Evaluation of Textile Materials
Prof. Apurba Das
Department of Textile Technology
Indian Institute of Technology-Delhi

Lecture-26
Evaluation of Yarn and Fabric Hairiness (Contd..)

So, hello everyone, so we will continue with the topic yarn hairiness and now we will discuss different techniques of measurement of yarn hairiness, as we have discussed in last class that the techniques there are basically 2 different techniques are there. One is measurement of yarn hairiness, but number of hairs beyond certain specified length. And another technique is that measurement of total number of total length of hairs beyond certain length ok.

So that is both this methods they have their positive point and negative points, this detailed we have discussed in last class. Now we will discuss the exact measurement technique first is that Shirley yarn hairiness tester ok.

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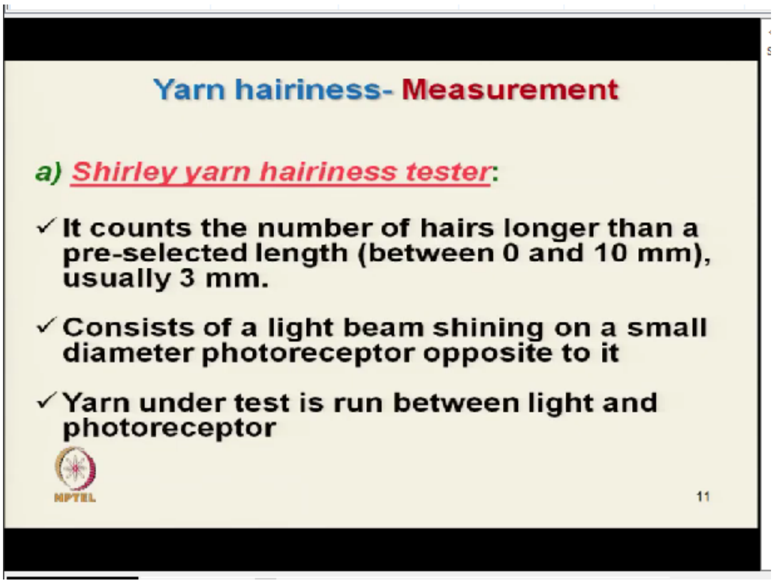

Here we actually measure we count the number of hairs longer than a pre-selected length between 0 to 10 millimeter and usually if we see it is a 3millmeter ok.

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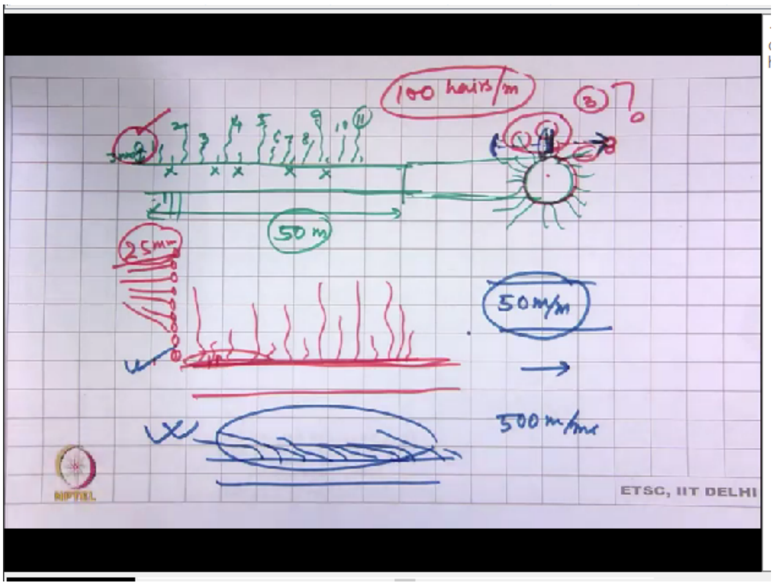

Now suppose this is yarn ok here we have different length, now what we want we want to measure the length of number of hairs. So these are in on the both side, we want to measure suppose this one is the length 3 millimeter. So it will count whatever num whichever here or more than the 3 millimeter length the 3milimeter. So this will keep on counting this is the 1, it will count 2, 3 this will be not be counted 4, it will not be counted 5. This is just belong 6, 7 not counted 8, 9 not counted 10, 11 in this way

So it will keep on counting the number of hairs for unit length suppose this is suppose 50 meter, 50 meter length of yarn has been passed. So, it will there will be photo sensor this will count now the condition that situation here it is it will only count the hairs which is beyond 3 millimeter. And yarn is not 1 dimension or 2 dimensional material it is a 3D material, it is a almost if we seen circular in process suppose if we draw this yarn cross-section this is a cross-section.

This is yarn cross-section, the same yarn cross-section, now the hairs are like this. Hairs are not in a particular direction. This is actual this hairs are covering the entire surface, now what is happening here this sensor here photo sensor. It actually sense only from one point not even surface, only from one point suppose this is a sensor. It is placed beyond 3 millimeter, so the here it is a 3 millimeter sensor.

Now this sensor is only sensing whatever hairs, the yarn is actually moving in this fashion. This is the movement yarn movements direction yarns direction ok. So, in this picture only this hair are this hair or may be this 3 hairs will be complicate ok. And if there is some small hair here this will not be counted that is actually we want. But this 3 hairs are counted the signal will be the number of hairs will be 3.

But actually there are large number of hairs, even this hair will not be counted because this is not coming in that range ok. So that means is it giving the correct result, so the count what we are getting same say 100 hairs per say meter or 1000 hairs/meter whatever may be the count, are we getting the exact count of the hair number of hair no, we are not getting, where getting the indication of hairs with an assumption that the hairs are actually covered uniformly throughout the yarn surface ok, same will see same is the case of the if we want to measure the fiber hair length ok.

So, this is the here one should not get confused that this gives the total number of hairs it is not the total number of hairs. It is the hair only within these zone and rest hairs are not counted. But the condition that actually for comparison or for some gridding this is enough ok. Because with the assumption that the hairs are uniformly distributed throughout the surface ok.

Now, so in Shirley hairiness tester what we do here it is not usually it measured the hairs beyond whatever the length the more than 3 millimeter it counts the number of hairs ok. But if another set it can actually be, there is a 2 set of rollers are there one is the fixed roller which is fixed at the 3 millimeter the length beyond the yarn surface. Another one it is a variable which varies from 0 millimeter 0 to same 10 millimeter maximum 10 millimeter and it counts the number of hairs.

So, it consists of a light beam shining on a small diameter photoreceptors opposite to it. So, in that picture what we have seen here there will be one light source. So, if suppose it is a light source is there**,** so this light source and in other side there will be photoreceptors, this photoreceptor will actually get the signal ok. Now while the yarn is moving suppose there is no hair this light totally it will reach to the photoreceptor.

But in case of hairs coming in between, so that obstruction will give indication that there is only one hair ok. Now the another problem here is that very high density hair concentration, in that case if there are 2 hairs coming together. This way give signal of one hair but in any case this gives rough idea about the number of hairs ok. So, the light beam it consist of light beam and a photoreceptor of small diameter light beam.

