Textile Finishing
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Lecture - 25
Wool Setting

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

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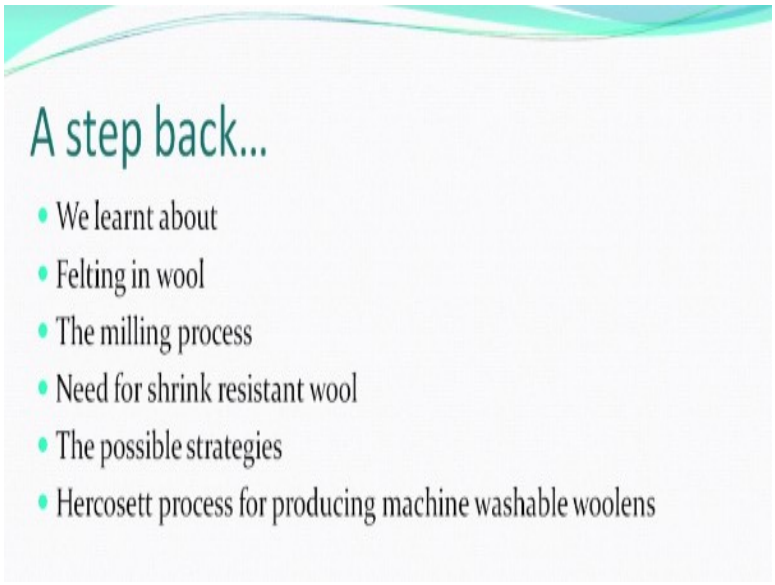

We were learning about some finishes on wool. One of the properties that we learned about was the felting in wool which is basically because of the scales on the surface that we see. Because of this, we had one interesting process called the milling process and another process which is opposite to the milling process, the shrink-resistant finishing process where it is desirable that you could make machine washable woolens so that you do not have to go for dry cleaning. These were some of the things which we learned about and some of the processes which can be used to do these finishes, particularly the shrink-resist finishing.

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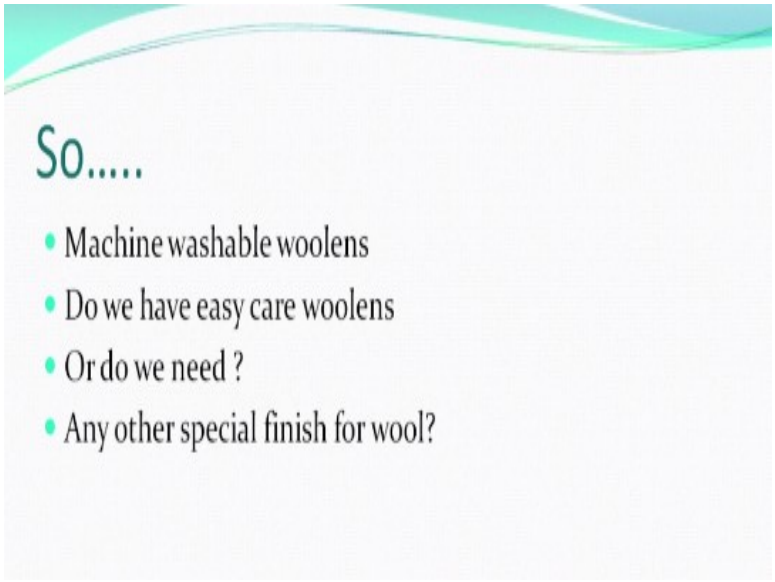

So, we have learnt about the machine washable woolens, that is one. One thing which you may like to answer is do we have easy care woolens as such, so that is what important thing is, does the machine washable means that this has to be in easy care like you wash and use. One is that it would not shrink, the other is that it would be a smooth nice beautiful surface, so that is a question which we have to ask, does the anti-crease treatment will lead to such a condition or we would need something else, any special finish for wool, that is the question we shall be answering today.

So, there is a finishing process or processes which come under what we call as setting, that is whether it is a surface which is flat, or you have creases like the crease here or pleats if you want to set, then what will you do alright. So, one of course is the plain surface, smooth surface, which is generally creaseless, so setting will come there.

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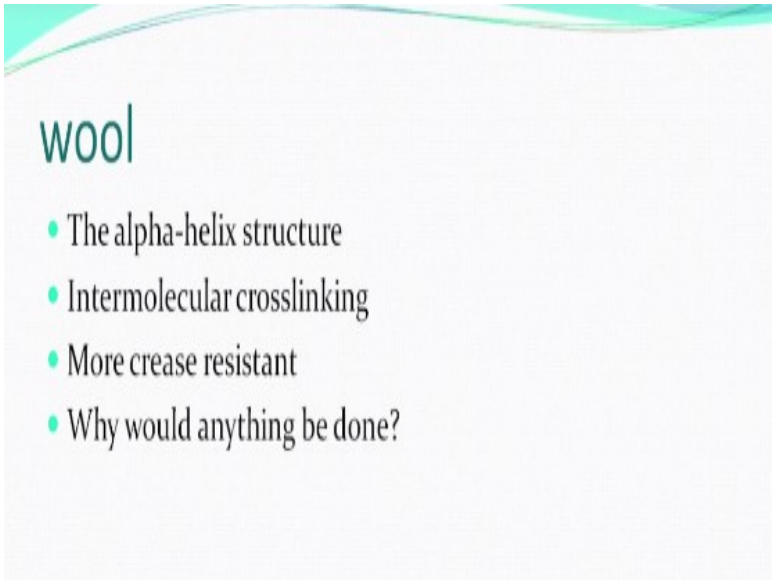

