Science of Clothing Comfort
Prof. Apurba Das
Department of Textile Technology
Indian Institute of Technology, Delhi

Lecture – 40
Garment Fit & Comfort (contd…)

Hello everyone. So, we have reached almost in the last segment of our course Science of Clothing Comfort and in last class, we have discussed that garment fit related aspects and we have been discussing that the factors related to the garment pressure, different issues related to the garment pressure and the.

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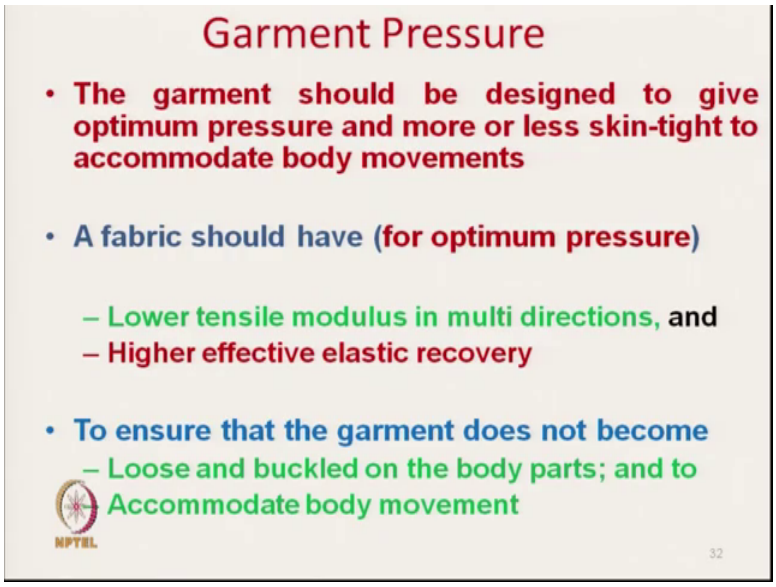

We have mentioned the garment should be designed to keep optimum pressure and more or less skin tight to accommodate body movement and for optimum pressure, the fabric should have some characteristics. These are, it should have lower tensile modulus in multidirectional million warp and weft direction should be there. Higher effective elastic recovery, so that it should not be permanent. There should not be permanent deformation. That is there should not be any bagging effect. It is required to actual, so that the garment does not become loose and buckled on the body part and to accommodate body movement.

So, these are the basic requirements of a particular fabric, so that it gives proper pressure on our body and we get the comfort related to fit. So, there are few studies. So, we will now discuss few studies related to garment pressure.

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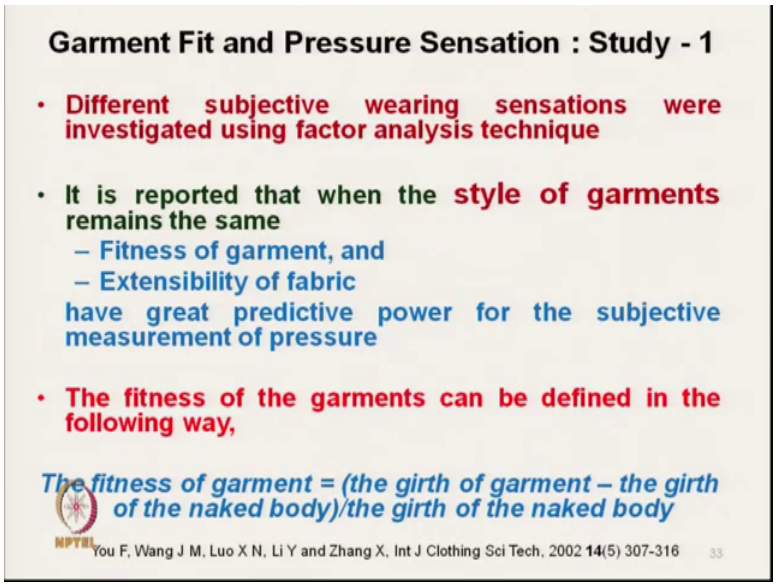

To start first study where the different subjective wearing sensations were investigated because garment pressure it is because you may test by subjective sensation or objectively by incorporating some sensor, pressure sensor. In this study the subjective sensations where study it is reported that when the style of garment remain same, they have kept the style of garment same. The fitness of garment and the extensibility of the garment have great predictive power for subjective measurement of pressure.

So, for same style the fitness if it is a tight fit garment, it will give higher pressure. If the fabric extensibility is less, then it will give higher pressure. The fitness of garment can be defined as the earlier we have seen the tightness of garment can be expressed by F value. Here fitness of garment is expressed in terms of the girth of garment and the girth of the naked body divided by the girth of the garment.

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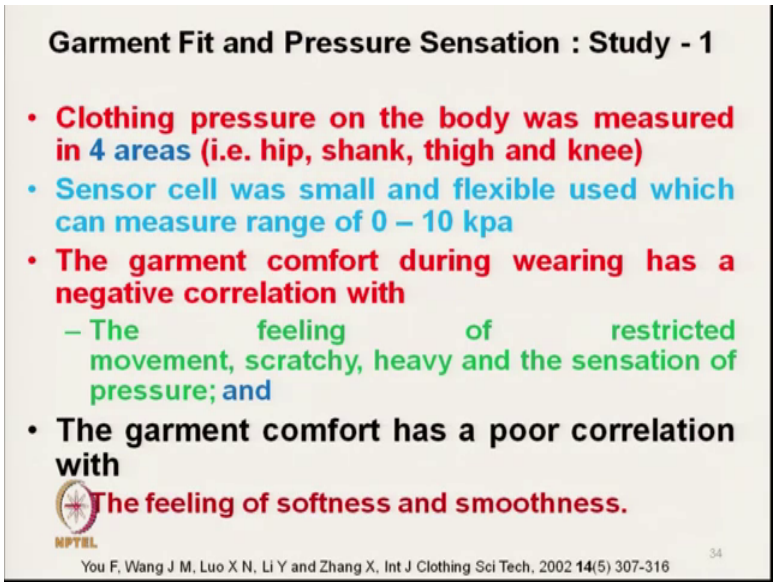

With that expression one can express the fitness of the garment. So, the clothing pressure was assist at four different areas; in the hip, shank, thigh and knee. At four different places they have assisted the pressure and experts were asked to measure the take the sensation and also the sensors were used. The sensor cell was actually it is smaller in size and flexible in nature

So, flexible and smaller sensors we have used that can measure the pressure of 10 to 0 to 10 kilo Pascal. Why is it flexible? Otherwise it will not confirm to our body curvature and small, it should be there. So, the garment comfort during wearing has a negative correlation with the feeling of the restricted movement. That means, restricted movement feeling if it is more, that comfort will be less, ok. That has got negative correlation.

So, fabric with higher garment with higher comfort will not restrict the body movement, it will not be scratchy, it will not be heavy and will not have sensation of pressure,. So, this scratchy heavy sensation and sensation of pressure if it is there or restricted movement is there, then the garment will give discomfort sensation and the compressibility characteristics, the softness characteristics and smoothness it is actually in the correlation they have found, it is not that highly correlated.

