Textile Finishing
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Lecture-4
Wrinkle resistant finishing: Performance characteristics

Welcome back to our series of lectures on textile finishing like last time we said although we will be correlating various aspects of chemistry of the chemicals and the chemistry of the fibers. But we shall not be mentioning every time but we will use whenever we need to and that is an important aspect in any case.

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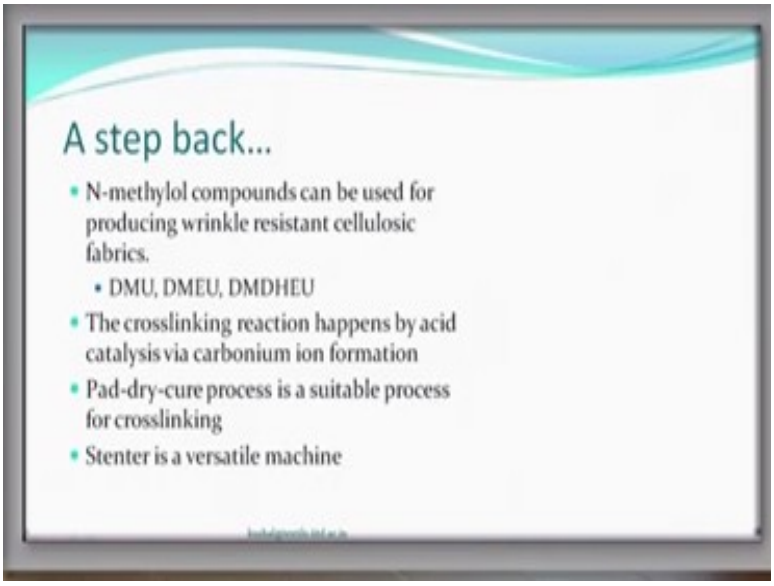

Let us look back as to what we have done, we have understood that the N-methylol compounds can be use for producing wrinkle resistant cotton viscose fabrics. That is this fabrics based on cellulosic material and some of the agents the name that have been used the chemical that have been used or DMU, DMEU and DMDHEU I would ask you to look at some other chemicals also, I hope you have had time to look into those chemicals as well.

Also we learn that the reaction with these N-methylol compounds and hydroxyl groups of cellulosic material is an acid catalyzed mechanism via carbonium ion formation. The process

which we said is more suitable to finishing particularly wrinkle resist finishing is pad dry cure process, this an important process in which we believe will always give you a smooth surface.

We also learn that the machine that we actually rely on other than a mangle is stenter which can control the dimension of the fabric which is being finished.

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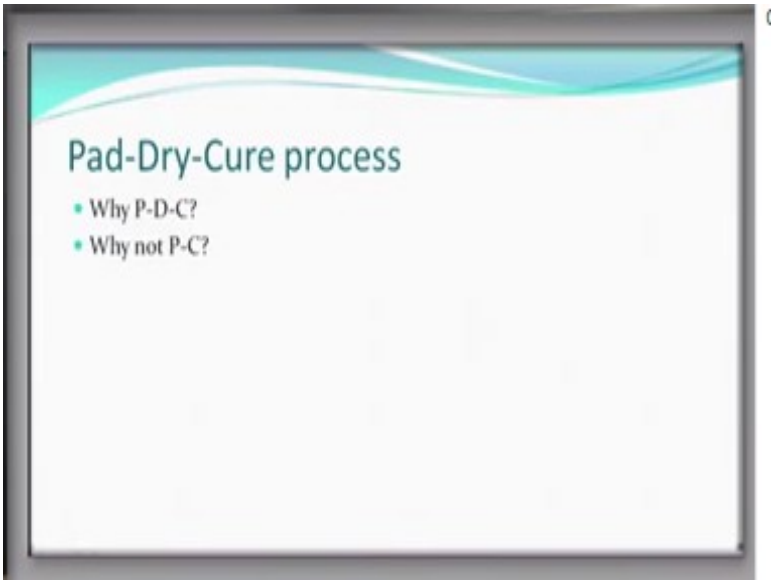

We also try to argue why should we go for a pad dry cure process and not simply a pad cure process. Because curing is obviously done at higher temperature and the drying obviously can take place at this temperature as well remember what we said, we said there can be non uniform treatment.

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And why it is because we can have migration of chemicals across the material where there will be tendency to move out along with the water which is being evaporated. There is a rate of evaporation of water if it is very high which will be sure if the temperature difference is high that mean curing temperature is high 150 degree temperature for example. And the fabric entering is at room temperatures, so difference is pretty high.

So, rate of evaporation will be high and that rate of evaporation the chemicals can also move out along with the water, water will evaporate. But the concentration of chemicals around the surface will be higher than let us say in the bulk you remember we said crosslinking should be uniform and what it means is if we consider as a wrinkle recovery as a finish this is a change in the bulk property not a surface property.

So, we are changing the whole fibre, the yarn and the fabric obviously at a molecular level but we must penetrate we must ensure diffusion uniform diffusion of the chemicals across whole fibre and the yarn and the fabric.

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Now we take this discussion little further, so we are preparing a fabric which is wrinkle resistant there must be some way to measure the performance of this fabric and this is what we will try to highlight more in this lecture.

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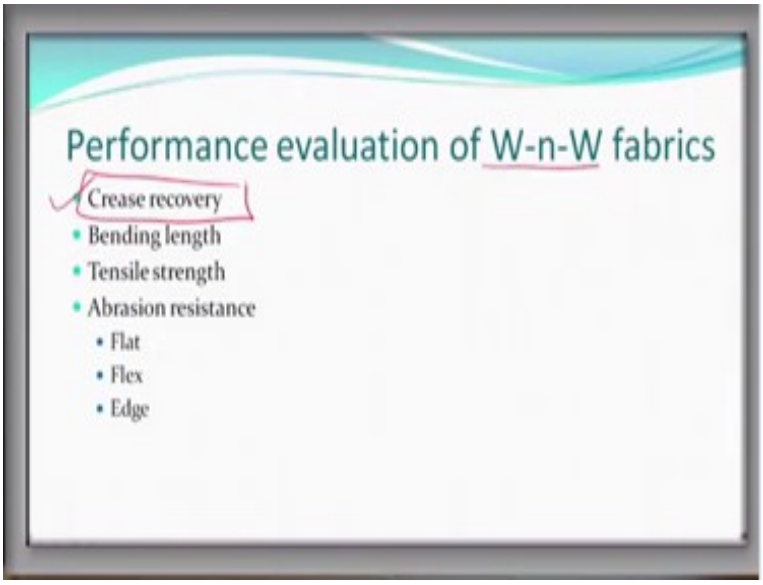

The performance of these fabrics sometimes also known as wash and wear fabrics can be done by measuring crease recovery, bending length, strength tensile strength, abrasion resistance. Important thing of course for us is crease recovery because only the motivation for us was basically to improve this recovery properties you know by this crosslinking, so that is of course important, we know how to measure, what would be .

