Textile Finishing
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Lecture - 29
Finishing of Synthetics: Antistatic Finish

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Welcome back to the class on textile finishing, what did we do till last time? We have learnt which fibers are called the synthetic fibers. The fibers were the polymer does not exist in nature, which of them are thermoplastic because thermoplasticity will help in dimensional, dimensional stability in achieving the dimensional stability of garments and fabrics, this thermomechanical setting is also called the heat setting aim is dimensional stability. We have seen some effect on the dying because polyester disperse combination is dependent on the morphological structure.

Which changes during heat setting and therefore, the dyeing characteristic also change in a very peculiar way and we also learned about the mechanical properties that they get affected by heat setting process, what we want to do today? Today we will talk about Antistatic finish, this also is in some sense little specific to the synthetic fibers that because general design although it could be for any fiber for that matter.

But the synthetic fibers do require antistatic finish we did talk about it so today we will spend some time on this topic. So, let us say particularly in winter season when you alight from a car, did you ever feel any shock any little spark,

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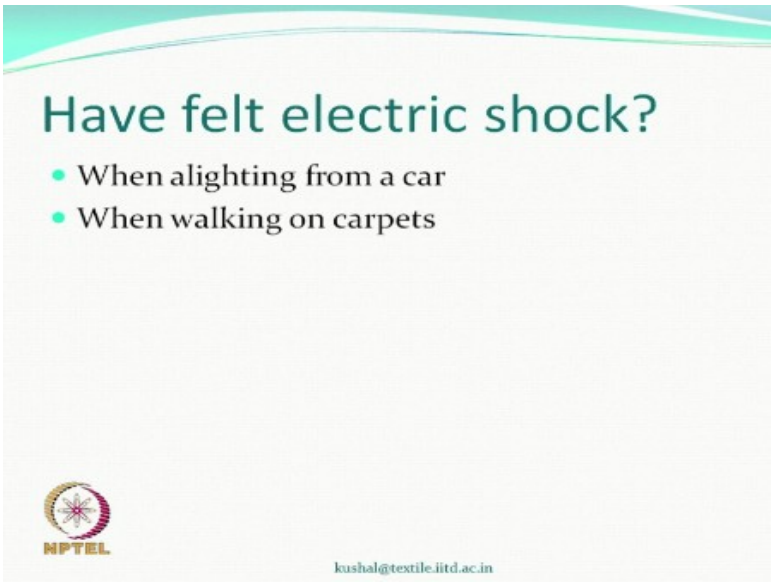

As you get down or sometimes walking on carpets, particularly carpets made from polypropylene, nylon, acrylic and so on so forth, have you ever felt that? I'm sure some of you must have felt the kind of a shock at least from when getting down from the car because when you are inside the car, you are rubbing against the upholstery of the car and when you get down whatever little charge that may have developed during this process.

Now gets dissipated through this little shock now, this may not be very harmful may not have been very harmful to you, but at least is there in some cases that could be very harmful also.

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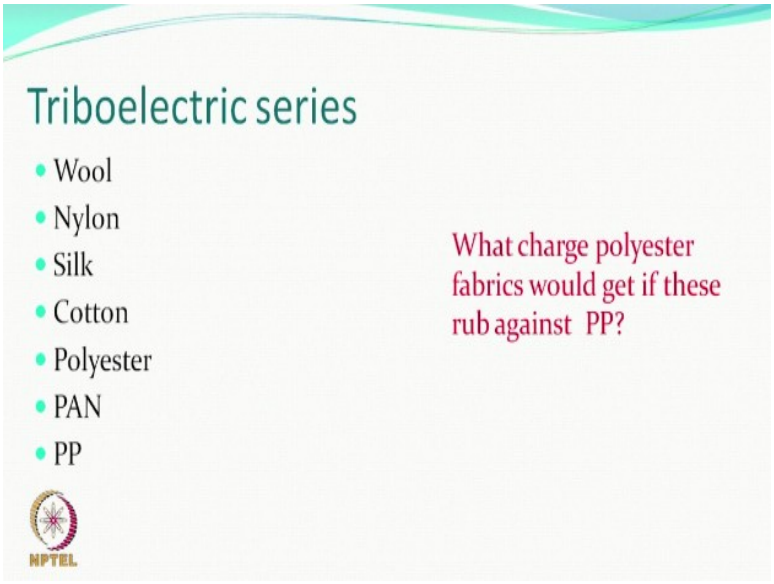

So, there is something called a triboelectric series, various types of generally non conducting electrically non conducting materials. They behave like dielectrics and they develop charge either positive or negative based on their surface, based on the ease with which the electron could be transferred, let us say when you rub 2 surfaces, one of the polymer fiber textiles may be able to you know give out more electrons.

So, when it gives up more electrons becomes positively charged it takes up the electron with a negative charge. So, if some kind of a transfer takes place, then they develop some charges you must have seen in your school days also when you take a fountain pen and rub it on your hair and try to take it near the pieces of let us say paper, they start getting attracted. So, this transfer of a bit of a charge from one surface to another it can happen just because the contact that they were in the contact for some time and then you remove them, or you rub them.

So, any of these processes would be able to transfer part of the charge carrier which is let us say electron in one case it could be anything else. So, some of them will have a tendency to develop a positive charge, others would have a tendency to develop negative charge. For example in this series the wool is at the top there are other which could be in between also, I have not taken all the material, so that all materials, different kind of material, the glass is also a material, ebonite is also a material, so if you keep taking various types of materials, you will find a long triboelectric series.

But I thought these are some of the textile materials so you may be interested in just looking at them. Cotton comes somewhere in between, so if you rub the fiber which is written on the top, , with the fiber which is below it the top fiber a likely to get the positive charged the other than obviously will get negative charge because finally it's sum is neutral, sum is 0, so let us say if he asked one question,

What charged let us say polyester fabric would developer if they rub against wool charge on the polyester fabric what would be the charge on the polyester fabric if you rub against wool? Charge on the polyester will be negative, is that right based on the series? If you do the same thing like the polyester fabric getting rubbed against polyprolyne fabrics, then what will be the charge on the polyester fabrics is likely to be positive, is it right?

So this is a little small information that you will like to carry with you gas, the air, the nitrogen and all kinds of things they are there, they are generally insulators like if you can understand you have a switch electrical switch, when you turn it off the current does not flow because you have created a gap, why the current is not flowing? Because air which is also a gas is an insulator so, the current does not flow.

When you switch on then you touch the electrodes and then the current start flowing so, this is a common phenomenon which we everyday experience, so gases are insulators.

