Textile Finishing
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Module - 7
Lecture - 16
Waterproof Breathable Textiles

Welcome back to this class on textile finishing. So, let us see what we have covered till now.

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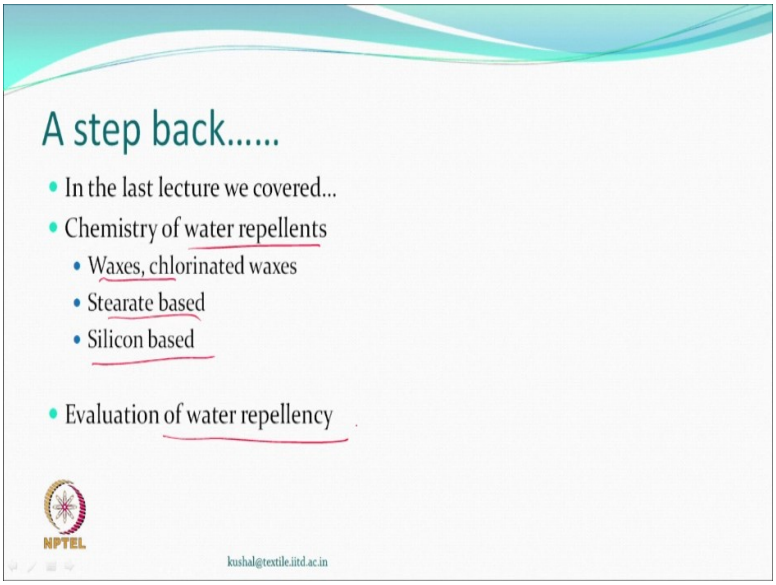

If you look at the past few weeks, we had done chemistry of water repellents, which meant waxes, stearate based compounds and silicon based compounds. Also, we tried to learn as to how water repellency can be evaluated. Okay. So, let us go further and see what we are going to do.

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We also learnt on the way that there is something common between water repellency and softening. And the common part was that both are spin finish, surface finishes; both are surface finishes. They reduce friction. And in other case we reduce surface energy, which is requirement. But hydrophobicity can be achieved by long chain fatty compounds. Also, it can be achieved by a silicon based compounds, in which polydimethylsiloxane is one of compounds. So, that is how we achieved water repellency.

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So, we are going to be talking today on another product which is called waterproof breathable textiles. Now, these are high performance textiles and would combine the characteristics of the 2 products, just before we learnt about. So, let us just recall again. How did we, let us say, produce a waterproof textile?

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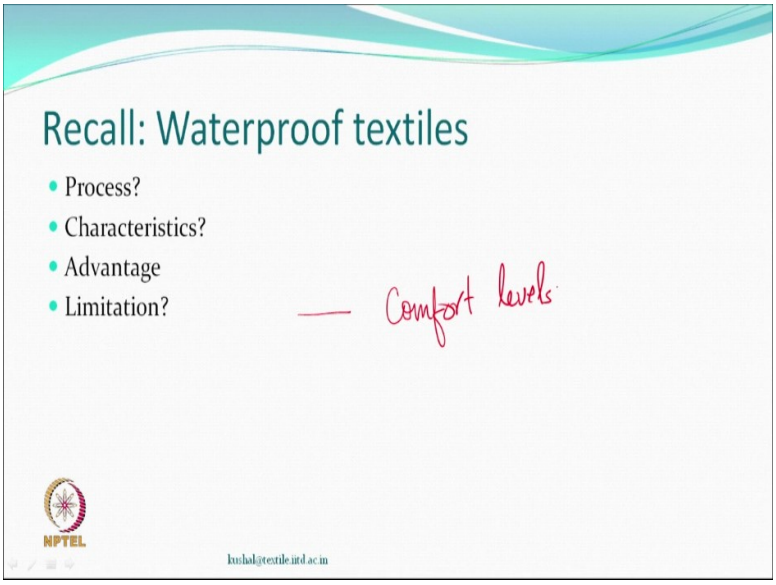

The procedure mainly was that you wanted to close the interstices of a fabric. And this was done, normally is done by coating a polymer layer or you can laminate also. So, that is the process. You close everything, so that nothing can penetrate. And so, resistance to penetration of water is increased. So, characterization, as far as the characteristics are concerned, the resistance to penetration of water is increased many folds.

And that is what was expected in a waterproof textile. The advantage obviously, you are safe. Water cannot penetrate. Examples like raincoats and other sort of materials could be used, produced to save you from getting wet. The limitation was that these materials, not only did increase the resistance to penetration of water, but also they became impermeable to air. What also meant was, that there were no pores left.

And so, what we had a situation or what we have a situation is that the comfort levels are low. Why? Because, we are producing continuously by way of perspiration, moisture vapor. And if it condenses and cannot pass through, comfort level goes down. Normally, when we say we are comfortable, what it means is, whatever heat we produce because of active routine or even passive routine, the heat generated as well as the moisture generated gets out of the textiles very easily.

And therefore, we say we are comfortable. So, what it actually means is that we should not feel that you are wearing something. But if you wear a waterproof textile, it will be pretty difficult for you to remain very comfortable, let us say after 15-20 minutes of continuous use. Of course, the external temperatures will also play some role.

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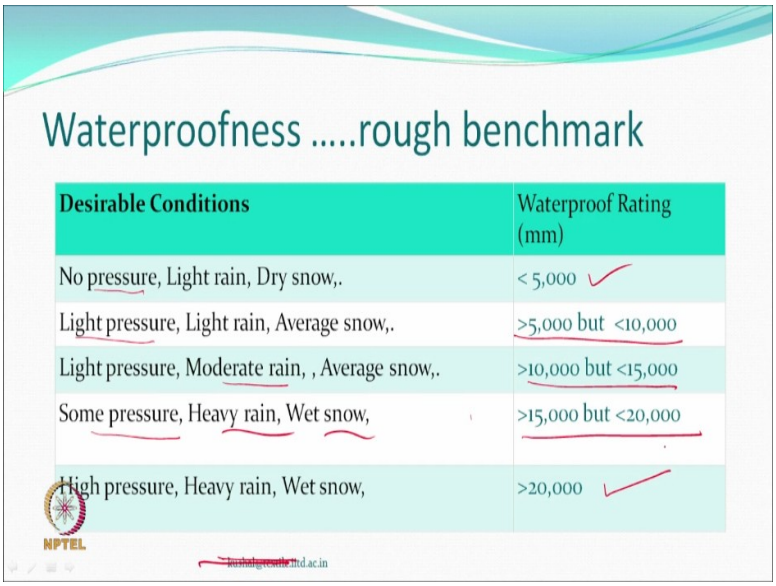

So, some of the benchmarks, roughly a benchmark could be that you may require, you know, as we remember that the water head in millimeters that a fabric can support before it leaks. Right. So, one expects a waterproof material where there is hardly any pressure expected. A light rain, very dry snow or something like that. So, you may have less than 5,000 mm of water head.

And, but if you have some pressure because more rain is there or the water gets collected in some trough, which is a fabric trough. Then, you may require in the range which is 5,000 to 10,000 range. If you have light pressure but moderate rain instead of a light rain, then you may require little more. If some pressure is expected which is heavy enough, heavy rain or wet snow, then you will be in the range of 15,000 to 20,000. Okay.

And very high pressure situation, very heavy rain, very wet snow. For a waterproof fabric to be successful, you expect even this much rating. So, you can appreciate. This is highly closed. It resists so much. So, obviously, in some sense we can say, it does not breathe, because air cannot pass through; water vapor also cannot pass through. On the other hand, if we recall what did we do.

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When we produced water repellent fabrics, what did we do? We made the surfaces, the surface of the fabric, a low energy surface. That became a water repellent. So, main characteristics are: That if you put a water drop, it will roll off. That is repellency. But it does not offer you any significant resistance to penetration of water. So, if it is a light rain, very, very light drizzle, it is fine.

But if you actually expect heavy rain, then the water will go through. But on the other hand, if you keep wearing them, the moisture, because it is permeable to air, therefore it is permeable to moisture vapor, therefore the comfort levels are going to be high. So, that is the advantage that you will get. The comfort levels in water repellent fabrics are going to be high. Okay. That is an advantage.