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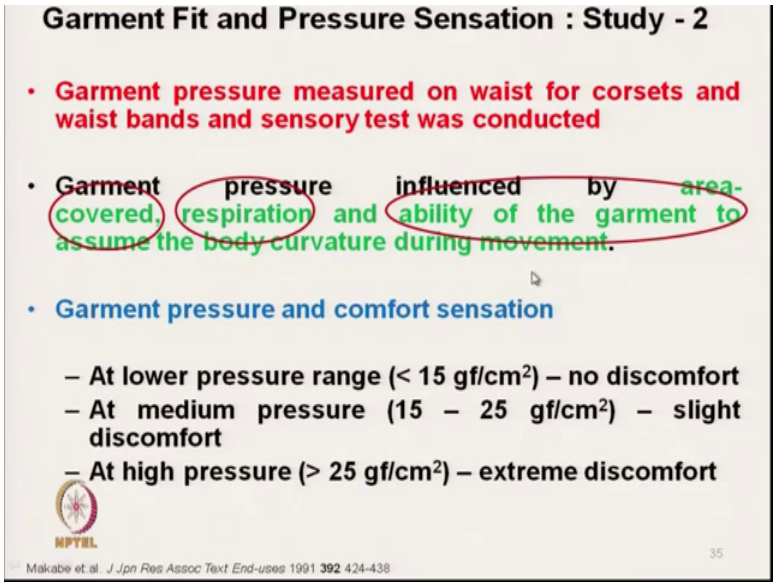

In study 2, the garment pressure measured on waist for corset and waistband that waist it was a measured and sensory test was conducted, the sensation of pressure was conducted. What has been observed that the garment pressure is influenced by area covered respiration and ability of garment to assume the body curvature. That means, the higher area cover will give the lesser pressure. The respiration level is also there. It changes and ability of garment to assume the body curvature. That means, garment made up of stiff fabric or a fabric with higher shear rigidity will give higher pressure sensation. So, covered respiration and ability of movement of garment or ability of garment to assume our body curvature and garment pressure and comfort sensation is that it is earlier we have seen the garment discomfort sensation starts from 60 gram per square centimeter.

Here at pressure less than 15 gram force per square centimeter, there is no discomfort that discomfort sensation was not there ok. When the pressure was measured less than 15 gram force per square centimeter and discomfort the sensation increases from 15 to 25. It gradually increases, but at pressure more than 25 gram per square centimeter, it gives high discomfort. Here what we are talking about? There at the overall pressure, overall it is not the specific area and this is these are the garments. It is normal garment.

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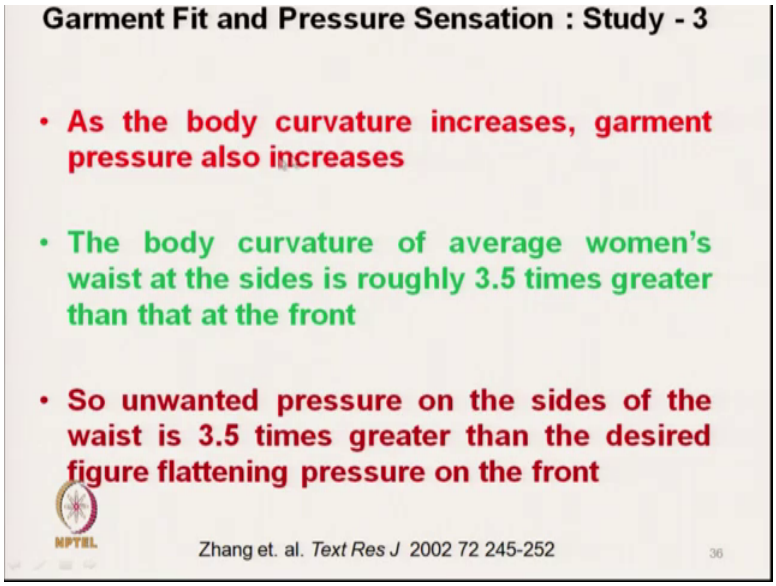

As the body curvature increases, the garment pressure also increases that we have. It is in study 3. Another study what they have concluded that as the body curvature increases the garment also gives the pressure, higher pressure. The body curvature of average women's waist at the side is roughly 3.5 times greater than at the front.

So, that means at the side there will be higher pressure and what they observed that waist at the side gives 3.5 times higher pressure than the front and this that is it is directly related to the curvature.

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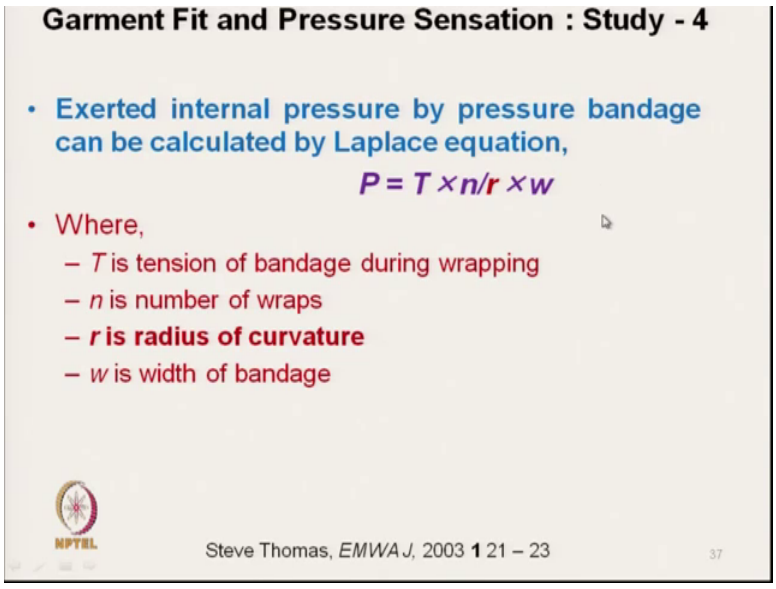

And which is actually proved by another study where they have used the Laplace equation. In the Laplace equation, the pressure exerted by the garment sequel to the it is proportional to the tension of the garment or bandage wrapping. It is basically in the compression bandage, the study was on compression bandage, the number of wraps. As we increase the number of wraps, the pressure excreted on the body part increases inversely proportional to the radius of curvature.

That means, higher radius of curvature it is basically that it will be it will give the lesser pressure. That means, higher radius of curvature means less curvature, so that you have already seen the width of the bandage. So, higher width gives less, higher the pressure divided it is in the denominator. Higher width gives less pressure,. Here also there is same handing there by the pressure increases with the increasing curvature of the limb.

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Now, we will see the Pressure Dynamic Compression Behaviour of Compression Athletic Wear. Now, for a compression athletic wear, that means which is body fit tight garment how this garment exert pressure on our body in dynamic condition. So, basically it depends on the elastic recovery characteristics of the fabric and dynamic interface of pressure.

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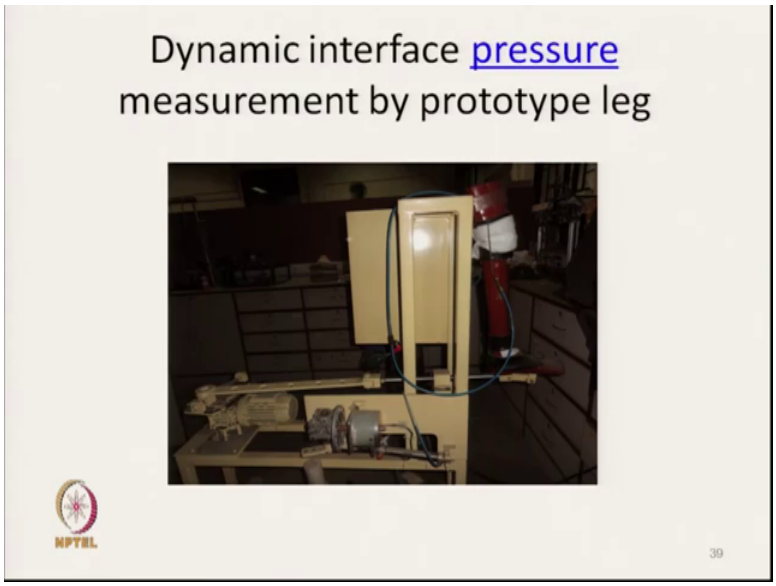

Now, this is the instrument which measures the dynamic characteristics of pressure and quick and wrap our bandage here and this leg, manniquin leg can move at different speed, and as it stretch it is as it bend the knee, there will be a stretching and it will exert the garment will exert pressure. Here the bandage will exert pressure. In our case, we have to use the compression athletic wear,.

