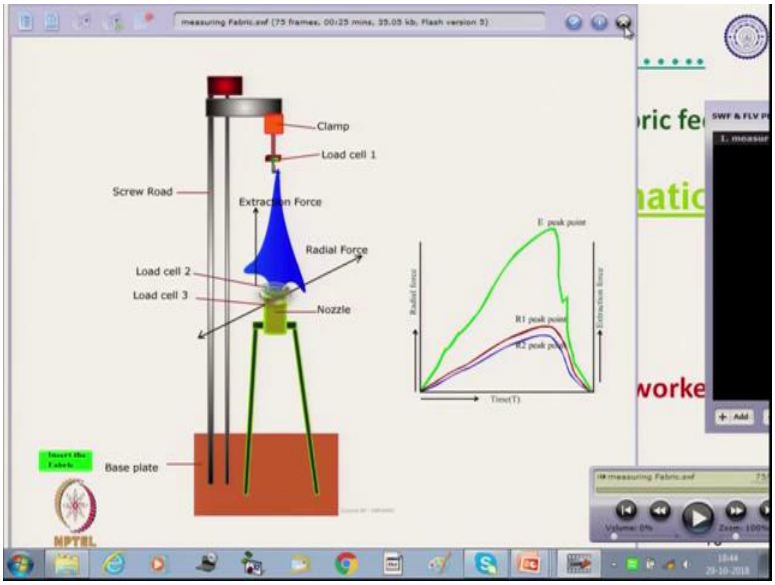

So, here in this instrument this is the nozzle. The nozzle is very specially designed nozzle, where we measure the extraction force as well as the radial force. The force during the extraction, the force exerted by the fabric on the nozzle the radial force that also can be measured here. And, the extraction force is measured by load cell 1 here this is a load cell 1. And, radial force is measured by other 2 load cell, load cell 2 and load cell 3 and fabric is actually pulled through this nozzle ok.

Now, let us see and this is plot you can see this is a fabric circular fabric and holding at the centre. And, fabric is gripped with the, this jaw. And, now once we start this cross head will move up and the load also. So, this is the cross head is moving up fabric is being extracted through the nozzle and this is the load extraction curve. This is the extraction curve and these are the radial force.

So, load cell 1, load cell 2, load cell 3, we get the plot and using this plots using this graph, we can actually get the value of the fabric feel. And, in our experiment the research experiment which we have done, which shows very good correlation with the, this fabric feel value which we obtained from the this instrument and with the subjective test.

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And, the instrument is very cheap small scale industries can afford.

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This is the nozzle a picture of the nozzle and it is gripped at the centre. So, it is a low complex stress is applied which is non-linear in nature.

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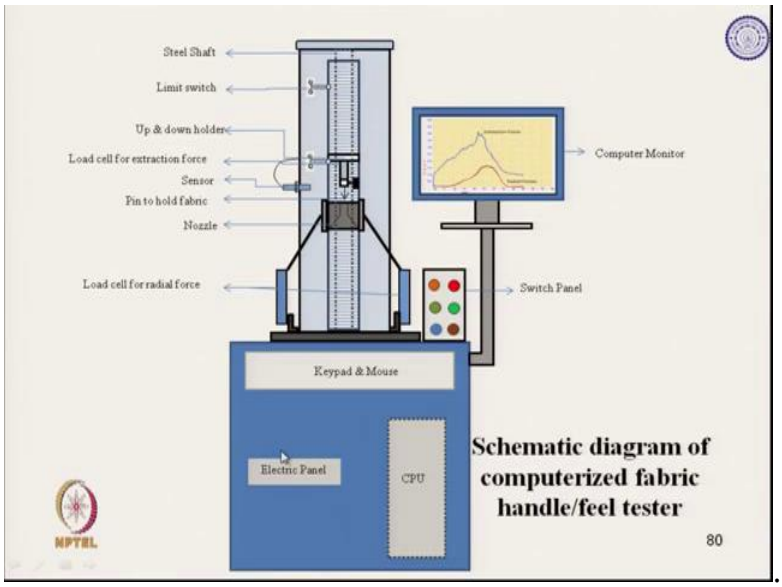

This is the schematic diagram of the instrument, where it is a shaft limit switch is there load cell for the extraction force; load cell for radial forces, nozzle is there ok, pin to hold the fabric ok.