And of course, limitation is that the water can pass through whenever there is heavy downpour. And in any of situations it cannot obviously resist. The purpose is very different. And of course, we do not do any coating here. It is only surface treatment, changing the surface energy. And what are we doing? Reducing the surface energy. Now, let us say, we want something different. And what is the difference?

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So, we say, we want to combine obviously comfort. We want everything that we wear should be comfortable but mean it should be able to transport any moisture that we generate. So, these are the physiological phenomena which will obviously happen anytime that you wear and work. We would want waterproofness. We want water repellency and comfort. Now, comfort becomes important.

Which means that something must happen that the water vapor must pass through. Contradictory. Waterproofness is penetration or resistance to water has increased tremendously. Here you want the vapor to pass through. And there was no air permeability. So, these are contradictory requirements. Repellency obviously is something which you would want. Anything which falls on, rolls off the surface will be very nice.

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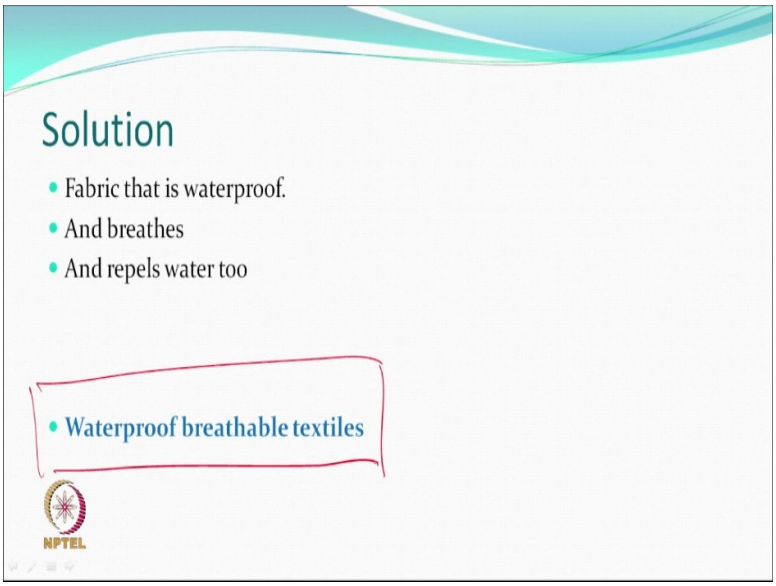

That brings us to the topic that we will spend some time today, called the waterproof breathable textiles.

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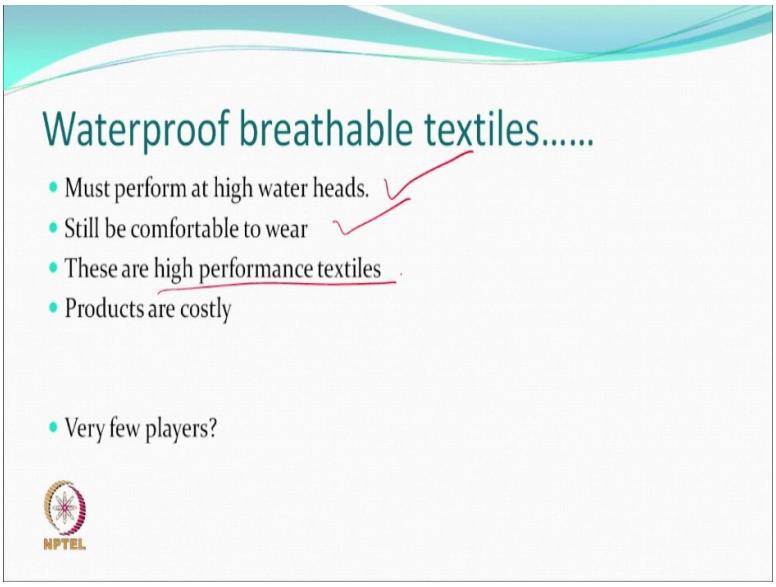

So, waterproof breathable textile, what do we expect? Must perform at high water heads. That is the pressure, at high pressures. And still, it should be comfortable to wear. And if you can do this; and which we will see how it can be done. Then they will be in the category of high performance textiles. So, they are special fabrics which will be used by at special conditions.

And it is understood that these products are going to be costly, because the process is going to be slightly more complex. And that is the reason why there are very few players who make these fabrics; and then the products thereof. And the need is quite a lot. Who needs?

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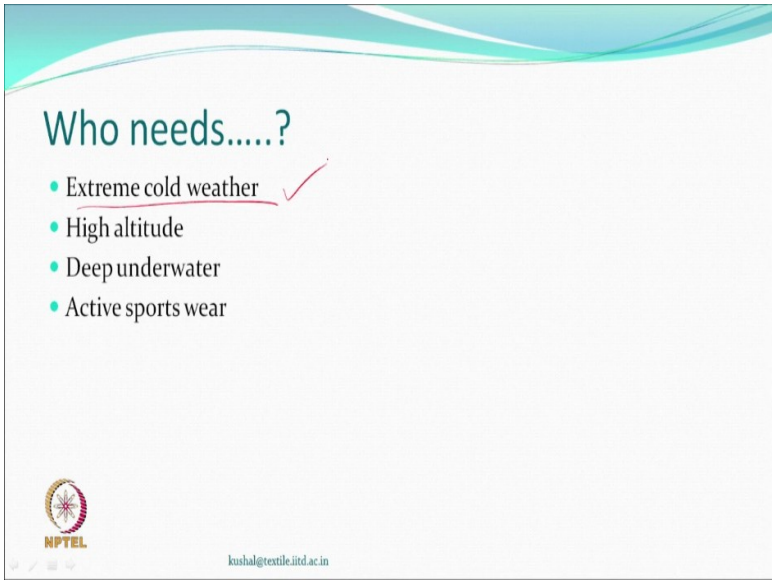

Anyone who is there in extreme cold weather, where you have to keep wearing the garments. Extreme cold, we would looking at, let us say – 20 degree centigrade, – 40 degree centigrade. So, that is an extreme cold. So, normal clothing may not work for you. High altitude, that also becomes very cold. Deep under water, if you want to work; or very active sports wear; and conditions which are, external conditions may be cold.

Or otherwise, these are interesting and important type of garments which will be required. For example, in Siachen, what people, they have to stay, the soldiers have to stay for a long, long period in the same place. You require extreme cold, you know, weather clothing. And that is high altitude as well. So, special requirements for either sports people, those who ski on the mountain ranges; and any other sport which requires active work, physical exercises. And therefore, lot of moisture is going to be produced; and you still want to be safe. There, we require what we now know is waterproof breathable textiles.

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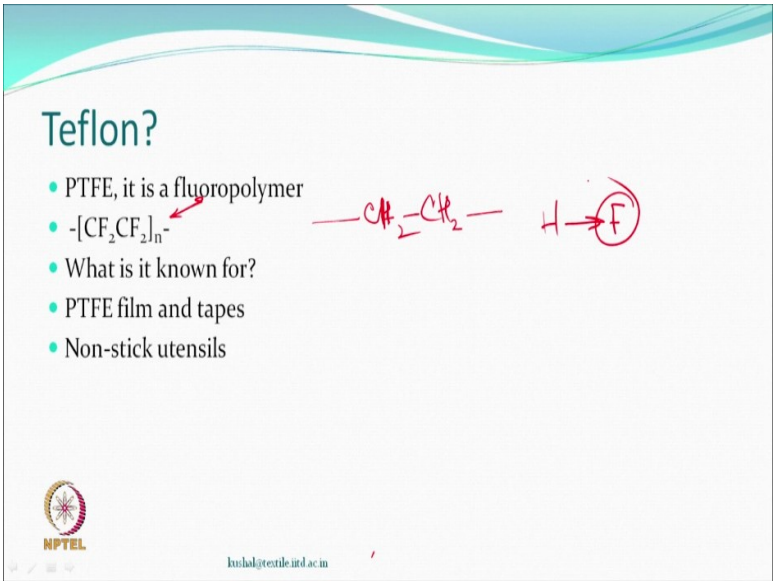

We digress a bit from this, just to understand a very important polymer, which is called Teflon. Have you heard of this name, Teflon? Of course, you must have. This is polytetrafluoroethylene polymer. Okay. So, it is a fluoropolymer. So, fluorine is there. So, otherwise, normally we had our compound which is polyethylene. For example, we are there. There were hydrocarbons. And then, this is a fluorocarbon, in some sense. Okay.

