Textured Yarn Technology
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Lecture – 31
Texturing of spun yarns

So, we have looked at various processes which have been used for texturing multi filament yarns and last time we did look at spun yarn texturing also, which was the bulked yarn Hi-bulk yarns. So, Hi-bulk acrylic yarn we know can be produced by mixing two fibers shrinkable, non shrinkable with a substantial differential shrinkage.

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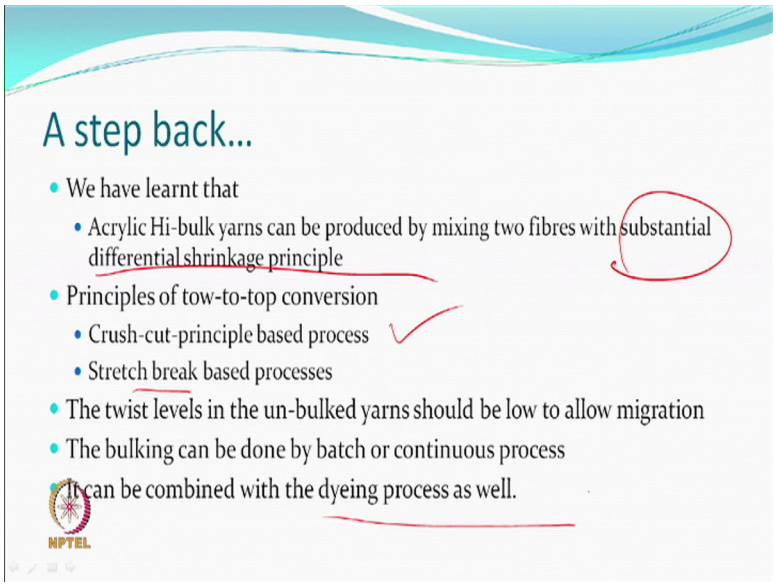

So, the principle would be differential shrinkage principle, but there should be a substantial difference between the shrinkage. Then we did talk about the total top conversion two basic principles; crush cut and stretch break. The twist levels in the un-bulked yarn should be low to allow migration of fibers, because shrinkable component is supposed to migrate to core at least towards the core of the yarn and the non shrinkable component would come out and be majorly responsible for the bulk generation.

The bulking can be done by a batch or a continuous process separately by steaming or any other dry heat that you may like to use; what is possible to combine the process of bulking with dyeing such as simultaneous dyeing and bulking can be done.

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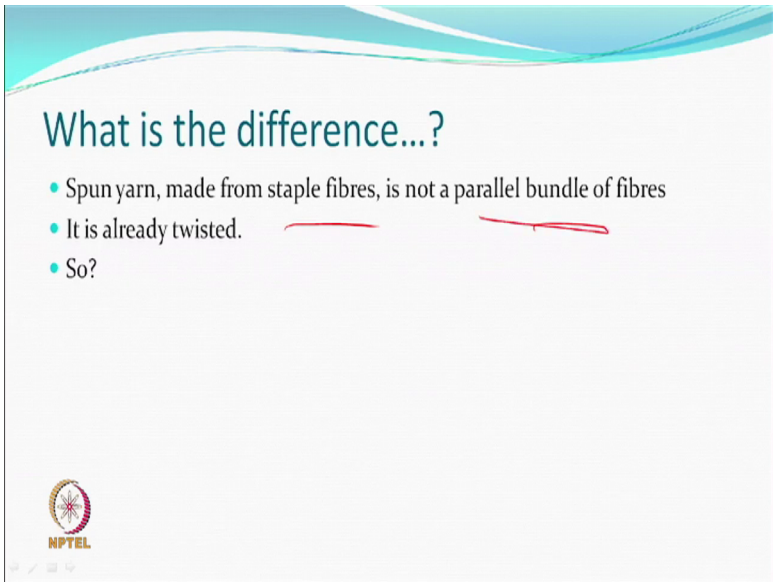

So, we look at the texturing of spun yarn. The yarns which are already spun using staple fibers and we want to get the same or similar effect which means that we would have stretch and bulk. So, twist texturing of spun yarns. So, difference between the previous one is the spun yarns are made from staple fibers, we were working on filament yarns, this texturing is concerned and they are definitely not parallel bundles of fiber they are already twisted material.

So, what do we do? If we do the same process that twist, d twist, untwist. So, there is a possibility that you may actually over twist because a normal spun yarn has got enough twist for all the properties that you desire, going beyond that optimum can either make it very highly of a nature which is snarling nature or may break fibers. So, how do we twist more? So, this has to be different than what we have been doing before because it is neither a filament and nor a parallel bundle.

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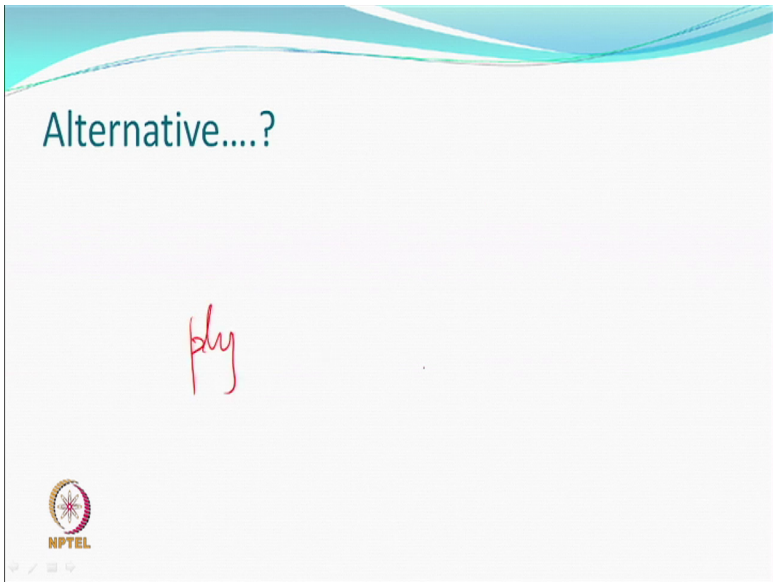

So, what is the alternative? The alternative could be that you ply or double take two yarns and then twist the ply give them ply twist so that you can give the ply twist of whatever desirable level based on the denier of the yarn and untwist after setting. So, this could be the one, we cannot probably use a single spun yarn and do similar things. We may also not be interested in having too many spun yarns let us say 10 spun yarns being twisted together, the denier is too high and it may or may not say. So, what people have tried is taking a double yarn giving a ply twist and then do whatever you were doing.