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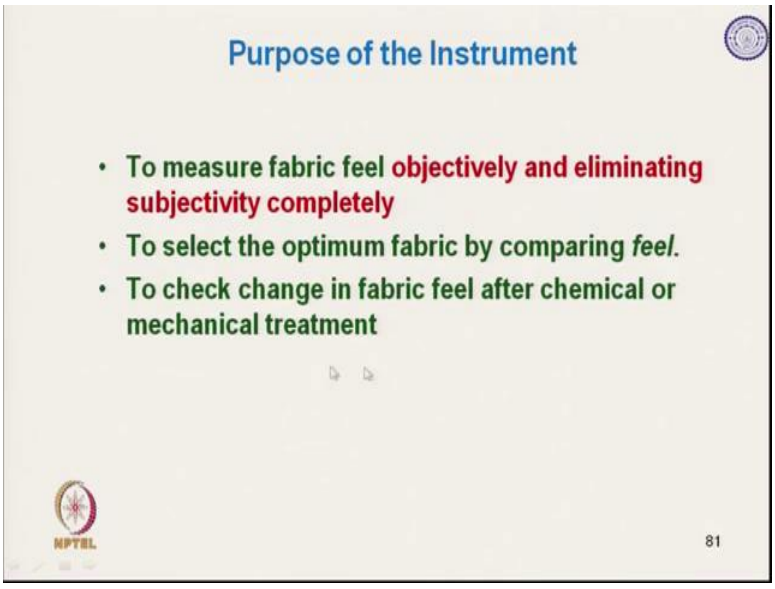

So, the purpose of this instrument is to measure the fabric feel objectively and eliminating the subjectivity completely. So, completely it eliminates the subjectivity. So, it does not actually depend on the perception of a person to select, the optimum fabric by comparing the feel. Suppose, we have 10 fabrics of same variety, a fabric is actually a particular fabric

is treated with 10 different finishes, and we have to pick the best fabric, optimum fabric. So, from by testing the fabrics with this instrument quickly we can select the optimum fabric.

To check the fabric feel after chemical or mechanical treatment. So, suppose we want to test whether the particular mechanical treatment or chemical finish improves his feel characteristics that we can check quickly.

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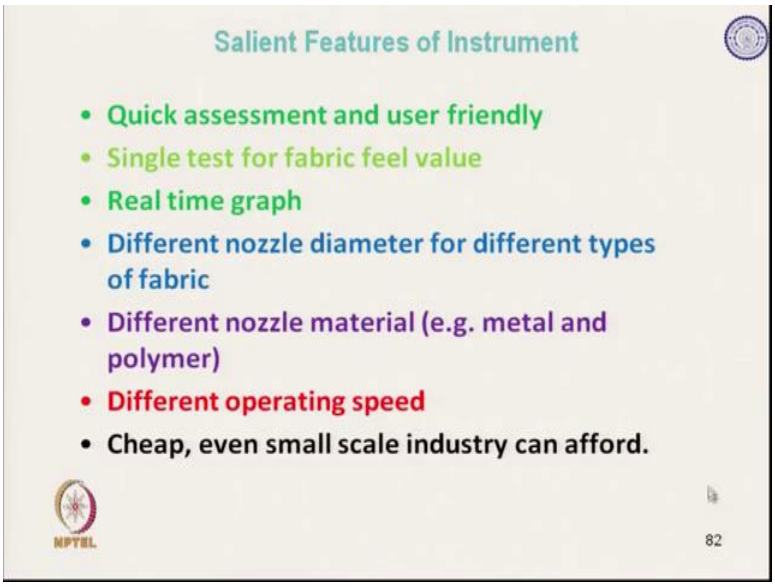

It is a quick assessment and it is user friendly, single test of fabric feel value, we can get the fabric feel value with a single real time this part we have already discussed. And, different fabric nozzle, different nozzle material we can use metal we can use, polymer you can use, depending on the type of fabric and requirement. And, different size of nozzle we can use, because for a stiffer fabric we can use a larger nozzle, for flexible fabric we can use smaller nozzle like knitted fabric we can use smaller nozzle, and different operating speed we can use here, it is a cheap even small scale industry can afford.