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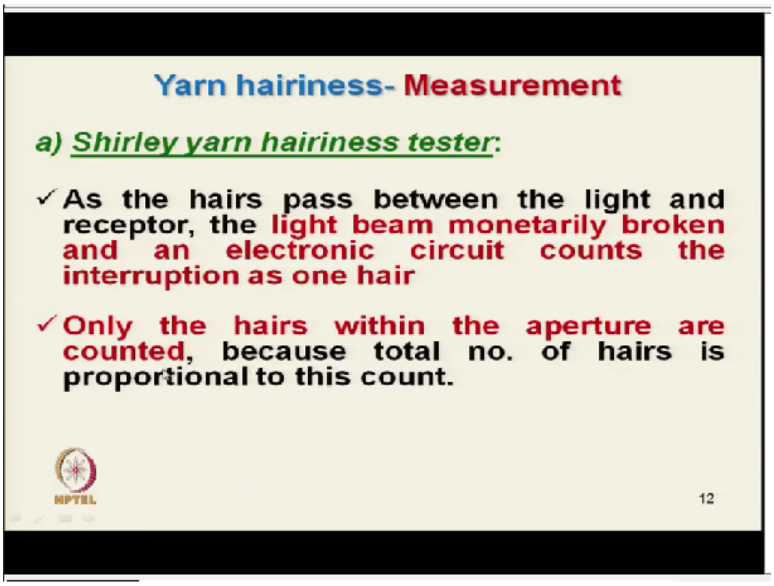

So yarn under test is run between the light and the photoreceptors when it is moving the hairs pass between the light and receptor, the light beam monetarily broken ok. And the electronic circuit counts the interruption it counts the number of interruption. So as one hair, so if it is interrupted once may be by single hair or may be a cluster of hair it will be counted as one hair ok.

So, that one hair only the hairs within the aperture are counted if it is below if it is beyond that aperture as I have mentioned. So because the yarns are covered with the total hairs throughout the surface because total number of hairs is proportional to this count ok.

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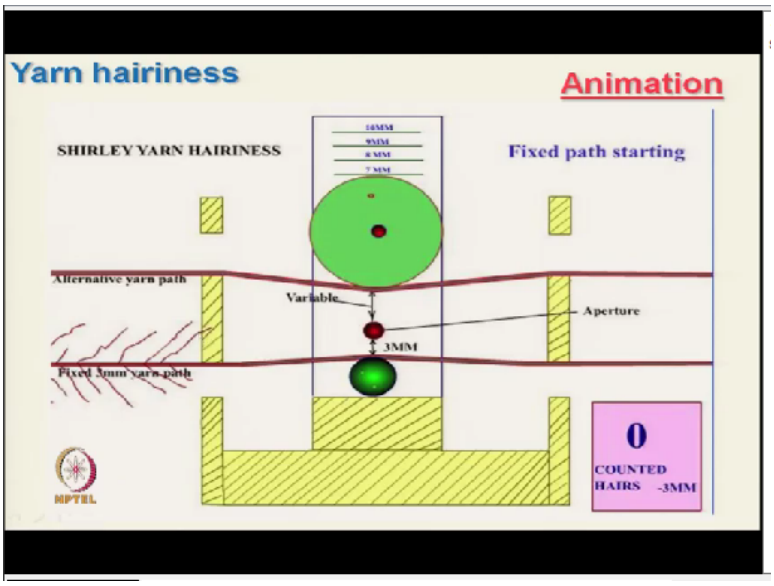

Now this is the instrument here we have 2 yarn paths this yarn path at the bottom it is a called the fixed yarn path. So, here the yarn will move and this is the guide and here this is the aperture and distance where light passes through that and the distance between this aperture. And this guide it is fixed here it is a 3 millimeter. Now the 3millimeter distance that may vary depending on the diameter of the yarn ok.

So that it has to be initially it has to be actually set passed okay calibrated that initial distance based on the diameter of the yarns. So, for forcer count yarn we have to move this guide little bit further away. So that the outer surface this top surface of yarn and this aperture the distance remains 3 millimeter and as the yarn moves in this direction from left to right. So this hairs will be actually will get give obstruction here in the light beam and it will this will be counted.

Now if we want to measure the hairiness other than the 3millimeter. We have to select the variable path where another guide roller is there but which is movable guide, here it is a fixed guide roller this. This guide roller is movable and it is between, so 0 and we can set at anything between 0 to anywhere between 0 to same 10 millimeter. So that if we want a higher length of hair want to measure. So, we will shift this guide roller little bit above this. So that take care of the let us see the animation here.

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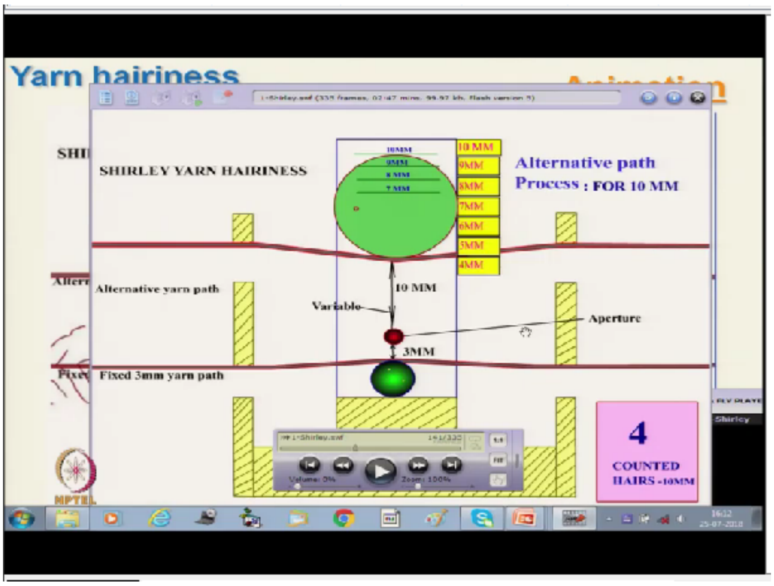

Now it is a fixed path that means now it is a moving yarn is moving. Now it is a one abstraction, 2 abstraction, 3, 4 and it is not this one is not obstructive 5, 6 those obstruction are coming under this aperture or counted ok. But it is you can see this is not counting the hairs below or in other side. So this counter, so for certain length it has count it is a 19, so 19 hairs that are more than 3millimeter of length okay that is actually gives as the idea about the hairiness ok.

Now we will use the variable path ok, this is the variable path for different. So like like 10 millimeter we want to measure number of hairs beyond 10milimeter this one only one hair this one will be counted. Now it is a rest other are now it is 2 now this one will be counted only it is a 3. So in this way this one will be counted, this is 4 that means there are 4 hairs beyond 10 millimeter length.

So that way we can get fair idea about the length of hair and also the number of hair ok. Now we have shifted it to another distance it is a 9 millimeter, now same yarn if we pass, so accordingly will get different count. So, earlier it was a 4 hairs beyond a 9 10 millimeter now we have 5 we have we can observe it is a it is basically around say 6 hairs beyond this ok. So, in this way we can get that detailed idea about the number of hair and length of the hair distribution ok.

Now it has been shifted to another length, so say 8 millimeter. So for 8 millimeter gain we can test, so this way this variable length works ok. So, it is counting the hairs beyond that, so same yarn we are passing again. So, it gives the idea it is a say 7, say 8 ok 9, 10 it will give say 10 hairs ok. Now if we can see it is an 8 millimeter now we are you are we have shifted little bit more 7.

So it should be more than that ok, so that way we will get total distribution in the hairiness. But here we cannot test more than one setting at a time, here we have to change the setting, we have only one setting at a time you have to take ok 7 millimeter it is a giving 11, say 12, 13 it will be 12 and 13 it is there ok.

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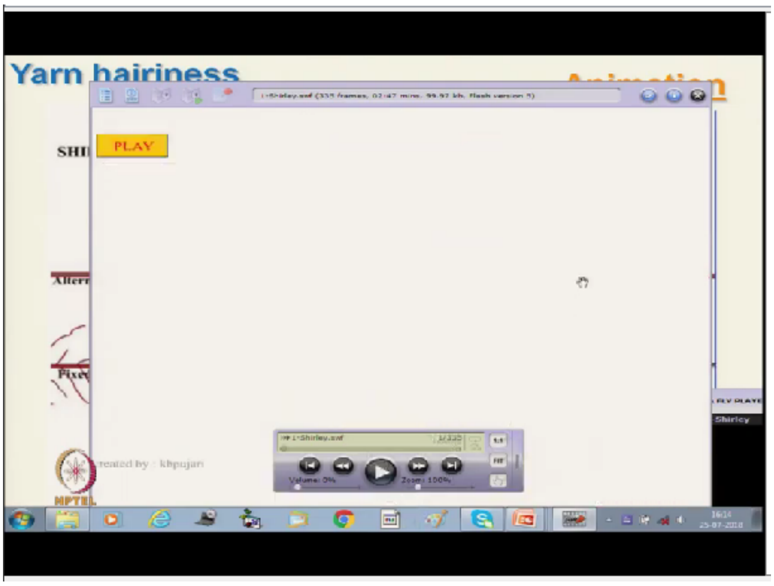

Now if we say now that is the end of this, so we can **we can** test at other 6 millimeter, 5 millimeter, 4 millimeter, in that way we will get the result ok.