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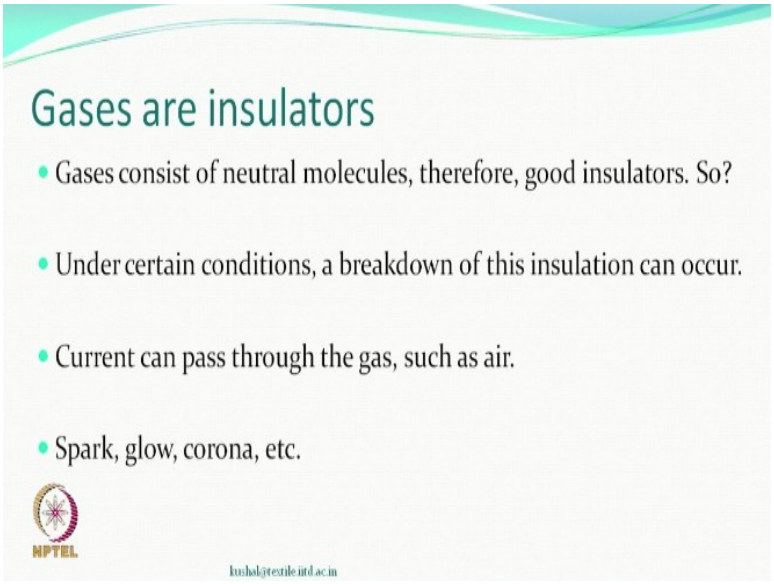

Because they will consider various kinds of molecules and which will be neutral in general sense and so they are insulator. So, it is helpful also right? You see the high-tension wires running across the skyline, they carry large amount of voltages, very large voltages. If air was not the insulator, then the current to start flowing through the air and then a lot of things would happen which you may not be happy with. Alright. So, it is good that the gases were insulators in general.

However, under certain conditions this insulation can break down. For example, if you create a very high voltage it can break down, some time is interesting to see that. So, you create high voltages can break down have you seen a gas lighter, lighter which you can light the flame gas flame you see a spark so, why the spark? That for a very short period of time you have developed within the 2 electrodes enough voltage that the breakdown of this so-called insulation takes place so, you have a breakdown voltage can be created.

Similarly, in cars for example which use spark plugs so, every time a voltage is created between a thing a spark is there and then you have the fuel burning and the car moves. So, you can create situations which may be conducive to the charge flow through the gas if enough voltage is there and distances are less. So, if that is what happened the current can actually pass through the air so, this is a special situation.

This is what happens that I talked about spark plug and talk about the gas lighter that you have a spark or other phenomena also, which are interesting phenomena like a glow it can happen corona discharge. So, these are all discharge phenomena which are taking place under conditions which are suitable for these that means, the gas by itself can in a way either ionized or allow some of the flow of charge carriers through the distance between the electrodes.

So, let us talk about spark, because we are talking about static development on a textile type of material, whichever we talk about wool, silk. So, if some of you may have seen a bit of spark at some stage, what is the spark? Spark obviously, is what we described the through the gas if discharge takes place at almost a rapid rate and then you see what some light you see up and maybe some noise, these things maybe associated with this happening and what actually happening is breakdown of this dielectric property takes place under these conditions.

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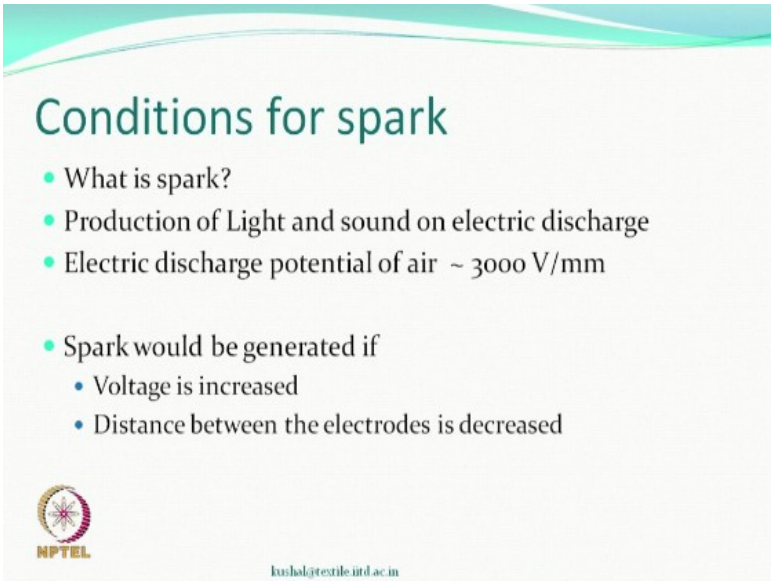

Now, when will it happen? In air approximately discharge will take place to the air if the voltage is or close to 3000 volts per millimeter. So, if there is a millimeter gap and if you have 3000 volt approximately then you will see spark taking place, if the distance is large even at this voltage you will not see, therefore, the voltage are very very high when you have the high tension wires going and still you do not see any spark.

Because the distance between the wire is quite large, but if the distance becomes less than you can see it so, we can say that the spark would be generated if voltage is voltages increased to beyond the threshold level and if the distance between the electrodes are decreased, then we will be able to see which is useful in some application that we talked about earlier. If somehow you make the gap 0 like you touch the electrodes, then what happens? That is called short circuiting.

You can see this spark there as well a lot of wrong things can happen because of these 0 gaps. So, when the gap is not 0 spark can take place, certain voltages will be required and if this kind voltage are generated, then you will see something called a spark which is discharge, electrical discharge.

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So, it has been observed if people are walking continuously, particularly in winter season, winter season is a dry season generally and lot of people walking at a certain stage people can actually feel and see this spark in synthetic carpets. So that is something where the textiles are playing role because textile as such were insulator, they can act like dielectric, they can as insulator can keep the charge on them and then when there is a gap and enough voltages could be generated, then you can see a spark.