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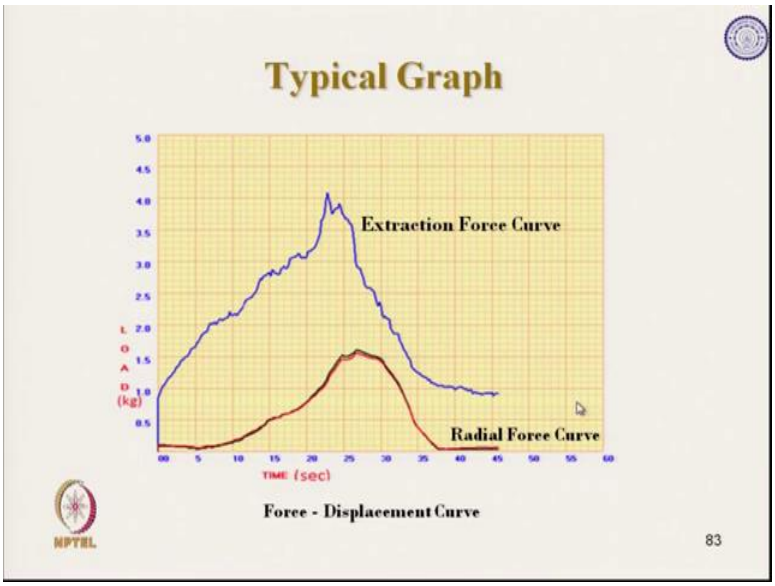

Now, this is the graph we get, this is the typical graph, it is the extension graph. So, by Extraction Force Curve and the Radial Force Curves.

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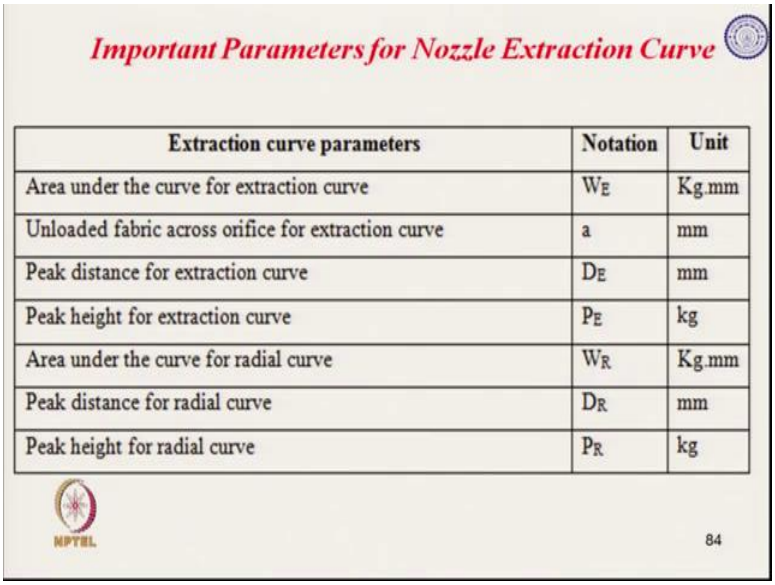

Extraction curve parameters	Notation	Unit
Area under the curve for extraction curve	W_E	Kg.mm
Unloaded fabric across orifice for extraction curve	a	mm
Peak distance for extraction curve	D_E	mm
Peak height for extraction curve	P_E	kg
Area under the curve for radial curve	W_R	Kg.mm
Peak distance for radial curve	D_R	mm
Peak height for radial curve	P_R	kg

And, from this extension and radial curve, we can get different parameters like, W_E is the area under the curve for extension. So, extraction curve so, it is W_E unloaded fabric across the orifice or extraction curve. So, that is the length in millimetre where there is no load is swing. Peak distance for extraction curve D_E, Peak height for extraction curve P_E, area under the curve for radial direction W_R, peak distance for radial curve is the D_R, peak

height for radial curve P_R. So, these are the parameters we can get from the extraction and radial curve.

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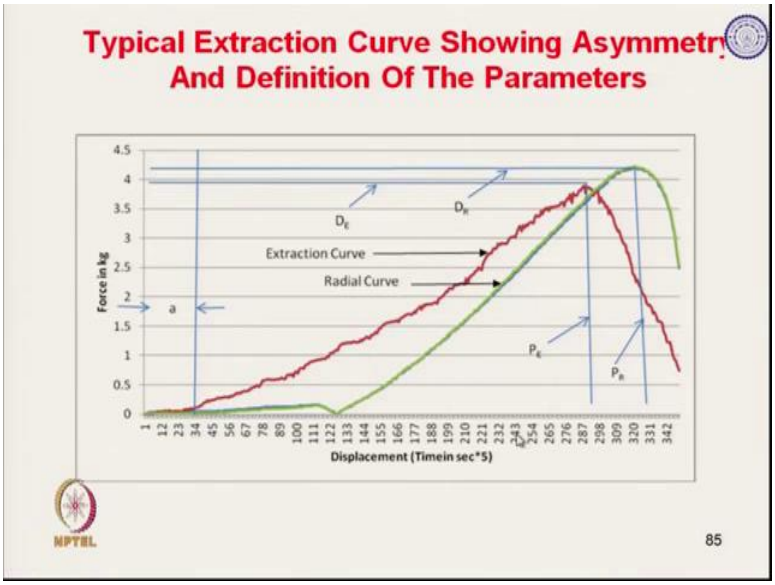

