Science of Clothing Comfort
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Lecture - 38
Thermo-Physiological Comfort of Functional Clothing

Hello everyone, so today's topic is Thermo-Physiological Comfort of Functional Clothing. So, Functional Clothing's are particular segment of clothing where specific functions are required are expected from a clothing ensembles. Like fire fighter clothing, or clothing for extreme cold, these are the functional clothing's. And here we will discuss the nature of functional clothing, various components of functional clothing. They are thermo physiological comfort aspects of functional clothing and the how to achieve the how to achieve the comfort characteristics of functional clothing. And we will discuss the heat and mass transmission both.

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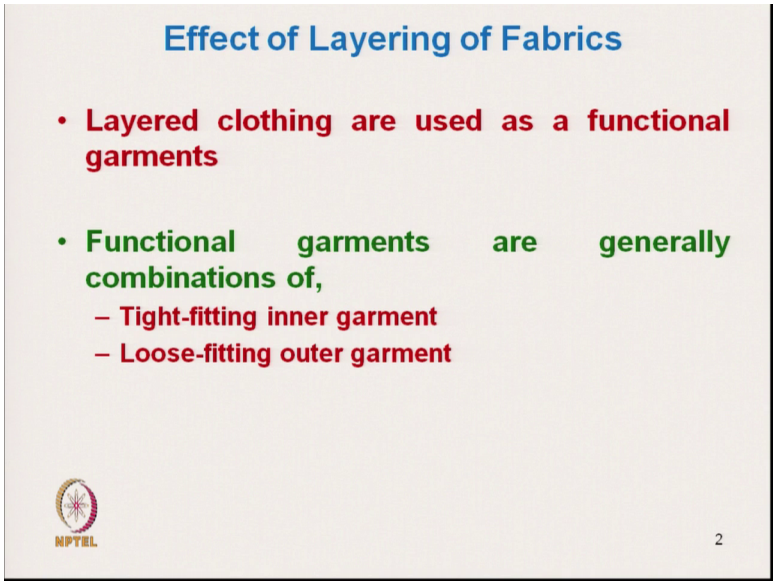

So, if we see the functional clothing they are basically of two different layers are there two basic layers are required. So, first is that tight fit inner garment, it must be there for any functional clothing. So, one tight fit inner garment should be there, and one loose fit outer garment should be there. We can have any other layers, but these two separate clothings will be there. So, if you want to incorporate some more attributes. So, we can

play with the loose fit outer garment we can add different layers, but these two layers must be there.

So, one tight fit garment which is separate another is loose fit outer garment. And when the person was or he is active so the wind penetrates to the loose fit outer garment. That is there will be one air layer air ventilation between the tight fit and loose fit garment. So, it is not the microclimate; microclimate is between the skin and the first layer. Here we are not talking about the microclimate here it is a layer between tight fit and loose fit garment.

So, if there are wind blowing so the warm air or high humidity will get replaced with the cold air or low humidity from environment will replace this warm and moist air. So, ultimately this ventilation will help in maintaining the temperature and humidity of micro climate and also the body; so body will become comfortable. So, this ventilation in functional garment is extremely important.

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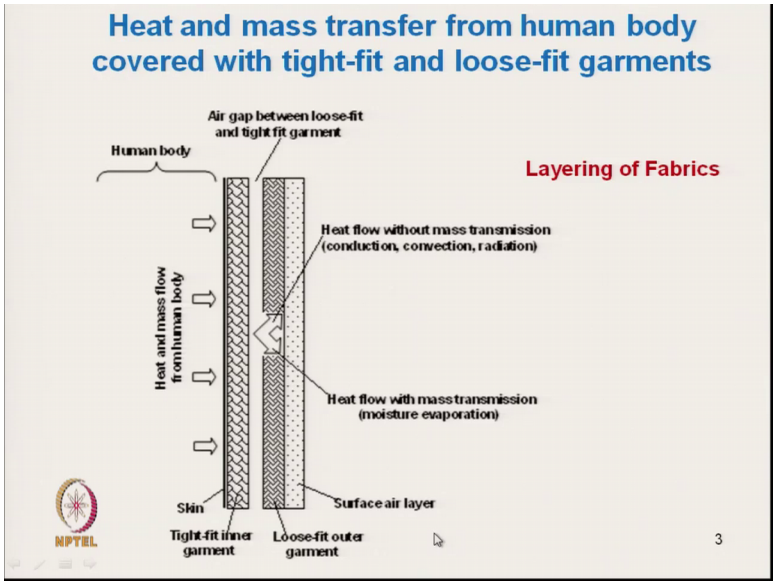

So, if you see this diagram here in the left side it is a human body ok. And the heat and moisture from human body comes through the skin and just after the skin the next layer is the tight fit garment. And after that there will be loose fit garment and then the outside of the loose fit garment there is a air layer steel air layer ok it is called Surface Air Layer; which also incorporate the insulation.

In between the tight fit and loose fit garment, there is a air channel air gap is there. In case of wind blowing or the person is walking the wind will blow through this air gap so it will create ventilation. So, for any functional garment if you can create this ventilation so we can create the thermo physiological comfort, in addition to the fabric characteristics.

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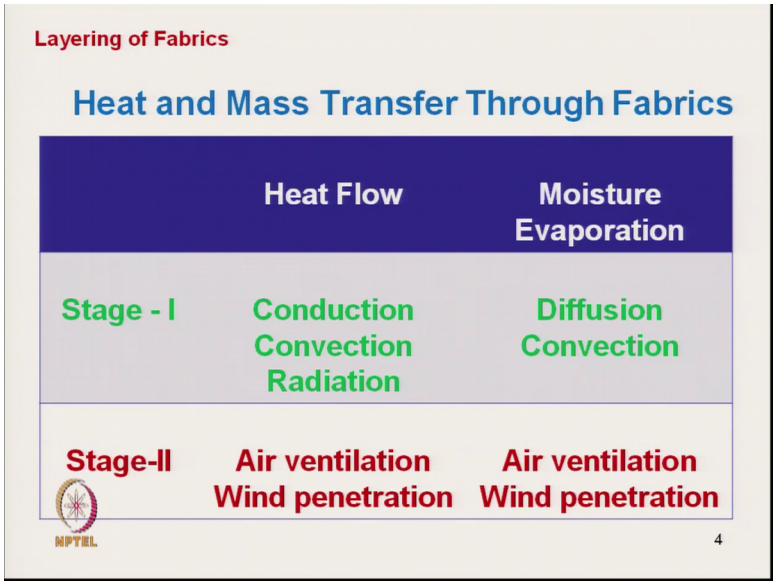

So, the heat and mass transfer through fabrics are of two stages. The first stage is normal heat and mass transmission which we have already discuss in details. So, the dry heat transmission is basically through conduction convection and radiation. And moisture evaporation is through diffusion and convection this we have discussed in detail.

The second stage here it is created between tight fit and loose fit garment just to have air ventilation. So, when the person is moving or wind is blowing the wind will penetrate through this opening and the ventilation will create. And that created ventilation will control the heat and moisture condition of micro climate also.

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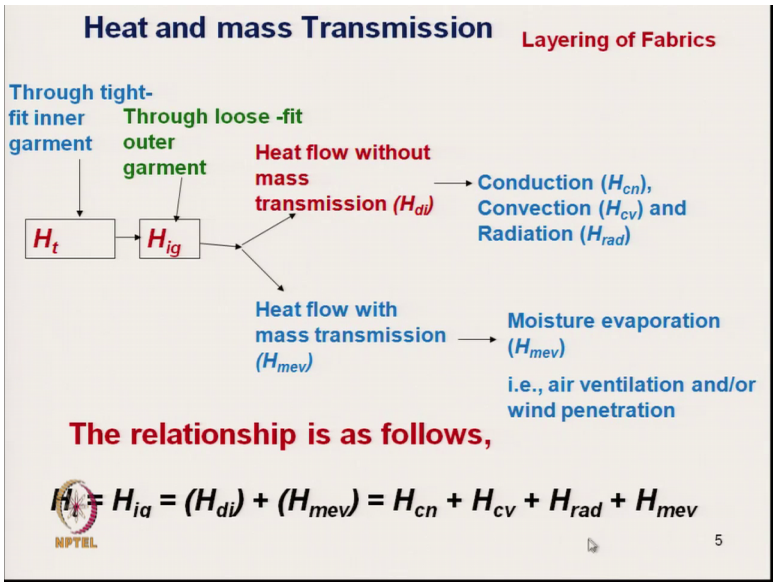

So, if you see this schematic diagram here the H t is the heat flow through tight garment. Just from the skin the total heat flow H t through the tight garment and then the heat will flow through the loose garment. And here we are talking about the stage 1 where ventilation effect is neglected, the whatever heat is coming out from the tight fit garment will actually transfer through the loose fit garment. And then from loose fit garment the heat will come out in the form of dry heat which is H di.

So, heat flow without mass transmission; that is the dry heat transmission and then heat flow with mass transmission that is H mev it is a mass transmission. So, dry heat transmission is by conduction, convection, and radiation. And mass transmission through moisture evaporation that is H mev it is a moisture evaporation. And it is basically through air ventilation and in penetration it actually it enhance this.

But basically this total phenomena here it is a stage 1 phenomena. And if you see the relationship here; H t equal to H i g; that means, the heat which is flowing out from the tight fit garment, equals to the heat flowing out through the loose fit garment, and then it is a summation of dry heat and through mass transmission. And dry heat through conduction, convection, and radiation, and through mass transmission.

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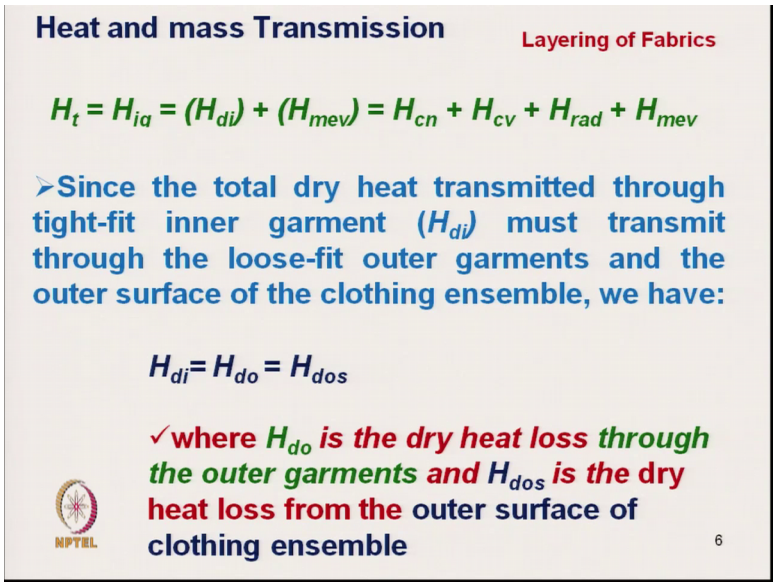

Next is that the total heat, that is total dry heat transmitted through the tight fit garment, H di total dry heat ok; must transmit through the loose fit garment if you talk about the stage 1 and the outer surface of the clothing.

So, H d i equal to H d o and H d o s; where H d o is the dry heat transmission through the outer garment. And H d o s is the dry heat transmission through the surface air surface beyond the loose fit garment outer garment ok. So, this three will be equal in case of there is no ventilation.