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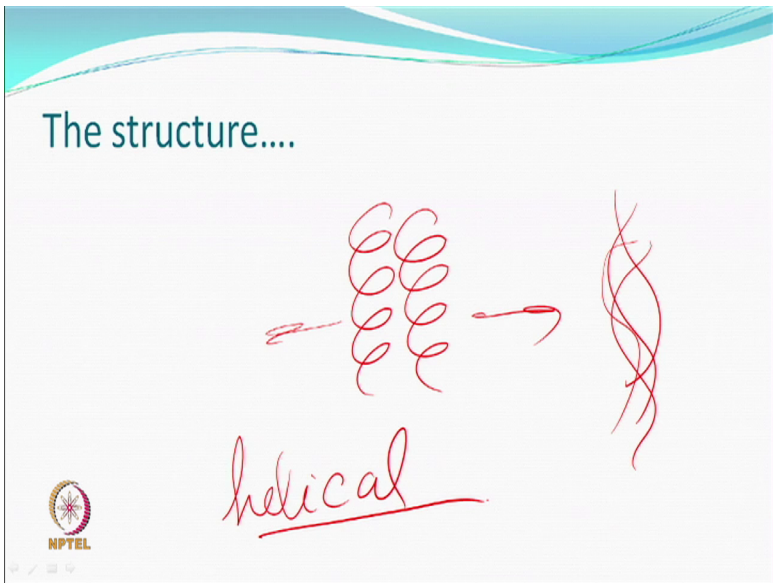

So, this structure will be if it is a twist texturing will be different in the sense that there are only two yarns which probably may have whatever structures that they can have and not many yarn. And therefore, if you are looking at the bulk generation it will be there because it is still a yarn, the denier of any spun yarn is not going to be small it will not like a denier of per filament of a filament yarn there will be much larger. And therefore, you will get the coils in a twisted structure, but then you are saying there are only two yarns likely to be there. And so, these yarns are; obviously, wrapping over each other when they are twisting right.

So, this is two yarns wrapping over each other not more than that. And so, this structure is like slightly different, but it will still be helical because you have the given twist, the same type of migration effects we will not see here, we do not expect in a ply twist the fibers from one yarn are going to migrate to the other yarn and then happen. So, those type of things will not happen. But really they are going to be wrapping over and so in three-dimensional space you will be able to get a helical structure.

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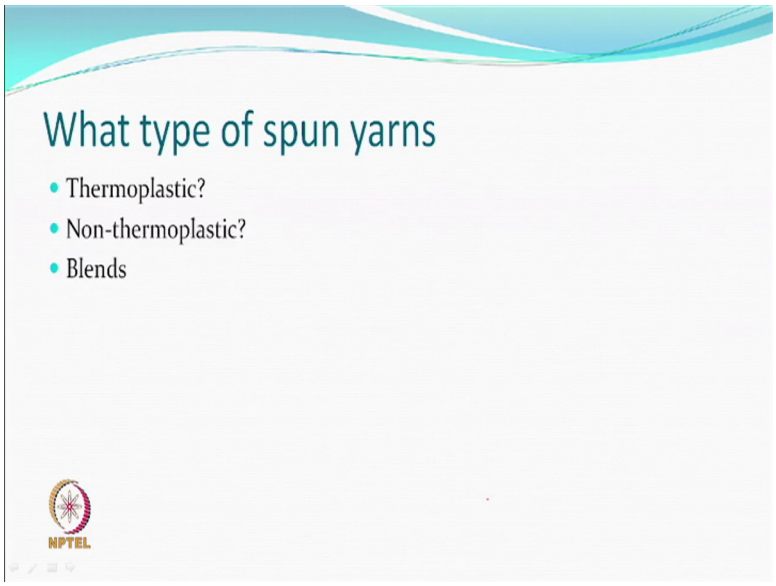

So, spun yarns are available of all types the thermoplastic ones like polyesters polypropylenes and non-thermoplastic you have all kinds of natural fibers that we have they are also available. So, what we are looking at and possibility of texturizing these things and yarns are also available as blends. So, you can have a polyester viscose polyester cotton type of blend also.

So, now you have another opportunity getting created where either the thermoplastic nature could be used in blends and do not use anything else or use mechanisms to set the non thermoplastic part also.

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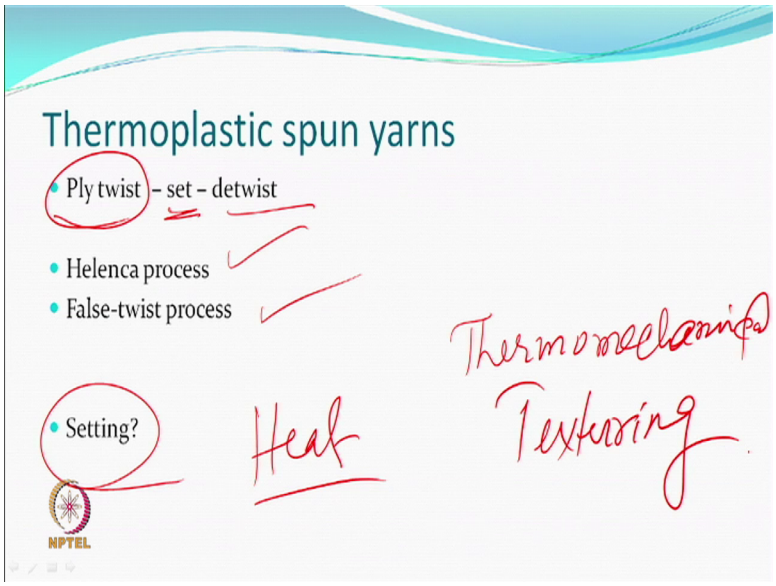

So, if there are thermoplastic fibers. So, you give a ply twist then you set and then detwist. So, this is the same type of process which under advice was a helenca process or a false twist process. So, one can use and employ these processes helenca being a best process it can be used a false twist is the continuous process this can be used, and the setting will be done by heat and therefore, this process should be considered as a thermo mechanical texturing. So, as a principle is the same thing all those setting by release of energy principles are involved.