So, one off course, we have seen a spark, in a gas light or a spark in a spark plug in a car are useful phenomena, off course, lightning that takes place also is a very useful phenomena in some

sense. Some people obviously may not be happy some properties can be disturbed, but that is a phenomenon that we see a lot of thunder, lot of sound, lot of light so harm can also take place, let us see what,

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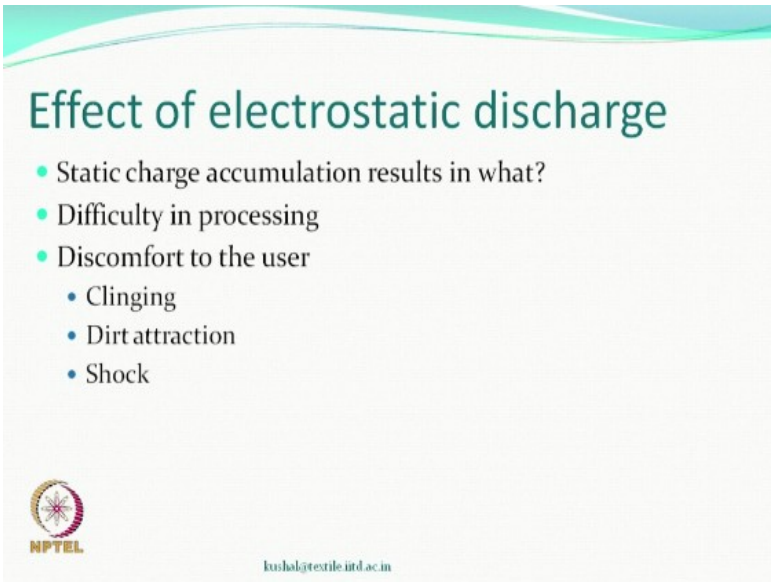

If charge accumulates obviously, whenever there will be possibility whenever threshold levels are reach will get discharged and so, what will happen if the textile material for example, like a filament yarn wound on a bobbin, it gets developed charge. So, when you unwind you will find that there is a ballooning all the filaments of let us say a similar charge and they want to separate out if you want to process this yarn there will be very difficult.

Any small one filament can get entangled other than anything so difficult in processing, what about the user? You may find sometimes certain types of fabric they cling to your body, have you felt that? So, the cling to the body because the charges may be positive, but you may not love it. Based on the charge, nature of the charge and the nature of the charge on the dust which obviously is there the particles they can get attracted and you can have additional dust and off course, you can get shock, these are one thing.

However, a little bit of this kind of discharge possibility is very detrimental to the electronic equipment. So, there you may find that the flooring has to be electrostatically treated the wiring obviously and the slabs all those materials have to be treated. Otherwise any such spot little bit of

thing could damage the electronic equipment and more importantly, the information stored in them if that gets corrupted then gets corrupted.

So, the harm it is these are the harms we shall see that. So, it is pertinent that we talk about antistatic finish and we are talking about synthetic finishing of synthetics where antistatic finish becomes an important finishing treatment. So, let us ask this question again whatever antistatic finishes we are going to give is this whole finishing system, a surface phenomenon going to be or a bulk phenomenon.

You understand now the difference between the surface finish or surface requirement of a finish versus the bulk requirement for finishing, you understand those things? Where does the charge normally reside on an insulator for that matter? The charges are found on the surfaces is it true, if this is true, then we only have to worry about the surface of a material, we do not have to change the bulk properties of the material only surface properties.

If we change then we should be able to get antistatic finish therefore, antistatic finished also is a surface phenomenon, surface dependent finish and therefore, you would like to treat the surface only. So, let us see some of the small observations which you may have already seen in your daily life and you might like to sort of answer them, think about it.

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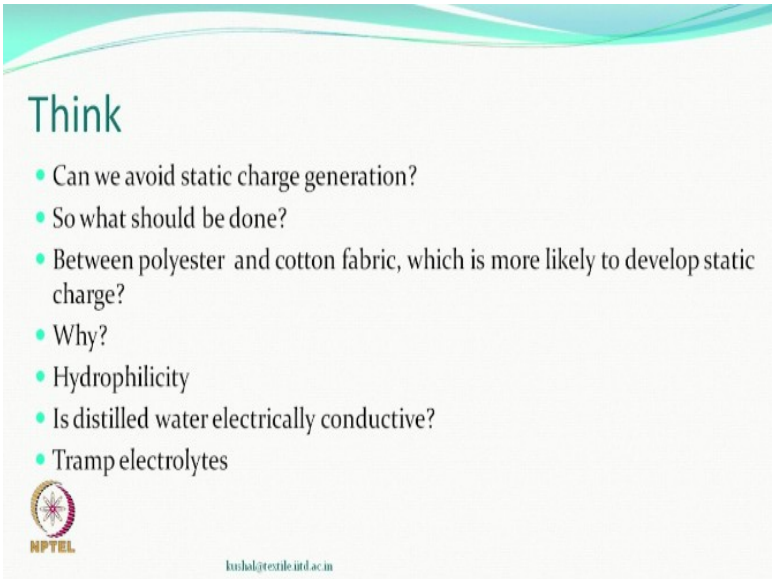

Now, we have seen the triboelectric series fibers, polymers, surfaces are going to rub at some stage or the other. So, friction will be part of it can we avoid static charges generation as possible? May be not, because if there is a difference between their surface characteristics, because of the contact being or because of friction, some of the charge carriers may get transferred from one to the other and if that happens, that happens that can be quite difficult to say that will not do something so, that charge does not generate.

So, what do we do? What can we do? Before that maybe you like to answer this question. If you have polyester and cotton fabrics with you, you have been using them as a user, what is your opinion, which of these is likely to develop static charge? Let us say relative more likely more likely to develop static charge between polyester and cotton from your own experience what do you say cotton or polyester?

It is polyester likely to develop more charge you may have seen this, the cotton fabrics in general do not seem to be having this problem therefore we are talking about also antistatic finishing of synthetics, that is one, what is the common-sense part of why does this happen? Why they should be true? What is the difference between them? One of the differences between them is the hydrophobic nature of polyester compared to cotton, which is more hydrophilic.

So, hydrophilicity which is the part of the cotton fabric is in some sense responsible for avoiding this static generation or static problem shall we say, is that true, can we say that they are more hydrophilic, moisture again of cotton is how much? 7-8% right, but polyester 0.4 so there is a difference, because of the chemistry of these 2 fibers that we already know. So, if you say hydrophilicity that means they can have water absorbed on them on their surfaces.

So, water is the one which is conducting electricity, if somebody asked this question is distilled water electrically conducting? distilled water, no. so how does it matter if it has got a lot of water so, why would it conduct electricity? The water distilled water, which is distilled water which is actually H_2O as it is does not conduct electricity so, when does it conduct electricity if you add a drop of let us say HCL into the solution and it will suddenly start to conduct electricity.

It becomes the ions are all over and then electricity gets generated once it starts generating then current will flow through this. So, by this fiber, which is let say cotton, they can more hydrophilic maybe has more water in it, how does it become electrically conducting? No fiber surface is so pure that has no ions and the charged particles, various types of electrolytes in whichever little quantity they may be available.

