Science of Clothing Comfort
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Lecture – 16
Tactile Aspects of Clothing Comfort (contd…)

Hello everyone, so we will continue with measurement of yarn hairiness. So, in our last segment, we have discussed the two methods; one is Shirley yarn hairiness tester, another is Zweigle hairiness tester. Now, we will discuss the Uster hairiness testing system.

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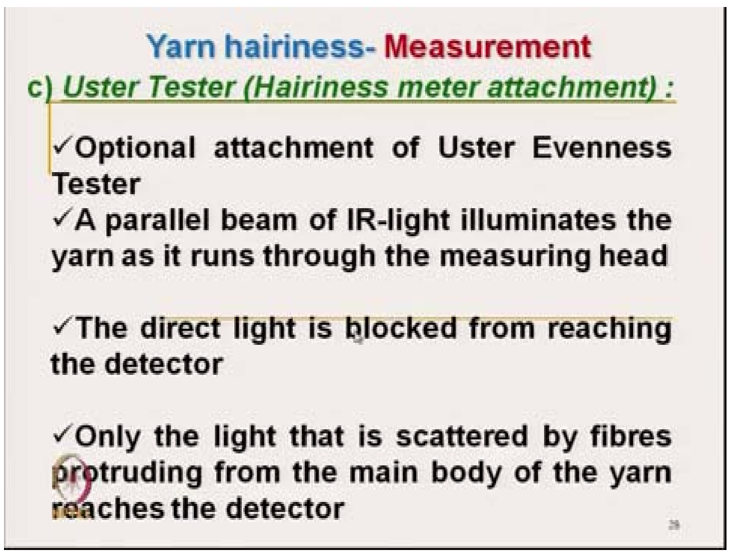

So, what we have discussed earlier, we have seen the in Zweigle and Shirley, we measure the length of hair protruding above the yarn surface at certain specific setting. And in Uster, it measures the amount of light scattered by hairs. So, parallel beam of infrared light is illuminated.

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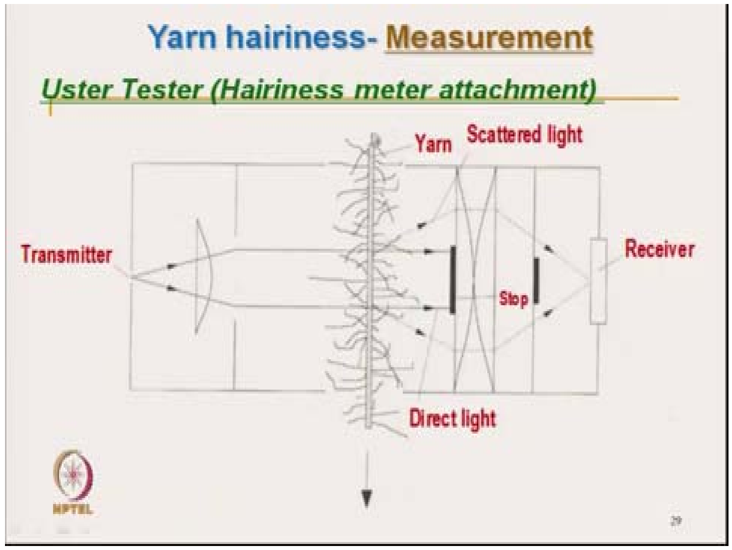

And suppose there are no yarn present here, this parallel light will be blocked here by the stop arrangement. These are the stop arrangement and the light would not reach receiver. Suppose, the yarn has no hairs. Still in case of filament yarn, there would not be any light scattering due to hair, so this light will not reach receiver. Thus light will either be blocked by the yarn or if it goes parallel would be blocked here, so that setting size of the block is actually equal or little bit higher than the diameter of this aperture.

Now, if there is light and there are hairs. So, hairs present will start scattering the light. So, light will get scattered and will try to move away from the straight path. And all these lights try to get scattered. And the lights which will come gets scattered, scattered light will get captured and will get transmitted and ultimately it will be projected on to the receiver. So, the amount of light which receiver is receiving, it is intensity, its quantity, it will receive will be proportional to the number of hairs.

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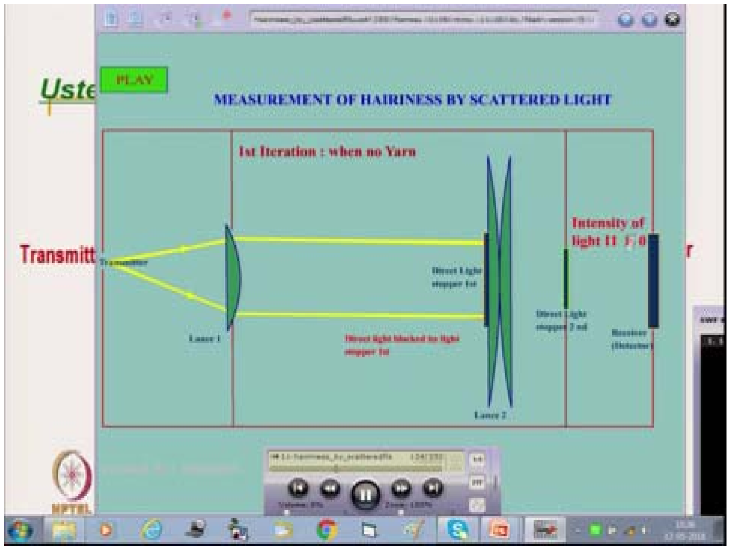

So, let us see the animation of this principle. So, this is a light source. It is light when there is no yarn present. So, light is actually falling on this lens. And, then it has converted to parallel light and actually light will be blocked here. Direct light will be stopped. So, any light coming through hair, transmit. Intensity of light is 0. So, there is no light coming here. This is a yarn that does not have any hair.

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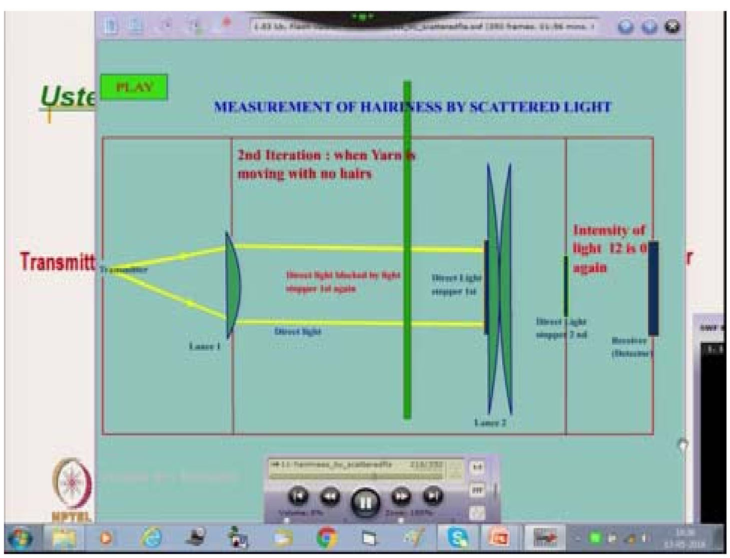

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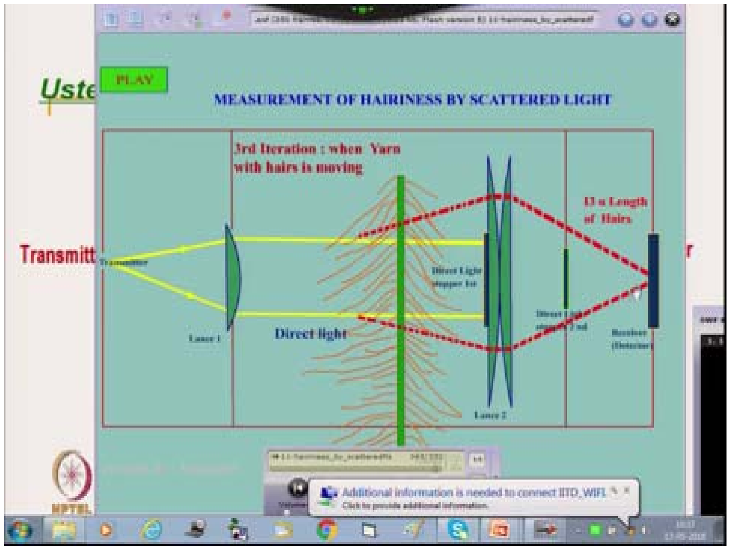

So, again the ultimate impact will be the same, because actually it is not receiving any scattered light. Now, let us see yarn with large number of hairs, this light will start, these hairs will start scattering the light which will be beyond this stop mechanism, and then this will be actually through this lens system, it will get projected. So, this amount of light, this is actually proportional to the length of the hair. So, indirectly by measuring this intensity, we can get idea about the intensity or total length of the hairs. So, this is the indirect method way of measurement of hairiness, we can get idea about the prickle sensation.