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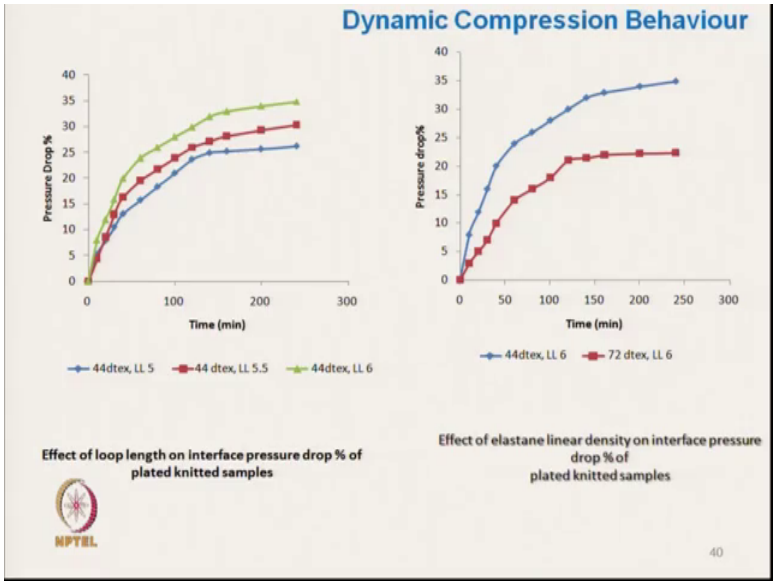

Here the dynamic compression behaviour it shows these are the fabrics. The blue one is made of these are all these are the knitted fabrics. In x axis, it is showing the time of test

and y axis it is a percentage pressure drop. So, what is the percentage pressure drop here? Initially we have wrapped the garment on the body part and initially the pressure has been measured at initial stage, ok.

Now, after activity, the pressure will drop due to the creep or stress relaxation of the structure and that percentage drop is measured here and it is gives in the y axis. Now, what does it show with the increase in time elapse? The drop in pressure drop increases. That means, the garment will actually impart lesser and lesser pressure. Now, here these are the knitted structure because athletic wear compression athletic wears are basically knitted in structure and that is for the two, for ease body movement and three, different fabrics we are made. This first blue one, it gives it is made up 44 dicitex filament. With all three are made up of 44 dicitex filament and blue one is made of the loop length of 5, the red one is 5.5 and the green one it is 6. That is the lower. This is the tighter structure relatively loose structure. This is the loose structure of fabric and it shows that the tight structure fabric, the pressure drop is less. That means it can retain pressure for longer time.

So, to retain the pressure in the compression athletic wear because the pressure retention is the prime important factor, here this study shows that we have to go for fabric with the lower loop length. Similarly in this study here the effect of elastane linear density here what we have? We have used the elastane fibre, also elastane, here elastane linear density is 44 dicitex and red one is 72 dicitex coarse elastane has been used.

So, if you have to maintain the pressure in the garment which is required, so we should go for coarser elastane. So, coarser elastane will have less pressure drop.

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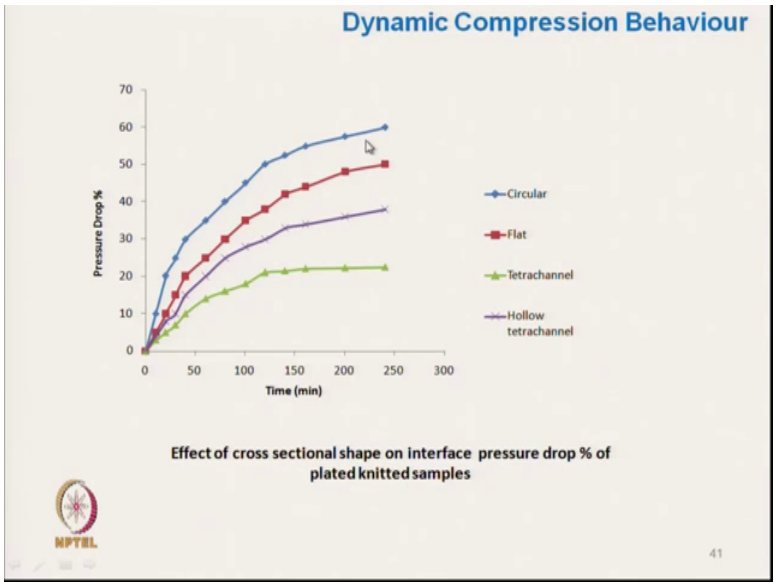

Another study was conducted where with different types of cross sectional shape, the fibre, the polyester fibre we have used, polyester filament knitted fabric has been used and all the fabrics were made up the same loop length and the filament linear densities were same. Only thing is that their cross section were different. The blue curve shows the cross section with a circular cross section, this is with a flat cross section, the green one is tetrachannel and the purple one is the hollow tetrachannel.

What has been observed that the circular, the fabric made of circular filament gives highest pressure drop. That means, it loses its pressure where as the tetrachannel fabric, the fabric made of tetrachannel filament gives and retains the pressure nicely. So, it is recommended that the for at a compression athletic wear, one should go for the tetrachannel filament with higher elastane content higher linear of the elastane and lower loop length of knitted fabric to maintain the pressure.

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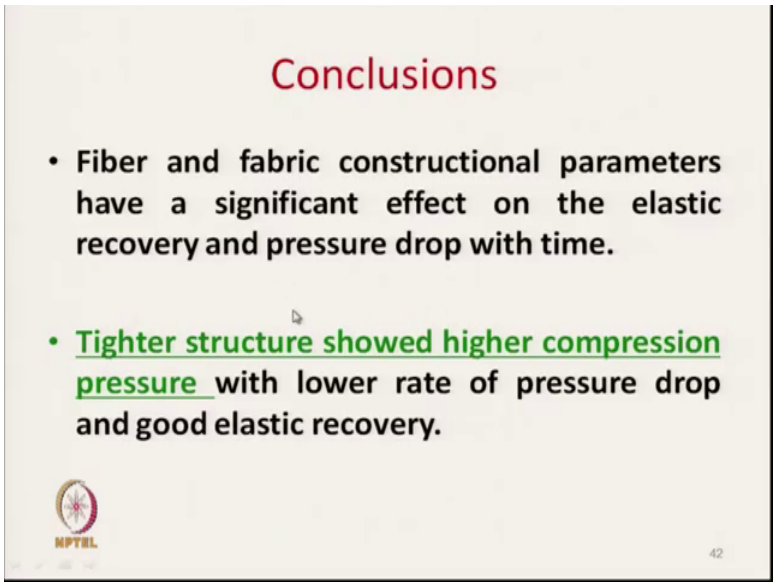

So, in the conclusion the fibre and fabric constructional parameters have a significant effect on the elastic recovery and pressure drop with time. Tighter structure shows higher compression pressure with lower rate of pressure drop and good elastic recovery fabric knitted with coarse elastane.