So, although you will be having generally two spun yarn applied together and then heat set and then de-twisting and you will get similar the retraction properties because you are now setting this process.

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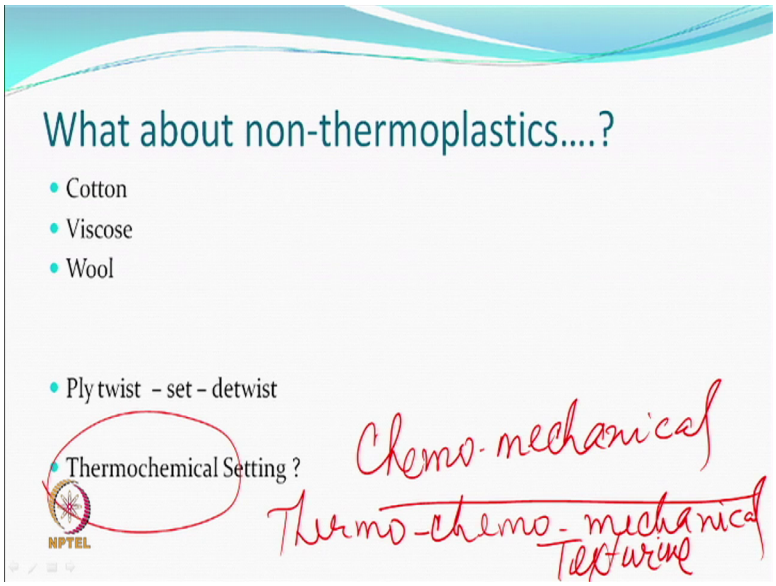

If we look at the non-thermoplastics so any material can be used, but a good amount of work was done on cotton viscose, some amount on wool and in some different senses it if you consider as a Hi-bulk material. So, jute, polypropylene combinations have also been done which are also as we said earlier they are spun yarn. But definitely there was an interest in this, a good amount of research papers were published we cannot say that they are commercially successful and people are not using them, but interest has been there and reasonable properties also were obtained from the bulk ans stretch point of view.

So, process will be the same, here also take two yarns give them apply twist of an appropriate value and set and detwist only thing is now the setting may not be thermo mechanical, but maybe thermo chemo mechanical so you can call thermochemical setting. So, mechanics anyway will come because you are twisting. So, it is in a way either a thermo chemical that is you may be requiring some heat as well to do the process or it may be simply a chemo mechanical. If your systems can work at room temperature, but invariably we might just say that it may be thermo chemo mechanical texturing.

So, one important thing is that chemicals now have to come into play. Whenever chemicals come into play means that you are not really going to be dealing with a completely dry process. So, whatever are the difficulties with a wet process those difficulties will have to be seen. Although final chemistry reactions may also take place

quickly, but invariably the time requirements here are not going to be very easily comparable with the thermal system. So, you may have to be very choosy about things.

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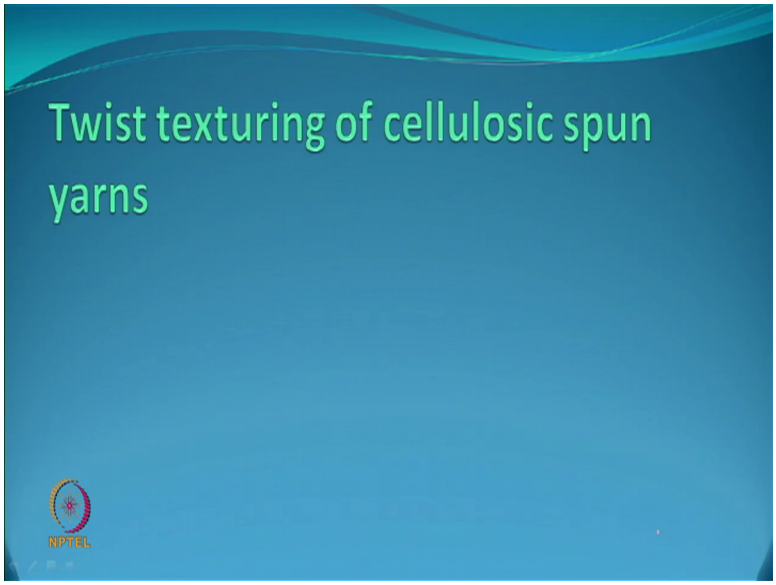

So, let us for some time look at texturing of cellulosic spun yarn, which means cotton viscose and such type of material.

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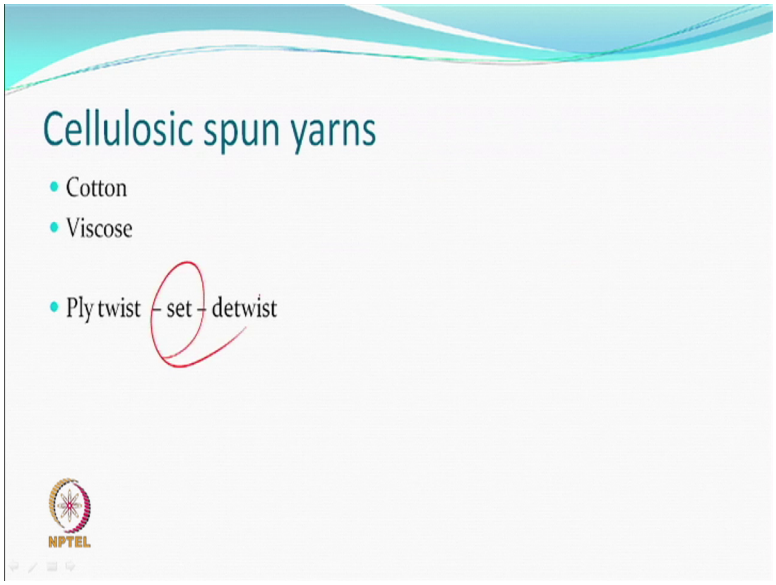

So, this is what it is which we said we will use these materials and go by the process except the difference will be here.