One important thing again we are asking is does wool need extra care for this purpose against creasing and maybe dimensional stability. Why are we asking this question? Because if you remember our fibre which is wool it is a protein fibre which has alpha-helix structure and also it has intermolecular covalent crosslinks in the form of disulfide linkages. So, normally we would expect that wool will be more crease resistant which is true also.

So why should anything be done, you know that would be the question which people would like to ask, why should anything be done when already you have intermolecular crosslink and that is what should satisfy any type of crease resistance that is required. Let us see if it happens or it does not.

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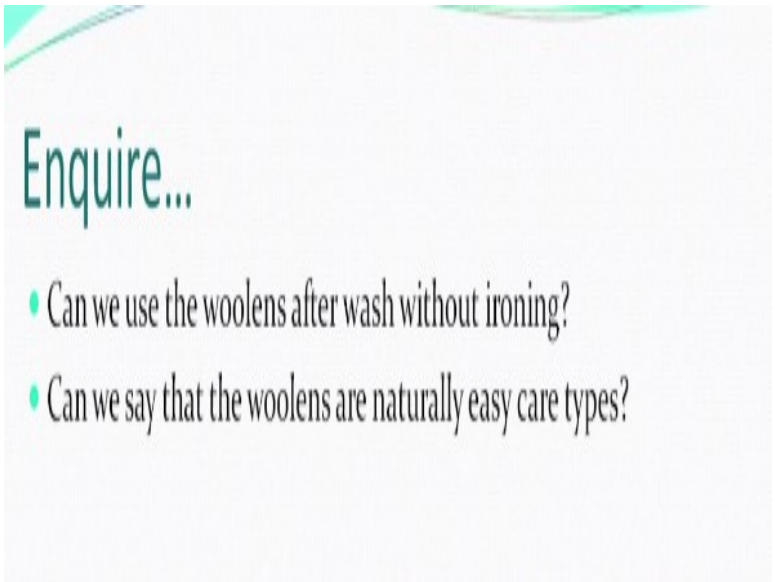

So, this question you may like to answer from your own experience if you have. Can you use woolens after washing without ironing, jackets or sweaters or cardigans and what have you, would you like to use them without ironing, and can we say wool or woolen fabrics are naturally crease resistant and easy-care types. If you answer these questions, generally we may come to the thing now we will have to do some a bit of an ironing before we say well we are good alright, that means whatever exists as it is may not be sufficient enough to do what you expect, let us say from a crease resist finished fabric.

Therefore, this setting of wool comes as a topic or a finishing thing. So, we will discuss something about what is this setting of wool which already is supposed to have intermolecular crosslinks, but remember there are many other intermolecular links, their ionic bonds are also there, you have hydrogen bonding also. These bonds can obviously give away whenever wet right abundant in number. So, setting if we talk about, there is a relaxation setting you see.

Relaxation means if there are sprain, stresses which are already stored within the fabric or a garment during manufacture or for any other reason, they should be released. If you release those stresses, then you can set.

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So, if you leave the material in cold water for some time, material I am talking about obviously is the wool fabric in cold water, what will happen? Yes, some of the hydrogen bonds would break, if there is no tension it can set, that means it can release its energy and be in a comfortable position thermodynamically, but let us say there was if you remember a

process we discussed sometime back called the London shrinkage that was exactly the kind of process that you leave the fabrics in a folded form or otherwise for some time in not so tension conditions, free of tension conditions.

That is tension free conditions and hope all these stresses will be released and the fabric will be relaxed and so it will be set in some sense. What it means, it will not like to go to any other state because it is probably in the lowest energy state, but when you set anything in cold water and you wash it again, you might find that whatever set was there it gets washed off because when you wash that is also cold water. So first setting which was done in the same condition, if another condition is provided during washing, then the previous set could be undone.

So then, people thought maybe if we do the setting in hot water where more opportunity for intermolecular forces rearrangement can be permitted, in that case maybe it would behave better. So, it was seen that if you set something, not something sorry the wool fabric, in hot conditions, hot water, then whatever setting was done in the hot water, it would remain as it is if you wash in the cold water. So normally, what you are saying, we do not wash, why should we wash in hot water if we can do at a room temperature or cold-water condition.