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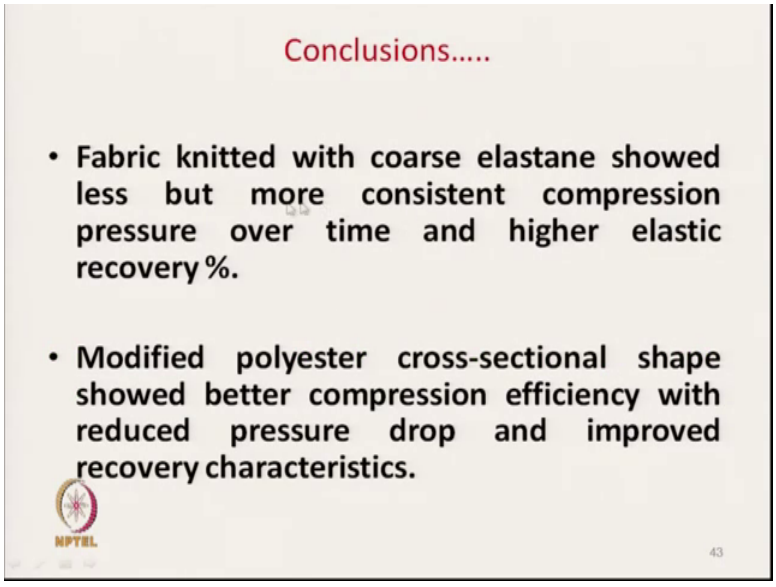

So less, but more consistent pressure over time and higher elastic recovery modified polyester cross sectional shape shows better compression efficiency with which with reduced pressure drop and improved recovery characteristics. So, now we will discuss

how to evaluate tactile perception to fit. So, we have discussed earlier when we are we will discuss the neurophysiological or tactile sensation.

So, that and there we have discussed in detail here we will only focus on the fit related tactile sensation.

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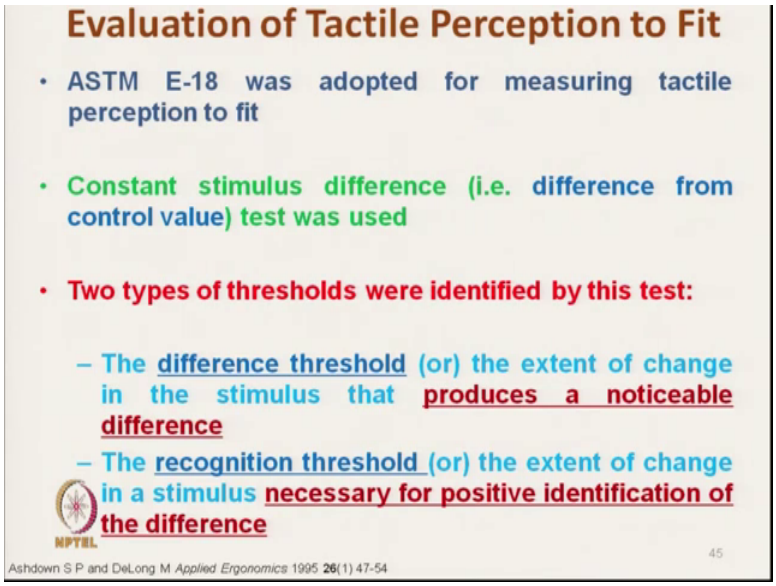

So, in ASTM E-18 that test method it was adopted to measure the tactile perception to fit that particular test method. Constant stimulus difference is there that we have already discussed and two types of thresholds are there. One is different threshold; another is the recognition threshold which is actually positive identification of difference and difference threshold which we have already discussed that it produced noticeable difference,.

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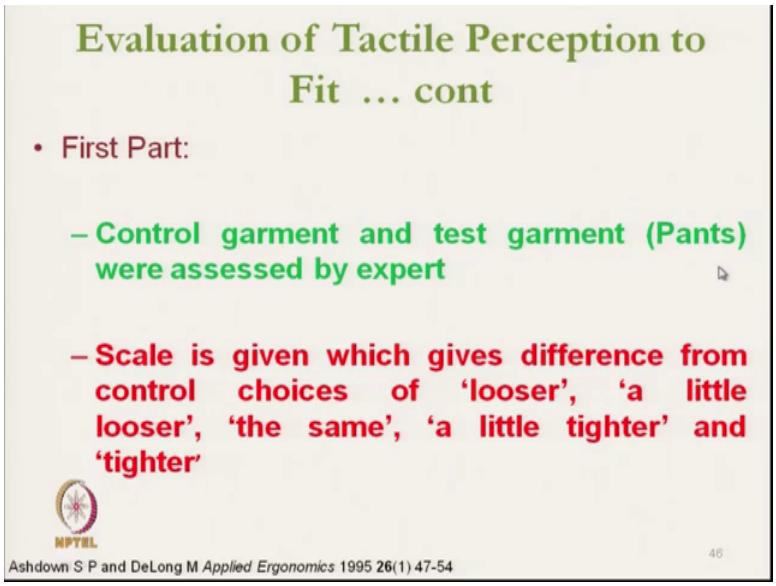

So, there are 3 parts are there. In first part, the control garment and test garment that is pant were assessed by the experts. The scales were given, the rating scales it is a loose loser actually and a little loser, the same little tighter and tighter. So, the pants were given to the experts and they have been asked to rate with this rating scale.

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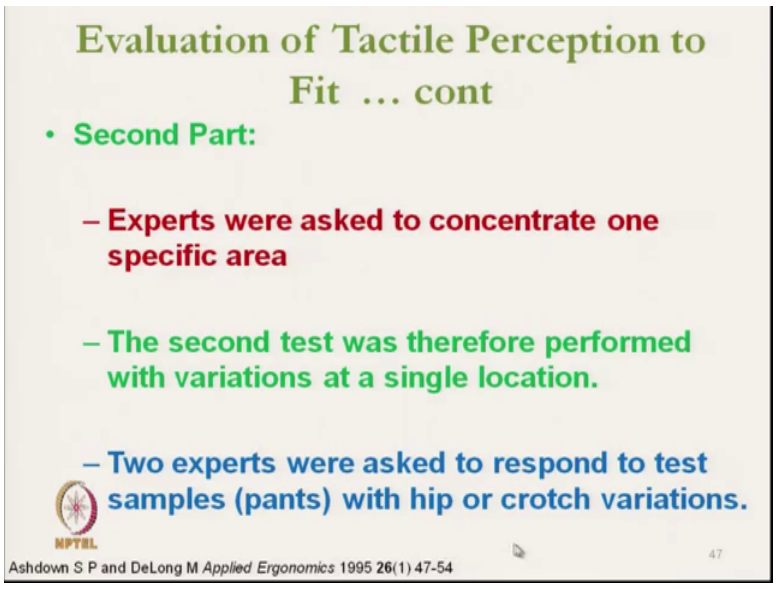

In the second part, expert were asked to concentrate on specific area, not over all. Earlier it was over all area. Now, they have been asked to concentrate on specific area. Different experts were asked the second test was therefore performed with variation at a single

location, ok. At single location two experts were asked to respond to test sample with the hip and crotch variation,.

So, hip and hip what is the difference in pressure they have been asked?