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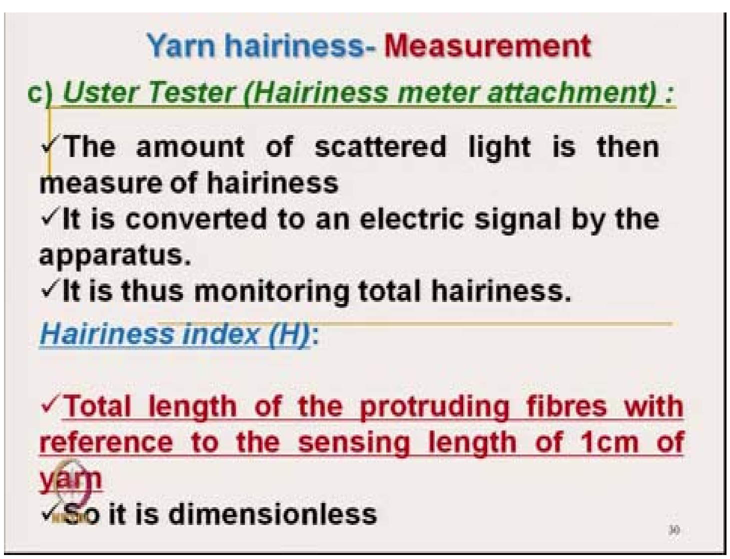

So, amount of scattered light is measure of hairiness. And we get ultimately hairiness index. So, total number of length of hair per unit length of yarn, it is a dimensionless. So, we get one index. So, this is for comparing the values.

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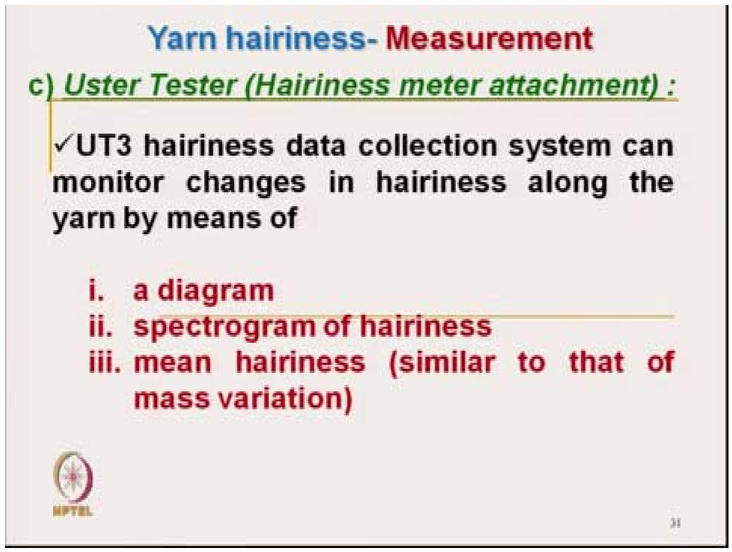

So, these are the different ways of getting data by way of spectrogram.

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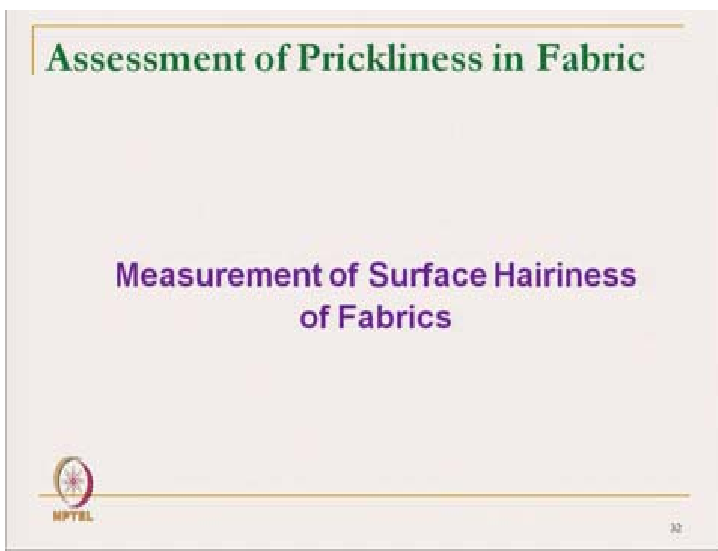

Now, we will discuss the assessment of fabric surface hairiness to assess the prickliness of fabric.

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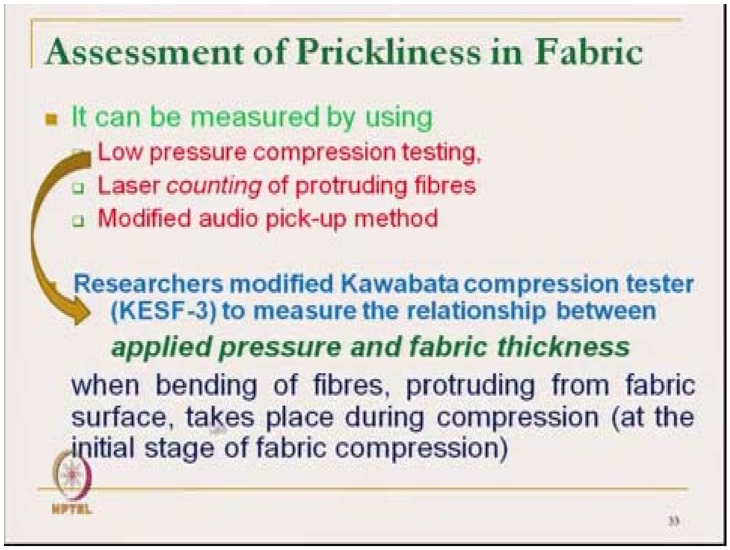

So, this is measured by first method; it is by low stress compression mechanism. So, if stress, that means, that will give indirect indication of the hairiness, because, normally yarn is not that compressible at very low stress. If the fabric is very compressible at low stress that indirectly gives the idea about the hairiness present at the surface and indirectly gives the prickliness sensation characteristics of fabric.

Then, it is by of counting the protruding fibres of the surface. It is similar to the laser counting of protruding fibre. It is actually similar to Uster measurement technique. It is based on light scattering technique. And third is the modified audio pick up method. It gives idea about the buckling force that we will discuss here; buckling force and bending force of measurement. So, if we modify Kawabata system like KESF-3 compression system, which indirectly gives the low stress, low pressure, compression testing, so that from data at low pressure gives the prickliness sensation indirectly. So, relationship between applied pressure and fabric thickness can be measured.

So, when bending of fibres protruding from the surface, takes place during compression. So, at that time we can get the idea of the hairiness or prickliness by low pressure compression system.

