Science of Clothing Comfort
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Lecture - 31
Moisture Transmission & Clothing Comfort (contd..)

Hello everyone. So, we will continue with the study which we are which you are studying in that effect of fibre shape factor and fabric structure for high active sportswear. And we have seen that the almost all the high active sportswear, the fabrics are basically made of polyester filament and polyester filaments are of different shape factors.

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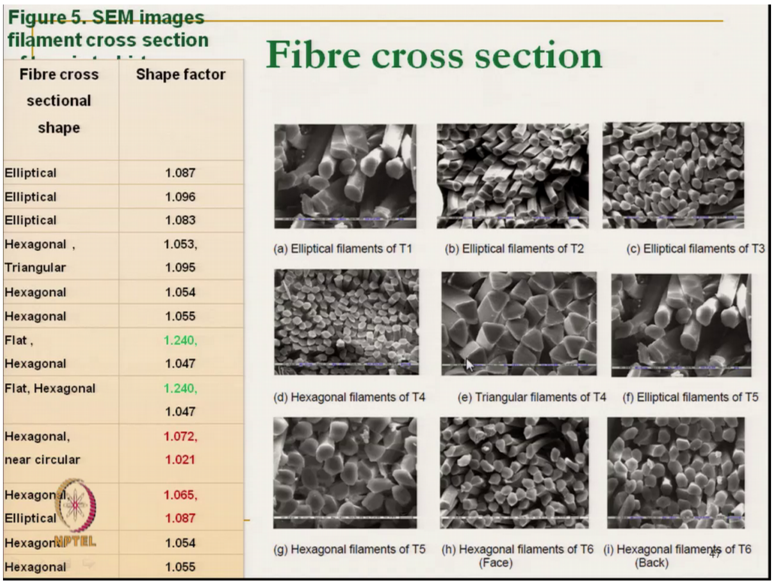

And these are the polyester filaments for used for selected for net tennis ok, where these differential factors are it is made of elliptical, hexagonal, triangular.

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Fibre cross sectional shape	Shape factor
Elliptical	1.087
Elliptical	1.096
Elliptical	1.083
Hexagonal ,	1.053,
Triangular	1.095
Hexagonal	1.054
Hexagonal	1.055
Flat ,	1.240,
Hexagonal	1.047
Flat, Hexagonal	1.240,
	1.047
Hexagonal,	1.072,
near circular	1.021
Hexagonal,	1.065,
Elliptical	1.087
Hexagonal	1.054
Hexagonal	1.055

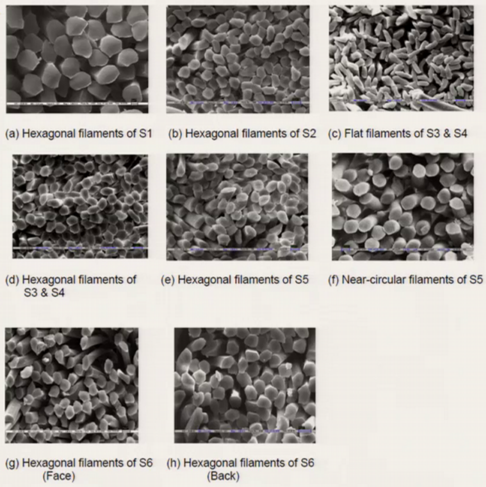

Figure6. SEM images filament cross section of Soccer t-shirts (series S)

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These are scanning electron microscope images for fibres used for soccer ok the series S. So, same similar elliptical, hexagonal, triangular different shapes of polyester filaments have been used. And also we have seen that the fabric structure are netted mainly they are made up either interlock, plated or double layer structure.

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Table 2. Properties of fabric samples

Sample code	Fabric mass per unit area g/m^2	Fabric Thickness mm	Fabric Porosity	Wpi	Cpi	Vertical wicking height cm		Time for horizontal wicking Sec	Specific absorbent capacity
						Walewise	Coursewise		
T1	168	0.500	75.82	48	56	11.1	10.3	60	2.36
T2	167	0.490	75.47	46	53	11.5	10	52	2.47
T3	156	0.520	78.41	46	54	9.9	9	54	3.26
T4	206	0.600	75.29	35	33	10.35	8.8	59	2.47
S1	157	0.480	76.46	48	53	6.8	6.2	63	2.55
S2	154	0.480	76.91	41	58	8	6	73	3.16
S3	182	0.516	74.61	33	50	11.1	10.8	62	2.46
S4	186	0.572	76.60	33	50	7.8	9.1	49	2.59
S5	136	0.419	76.64	46	46	7.5	8.6	42	1.77
T5	147	0.610	82.66	35	35	9	9	42	2.82
T6	184	0.812	83.69	44	66	6.3	6.5	89	3.33
S6	139	0.600	83.33	40	42	9.1	9	49	2.88

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And these are the different characteristics we will discuss this in form of graphs curve form.

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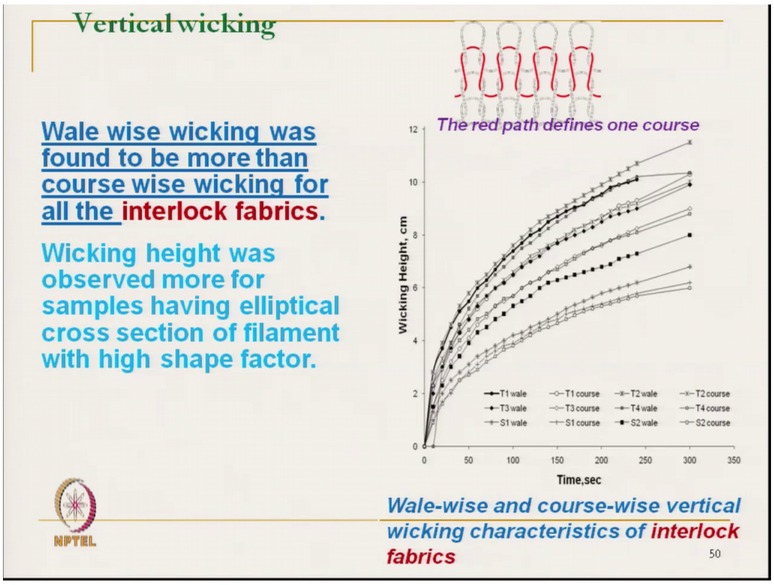

Now, if we see the vertical wicking, vertical wicking in case of interlock structure, here this graphs; this curve shows that time versus wicking height for different fabrics in both course wise direction which is shown in red colour loops. This is a course direction and this one vertical direction is the wale-wise direction of interlock fabrics. So, here it has been observed that wale wise wicking was found to be more than the course wise wicking of interlock structure.

So, course wise when we test the vertical wicking it is slow which shows which is mainly due to that course wise if you see the liquid has to travel a longer path when it travels in the course direction in interlock structure, but wale-wise direction it is actually faster.

Wicking height was observed more for sample having elliptical cross sectional side of filament with the higher shape factor. So, if we see the shape factor as we have seen elliptical fibre, elliptical fibre has got higher shape factor than other anyone, so that is how it is actually elliptical fibre gives higher shape factor, and so it is wicking height becomes high.

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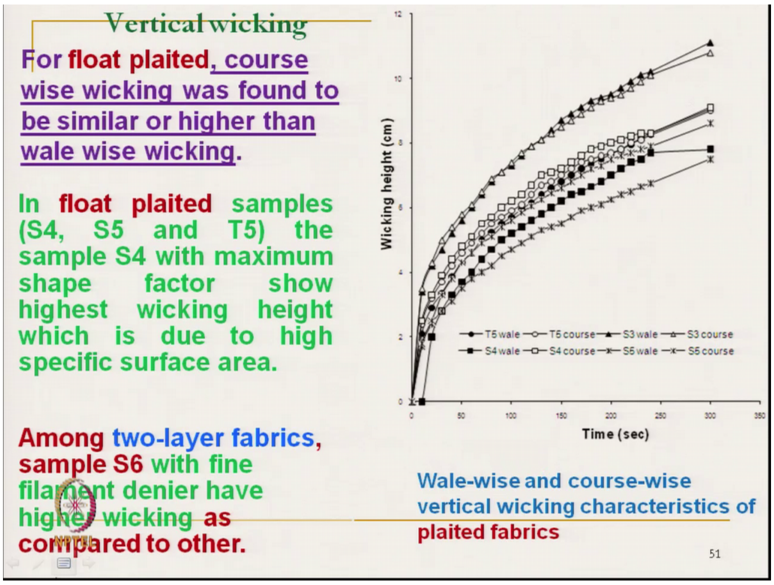

Now, coming to the float plaited structure, the course wise wicking was found to be same as or little bit higher than the wick wale wised direction. Here the due to the structure and due to structural difference and the wale wise and course wise liquid flow is almost same. In float plaited sample the sample 4 with minimum shape factor shows with maximum shape factor. So, sample 4, if you see it is made of say elliptically it is with maximum shape factor shown highest wicking rate due to higher specific surface area. So, and if we talk about the two layer structure, so sample 6 S6 that soccer 6 with finer denier filament having higher wicking as compared to other. So, both the shape factor and the fibre denier here also it plays a great role in wicking. So, we can see the difference in wicking height ok.