So, it is an very interesting product. You may be, you may have used also, at some stage or the other. A representation where it can be less. So, you can see, it is a fluoropolymer. Instead of hydrogen, you all the time have, which was, let us say in the case of polyethylene you had this type of a structure. Which now is, all hydrogens are replaced by fluorine. So, it is a very interesting polymer and very useful in many industrial applications.

What it is known for? So, one of the thing which you may have sense, that these are the Teflon coated utensils for example. They are used everywhere. That is one important thing where, say nonstick type of appliances where this compound could be used or is being used. It is available in the films form or in tape form. Sometimes, electrical insulation that you do. It can be done by this.

Many a times, when the plumbing is done, you fix one pipe over another socket. So, you wrap it around a polythene, polytetrafluoroethylene tape and then tighten it. So, it becomes, so it is very useful compound from that point of view. So, you have some interesting applications. As we said, nonstick utensils are something which people are quite well aware of.

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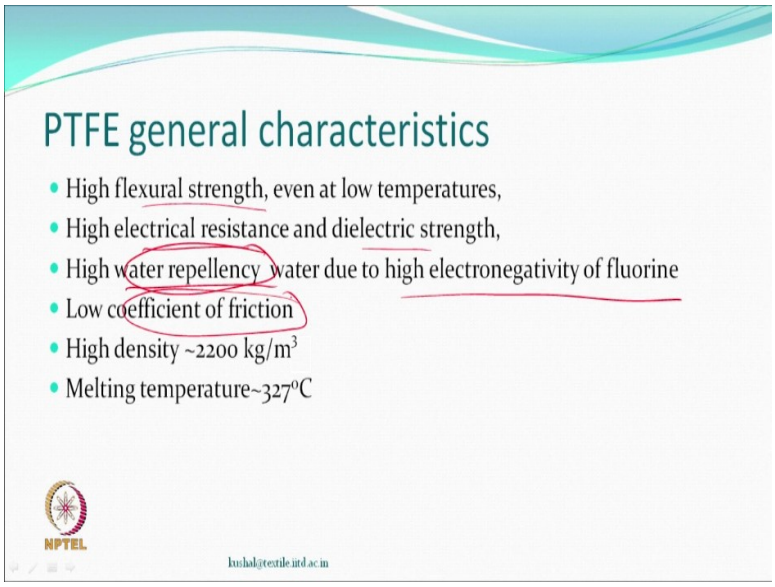

What are the general characteristics? Very high flexural strength, even at low temperatures. And now, this is important. You know, we are not talking about room temperature. It is very flexible. But at – 30, – 40 also, it could be very flexible. It has got high electrical resistance and dielectric constant. So, from electrical properties, it can be very interesting; from as a insulation material.

It has got high water repellency. That is why you had this Teflon coated utensils. And it is because of the high electro negativity of the fluorine. So, compared to, let us say the hydrogen, which was in hydrocarbons. So, that is an important part. Very low coefficient of friction. And therefore, things can slip over it very easily. So, some of the things which you could do, with wherever you require less friction, they will be very interesting.

Density is high, quite high, compared to let us say polyethylene, a very high density. Melting temperature also is high. Therefore, thermal stability is also much, much better, compared to let us say polyethylene. So, if you compare, polyethylene which is similar looking polymer, but because of the fluorine here, lot of things change. Some of the things which will interest us are these. Some of the things which in will interest us are this, as a textile person or even as a, let us say any engineering application that you are thinking about.

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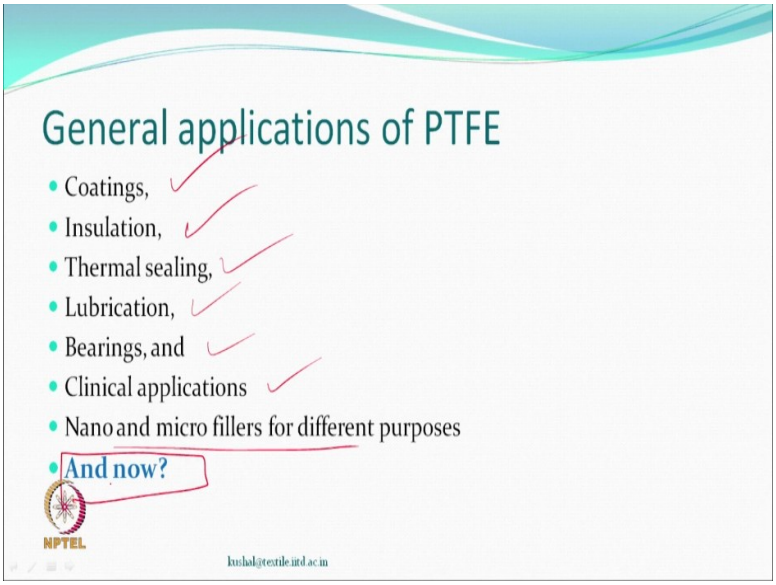

So, generally, it will be used for various application. One can do coatings that we have talked about. You can do insulation, electrical, thermal sealing, lubrication, bearings, clinical applications, fillers. And so, various things happen. So, where do we come into picture? We come into picture now. We will use them to do what we just set out to do. Combine the properties of waterproofness as well as comfort. So, there is one another variant of this polymer, not, the chemistry is not, it is the micro structure which gets changed.

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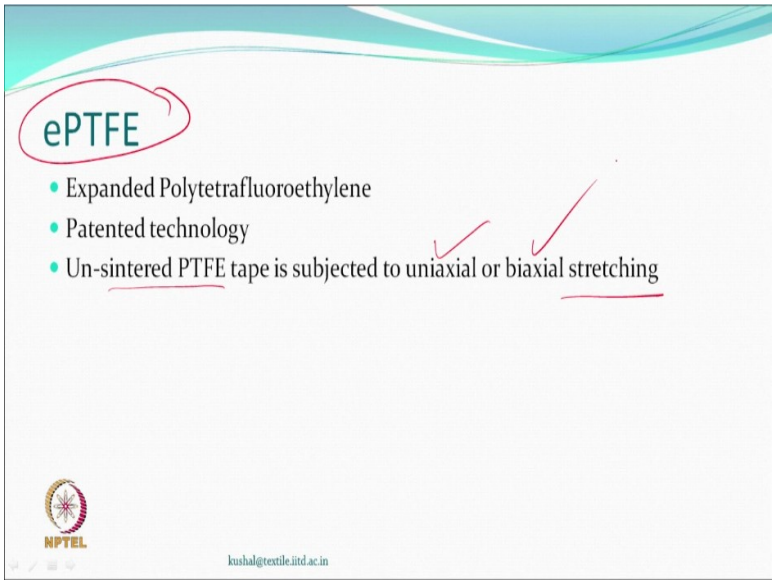

Is called ePTFE, which is called the, which is the expanded PTFE. It is a patented technology as far as the waterproof breathables are concerned. Interestingly, an un-sintered PTFE tape is taken and is subjected to stretching, either uniaxial or biaxial stretching.