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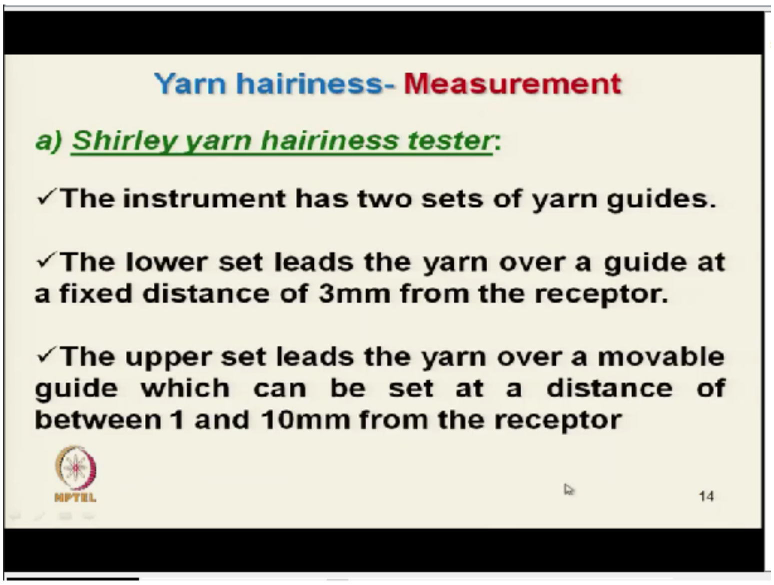

Now this yarn hairiness tester it has got 2 sets of guide yarn guide that we have discussed. Lower set leads the yarn over a guide at a fixed distance 3 millimeter from the receptor. Because the guide roller actually set the distance the upper set it lead the yarn guide actually it is a movable ok, at different distance from the receptor ok between 1 millimeter to 10 millimeter ok.

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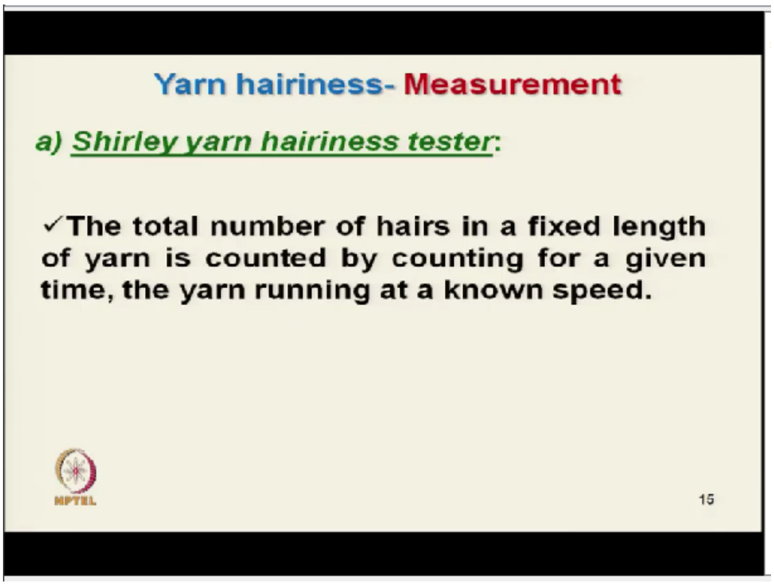

The total number of hairs in a fixed length of yarn is counted ok, so for say fixed length say 100meter here, for 100 meter we can count the total number of hairs ok. And if we know the speed of testing and if we know the count time, so you can calculate the number of hairs per unit length.

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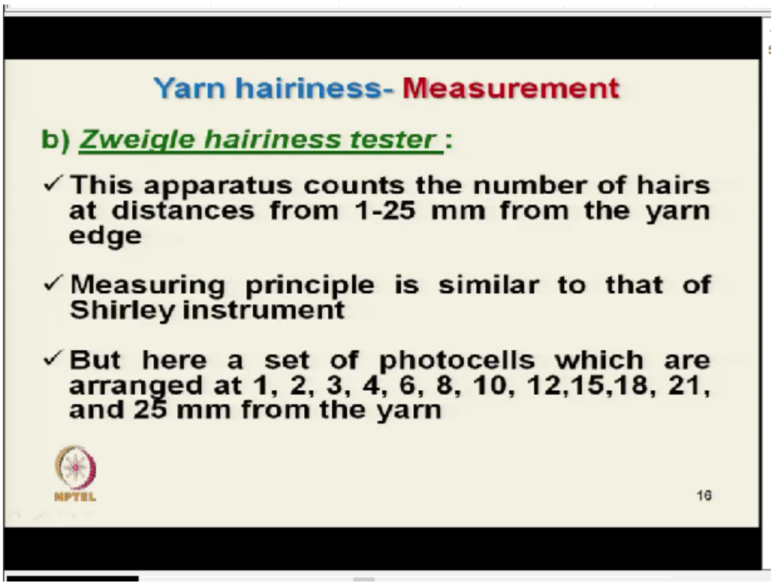

The next method is that it is a Zweigle hairiness tester now the it is principally is exactly same as the Shirley hairiness tester but the main problem with the Shirley hairiness tester we can get the data one hairiness, one particular set of hairiness at a time ok. If we want to test 3 millimeter and beyond number of hairs of length 3 millimeter and more then we have one test we have to have one test. Then if we want to have say 4 millimeter or 5 millimeter then we have to have repeated testing.

But this method gives the total range of hairiness length it also it measures like Shirley hairiness tester. It measures the length of hair ok, so the aperture counts the number of hairs at a distance from 1 to 25 millimeter from the yarn edge ok, suppose this is the yarn edge and there are hairs at different. So in this in Shirley what we have observed there is only one that photoreceptor ok.

But here we have number of photoreceptor typically 12 photoreceptors are there of different length from 1 millimeter to 25 millimeter and they gets signal simultaneously. And totally at in one go one test we can get the total distribution of number of hairs of different length ok different projected length. Now the measuring principle as I have mentioned it is a exactly same as the it is a similar to Shirley instrument.

And here we have total 12 set, so there are set of photocells ok here typically it is a 12 at different distance from the yarn surface 1 millimeter, 2, 3, 4, 6, 8, 10, 12, 15, 18, 21 and 25 ok millimeter from the yarn. And that initial setting we can do by proper initial adjustment.

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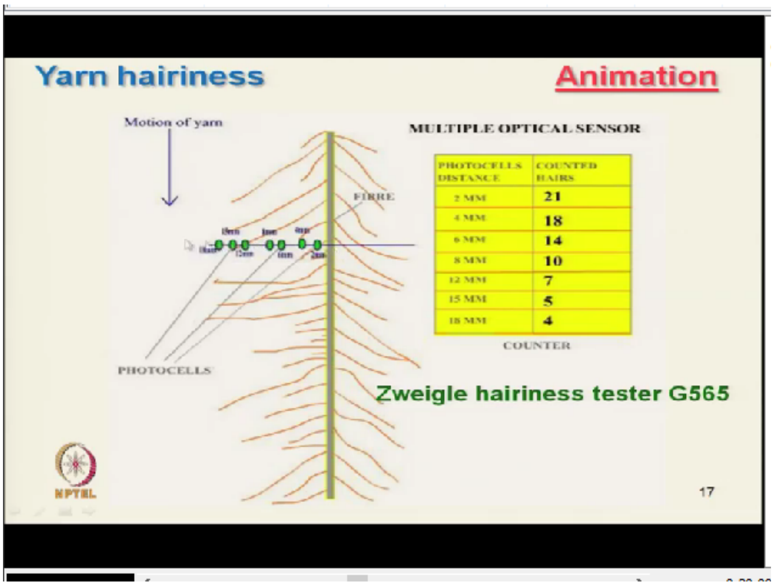

Now this is the animation and the picture it shows that here we have different photo sensor ok, this is the photo sensor. And here when yarn moves similar to that Shirley hairiness tester it is also refer the number of hairs ok.