So, this is these are the curve. So, we get software will automatically record all these data. So, D_R, D_E, P_E, P_R a value without any load. So, this value will software will automatically collect an area under the curve will automatically be calculated. And once we calculate, we can get some regression equation using all these value, which is predetermined regression equation for fabric feel factor, which has been obtained based on large number of data, large number of fabric we have got the value.

So, I will come back to that aspect.

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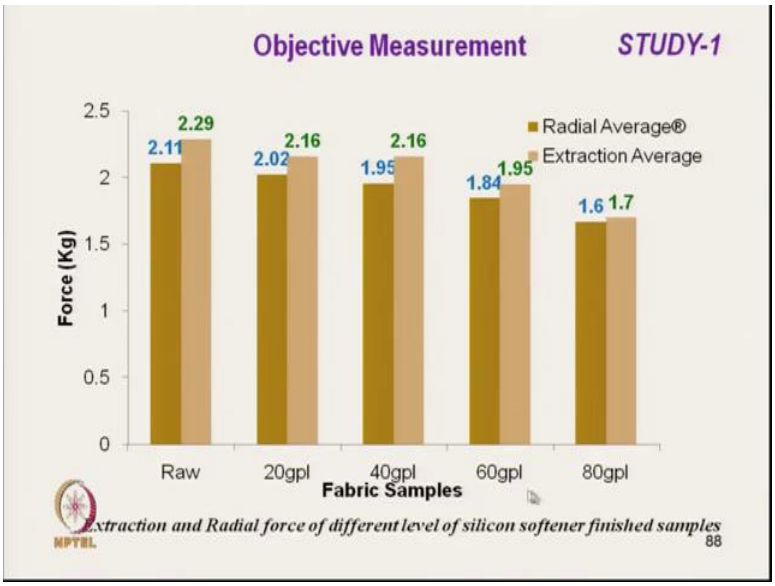

So, in our research what we have done in to study the tactile aspects, the fabric is actually treated with a finishing agent with silicon finishing agent with different concentration level. So, if this is the raw means without any finish. And, the concentration level 20 g/l 40 60 80. And, with the increase in finishing level what we have observed? The extraction force reduces; that means, it source the fabric is becomes the softer or it actually the force required to extract the fabric becomes the lower as the fabric surface becomes smoother.

So, this gives here idea that the fabric objectively we can test the fabric fill. Now in study to, what we have done?

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We have taken a denim fabric and that fabric is finished with a wide range of finishing. So, the yellow highlighted fabric it is a raw fabric a denim fabric and the fabrics are treated with different type of wash. So, the raw wash desize only and all these like this number 8 is stone wash for 75 minutes it is a very harsh wash.

. So, different types of washing treatments are given for same fabric. And, these samples we have collected from a particular industry. And, the mass per unit area are almost very close, the same fabric these are due to the washing treatment some changes are there, but other ways it is a we can consider it is a there is no difference is there.

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And, then the fabrics are tested with a 1 is subjective assessment we have done, and then the fabric we have tested in the instrument for objective assessment. For subjective assessment what we have done.

We have taken around 125 subject 125 people were taken of different age groups, and both male and female different professional level we have taken, the these are the subjects we have taken, and the rating we have given 10 ratings were actually proposed. Where one is very very soft and 10 being the harshest may be. And, what we have given we have asked the judge to judge the fabric 10 different fabrics from 1 to 10 ok.