So, if you set something in hot water condition and wash in the normal temperature, then you might find that the setting stays, right, you understand. If you set in the cold water and wash in the cold water, it goes off. If you set in the hot water which could be let us say 60 degrees, 80 degrees or whatever, water maybe boiled, then at a lower temperature if you wash, it stays, but if some process requires higher temperature washing, then you may find that part of the history which was created during this process of hot water setting can be changed.

Then came another state that if you suppose do the same thing in steam, steam obviously is above 100 degree centigrade if it is atmospheric, but it has got many things. What the things it has? One the steam has a latent heat. So when it strikes the changes that you can bring about compared to let us say water at 100 degree centigrade versus a steam at 100 degree centigrade the amount of energy that can be transferred from the steam will be much higher because steam contains what the energy due to the latent heat condition, alright you understand.

If that is true, so anything which would be set in the steam, this is what people observed, then it can be washed even at a higher temperature, certainly at a low temperature, at room temperature, the setting would remain for long period, what was the first observation shall we put it this way.

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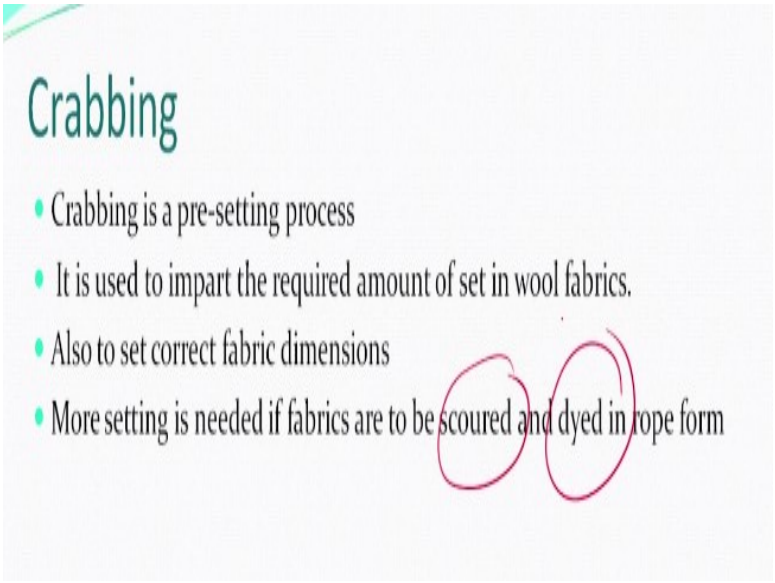

Based on this discussion that we had, a process, finishing process or a pre-finishing process, what we call it for woolen fabrics was designed and that was called crabbing okay, very funny name, but that is what it is. It is a presetting process, presetting means that is not a final process, normally we believe that all the processes which come in the finishing which we are discussing would be approximately the final processes, but crabbing is one of the interesting processes for woolen, a presetting process that means it is setting but not the final process.

So certain amount of required set, may not be permanent but it is quite good depends on what you are doing, so you like that kind of a thing to happen, during this process this is one of the objectives. Also if the fabric must have been processed in one way or the other, the dimensions are not right, so if you have to stretch, you have to extend in whichever direction, so you can do that and make a possibly dimensionally stable fabric, so that is what will be the aim of this type of a process.

Now the conditions of this process which is crabbing can be changed based on whether the fabric is going to be further processed in an open width form or in rope form, you understand what is rope form, so you collect the fabric and then make a rope of it and then process, if that is what you need to do for example you may like to do scouring, you may like to do

dyeing in the rope form, then maybe you will say the crabbing will be required and maybe the conditions will be slightly more higher. For example, more time, more temperature could be one of those things, a more stringent.

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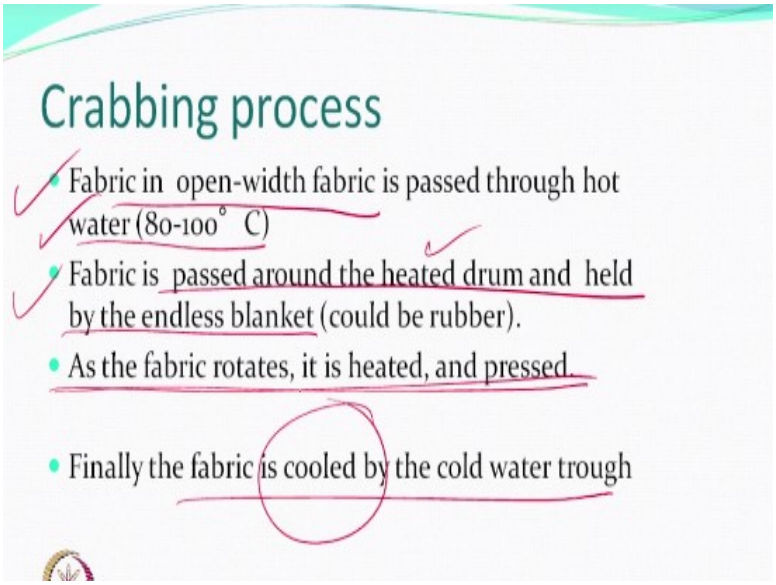

Of course, this process by itself is done in an open-width form okay and what is the process, open-width form you treat in a water which is 80 degrees to boil maybe and then this process is after putting in the hot water, you may like to pass the fabric around a drum which is heated, the fabric may be held by an endless blanket. The blanket could be a rubber blanket also. The idea is that it should be pressed against the hot cylinder and fabric as it goes over and over that heated drum, it gets set and of course as it comes out you must cool this fabric, then you are done, so cooling is important also.