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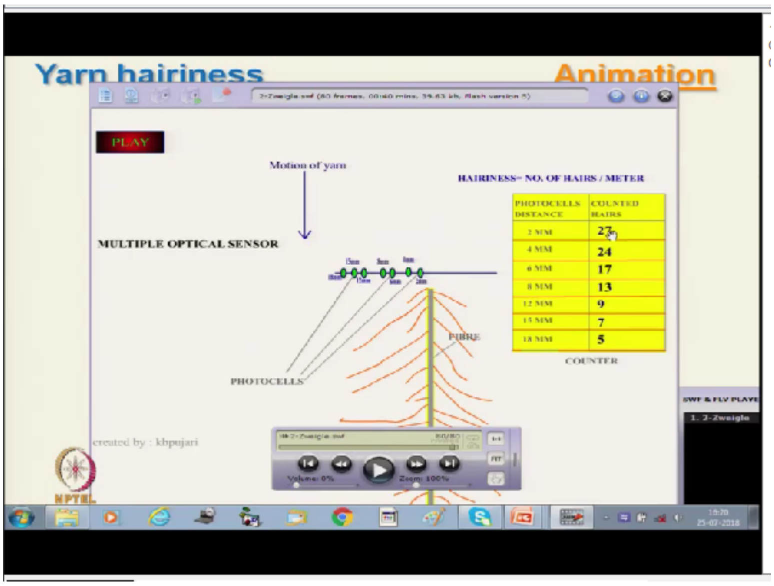

Now you can see here now yarn is moving, now counter as started at different the 2 millimeter, 4 millimeter, 6 millimeter like that ok. And this is giving result number of hairs, so it is exactly in the same way, but we are getting all the data detailed ok. So and here this actually cumulative total this one will give us the total idea of the number of hairs beyond that length ok. So, that means it is a there are 27 hairs beyond 2 millimeter, 24 hairs beyond say 4 millimeter.

So between 22 to 24 millimeter if we want to measure it the we can also measure by subtract it. So, this keeps the total idea oral idea of the length of the hair which is very important because it is the length of the hair which is very important. And it is the number of hairs number and length of hair and it gives the total distribution ok.

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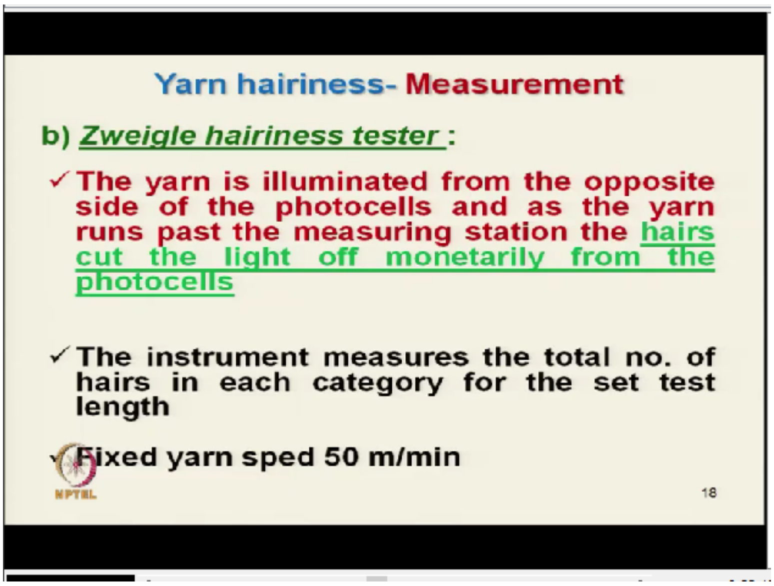

And in this method the yarn is illuminated from the opposite side of the photocell and as the yarn runs past to the measuring station the hairs cut the light off monetarily exactly same as the Shirley hairiness tester. The instrument measures the total number of hairs in each category for the set of test and typically the fixed speed is kept it is a 50 meter/minute that is important. If I I have already discussed if we increase or decrease the speed.

Then it is not comparable ok. Now let us see this is the yarn suppose this yarn if it is running at a 50 meter/minute**.** This yarn will give certain result and 50 meter/minute it is sufficiently high for to have quick test and sufficiently low. So that the yarn the hair does not get distorted ok. But suppose I want to finish by test quickly I have increased to 500 meter/minute. The thing will be that the this hairs will be due to the air drag I have mention this will try to have different orientation.

And this will give entirely different result, that is why this the speed in this instrument is specified if we change the speed total hairiness reading will be different, for same yarn. So that is why it is recommended we must run the yarn at a specified speed ok. So, that if we change the speed we can get all together different result.

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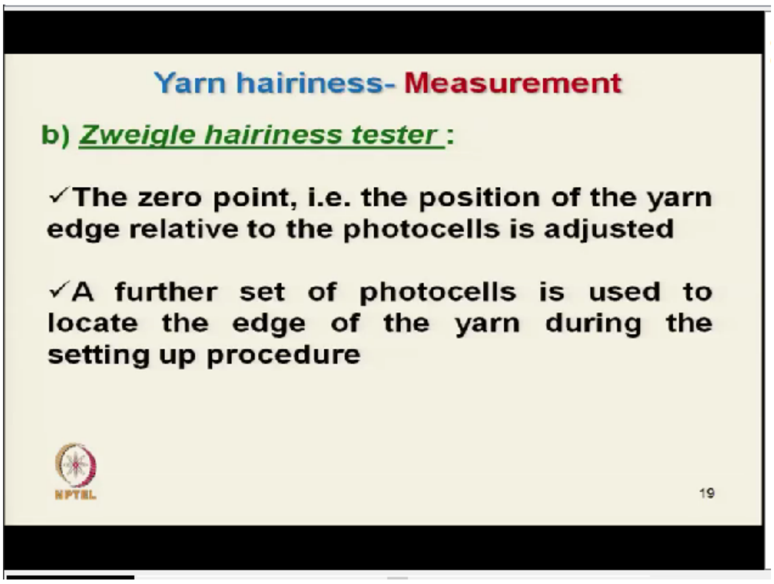

So that zero point it is important, it is important not only for this also but for the Zweigle hairiness tester zero point setting is important that is the position of the yarn edge relative to the photo cell is adjusted that we have to adjust perfectly ok. A further set of photocell is used for this hair to locate the edge of the yarn. So, you must locate the edge of the yarn now how to locate the edge, so that it is a basically it gives the point like here the how to locate this edge.

If this photocell will locate where the density that light the density is very high that means light will not pass. And after just beyond this edge light will start pass ok, so that edge detection is done by a separate photocell ok. This edge has it is important then only that reference this is ultimately this will be the reference point. So, beyond this reference point then it will start counting or measuring the length of the hair.