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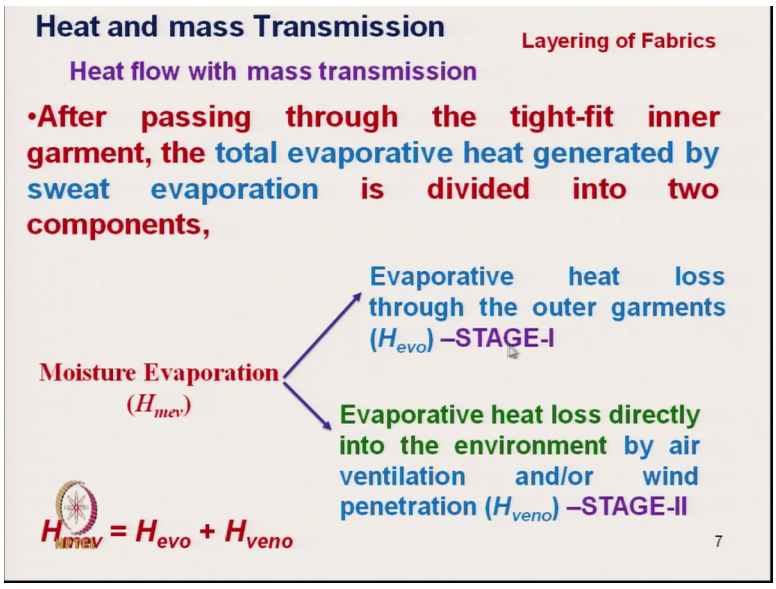

So, after passing through the tight fit garment; the total evaporative heat generated by sweat evaporation is divided into two components. So, one is this sweat evaporation it is due to stage one so, evaporative heat loss through the outer garment the without any ventilation and if you talk about the ventilation that is stage two, evaporative heat loss directly into the environment by air ventilation. So, when wind is blowing so H m e v is again sub divide into the stage 1 and stage 2.

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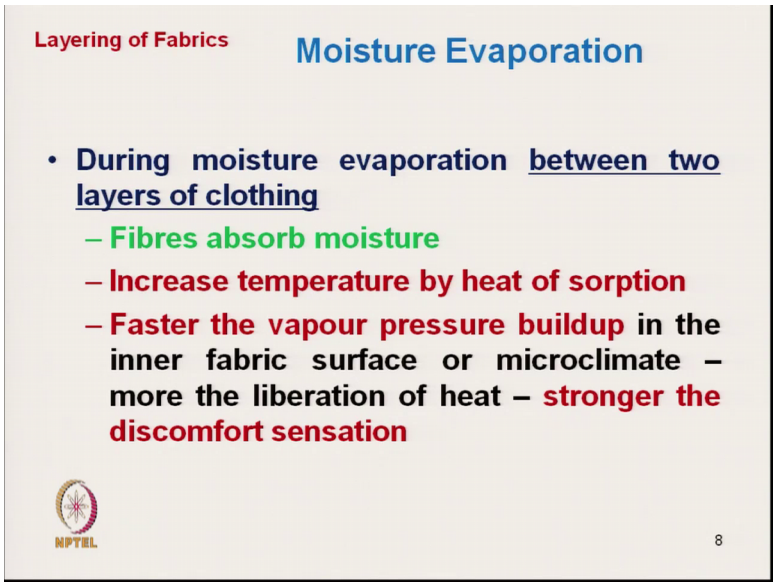

So, during moisture evaporation between two layers of clothing the things which are happening here; fibers absorb moisture. So, first fibers absorb moisture, then due to the heat of sorption the heat or temperate it releases heat so temperate increases. So, faster the absorption capacity faster the vapour pressure generated so then it will absorb at faster rate. So, the release of heat will be low, weaker, and the more discomfort sensation will be there so it is directly related with the vapour pressure buildup.

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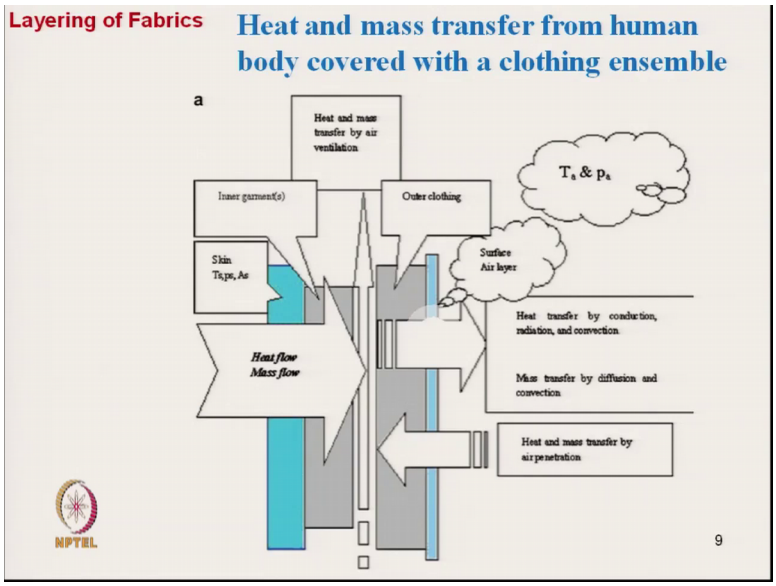

Now this is the diagram which shows the different layers and there relationship. So, if you see this blue color it is a skin, human skin and after that it is a next layer is the tight fit layer. And between tight fit and loose fit layer there is a air channel which is actually which helps in ventilation. And after the loose fit there is another layer which is the surface air layer, blue color layer.

So, if you see the actual the resistance if you compare with the electrical resistance. This tight fit and loose tight fit loose fit and outer layer outer air layer there in series. But when the wind blows there will be a reduction in the, that is enhancement in heat transmission so it will go in parallel session.

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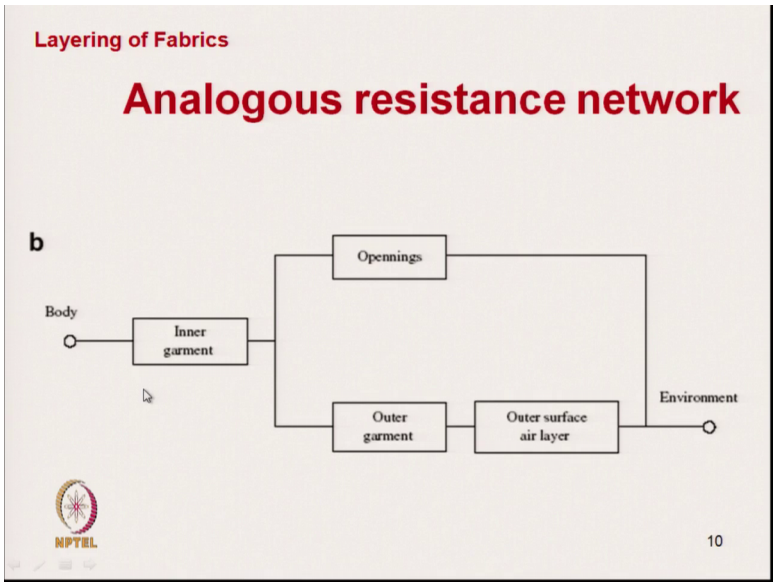

So if you see this the inner garment, outer garment, and outer air layer and it is an parallel with the opening so this is the total resistance of the system. So, if you know the resistance of inner layer, resistance of outer layer, resistance of outer garment, resistance of opening. So, we can calculate the total resistance of the system; by this Analogues resistance network.

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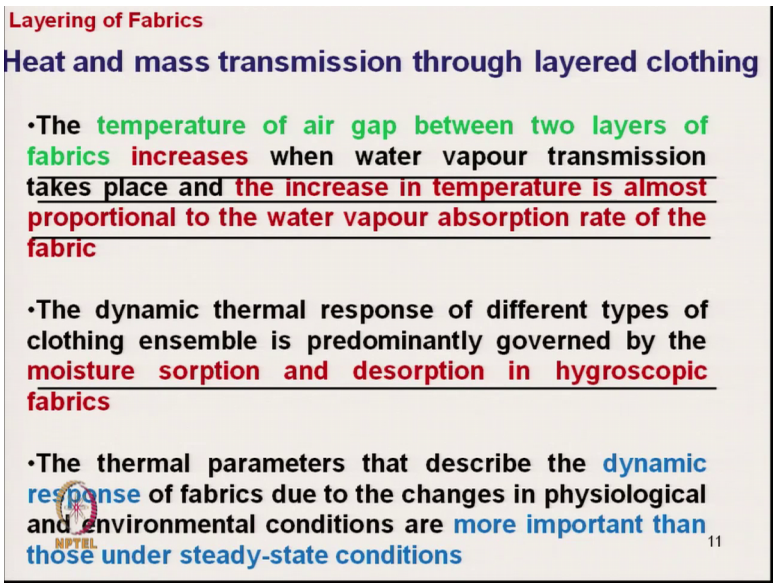

The temperate of air gap between two layers this increases when vapour transmission take place; that means, and the increase in temperature is almost propositional to the heat

of absorption. So, that is the water vapour as the fibre absorb water vapour due to heat of absorption the temperature between the layers the air gap between the layers it increases ok; this is due to water vapour absorption.

The dynamic thermal response of different types of clothing ensemble is predominantly governed by the moisture sorption and desorption in hydroscopic fabrics. That means, as the fabric absorb moisture it will release heat and during the desorption it will take away the heat. So, depending on the condition whether it is absorbing moisture or whether the fabric is releasing moisture it controls the temperature of the air gap.

And the thermal parameters that describe the dynamic response of fabric due to the change of physiological and environmental conditions are more important than those in steady state condition. So, as we are always in dynamic condition, always the environments are in dynamic condition. So understanding the dynamic response extremely important. So, it is only the steady state condition will not help; we must understand the ventilation characteristics and we can predict knowing the steady state nature.

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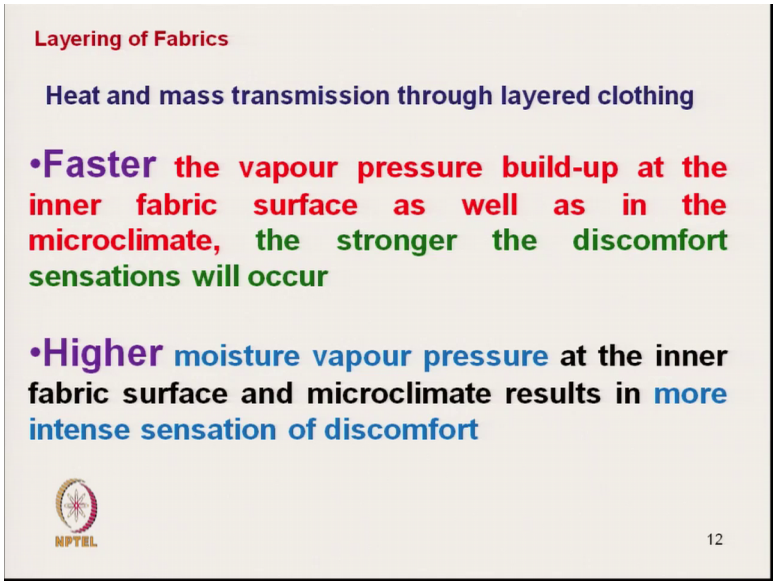

And the heat and mass transmission through layered clothing. So, in that case the faster the vapour pressure buildup. So, if the vapour pressure buildup is fast then the there will be stronger discomfort sensation. So, if the vapour pressure generation is slower then; fabric will take care of the vapour transmission and gradually the vapour pressure will

reduce. So, the during due to normal vapour transmission will not fill that much discomfort sensation.