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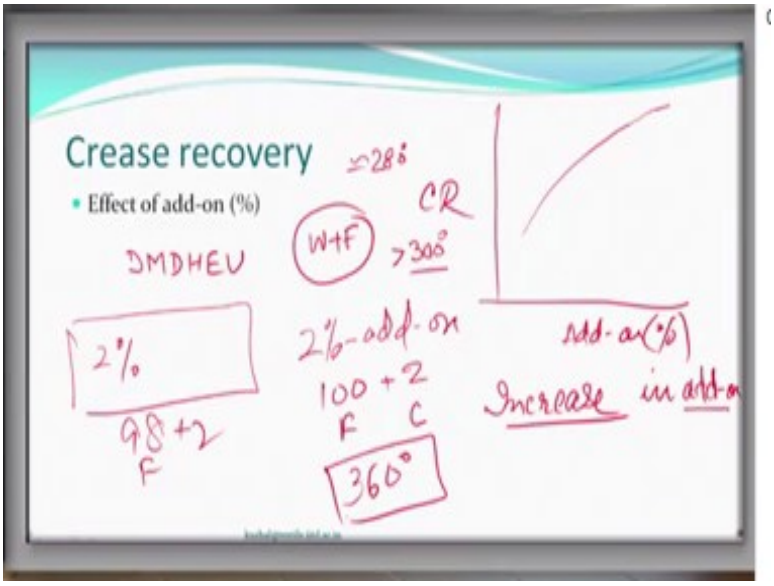

Let us say the effect of add-on, add-on let us say I am suing DMDHEU how much what percentage of this chemical has actually been added onto the fabric. This is an important information which we may like to know how can this be done, well this can be done by taking initial weight of the fabric if correctly taken. And then after padding, drying, curing we take the final weight hoping the reaction is 100% then we will be able to see how much chemical has been added.

You must remember, I hope you remember already that there is a difference between content and add-on ok. If somebody says the chemical is 2% of the weight is a particular chemical in the fabric then it means 98 + 2 in 100. But if somebody says 2% has been is add-on, so what we mean is 100 is the fabric and 2 is the chemical that we have added alright. So, this is how one would be able to understand the difference between the add-on.

Let us say we are talking about add-on if you increase the add-on then what would we expect would happen to increase recovery what will happen to crease recovery, crease recovery should increase alright. So, let us say in general if we try to plot the add-on versus crease recovery you remember how crease recovery is measured, crease recovery is measured as a recovery angle of wash + weft alright.

So, they should increase, so generally we believe that will increase but if you keep on increasing you cannot hopefully you may get some kind of saturation value and the rate of increase maybe less. But generally we expect that there will be increased maybe may or may not be linear although over the whole range of add-on, but that is what will make. So, how much increased recovery you want will also depend on what kind of a material that you want.

If you want very highly durable press type of a material then we may want to have crease recovery angles more than 300 degrees right. And if we are looking at a wash and wear maybe we are around 280 degrees, how much can be the maximum crease recovery angle if everything is the best how much maximum, it cannot be maximum 360 degrees right 360 degrees.

So, when we increase the add-on that means we have added more chemical where padding process drying and curing of course and then you get more crease recovery, obviously somebody will limit this.

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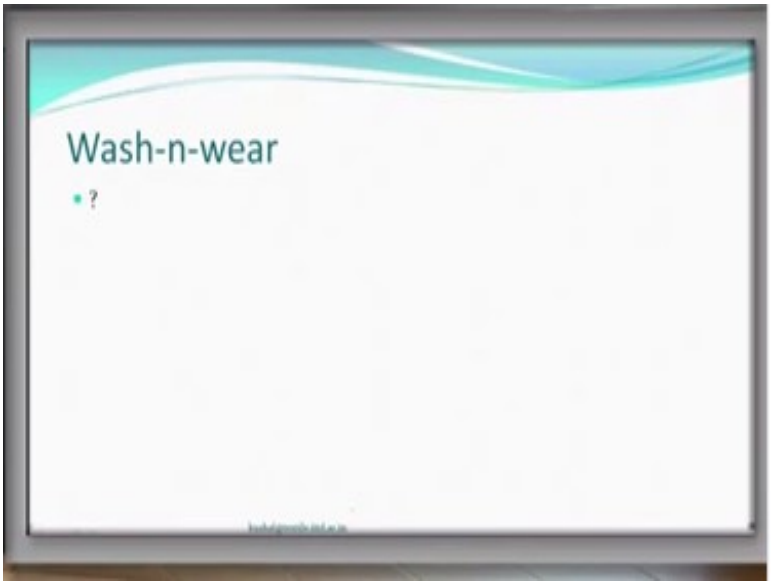

Then this term that we talked about just before wash and wear this was the term which was coined in the early days when the creased resistance finishing was though about what it meant was do not worry about anything take a garment wear it wash it and then without ironing wear. So, very good concept but the only thing which people found was that the after a few washers the fabric does not appear to be as smooth and you may have to iron.

And therefore generally saying well it is a wash and wear type of finish it may not really be true to these sentiments and therefore people talked about the effect how much is the effect which remains after washing. And so instead of saying wash and wear we said wrinkle resist, so it is resisting the wrinkling process and not completely material which can be just washed and wear ok. So, that is a kind of a difference and therefore people talked about other ratings also.

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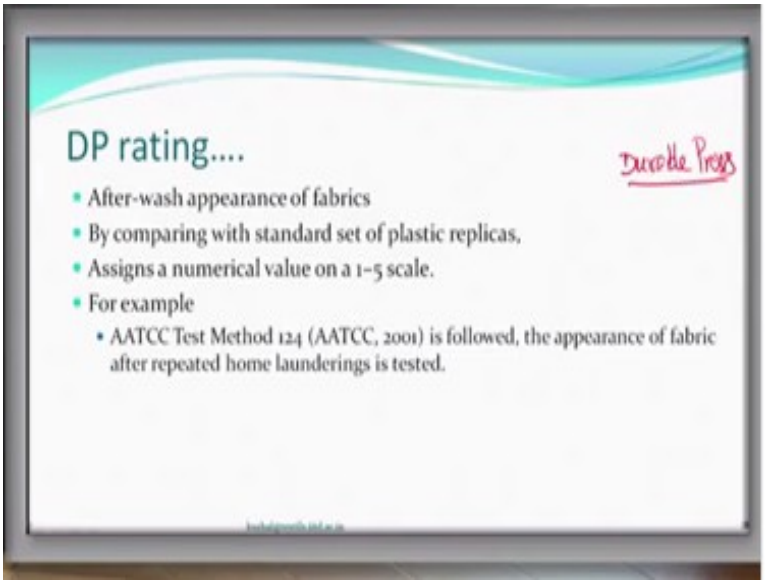

The other rating which people use you know when you sell and it in the client they may like to know is DP rating, DP means durable press.

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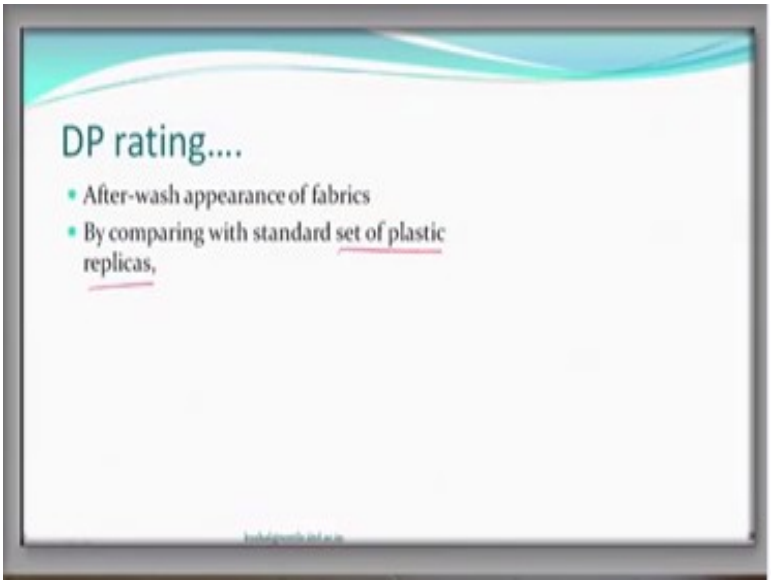

So, what is have, so durable press rating is appearance of a fabric after we have washed, so normally I said it is a final finish, so the fabric may not have been obviously washed or even if it is washed maybe another process would have been given like a calendaring process. So, it is a smooth surface which you get but when you wash what happens to the appearance that is something people want to determine.