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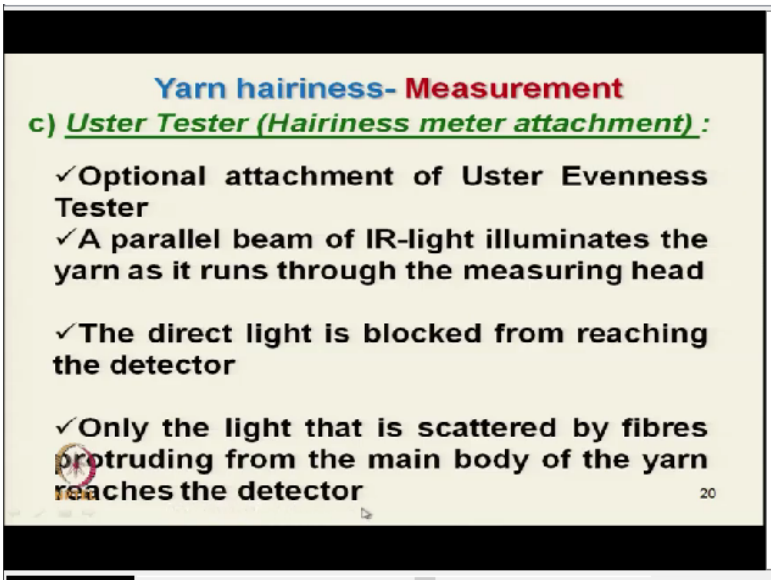

And next technique is that it is a Uster tester Uster actually this is a an attachment with Uster evenness tester. And one should not get confused that Uster evenness tester that will discuss later, it works on capacitance principle. But as because it is attached with the Uster evenness tester people make get confuse that it is a it works on capacitance principle. Because in capacitance principle we cannot measure the hairiness here the technique is that it is a again light principle.

It is a it works on light scattering principle but it is an attachment but it is independent instrument ok, optional attachment of Uster Evenness tester. But the as the software is there in Uster which gives a different types of characteristics like different types of grams, graphs like that spectrogram, histogram all this type of different mass variation diagram ok that is called diagram it is called, so this type of this is for the mass variation like evenness.

And similar variability variation similar calms we may gate also or hairiness also. So, it works on higher light illumination ok. And it is light scattering principle, a parallel beam of higher light illuminates the yarn as it runs through the measuring head ok. And the direct light is blocked from reaching the detector and that is important. So if there is a no yarn suppose yarn is absent. The instrument will show it is nothing no light is coming ok, only light that is scattered by hairs protruding from the main body of the yarn reaches the detector.

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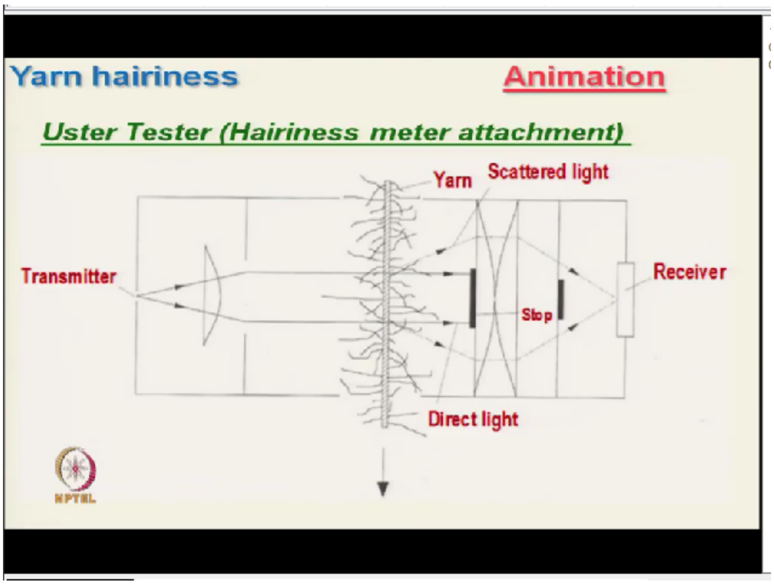

So, like now this I will explain here.

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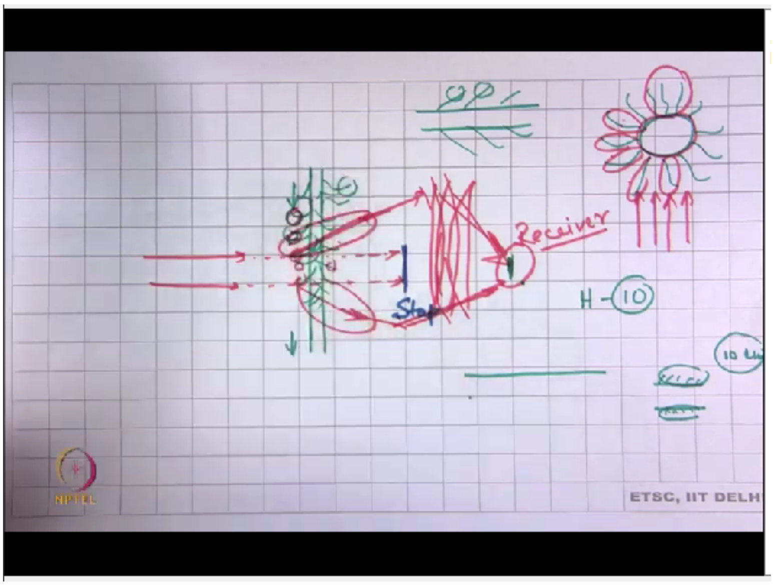

Suppose it is a light source is coming this is a light source ok now and here you have something which is blocking this is blocked ok which is a light stopping stop which blocks the light. And somewhere here we have receptor light receiver ok this one. Now in normal case there is no yarn, yarn passes through this point, this is the yarn path, path of the yarn, suppose there is no yarn, in that case what will happen light will directly projected on this stop and light will never reach in the receiver ok, this is the receiver.

So this is the this stop will actually stop the light, now after that what we are doing suppose this is 1 filament yarn or yarn with 0 hairiness it is move again what will happen?. This yarn will block light to some extent but beyond that whatever light is passing this will be blocked again. So in that case also nothing is reaching here, no light is reaching here. So that hence it shows that the there is no hairs.

Next case a yarn with hairiness, this hairiness it is coming now what will happen this the yarn has got 2 portion, 2 distinct portion, 1 is its body another is hairs. The body of the yarn core of the yarn it is as good as the filament, it will act as the filament. So it will block the light, light will not pass but the when the light will fall on this hairs this hairs ok. The hair when it is coming here this hair will start actually scattering the light.

Light will get scattered by this hairs, now again the issue of the totality I am drawing the cross-section here, here this is the cross-section. When the yarn is moving suppose the light is this is the light ok, now light will scatter all it will get scattered by the hairs which are coming on it is way. Now all this hair will come but this hair may not come just opposite side and also this hair if it at all scattered this may be blocked again by the body.

So, but whatever the amount of the light quantity of light it is scattered it is definitely proportional to the number of yarn total length of the yarn**.** Now the yarn that this light is scattered throughout by throughout the surface. So this the total quantity of light it is scattering it is proportional to the length of the hair coming across the light source light path of the light and this will gets scattered and with the help of some this lens arrangement.

This will be actually taken, so this type of lens arrangement will be there and it this will again be converse here and it will fall on the receiver ok. So, then the quantity of light the received by the receiver is proportional to the total length of hairs projection. So here this is the transmitter which transmits the higher light and it is a through this optical arrangement this is the parallel light is going.

And it is blocked by the this stop arrangement and this is the actual this is the stop arrangement here it is again it is a blocked by this arrangement. Now this will be blocked when there is no yarn and when there is yarn without any hairs but as the hairiness is there. So this hairiness will actually scattered the light, this scattered light will get again conversed here and receiver will receive the light.