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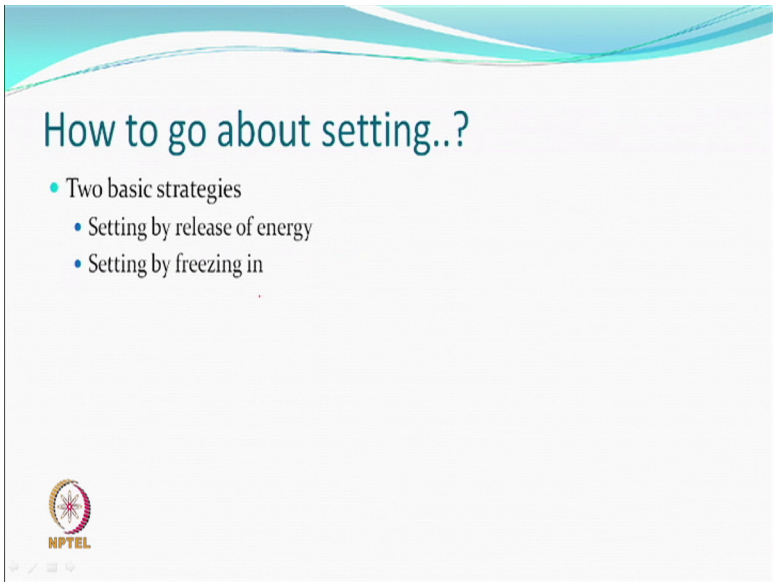

So, for this is concerned there are two basic strategies they do not change, you can set by release of energy or you can set by freezing in. So, the same thing that we discussed before will be valid here as well, only thing that may change is which chemical with solvent what kind of things you like.

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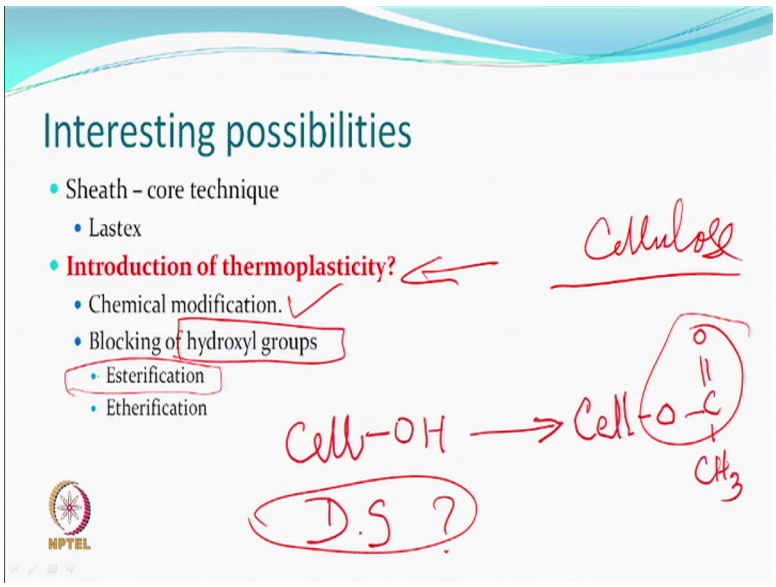

So, there were enough interest in textured yarn therefore, the earliest yarn which actually had the advantage of bulk and also stretch were the sheath core yarns, earlier one somewhere in 20's and 30's elastics. So, where elastomeric yarn was in the core and the

sheath was any natural fiber and so you get the aesthetics of natural fibres because a spun yarn through the bulk was definitely higher than a filament yarn and stretch was being given, this type of techniques are being used even today. So, wherever you have the sheath core system so, all the garments wherever they are supposed to fit snugly, let us say the upper part of the socks for that matter they could be sheath core based systems.

So, this is in some sense you can always say much before the advent of synthetic fibers you actually started enjoying the advantages of the bulk and also of the sheath. But because thermoplastic and thermo mechanical; thermoplastic yarn the thorough mechanical texturing was attracting attention and people wanted to use the natural fibers as well. So, introduction of thermoplasticity was also taken as a route to texturing. If somebody says well thermo mechanical means can be used then you try to introduce thermoplasticity to the yarn. So, that is like a chemical modification of the fiber itself. So, one can always say well this no more is cellulose as it is, but a modified version of cellulose because they are now doing chemical modification.

So, the plasticity thermoplasticity can be introduced by blocking of hydroxyl groups. It is the hydroxyl group which are in abundance for example, in cellulose because of which you do not see thermoplasticity when you heat the intermolecular bondings are so, strong that before any movement takes place between the molecules the main chain starts degrading. So, it has been one of the principles that if you want the material to respond to heat, then you reduce the hydroxyl groups how much that will call as a degree of substitution. This can be done by many means, you can do any kind of things, but esterification we already know we have triacetate diacetate fibers.

So, you were doing the ester linkage was being introduced. So, depending upon what degree of substitution the glass transition will keep coming down. So, in cotton you do not see glass transition, you do not see melting you do not see glass transition; that means, the molecules will not move with respect to each other because of heat. But when you start blocking them hydroxyl group with a polar group are getting blocked. So, one this bond cannot be hydrogen bond cannot be made the distance between the molecules also starts increasing and therefore, as you increase the temperature kinetic energy can increase and so you can see glass transition temperatures also and that mean thermoplasticity is being introduced.

So, simple reactions like this can do the quite aware. So, people use the same process the cellulose acetate was made by using a pulp and completely acetylation and then you dissolve it and then make a fiber out of it this is not the case here you want the cotton to look like cotton the spun yarn, as it is the chemistry was done in the spun yarn stage without destroying the yarn.