So, if let us say heating make some changes at whatever level, that molecular level, intermolecular level at the intermolecular interaction level, they must be stabilized and if you want to stabilize, then after this there must be a cooling process, so this is what a sequence. So, you have open-width fabric, treat in the hot water, pass around the drum in that condition which is also heated, pressed by a blanket, so the fabric from one end to the other end can go as the drum is rotating, and finally you cool right.

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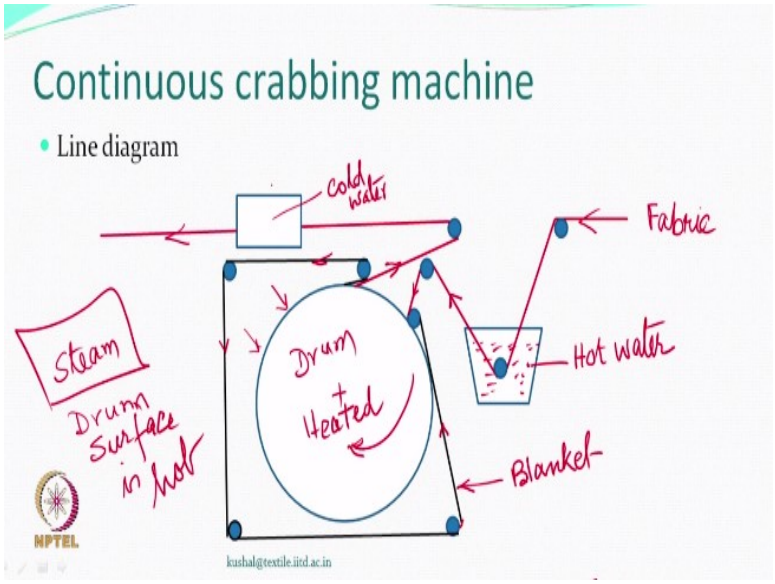

Just a line diagram of a continuous crabbing machine. So, what is this, let us say the fabric is coming from here, this is the fabric, and it goes through a trough which has got hot water. This drum is rotating in this way, so fabric after this goes through this, goes in and then this is the blanket, and this is the drum heated of course. So, this endless blanket also goes along all over the drum and then gets out, well the fabric gets out like this and goes through let us say an environment which may have let us say cold water for cooling purpose and this endless blanket keeps on moving.

Purpose of the endless blanket is to put pressure. The heating can be done of the drum by steam, remember the steam is not heating the fabric, steam is heating the drum, so drum surface is hot alright. So, drum surface is hot which is being heated by steam, the fabric along with let us say an endless blanket enters, a pressure is created also, so that one of the surfaces becomes flat and the fabric remains heated for some time and then through a cold-water trough it can go out.

So, there may be different types of sequences, but approximately something like this in a continuous crabbing machine you may see and so this is in a way a setting process, hot water mainly okay.

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Now another term which I am just introducing at the moment it is called the permanent setting, remember one thing in life there is nothing permanent but is a relative term, relative means that if something which has been said permanently, if you normally wash go through various laundry cycles, you would see the same stability, same surface structure being maintained for a certain number of laundry cycles okay, it is not infinite, so that way permanent obviously means a limited kind of a permanency, that is what we are going to talk about.

Steam is very interesting, we discussed a few minutes ago that you can actually do the setting through steam because not only temperature is higher, but it has additional heat stored because of the latent heat.

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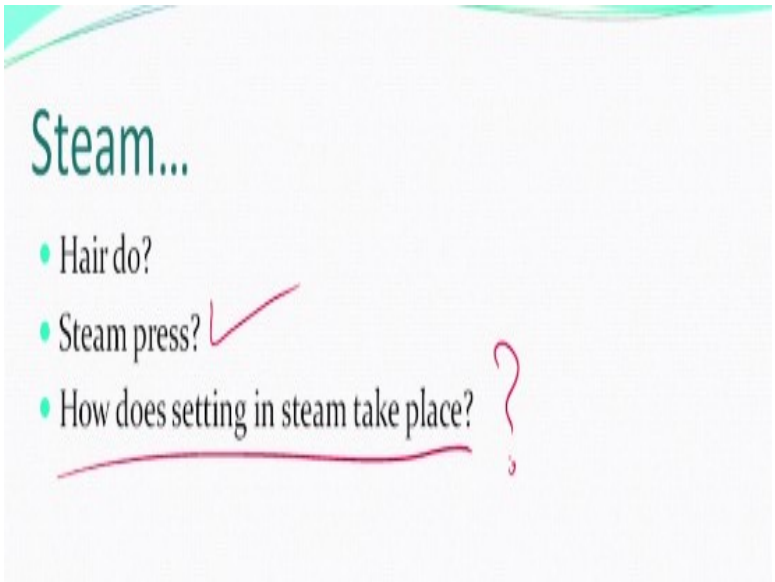