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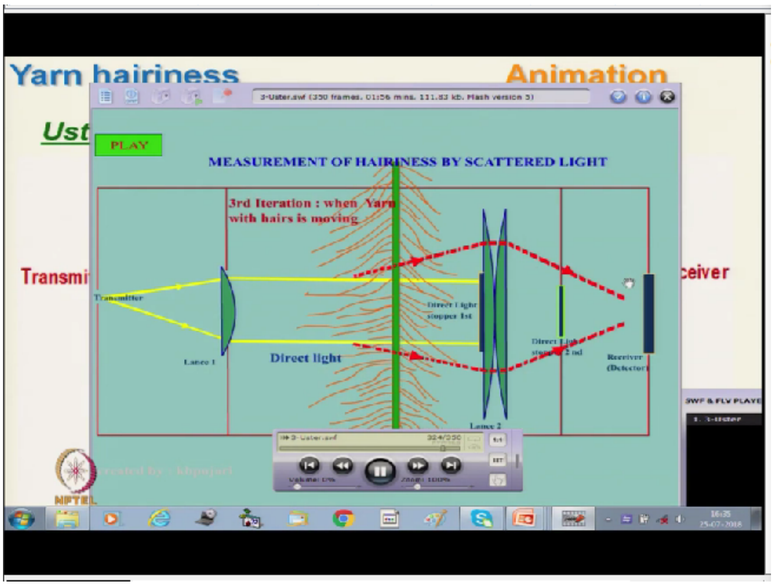

Now let us see the animation here, this light is diverging light is coming and due to this lens arrangement lens1 it has become parallel ray of light. And first it reason is when there is no yarn and it will be it is a blocked by this blocker, so block here, no light is going to the receiver intensity of receiver i2 is i1 is 0. Now again the yarn without any hairiness is coming as like filament end when yarn moving with no hair.

So nothing will change ok, it is actually again the intensity of light here it is 0. So, it will, so there is no hair. Now the yarn with hairiness is coming and now the light will start getting scattered by the hairs. And this scattered light ok will fall on this optical lens system is 2 and then gain it will be converged and it will now this light the intensity of hair is i3 is proportional to the length of the hair what we ar getting hair?

We are not actually measuring the length but we are getting an idea which is proportional to the that intensity which is proportional to the length of the hair ok. And this intensity how doing how are you getting the length because it has been actually gauged from prior data which has been actually gauged that much intensity means this is the length of the hairs ok**.**

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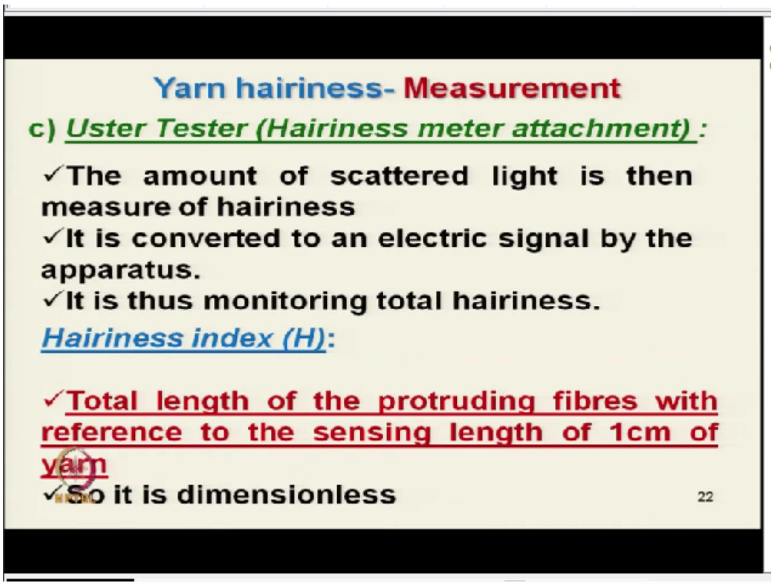

So, the amount of scattered light is then measured it is a measure of hairiness. It is converted to an electrical signal by the apparatus. It is thus monitoring total hairiness ok and the instrument gives a data which is known as the hairiness index that means total length of protruding fibre with the reference to the sensing length what is the sensing length of the 1centimeter of yarn that is important total length of hair in centimeter divided by the length of yarn in centimeter ok.

So, that is why this is dimensional lens okay centimeter by centimeter okay that means higher h value means higher length of hair protruding ok.

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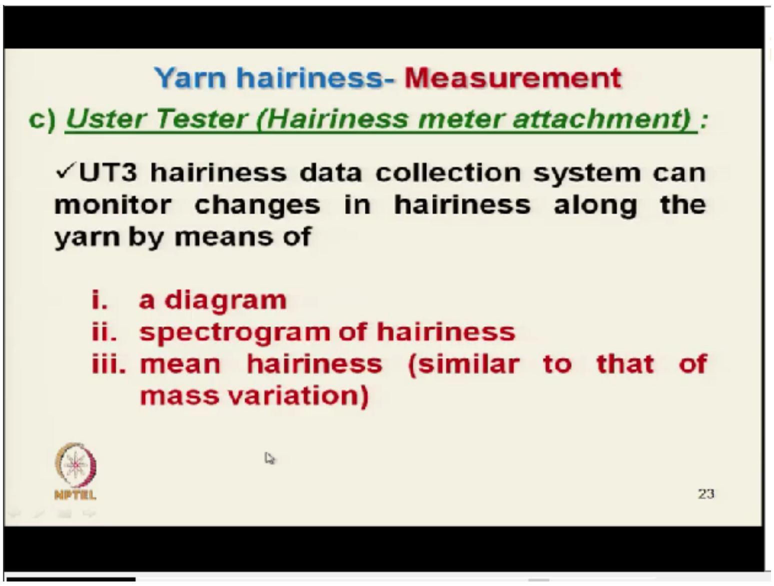

So, h value of say 5 means in 1 centimeter yarn, so say h values say h value of H-10 what does it mean? suppose we are taking say 1centimeter yarn and it is the if we take the total length of the hair if we add together total length it will become 10 centimeter. So, 10centimeter is the total length, so higher edge value means higher length of hair. So, as I have mentioned that it is attachment with UT3 Uster tester hairiness evenness tester 3.

So, it gives the hairiness evenness tester gives the diagram, mass variation here it gives the diagram of hairiness variation. UT3 gives the spectrogram of mass variation here it gives the spectrogram of hairiness and there UT3 gives the mean value. Here also it is the mean value of hairiness similar to that of mass variation.

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Now we will discuss the measurement of hairiness of fabrics ok, there are few techniques.

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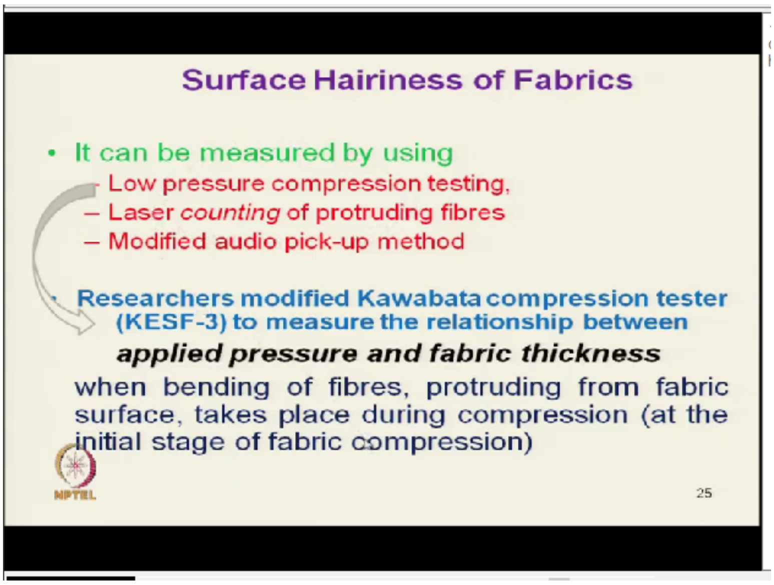

The surface hairiness is the basically it is a indication it gets higher the yarn hairiness that will result higher surface hairiness. And it can be measured by a different techniques one is that low compression testing ok. Now the fabric hairiness suppose we have 2 fabrics.