Some people will say well I have given one wash but a fabric is going to last more than 1 wash and so we would like to see how this appearance changes. Let us say after 5 washes which kind of washes the washes could be hand wash, the wash could be machine wash by then you would like to see. So, that would depend on a client for example we tell a where we would like to see your DP rating after let us say x number of washes and we will then buy our fabric or not buy our fabric, so that is the limitation that is I am going to put.

So, how do we measure the appearance, the appearance is measured by a set of plastic replicas, replicas is like you take a photograph some by people obviously the people who decides standards and we agree to those standards. They look at which fabric wrinkles more, which fabric wrinkles less after washing and then based on some gradation they have agree to say a certain set of grades and certain set of appearances.

And you made replicas in plastic that this is how a fabric is going to appear after wash, so you have replicas then it people compare with replica as like a you can actually have a photograph also or you can have plastic replicas. So, you compare as to how your fabric which is you have treated versus a standard we should have been where does it fall and then you assign a number.

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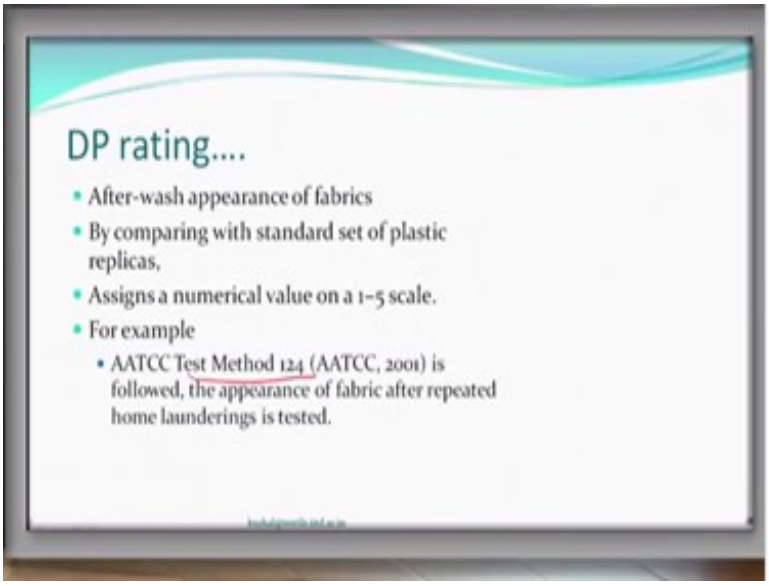

So these days like you assign a number in washed fasteners from 1 to 5 here also you give a number numerical value from 1 to 5, 5 being the best and 1 is not being the poor that is how one would look at it. So, various standards organizations like AATCC or ASTM or in Indian situation BIS all of them have their defined has to this is how the replicas are there this is how the photographs are there and you compare with them.

And of course they decide on the processes to how and which process must be followed so that there is some standardization which you can communicate properly with your client. For example one of the standards is AATCC test method 124, so this is a method which talks about how to cut your samples, how to wash the samples what conditions to wash the samples depends on how many number of cycles that you want that can specified and then after that you compare with the standard replicas.

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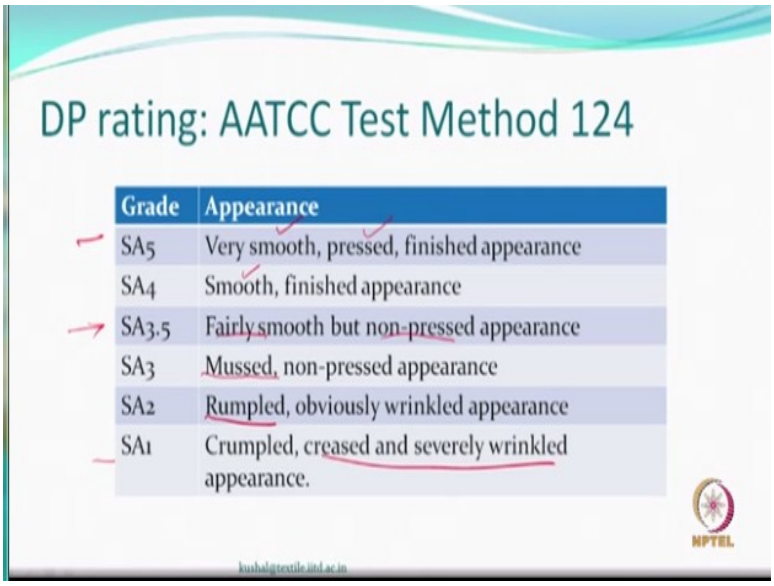

So, this test method therefore talks about standard from 1 to 5 but in between also they have put another value 3.5 that is they have decided, so you follow. So, obviously SA is smooth appearance if you appears very smooth after laundering it will be called SA5. So, it would be classified or characterized by let us say very smooth appearance like a pressed garment itself in very finished kind of appearance.

The SA4 is slightly less that it does not appear to be pressed but still smooth not very smooth in between you have fairly smooth but non pressed appearance is say well is nobody is iron this but ok is smooth enough. SA3 is mused it looks like as if somebody has crushed a bit used and non pressed appearance, 2 is rumpled and 1 is actually creased and severely wrinkled if this is the kind of appearance that you have people will give this kind of ratings.

So, this rating can be given after first wash can be given after fifth wash it can be given after tenth wash based on the requirement of the client also. And so one can say well after so many washes this is the rating some people would obviously be interested to know this alright. So, this is one way in which one can look at the fabrics performance as for as the wrinkle recovery is concern.

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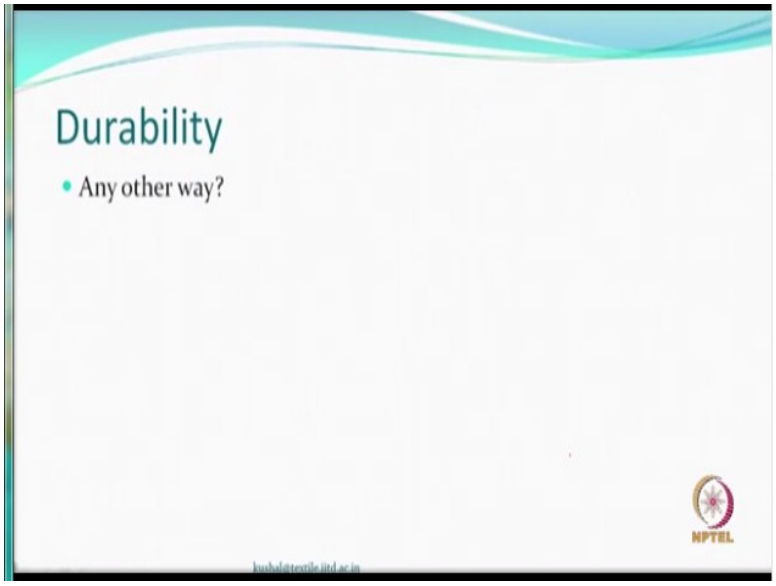

And then what do we do is there any other way you can measure well you can measure by again washing and instead of going for a wrinkle recovery you can also see the durability in the sense that you just look at the creased recovery angle again do 5 washes look at the creased recovery angle this will be something which people will be able to identify and say well the creased recovery has reduced and so we may accept, we may not accept the performance.