So, you are only modifying part of the yarn; the yarn as a spun yarn will still look like a spun yarn right. So, the trick is that you do not change too much first change enough which can give you some respond to heat and therefore, this was one of the methods people tried to do chemical modification by blocking hydroxyl groups first by esterification which they were quite familiar with. Other is etherification that instead of making an ester you make an ether link which also means that you are your hydroxyl group is not available as it is.

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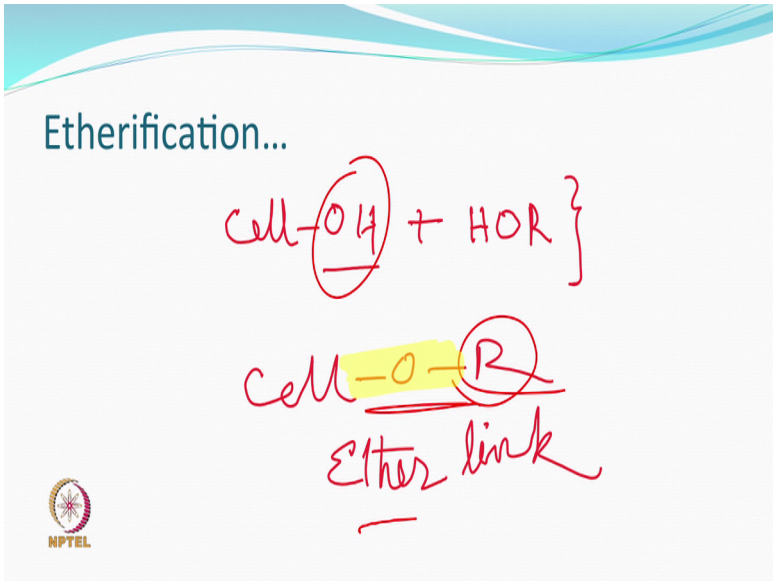

So, for example, ether means you have two alcohols reacting with each other and so, you produce an ether link. From the point of view of stability of these links, ester links are more susceptible to alkaline conditions; ether links are more susceptible to acidic conditions.

So, theoretically you can hydrolyze anything, but what we understand is that when you do normal washing laundering kind of conditions that you give whether these bonds of to break no not very easily. So, based on this R the size, the distance between the two

adjacent molecules will be decided. Other than blocking you have a steric moiety also which I will take space. So, if it r is smaller or R larger the changes that you can expect in the properties of these fibers let us say viscose or cotton can be different.

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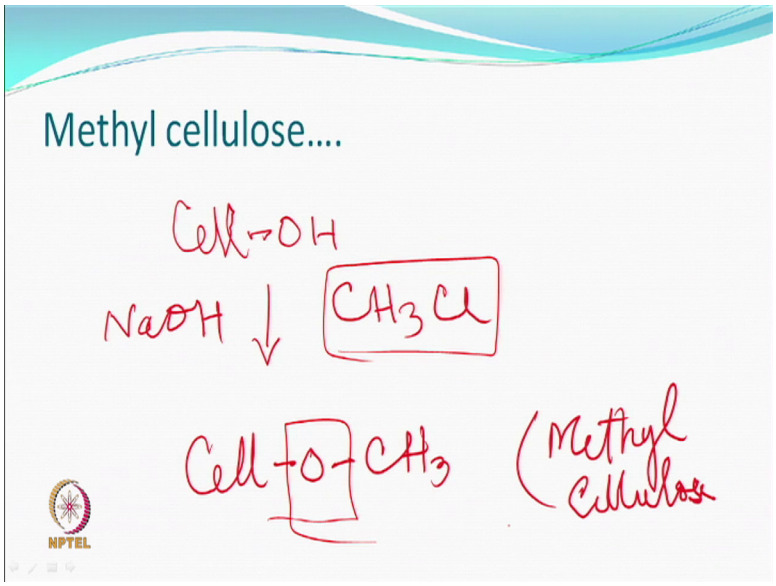

So, this is one of those things people know, some of these compounds have also been used as thickeners. So, to get a methyl cellulose so instead of taking alcohol you take a chloride which means the reactions can happen at a temperature which is not too harsh like for example, it was a methyl alcohol and you want to use cellulose, and keep boiling it you may find no ester group has generated.

Now, not whatever and normally alcohols will boil before evaporate before anything else happen. But the moment you add chlorine group the reactivity becomes quite high and so in alkaline conditions you can expect an ether link being generated, which is called the methyl cellulose. That means, what will be the garage transition temperature, how much will be the change will depend on how many OH groups you want to block. So, stoichiometric reactions may have to be done to say if you block more change will be more if you block less change will be less change definitely there will be.

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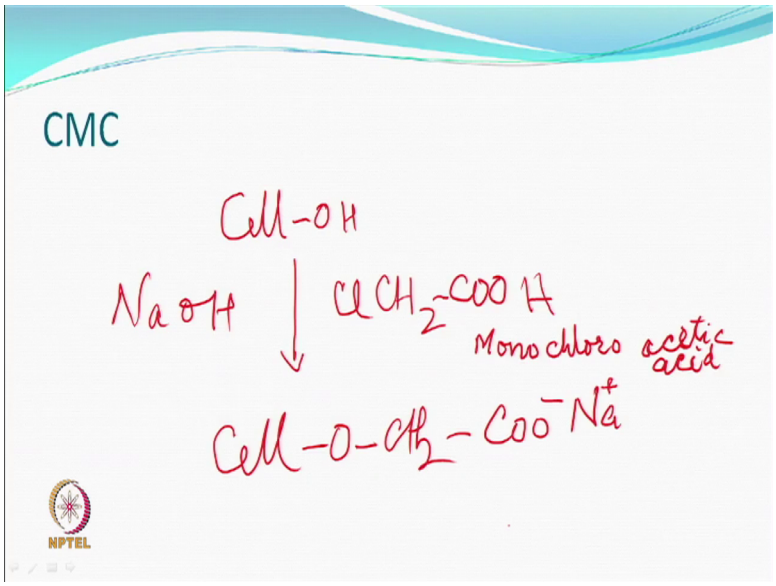

This is called carboxymethyl cellulose, now here instead of methyl you have carboxymethyl group being added. So, the size is more ether link still remains and you are using a mono chloro acetic acid. So, again you have a chloride often acetic acid, which gives you the CMC carboxymethyl cellulose. You can appreciate carboxymethyl cellulose also can be sodium salt of the thing can be dissolved in water if you do good it is used as thickener.