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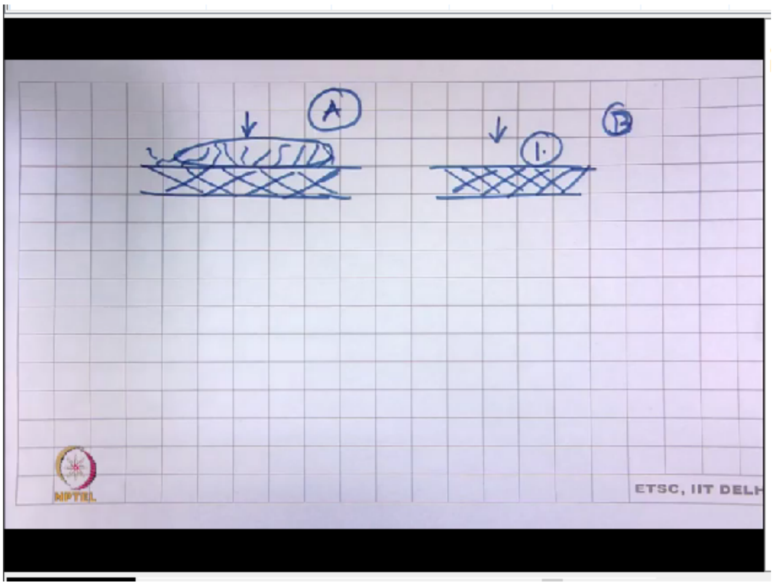

This is fabric1 fabric code and it has got hairiness these are the hairs on the surface. Another fabric suppose there is no hairiness, now how do you get the indication of hairiness in the fabric on the surface of fabric. If we test the compressibility at low pressure, so the fabric with higher hairiness will give higher compressibility. But this fabric fabricA will give higher compressibility and fabricB will give least compressibility it will not be compressible.

So, this compressible by knowing the compressional value at low pressure will give idea about the presence of surface hair. It is called low pressure compression testing. Next is the laser counting of protruding fibres. It is a similar to that of the Uster hairiness tester of yarn it works on almost similar principle of light scattering principle and third one is modified audio pick-up a measurement which will give as the idea about the hairiness as well as it predicts the prickliness of the fabric ok prickle sensation.

And this low pressure compression testing it is a Kawabata KESF-3 if we convert if we just modify, so that will give as the indication of low pressure testing. It is the compression meter we can test. So, applied pressure and fabric thickness get we can from there we can get when the bending of fibre protruding from the surface takes place during compression. So, that protruding fibres bending from that we can get idea about the presence of hairiness.

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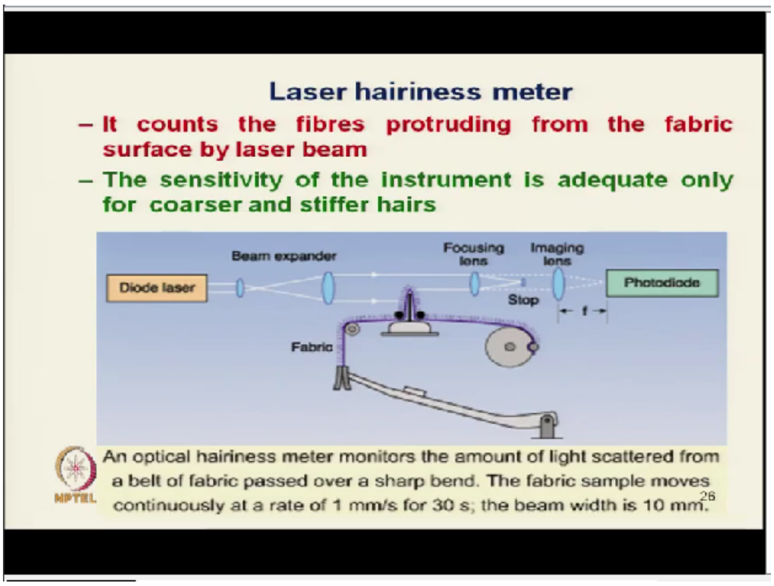

And this is the it is a laser hairiness meter, it counts the fibre protruding from the fabric surface by laser beam. This is the actually laser beam here and this one is the fabric ok. And fabric coming from this point and it is goes through the one edge ok knife edge type system. Then it is a winding of hair ok. Now from there at this point at the tip point when the light is coming it counts the number of hairs ok.

And from there one can count the hairs present the sensitivity of the instrument is adequate only for coarser and stiffer hair. So that limitation of this instrument if it the hairs are coarser and stiffer it is projecting beyond the surface in straight fashion. There is no bend and, so in those case it can the instrument measures actual accurately.

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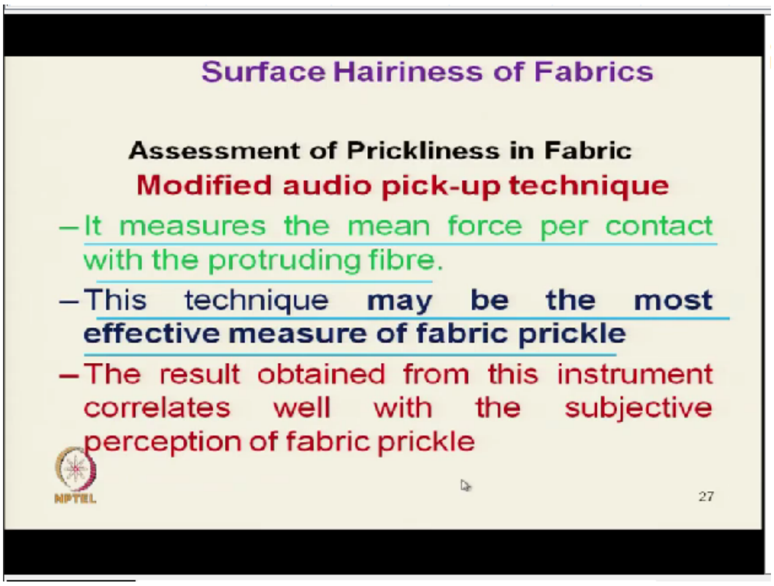

The surface hairiness of fabric another technique is modified audio pick-up technique which the result gives the idea about the prickle sensation of fabric ok. It measures the mean force per contact with the protruding fibre, so that will measure protruding fibre. And this technique may be the most effective measure of fabric prickliness and the technique is the result obtain from this instrument correlates well with the subjective perception of fabric prickle which is directly related with the hairiness yarn hairiness or fabric hairiness.

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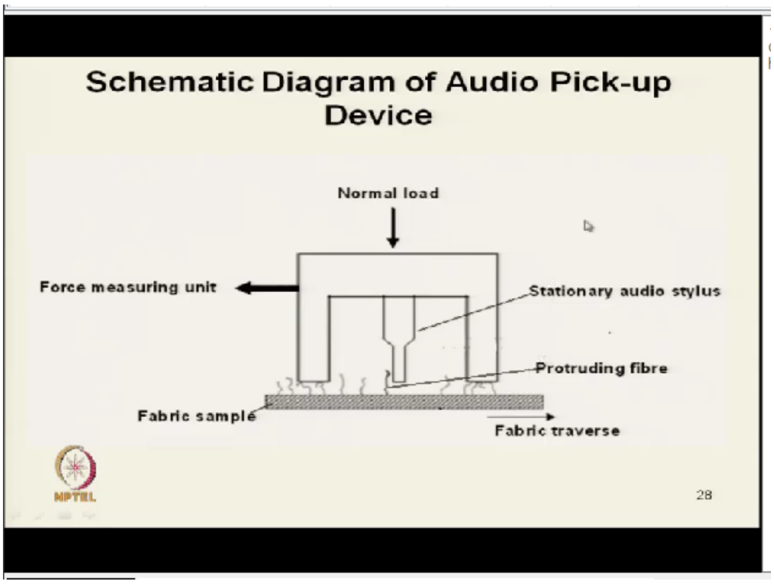

This is the schematic diagram of the instrument, now this is the fabric sample with protruding hairs, it has got 2 sensors. One is it is stationary audio stylus, so that is this is basically it is a it measures the number of hairs here and the bending force the actually the hairs are projected in it measures the number as well as the bending cantilever bending force of the hairs. And normal load is placed and here the buckling force of the hairs are measured ok. The 2 measurements are there simultaneously here.