Why would this creased recovery reduce after washing, it can reduce because there can be hydrolysis and some of the crosslinks can break you remember the fishy order. If the fishy order keeps coming that means some of the crosslinks are also being broken and because they are being broken. So, the performance can obviously go down.

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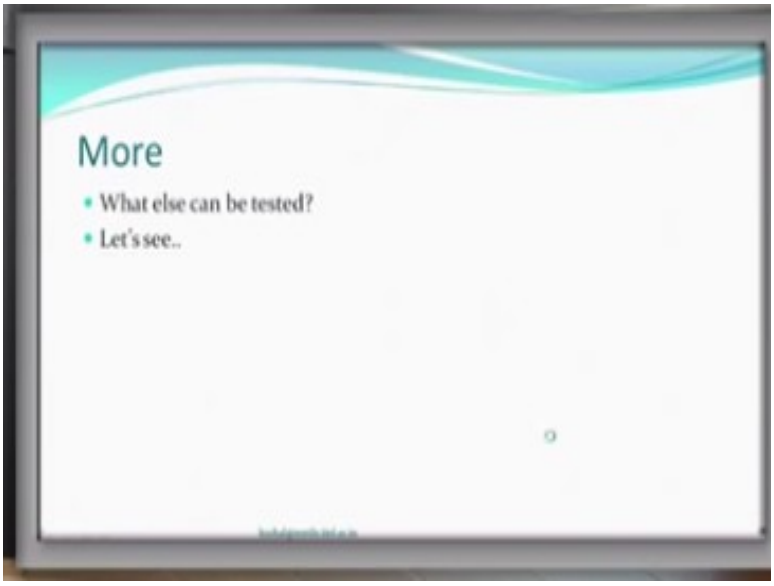

What else can be tested, creased recovery of course is the most important one do note about it, well, let us see what else can be tested.

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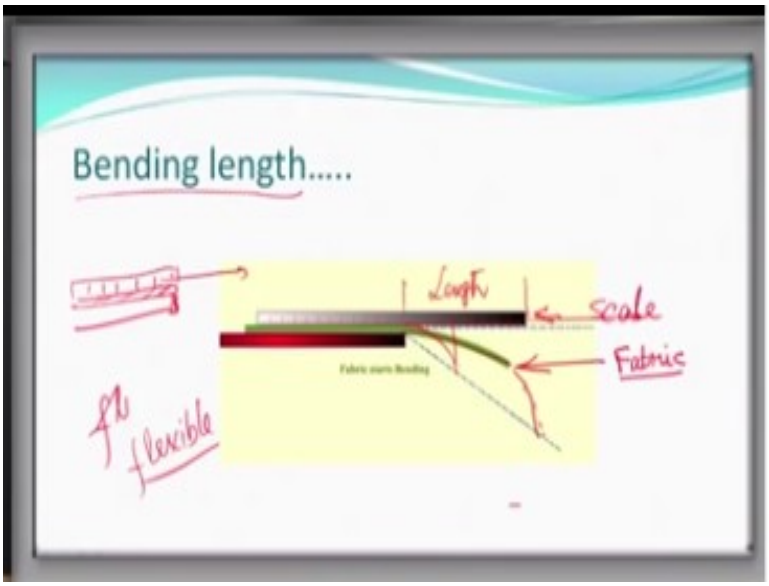

One thing that can be tested is bending length ok, bending length can be tested by taking a strip of fabric again based on the standards, let us say this is the fabric. And there is a scale so initially you may have a situation the platform, the fabric and the scale are aligned and then the combination of because there is a friction between the 2 when you move this out the fabric also moves out like this.

And at a defined plane after some time it may touch as you are moving out, so when you move this how much is the length before this edge of this fabric touches this thing. So, you can appreciate if the fabric is very very rigid fabric then you will have this length you will have to move it much more before it can touch this if it is flexible. Then it can touch maybe here, so length can be less, so what it means is the bending length is a measure of stiffness of any fabric.

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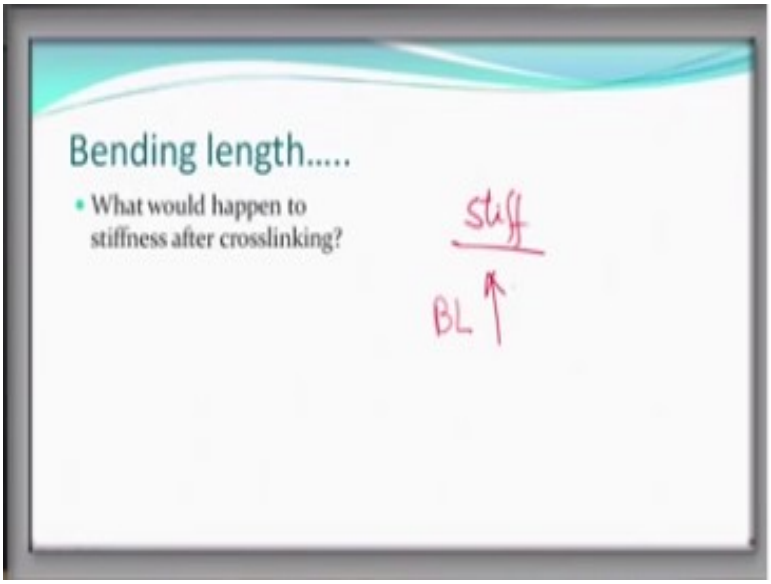

So, what would happen to the fabric after have a crosslinking treatment wrinkle resist finishing treatment, what do you think. The bending length would increase or bending length would decrease or you can answer the other way is it the fabric going to be become softer or the fabric is going to become stiffer what do you say the fabric is going to become stiff, why it become stiff, it will become stiff because you have created intermolecular resistances by introducing covalent bonds just strong.

So, they will resist any bending stiffness normally is reflected in the bending properties, bending length is one of them. So, after crosslinking one can expect that the fabric may become stiffer, now you have to define how much stiffness acceptable based on that you would say how much add-on should be there and so one would consider this is an important property. So, fabric would becomes strength and the bending length would increase right or no yes bending length would increase.