So, if you do too much of this, then you will get a material which is changing so, much not just to heat where to we till respond to any aqueous solution making process as well. So obviously, we do not want to go to that thing otherwise no point. So, in every kind of a thing where you are looking a partial modification, but then you also are concerned as to how much reaction you must do and how much change you are going to get. So, what people did obviously was, modify these and cotton yarns and then take it to thermo mechanical texturing process and get some effects and which are permanent in the sense whatever permanent means in this world, that during normal washing you would not see any change happening. As if remember hyper lean process of viscous texturing involved only setting by steam.

So, they are very happy about the process, but when you put it in water all the new bonds, new hydron bonds made in different positions will get broken down and make bonds a new position. So, all that effect would go, but if you do go by this process effects

will not go how much will be the better effect will depend how much blocking you have done. So, that remains is the degree of substitution.

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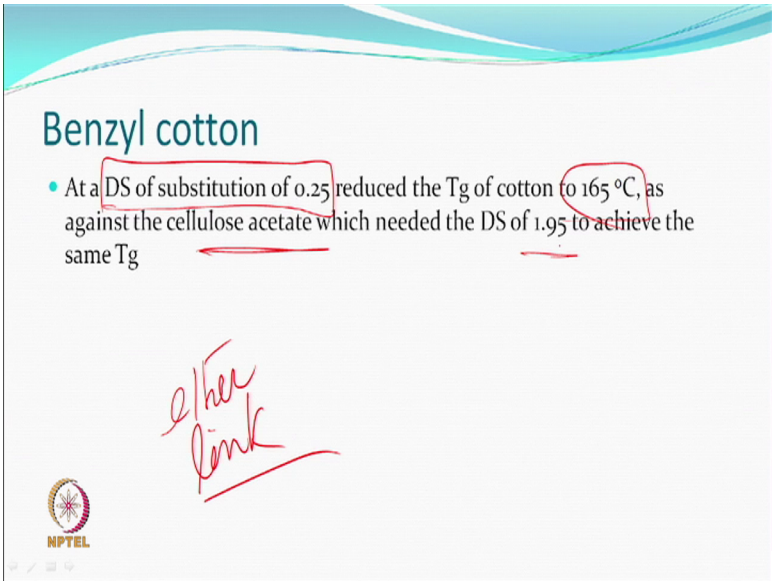

So, one of the thing which they found was quite successful in making textured yarns, this is also an ether link being created is called the benzyl cotton, using benzyl chloride that they found that at a degree of substitution of 0.25.

So, theoretically we could do three maximum. So, at a degree of substitution of 0.25, the glass sense temperature of cotton was found to reduce to 165. If you do more it will go further down compared to a cellulose acetate if you wanted that if you will not for me, you require almost 1.95 or more to get to 165 degrees of glass sense temperature. And why because benzyl means there is an aromatic ring which is also getting attached and therefore, distance between the molecules can be large and so, it became more effective less change, but more effective. You go 0.5 maybe temperatures will come down further glass transition temperature and so some of the changes could take place that is what there.

So, they found etherification by using benzyl chloride, it was an effective way to modify cotton to be good for using finally, thermo mechanical means for texturing. You can appreciate the kind of expectations that you have with a multifilament yarn, we are not there here, this any spun yarn is much more bulkier compared to a multi filament yarn. So, they were already bulk now if you increase any further everybody liked it, but more

than that the stretch that comes. So, as long as the setting is optimized then you could get. So, this is how people working on; that means, that the textured yarn and the properties there of were of considerable interest to the people.

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So, I mean other methods are also tried not really so, successful like cyanoethylation of cotton also could introduce thermoplasticity. Other process people tried was called and the principal called crystallization, de crystallization or in the other way, if we say decrystallization and recrystallization, it is something similar to melting or a partial melting. In partial melting as we say thermo mechanical systems also we said partially it will be decrystallize and then recrystallize. So, decrystallization recrystallization processes going on. If that can be done by chemical means it should again lead to a setting.

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So, crystallization decrystallization process was tried and what do you do there? You need a solvent. It is not easy to dissolve cotton, difficult solvents are being used therefore it is stable, sodium hydroxide solutions moisturizing caustic it withstands. Here boiling four hours 10 hours together with stands. So, the normal common systems are it is much more stable and that also just in a way proves that the so, called ether lake and the inter molecular and bonding strong enough. So, solvents are required.

So, one of these solvents if you are aware was called a cuprammonium hydroxide. How many people heard this solvent? So, what does it do, what do we do with this now; what do we do with the solvent? So, one is the rayon itself. So, there were two processes which are being followed; which were being followed in earlier days. One was a xanthate process of dissolving the cellulose first modifying and dissolving and then regeneration. Otherwise directs solubilizing using cuprammonium rayon, copper and ammonium this hydroxide is a complex which is very delicate complex. Change of a bit of a temperature here and then the gas would go and find this is not more effective. But even today this cuprammonium hydroxide solution is used to determine the fluidity of cotton or cellulose. Fluidity is inverse of viscosity right when you do is covering when you do bleaching there is a degradation of the molecule.

So, people like to know how much molecule has been degraded. So, if it degraded more fluidity is more with the same concentration. So, this can be used, but again people found

it difficult to handle this solvent for a process for modification. Then they found another you know organic compounds like zinc chloride at different aqueous concentrations, this can be the act like a solvent. The solvent means that it would be able to separate the molecules without degrading, sulfuric acid can do the same thing if you do a concentrated sulfuric acid cotton will become completely solubilized.