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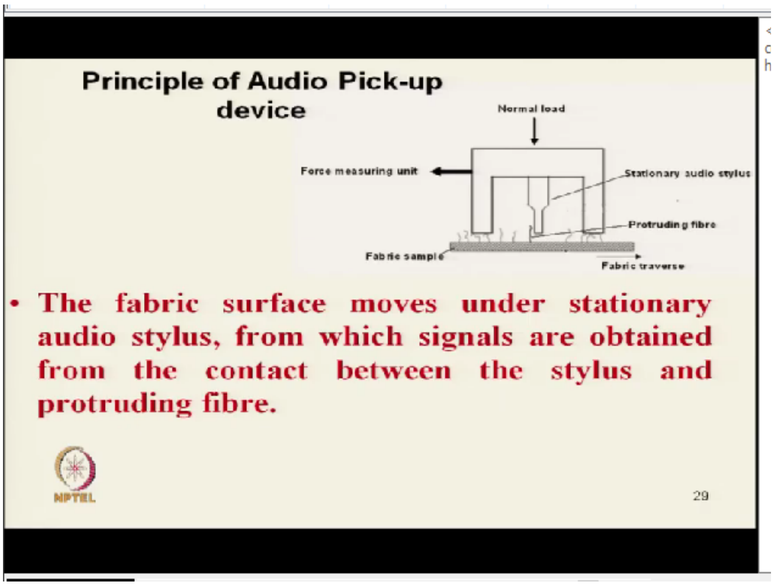

Now the fabric surface moved under stationary audio stylus, so this is the audio stylus here and this the fabric moves in this fashion ok that is mean pooled from which the signals are obtained from the contact between the this wind and the protruding fibre. And this create some sound and some section is that and that will give as the idea about the stiffness of hair. And also number of hairs all it will give some idea ok.

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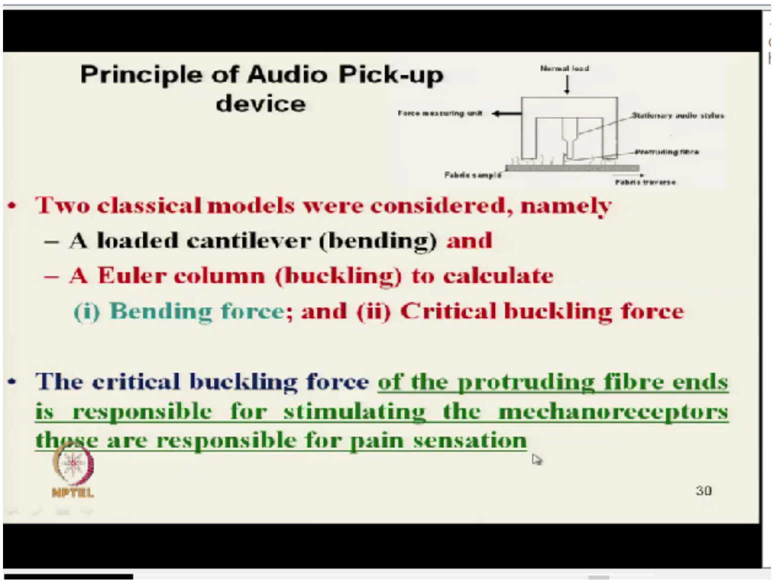

In addition, so 2 classical models are considered here one is that loaded cantilever model that is by the audio stylus model. Another is that it is a Euler column it is a buckling, buckling force, so buckling force is calculated. So bending force and critical buckling force they are calculated and that this are actually generated from the hairiness of fabric surface which actually in turns coming from the yarn hairiness.

And this gives that the critical buckling force of the protruding fibre ends is responsible for stimulating the mechanoreceptors those are responsible for pain sensation that prickle sensation. It gives idea and this is the model ok.

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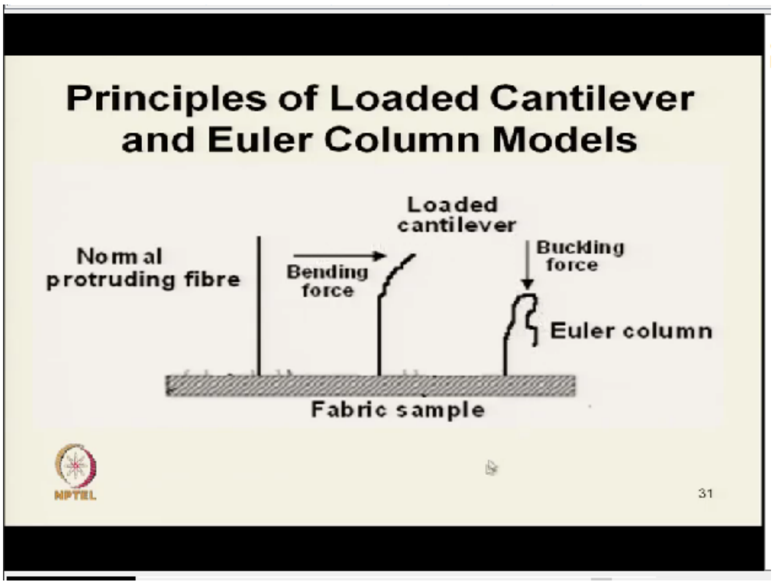

Now the principle is this is a normal fibre and here is the bending force we can measure and also buckling force we can measure with this.

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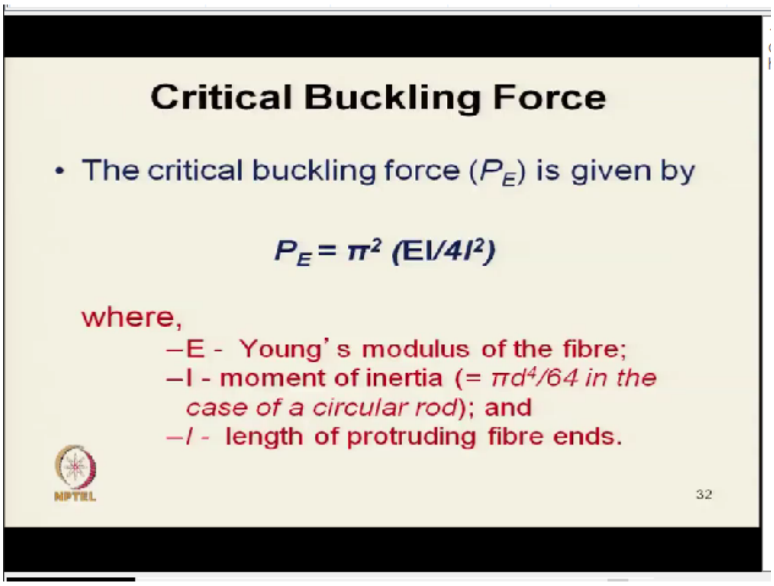

So critical buckling force is actually giving by the equation PE is the buckling force and where E is the Young's modulus of the fibre. Now so if the Young's modulus initial modulus of the fibre is high then it will create higher buckling force that means it will give the prickle sensation. I is the moment of inertia that means it is proportional to the fourth order of diameter.

So, if the fibre diameter is more as we have seen discussed earlier also if the fibre diameter is more it will create hairs and if it is hair is created. And it with the for higher diameter it will give higher momentum of inertia and the buckling force will be more. And that means it will create the prickle sensation and also the length of the hair, now length here for prickle sensation the length of the hair if it is less then it will give as more buckling force critical buckling force.

And that will actually in turn result prickle sensation ok. So, it is inversely proportional to the square of the length of the hair. So, I think we have covered the hairiness of yarn and fabrics in detailed here and we have seen various techniques of measurement and their implication in product final product and will end the session here, thank you.