But if the vapour pressure generation is faster than the release by the fabric than there will be stronger discomfort sensation due to the loss of heat due that release of heat of sorption. Similarly; if the higher moisture vapour pressure is there at the inner fabric surface the micro climate result in more intense sense of discomfort. So, in case of faster vapour pressure generation or higher vapour pressure generation in both the cases will say will sense the discomfort

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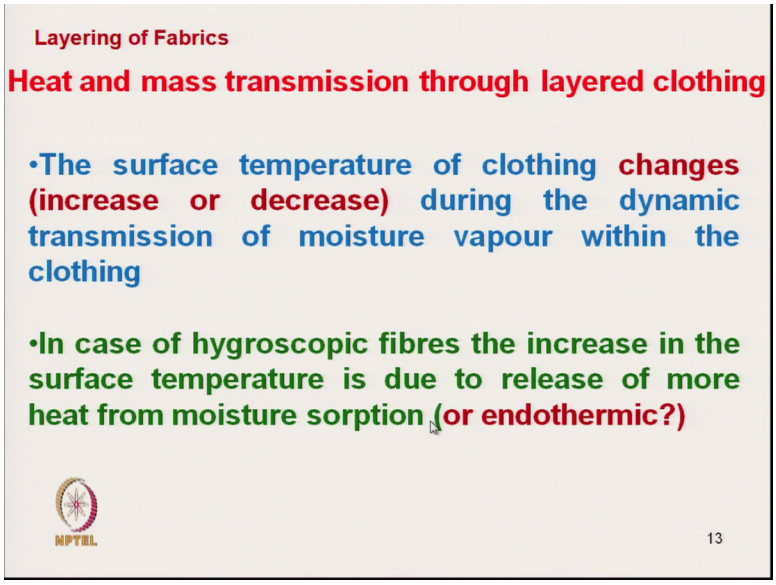

The surface temperature of clothing changes, so it can increase or decrease depending on whether it is absorbing moisture or it is a releasing moisture, whether it is a exothermic reaction or endothermic reaction. So, that changes during the dynamic transmission of moisture vapour within the clothing. So, in case of hydroscopic fibre the increasing surface temperature is due to due to release of heat; that is heat of sorption.

But if it is endothermic in nature then there will be cooler feeling. So, that we have to select fibre accordingly; we have to select the finishing material accordingly. Now we will discuss the functional fabrics and their physiological comfort and how to incorporate comforts in functional fabrics.

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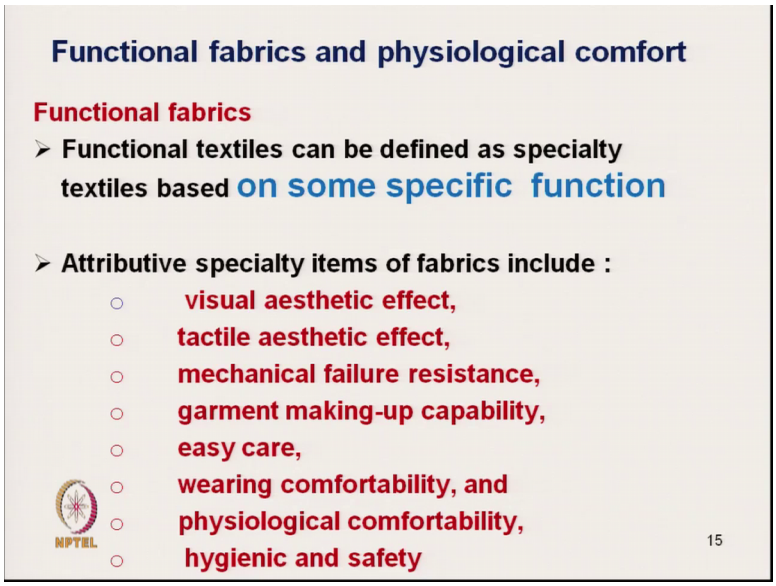

The functional fabrics are that are those fabrics are basically use for some specific function ok. And this attributes are in addition to their targeted function like; let us take one example, of fire fighter clothing. So, in addition to the fire fighting performance these are the attributes we must incorporate like visual aesthetic effect.

So, visual aesthetic effect we have to incorporate. We have to incorporate tactile aesthetic effects, then mechanical failure resistance it has to be strong enough. The fabric has to have some capability of garment material, we cannot have a fabric after coating after doing everything very stiff so that we cannot form a garment. So, garment making capability should be there in the fabric, it should be easy can so that total characteristics which have been incorporated should remain there after during the use.

Wearing compatibility it should be comfortable and the physiological comfortability, so, this are the characteristics plus hygiene and safety. So, all these characteristics should be there in any of the specific functional clothing. So, we have to see this effect should be there this are the parameters these are the attributes should be there.

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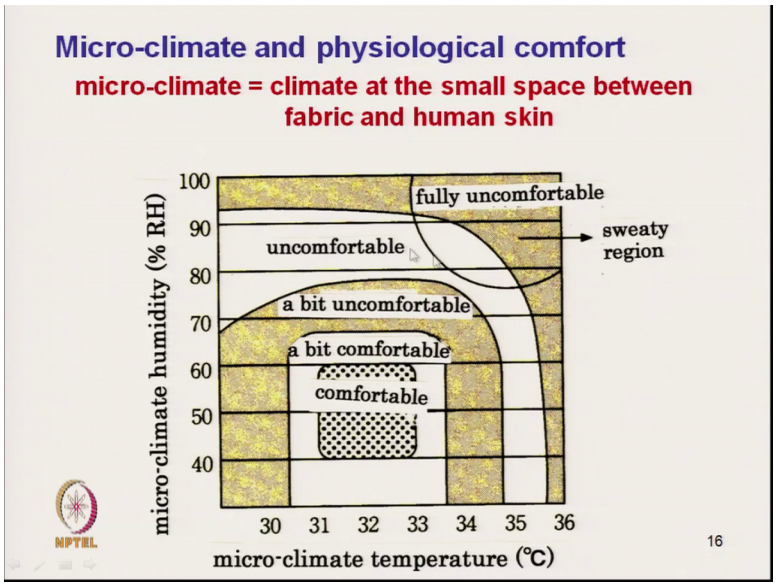

So, if you see the microclimate; microclimate we have already discussed the temperature of microclimate should be between 30 to 33 or 34 degree Celsius. And the humidity should we say 30 to 60 it is the most preferable microclimate ok. If we go beyond that it will be gradually uncomfortable. So, our target should be to this the in this zone where the total comfort is there.

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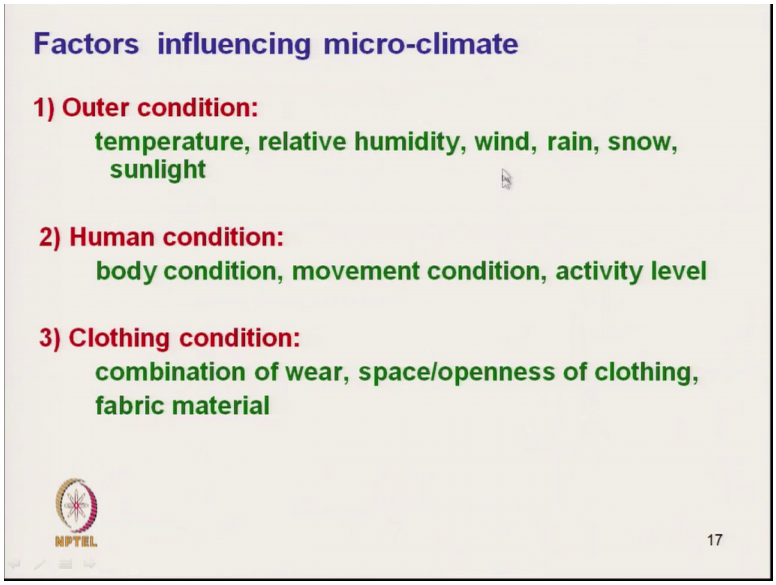

So, the factors which affect the microclimate we must understand first; the factors the outer condition environmental conditions are the temperature, if the temperature of the

environment is increased automatically it will affect the temperature of microclimate relative humidity. If it is high relative humidity then the release of moisture vapour will not be there properly. So, relative humidity will also increase, wind condition you must understand, rain, snow or sunlight.

So, if we know the outer condition for any functional clothing so we can develop our clothing we can use particular fabric or finish to have proper comfortable microclimate. Then we must understand the human condition that is body condition, movement condition and level activities. So, we must know the heat generation we must know the level of moisture generation so to control the microclimate and condition of clothing.

So, if we know the outer condition and human condition which we normally cannot we do not have any control on this. But we can knowing all this to first and second point we can develop clothing. Then we can develop clothing of combination of wear like we can develop different layers we can design different layer space and opening of clothing we can design clothing of different opening. So, that we can control the ventilation we can develop different fabric materials so that it can absorb or it can transmit moisture or heat properly.

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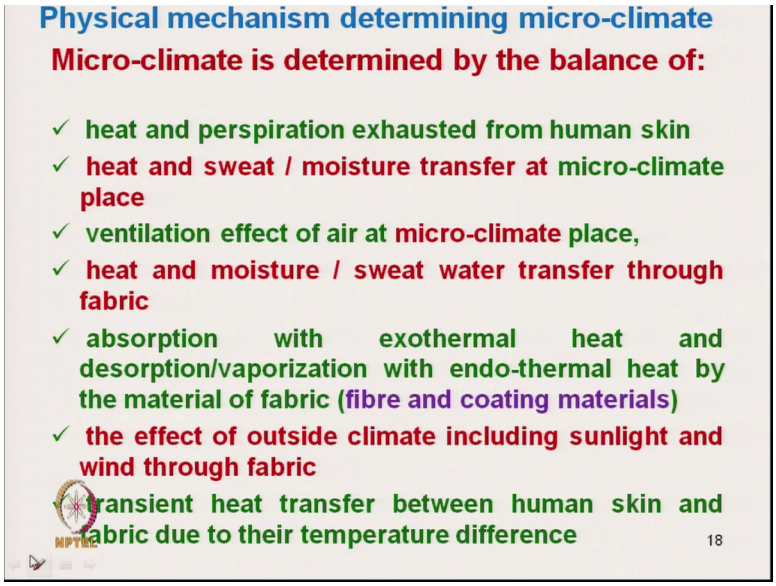

So, microclimate is determined by the balance of heat and perspiration exhausted from the human skin. So, if the heat and perspiration is more; obviously, the microclimate temperature and humidity will be more. So, it is controlled by the heat and perspiration

exhausted from human skin. Next is that heat and sweat or moisture transfer at micro climate place. So, how the heat or moisture is getting transmitted from the human skin to the microclimate, ventilation effect at the microclimate.

If the ventilation effect is good then even if there are more higher temperature or higher humidity that can be controlled. Heat and moisture or sweat water absorption or transmission through the fabric. So, how the heat is getting transmitted or moisture is getting transmitted that will control the microclimate condition. And absorption with exothermal heat or desorption or vaporization with endothermal heat by material or fabric. One is fabric if the fabric cannot do cannot control the exothermal or endothermal heat, then we can use some coating materials also.

So, if fibre does the thing then it is otherwise we can add some coating material with proper exothermal or endothermal characteristics. So, sometime we use the different types of coating that we will discuss the effect of outside climate including the sunlight and wind that also control the microclimate that we have discussed already. And transient heat transmission between human skin and fabric that is transient heat of absorption or transient heat transmission that is also important ok.