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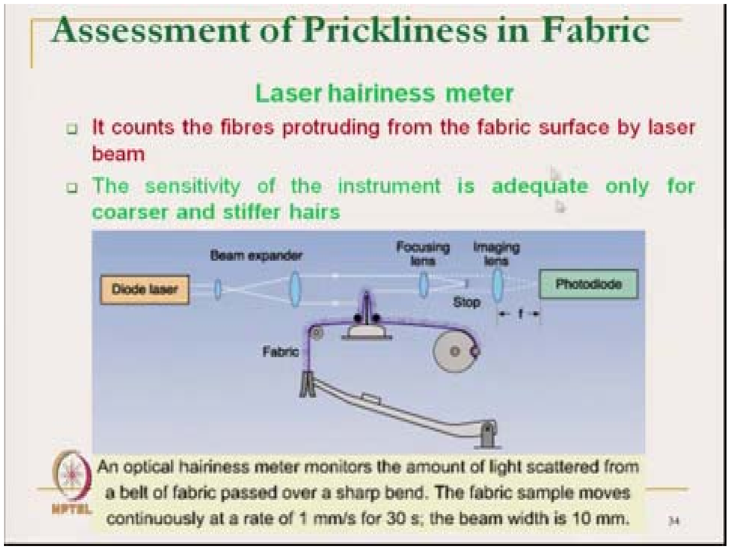

Next technique, it is a hair optical system as we have seen in the Uster hairiness tester. It counts the fibres protruding from the fabric surface. So, this is the fabric surface, this is the fabric roll, it is the fabric let off, and here is the take up arrangement. And this is a knife edge through which fabric is moving. And whatever the hairs protruding here, these hairs will actually scatter light and this scattered light will be received by the photoreceptor.

So, this is the similar to an optical hairiness meter; it monitors the amount of light scattered from the belt of the fabric passed over the sharp bend. The fabric sample moves continuously at certain speed and then we will measure. So, this technique is similar to the light scattering technique by Uster. And we get idea about the fabric surface hairiness and indirectly get idea about the prickliness sensation.

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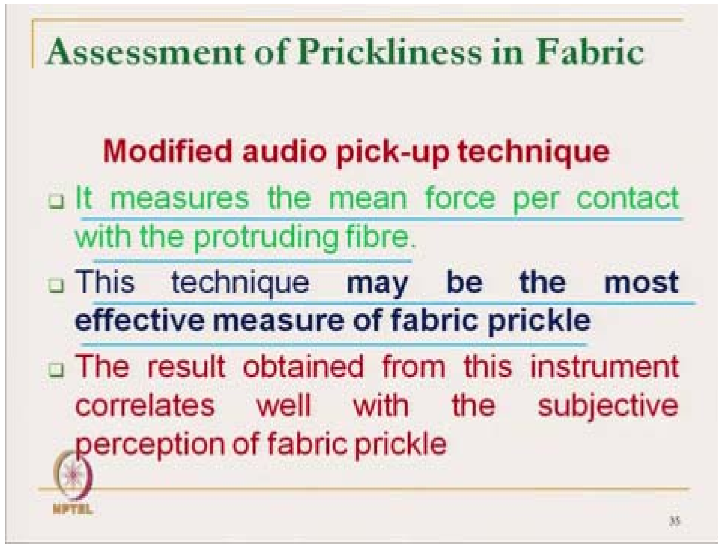

Next one, actually measures the prickliness sensation directly, which is modified audio pick up technique. It measures the mean force per contact with the protruding fibre, what is the mean force per protruding fibre, it measures which actually directly gives indication of prickliness sensation and protruding fibres. So, this technique may be the most effective technique by of fabric prickliness. And the result obtained from this instrument actually directly correlate with the subjective perception of the fabric prickle. This is the most effective technique for fabric prickliness sensation measurement.

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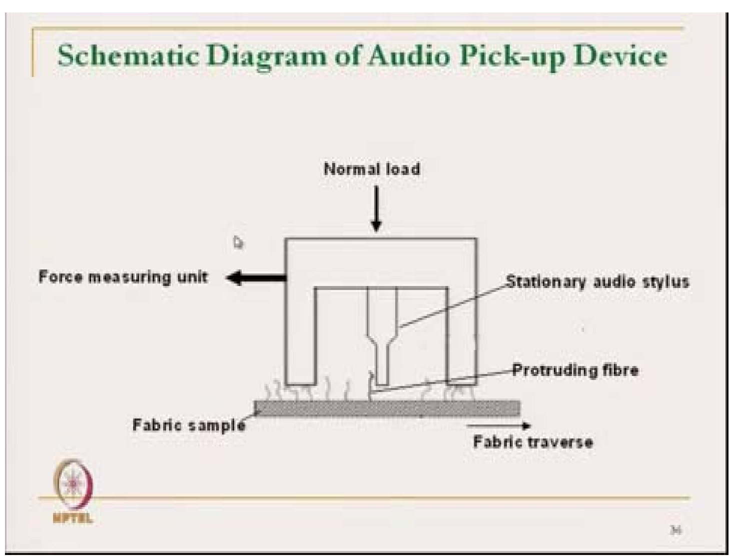

Now, this is the instrument. Here, this is the light block. It is actually connected with the load cell. Normal load you are applying and here, load cell is there and here a normal light force is applied. And these are the surfaces where it measures, these surfaces are used to buckle the protruding fibre. So, the buckling takes place at this point. So, buckling of fibres take place; and this is the stationary audio stylus which actually sense the bending force.

Now, with this arrangement, now if we start moving the fabric, this is the stationary measurement. Now, the applied normal load gives the idea about the buckling force. So, we can measure the erected hairs, these projected hair and if we apply load. So, we have the buckling force. So, this gives the buckling force and when we move the fabric here, the force is measured by some force measuring unit and how does this force come into picture, this force is coming into picture due to the projected hairs. These projected hair are due to the bending force of hair. It gives signal from it to audio stylus is there, and ultimately we get measurement of force here.

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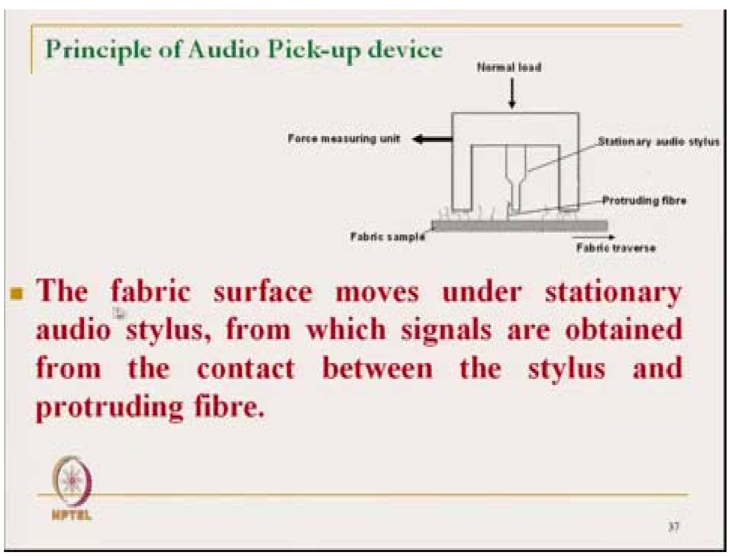

So, force unit measuring unit gives the bending force of these hairs. So, we get characteristics one is, as the fabric surface moves under stationery audio stylus, from which the signals are obtained from the contact between stylus and the protruding fibre that we get some signal of the fabric, bending and the buckling of the fabric.