So, have you visited a beautician who is doing hairdo like you set your hair by putting a helmet or headgear which passes steam, scary condition right, when you get cold but that is controlled one, but remember this hair is also protein and actually keratin just like wool? So, whatever this steam does hair so you people get the styling done by the steaming process and of course you must have seen a steam press right where the fabric woolen is compressed and the steam goes through, steam press.

Then the people understand that if you do steam press, woolen gets set better. You can put crease, you can make a flat surface whatever you want. So, we would like to answer this question today right, what does this steam do.

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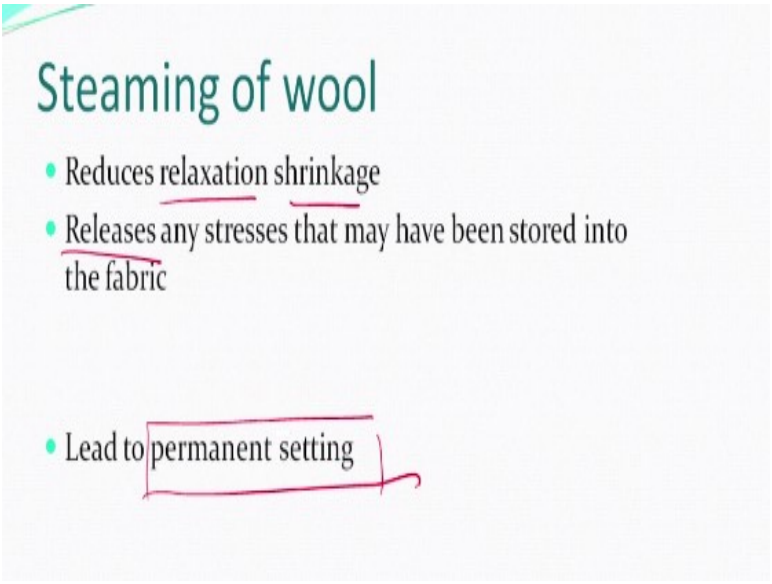

So one thing which obviously we can expect steam can also help in reducing the shrinkage due to relaxation, that means if you put your fabrics in tensionless condition and steam them, so whatever stresses are there they would be released and so you will achieve a position of a low energy position which is more stable, but also it can lead to another thing which now we can call it as a permanent setting, the way we define the permanency.

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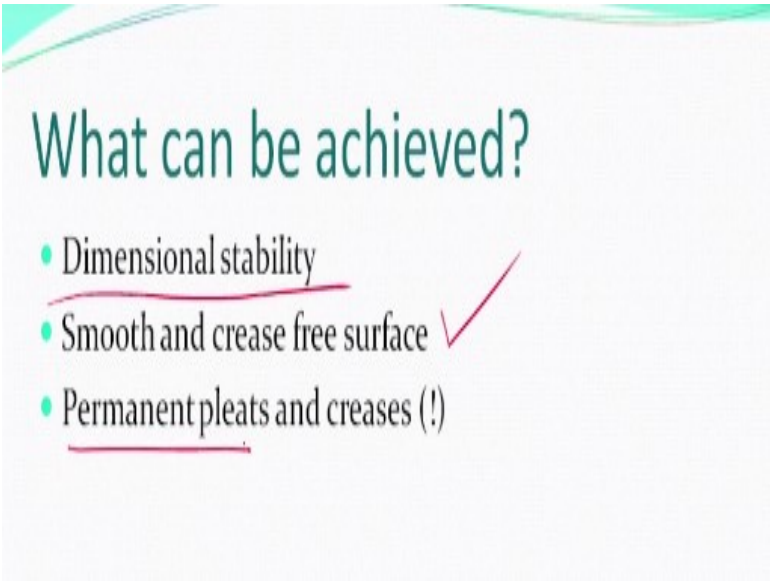

What can be achieved in this kind of processes like steaming process? One, dimension stability for sure, that is one of the ways, one of the reasons why we have started this process, you want to keep a flat surface. Smooth and crease free surface. One may be interested in permanent pleats and creases like a skirt for example many pleats are there, you may like the pleats to actually appear as it is or creases for example on a jacket.

So unlike for example just a crease-resistant condition, you also may be interested in creasing and creasing should be permanent like you when you wash around, the crease will still appear to be there, that could be one of those things which can be achieved by steaming. After washing also, this type of a condition would be visible okay.