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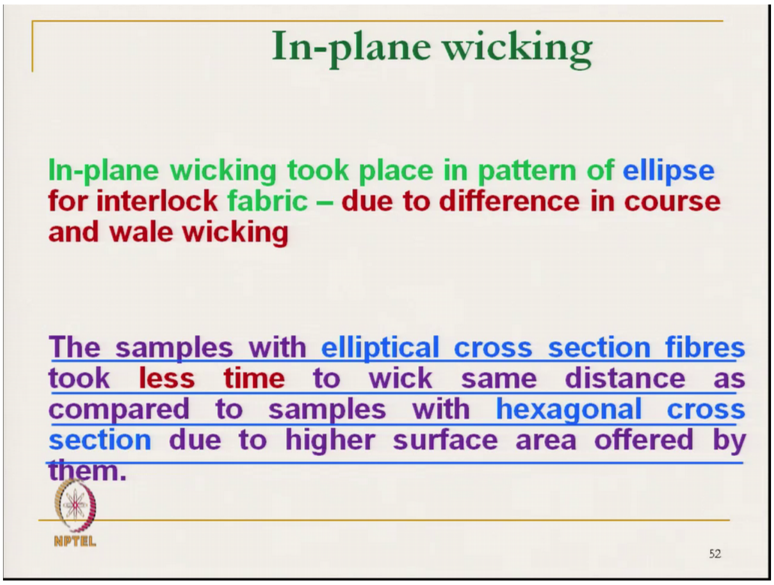

And if we talk about the in plane wicking, in plane wicking took place in pattern of ellipse for interlock a structure that means, that we have seen in the in case of vertical wicking, the wale wise direction and course wise direction the rate of wicking was different. The same phenomena as is actually it is predominant here to have the elliptical structure in place of circular structure. So, the sample with elliptical cross section that is the ellipse means that water front shape is the elliptical here.

And if it the sample with elliptical cross section fibre took less time because of the higher shape factor to travel same distance as compared to the hexagonal and section cross section due to higher shape factor higher surface offered. So, higher surface` if the fibre if the pore offer higher surface that means, the drag force will be high. So, the drag force is also proportional to the surface offered by the fibre ok, inside the pore.

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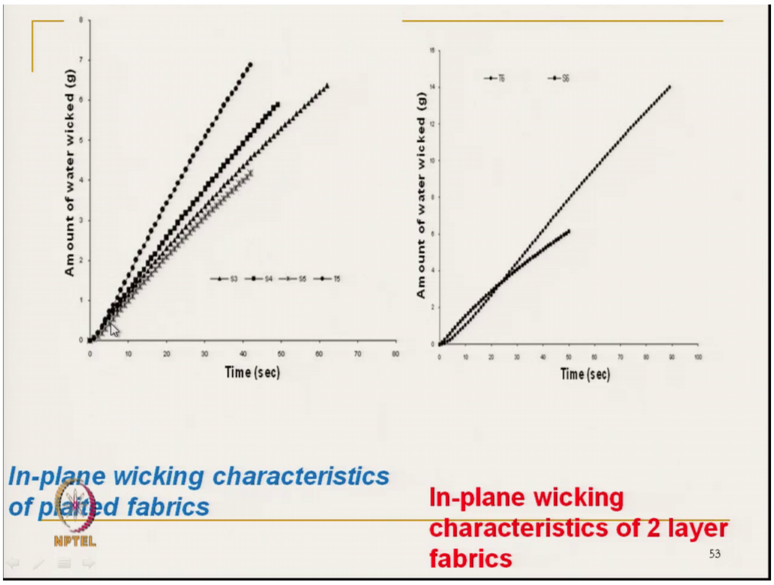

And in plane wicking of plaited fire fabric and two layer fabric here, the time with the time and the water uptake amount of water uptake, so that it increases with the time.

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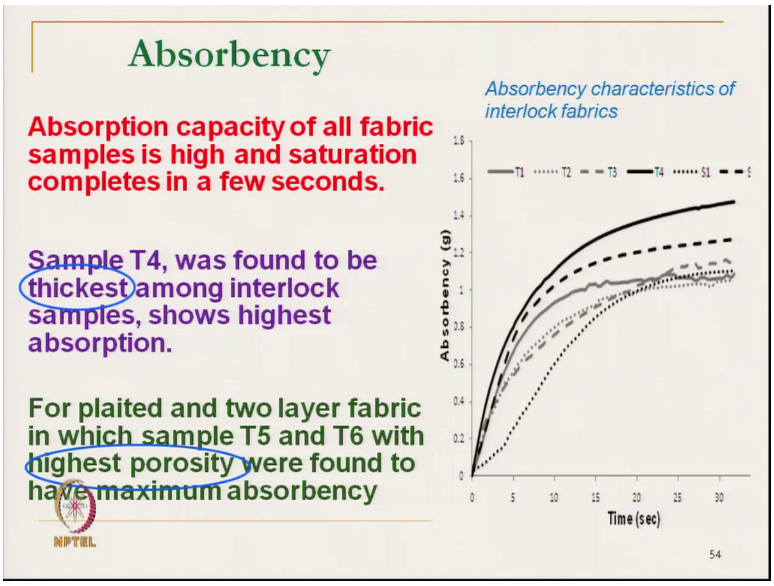

And coming to the absorbency, so one is the wicking that is the transportation and absorbency mean it will absorb. So, absorbency capacity of all the fabric samples is high. Now, in general it is high and saturation as compared it say it is completed in few seconds. So, if we see the fabrics for high active clothing has been generated is been developed in such a fashion, it actually gives the very high wetting rate, very high rate of absorbency, then the wicking will take place.

Sample T4 that means, for tennis the 4 sample was found to be the thickest among the interlock fabric. So, if we see the thickness, it is a thickest fabric shows highest absorption. So, if we talk about that amount of liquid fluid absorption absorb. So, it depends on the thickness also number of capillaries present. So, depending on the rate of wicking we have to also adjust the thickness adjust the number of capillary channel. So, the thickness is also important to have more and more water or a sweat absorbing absorbed from the skin for a plaited and two layer fabric in which the sample T5 and T6 with highest porosity was found to be have maximum absorbency.

So, what does it mean? So, a fabric we need with a higher thickness and higher porosity then only it will get it will absorb at will absorb more and more moisture liquid from the skin and skin will remain dry. Then the structure of fabric it is the duty of the structure of the fabric to transmit the moisture to either other surface or to distribute.

But here the porosity higher porosity means higher absorption, but higher porosity not necessary it means higher wicking because it also depends on if it is the porosity is high with the higher capillary diameter, that means, it will reduce the capillary pressure. So that means, if we have to create higher porosity, but the smaller pores, so that we have to very careful in designing the clothing. So, thickness is important and porosity is important for the absorbency. But, for wicking, our pore geometry is important.

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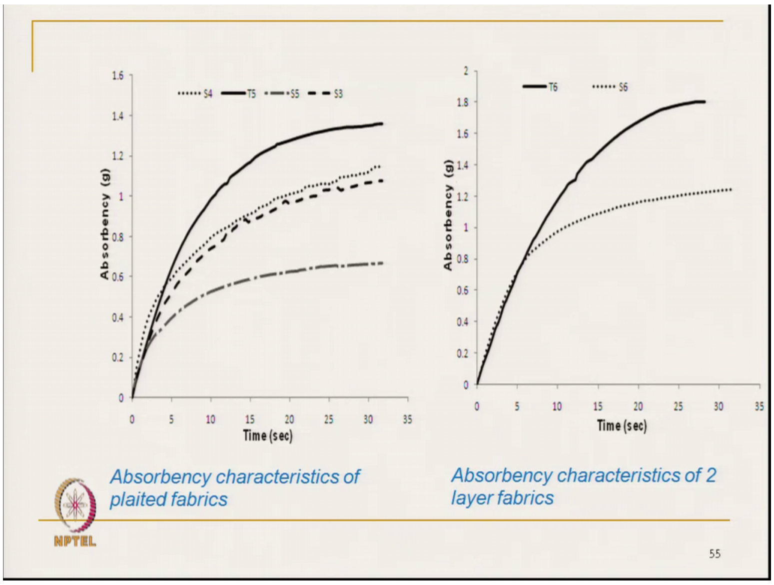

So, these are the fabrics as we have mentioned.