Because you washed through a detergent by a detergent, you remove the detergent but not 100 percent, maybe 0.01 percent that is good enough that is an electrolyte is ionic if any such type of material is there and then water also is there then obviously you can understand current will flow is that right? Good.

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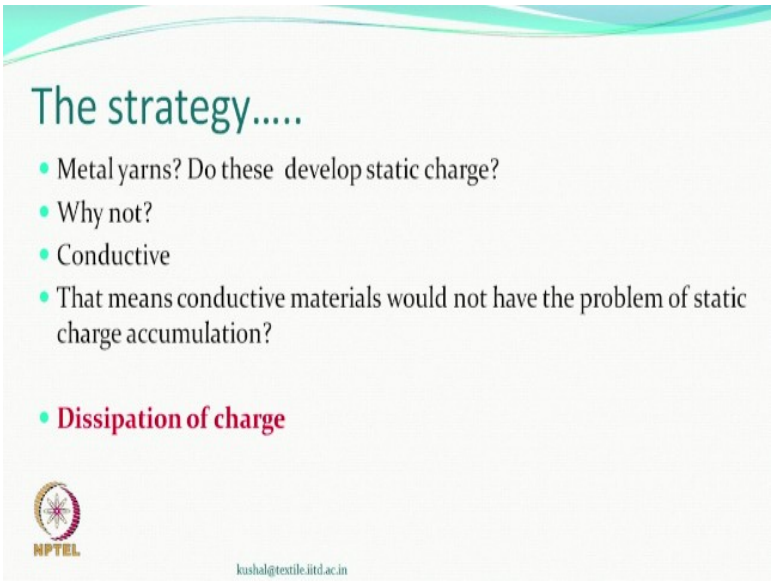

So, what should be are strategy, look at the metal ions does anybody has anybody complained that well metal has developed static, no one why not? Because they can conduct, they can conduct whatever charge is there either through positive source if it comes or otherwise it will just conduct and so no charges stored, so that is important from that point of view does it mean that if we increase the conductivity of the material, then would have less problem less accumulation of charge? That is true.

So, our strategy would be not to do something so that charge generation is reduced, but strategy should be charged dissipation should be faster as fast as possible, the faster it is better for us, is that true, make sense, right?

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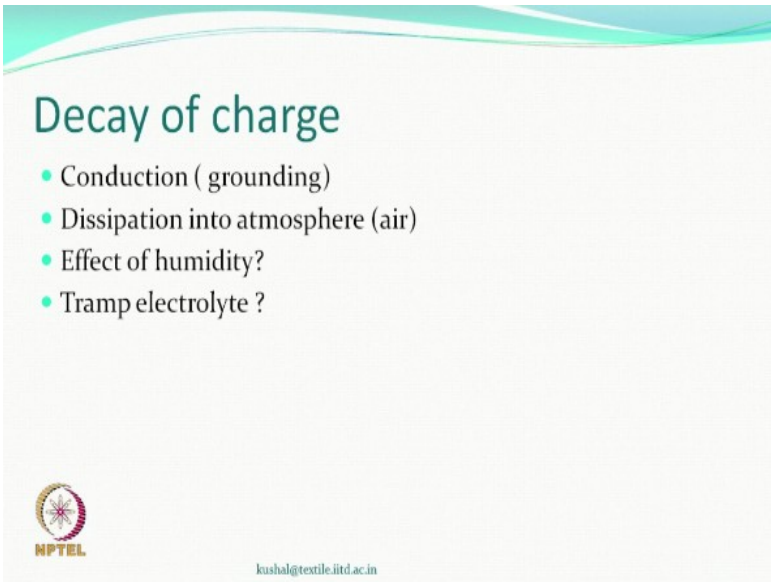

So how can the charge decay well if it touches like you, alighted from a car touch the ground and touch the body of the car suddenly there was a connection and charges would get transferred or if nothing else slowly it can be transferred to the gas the environment also because some charge particles may be there and they can come in contact and some neutralization can take place. Off course as we said if humidity is more, then charge transfer also or decay can take place faster.

So, that is why people say in the winter season, even the hydrophilic materials can develop static electricity can accumulate charge. Wool, which has got so much moisture again but in severe winter condition when the humidity levels maybe 30% or so, then this fiber also can accumulate static charge. So, if humidity is more chances of decay will be faster and off course, we talked about tramp electrolytes, which are the electrolyte which are on the surface or in the body wherever they are there, they along in the moist environment would be able to conduct away the charge carriers.

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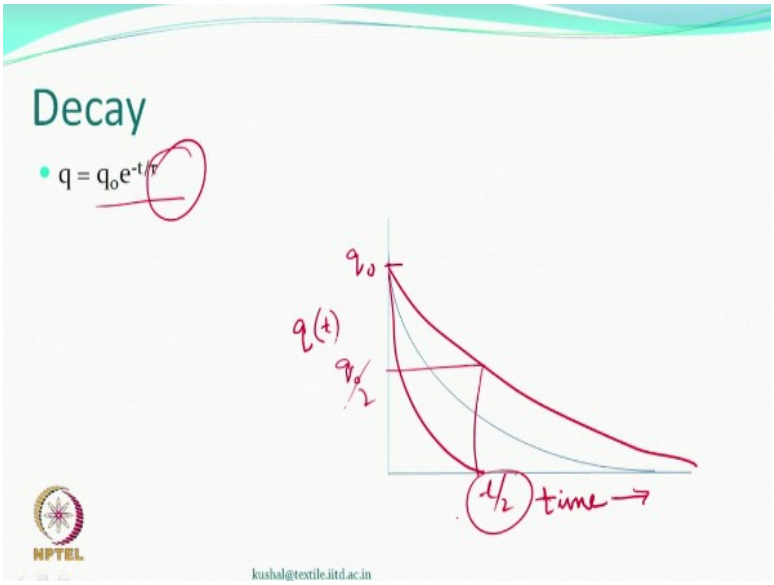

Something like this would be seen, so you have so let us say is time this is charge at some time t this is the initial charge. So, it decays with the time this is the general characteristics. So, you have time and the material characteristic which is represented by tau, some will be able to dissipate faster others may dissipate slowly depending upon this value of the tau, so people do sometimes talk about half time so, halftime to dissipate charge.

So, this if you do a treatment or you are comparing different materials the way like to measure some of these things in different thing let us say in air or any other gas for that matter, you may like to measure and compare which material is better than the other. So now, we coming to one conclusion that if there is a possibility of conduction, then the charge accumulation will be less and if that is true, then we would have much less problem of the static. So, there can be materials which are inherently conducting like metals.