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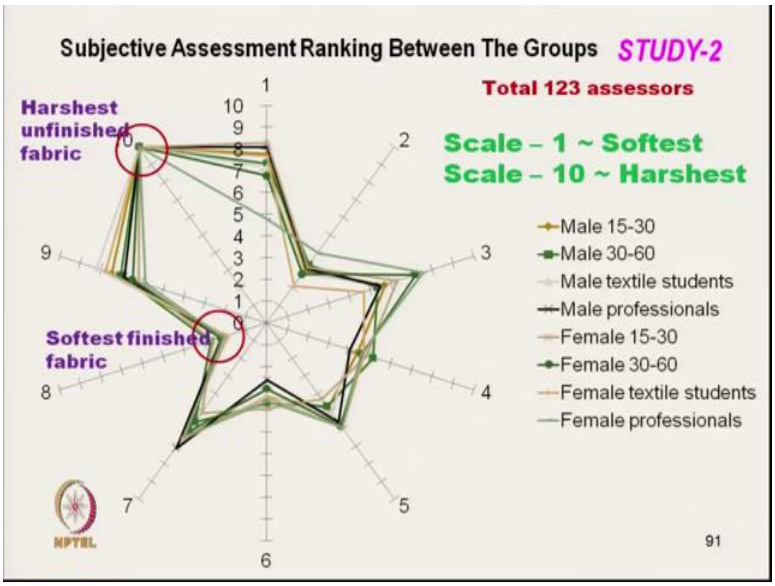

At different level we have asked them to judge and to 123 assessors were there. And, which shows the fabric this fabric is fabric 10, which is unwashed fabric, which gives maximum harshness it is a 10.

10 level it is of harshest fabric ok. And, the softest quantity is the typically around 1 which is given by the sample 8, sample 8 means the stone was very harsh treatment. So, that gives the idea about the this that unwashed, untreated fabric gives harshest fabric and the stone was gives the, and this trend is almost same this trend is a almost same for all the fabrics all the this assessors ok.

So, they have given the assessment and then what we have done, we have taken the same fabrics to the instrument.

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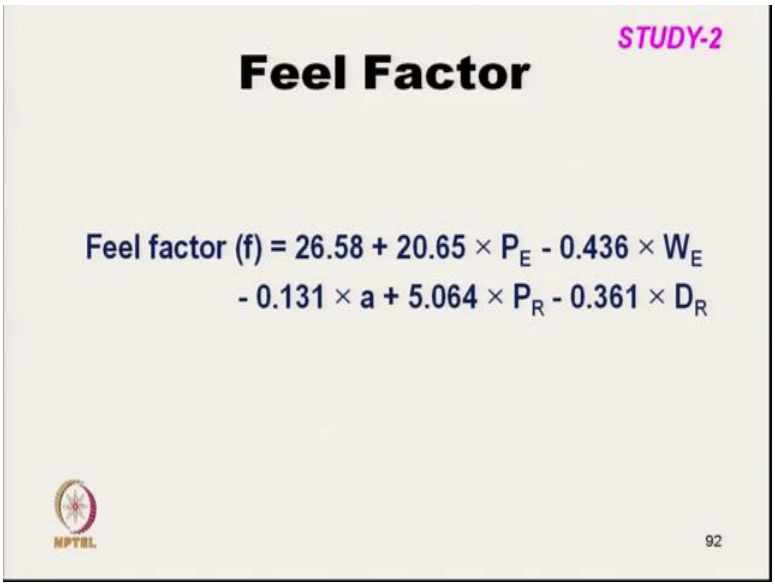

And, we have measured the fabric feel factor.

This is the using this regression equation ok. And, where this P_E W_E D_R P_R a this values we have obtained from the extraction curve, extraction and radial curve we have got this values.

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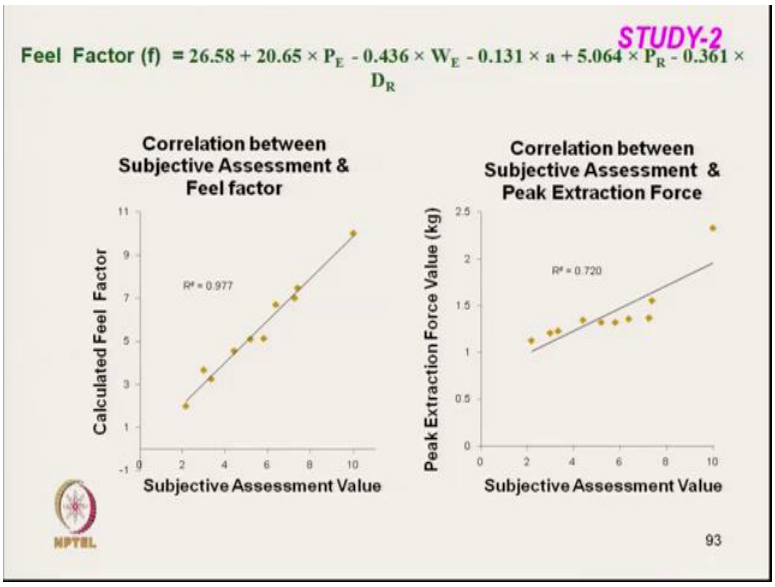