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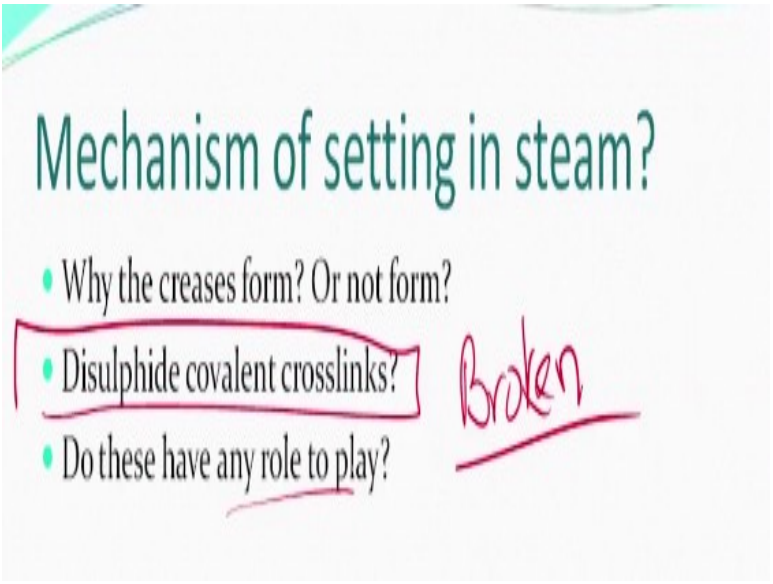

So now crease or no crease, why the crease forms or why something is crease resistant? So, we already have crosslinks, so why would the crosslinks change their positions? You see in the earlier case, we talked about let us say cellulose, there are lot of hydrogen bonds that can break of course, but covalent bonds are stronger, they do not break, why would the original position whatever the position was changed, the fibre itself has inbuilt covalent crosslinks.

So why would it change even if let us say I am interested in setting condition or position like crease actually or a pleat, I want to do pleats. So why would the pleat form at all, because unless and until you have this covalent bond broken, if this covalent bond is broken, only then you can expect a new position, new configuration will be set right. So, this is not the condition for example in the case of cellulose where the creases can easily be formed, you can iron, of course can go off, that is why you said you will do crosslinking.

Here there is already crosslink, so what was happening now? Whether they have any role to play, we like to check.

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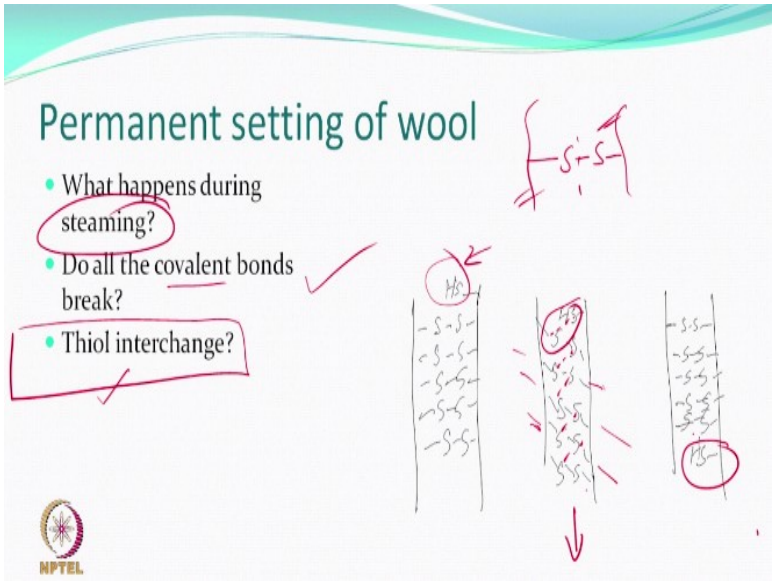

So, what happens during steaming, this question is what we want to answer. Do all the covalent bond break? Actually, people try to do some theoretical analysis. The strength of a polar bond like hydrogen bond or any other Vander Waal forces very small, very weak bond these are, and so even if there are large in number or whatever happens, when you put a crease, when you bend, you crush they can break and form also at new places because there are lot of hydroxyl groups, so you break from one, make somewhere else and so creases can form, but here we have covalent bonds and these covalent bonds how will they break?

If suppose the energy required when the steam was so that all the covalent bond which are the disulfide bonds, if they all break and then reform somewhere else at a new position, let us say the pleats where you have created, then in that case the total energy required will be so high that actually you can have a breakdown of the primary chain itself, it does not happen in steam, so they found there is another mechanism which is applicable and that is called thiol-interchange mechanism that is very interesting.

This type of thing obviously does not happen in other fibres or other kind of crosslinks, this happens in wool. So, what is the wool thiol exchange, that this is let us say this, so this is the kind of link that you have right. Now what we are expecting is either this link breaks completely, in that case all these links will break and then the energy required to break all these links, and of course when they form, whatever happens, happens, reform.