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So, have you worn any material which is made from metal? Not these days, people used to wear armors for protection obviously, they would not have had the problem of static as such. But for fashion or other purposes, you may use metallic yarn, copper is one of the yarns which can be used in various industrial applications wherever you believe that the charge accumulation is going to be a problem, one may use these and similarly steel and aluminum.

For example, carpets so carpet has a pile and carpet has a backing. So, in the backing from one end of the floor to the other and the floor or on the sides of the thing in between, you can get some inter spaced metallic yarns could be any one of them, they would conduct electricity whenever there and get grounded, if you have a strip or something near the wall. So, you would not have those type of situation where a synthetic carpet can generate so much of a charge that you can see spark.

So, if you do not want them some of these things could be very interesting from the antistatic treatment point of view, how do you put them? As I said, they can be embedded in the carpet backing or you can have core-sis yarn made where the sheet could be normal textile core of the yarn may have some metallic systems in high end utilization, if you may want to use them, you can use them.

Well, people sometimes use gold and silver as embroidered material for the fashion that is if they are wearing that obviously the antistatic nature also will be imparted to these types of garment but that is a different story altogether fashion is different, but it can do the same job which a metallic yarn can do limitation. Limitation of such type of things particularly when you want a flexible system the one which you want to bend quite a lot the metal can obviously break the fatigue section.

In faster than a normal textile, if you take a metal wire into 20 times you will have broken metal wire a textile on that matter can 1000 times you can squeeze or twist nothing happens. So, the flexibility if there is the question then metallic yarns may not do then of course the density is also high. The density is also high and so you have to be carrying a lot of weight along with the textiles, if you are caring on the floor no problem.

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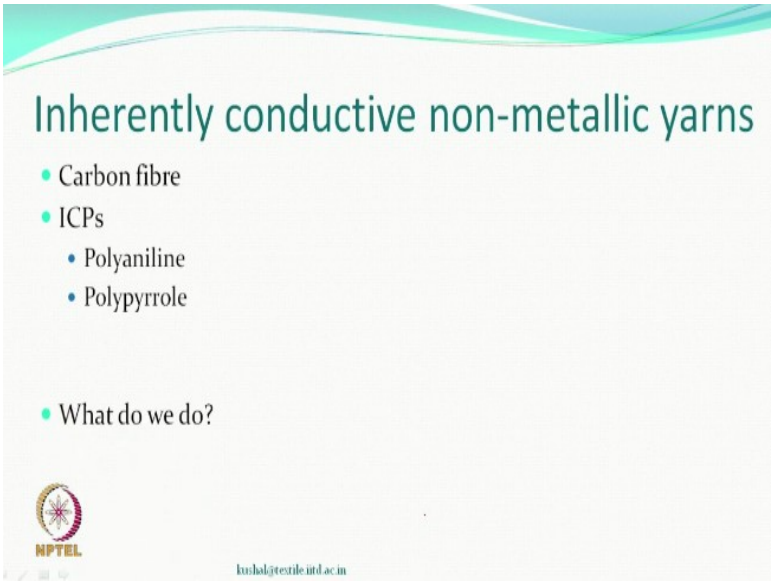

So, there are some inherently conducting non metallic yarns can also be produced. In the metallic ones also know these days instead of having the full yarn of metal, you can have metal particles, nano level particles deposited on the yarn that also can do the job or they may be embedded while or introduced or as additive during manufacturer of the fiber knowing fully well. The static is surface phenomena, if you add too much in bulk that is not going to really be contributing so much but no problem it will be there somewhere to do certain kind of job.

So, you can produce those type of synthetic materials they say silver embedded, nylon polyester filament yarn would be available, they will be highly conducting, but non metallic conducting material textiles can also be obtained. For example, carbon is quite conducting by itself as it is, the inherently conducting polymers which are like polyaniline, polypyrrole etc they are conducting by themselves they do not make fibers, but they can be coated onto textiles.

So, what do we do? Use these? Yes. So, you can use them either as a coating as an in-situ polymerization, some of those type of techniques could be used to make the textile a flexible textile electrically conducting, but that is one solution which is inherently material which are conducting material, but normally we may like to do it as a finish. So, we use into static agents and these antistatic agents if they are applied on to the textile then you can get antistatic properties.

Spin finish is a term which you may have heard every synthetic manmade fiber as it is being produced before winding on to a package you apply something called a spin finish.

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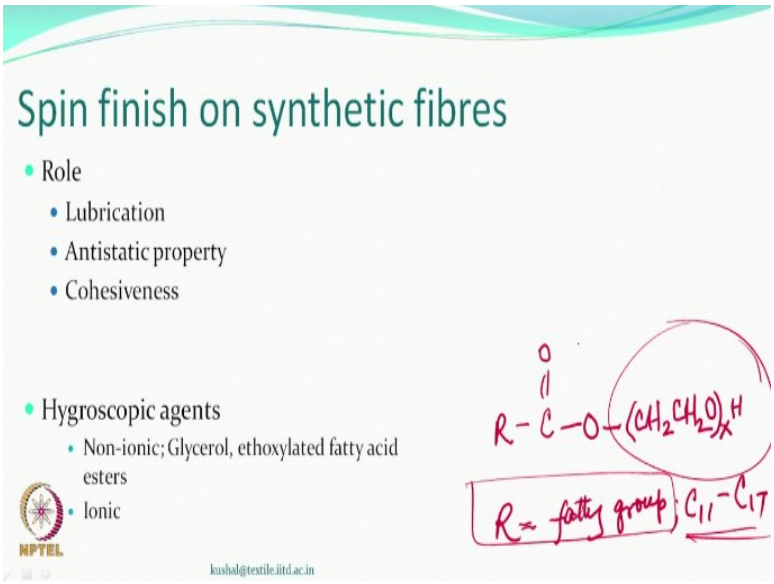

Spin finishes 3 roles lubrication, so that fiber, fiber friction, fiber to metal friction, fiber to ceramic guide friction all that is reduced because these yarns have to pass through different parts of the machines. Other important thing of course is antistatic properties, because synthetic materials can develop static charge as we understood and therefore, processing can be very

difficult. So, you apply, antistatic, so, there will be other thing is that if there are multi filament yarns you do not want them to be separated so, cohesiveness also could be one of the parts.

So, you would have lubrication lubricating agents like fatty compounds you know antistatic which will just try to work around cohesiveness because there is a liquid-liquid of the film formation systems and therefore, they keep the bunch of the filaments together. So, what do they use for the antistatic part of it? So, learning from the fact that the cotton or woolen or silk could develop less static compared to let us say synthetic understanding absorption of moisture is an important thing.