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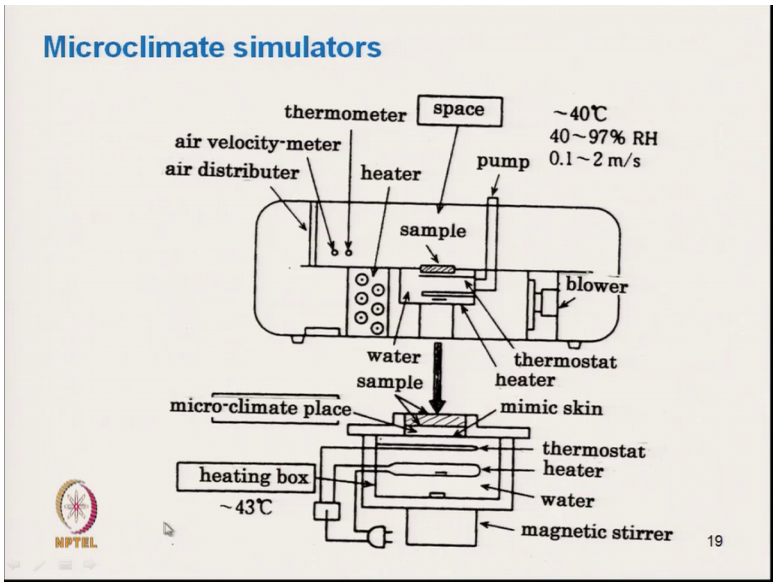

Now, this is the microclimate simulator; here the moisture generated is there, water tank is there, with the thermostat control and that temperature is kept around 43 degree Celsius. So, from there, there is a mimic skin some material then which stimulate the

skin the ports are there. So, from there moisture gets a transmitted through that this portion is the microclimate where you can control the, we can measure the heat temperature and moisture and this is the fabric sample.

So, using this microclimate simulator one can test the effect of different parameters on microclimate for different types of fabrics. Now we will start discussing the different approaches to incorporate thermo physiological comfort of functional clothing's.

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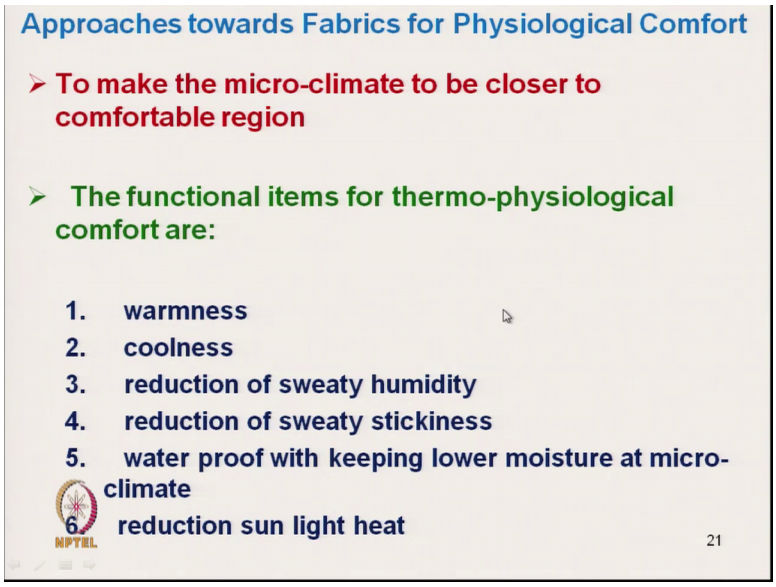

So, to make the microclimate to be closer to comfortable region, that is the first approach ok. We have to make the microclimate towards the comfortable region around the temperature is should be around 30 to 32 degree Celsius. The functional items of thermo physiological comfort are ok. These are the functional items we must incorporate. So, if we want to incorporate warmth so that we will see how to incorporate warmth in the fabric that is our requirement.

If our requirement is to incorporate coolness so warmth is required in cold climate. That will see how to incorporate warmth in the functional clothing; in hot climate we may need to incorporate coolness that will see how to incorporate coolness in the clothing. Then we may need to incorporate reduction of sweat humidity. So, microclimate if it becomes sweaty then we feel discomfort so to counteract this sweaty humidity, how can we improve, how can we incorporate some characteristics which will reduce the sweaty humidity that we will see.

Reduction in sweaty stickiness it is a different from sweaty humidity; here due to increase in humidity condition the fabric stickiness increases. So, how to reduce the stickiness, sixth one is that we may sometime require water proofing, but at the same time we would like to reduce the humidity in the microclimate.

So, waterproof with keeping lower moisture at microclimate that how to incorporate that characteristics and reduction of sunlight heat, direct sunlight heat sometime we may need to reduce. Like traffic police, so, where the people who are working directly under sun so in those fabrics how to incorporate what how to design clothing to reduce the sunlight heat. So, first is the how to impart the warmth warmness in the clothing ok.

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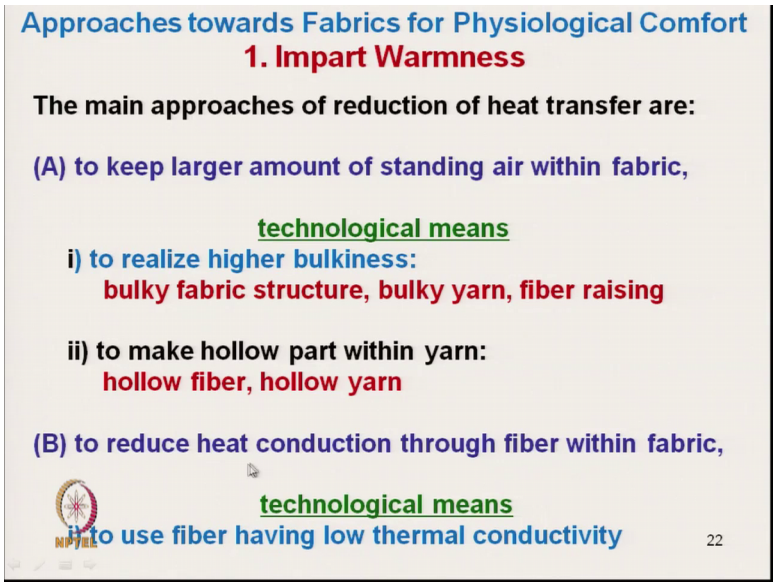

The main approaches are; first is to keep larger amount of steel air within fabric, that is the first step that we have already discussed. So, the technological means are there to incorporate bulkiness. If we incorporate bulkiness; that means, the entrapped air will be more and it will incorporate the insulation. So, warmth will be retained so heat it will not allow the heat to come out from the body from the microclimate. So, in the microclimate heat will be retained, so by using fabric or yarn with bulky in nature.

Next is the to make hollow yarn so in both the cases what we are trying we are trying to retain or retain some steel air within the fabric structure. The next approach is to impart warmth is to reduce the heat conduction through fibre within fabric. That means, heat gets conducted through the air space that we have discussed in a and also through the

fiber. Through the fibre if we want to reduce the heat flow; that means, we have to use the fibre with lower thermal conductivity. So, this two approaches are, one is the imparting the steel air another is introduction of fibre with lower thermal conductivity.

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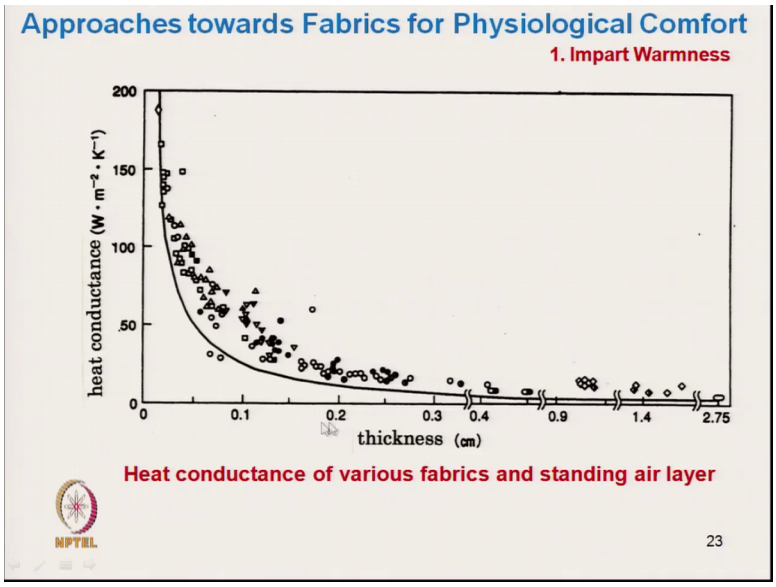

So, this curves shows that as the thickness of fabric keeping the mass per unit area constant. If we increase the thickness of the material, thickness of fabric the heat conductivity reduces; that means, thermal resistance increases. So, that is incorporation of the bulk.

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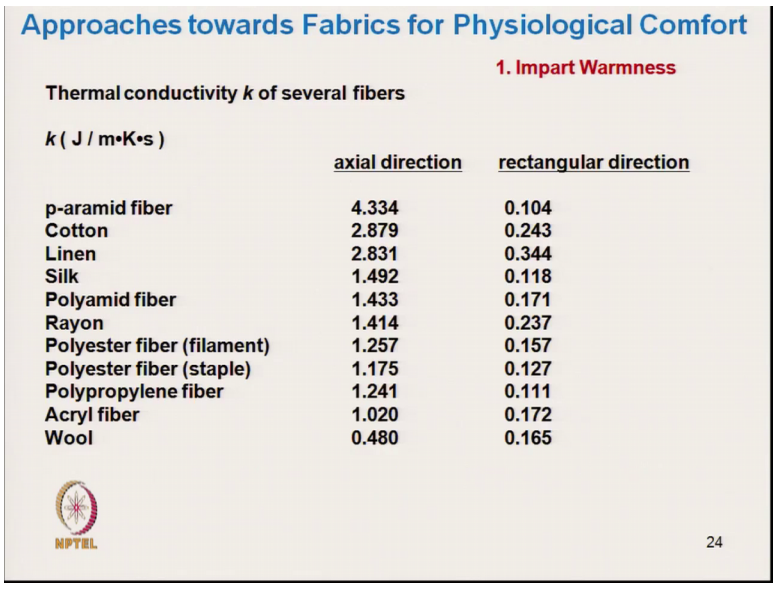

And next is the guidelines this is few fibers which are normally used for apparel application or garment. These are the thermal conductivity in axial direction and the transverse direction. So, these are the guideline if we want to incorporate something, if you want to incorporate the thermal insulation we may select. Like wool if you see wool has got list thermal conductivity so if we use wool; obviously, it will give the insulation.

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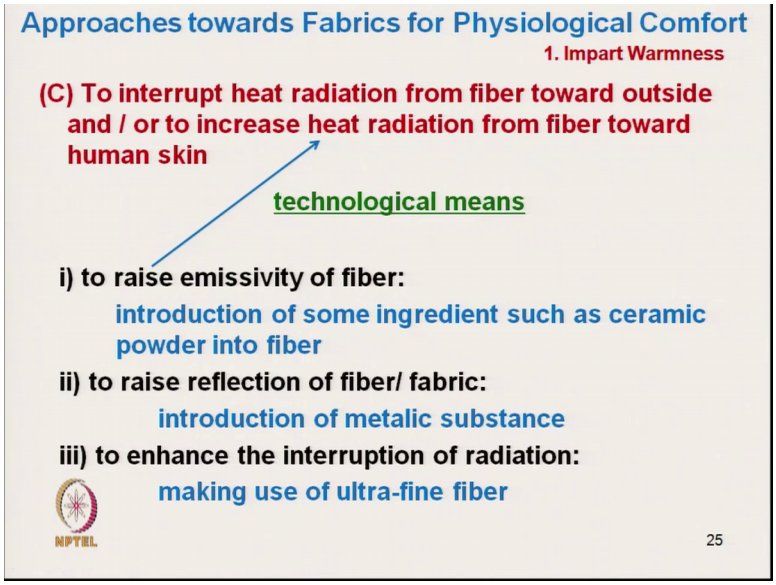

Third approach is that to interrupt heat radiation from fibre towards outside. So, radiative heat reduction from the body we can do or to increase heat radiation from fibre towards human skin. That means, if from outside whatever heat is possible if it can penetrate through the fibre to the human body so that both the ways, if you see they are totally opposite requirement one is to retain heat to fibre should be able to interrupt or prevent heat radiation or if there are some heat source fibre should able to should able to take the heat ok.