Then the new positions can be set, but what is found that the steam would not be able to provide that much energy were all such bonds can be broken because at that kind of energy requirements if at all, then main chain itself can break right. So, a new mechanism we call it now thiol interchange. Why does it happen? Let us say this is roughly a representation of a native wool, you know a virgin wool, so you may have remembered that this formation takes place as the wool fibre is growing and that process is keratinization.

So, originally you have thiol groups okay. The thiol groups combine to make a disulfide linkages during this process of keratinization itself, but when you look at it, it is quite possible statistically that all the thiol groups are not reacted and so some of the thiol groups may be free like this, very simple representation, but this is how we are now representing this at a molecular level. So, there may be many thiol groups which have already reacted and made a disulfide linkage, but some in the virgin wool may be just free.

What happens, let us say when we stretch, let us say in one direction we stretch. So, we stretch this fibre, let us say this fibre has been stretched okay. So, these bonds also get stretched, so the direction is changed, so they are becoming in this direction. Now what happens? So, they are strained also because you are stretching, so there is a strain, so normally if you leave the strain, they will have to go back, but what you are doing, you are also steaming at the same time giving some energy.

What happens that these two are a free thiol group versus one other sulfur, they may come little closer and after all you are stretching so one of them is there, the other one has been pulled down and so they may come very close to each other compared to the other sulfur end which is making the link. So, what happens is called a thiol exchange. See, we told you everything including covalent bonding is a contract, if a better situation comes, the contract can be changed from one body to another, one group to the other one.

So, it is possible now that these two start making a link, these two start coming closer, then like this and like this, and then this happens and this free thiol group which was here now is here, this is called thiol interchange, are you getting, thiol interchange and because of this, now the wool whichever the fibre it was, all the fibre and the yarn they all are now in a new position. So, this is what exactly we thought earlier that you have some covalent bond or whatever bond in the first position, you change the position like you bend it, crease it, then steam it, then they change their position like this.

This process requires much less energy compared to the assumption that if you break all these bonds and then all these bonds reform later right, during steaming, this type of thing happens. Therefore, steaming for woolens is a very acceptable process okay.

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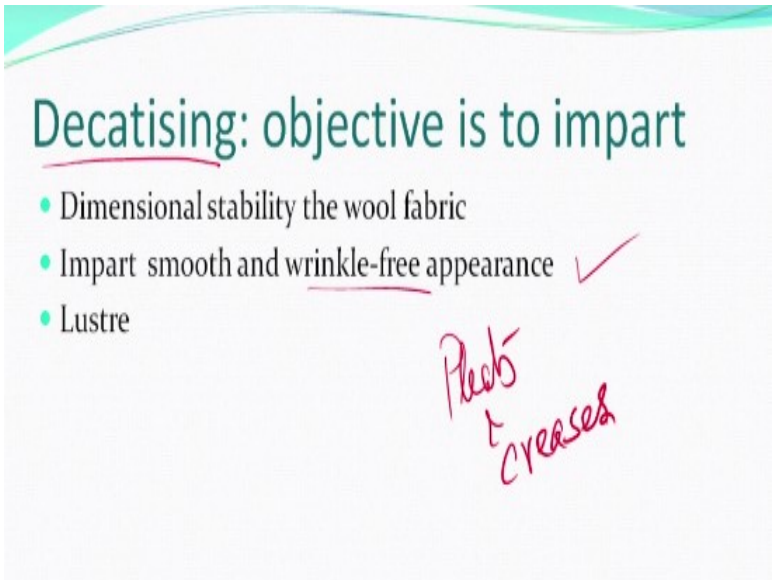

So, one of the other processes which is used for the wool finishing is called decatising. What is the objective? Objective is as we discussed what the steam can do dimensional stability, so that it does not change you see, smooth and wrinkle free finish, and if do very nicely maybe it

can give you a bit of a lustrous thing also like your steam iron fabric too much, then you will see well it becomes lustrous, you may not like it, so you say well do it softly.

If you say no, I want a lustrous surface, you may do it under little more pressure and steam, then you can get luster also, but more important is you can get dimensional stability and form also right. So, if it is wrinkle-free appearances is one form, the other could be pleats and creases right.