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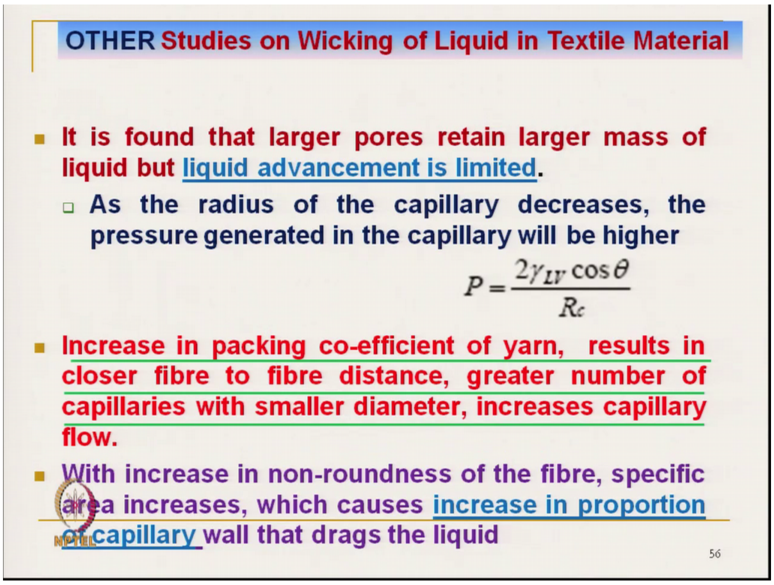

Now, apart from this there are different other studies available on wicking characteristics of liquid. So, in one of this, it was found that the larger pore retain larger mass of liquid ok. But, if we see as we have just mentioned that if the pore size is more, so it will actually limit the advancement of the flow; liquid flow due to higher diameter pore diameter. As the radius of capillary decreases, the pressure generated in the capillary will be higher, so that means, we have to have large number higher porosity, but the pore diameter should be small ok.

Increase in packing coefficient of yarn. So, if we increase the packing coefficient means the filament or fibres are coming closer that means, the R c which is the pore radius; radius of pore will be low. So, resulting in closer fibre to fibre distance, greater number of capillary will be there because for same yarn. So, it is a number of fibre number of capillary will be there and smaller diameter of capillary will be there, it will increase the capillary flow. So that means a larger pore of smaller number and smaller pore in larger number. So, second one is better, smaller pore in larger number is better for liquid transmission through the capillary ok, although the total porosity remains same.

With the increase in non-roundness of fibre which is very important. Now, a filament suppose it is a not round it is a round that means, its shape factor is less. So, with the increasing round non round is of the fibre, specific area increases which causes the increase in proportion of the capillary, increase the proportion of capillary wall that drags the liquid that means the with the increase shape factor as we have seen that the wetting takes place due to apparent reduction in apparent wetting angle and also the in the capillary it gives a higher proportion of capillary wall which actually enhance the drag, so that is why this the pressure increases.

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Studies on Wicking of Liquid in Textile Material

Fabric Sample	Wicking height, cm					
	Warp			Weft		
	1 min	3 min	5 min	1 min	3 min	5 min
Normal Yarn	1.2	2.8	3.6	1.4	2.7	3.6
Twistless Yarn	1.0	2.9	3.4	4.9	6.8	8.7
Hollow Yarn	1.2	2.9	3.7	3.2	5.5	6.4

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And this phenomenon this shows that the (Refer Time: 13:09) of the fabric. So, if the and the fibres are say in angular helix cross section helix form in the yarn that will gives a normally and it gives the wicking height it is a less or wick lower wicking height. But if the capillary channels are straight capillary channel that will give us the very high wicking height; that means, the if we increase the twist that the capillary path will be will not be it will be helix path, so that flow of fluid will be reduced, so that it shows the twistless yarn in case of twistless yarn the capillary that capillaries are straight. So, the rate of wicking is very high, wicking height is very high.

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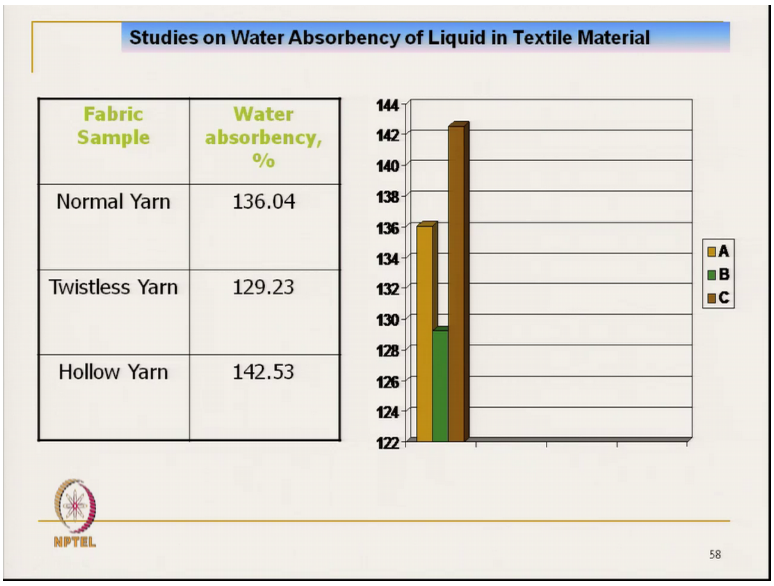

Similarly, the absorbency if you see, the absorbency is actually it is high when the pore volumes are high. Here we are not talking about it is a wicking. So, here hollow yarn which has got very high pores. So, it has got very high absorbency. So, it means it absorbs well due to the pores, but it cannot wick, its wicking is lesser than this because this lesser than the twist less yarn because it actually due to a larger pore, it cannot create that the pressure capillary pressure that is why wicking height is less.

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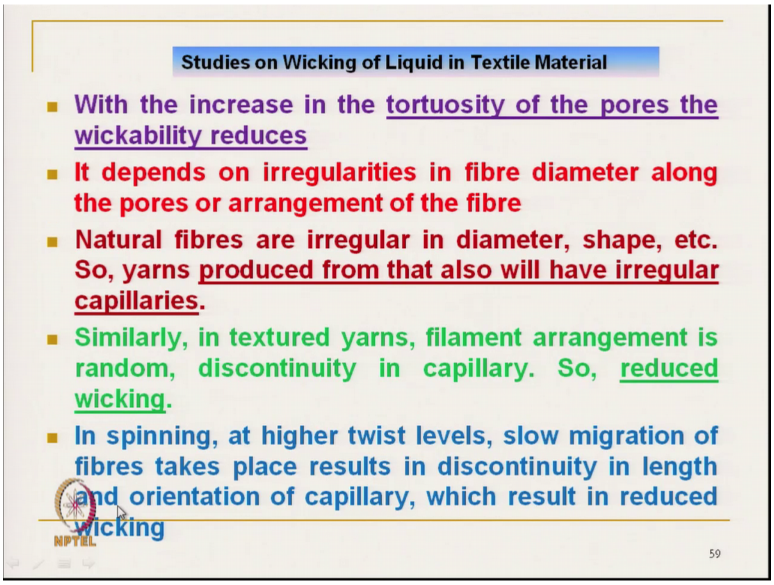

With the increase in tortuosity of the pores the wickability reduces that we have all just mentioned. It depends on the irregularity of the fibre diameter. So, as the fibre diameters are regular. So, like filament yarn the pore geometry is uniform pore geometry. But if we you talk about the natural fibre like cotton, the fibre diameters are different even a single fibre if we see the diameter of the fibres are different; that means the pore structure; pore structure developed by the cotton yarn is not uniform, and due to the random arrangement of the fibre because of the staple fibre in nature.

So, pores are not continuous. So, pores are not continuous in nature, pore diameters are not uniform. So, all these things affect the transmission characteristics; wicking characteristics. Natural fibres are irregular in diameter and shape. So, the yarn produced from that all this fibres also have irregular capillaries. So, if we talk about the fibre natural fibre or say synthetic fibre, so or say multifilament fibre, the pore geometry that is capillaries are totally irregular capillary in natural fibres staple yarn and these are not continuous, this actually affect the wicking characteristics.

And also for say polyester filament if we texture it if we make the texture filament, and its tactile characteristics improves, its softness improves, but if we talk about the moisture in liquid form, liquid moisture transmission it is reduced. It reduced wicking because of the discontinuity in the capillary channel non uniform capillary channel. So, the total capillary pressure generated will be reduced and capillary flow will be reduced. So, wicking characteristics will be reduced.

So, if we compare the texture filament and normal flat filament, same filament, if we use normal straight filament and non-untwisted filament and textured filament the textured filament fabric will may absorb more moisture, but wicking will not be high. Wicking will be slow for textured filament. So, most of the high active sportswear high active clothing you know that it is not the texture, it is a straight filament. And also in spinning in a staple fibre spinning at height twist level, slow migration of fibre takes place with the discontinuity in length, so and the orientation of capillary will be different. So, it actually it creates lower wicking rate.

So, ultimately reduced wicking will be there. So, if we compare with the say polyester fibre if you take the same polyester one is in the filament form; another is the staple form. So, staple polyester will have much lower wicking than the filament.