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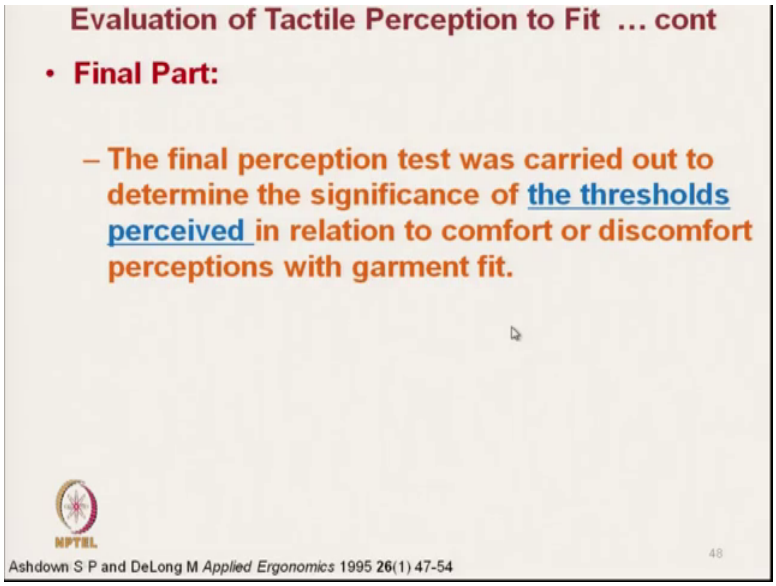

And in final part, the final perception of test was carried out to determine the significance of the threshold perceived in relation with the comfort or discomfort perception of the garment fit, so that whatever threshold they have perceived and finally, they have been asked whether the garment is comfortable as per as the pressure is tactile, perception is concerned.

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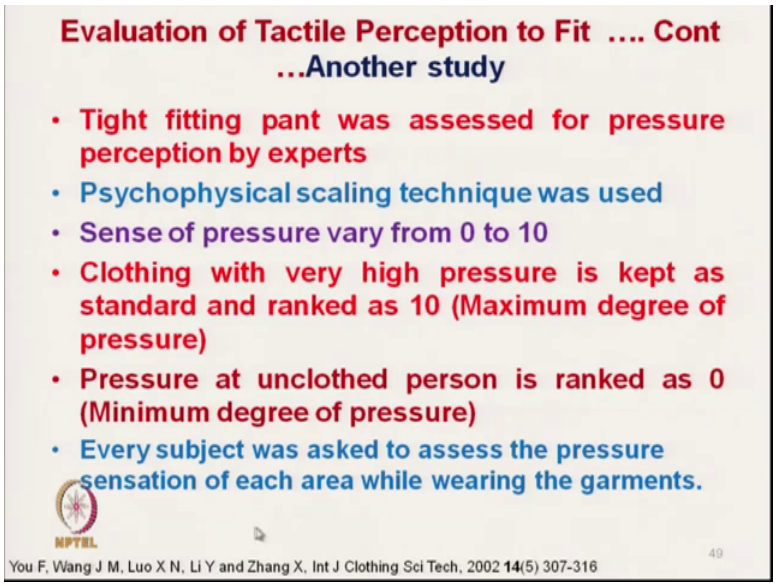

So, in another study the tight fitting pants were assessed for pressure perceptions by experts, ok. So, here psychophysical scaling techniques were used and sensations were actually different sensations where is the pressure sensation from 0 to 10. 10 means maximum high pressure which is very highly discomfort maximum degree of pressure and 0 sensation means naked. There is no cloth. Cloth pressure is not there. So, every subject was asked to assess the pressure sensation of each area while wearing the garment they have been asked. So, they and then they have rated. Now, there are different factors related to the garment fit. These factors are, first factor is the Air Gap Thickness.

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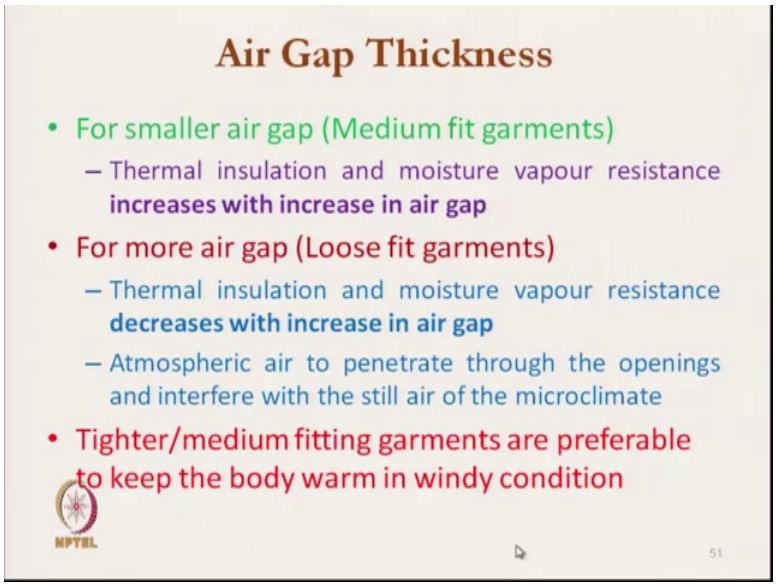

If the fabric is loose, its fit is loose, then air gap thickness will be high. So, for smaller air gap now we will discuss different aspects. For smaller air gap that is medium fit garment, the thermal insulation and moisture vapour resistance increases with the increase in air gap. For more air, loose fit garment, the thermal insulation and moisture vapour resistance decreases with the increasing air gap. So, if we are talking about the medium fit garment to loose fit garment that was if it increases that it the looseness increases, then it will increase the thermal resistance, but if the we are talking about the loose fit garment, then the actual phenomena will be totally different,.

The atmospheric air in that case will penetrate through the opening and interfere with the still air. Tight or medium fitted garments are preferable to keep the body warm up in windy condition. So, in windy condition the loose fit garment is not actual recommended if we want to keep our body warm.

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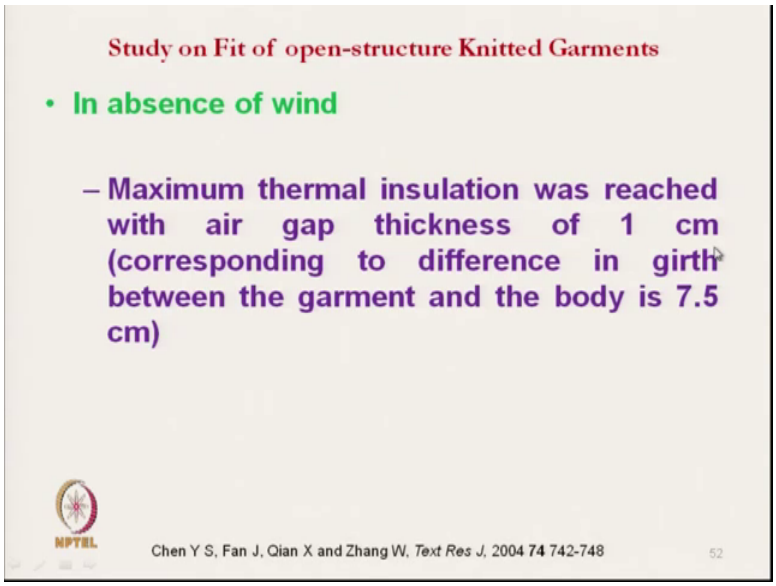

And in absence of wind, maximum thermal insulation was reached with air gap thickness of 1 centimeter. So, that is actually in absence of wind. It has been observed that if the air gap thickness is actually 1 centimeter which is equivalent to the girth, basically difference in girth between the body and garment of 7.5 centimeter that if we take the actual length, it will be 7.5 centimeter, but effective thickness is 1 centimeter. Its maximum insulation one can achieve if there is no wind.