So, heat should come from fibre towards the human body. So, the second part the increase of heat radiation from fibre towards human body can be incorporated by raising the emissivity of fibre, heat emissivity of the fibre ok. Introduction of some ingredient such as ceramic powder into the fiber, so if you want to increase the emissivity, so that to get heat radiative heat from outside; so we can incorporate some ceramic powder into the fiber. On the other hand if you want to retain the radiative heat within the body.

So, to raise the reflection of fibre so, we can coat something reflective material ok. Introduction of metallic substance, if we incorporate some metallic substance so it will reflect back the radiative heat and retain the body heat ok and third approach is that to enhance the interruption of radiation by making the ultra fibre, the microfiber if we can use it will reflect back the radiative heat. So, for radiative heat interruption or transmission we can use this by this three approaches and we can keep our body warm.

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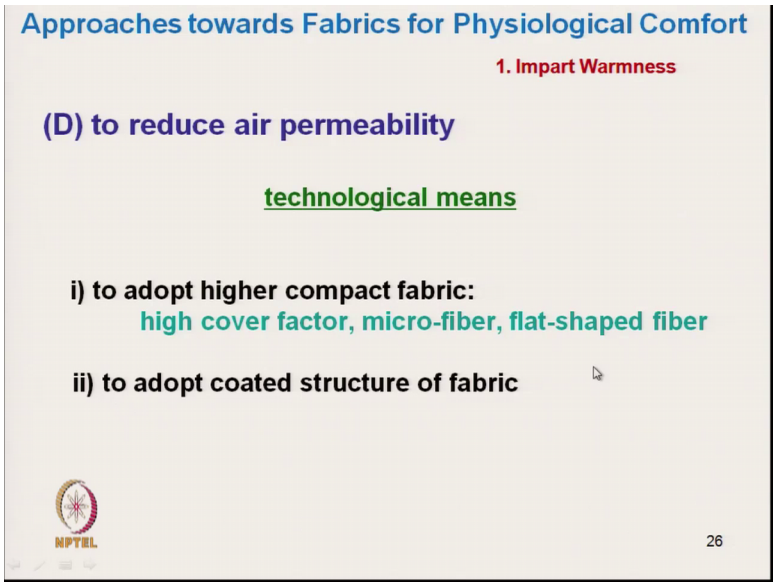

The fourth approach is that to reduce the air permeability. Whatever heat is there in our body it can get transmitted through moisture vapour or through air. So, if we can reduce the air permeability if we can make the fabric compact. So, higher cover factor if we use microfiber or flat shaped fibre with high shape factor. So, it will automatically reduce the air permeability and that in that case it will retain the warmth in our body. And to adopt coated fabric structure ok. So, coated fabric we can use to reduce the air permeability. So, if we reduce the air permeability we can indirectly retain the body heat. But we have to take care of the moisture vapour permeability.

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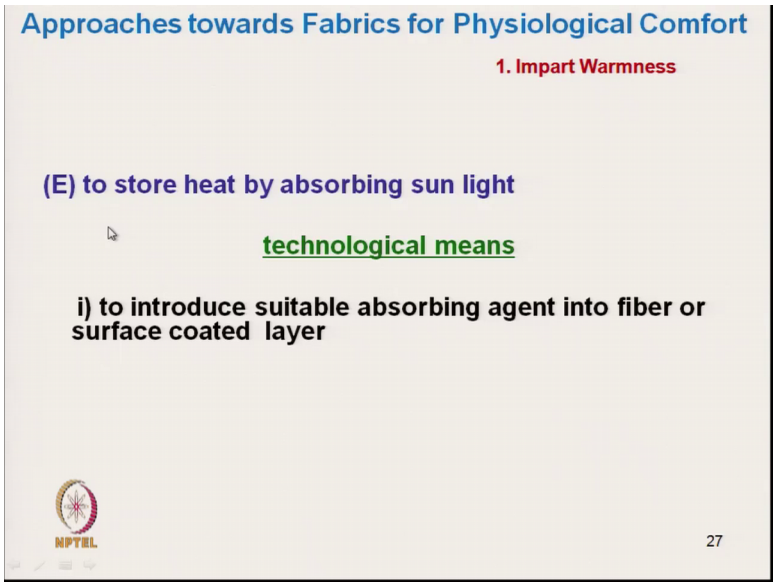

To store heat by absorbing sunlight, so we can incorporate some material, some agent some surface coating. So, to introduce suitable absorbing agent into fibre or surface coated layer. So, if we can incorporate some material which absorbs sunlight so we can increase the warmth.

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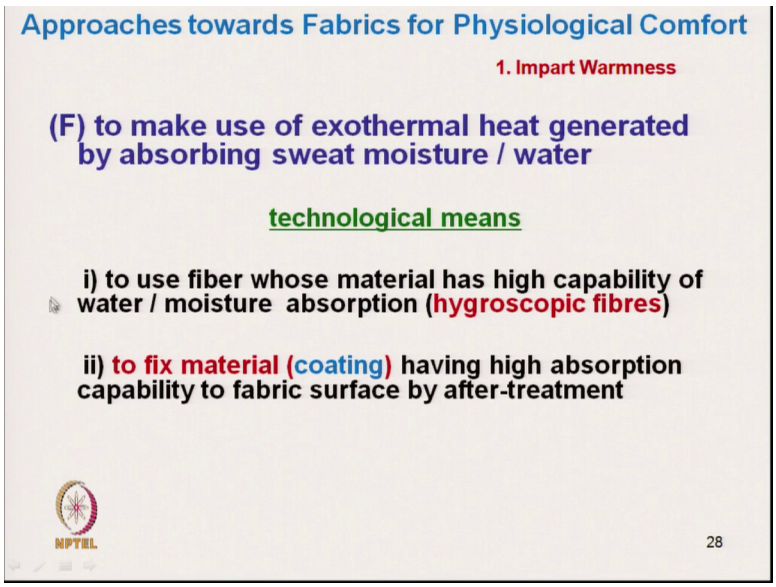

Next one is the to make use of exothermal heat generated by absorbing sweat moisture. So, that phenomena we can use some exothermic fibre hydroscopic fiber. So, that uses fibre whose material has high capability of water and moisture absorption. So, high

exothermic heat it can generate so body become warm. So, it absorb moisture from environment or it can absorb moisture from the micro climate.

And after absorption it will release the exothermic heat and automatically the microclimate will become warm. If the fibre cannot absorb the moisture it is not if it is not hydroscopic. We can still make the fabric hydroscopic by coating. So, by fixing some material by coating so with high absorbing capacity so we can also generate some exothermic heat. So, we can you make use of exothermal heat generation so to keep the body warmer.

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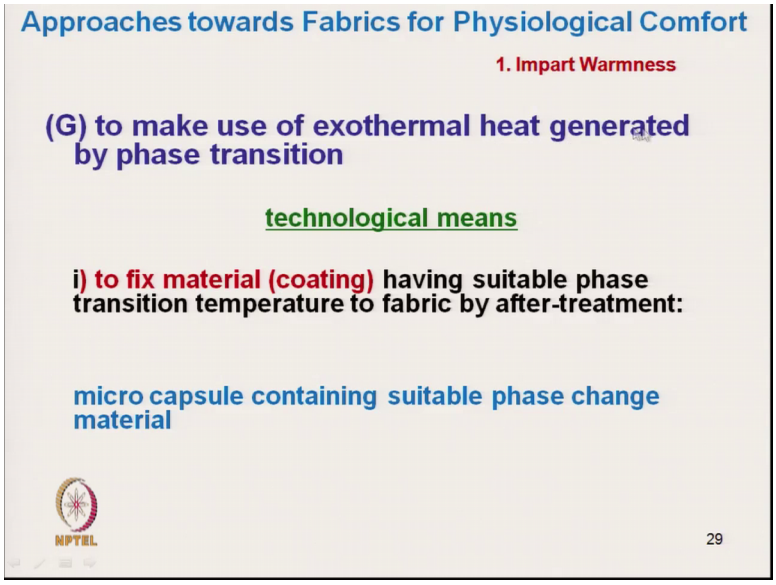

And also we can do to make use of exothermal heat generation by phase change material. The phase transition material we can use like to fix material we can coat material with the some microencapsulation technique. We can coat some material with exothermal heat generation with the some suitable phase changing temperature phase transition temperature to the fabric.

So, this phase change transition temperature at particular temperature the chemical the material will absorb moisture at immediately it will release it. So, through microencapsulation; we can incorporate through coating. Next is that impart coolness so after imparting warm if you want to impart coolness, so how do we impart coolness?

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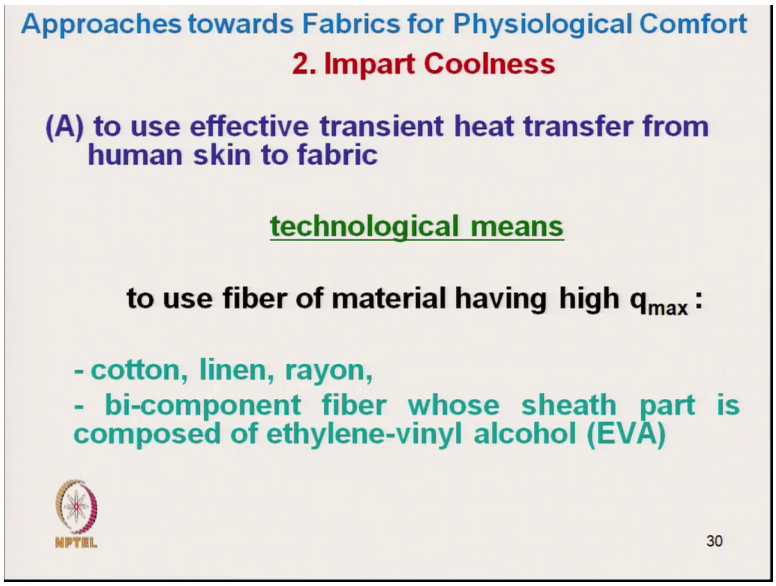

There are different approaches, first is that we use effective transient heat transfer from human skin to fabric. That means, we have to use some material some fibre which has got high transient heat that is q max we have discussed.

So, we can use cotton, linen, or rayon; these fibers are generally there high q max value as soon as there in touch with the body that I immediately take heat and we feel coolness. So, if we want to incorporate coolness we may go for cotton linen or rayon or we can develop bi-component fibre whose sheath part is composed of ethylene vinyl alcohol. So, EVA has nature as a particular characteristics of high q max value so this approaches we can use.