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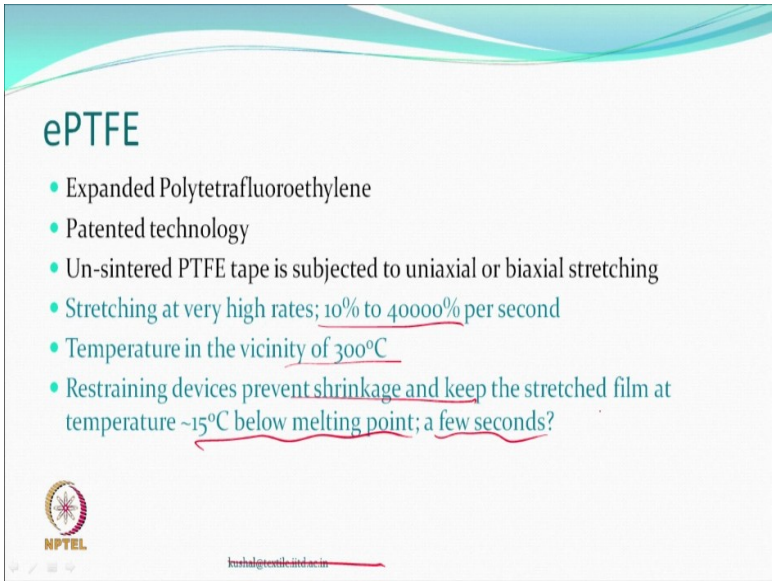

And the stretching also at a very high strain rate it could be. Very high, if you do, temperatures could be also high. You stretch this material. And if you have a restraining device which can keep it in the stretched film in a, for a little longer period, at temperature which may be slightly below the melting point. And you keep it for few seconds. You get a beautiful structure. That is fibrillation. And interesting properties that you get;

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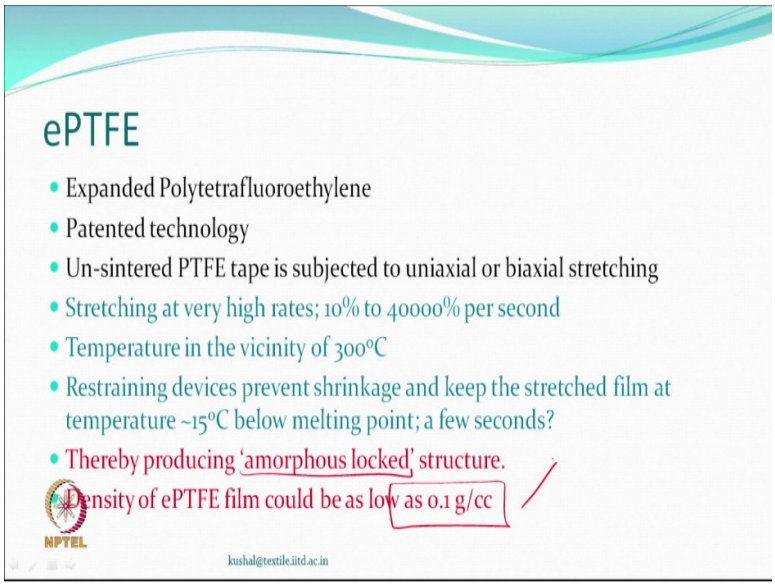

It gets amorphous locked and becomes very open structure. If you stretch pretty nicely and allow fibrillation to occur. And its density can be as low as this. From high density, it has become a low density. So, what is happening? Obviously, overheads are being created by doing this. It is a very, very interesting way a material which is a polymer can be changed, just by a process called uniaxial, biaxial stretching at a little high temperature and a very fast

rate. That is something which is interesting. So, there is a very interesting commercial product which is in, sold as the Gore-Tex.

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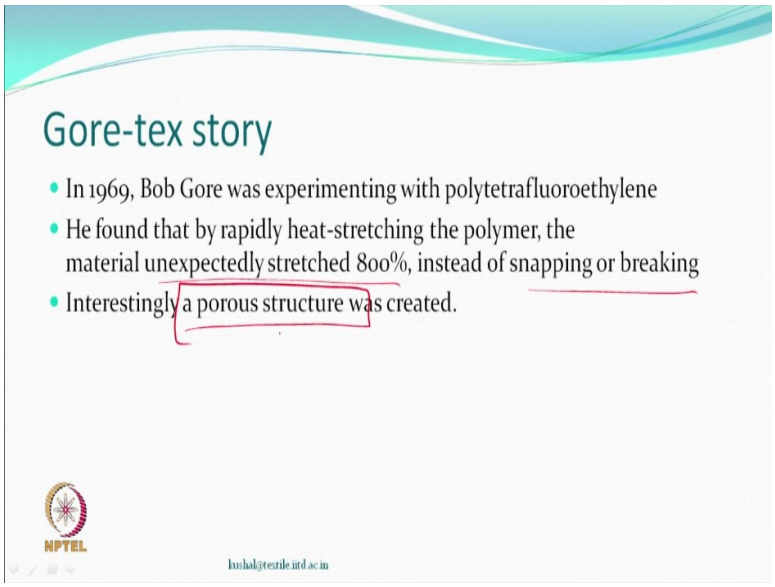

So, the, what is the Gore-Tex story? It has something to do with the ePTFE. That is, expanded polyethylene or polytetrafluoroethylene, okay, tetrafluoroethylene. So, sometimes in 1969, Gore was experimenting with PTFE. So, this is some of the phenomena which he noticed, which became such an interesting part. And what was doing was, he found that, by rapidly stretching or heat stretching, this polymer material stretched and kept on stretching for a large percentage, instead of breaking or snapping.

It did not break, but kept on stretching. Because you were getting at a little higher temperature, how heat stretching. And also he noticed, finally, it created a porous structure. A porous structure was created. That was very interesting. So, you see, some of the things do happen almost accidentally. And there are very few products which will carry the name of inventor with it.

Like Gore-Tex is the name which is carried of the scientist into, to the product itself. In the other part of textiles, you had the Mercerization where John Mercer had found something accidentally. So, you had Mercerization. So now, you have a story which is the Gore-Tex story, which has started with this kind of a experiment where it was almost like an accident, shall we say. But an interesting observation, which obviously led to a very new product.

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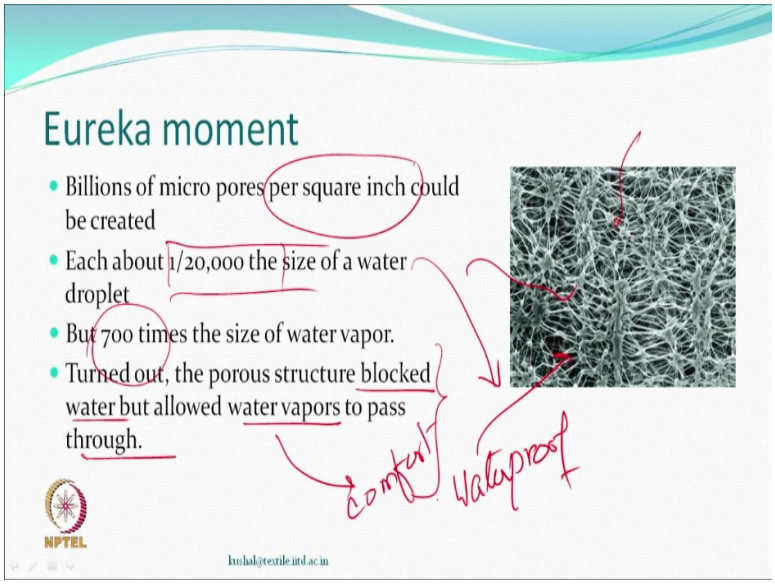

It was almost like a eureka moment. You get structure like this. See, highly, highly porous structure. Or we were, you see, fibrils are there. So, some fibrillation takes place. And so, you have more air, more pores than the material itself. Therefore, the density would go down, because it is mostly air now. But what is important? He could create billions of micropores per square inch.

Very interesting. So, so many pores were created. And it became a very porous structure, but micropores. Each of a size of almost 1 over 20,000 of a size of a smallest droplet that you can think of, water droplet. And therefore, the droplet, water droplet is of a heavy size, larger size. So, it cannot penetrate. But, this pore was still 700 times the size of water vapor; it is just a molecule, water vapor.

So, now you have a beautiful situation, where the liquid drop cannot pass through, but vapor can pass through. So, this was something which became such an interesting material that it not only carried the name of the inventor, but it created a product of a kind which was never seen before. So, porous structure blocked the water, but allowed water vapor to pass through. So, waterproof. Yep, because of this. And comfort because of this. So, in some sense, you had the start of what is called waterproof breathables.