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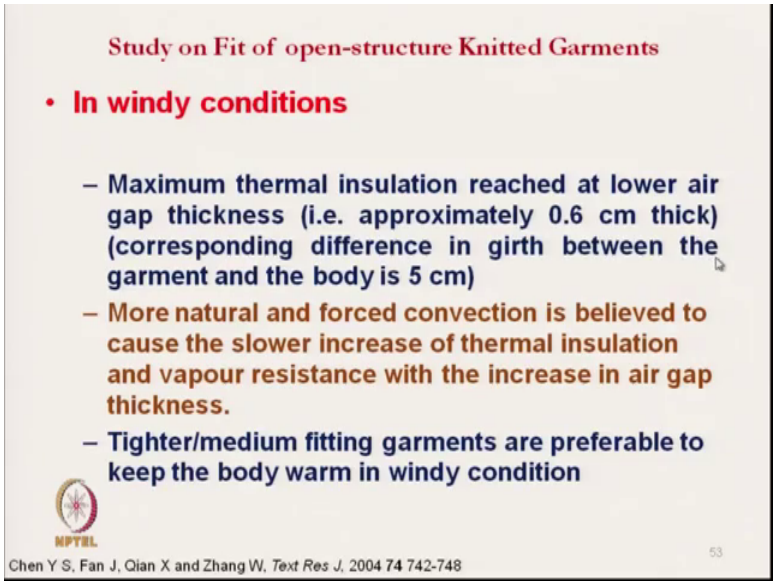

But in case of windy condition, if in windy condition that will be reduced we have to reduce the thickness that means, from loose fit garment to you have to have little bit medium fit garment that it is a typically 0.6 centimeter thick.

So, we have to reduce the total length of the garment by 2 centigram from 7 7.5 centimeter to approximately 5 centimeter. So, 2.5 centimeter reduction in the size should be there in case of wind windy conditions. More natural and forced convection is believed to cause the slower increase of thermal insulation, ok. So, tight medium fit garments are preferable to keep the body warm in windy condition. So, that is the actually findings of this study.

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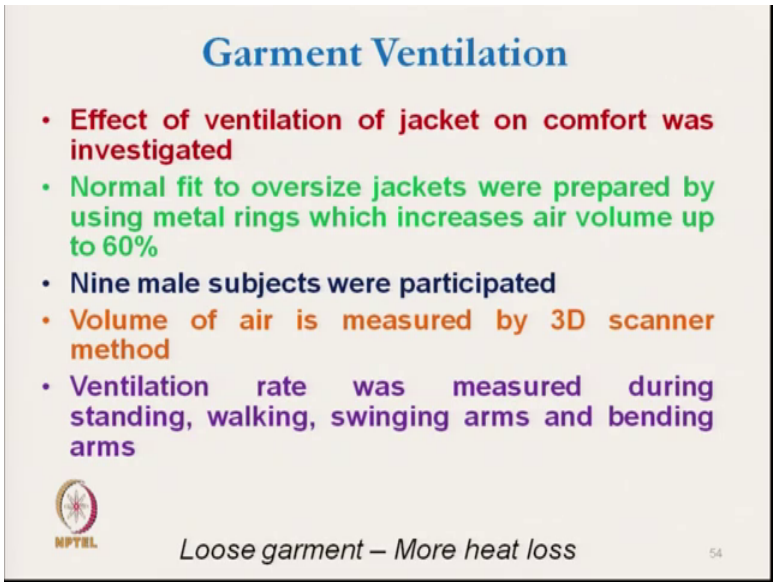

And then, another issue is related to the Garment Fit is Garment Ventilation. So, effect of ventilation of jacket on comfort was investigated normal fit to over sized jacket were prepared using metal rings which increases the air volume up to 60 percent.

So, different metal rings were created, 9 male subjects were participated volume of air is measured by 3D scanner method.

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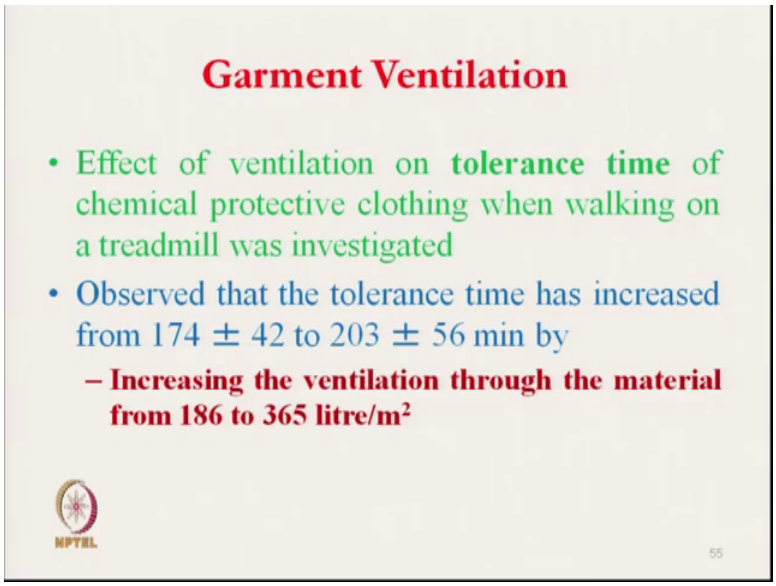

So, volume of air has been measured and ventilation rate was measured during the standing, walking, swinging arm and bending arm. So, both ventilation rate and the volume of air was measured. Higher ventilation is observed for loose fit garment. So, more lose fit garment is more heat loss, so that in this ventilation was measured where volume of air is measured by 3D scanner method. So, effect of ventilation on tolerance time of chemically protective garment when walking on the treadmill was investigated.

So, the protective garment which is actually is heavy in nature which is actually which is coated, so in that case the moisture vapour transmission through clothing will be less. So, it is attached to depend on only the ventilation. So, in that case it has been observed that the tallest time has increased from 174 plus minus 42 minute to 203 plus minus 56 minute by increasing the ventilation through the material from 180 to 365 meter per square meter. So, if we can increase the ventilation amount, amount of fluid amount of air ventilating, then tolerance time can be increased.

Now, we will discuss the condition of fluctuating moisture, fluctuating relative humidity of microclimate. Because of ventilation constant movement, the microclimate gets continuous change in the atmospheric humidity atmospheric, the total continuous change in the supply of fresh air.

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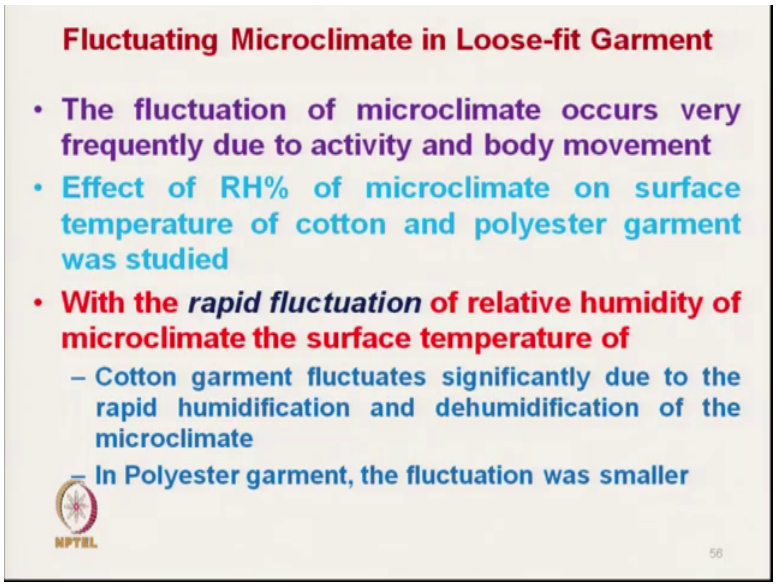

So, microclimate gets and the condition gets fluctuating,. So, the fluctuating microclimate occurs the fluctuation occurs very frequently due to activity and body movement. So, effect of relative humidity of microclimate on surface temperature of cotton and polyester garment was studied. So, there are two conditions were studied. One is the rapid fluctuation of microclimate. That means, a person is running with or walking higher speed very quick body movement. In that case there will be rapid fluctuation of relative humidity of microclimate and it has been measured two types of garment was tested. One is the cotton garment. In cotton garment actually it fluctuates significantly due to rapid humidification and dehumidification. In case of polyester garment, fluctuation was smaller.