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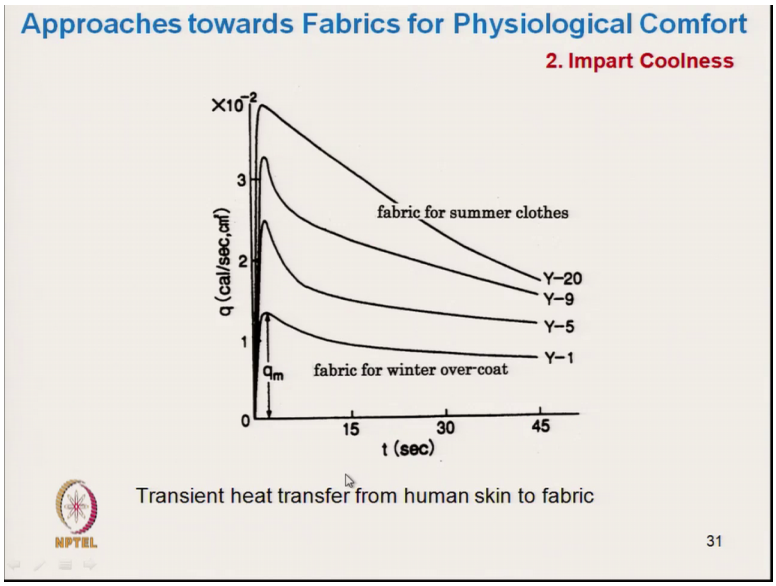

So, if you see this is the q max value, the maximum q max value this will we can use for summer clothing and minimum q max value we can use for winter clothing. So, depending on the q max value we can select.

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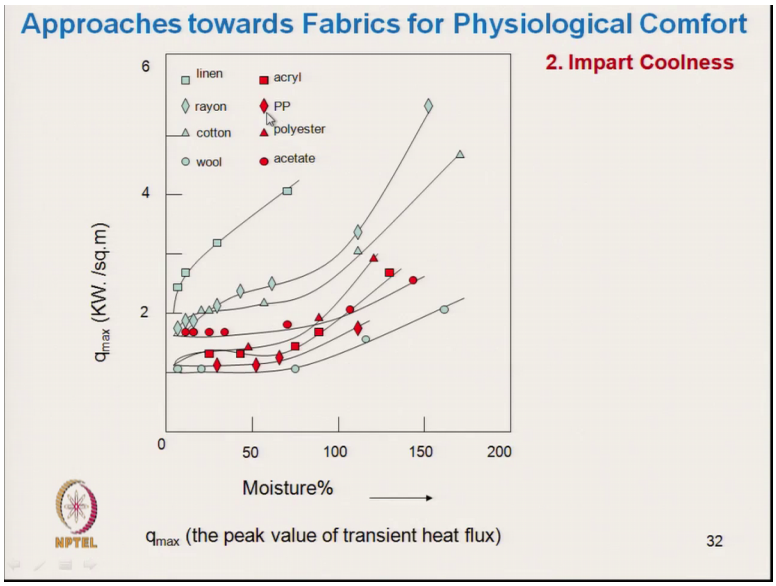

So, if you see here it is a this one is a linen; linen has got very high q max value so it is a cool touch fabric. And then followed by rayon, we can go for rayon or cotton. This three fibre if you see their high q max value so there cool touch we can make use of this

characteristics. If you want warmth, if you do not want coolness we can go for wool which has got very low q max value.

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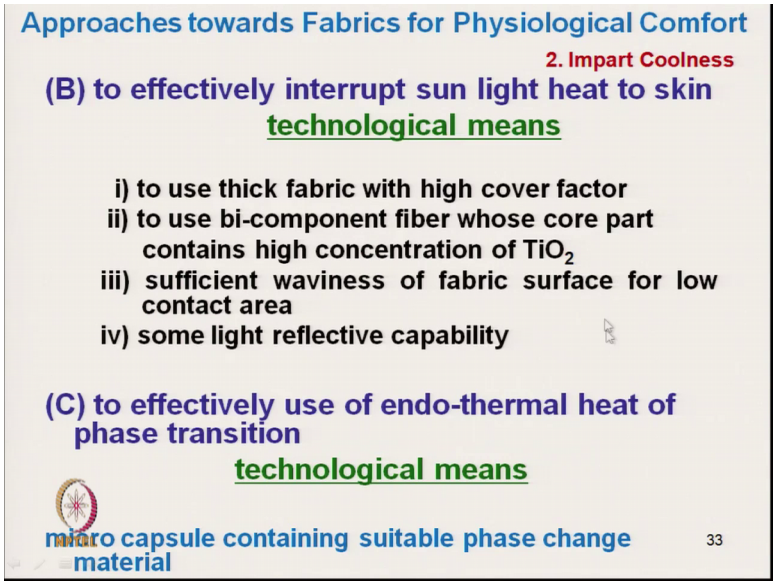

The next approaches that, to effectively interrupt sunlight heat to the skin. So, in if you need warmth so we have to absorb we have to use some material which will absorb heat we can have fabric which will absorb heat. But if we want coolness so we have to interrupt the sunlight, direct sunlight heat. So, this we can achieve by using thick fabric with high cover factor. So, if we want to interrupt sunlight heat, direct sunlight heat the idea is to we have to use a highly compact fabric direct sunlight heat will not penetrate.

To use bi-component fibre whose core part contains high concentration of TIO. It will not allow direct sunlight to penetrate, it will it reflect the direct sunlight heat, sufficient waviness of fabric surface for low contact area. So, again when the fabric surface is directly under sunlight it will get heated. The fabric will get heated and if it is the it has got high contact area with our body then our body will feel heat.

So, if we can develop a fabric with a wavy structure, just to reduce the contact area then our contact area will be less and our feeling sensation of warmth will be less so we will feel little bit cooler. So, one can do experiment making only the fabric from the same material only changing the waviness structure. The wavy fabric will fill cooler in nature. Some light reflective materials and can be used or some fabric can use. So, the fabric

which will reflect the light will give coolness. So, in that case if we compare the plain woven or twill with the setting.

The setting fabric will give higher coolness keeping all other parameters constant and this is due to the reflecting capacity of the fabric. The sunlight will get reflected better with the second fabric, the effectively use of endothermal heat of phase changes material in case of warmth which we have seen the endothermal material we have we can use here we will use the in case of the warmth we have used the exothermal heat of phase transition here we will use endothermal heat of phase transition. So, we have to select material accordingly and we can incorporate by microencapsulation method.

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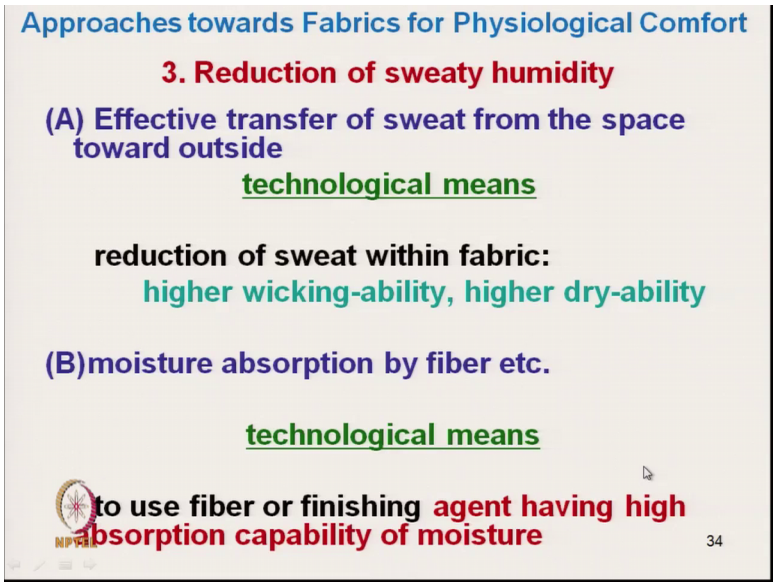

Third requirement is that reduction of sweaty humidity, the in the microclimate whatever sweaty humidity is there we how can we reduce this. So, we reduce, we release a sweat, we release moisture vapour. So, that first technological means is that to reduce sweat within the fabric we have to incorporate the high wick ability of the fabric. So, higher wick ability we can incorporate or higher dry ability. So, higher wick ability we have seen that in case of say high active clothing, if we use polyester fabric with high shape factor it will wick at higher rate the body will feel little bit dryer.

Moisture absorption by fiber; one is that the wick ability where it may or may not absorb moisture. But it will wick, but in case of moisture generation at lower level in that case the fibre we which we can use with the higher absorption capacity the use of moisture

with higher absorption capacity. If it is not possible we can incorporate some finishes with finishing agent with higher absorption capacity. So, then the fabric will immediately absorb moisture and our microclimate will become dry. So, it will reduce the sweat humidity.

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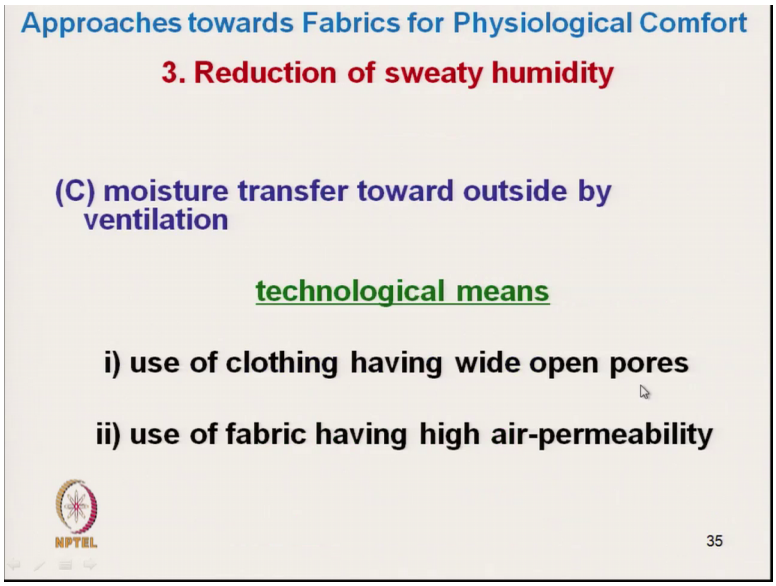

The third approach is that the moisture transmission towards outside through ventilation. So, if we can incorporate ventilation by proper opening. If we can widen the openness, widen the port the moisture will directly get transmitted ok. The use of fabric having high air permeability; so, that means, that will create extra ventilation. So, if we want to reduce the sweaty humidity we have to use open structure fabric with high wick ability.

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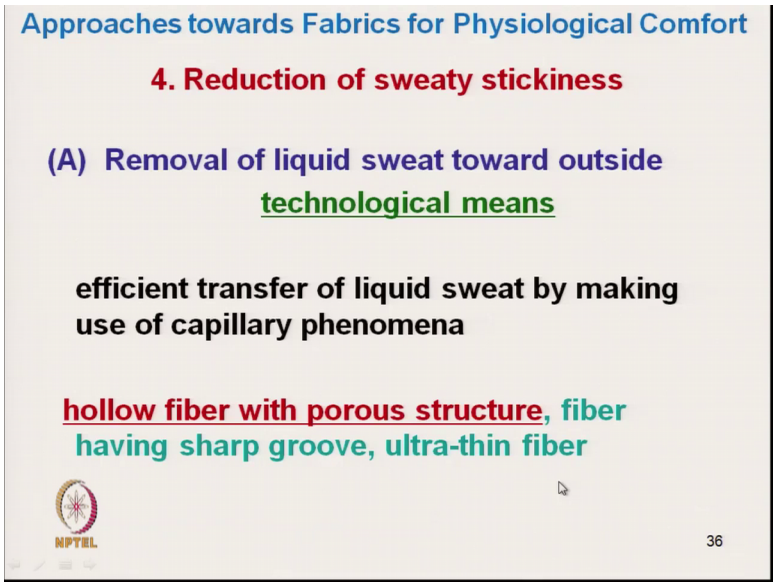

Fourth requirement is that reduction of sweaty stickiness. Here in addition to the sweat we are talking about the stickiness; that means, first if you want to reduce the sweaty stickiness we have to reduce the moisture buildup, the effective transmission of liquid sweat by making use of capillary phenomena. One we can do by using the capillary phenomena by using the fabric with higher shape factor fabric with higher ultra thin fiber.