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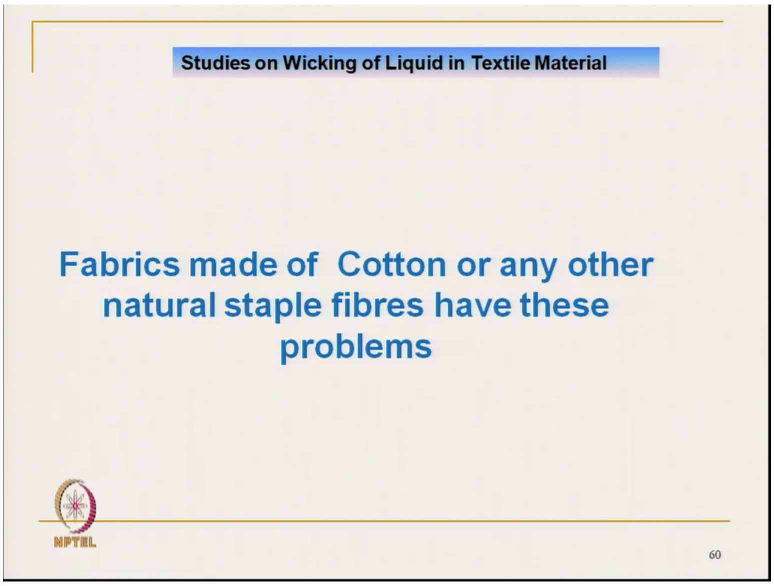

So, that is why fabric made of cotton or any other natural fibre have this problems. So, wicking rate will be less although cotton has gotten two problems; one is that its hydrophilic in nature it retains the moisture, and also it actually the wicking also it is less due to the shape of the that pores.

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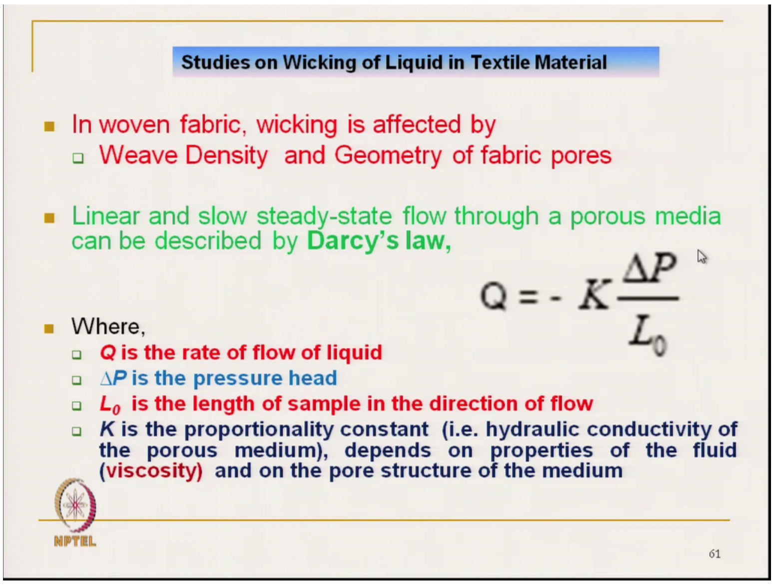

And now the in woven fabric wicking is affected by weave geometry and weave density. So, density of weave that is a how compact is the fabric; that means, if we increase the weave density that means yarns are close to each other it will create some capillary pore and wicking will take place. But if the fabrics are open structure open structure, that means, it will not be able to create that pressure the capillary pressure the wicking will be less, so that is why for a compact type coal close woven fabric made of polyester filament will have higher wicking rate than open structure.

And linear and steady flow of fluid through porous medium is actually governed is described by Darcy's law. So, here Q is the flow rate flow rate of liquid. And delta P is a pressure head, and L 0 is the length of the sample in the direction of flow, so that this is the governing equation, and K is the proportionality constant which is hydraulic conductivity of the pore ok. And this K hydraulic conductivity depends on the viscosity of the fluid.

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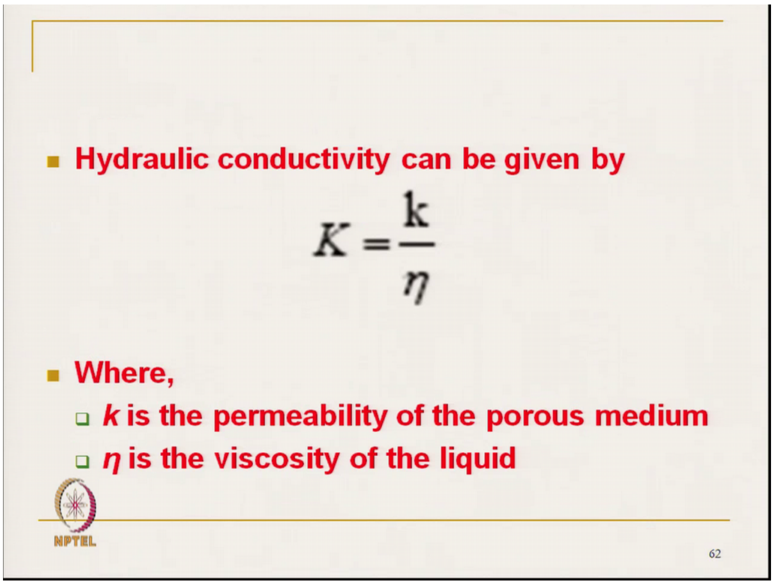

So, if the fluid is viscosity is high that means, the K value hydraulic conductivity will be low that means, it will create the lower flow rate of them. So, viscosity if we can control the viscosity we can control the K value. So, length of the sample and pressure difference pressure is a pressure head generated. So, here this pressure is generated by the capillary pressure.

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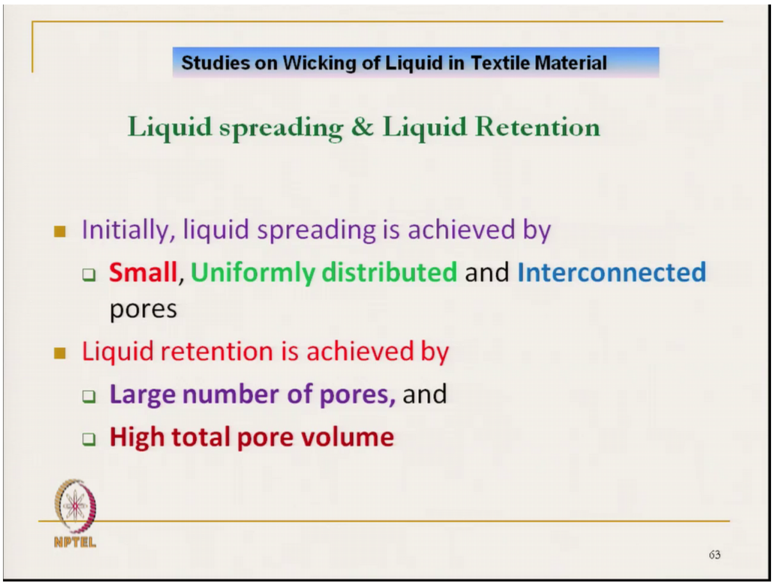

And liquid spreading and liquid retention, here initially liquid spreading is achieved by small uniformly distributed and interconnected pores that means the liquid gets distributed within the structure, so as soon as the liquid drop is actually it is a comes under contract with the fabric surface. Whatever small pores uniformly distributed pores and interconnected pores they actually spread the liquid, then it is a retained by the larger pores. So this smaller pores distribute the liquid to the larger pore with high volume and they retain it. So, this is the type of the structure if we understand this phenomena, we can control the flow means if we have larger pores; that means, the liquid is going to stay there remain there because of the larger pore means it will not be able to create the pressure so, it will try to.

So, whether do you want that type of structure or we want smaller in uniformly distributed interconnected pore. So, if our idea is to distribute and transmit the moisture transmit the liquid, then we need the first type of structure. If our idea is to retain the liquid like absorbent type of wick sorry some wipes, and all these type of application, where we need larger type of pore where the water has to be retained their liquid has to be retained there. So, this understanding is very important to design clothing.

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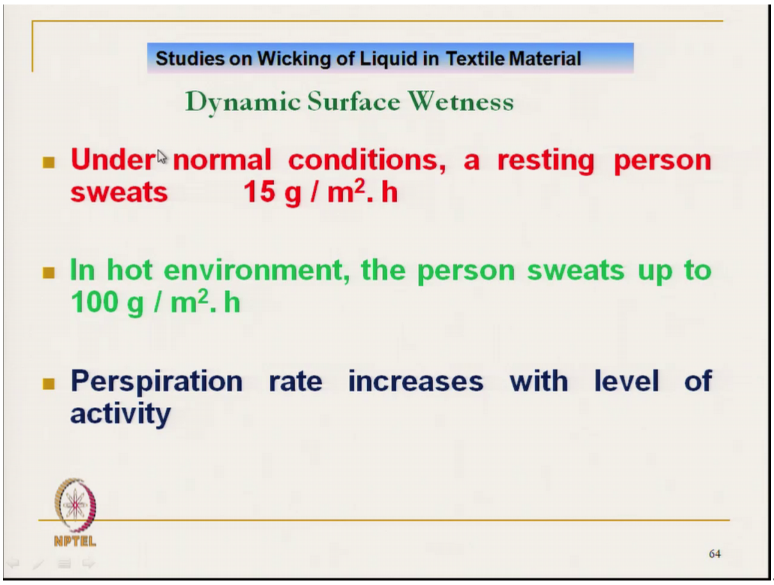

And now coming one very important aspect which is called a dynamic surface wetness ok surface wetness is important ok, but what is dynamic surface wetness, because the fabric when it comes under contact with the sweating skin, it gets wet that is wetness, but it has to transmit from inner side to outer side, so that is called it is a dynamic surface wetness. So, under normal condition a resting person sweats at the rate of approximately

15 gram per square metre per hour. So, this value will see a different at different places, so that it is a different at different condition gram per square metre per hour that means if we consider the 2 square meter of our body, so 30 gram, it is normally; in hot climate it is 100 gram, so that is the sweating rate perspiration rate increases with the activity level as we know.