But you will not be able to get back anything because the main chain also has been broken down. It is like N going for a flaming portion heating going to temperatures of 200 550 300 degree centigrade that degradation is permanent. But these type of solvents at certain concentrations can act like two solvents without degrading thing they can break down the intermolecular bonds, they can work at the crystalline region decrystallize.

So, if you treat with this the crystallinity of the compound material will go down of the cellulose and again can be recrystallize. Things like ethylene diamine they are also considered to be good solvents, tetraethyl ammonium hydroxide TEA is also a good solvent and they are not as delicate as cuprammonium hydroxide and they have been also tried to do the texturing.

Now, in this case you are dependent only on a solvency property, and not introduction of thermoplasticity. In the first case you were first introducing thermoplasticity and then using thermal means to do the texturizing. In this case you are using this solvent to do exactly what you were doing is a partial melting and recrystallization. So, decrystallization and recrystallization using these solvents; obviously, optimize and then you can remember here like during heating melting and recrystallization both take place. Similarly during solvent absorption decrystallization and recognization can also take place because crystallization is still a thermo dynamic process if you give opportunity molecules will like to crystallize.

So, you can have a complete solution through which crystallization take place, if that was not true, you would not be able to make solution spun fibers they all crystallize. So, it is a kin to melting process melting recrystallization partial melting decrystallization. So, you have partial decrystallization and recrystallization. So, this is the process which the solvents follow and expected the people who are working on these found the crimp rigidity of the textured yarn; obviously, was influenced by the extent of decrystallization

and recrystallization. The process optimization for the same kind of solvents with viscose versus cotton will be different because cotton is more crystalline compared to viscose.

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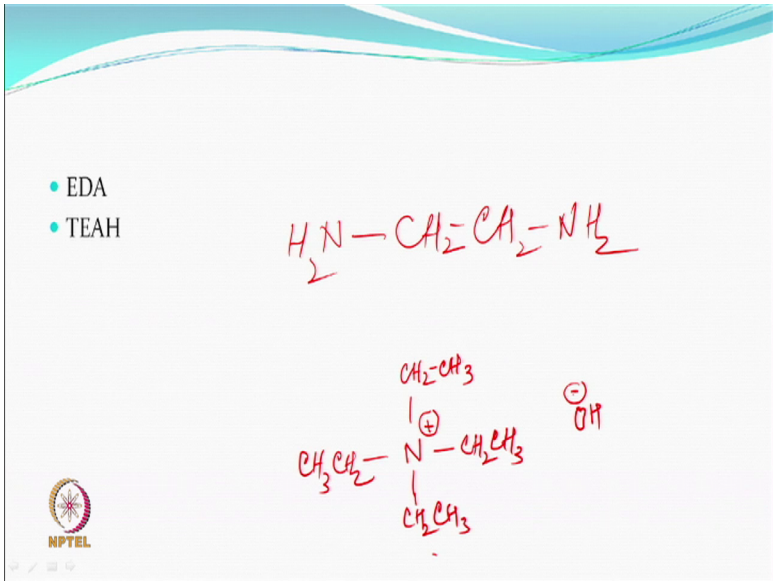

So, difference is almost about 20 percent or more and so optimized temperatures more than temperature let us say time would be different. So, ethylene diamine is an organic system and try itethyl ammonium hydroxide is; obviously, an ammonium bound. So, ammonium compounds are for linkages therefore, they get a positive charge and an hydroxyl group which may be associated with this. So, is an ammonium salt. So, they can also break quite effectively the intermolecular hydrogen bonds within the crystalline region also. So, they have been used for decrystallization recrystallization process to get a textured yarn of cotton and viscose.

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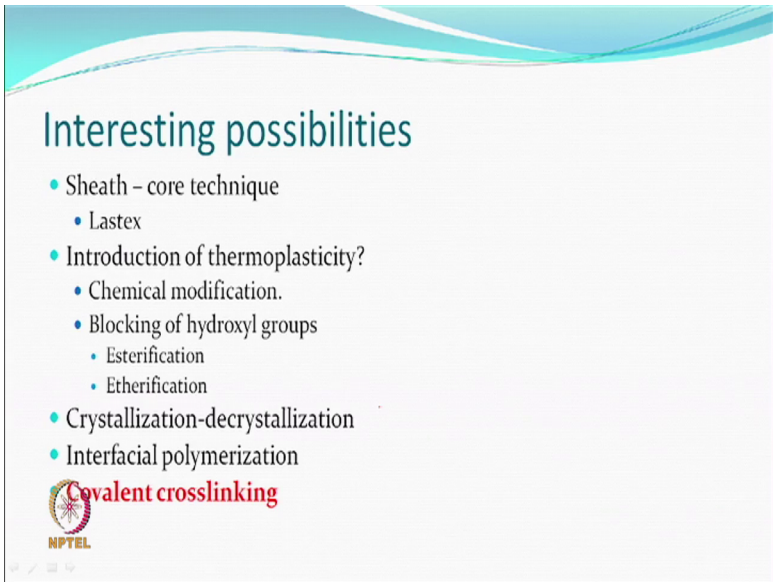

So, it is just showing that there have been enough interest for people to keep working. So, interfacial polymerization of the yarn spun yarns let us say cotton we will also been attempted. This is different than thermo introduction or thermoplasticity by chemical modification here there is no chemical modification it is only deposition of the polymer on the surface. So, this was found to be one of the easier techniques to get a layer of thermoplastic material on a fiber surfaces.