Or some hollow fibre with porous structure have been developed, like polyester with hollow fibre having porous structure that will absorb moisture very quickly, and our body will be, that microclimate will be dry immediately and it will reduce the stickiness.

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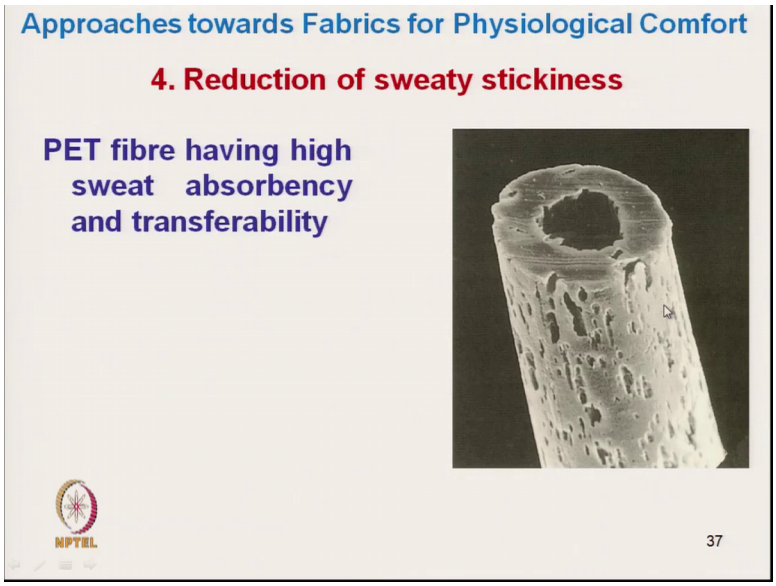

So, the example is this is the picture the PET fibre having high sweat absorption and transferability. So, this will immediately absorb moisture, if we develop fabric from this fiber. It will immediately absorb moisture from the microclimate and microclimate remains dry and sweaty stickiness will not be there.

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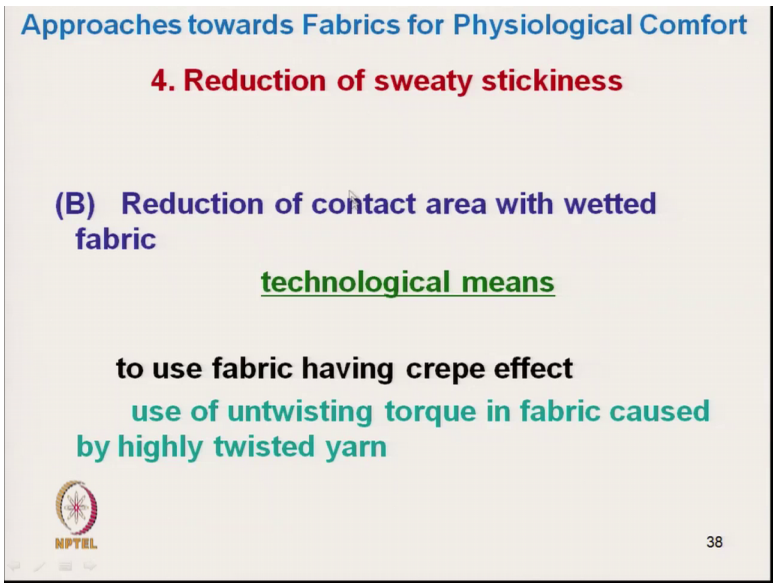

The next approach is that to reduce the sweaty stickiness is to have fabric with crepe effect. If we incorporate crepe effect that by using the untwisting tour of the fabric it will have less contact area. Because fibers fabric surface will be wavy and the there will be

less contact area and stickiness will not be there. That means, it will reduce the cleanliness that we have already discussed earlier. So, if we can incorporate a crepe effect even if there are high sweat, high moisture developed in the microclimate. The fabric it will not be stickiness it will be sweaty definitely, but stickiness would not be there.

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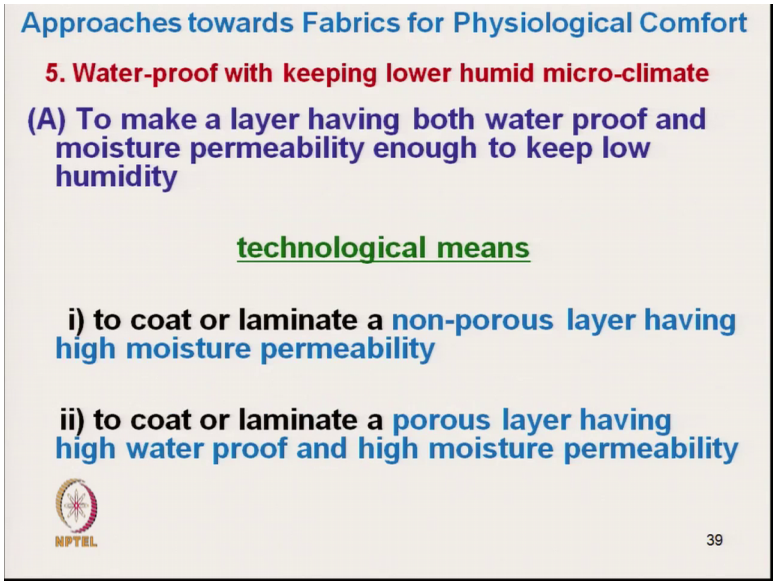

The fifth approach is that fifth requirement is that waterproof with keeping lower humidity in microclimate. So, we need waterproofing to prevent the water to come out. But at the same time we have to reduce the moisture buildup, to make a layer having both waterproof and moisture permeability enough to keep low humidity. So, it should prevent the water to come out the and at the same time moisture to come to be released. The technological means at that to coat or laminate a non porous layer having high moisture permeability.

The layer should be non porous sufficient to prevent the water to come in but it should allow the moisture to be released. And next approach is that to coat or laminate of porous layer having high waterproof. The layers should be porous, but it should be waterproof and high moisture permeability. So, it should be what we should coat with such a material which will incorporate high water proofness and at the same time high moisture permeability.

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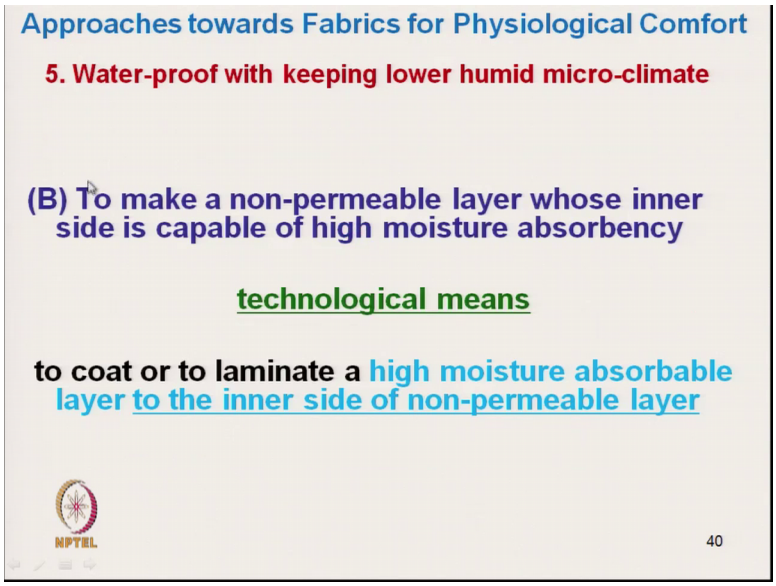

Another approach is that to make non permeable layer whose outer layer is non permeable, but inner layer coating should be such that it is highly moisture absorbent. So, that will actually take care of the absorption of humidity, absorption of moisture, but at the same time it will be waterproof. So, to coat or to laminate high moisture absorbable layer to the inner side of non permeable layer. So, let the fabric be non permeable if we can coat the fabric inner layer with the moisture that layer to some extent will take care of the absorption or moisture vapour and reduce the moisture buildup.

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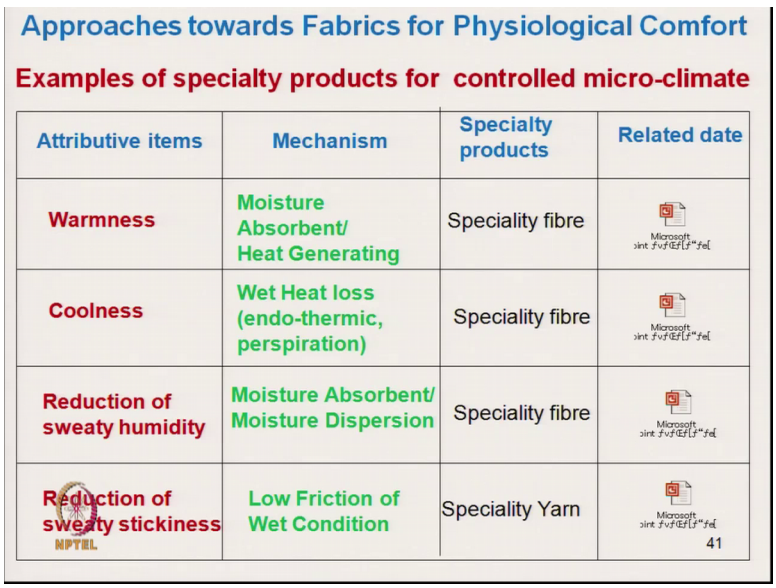

Now try to see the some commercial product available the warmness to incorporate warmness the it should be absorbable to moisture it should absorb moisture and at the same time it should generate heat. So, heat of absorption is created with the speciality fibre, we are not using the commercial name here. But some speciality fibers have been developed, synthetic fibre have been developed which absorbs moisture and releases the heat.

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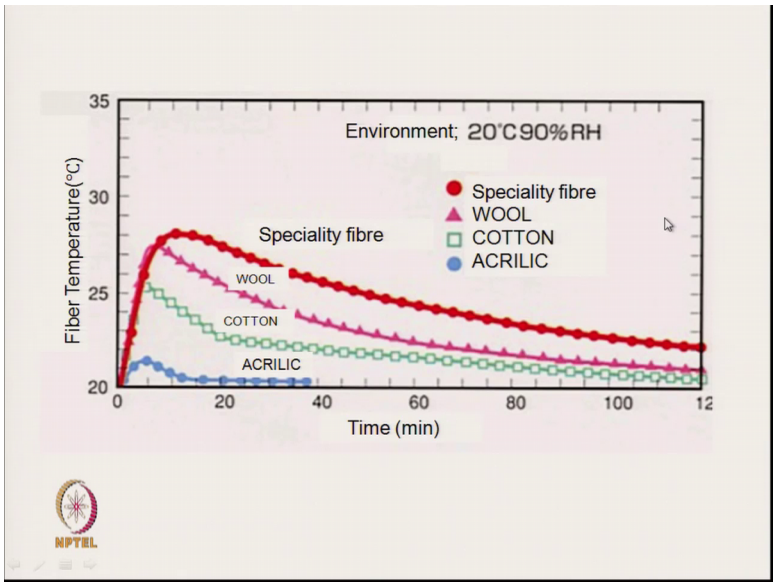

So, these are the comparison the blue one is acrylic, this one is cotton green, wool and this one specialist specialty fiber. Now if we see with the time the fibre temperature it increases it is high always it is high it. That means, with absorption of moisture it releases heat. So, temperature (Refer Time: 52:54) high so this fibre we can use to keep our body warm; next is the coolness. So, the fibre is it is a endo thermal reaction is the endothermic perspiration. It absorbs perspiration and it takes away heat.