It acts by way of tramp electrolytes, but it does work. So, you are looking at hygroscopic agents, so you add something which can absorb moisture so it is available surface from the environment will absorb moisture and so do exactly what let us say they synthetic the natural fibers are doing. They were also absorbing moisture because they were hydrophilic, they are hydrophobic, so we are giving we are putting hygroscopic agents in the spin finish.

So that it can absorb moisture and give us the antistatic property. Some examples could be like this, which is ethoxylated fatty acid for example, they could be non ionic, ionic based on whatever into those type of in fact, they will be mixtures of many of those compounds in it has been finished, it is like a recipe, which is pretty complex, but it will be having hygroscopic scoping agents, glycerol is the compound that we just mentioned here.

So, we are looking at this R could be a fatty group C_{11}, C_{17} type. So, are you getting something? Have you seen such material? Yeah. They are the ones you use almost like softeners. So, you have a fatty compound, what you have a fatty compound because it will have affinity for hydrophobic substances. So, it will get attracted, while the hydrophilic part which is this part well absorb moisture, similar looking things with you done.

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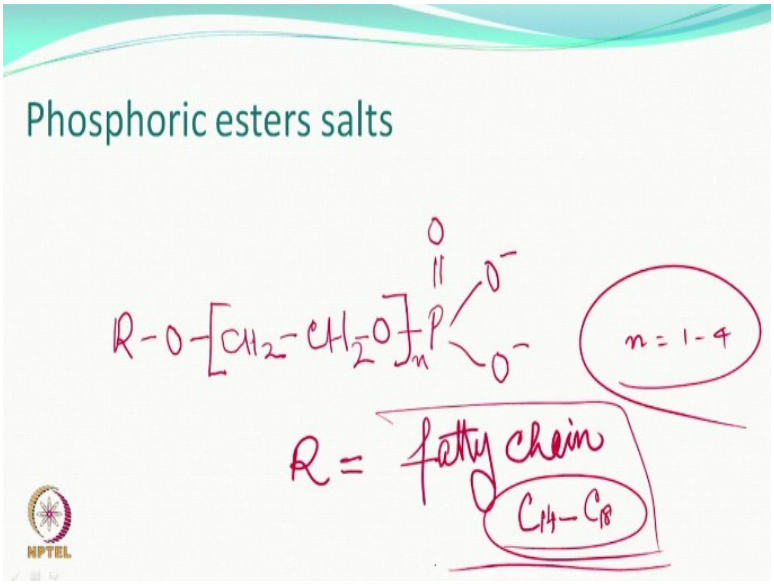

This type of thing also you must have read before phosphoric esters salts, something like this. So, you can have this type of compound here, this number could be different can have more numbers. For example, the R is let us say 14 to 18 you can have this also you can have let us say N, which may be let us say 1 to 4, 1 to 5 based on the kind of thing that you want all these things can be done they are almost similar to what we have seen before.

So, they are ionic kind of compounds and they can be applied on textiles any textile obviously we have in applying the softener so, they will work. So, they have so, how much hydrophilicity you want will be dependent on this N, the hydrophobicity which we already know we like to go hydrophobic material goes to the hydrophobic know they like, like dissolve like this principle remains, is it true.

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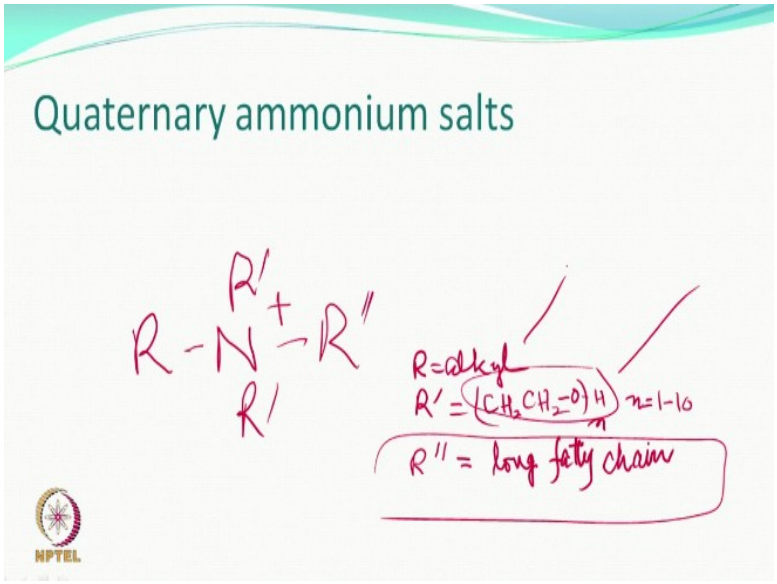

Quaternary ammonium salts we are we have used them where again So, just imagine you like what are you using otherwise long as there is there are ionic, if there is a positive charge there will be a negative charge somewhere sitting and so you have ions so ions will also conduct electricity and this can be a lot of hydrophilic groups you can have fatty chain simple alkyl so, you have you can manipulate this kind of a molecule.

But we must bring in the hydrophilic part the hygroscopic part, which is what going to contribute to the antistatic. But if you add these kinds of compounds, some of them will give you softening also.

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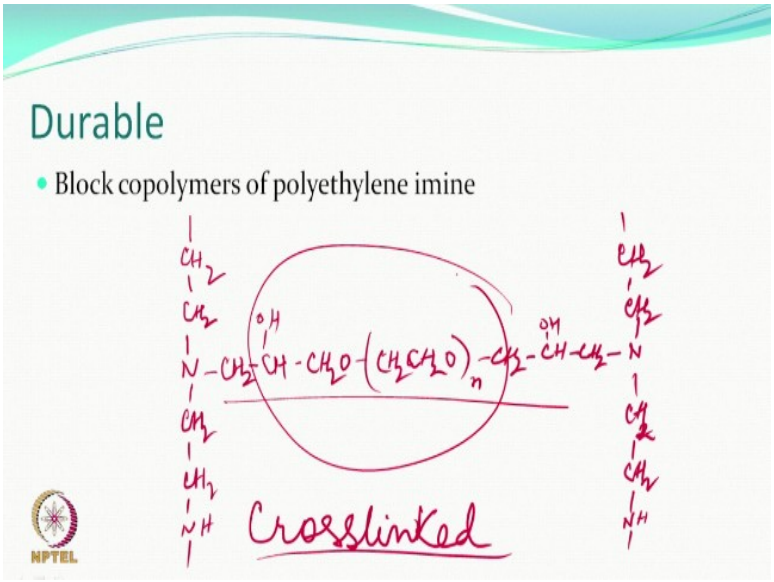

We make more durable than you require little bit cross linking. So, one of these is polyethylene imine base system, which is once it gets cross link from here, all this part is hydrophillic it can attract moisture and hopefully give more permanency, more durability when you apply as a finish to a textile.