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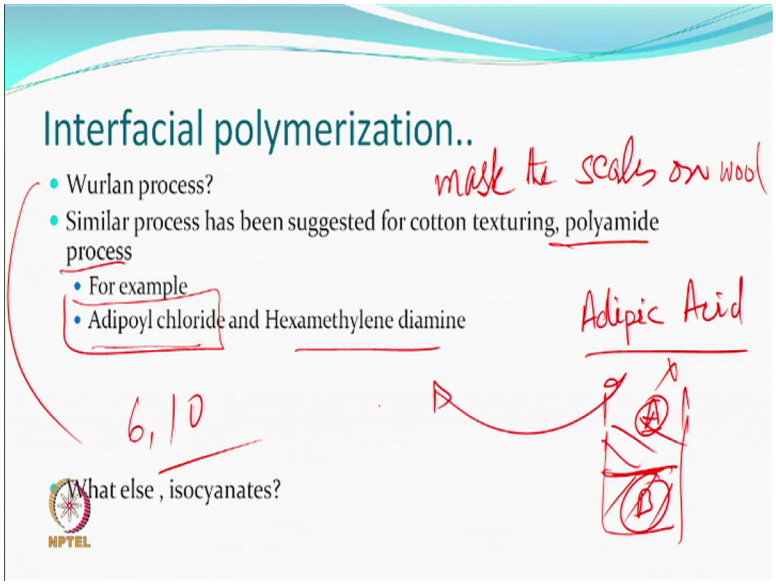


Have you heard a Wurlan process, how many, what is it?

Student: To reduces the scale of wool on the surface of the (Refer Time: 37:56)

Alright so, this process has been used.

Student: Scale.

To mask the scales on wool so we know woolens have the process in which you call the shrinking takes place because of felting and which is because of the scales that you have on surface so that directional frictional effect as the column. And the only way to avoid this was either remove the scales by mechanical or a chemical process or cover them up by a polymer. So, Wurlan process used interfacial polymerization method to coat the fibers.

Similar process were tried for texturing also and they called it a polyamide process because you were generating a polyamide on the surface. So, if you have adipic acid and hexamethylene diamine, if these two things are there what do they give?

Student: Nylon 66.

So, they give nylon 66 then you know how the nylon 66 is polymerized it is polymerized at a very very high temperature pressure conditions right. But in case instead of using adipic acid use adipoyl chloride, reaction can take place instantaneously at room temperature just like that that is what will interfacial polymerization. So, interfacial polymerization the reactants are highly reactive. So, making a chloride of an acid can give you a very highly reactive compound. So, normally what would happen is that, if you have two solutions and you have one reactant here A and the other as B and highly reactive. And if there is an interface let us say one dissolves in organic solvent the other dissolves in equus systems.

So, interface they do not mix they come in contact only at the interface and immediately polymerization takes place and that is what is called the interfacial polymerization. So, what we people do adipoyl chloride is reactive and goes in organic phase heptanes, hexanes so on so forth and hexamethylenediamine can be in equus phase.

So, you can pad a sheet of yarn through hexamethylenediamine and then let it again after padding squeezing let it go through the adipoyl chloride immediately there will be a polymer formation on the surface. As it is passing this reaction is very quick at room

temperature and then of course, you can wash dry whatever. That means, you have a thermoplastic layer nylon polyamide is a thermoplastic layer you can use this.

So, theoretically any acid right can be used this is a six membered carbon you can have a ten carbon like a super coil chloride different kind of polymers can be made, wurlan process used a nylon 6, 10 to get this polymer done. So, you could use any one of them. So, this type of a process which has been used has been used with other polymers all monomers also like isocyanates. You heard about isocyanates somewhere, how do you have, where have you heard about isocyanates?

Student: Poly urethane.

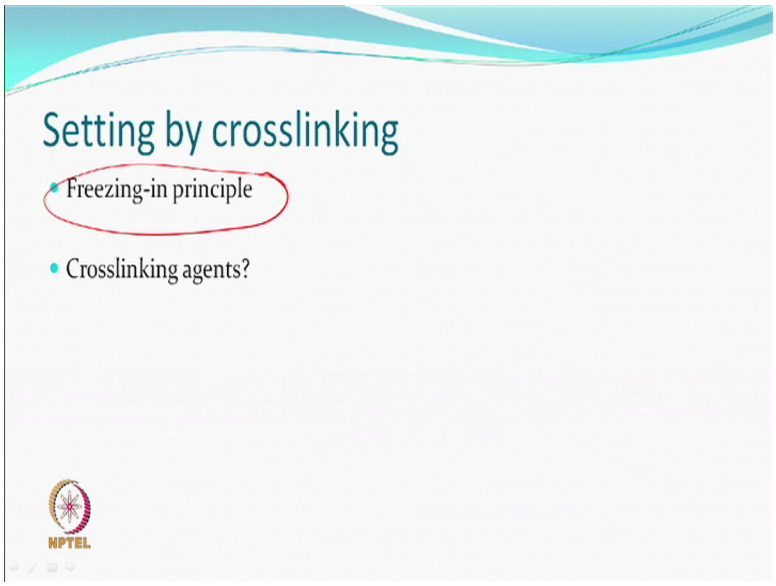
You have any story on that?

Student: (Refer Time: 42:48).

Right so it is a disastrous kind of thing is disaster because it just the moment it looks at the hydroxyl group it reacts. You see a what are just reacts does not have done wait so, quick. So, you have to really contain it. So, working with isocyanates can also be done polymerization can be done, you can make poly urethanes, poly urethanes are being made now also, you have to be very very careful when the reactions takes place. After reaction is taking place polymer is relatively more safe right, the monomer is very very active. So, acidic chloride like adipoyl or isocyanates can be very reactive compound which can participate in interfacial polymerizations and; that means, you can coat the material and then use the thermal means.

So, the other thing look and see that the cotton and cellulose had attracted attention of the researchers so much that many methods have been tried finding that this is not a thermoplastic material what do we do? So, this is what peoples are doing it they finally, what is called a covalent crosslinking that you there is a different than what has happened before. That you are actually making a covalent crosslinking between the molecule rather than breaking anything, to adding things and so this employer is definitely a principal of freezing in.

(Refer Slide Time: 44:17)



So, this could be done with the multi filaments also viscose which we said sometimes you could do it can be done with the cotton viscose staple fibers as well. It can be done on wool also in case you have a nice kind of a crosslinking agent, which can link with wool or a sell any material where you can produce a cross link covalent cross link. And covalent cross link obviously, must stronger than any hardened bonds, if that happens then the effect that you will get is going to be permanent; you know permanency as we said is a relative term. So, we can stop here and continue from here further.