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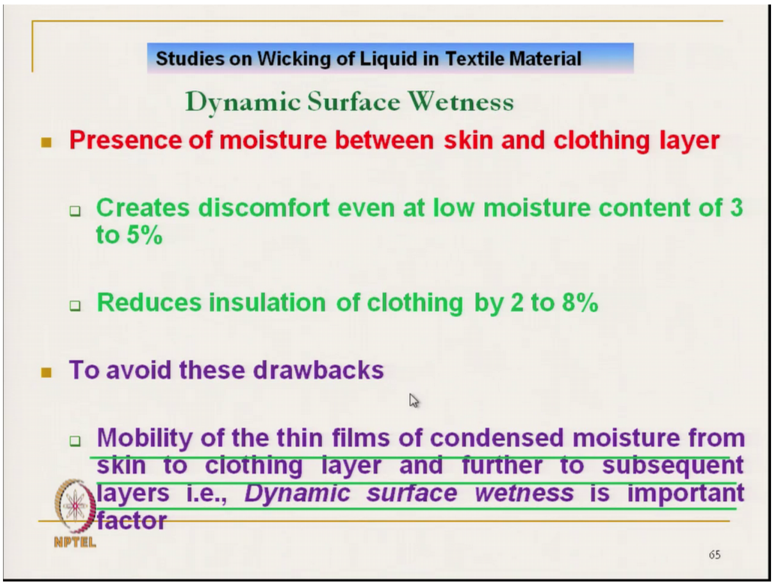

Presence of moisture between skin and clothing creates always discomfort even at low moisture level. So, 3 to 5 percent moisture if it is there, so that also creates it should be dry at that level also it creates discomfort. And as we have mentioned it reduces insulation of clothing as it becomes high because clothing gets wet, so that is how we have to actually there should be dynamic movement of water always. To avoid this drawback, mobility of the thin film of condensed moisture from skin to clothing layer, so it has to move from the skin to clothing layer the thin layer of moisture and further to the subsequent layer that is why dynamic surface wetness is important so that has to get transmitted from inner layer to outer layer and that is through wicking.

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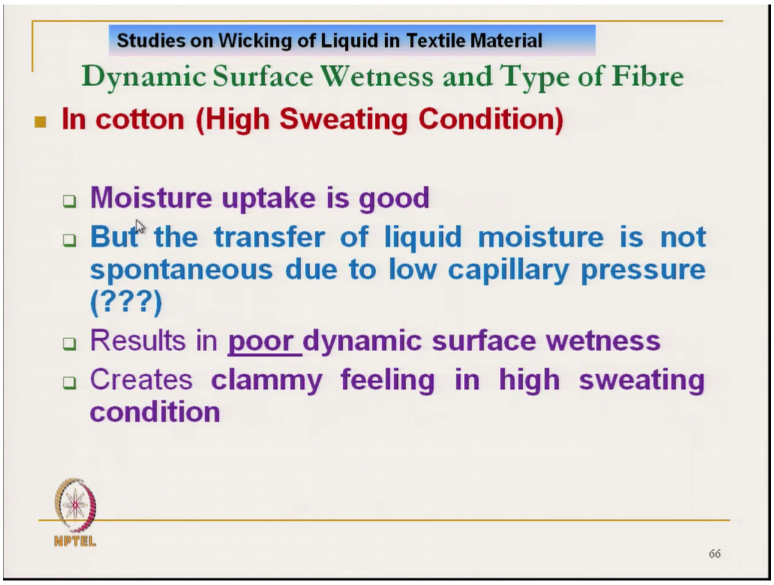

So, in cotton at high sweating condition what happens, at high sweating condition moisture uptake is good that you have seen. But, transfer of liquid moisture is not spontaneous due to low capillary pressure, and we have seen due to drag formation of bond ok. Results poor dynamic surface wetness, it tries to retain the moisture. So, dynamic wetness is surface wetness is poor. Creates clammy feeling at high sweating condition, it we start feeling (Refer Time: 26:34) discomfort is there.

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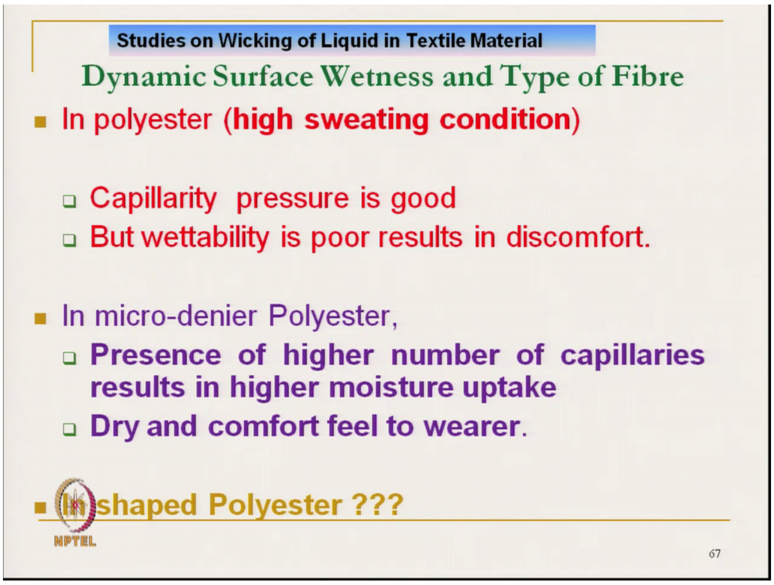

But, in polyester at high sweating condition due to the higher capillary pressure, if you can generate higher capillary pressure. But, if we cannot generate higher wettability it creates a discomfort. And on the other hand for micro claim micro-denier polyester or polyester with higher shape factor, presence of high number of capillaries or higher capillary wall result high moisture uptake and dry and comfort feeling of wearer. So, higher surface wetness is required, high dynamic surface wetness is required and in safe polyester studies exactly same as that.

So, understanding of pores structure, understanding of fibre structure ok, pore structure distribution is extremely important in liquid moisture transmission. And as the wicking characteristics increases, dynamic surface wetness also increases. And this dynamic surface wetness depends on the type of pores, type of fibre, type of fabric structure.

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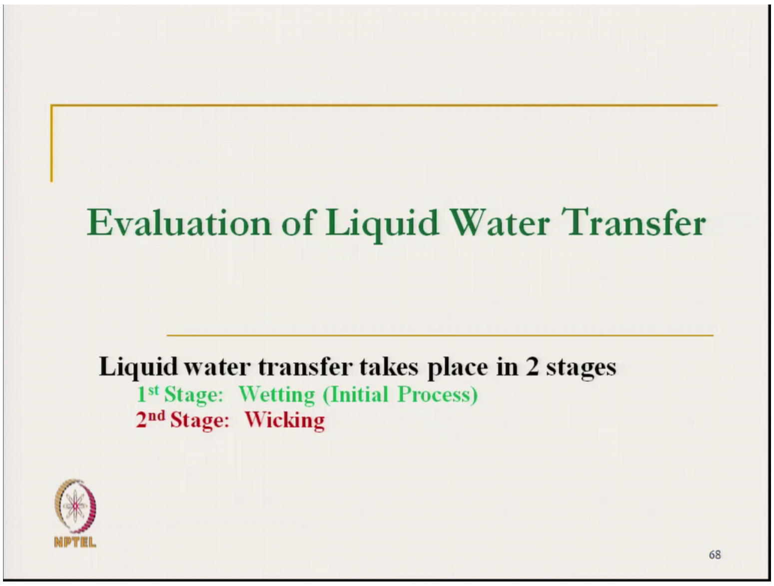

Now, we will see the different evaluation techniques of liquid moisture transmission. So, in liquid moisture transmission and next we will discuss the moisture vapour transmission. Here in this segment, we will discuss only moisture transmission through fabric in liquid form. And also in liquid form there are two stages, as we mentioned wetting and wicking.