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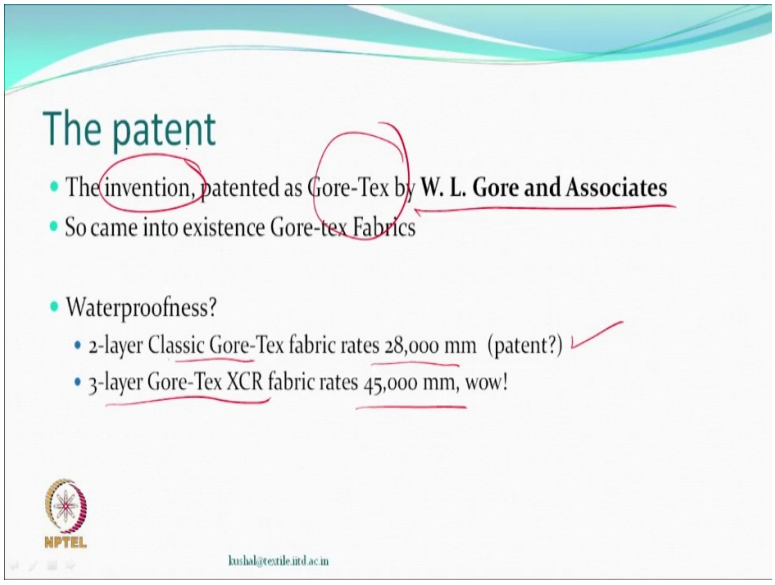

So obviously, a patent was there. The patent was by a company. The product was Gore-Tex cater the name. And for a long time, they could keep on making the product and never sold the patent, because that was so good. And they could, kept on making money out of this. One of the most important product. So now, we have what we sometimes call them a Gore-Tex, but this is a commercial product.

Later on, other things have also come up. But the concept that PTFE actually could be converted to or fibrillated into so many fibrils with so much of micropores, so many. That was one of the important outcomes of this whole thing. And therefore, this became very commercially successful process. This type of a normal classic Gore-Tex fabrics could withstand 28,000 millimeter of water head; highly waterproof.

But still allowed vapors to go through, comfort. Now, the patent, now after 20 years obviously, the time has passed. So, other people have started making this. Before that, before that time, nobody else could make this product using thing. Now, there are lot of people are making, ideas are also different. But in addition to, they have made a new product, which is the XCR. So, this extreme comfort rating, which can also withstand very high rate and is very, very comfortable.

So, you are getting new and newer products. But that is the, what we call as a innovation and product and process development. But the first thing was invention. This actually in the category of invention.

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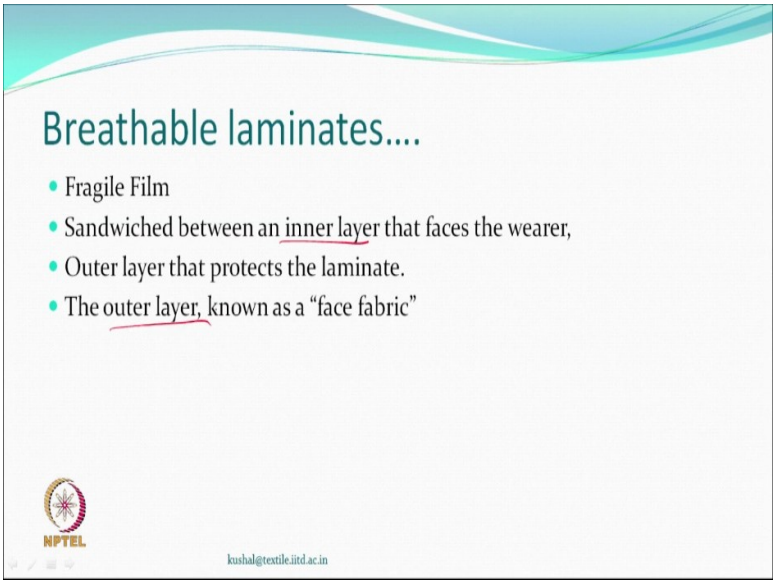

So, one important thing which you will see that, once you have stretched the film which was otherwise very flexible film. And now, it is very light. It is doing the purpose. By itself, if you keep the film, then there can be problems that it can get torn. You cannot afford that. So, you need to support this film. And how do we support? You can have an inner layer or an outer layer.

In between, you have a film which can be laminated. And this itself is called the, let us say the product; final product which can be sold. And what it happens is, the outer layer is going to protect from the thing. And it will be exposed, the face of the fabric. It may be printed; it may be water repellent; it may be any type of design that you may look; a plain woven or a twill; or whatever type of thing.

Any fiber you may like to use; polyester, nylon and so on so forth. That you can do. In between, you have the laminate which is going to do the function. Alright. So, that is going to do the function. And the inner layer could be very flexible thing, which is, may be nearer to the wearer, of the skin for example. It could be a knitted structure or a woven structure. So, these are important thing, what one could see, that a beautiful product has come out.

So, other part of the textile obviously is supporting this film which is very flexible and very performance oriented film. And what is it? Expanded PTFE film in a laminated conditions being used. So, you have a film which is to be laminated. It is not a solution which has to be coated, in this case. Alright. So, many things can happen. It does not have to be only, let us

say the film which is water repellent or waterproof or vapor penetration is easy or comfort is more. But you can also have other things.

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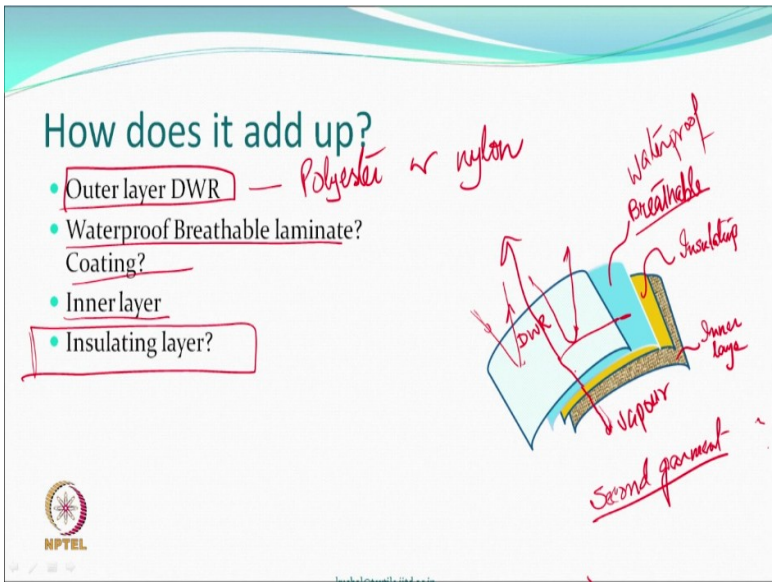

For example, the outer layer could be, let us say a fabric that we talk about. Outer layer, which can be a DWR, mean durable water repellent. So, you can have, as we said, polyester or nylon type of material. And obviously, at one stage, immediately after that, it could be a waterproof breathable laminate which could be sandwiched. Then you have an inner layer which can be next to the skin.

But if, let us say extreme cold conditions are there, where a person has to be for a long, long period, hours together; maybe they are staying there itself. Then you may have an insulating layer, which would obviously keep the person warm as well. This is not just the moisture.. So, what do we have? We can have situation, that you have a outermost layer which is in some sense water repellent.

Then, you have the breathable layer. You can have an insulating layer. And you can have the inner layer. Or you can have the insulating layer as another garment, worn separately. And the waterproof breathable laminated material comes as a separate, let us say shell garment. So, costly; high performance; better to be used; very, very comfortably. But it is costly. Therefore, as we said, not many people are manufacturing the basic fabric. The garments, there may be many more companies who are making the garments. But the basic fabrics, not many people would be making.