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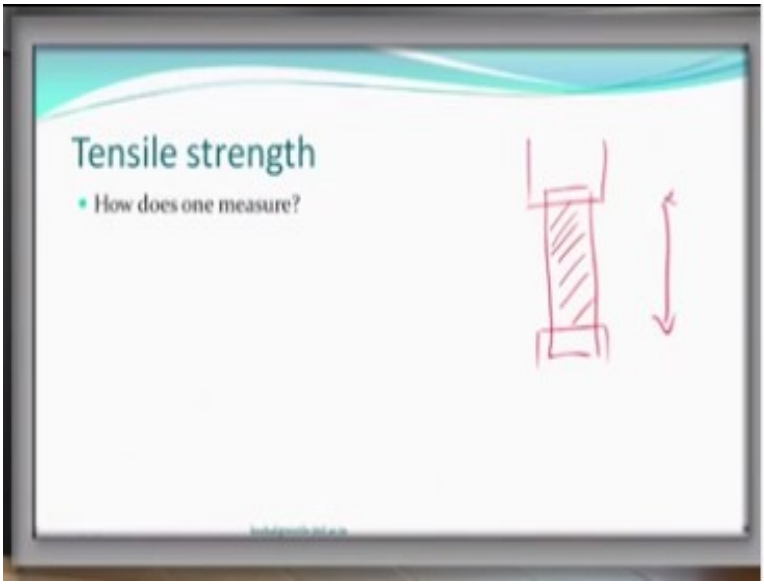

What about tensile strength, how do we measure tensile strength well you can have some tensile testing equipment which may have jaws you can grip you fabric in the jaws and then increase the distance till it breaks. And then one can see and measure the tensile strength, the tensile strength of fabric or a tensile strength of yarn or a fibre they are measured in different ways which have been already defined I am sure you would have gone through some procedure to measure the tensile strength of fabric.

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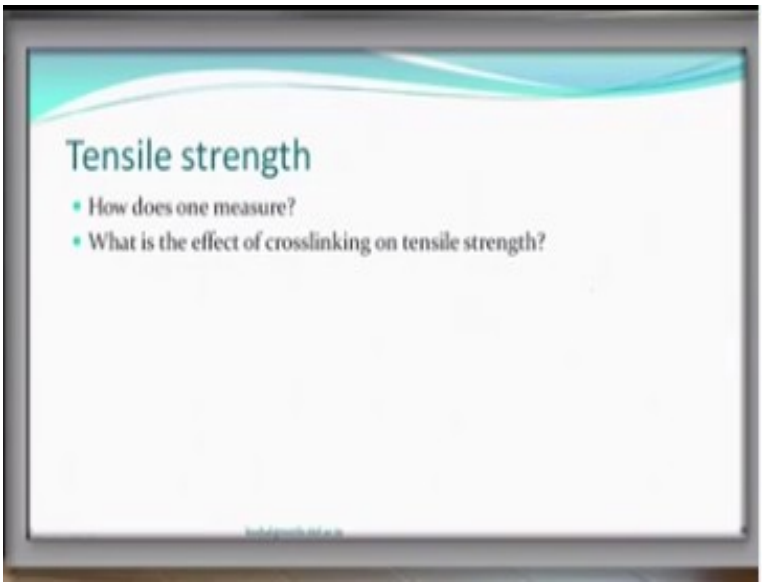

What would be the effect of crosslinking on the tensile strength, so we have done the crosslinking when we have seen the crease recovery has improved we are happy about it. The bending length has increased we may not be so happy about it depends but normally an increase

in stiffness may not be desirable after every finishing treatment. So, next is whether anything happens to the tensile strength.

So what have you done you have fibres, you have molecules in the fibres which have been crosslinked. So after the crosslinking and now you want to give the tensile load and the crosslinks that have been formed are obviously covalent bonds stronger bonds. So, what do you normally expect would happen if you do such kind of a linkages in any molecular structure intermolecular crosslinks what will they do.

We understood they will make the material stiffer bending will be more difficult you remember we talked about resiliency, resistance to deformation is one part of resiliency other was recovery from resiliency. Because these bonds are stronger so they resist that is the stiffness that is increased now what happens a tensile strength, what would happen.

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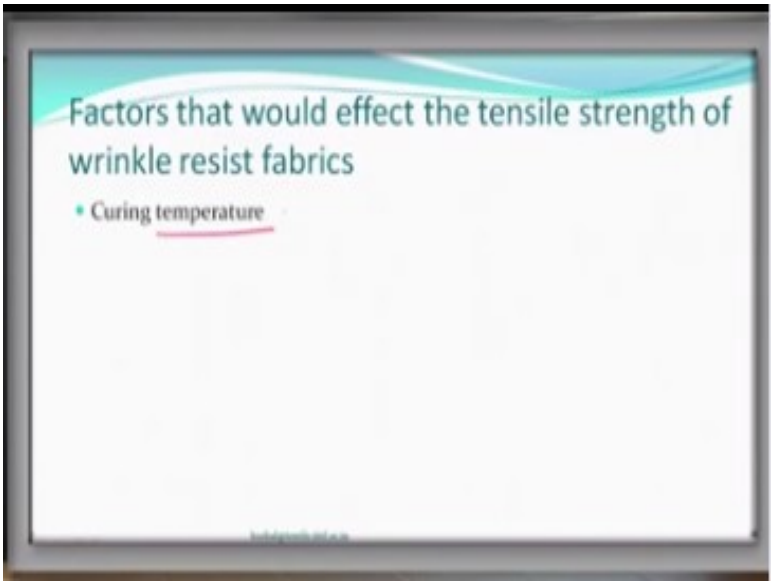

So, before we answer this question we should also try to find out what type of factors what conditions actually are being used for processing. One important thing we know is the during curing we do increase the temperature we said the temperature could be increase of 120 to 150 or 160 depending upon the reactivity the GSM of the fabric and the time that you give for completion of reaction.

So, curing temperature, so one we are obviously interested in completion of a reaction but during this process the fabric is also being subjected to higher temperature, what effect the temperatures could have. Now you seen any fabric put an oven for some time and what happens see the colour, what colour do you see after little exposure. Start becoming little yellow, little brown if you do bad job then obviously it is going black get char.

But obviously we are going to that kind of a temperatures and that kind of time but still heat is one of things which will definitely if not properly controlled would lead to some deterioration of properties. As deterioration property means what tensile strength can go down and that is why this is one important factor people would always like can I complete this process at a temperature which is shorter lesser.

Instead of 150 can I complete in 130 can I complete in 140, if you can reduce the optimum temperature by 10 degrees you will find as for as the strength and other properties are concern are going to better. But then we are now have a situation we have to complete a chemical reaction versus we have to also worry about the tensile properties or deterioration of the fabric itself.

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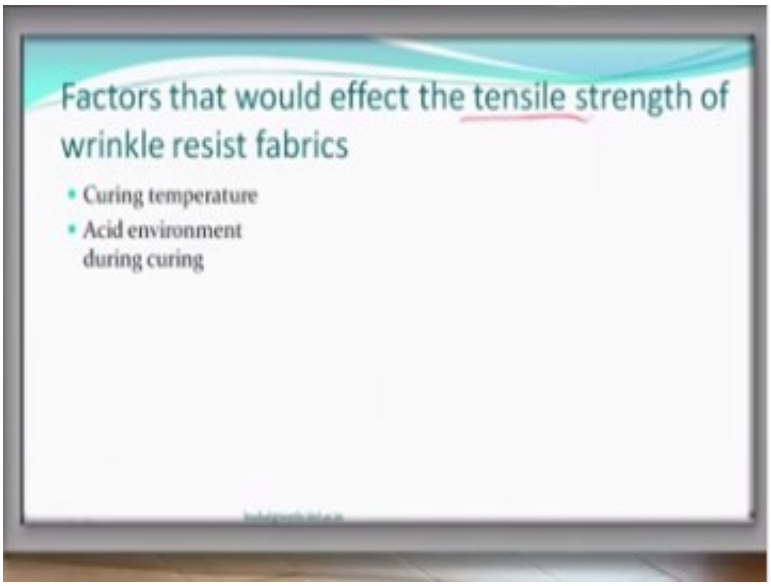

The other important thing that we have to remember as this reaction is acid catalyze reaction ok do you remember that acid catalyze reaction. Because it is an acid catalyze reaction therefore the

degradation can happen from the acid I am not sure if you remember if you put a concentrated sulfuric acid on a cotton fabric what happen, there will be a hole. Even if you have dilute sulfuric acid on a fabric it does not dissolve on a cotton fabric we talking about.