And, what we have got interestingly we have got very good correlation, very good correlation with subjective and calculated feel factor. Subjective assessment of fabric feel and calculated feel factor we have got the correlation coefficient is around 0.977 we have

got the correlation. It is a actually the fabric feel factor the value which we have actually proposed here, it is actually gauzed in such a fashion it is a the value will actual lie between 0 to 10 ok.

So, it is a basically it is a between 1 to 10 within that range it is lying. So, and our the subjective assessment was also between 1 to 10. So, that is how we have got very good correlation. And, also what we have tried? Why this complex equation? Can we actually use the peak extraction force, the peak value of the extraction force, with the subjective assessment we tried to get the correlation, but we found that this is not giving the good correlation; that means, it is not only the peak force which is important. In addition to the peak force there are other parameters, which we can extract from the extraction and radial curve.

So, this gives a fair idea about the performance of the our instrument. So, we can claim that thus this method although it is a very simple. If, we test the fabric properly, it will give us idea about the fabric feel, but the main drawback main limitation of this instrument is that, we cannot compare the values from 2 of 2 different type of fabrics. Here, we can compare only of same, similar type of fabric. Like one fabric very thin and stiff fabric may give same extraction force with a little bit thicker and very flexible fabric. So, that is why it is recommended that this instrument, this principle is to be used when we actually try to compare the same fabric.

Suppose the same fabric is treated with a large number of finishes. We want to judge which finish we want to select the optimum finish. In that case this equipment will give us very good result very quick. So, in the shop floor suppose for a particular fabric we are trying with the different types of softness treatment. So, we can give idea about the, which softness treatment will give the best optimum value. Another use is that suppose the fabric a feel value your buyer is using that it he cannot actually touch the fabric, but he can feel the fabric by knowing the feel factor.

So, feel factor if it is known. So, if it is matching with the given specimen, then one can get idea about the, your fabric which you have produced the feel value which is as per the standard or a specimen.

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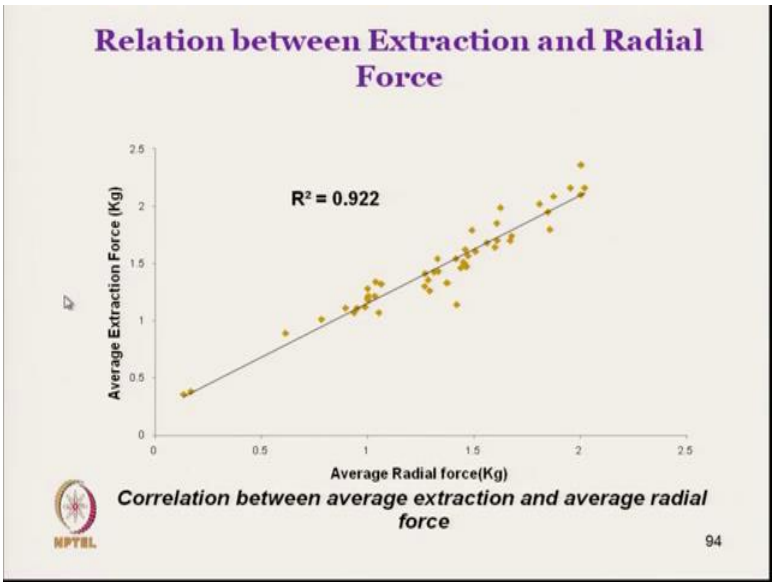

So, you also tried the relationship between a radial force and the extraction force. So, that you are getting a very good correlation. So, average radial force and average extraction force; that means, it gives us a clue we can also eliminate the radial force. We can because it gives the almost a very good correlation.

So, radial force without measuring the radial force only measuring the extraction force and get the giving the other values like the energy required to a for extraction and the peak extraction force. So, we can get the fabric feel factor only from the extraction curve and we will stop here ok.

Thank you, thank you for patient listening.