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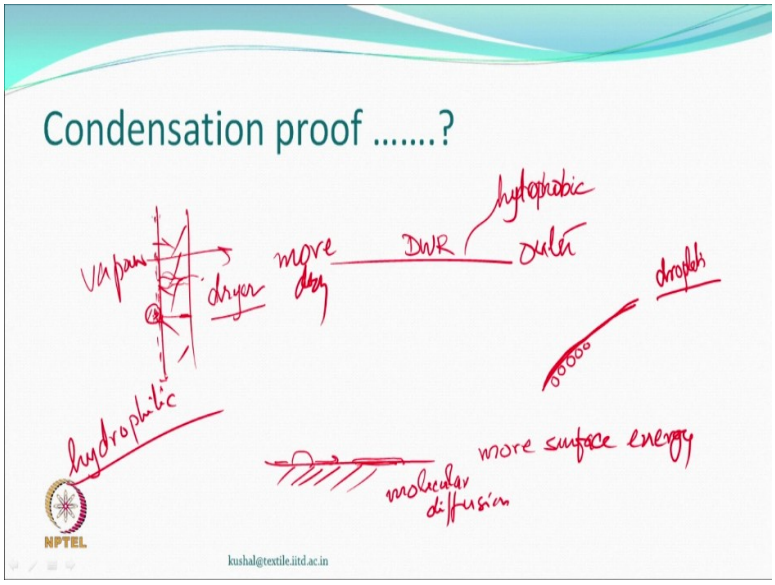

Now, let us just go back and see what was there. So, if let us say, the water droplet comes or water comes, so we are hoping that this will be rolled back from the outer surface. But we know, if the pressures are more, this water can penetrate, because the water penetration resistance of a outer layer may not be much. But we would like as much repellency as possible.

Something which will pass through to the second layer, which is the second layer here, which is the breathable layer. Then this drop from here will be resisted. It cannot go inside this. The heat and the moisture that has been created from inside can pass through. It can pass through and go out. So, vapors can go out, which are generating next to skin. The, generally, the water droplets will be repelled.

But if the water droplets passes through the top layer, the breathable waterproof layer would not allow it to go through. And so, it will be pushed out based on the concentration and so on so forth. So, it cannot go. However, the vapor which are being generated can go out. Okay. This is how things work. Now, if suppose, for some reason the innermost layer, because of either conditions which are cold, generates water droplets.

So, there is a inner layer. You have the waterproof. So, from outside, the water cannot go in. But if suppose the water gets generated inside, the liquid drop gets generated inside, because temperatures maybe very cold. And whatever, by the time the vapors go, they just condensed. And if they condense, then they will make liquid droplets. If the liquid droplets cannot come

from outside to inside; so obviously, you can understand, the liquid droplet cannot go from inside to outside also.

It could become very, very bad. So, as long as it is not condensed, the vapor will keep on moving out. But if gets condensed because temperature is so low, that is a bad thing now. Because, now this liquid droplet cannot go out, unless it again gets evaporated because of the body heat, which we hope will help to again vaporize this. But one thing you must remember. The body structure and the skin structure and the sensitivities are such governed; governed in such a manner, that if this, it is sensed that the skin is wet, it means, it, the water has not been evaporated.

And therefore, the temperature of the skin may not get cooled. And if it does not get cooled, then the body reacts and produces more, let us say perspiration. For example, in the rainy season, when evaporation rates are low, you start perspiring more, even if the temperatures are good enough. And so, if condensation takes place, that means, body is not really been cooled by that way, in a sense.

So, it will produce more. So, what is the best way? How do you defuse? How do you take the moisture out. One was the vapor form. So, if there is a vapor here, it can go out, because there are micropores in the structure. Other way of diffusion is, liquid which cannot happen from here. But if it becomes a drop, then we know, it will never be able to go. However, if suppose the surface is slightly hydrophilic on inside.

So remember, we have one structure which is outer, which is finished by water repellent. So, this obviously must be hydrophobic. Okay. As such, everything was repelling water in some sense. Now, if vapor becomes a droplet, it is a bad idea. If suppose, this is a hydrophilic surface. So, what do we remember from the earlier discussion that we have had? If the surface is hydrophilic, it has got more surface energy.

And so, a droplet would start spreading and may become like this. And after that, this moisture which is absorbed, can be transmitted through a molecular diffusions, you can say. Slow rate, hoping that the outside is dry or dryer, more dry. So, the, this moisture can diffuse slowly and go out. And the condensation will not be allowed. So, some of the newer products from all companies maybe having a little hydrophilic surface, so that the drop is not formed.

Then the diffusion can take place. If the drop is formed, then it cannot pass through. So, some new terms were coined like condensation proof products. Condensation proof, waterproof breathables. So, although Gore-Tex, but the leaders are still probably the leaders in this. There other companies and other materials have also been used.

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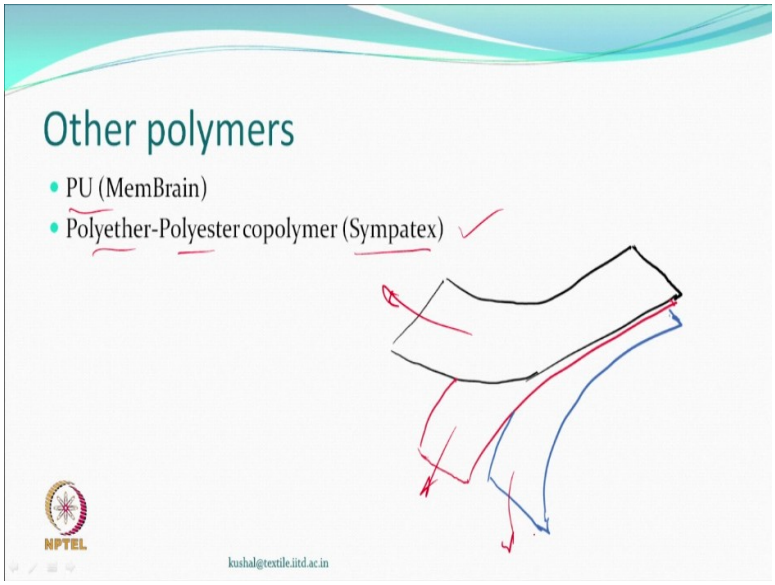

One of the very important product is Sympatex, which also had understood the importance of the hydrophilic inner surface for condensation proof. I had polyether, polyester type of things. All these things are polyurethane based products. One of them is called the membrane. Now, they are not produced necessarily by the same method of fibrillation. They could be coated, you can create microporous structure, by having differentially evaporating solvent; using solvent which have different boiling points.

And as they dry up, micropores can be created based on the molecular weight of the evaporating solvents. So, 2 types of solvents; one has a slightly higher boiling point and the other has slightly lower boiling point. And together, as they keep on moving, more solidification keeps taking place. As solidification keeps taking place, one can see the other evaporating.

Or wet coagulation is one, that one of this solvent, you know comes out fast in a wet coagulation system. And you can still create beautiful coatings, microporous coatings and things can. Therefore, you can produce today waterproof breathable structures by creating micropores. Either the fibrillation as a technology or a differential boiling point solvent

mixtures or by wet coagulation, where some of the solvents, it will come out first; and then the later, the other ones.

So, coagulation rate is controlled. And micropores can be created. And that is how, you may get structures, the outer one, the main waterproof laminate film or coating; and the inner one which could be next to the skin. So, very important products, high performance products.

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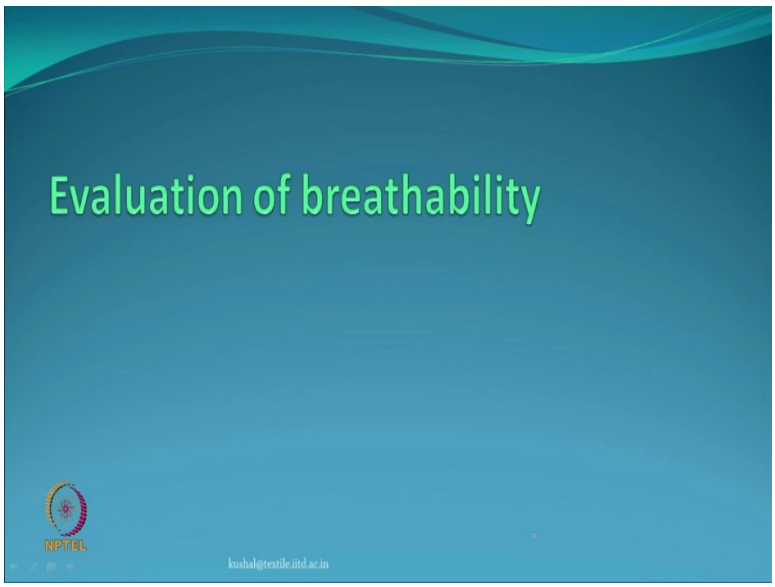

So, finally we say a few things about the measurement and evaluation of breathability. You remember how we evaluated the waterproofness, right; and water repellency, both. Okay. Now, we are looking at the breathability. So, breathability obviously means that you must somehow simulate conditions where the water vapors have to pass through. If and then measure, whatever is happening.