But when you dry the water goes, so what happens if the concentration of acid on the fabric it increases and so it can deteriorate. That means acids can deterioration the cotton cellulose right if this happens then obviously tensile strength what will happen to the tensile strength, it will go down again. So, you have reasons to believe the curing temperature and the acid at that temperature along with that is becoming little concentrated can have a deterioration effect.

So, one would say well low temperature or low time this is how we will optimize, so you do not really optimize only the crease recovery you have to worry about the tensile strength, you have to worry about the bending length. All of them are part of a thing, crease recoveries of course the most important performance characteristic there will like to make.

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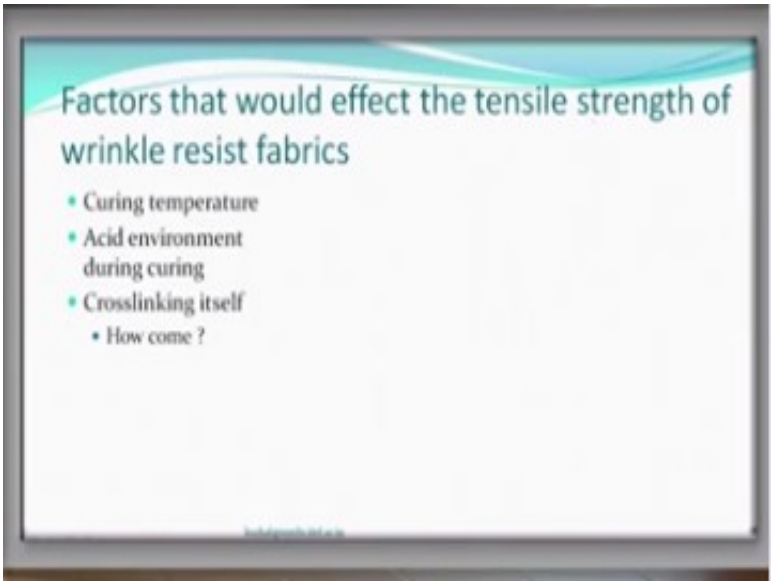

Then of course we are doing the crosslinking itself, so crosslinking what will be the effect of crosslinking acid is deteriorating, temperature is deteriorating what about crosslink. The crosslink in general is a common sense said well it can make a material stronger right you believe so. So, let us see something interesting.

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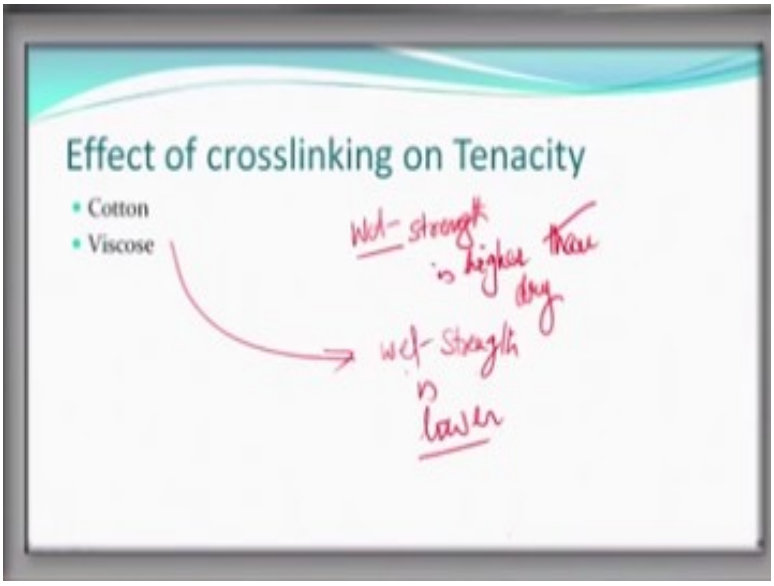

Effect of crosslinking on tenacity, tenacity of fabrics made from cotton of fabrics made from viscose. People found that this effect is different do you remember what happens is tenacity of cotton fibres, yarns, fabrics in wet condition compare to a dry condition. You may have been told that in the mills people keep little high humidity environment during processing on mechanical processing of fibres and yarns, you may have been told that the tenacity of cotton wet tenacity of cotton is high or is higher than dry.

So, wet strength of cotton is higher what about this viscose is always been seem that the wet tenacity or strength is lower, so that is the wet.

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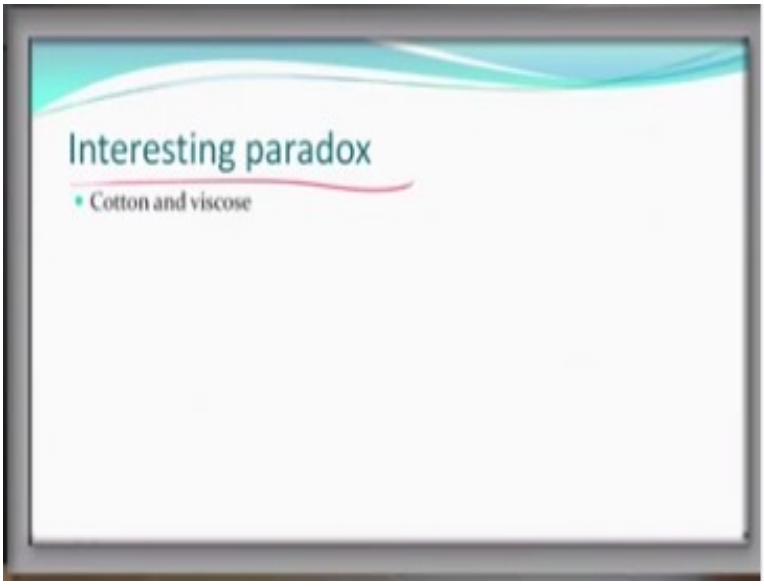

So, this is an interesting paradox the wet tenacity of cotton is higher and the wet tenacity of viscose is lower and why is that one of the reason of course we can think is the cotton basically is highly crystalline. But then why should the tenacity increase further this viscose is crystalline to the lesser extent why the tenacity changes here wetting process basically means some of the hydrogen bonds intermolecular hydrogen bonds have broken in the wet condition.

So, theoretically everything should become weak, but the cotton becomes stronger, so viscose becomes weaker interesting. And so how does one explain all this, this is the paradox.