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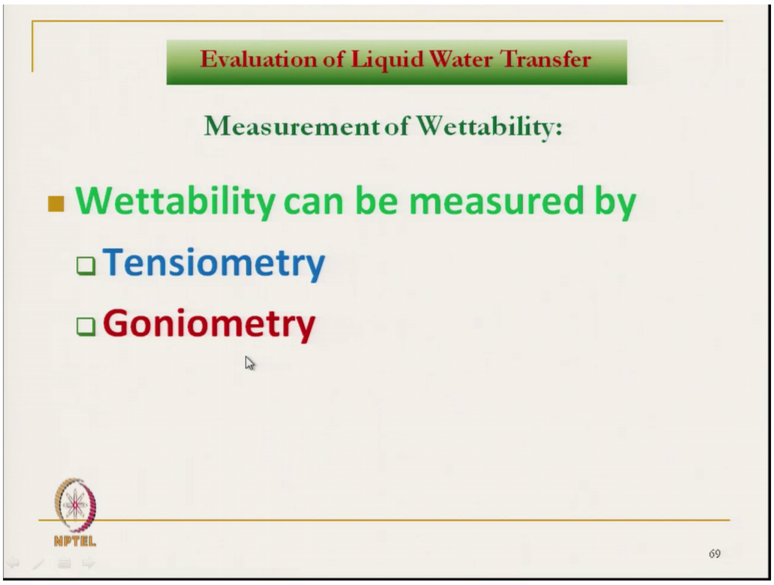

So, we will first discuss the method of measurement of wetting. How the wetting characteristics of fabrics are measured, then we will measure the water transmission characteristics. So, wettability can be measured by one is the tensiometry and goniometry. So, these two techniques are used for measuring the wetting characteristics of clothing.

So, in tensiometry the force tension to drag force, when the fabric is wet that is measured. So, higher drag force means, higher wettability characteristics. In goniometry, the contact angle is measured that means, indirectly you can say that if the on contact angle is high, then its wettability is less or contact angle is low wettability is high. So, goniometry is it measures the contact angle in static form as well as in dynamic form.

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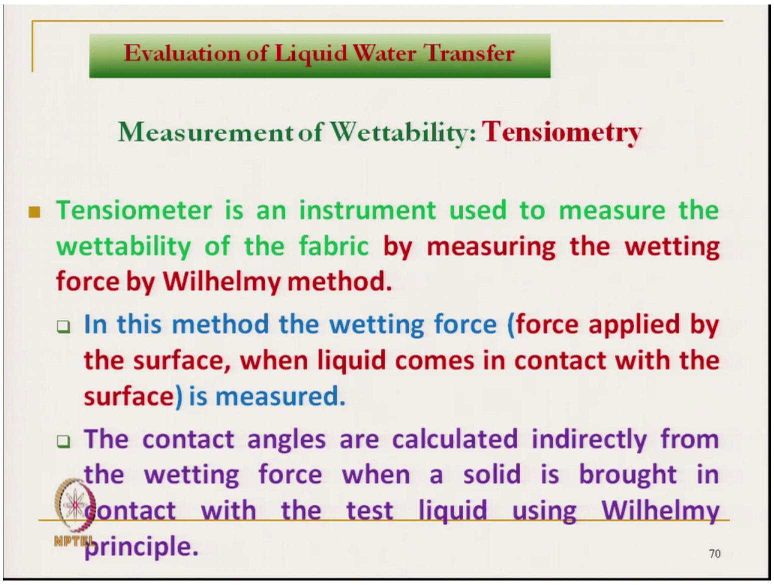

Let us see first the wet tensiometry. The tensiometer is an instrument used to measure the wettability of fabric by measuring the wetting force using Wilhelmy method. What is that, in this method the wetting force the force applied by the surface, when the liquid comes into contact with the surface is measured that means, in a dry condition it has got its own mass. And when it is in touch with a way a liquid, the liquid will try to drag the fabric. The extra force is required that wetting force is measured ok.

The wetting force and the contact angle measured in directly. If we can measure the wetting force indirectly by using certain equation using Wilhelmy principle, we can measure the contact angle. Contact angle is calculated in directly from the wetting force when the solid that means, in case of in our case it is a fabric, and this principle used for is used for many other material the wetting force solid in brought into contact with the test liquid using the Wilhelmy principle ok.

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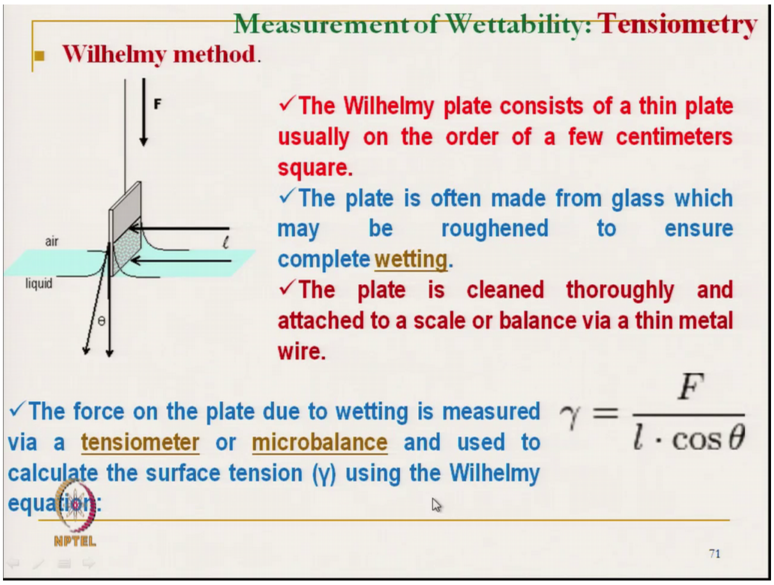

Now, this is the principle. Here in this plate, this is a plate consists of it is a thin plate usually in the order of few centimetre square, this is the plate. In our case, it will be the fabric sample. This sample that the plate is often made of glass or any material, where we want to measure. This plate is cleaned thoroughly and attached to the scale via thin wire, this is the scale.

Now, as soon as this is in touch with the liquid, this liquid will be dragged ok. By the plate there will be force exerted on the plate. The force on the plate due to wetting is measured via tensiometer or microbalance here with its measure. And it is calculated by using this formula, where the surface tension is equal to the wetting force ok, this is wetting force divided by the l; l is the length of contact, and cos theta; theta is the contact angle.

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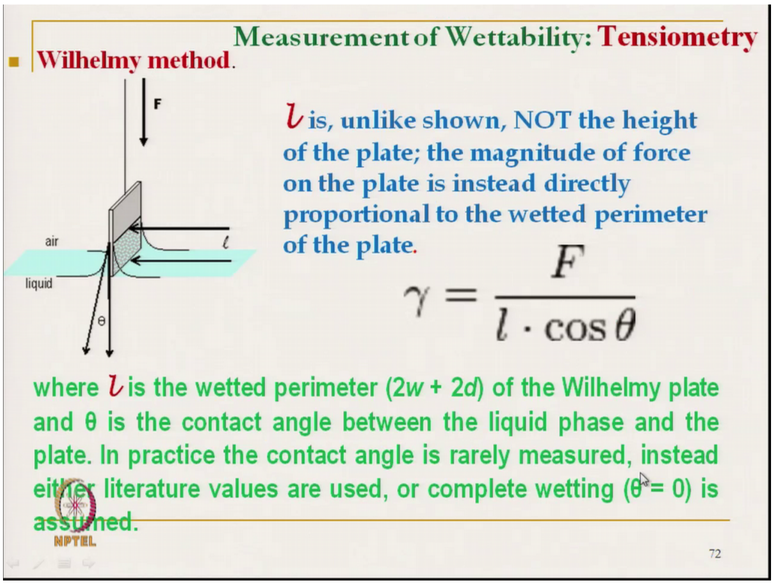

Now, this l it is not this is l, this l is not the length of this contact or length of the plate, it is the total contact length. In this case, it is a wetted perimeter; it is not the height of the plate ok. The magnitude of the force on the plate instead is directly proportional the wetted perimeter, l is nothing but wetted perimeter. Here, the wetted perimeter is the length of this contact wet length and width of the plate ok.

So, length width of the plate, so 2 d is the depth and width is w. So, l is equal to 2 w plus 2 d the total perimeter wetted perimeter. And here, we can for complete wetting theta equal to 0. So, from by using this formula, if we know the surface tension surface tension of a liquid against a material if we know, then we can we can calculate the contact angle indirectly. So, this surface tension is actually, it is we can use some standard value.