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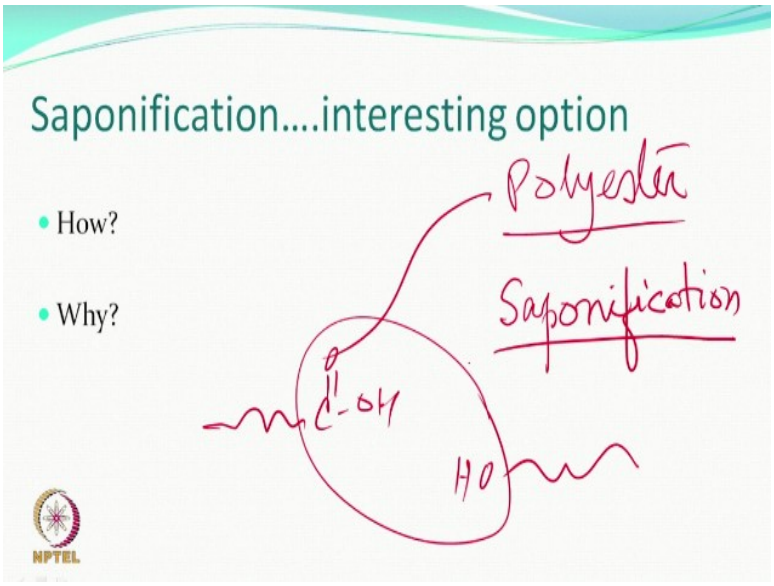

These are the interesting option particularly for example polyester, polyacrylonitrile or any other material which can be saponified, what is saponification? You know you understand treatment with alkali so, you get sodium salts of various kinds of fatty acid esters you remember those things which is saponification. So, if you have a polyester which is an ester so, the ester link in break by this saponification process in an alkaline solution which is sodium hydroxide caustic solution.

So, what will happen? You know esters are sensitive, if they are sensitive what will happen? Well carboxyl group will get separated hydroxyl group will get separated and so you will create on the surface let us say you do a very nice treatment, limited amount of treatment. Then the surface you will suddenly say a part of a chain which is long chain maybe embedded already but part of it is now broken is got broken.

Let us say a polyester may get broken into something like one end is created which is the acid and the other end is created which has got the alcohol. So, you have the hydrophilic moiety

getting generated on the surface, what do you think is it going to be an antistatic or not? Let us see,

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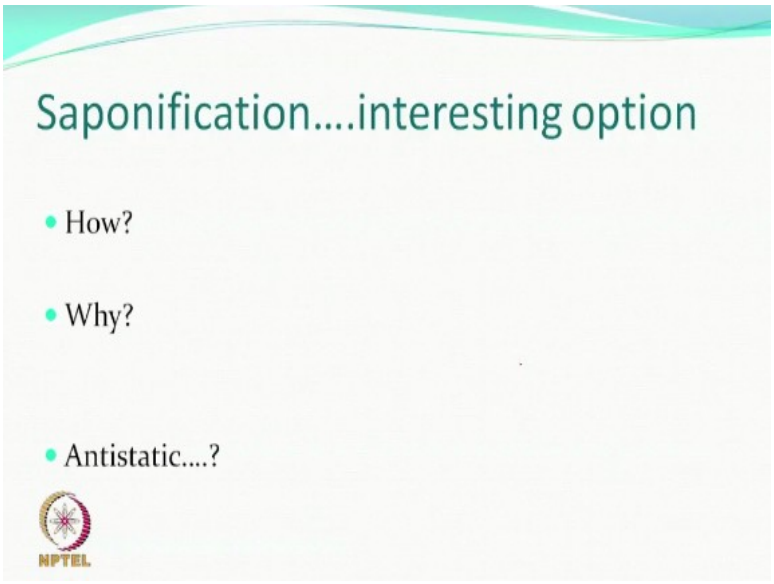

It is going to be antistatic as well. Well it is going to be durable or not? This is going to be durable also because a polymer molecule like polyester is long molecule part of it is inside somewhere something which was exposed got hydrolyzed into carboxyl and hydroxyl groups. So, what would happen is it will start attracting moisture, you will be surprised that the bulk property of this may not changed much almost nothing.

Even somebody says the moisture again has seen you might find the moisture again of the whole bulk of material has not changed, but on the surface, you have created some hydrophilic sites. You can check if you want to check whether it has been created not try to put in a cationic dye solution. You will see the surface is getting colored because of the ionic nature, interesting, is it? So, what is important is become antistatic.

If somebody asked this question will this material after this treatment let us say a polyester it become antistatic because hydrophilic surface has been created, it is more durable because nothing else can happen because the molecule cannot just come out. It also has another property, which is also a surface finish. Which we have give it before is soil release, you know, by doing this antistatic nature will also be there and it will release the soil easily.

We also said soil release finish also is a surface phenomena base surface energy if it is hydrophilic, the detergent solution goes in between the layers of the oily layer soil and then it can roll off. So, good way to treat let us say something similar can be seen on acrylic also. Something similar can be seen if you want even nylons also can be hydrolyzed so, because these amides can also be broken.

So, from the point of antistatic we have taken some examples some of these things can be used to create a good finishing environment people got little motivated by the same process which we said the use of alkali to do a bit of a saponification on the surface of let us say polyester, polyacrylonitrile or whatever. But for polyester one interesting finish people have developed what to call the de-weighting or weight reduction.

So, you reduce the weight by what, dissolve the material in this start from the surface treat little more time and you will see 5%, 2% sometime 10% of material can be removed that is de-weighting, why should somebody do such kind of thing? Off course, it will give you antistatic, but antistatic does not require so much of a reduction in weight. It can just do without that, but people found very interesting properties, the material became very soft almost silk like and so, a lot of synthetic material dress materials are available.

Which may have been given de-weighting treatment and they appear very, very soft synthetic that is a polyester itself. Because same alkaline hydrolysis will keep reducing the weight, if you take higher temperature, if you go more concentration can happen and so what will happen weight will get reduced. So, we will see 5% loss of the weight people may be unhappy, but people who are doing this treatment they are very happy.

Because they find some beautiful characteristics at the end of the day so, instead of going for high temperatures, people can reduce the temperature conditions can be made softer if you have additives, some of the additives people have talked about ethylenediamine.