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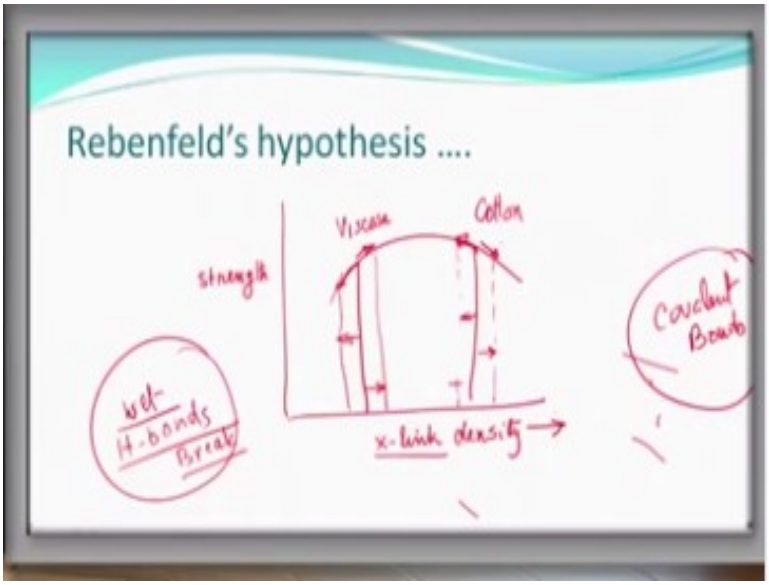

So, one scientist known as Rebenfeld had proposed a hypothesis if we plot crosslink density on one side and measure the strength. So, it does not follow the normal logical sequence it goes through a maximum that is initially when you increase a crosslink density the strength increases but beyond a certain value it may start decreasing. In this term called the crosslink density any type of he has assumed any type of intermolecular forces including hydrogen bond including crystalline regions including covalent crosslinks.

Everything which does a resistance of offers a resistance to movement of molecules which consider as a crosslink density not necessarily only covalent right. So, overall intermolecular bonding and forces that you have together if you put them and then try to plot. And what is

proposed an hypothesis was the cotton lies on this side of the curve the viscose lies on this side of the curve why curve said.

If we consider intermolecular crystallites which are there which also resist any movement are like crosslinks those are very high in cotton. Remember is more than two thirds of cotton as crystalline versus 35 to 40% crystallinity in viscose depending upon what you do it, it is a manmade or a manufactured fibres, so you can manipulate the microstructure**.** So, what happens if this is true then when you wet, so you are reducing crosslink density because hydrogen bonds are breaking ok.

So, if hydrogen bond break the crosslink density goes down, so according this curve viscose strength is going down. In the case of cotton if wetting takes place this phenomena will still be true that hydrogen bonds break they will break in the case of cotton as well. So, say because it was lying already on this side with too much of crystallinity already there and so it is strength increases.

This is the phenomena people had already seen in mechanical processing. Now when we introduce more covalent bonds then what happens, we are now increasing the crosslink density. So, we are going in this direction, so one has seen that if you go in this direction then the crosslink density increases the tenacity or tensile strength will increase in the case of viscose. Same thing when happens in the case of cotton the crosslink density increases but the strength goes down.

So, this is the hypothesis proposed by Rebenfeld because cotton is already highly crosslinked because of his crystallinity if you want to break molecule free. The molecules are go through the crystalline portion very difficult to remove, break because we have to then break the molecule, it is resistant suffered, so that is like a crosslink density, this is how we remember we define.

So, it is already so much crystalline therefore putting in more covalent bonds does not really help why is that so it should always help important thing is that absolute amorphous system. If you have and if you put crosslinks first diffusion can take place better, second uniform distribution of

the crosslinks will be there. And when you actually put load the load distribution among the molecules is going to be uniform all the molecules will share approximately similar amount of load.

And if everyone is together the total strength is more if this happens because of high crosslink density which exist already high crystallinity which exist already, you may not be able to diffuse the molecule as when you formally as you would have love to do that. And so there maybe some reason for believing that there are non uniform crosslinking takes place at the molecular level and when you subject to tensile load some molecules may have to bear or share more load than the others.

If they have approximately similar kind of strength the ones which bear more load will break first and once they break obviously the whole chain starts. So, this is the reason why the crosslinking itself in some cases can reduce the strength.

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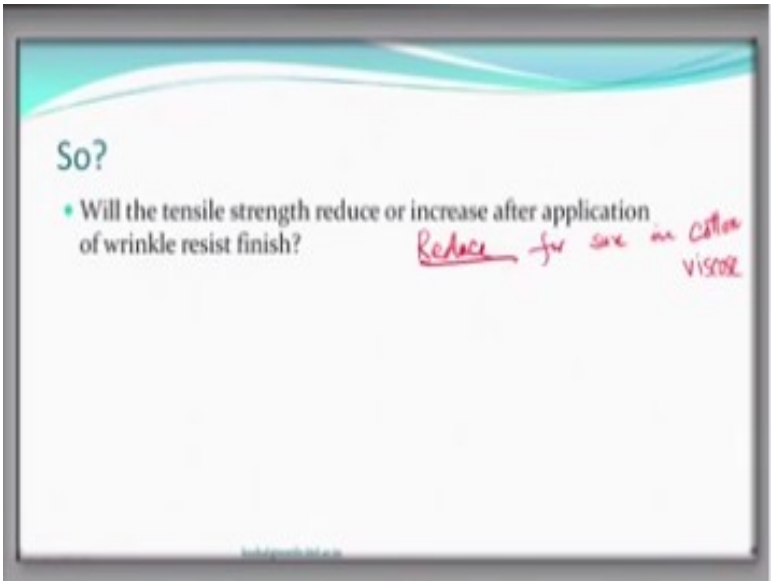

So you have the tensile strength reduces or increases after application this question obviously is answered would reduce for sure in the case of cotton right. Because there can be losses due to heat, there can be losses due to acid and of course crosslink himself. In the case of viscose thermal losses, acid losses if they are there they will be there however crosslinking can increase strength.

So, it is difficult question to answer alright, so what will do we would like to optimize in a manner that the losses due to heat and the losses due to acids are as less as possible. So, that whatever then happens, happens because of crosslinking itself.

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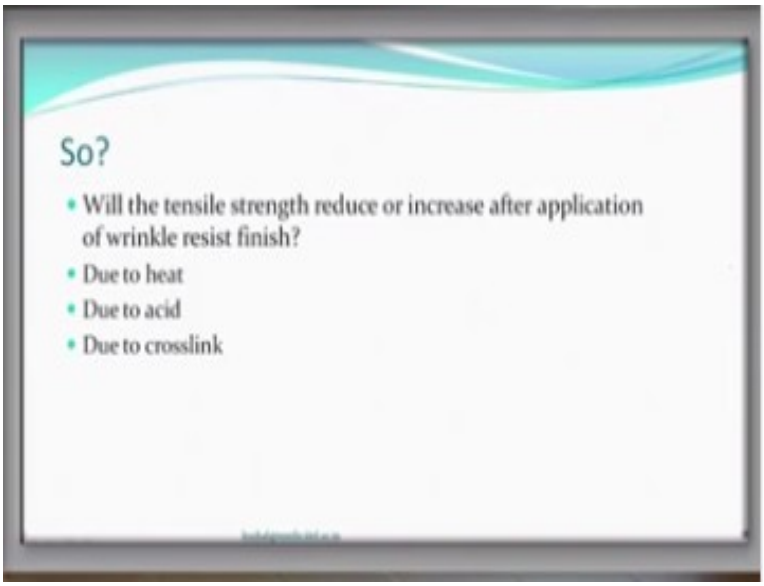

So, due to heat there can be losses, do not acid there will be losses if you do not control but you to crosslinking in both the fibre both types of fibres or wherever the crystallinity is less the behavior will be different them let us say cotton.