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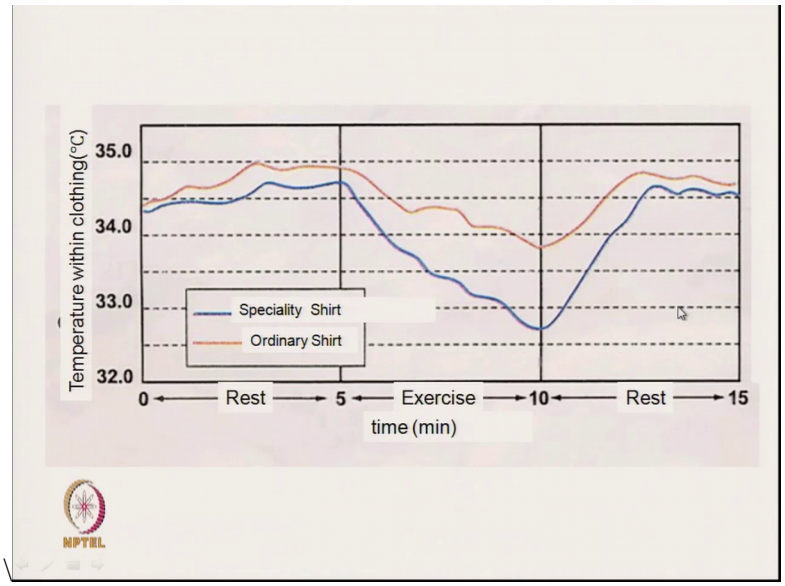

This is the, it is comparison with ordinary fibre with the ordinary fibre is a normal fibre cotton and this is the speciality fibre which uses the endothermic heat ok. And here with the in absorption of moisture it temperature reduces. So, we can use to keep our body cool we can use this fibre.

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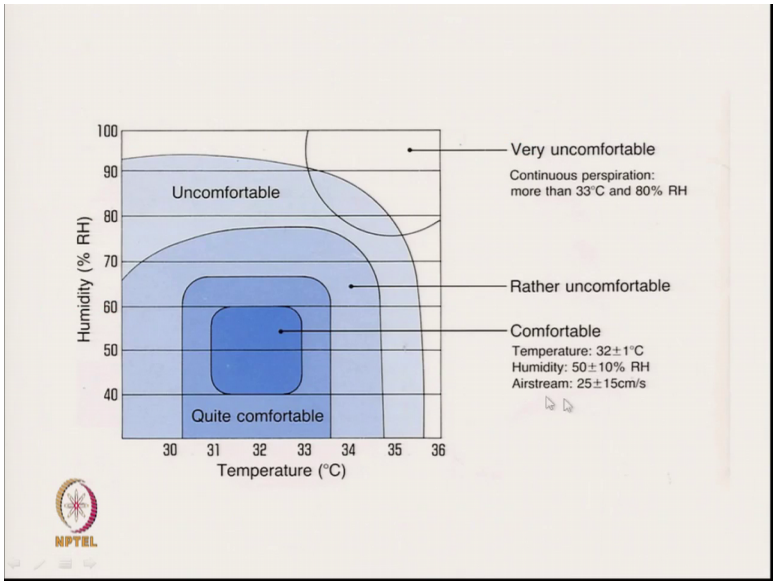

And to maintain the microclimate as we have seen, this microclimate we can maintain by proper release of humidity. And reduction of sweaty stickiness for that low friction fibre has been developed.

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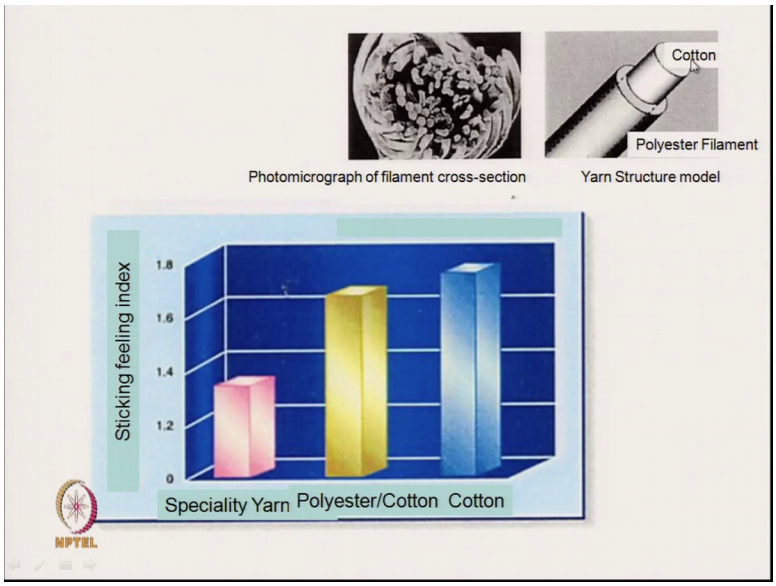

That is the this is the yarn structure normal polyester cotton this is the frictional stickiness index it is high. Normal cotton the stickiness index is higher than that, but the developed speciality yarn, the stickiness index is least. Here it that this core cotton fibre is used and at the sheath polyester filament are used. So, if we develop yarn from that this combination we can develop yarn with lower stickiness.

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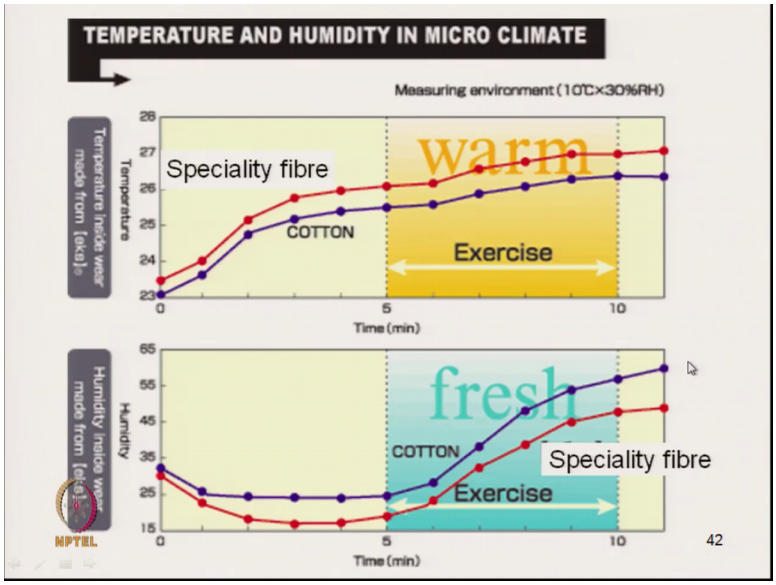

So, these are the some commercial products and if you see the first one with the temperature; here with the cotton and speciality fibre, cotton the temperature is lower

than the speciality fibre. So, it is keeping the warmth, but at the same time the humidity of the micro climate is lower. So, this particular fibre will keep the micro climate warm and dry so we can achieve this characteristics. And last segment is that we can use reversible dimension fibre change.

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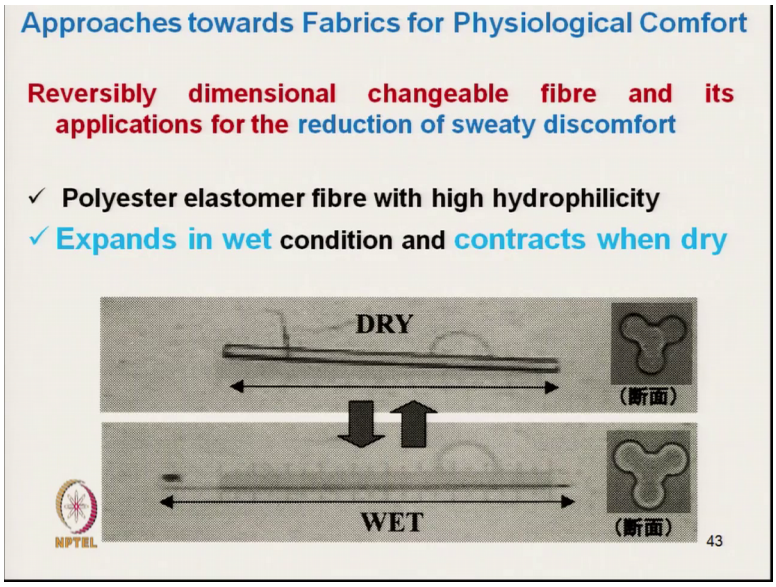

So, reversibility dimensional changeable fibre and it is application ok. What is the reversibility? The polyester elastomeric fibre have been developed with high hydrophilicity. This fibre has got unique characteristics it is a reversible characteristics, normally fibre after observing moisture get reduce the length get reduced.

But here in this fibre if it is wet in case of wet it gets expanded. So, expand in wet condition and contract in dry condition. So, this fibre if we use in the yarn manufacturing or in the directly this filament if you use to manufacture fabric we can achieve unique characteristics.

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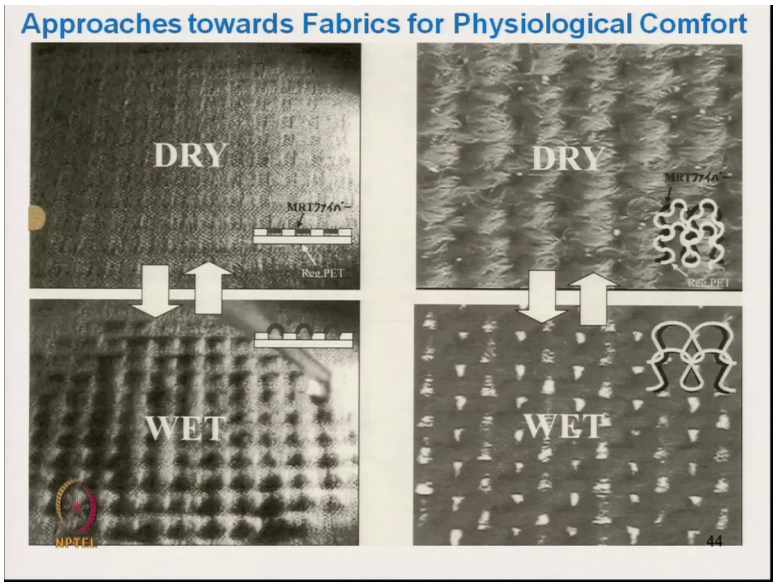

So, the unique characteristics we can see here this is the dry fabric ok. And this is woven fabric and this one wetted fabric; in case of dry fabric the dimensions are the contracted dimension. So, in the dry fabric these are in compact condition so, the pores are blocked so in case of dry when pores are blocked. So, we do not need to transfer any moisture, but when it is wet when we are wearing fabric or garment made of this fabric in case wet condition the fibre dimension changes, fibre get extended. So, at as this fibre it is get extended individual fibre that yarn dimension also get extended.

Whatever blocked pores are there the inter yarn space where there they will get opened up. And in the wet condition, in the high humidity condition there will be opening created which we required to release the moisture in the vapour from or in the liquid form. So, moisture gets transmitted through this opening. So, this is the characteristics which we can incorporate in the fabric to achieve the physiological comfort. So, this is all about the incorporation of thermo physiological comfort in functional clothing.

Thank you.