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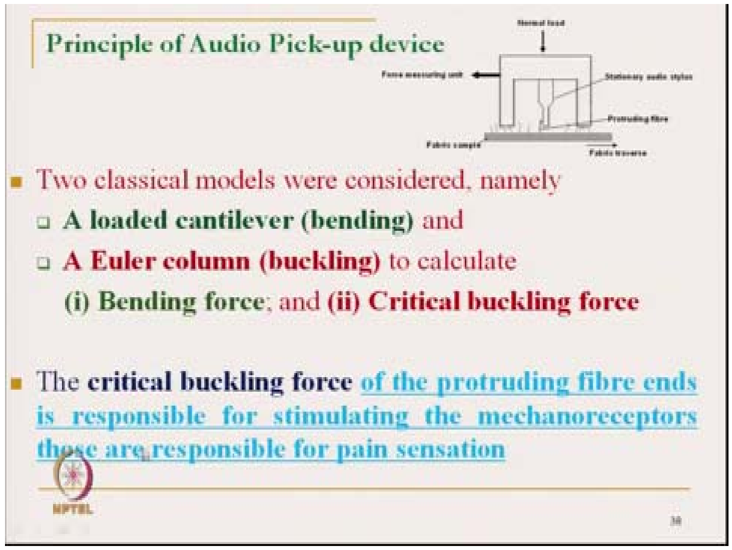

So, two classical models are here, one is a loaded cantilever, it is a bending force we measure and Euler column that is buckling, so calculates the bending force and critical buckling force. So, from these two parameters we get the idea about what type of hairs are present. Earlier measurement technique was indirect where we can only tell hairs are there. But here, we measure the type of hair. If the bending force or buckling forces, they are high so that means we can tell this particular hair will create problem in prickles, prickle sensation, so this type of buckling force is extremely important if the buckling force is less; that means, it will not create any problem of prickliness even if there are hairs.

So, the critical buckling force of the protruding fibre end is responsible for stimulating mechanoreceptors, it is high buckling force that will actually give stimulation to the pain receptors. So, this is the type of buckling force Euler column.

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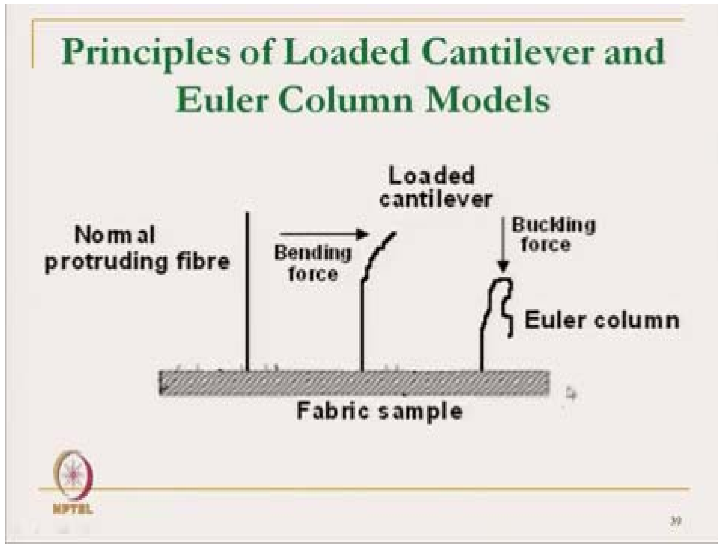

And this is the loaded cantilever. So, we get this is the normal protruding fibre and we can see, if the fibre length is more, what will happen, the bending force will be less and buckling force will also be less. If the fibre diameter is more, then we will get higher value.

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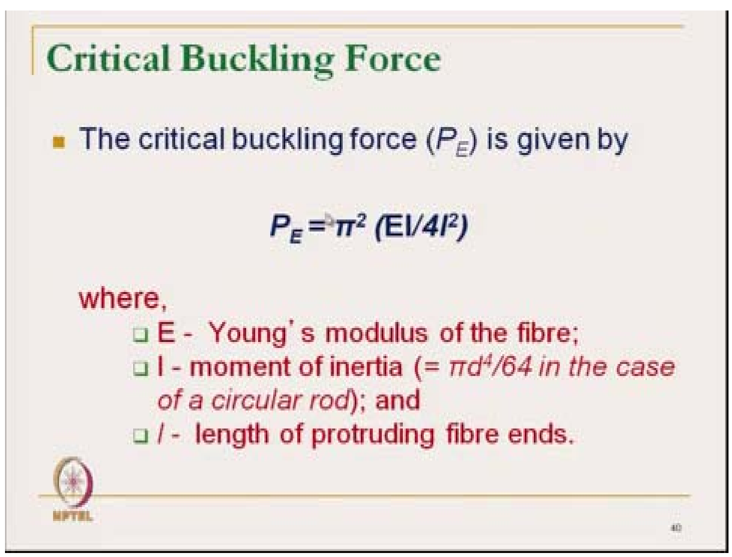

So, we have critical buckling force calculated. We can get this buckling force with the standard formula

$$P_E = \Pi^2 (EI/4L^2)$$

E is the Young's modulus, I is the moment of inertia and this L is the length of the protruding fibre. So, with above equation, we can get the critical buckling force that means, if we use a fibre with higher Young's modulus, it will give higher critical buckling force; that means, it will give higher prickle sensation.

If bending rigidity or moment of inertia of the fibre is high, so moment of inertia is actually directly proportional to the diameter of the base that means, if we use coarser fibre, coarser fibre will give higher buckling force, it will give higher prickle sensation. If we use longer fibre, it will give less buckling force, what does it means, it is a combination of Young's modulus, the diameter of fibre and length of fibre.

So, if we have coarser fibre, and if we use longer length that means, effectively buckling force will be less. So, it may not give the prickle sensation. The problem of prickle sensation is there, if it is a short fibre projected and coarser fibre with higher moment of inertia and higher in Young's modulus. Actually, if we use the coarser wool fibre that gives negative behavior, and ultimately we get this prickle sensation. So, if we know all this characteristic, we can design a cloth without prickle sensation.

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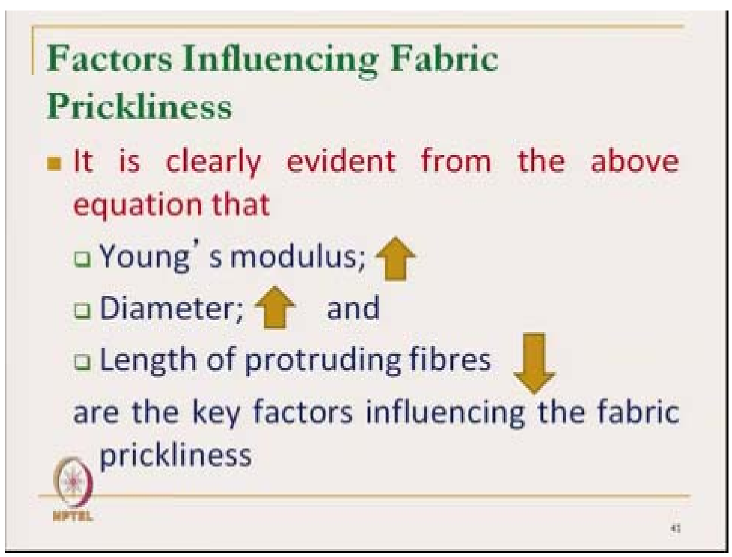

So, it is clear from this equation that prickliness of fabric is actually related with the Young's modulus, diameter of fibre and length of protruding fibre. So, they are the key factors of prickliness. So, we have discussed with the increase of Young's modulus, the prickliness increases, with the diameter increase, it increases and with an increase of length it reduces.

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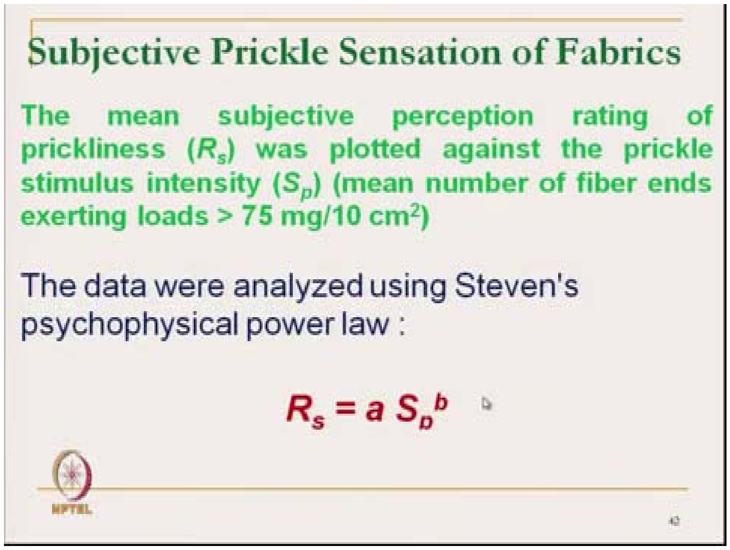

Now, we have discussed the objective measurement. Now, if you see the subjective measurement techniques. So, if we use the psycho laws of psychophysics that we have discussed; subjective perception is R_s and the prickle stimulus intensity it is S_p.

$$\mathbf{R_S = a\ S_p\ b}$$

We can use the stimulus intensity by the critical buckling forces stimulus intensity or mean number of fibres that is more than 75 milligram per 10 square centimeter. This number of fibres also, so these are relationship. So, the Steven psychophysical power law that we have discussed earlier.