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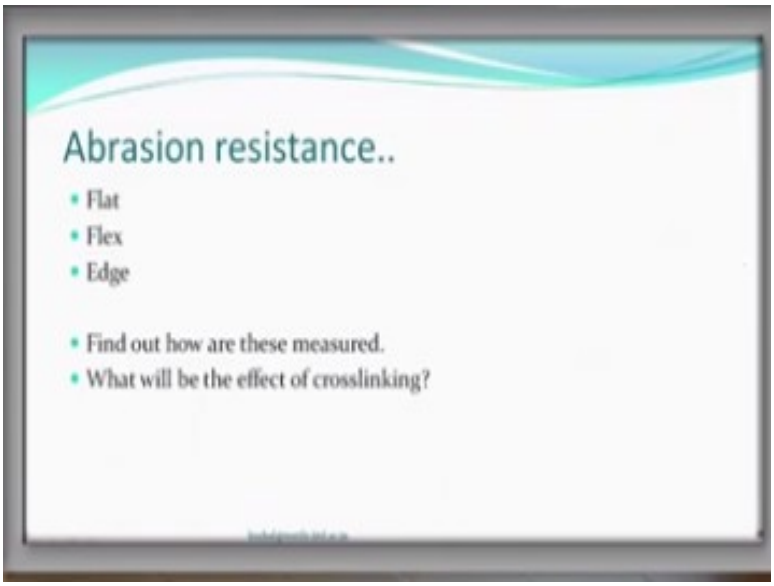

Finally let us look at another property which we call as an abrasion resistance, abrasion resistance textile is measured as flat abrasion like you rub surfaces or a flex abrasion like a bending. If you bend like this the fabric bends over itself and then abrades or the edge abrasion which is like in collars and cuffs. So, this is the way they have people measure the abrasion, so that is how you can try to check out which kind of a methods people actual testing methods how they are measure.

What will happen to this abrasion or any abrasion resistance after crosslinking will increase abrasion resistance. Because you have put some crosslinks or will it reduce if tensile strength has reduce abrasion resistance will also reduce because degradation is taking place as for as the crosslinking concern you can appreciate anything which become stiff is likely to abraded more because the abrading surface obviously is much more resistant and much more stronger compare to the textile.

And if textile wants to resist more instead of becoming flexible it is rigid it is more stiff than the abrasion resistance will go down. So, in some way we believe that crease recovery will improve we happy durable press rating would improve we have happy about it. But some of the other properties are going in the negative direction, so whenever somebody says well 1 + 2 down. Nevertheless if my aim is to produce a crease resistance fabric this finish is going to do your job.

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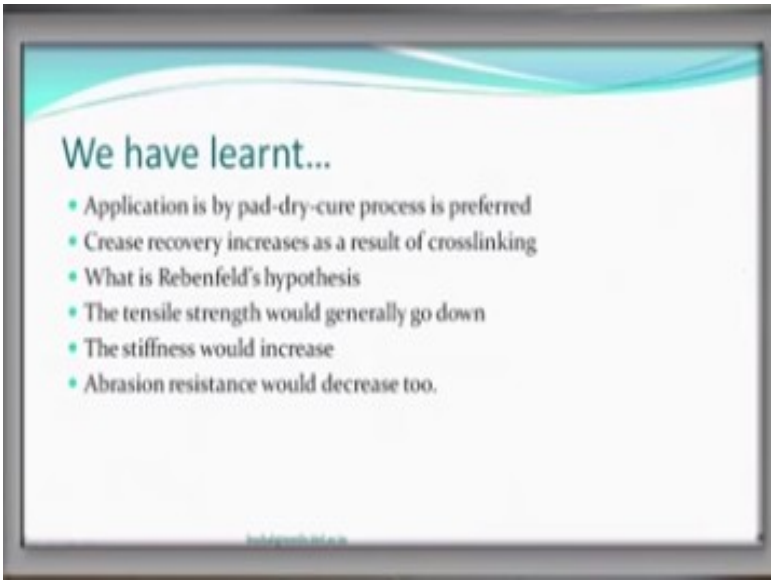

So, what have we learnt, we have learnt that the pad dry cure is a preferred process, creased recovery increases as a result of crosslinking. Rebenfeld hypothesis talks about how cotton and viscose behaved differently and by tensile strength generally we go down unless a case of viscose very optimize correctly. Stiffness would increase and abrasion resistance will decrease, resistance would decrease.

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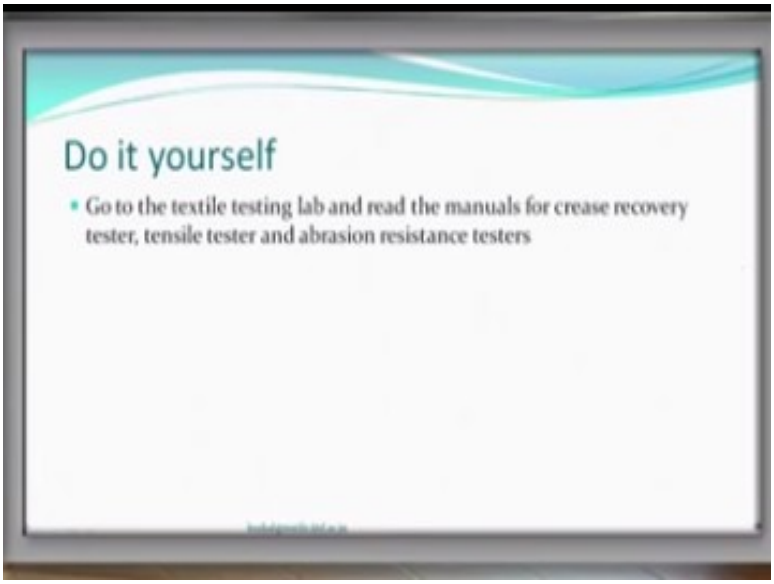

So, you can go to your lab check your manuals to find out how creased recovery testing is done, how tensile testing is done, abrasion measured or even bending length etc. So, you have some firsthand knowledge of how these tests are performed and you may then correlate as to why whatever we talked about is true.

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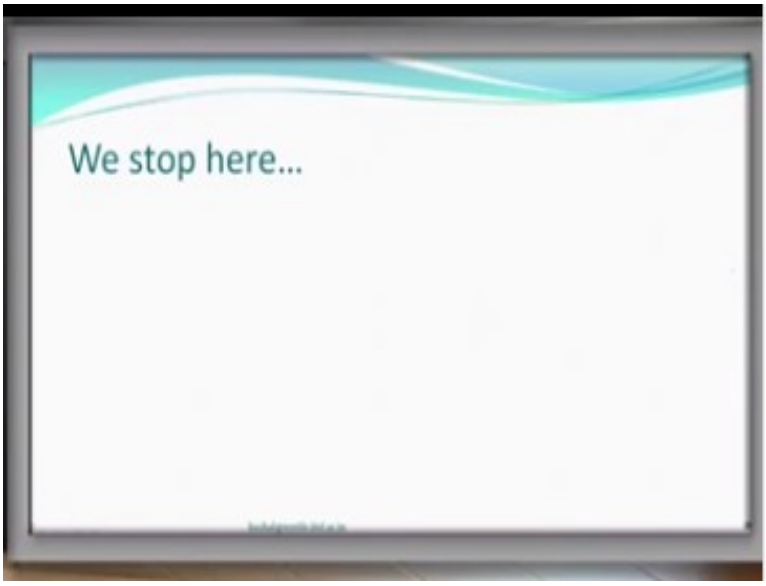

We stop here today, thank you.