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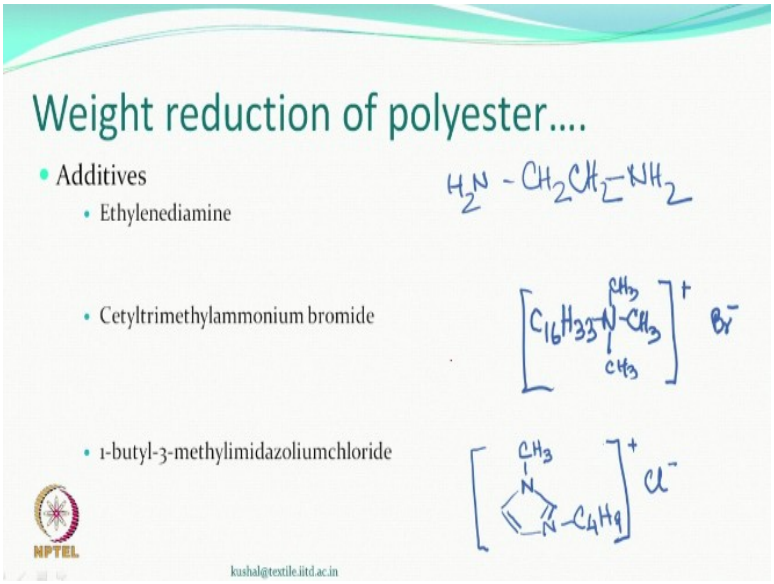

Which can reduce the time of treatment which is good, the same type of weight reduction can happen or some other cationic agents like cetyltrimethylammonium bromide, so interesting or some compound people have tried a complex compound which is the methylimidazolium chloride which also can if added in the solution along with the alcoholic it can reduce the processing conditions and particularly in the time and temperature and you can get a similar weight reduction so, weight reduction takes place so, weight reduction itself is a finish for polyester.

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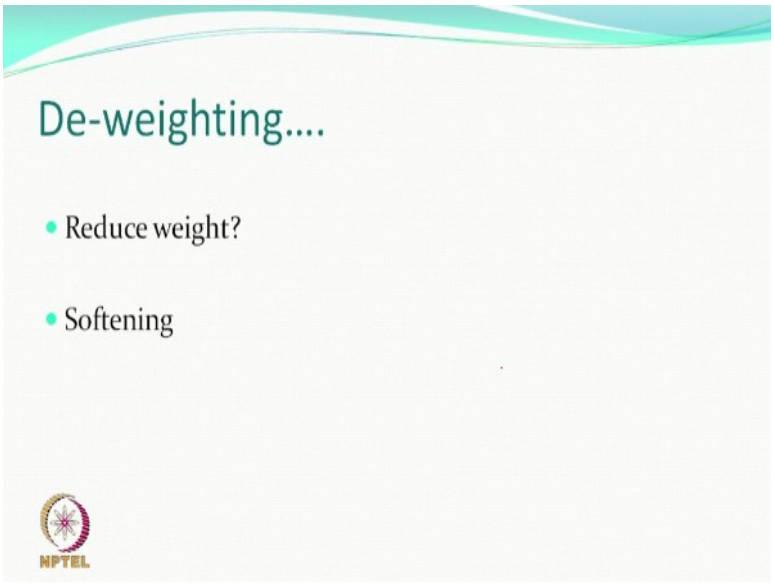

So, de-weighting from time known it reduce the weight but natural but gives you softening treatment, why does it get a softening treatment, does it change the bulk property? It is removing

the polymer from the surface that does not change the bulk property. Now it does not this bending and softness as we understood is a very low deformation property it is only bending does not say you extend it like you have a tensile stress you put a lot of elongation takes places.

But you bend hardly any elongation, hardly any very small, but it is very sensitive to hand touch, feel soft, stiff, stuff. We talked about earlier because the low deformation property, people are finding that some polymer which has come out let us say there is a fabric yarns were passing over each other warp weft so and so forth, there are contact points everywhere. If some of the material is removed, the distance between the 2 overlapping yarns between them slightly is more.

The slightly more means less contact, that means when you bend less resistance becomes softer, very soft and some of the oligomers may have been removed some of the spin finished parts may have been removed and surface also becomes almost silk like it is not silk obviously we know it is not silk, but silk like it shines little more softer, feels pretty good all those things are there therefore, people are ready to lose 10, 15% of the weight and get a better property. So, this is the de-waiting finish you can call it for process.

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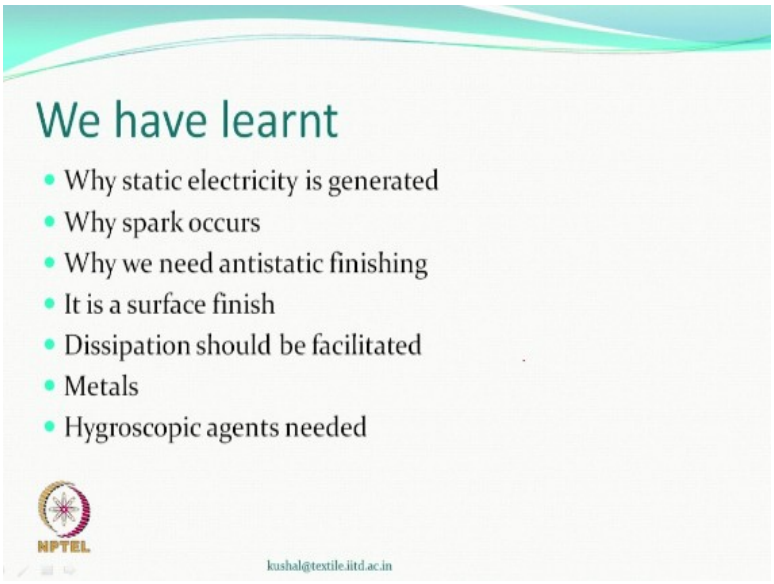

So, today we have learnt something why static electricity generated? We understood why spark occurs with your discharge takes place electrical discharge? Why do we need and definition antistatic finishing treatment simply because otherwise we will be having some trouble to the

user for processing or electronic equipment all of them can have important thing to remember it is a surface finish, dissipation is the mechanism?

By which we will all the antistatic agents are likely to work material by themselves can be used they are very conducting, or we use agent which can absorb moisture more and so, they are hygroscopic material which can be durable, non durable depending upon what kind of treatment that you give. But in principle, this is what is going to happen. So, in the next class that we go, we will talk about chemistry of various compounds.

And now this is next class will not be talking about any chemistry at all we will talk about minimum application technique what it means is can we reduce the water consumption during this application process, this is what we will do in the next class, till then see you all the best have fun.