Or create a condition where sweating, the way the sweating takes place. Those type of things can be created, simulated; and then you can see what is the effect of your treatment or your product on this breathability bonnet.

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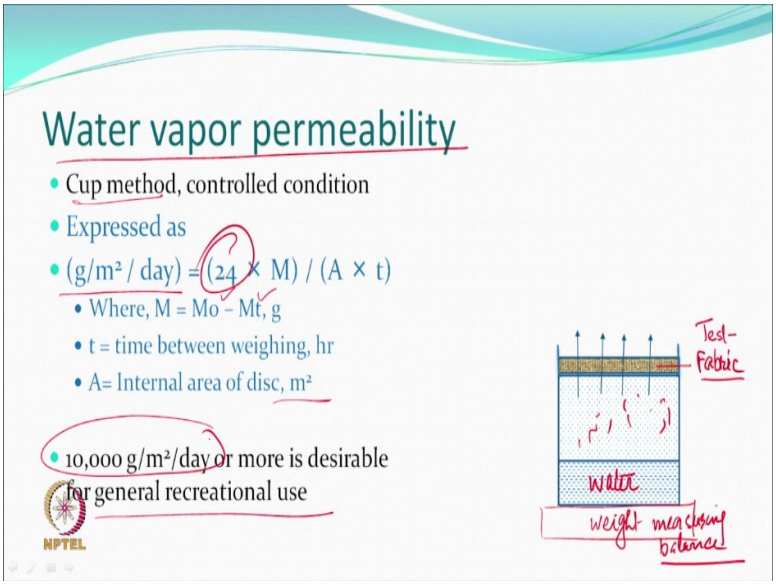

So, one is water vapor permeability. A simple test, a cup method which is called. So, what you have is, there is water here. And you have in locked up a fabric sample, let us say this is the fabric. So, at all temperatures including room temperatures, whatever conditions that we fix up as the standard, the water will get into the vapor form. And the vapor will pass through. So, here we have the fabric, which is the fabric which is being tested.

So, test fabric; you put it there. So, vapor cannot go from anywhere else, but they can have to pass through the fabric, okay, the vapors. And then, obviously you can probably have a weighing system. So, weight measuring balances. And what do you do, to say how much weight of or the water has evaporated? So, simple. Expressed as how many grams per meter square per day, water has gone out.

Obviously, you create a condition which is a test conditions, standard test conditions under which you check out how much water actually is evaporating. So, based on the water vapor permeability, the amount of water evaporated will be measured. So, in general, so, what we have? Initial mass; mass after the transfer of moisture has taken place; and simply the area in a meter square and 24 hours is the day.

And so, one can calculate this simple test. Anybody can do anywhere. And so, one of the benchmarks is for general recreational use. If the permeation is of this level is very, very comfortable, very desirable; and things like that. So, different type of activity will define as to what, whatever you want.

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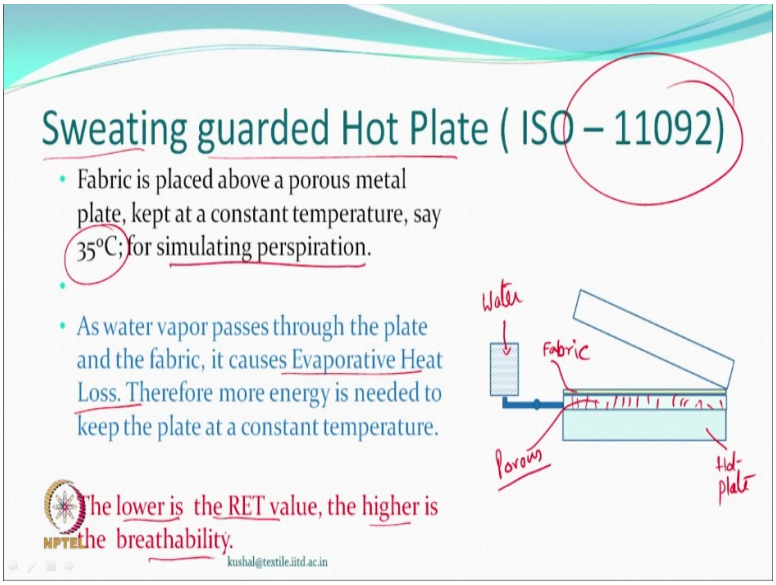

The other standard test for seeing the how much moisture can go through a textile is called the guarded hot plate method, which is simulating a perspiration. It is simulating perspiration. So, many equipment, many different types of equipment may be available, which will be doing in principle, something similar. So, you have a hot plate which is being controlled. Then, there is a reservoir of water.

So, this is water. It goes through another structure, which is the guarded porous structure. So, water penetrates and goes through. Then, here is the fabric which you want to test. And of course, it may be covered, so that the environment is controlled. So, it is not that the air is flowing all through. Because the rate of evaporation; if the air flows through will be different than a standard condition environment.

So, you create those environment. So, what it does is that you maintain the temperature of this plate, let us say at some temperature like this one. And if evaporation keeps on taking place; evaporation means, there is going to be cooling. And the equipment is going to keep supplying the energy, so that the temperature of the plate remains constant. So, as evaporation takes place, cooling will take place.

But you keep heating it, so that the temperature is remain constant. And so, this becomes an interesting experiment which is simulating as if you are sweating. Right. The temperatures are near the skin temperatures, are not high temperatures. So, that is what is there. So, some standards have been set up already of measuring this performance. It is called the RET value

which is measured. Higher, lower is the RET value; higher will be the breathability. Let us see some benchmarks.

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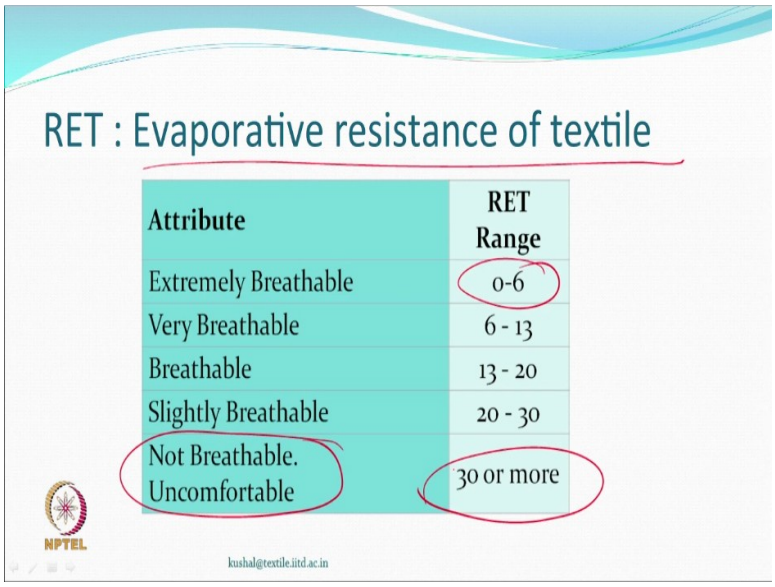

So, resistance to evaporation of the textile. A textile material which is resisting the evaporation; that is called the RET values. So, as we said, lower is this value; higher is the breathability. And so, extremely breathable fabrics may have ranges like this. Uncomfortable, non-breathable materials may have RET range 30 or more. Well, this is how you can evaluate. So, there may other methods also.

And various equipments may be available. But in general, these are the 2 principles which people will use to see whether the material is breathable or less breathable, more breathable and so on so forth.