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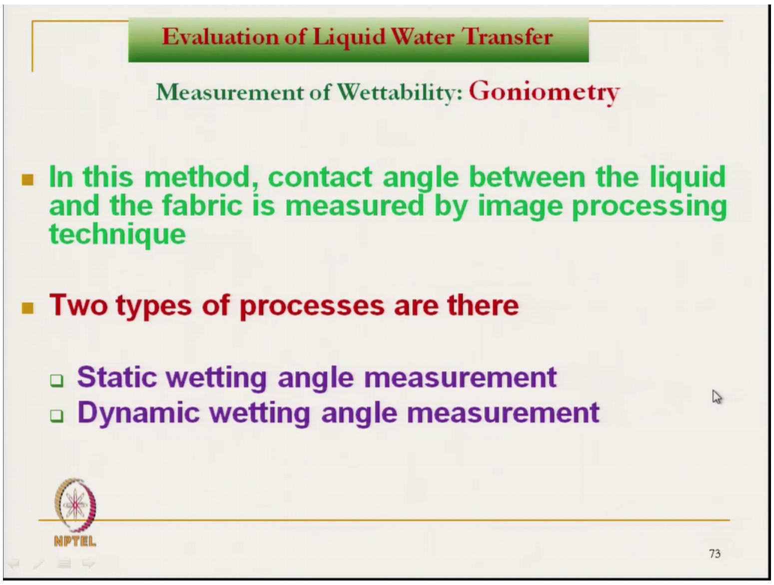

Now, goniometry principle; in this method, contact angle is directly measured between the liquid and the fabric by image processing. So, using image processing by using camera, we can directly measure the contact angle. And two types of processes are there. One is static wetting angle measurement and dynamic wetting angle measurement.

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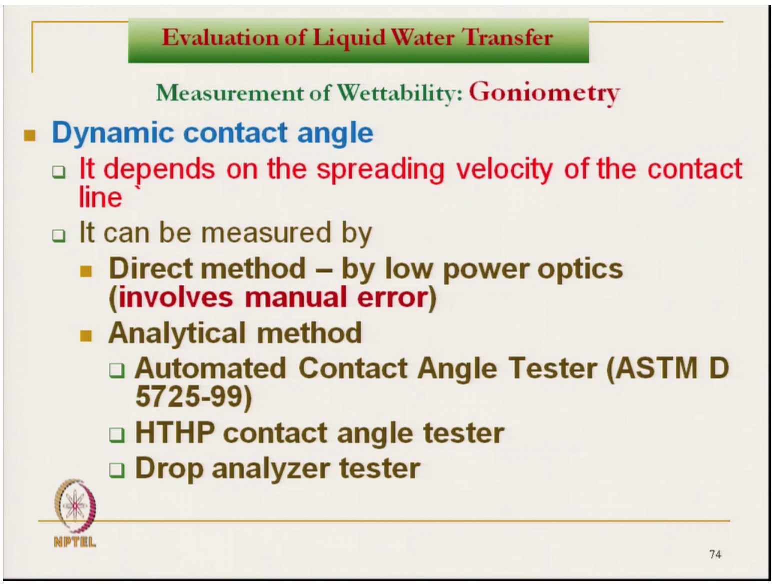

And in dynamic static is simple only by using image processing. In dynamic, it depends on the spreading velocity of the contact line. So, as soon as the liquid is dropped liquid remains liquid may not remain in that same position it as the drop as a, it will absorb the moist the liquid the fabric sample absorb the contact angle changes at that contact angle change in contact angle is recorded here.

It can be measured by direct method by low power optics ok, involve manual error. Analytical method, automated contact angle tester that is the goniometry ASTM D 5725-99 this method is a; or high actually that this HTHP contact angle tester is used. Drop analysis tester that is the contact angle directly. So, these are the different methods used, but the principle is going goniometry principle.

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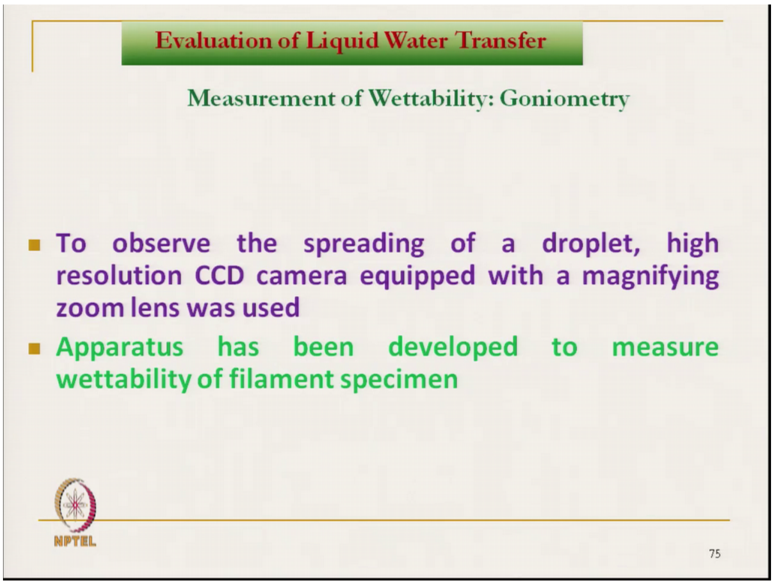

To observe the spreading of the droplet, high resolution CCD camera; equipped with magnifying zoom lens are used. The apparatus has been developed to measure the wettability of filament specimen, so with the filament the contact angle is measured.

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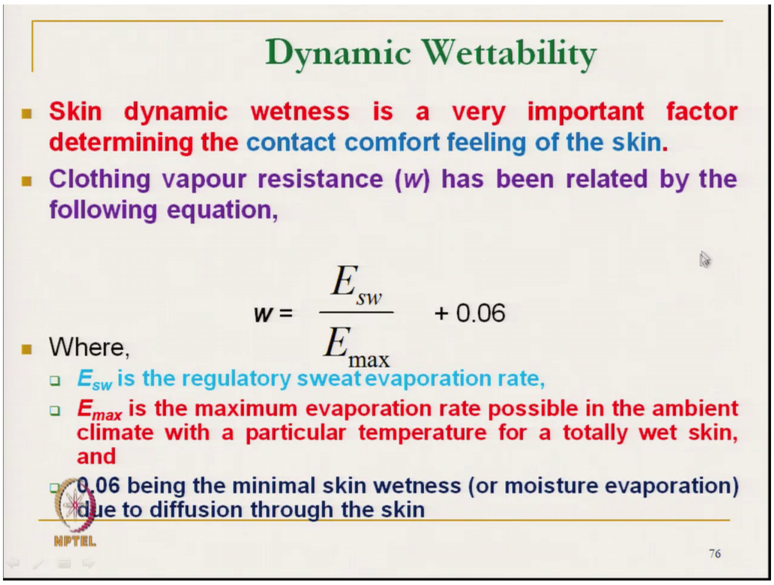

And the dynamic wettability, the skin dynamic wettability is also measured it is a very important factor in determining the contact comfort feeling of the clothing. This is the equation, where w is the clothing vapour resistance w. And this is the maximum rate of flow; sweat flow evaporation. This is the standard is a regulatory process with the clothing ok. And the ratio gives the clothing vapour resistance, so that one can measure.

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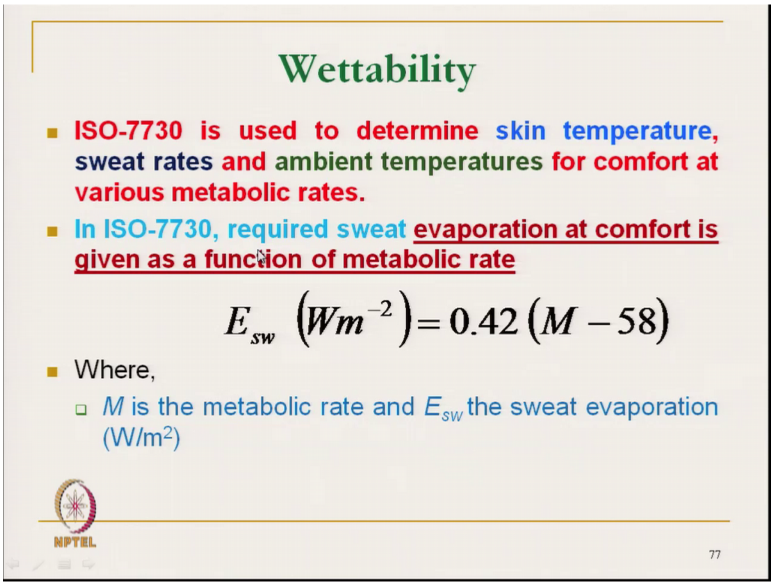

And it is actually, in ISO-7730 it is used to determine the skin temperature, sweat rate, and ambient temperature for comfort. So, for comfort if you want to measure the sweat skin temperature, sweat rate, and ambient temperature, we have to use ISO-7730. And in this method, the required sweating rate the required sweat evaporation at comfort is given as a function of metabolic heat. So, this is the required sweat rate, it is a function of metabolic heat with this equation. M is the metabolic rate E sw is the sweat evaporation, so that we can use this method.