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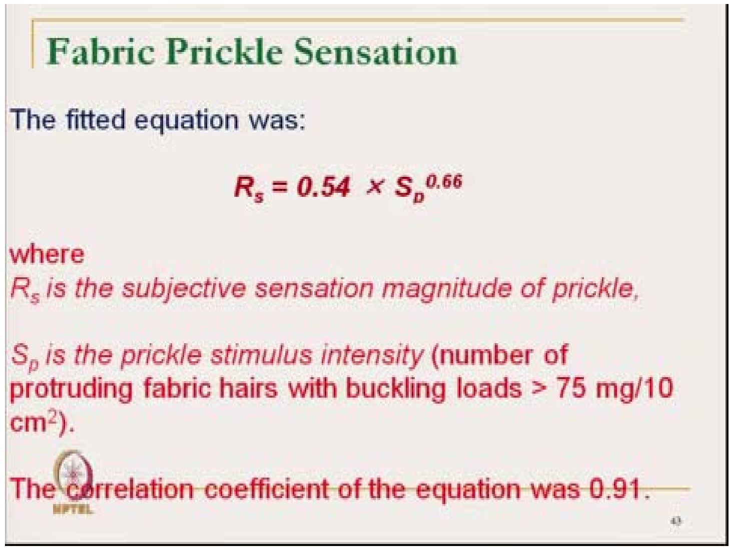

So, here the exponent b for prickliness sensation, it is typically 0.66. So, what we have seen earlier, for different types of sensations this exponent is different. For electric shock we have discussed it is 3.5. So, for a brightness, it was different. Similarly, for prickliness here it is 0.66.

$$\mathbf{R_s = 0.54 * S_p^{0.66}}$$

This is actually very closely correlated with the subjective assessment. So, R_s is the subjective response of the prickliness. And it is a prickle stimulus intensity that we have seen and the correlation coefficient here it is a 0.91. Very good correlation is there. So, we can see, this type of curve where x-axis is prickliness stimulus intensity and here Y axis is the sensation of prickliness.

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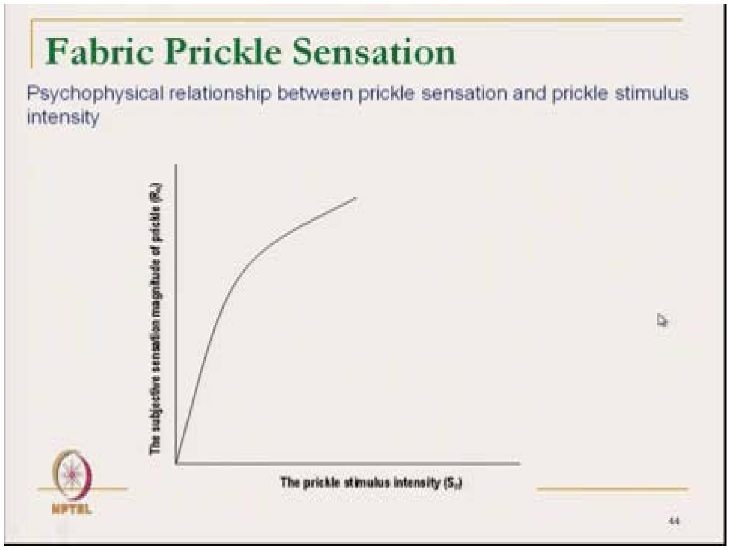

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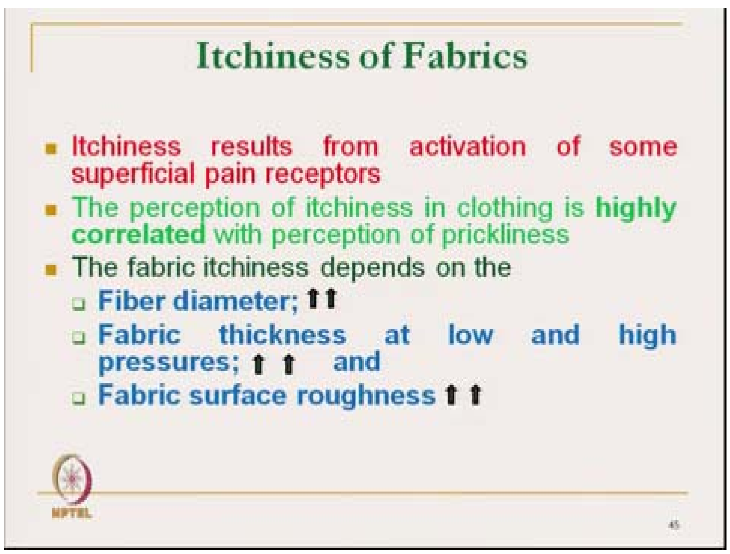

Now, coming to another tactile response which is important is called an itchiness of the fabric. And this itchiness is directly related as we have discussed earlier, it is an activity of superficial pain receptors directly related with the fabric prickliness. Actually these are highly correlated with the prickliness sensation and fabric itchiness depends on the fibre diameter, prickliness also depends on fabric thickness at low and high pressure that means, it is compressibility, it depends on compressibility and fabric surface roughness also. So, rough surface will give higher itchiness.

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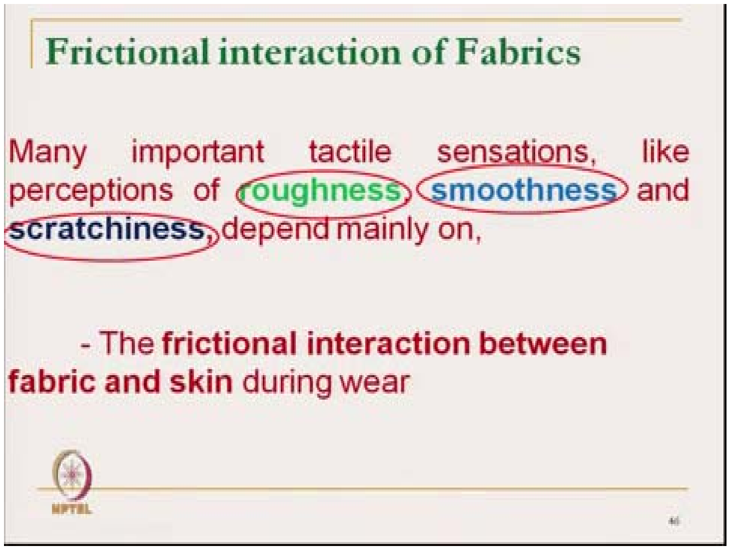

Next is the fabric frictional interaction. So, these tactile responses are that roughness perception, perception of smoothness, and perception of scratchiness, which are directly or indirectly related with the frictional characteristics of fabric. These are dependent on the basically frictional characteristics between fabric and skin.