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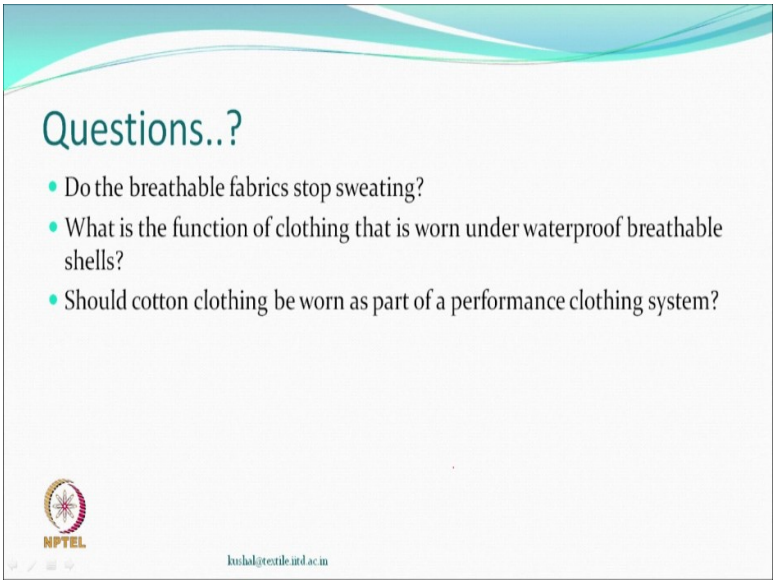

Before we end, let us say we have some questions which may like to answer. If somebody asks this question: Do the breathable fabrics stop the sweating? Do they stop sweating? No. What is sweating? Sweating is basically a way in which the body keeps itself cool, maintains its temperature. So, when you do an activity, the moisture is going to come out. So, it is not going to do that.

But it will allow permeation of water vapor, okay, so that moisture near the skin does not condense and is not felt around. And so, you do not feel wet. That is what will do. What would be the function of the clothing that you wear under this shell? The shell, which is the waterproof breathable shell. You may want insulation; you may want other kind of a soft comfort. So, that will be the function.

But this inner garment should obviously allow the vapors developed, moisture vapors developed, to just get transmitted through this garment. And so that it reaches our main garment, part made shell, which is the breathable, waterproof breathable shells. So, vapor should go out. It should not absorb; it should not stop. Otherwise, the whole function will say, if you wear something like a sheet or a coated material inside and then wear something on top of this, it is useless.

But you may have to wear, for the extreme cold climate, you may have another garment which is, let us say for insulation purpose, thermal insulation purpose. In that case, this garment should be open off obviously. Lot of air pockets. So, that the moisture goes out very

easily and then gets transmitted out. Should the cotton clothing be worn as a part of performance clothing? Should cotton clothing inside worn, should it be?

The answer is, should not be. Because it will absorb moisture and you will remain wet. And the transport, as I say as the molecular transport is very, very slow. It must remain in, generally in the vapor form. So, for performance clothing, this is not a good idea to wear the, next to skin. Some more points to remember in this context. The garments that you make. All the fabrics, somebody is making. The garments that you make cannot be stitched in the normal way. Because the stitch is too large, you are puncturing. Then the water will pass through. So, you cannot.

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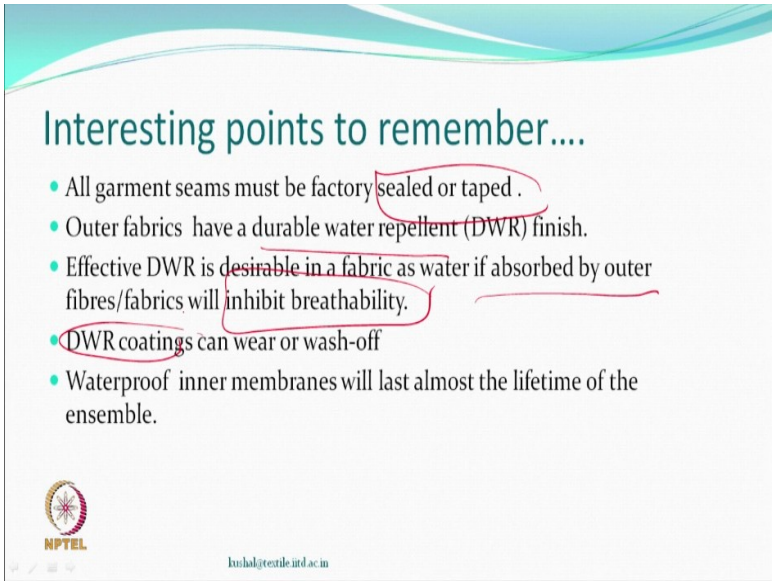

So, you do sealing with tapes which could be inside the thing. So, this is almost like factory finished garments. Somebody is making a garment. It is factory finished. Sealing has to be done in a manner, that like the garment itself is not, or the fabric does not allow water to go in. So, you should not be stitching in a normal way. Otherwise, there will punch holes which will obviously allow the water to go through.

Invariably, the outer fabrics must have a durable water repellent. Not just because we say, well it repels is good. But it is good even for maintaining the breathability. So, one, nothing will stick to it. The more repellent it is, the better for you. We at the moment talking about water repellency, durable water repellent finishes. Okay, that is okay. That will be there. So, it will improve performance.

How will it perform performance? Because, if the water gets absorbed and the outer fabrics are wet, then in some sense, the water vapor which wants to come out will also have difficulty. It may start getting condensed. And so, anywhere, somewhere, so it will inhibit the breathability. Therefore, the outer garments would have water repellent treatment. The outer surfaces, outer part of the laminate will be repellent.

Obviously, with time, the water repellency can decrease by rubbing or anything, because we said, mostly it is a surface phenomena, surface treatment, surface finish. But, the waterproof inner membranes will almost last the lifetime of the garment. So, because you are, you have protected it from all things, from the inclement weather and so on so forth. And, the one which is DWR, of course, you can give the treatment again, if you find that the repellency has reduced. That can be post-finished also, in different ways.

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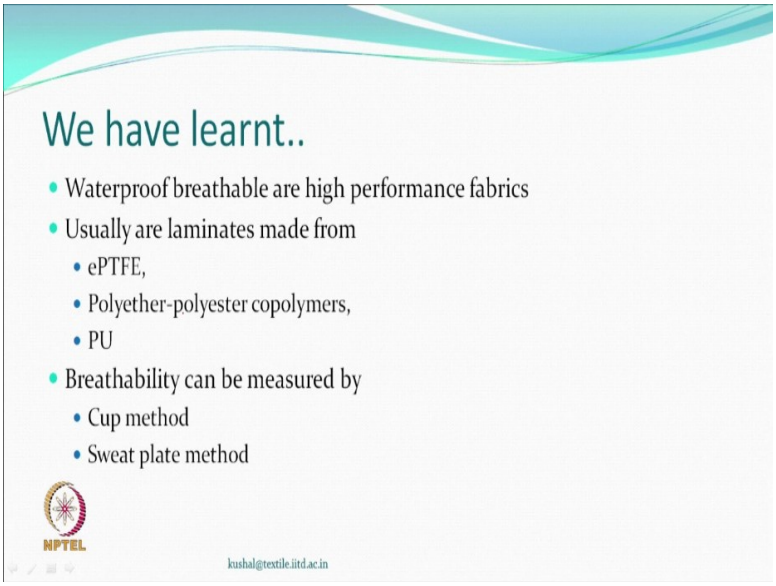

So, what have we learnt today? So, we have learnt that waterproof breathables are high performance fabrics. Okay. Usually, they are laminates made from either expanded PTFE or copolymers, films or coatings of the polyether, polyester based copolymers or polyurethane itself. Polyurethane, you know is also very soft polymer. You can make it a soft polymer. So, they are very soft. Breathability can be evaluated by cup method or sweat plate method.

So, that is what we have learnt today. Next time, we will talk about repellency. Not just water, but of the soil repellency, which could be oils and other solvents. And of course, if something gets soiled, how do we ensure that the soil is released from the textile surface? This is what we will do next time. Till then, have fun. Enjoy. See you. Thank you.