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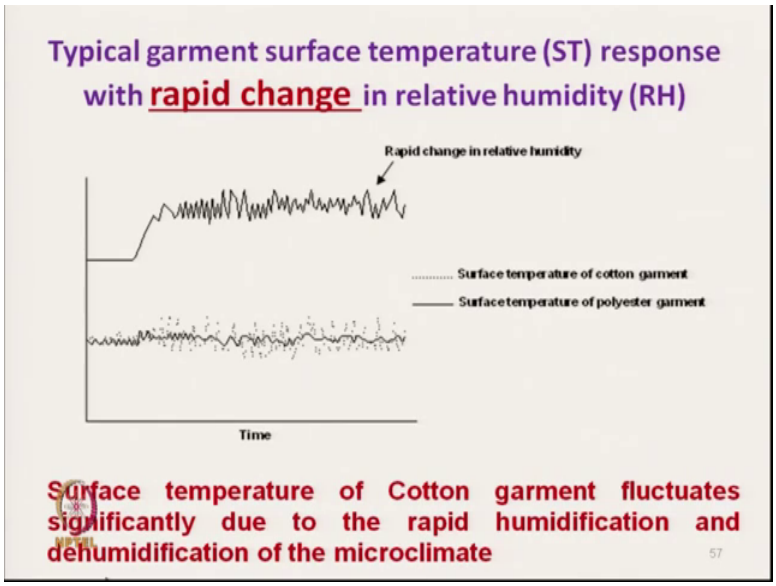

So, we can see that this is the fluctuation of relative humidity of the microclimate. This is the rapid fluctuation due to the body movement and tip and here it shows the surface temperature of the garment. So, if the rapid change in microclimate occurs, the cotton quickly humidify and dehumidify. So, due to that surface temperature fluctuates, but in case of polyester it is not happening because polyester does not absorb that quickly. We absorb moisture and that is why its surface temperature remains constant in case of rapid fluctuation. So, surface temperature of cotton garment fluctuates significantly due to rapid humidification and dehumidification of microclimate.

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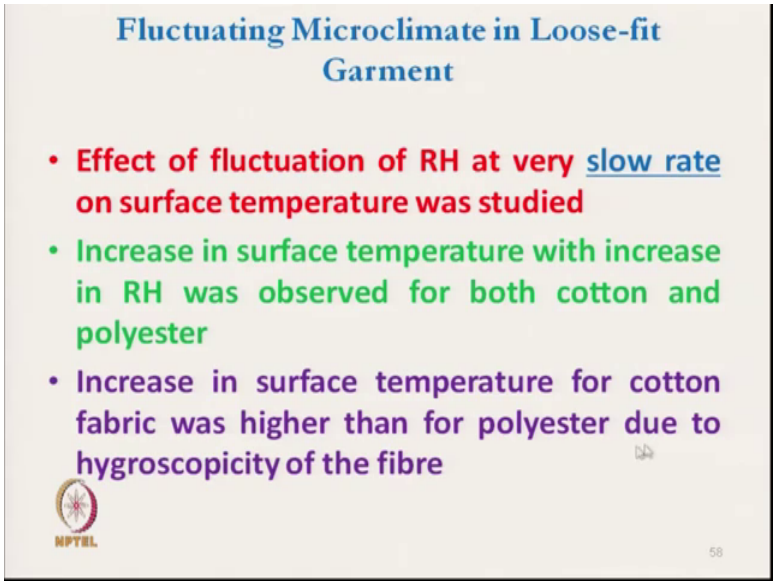

But in case of slow fluctuation, slow rate of fluctuation the increase of surface temperature with the increase of relative humidity was observed for both cotton and polyester. This has been the observation increase of surface temperature for cotton fabric was higher than polyester due to hygroscopicity of fibre.

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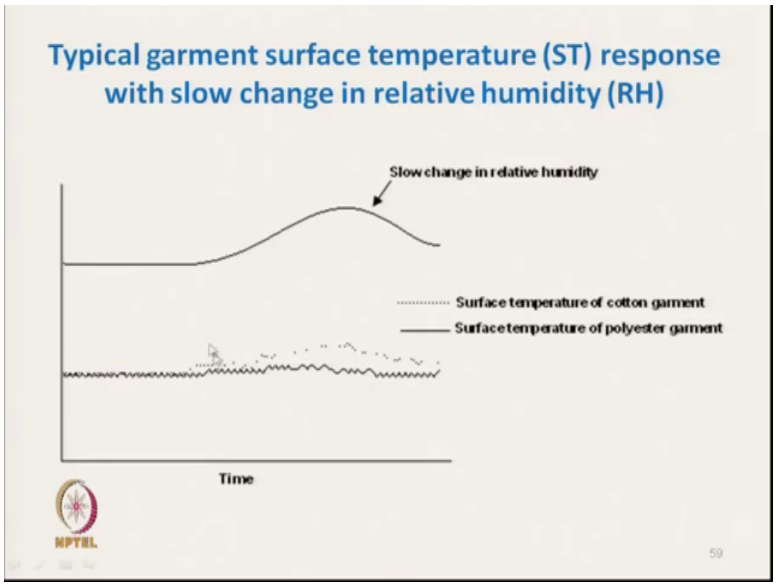

So, this is that there is a slight change in temperature of polyester, but in case of polyester and cotton it is high. This is the gradual increase in microclimate. That means, for suppose we can imagine a situation a person is sitting. It is not he is not moving, but air is blowing through and gives the ventilation in this type of situation. This may happen.

Now, you have reached to the extreme last end, this last segment of this course and now we will see how to measure the overall garment fit. Overall garment fit can be measured by measuring the garment by pattern measurement and the latest technique is the that by anthropometry technique tradition, it is measured by traditionally.

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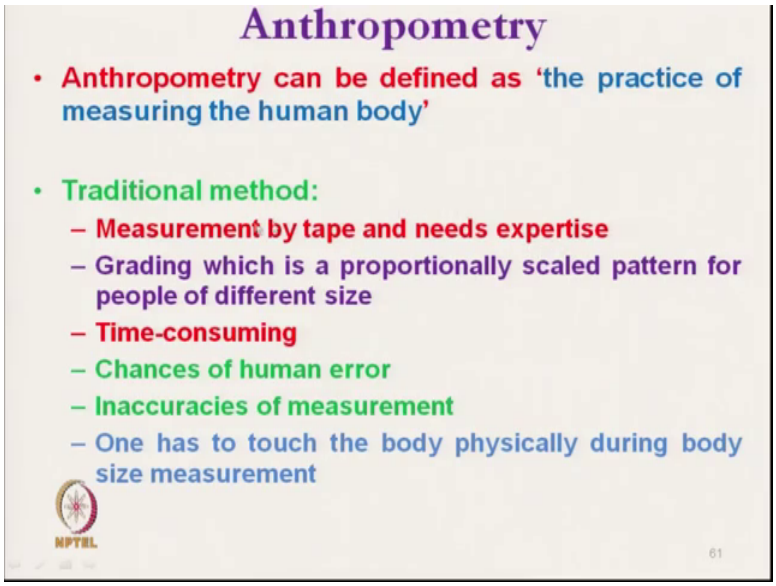

It is traditionally measured by the measuring tape which needs expertise and which is time consuming. Chances of human errors are there and one has to touch the body and it may be inaccurate.