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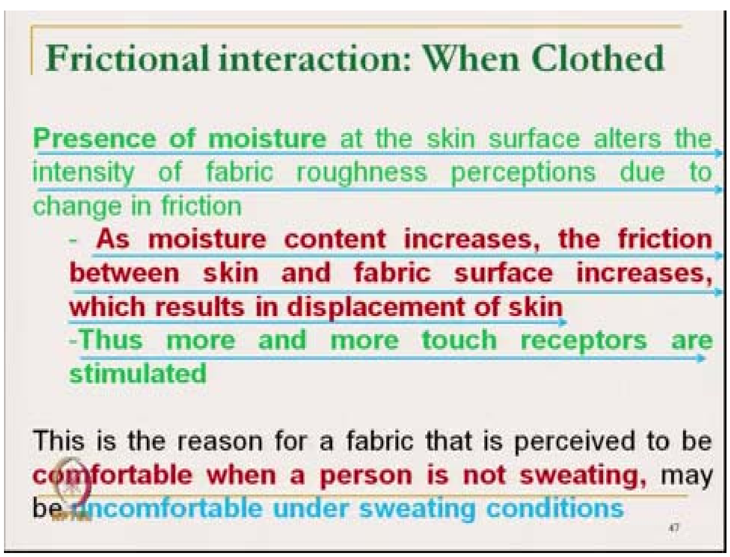

So, in the presence of moisture, actually the frictional characteristics is one aspect, but the perception of roughness increases with the increase in moisture content. So, presence of moisture at the skin surface totally altered the intensity of roughness perception due to change friction. So, what does it mean, so normally, in dry condition, if we perceive one type of scratchiness or roughness of fabric, if the moisture content in the skin, if we start sweating, our perception of roughness will change. So, as the moisture content increases the friction between skin and fabric surface increases, different type of tactile sensation will be there.

Suppose in dry condition, when the skin is dry, the fabric will try to slip over the skin surface, due to lower friction between skin and fabric, but as it gets wet, actual friction is increased, so it will try to pull the skin, so it results in displacement of skin due to the pull of the fabric. So, this gives idea thus the more and more touch receptors are stimulated. We will get totally different type of sensation due to different receptors. This is the reason actually fabric maybe comfortable, when we are not sweating. But, the same fabric will become uncomfortable as far as tactile sensation is concerned when we start sweating, that means, it actually starts to stimulate other receptors due to pull in the skin. And this is mainly due to the increase in friction between skin and the cloth due to presence of moisture.

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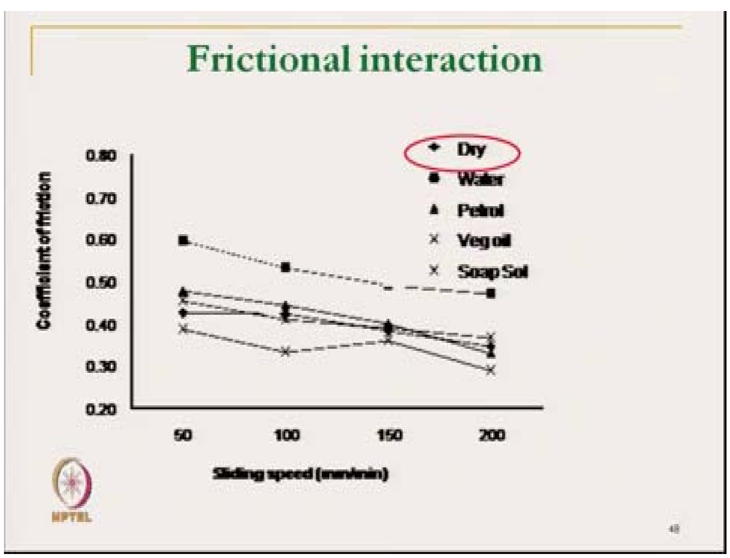

So, this is the one study report, which shows the coefficient of friction between skin and particular type of cloth at different types of material present. So, when it is a dry, we can see the friction at this point, this is the friction at lower level around 0. 4 or something, but when it is a wet, say water is present, the friction is the highest. There are theories present, it forms some bond. So, it tries to drag the fabric. So, higher friction due to presence of water or sweat, so it gives higher friction that actually stimulates different types of sensations.

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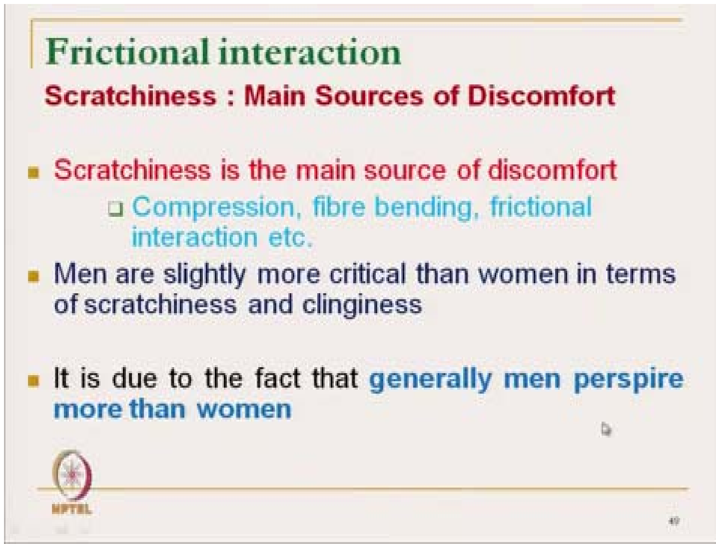

Now, the scratchiness, is another source of discomfort which are related with the frictional interaction. Now, we are discussing the prickliness and friction, Prickliness we have discussed, friction related aspects we are discussing here. And another way of sensation of prickliness friction related aspect is the scratchiness. So, main source of it is discomfort and it is related with the compression, bending and frictional interaction. It is actually common perception that actually men are slightly more critical as per as scratchiness is concerned than women in terms of scratchiness and clinginess. Clinginess is another aspect, which is related with the friction. Roughness, scratchiness, clinginess, these are related with frictional characteristics.

And the study report shows the men are little bit more critical. This is nothing but due to due to fact generally men perspire more than women. General perception, it may not be true. So, due to higher perspiration, higher amount of moisture present in the skin, so higher frictional interaction, higher scratchiness, higher friction, and higher clinginess. Now, scratchiness is main source of discomfort, it is more in hot and humid climate. So, we feel more scratchiness in hot and humid climate, why, because we sweat more.

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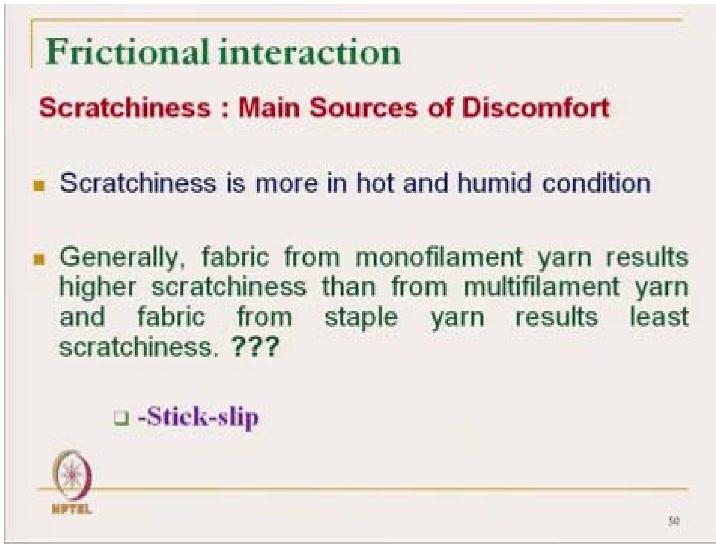

So, that is why in cold and dry climate, we do not feel normally scratchiness, but same fabric, we may feel scratchiness. Another observation is that generally fabric from monofilament yarn results in higher scratchiness than multifilament or staple yarn that is our general perception and general feeling. If we are wear a clothing made of woven fabric made of flat monofilament, I am talking about a flat monofilament, it is not bulky or textured; flat monofilament fabric, if we wear directly on our body, we feel scratchiness sensation. But, in case of a multifilament or staple or textured, we will not feel this type of scratchiness. So, the reason behind this is basically stick-slip nature. Monofilament fabric gives a stick-slip nature against the skin, that gives the scratchiness sensation, but for other type of fabric and yarn, it gives displacement, it does not give the stick slip that ever. So, this is the stick-slip mechanism.