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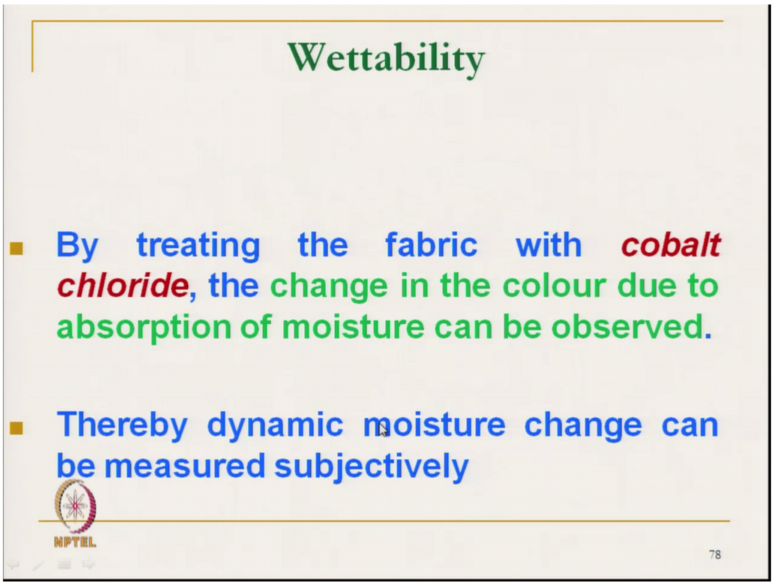

Another method is that it is a using the cobalt chloride, which actually says the change in colour. So, by treating the fabric with cobalt chloride, the change in colour due to the absorption moisture can be observed. So, the change in colour is recorded, and it gives the moisture change in moisture observed. Thereby dynamic moisture change can be measured subjectively. So, here the moisture change is measured dynamically with the so we can record the change, we can see we can observe the change in moisture by chang in colour ok, and when the fabric is treated with cobalt chloride. This is one technique of measurement subjective measurement of moisture absorption.

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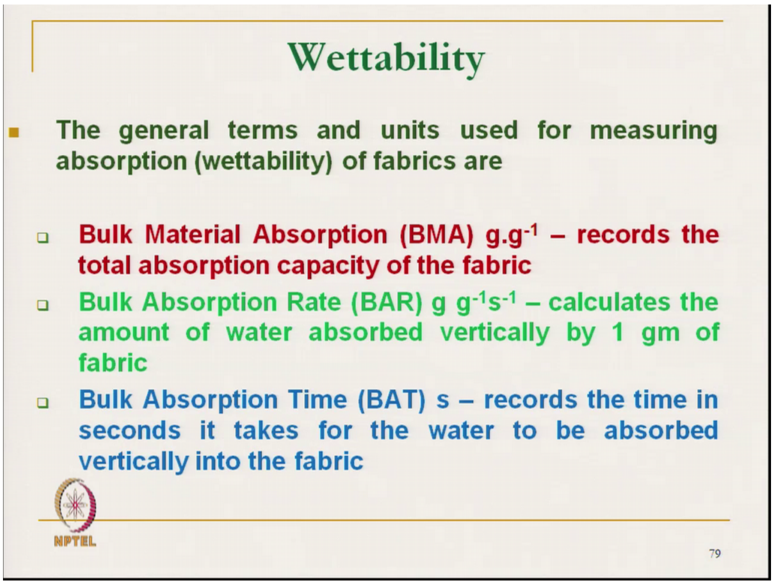

Now wettability; how to express the wettability? So, wettability the different terms are used. So, one is the Bulk Material Absorption BMA, which is which is nothing but the total liquid absorption by the fabric per in gram per gram of fabric. So, this is a gram per gram, so gram of liquid absorbed per gram of fabric. This is the one way of expressing the wettability characteristics.

Another is the Bulk Absorption Rate BAR that is gram, this BMA per unit time so that means, calculated the amount of water absorbed vertically by 1 gram of fabric per unit time, so that is a way of expression BAR. Another is bulk absorption time in second, record records the time in second it takes for water to be absorbed vertically into the fabric. So, these are the three ways of expression of wettability, in this way we can express.

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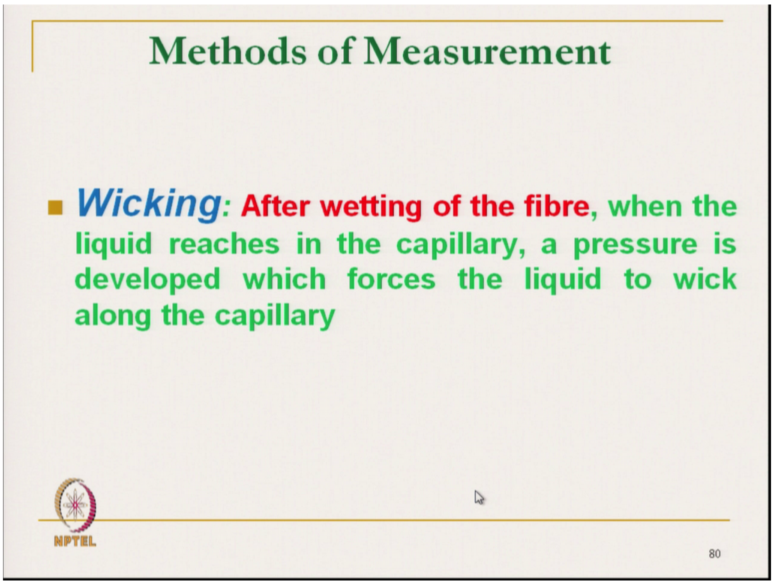

Now, coming to the next technique next principal, one is wetting, next is the after wetting. The next phenomena is wicking, where the liquid is transmitted, when the liquid is reached to the capillary by wetting, now pressure is generated and liquid is getting transmitted. So, transmission of liquid is that is wicking that is measured by different methods.

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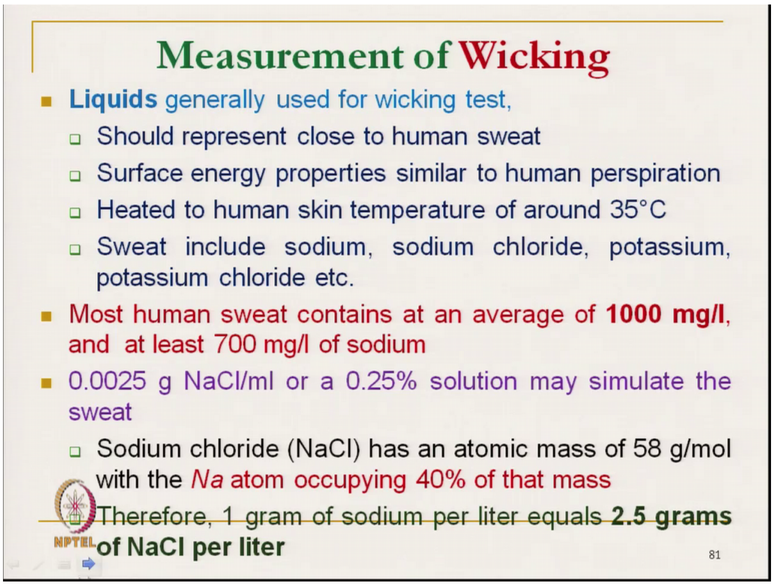

Now, for wicking test; before, we start to discuss the techniques of measurement. First, we have to understand the liquid, which liquid we should use to have to test wicking. The normal distilled water; normal water we should not use, because the characteristics of normal water and characteristics of sweat are entirely different ok. So, if we get a particular result of wicking with a normal distilled water normal tap water, it maybe sometime misleading, it may give totally wrong result, then in actual practice, so that is why, there is a standard liquid, standard fluid is actually prescribed, which is other than normal water ok.

And this liquid generally used for wicking test, it should represent close to human sweat. We should actually know what is there in the sweat, then only we can try to simulate. Surface energy properties similar to the human perspiration that the liquid which we use, its surface energy should be close to the humans skin human perspiration. Heated to human skin temperature to around 35 degree Celsius that means, the fluid during testing has to be around 35 degree Celsius that means the test which we do for wicking, it has to be performed around 35 degree Celsius. Because as the temperature changes the characteristics of fluid changes, so it may give wrong result so, it should be close to human sweat, the temperature should be around the skin temperature.

And sweat in the human sweat includes sodium, sodium chloride, potassium, potassium chloride etcetera. So, majority is the sodium chloride and sodium ok, so to simulate. So, most human sweat contains an average of hundred 1000 milligram per litre or at least 700 milligram per litre sodium. So, between 700 to 1000 milligram per litre that sodium is present in our human skin, so that is how, we have to create the liquid in the fluid in that situation in say to simulate that that is 0.25 percent solution may simulate the sweat, so that is how, this is the sodium chloride has an atomic mass of 58 gram per mole with in Na atom occupying 40 percent of the mass.

So, 40 percent of the mass, it comes out to be; that means, therefore 1 gram of sodium per litre equals 2.5 gram of NaCl per litre. 2.5 gram of NaCl per litre that means if we have 2.5 percent sodium so it will actually simulate to that. So, 2.5 gram of NaCl per litre if we can produce so NaCl is easily available. So, if we normal distilled water, if we add 2.5 gram per litre, so this will actually closely simulate to the sweat human sweat. And using this liquid we can test the wicking characteristics at 35 degree Celsius. So, in next class, we will discuss the measurement of wicking characteristics till then.

Thank you.