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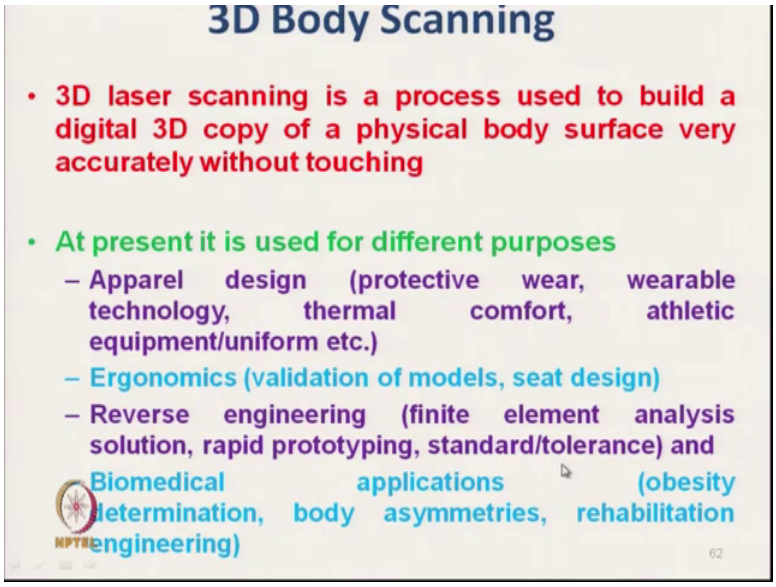

So, latest technique is that 3D body scanning technique and with the 3D body scanning technique here, 3D laser scanning is a process using used to build a digital 3D copy of the body physically digital. It will create a body structure without touching by the use of the laser scanning technique. So, at present this technique is used for different purposes,

the apparel designing like protective wear wearable technology, thermal comfort in this apparel design, it is used in ergonomics study it is used and also for reverse engineering it is used, for rapid prototype and. So, this type of fascist and even for biomedical application because this 3D body scanning technique is used and it is by in apparel designing now it has been used widely.

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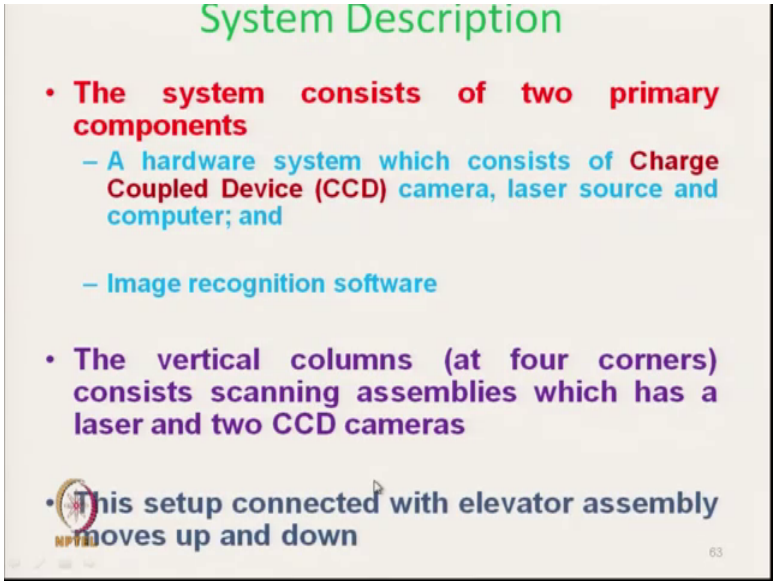

The technique is that here the system consists of two primary components. One is that that hardware component which consists of CCD camera and a laser source and a computer, and second one is that Image Recognition Software. So, these two systems are there.

Now, the hardware consists of also that are set up the vertical column is there with four corners and each of the corners will consists of scanning assembly. That means, a scanning assembly consists of 2 CCD camera and one laser source that is the configuration and at four different corners, this total scanning system will be placed, the setup connected with the elevator assembly. That means, they will move from top to bottom or from bottom to top for scanning.

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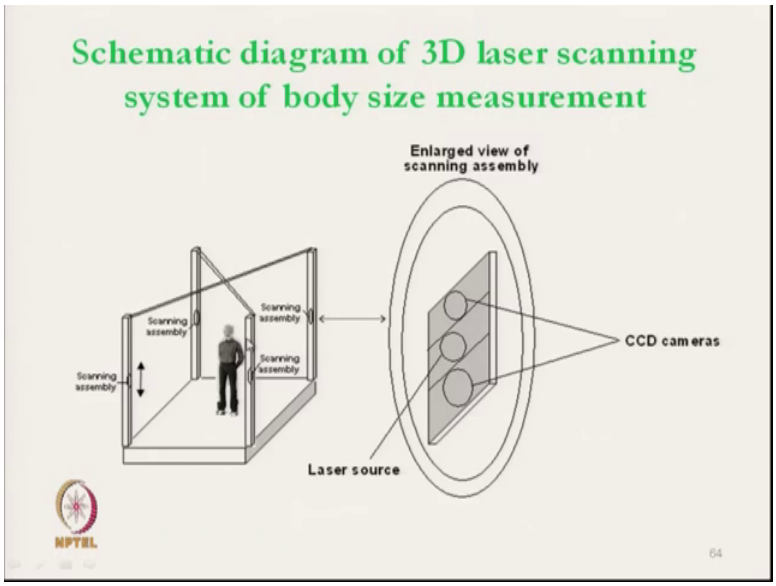

This is the system, the subject; the person is standing at the centre. There are 4 vertical columns. Each vertical column is consist of one scanning assembly. This is the scanning assembly enlarged version of this scanning assembly. It consists of 2 CCD cameras; one laser source and this at four different portion. In the four different, this scanning assembly will be there and it will either move from top to bottom or from bottom to top synchronous. This will be synchronized and the laser source will actually, so the body contour and CCD camera will capture this the contour and ultimately it will get transmitted to the software and software will create the total body contour.

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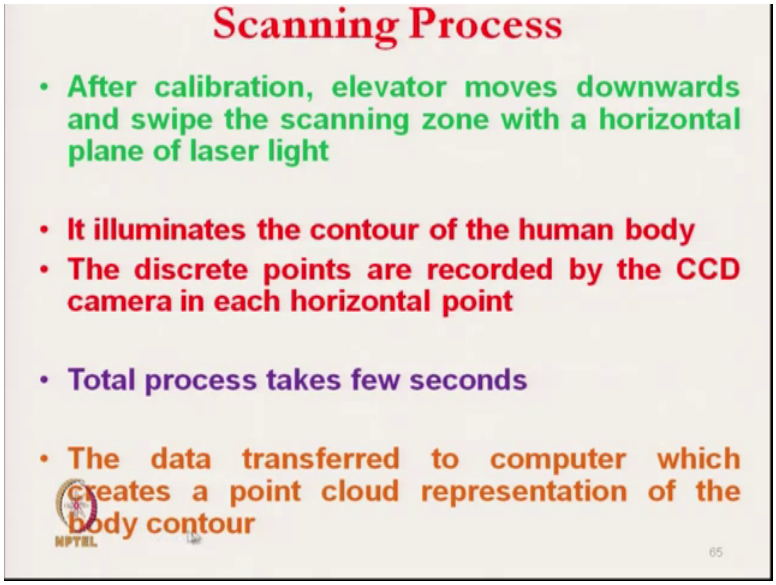

This is the system. After calibration elevator moves downward and swipe the scanning zone with the horizontal plane of laser light, laser light will move horizontal. It will create complete contour. It eliminates the contour of the human body, the discrete points are recorded by CCD camera in a horizontal point, total process takes few second, it moves and the data transferred to the computer which creates a point cloud representation of the body contour.

So, ultimately we are able to create complete body contour which actually helps in designing a cloth designing total garment, a total garment fit depending on our requirement, and that is the end of this course and here we have discussed all the aspects of clothing comfort. Hope this total course will help in designing comfortable clothing and we should be actual over all comfortable.

Thank you, goodbye.