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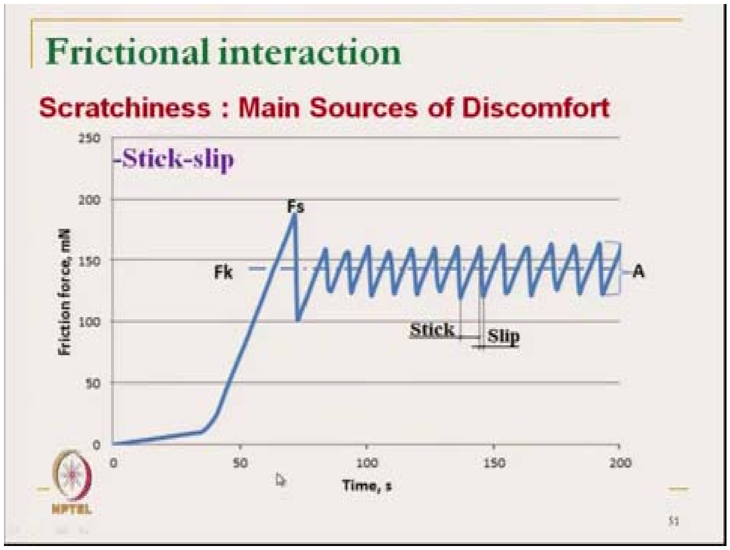

And this actually gives the scratchy sensation. Any movement with the stick-slip movement, it gives scratchiness sensation which is actually predominant, in case of monofilament fabric.

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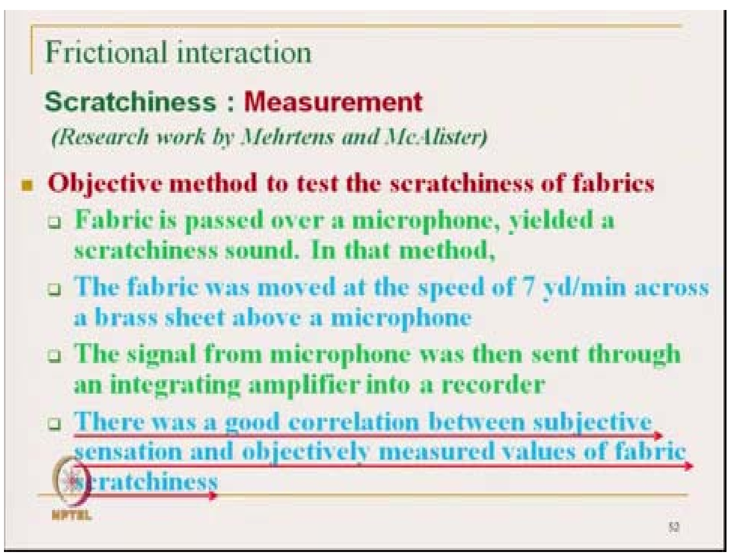

So, how to measure the scratchiness sensation objectively, so the objective measurement of scratchiness is that the fabric is passed over a microphone, yielded a scratchiness sound, so fabric system is there and below the attachment a microphone is placed. So, when fabric is moved, there will be if there is a scratchiness sensation, it will make some sound. And depending on the level of sound, one can get idea about the scratchiness sensation, so the fabric was moved at the speed of 7 yard per minute across a brass sheet above a microphone. So, brass sheet is placed above microphone and the fabric is moved at a certain speed.

So, if there is any roughness or any scratchiness, if there is any stick slip sensation, it will generate some sound, and that sound is actually measured. The signal from microphone was then sent through integrator amplifier and it records the sound. And there is a good correlation between the subjective measurement of scratchiness by human object, and this objective value of scratchiness, so there is a very good correlation between this object.

And this scratchiness depends on other factors also, a diameter of monofilament, if the diameter is low, we are measure, we have produced fibre from micro filament, the scratchiness maybe less as it has to have high bending rigidity. So, a coarse filament will give more scratchiness value, so good correlation has been observed.

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So, this is the objective measurement rating, and here is the subjective rating of scratchiness, so there is a good correlation between these two.

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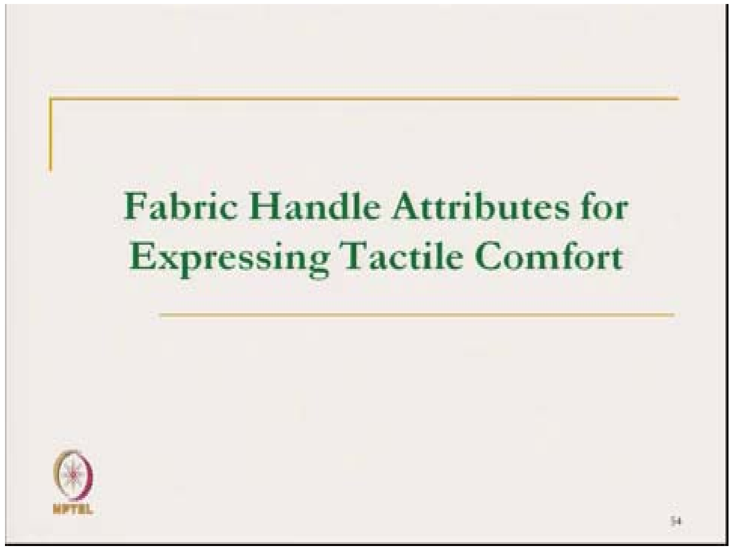

Now, we will discuss the fabric handle attributes used for expressing the tactile comfort.

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So, there are various fabric handle attributes; the quality of fabric is generally perceived through tactile sensation. The consumer always first touches the fabric before they buy, so this is the tactile aspect, it first senses before we can get idea about the fabric tactile sensation. And majority of the fabric is rejected even if the fabric is colour wise, even size wise, everything design wise is ok, but if the fabric is tactile sensation is poor, we normally do not purchase, because it will give unnecessary discomfort.

And there are improvement in this area of work to improve the finishing, and the fibre characteristics have been improved, specialty textile structure has been improved to improve the fabric handle. So, actually significant development has been done to improve the fabric tactile sensation.

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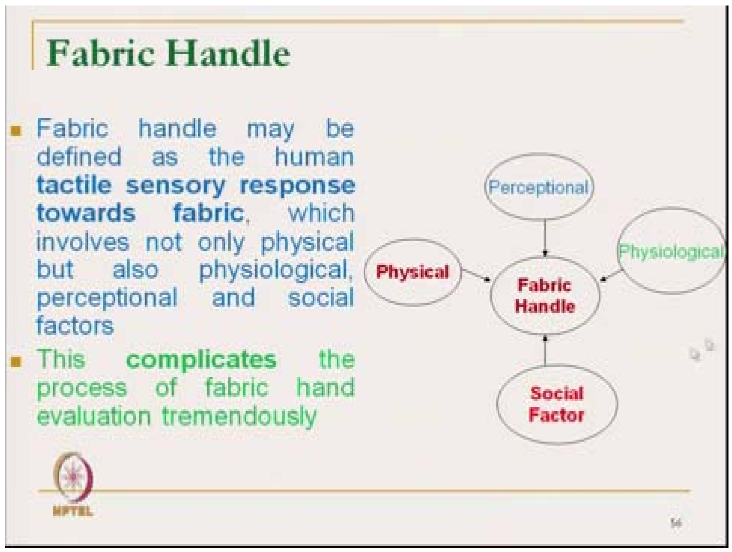

The fabric tactile sensation is actually not that simple, it may be defined as the human tactile response towards fabric, which involves not only physical, but physiological, perception and social factors. So, this is very complicated. So, that tactile sensation is not only fabric related characteristics, but other characteristics are also important like social factors. And, but we will discuss here only physical factors of the fabric, so fabric physical factors, perceptional factors and physiological factors are there.

So, this perception physiology, social factor that we have discussed during earlier session. Here, we will discuss the physical aspects of tactile sensations. And what are the different measurement? We can measure subjectively or objectively, so these aspects we will discuss here.

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So, fabric handle can be measured subjectively by judge or experience people from the industry, that is the present system and by physical movement of fabric. So, we can take the fabric sample and do some test quickly by hand and we can get idea about the fabrics handle or tactile responses like bending. If we try to bend the fabric by hand, we can get idea about flexibility that is one way of looking at.

Then it is rubbing, if we rub the fabric by our thumb finger, so that gives an idea about the friction or surface roughness. So, this is the stretching, if we press the fabric, we get idea about the softness or bulk characteristics. Here, is the stretching of a fabric we get elasticity or stress ability of fabric. And it is a shear characteristic, so we can get. So, this aspects, we try to measure when we select clothing, but this is not enough, because actually it has got total subjectivity. And we cannot get totality of a fabric. We can select a fabric broadly, so we need a measurement technique for this.

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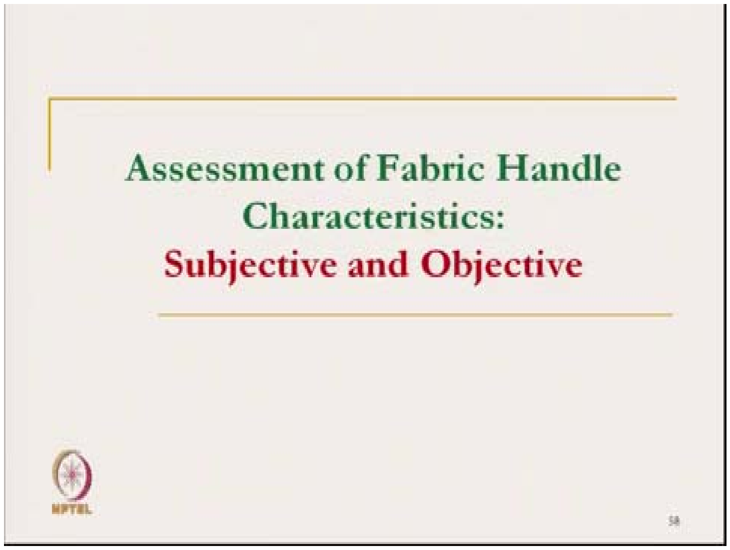

So, techniques available can be divided into two aspects; one is subjective measurement of fabric handle or tactile related characteristics and other is a objective characteristics. First we will discuss the subjective, what are the subjective ways of measurement of fabric tactile characteristics.

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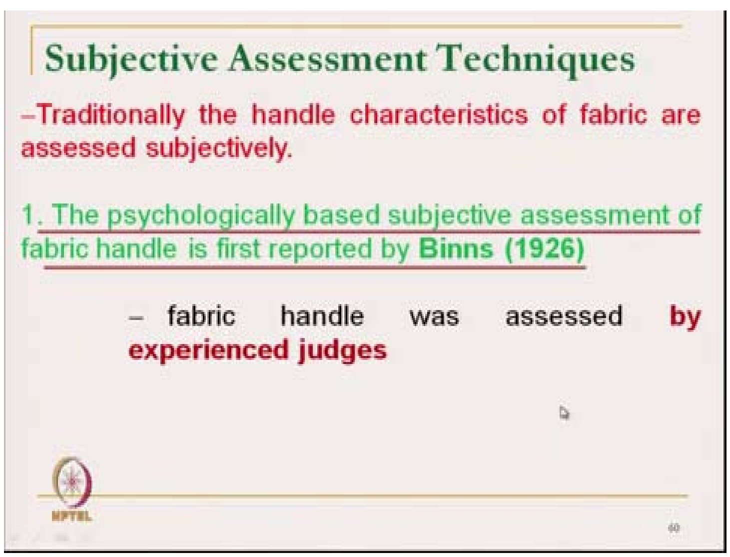

Traditionally, fabric handle was measured subjectively, and it has been reported by Binns in 1926. The physiologically based subjective assessment of fabric handle has been reported there. So, it measures the different cycle or subjective assessment and it gives the rating, we have discussed different psychological rating it gives value. Fabric is judged by the experienced judges, so they measure this softness or flexibility and give the ranking, so that has been reported in1926.

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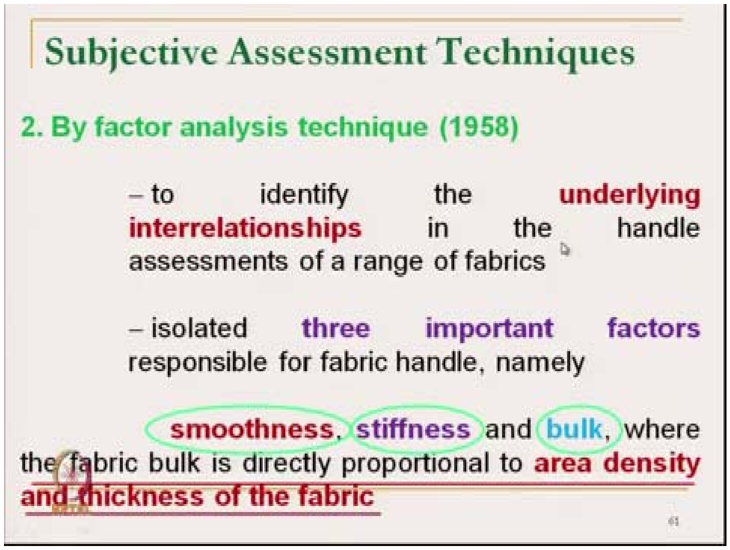

So, after that by a factor analysis technique 1958 it has been reported, so there are it different underlying relationship, interrelationship between fabric handle characteristics that is reported. So, they have isolated three important fabric handle related aspects. So, these are the smoothness of fabric, stiffness and fabric bulk, so these are actually the three subjective characteristics of fabric they have identified. And they have the bulk is directly proportional to the area density and thickness of the fabric. So, they have tried to correlate this subjective assessment with the sensation.

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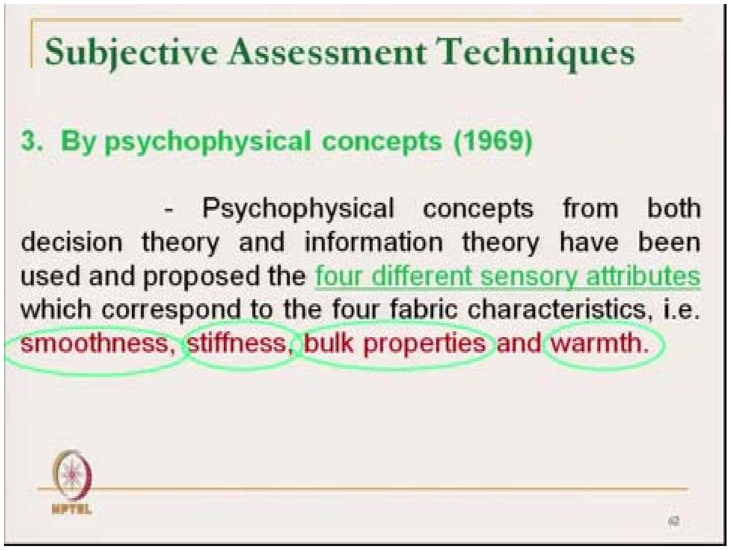

Then, psychophysical concept has been proposed from both decision theory and information theory and proposed the four different sensory attributes. These are smoothness, stiffness, bulk property and also it has been proposed earlier also, here they have proposed warmth of the fabric. So, warmness and coolness also gives the direct tactile response of fabric. A fabric may be very good in tactile sensation, and if it gives warmth, then we may feel little bit discomfort in tactile. So, they have introduced this warmness or coolness, so we will stop here, we will continue in the next class.

Thank you.