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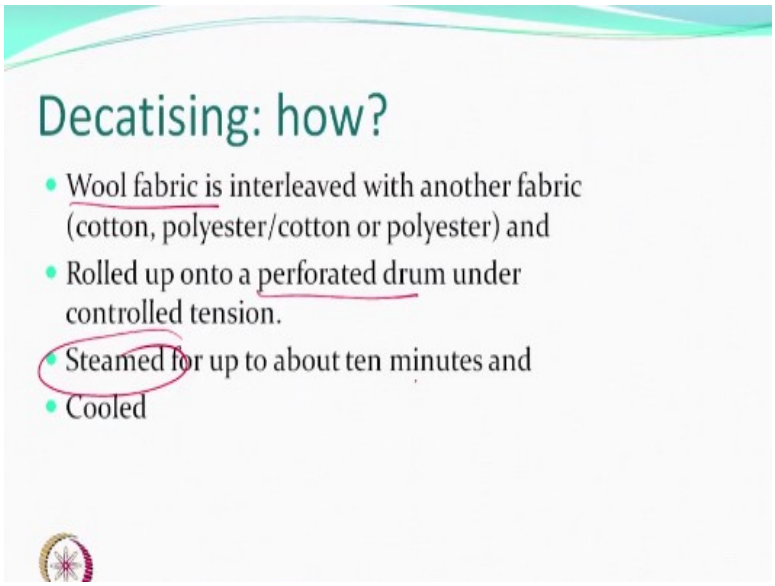

How do we do that, obviously steaming. So, you have wool fabric and it is interleaved with another fabric which is relatively more dimensionally stable okay. So the wool fabric is interleaved, the other fabric could be polyester or cotton or polyester cotton, whatever type, relatively more stable dimensionally, right, we are not talking about surface and this by layer okay, one fabric which is a woolen fabric, the other is the other fabric, together are wrapped right, keep wrapping over a perforated drum under some control tension.

So, when you have controlled tension, dimensions are being set okay. The wool fabric because let us say more layers you create, the wool will not touch the wool fabric itself, but between them will be another layer of a different fabric okay, so you create some layers, and then steam, the time let us not worry about, it could be 10 minutes or less than 10 minutes or more than 10 minutes depending upon what kind of machines that you may have, and how many layers you have made, the layers are less, less time could be required.

So, the process can be finished actually in very less time also in case for example you just have one layer and other layer. Have you seen people doing steam pressing, they put a wet fabric on the woolen garment and then press it, the steam generate there and then sometimes you may also iron on a wet fabric rather than spraying just to ensure that the wool does not get harm okay, but steam obviously has a relatively controlled temperature, timings can be different, and then cool.

So, the same process, steam and then cool, heat and cool, that will make you things kind of a final finish, this decatising will be final finish more or less because you have steamed and you have controlled your dimensions, but this process decatising will give you only flat creaseless surface okay. This process is not going to give you pleats, so for pleats, you will have to do something else like a steam press okay or a crease you will do something else because that are garments, this is fabric, a fabric which is to be finally sold out is supposed to be in the flat form right.

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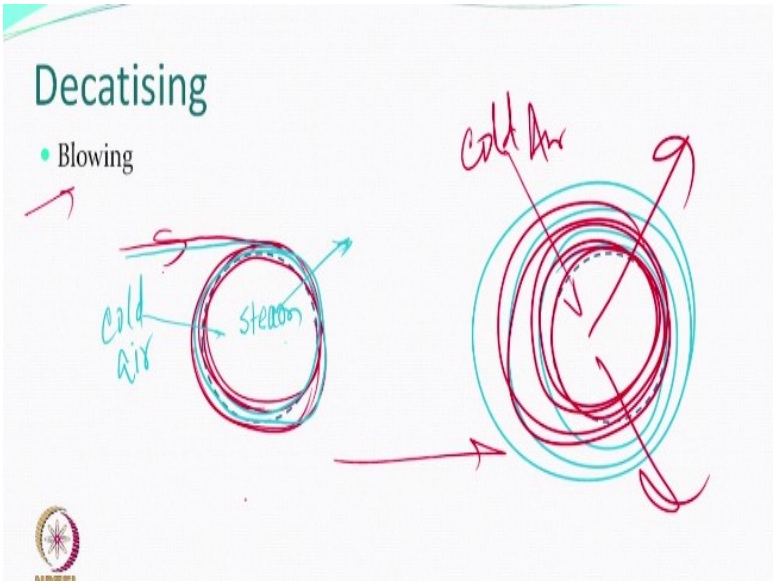

So sometimes this process is also called blowing, you know because you are blowing steam into something, something what, a perforated drum, this is a perforated drum. So, what you are doing is let us say you have one fabric okay being rolled, so you keep rolling the fabric onto this, but not just the drum, but you also have along with it let us say another fabric which is not woolen okay. Let us say this is the fabric also moving. So, you have layers over a perforated drum and then you inject steam.

The steam would come out, so it could be a batch process, so you can have a situation where first you make a roll and then after you have made the roll, you can steam. After you have done the steaming for whatever period that you have, then you can suck in cold air, this is the advantage of the perforate drum. So, if you inject steam from inside, it will go out, some pressure will be created because you have wrapped under a tension, many layers maybe, and then you keep it for some time like this, you may also have a situation that if you are not satisfied in one go.

Then you may take the same fabric and wrap it on a different roller exactly in the same way right okay. So you have those two fabrics again unrolled from the other one and rolled on the other roller and steam out and later cold air in, so you wrap on one roller, then wrap on the other roller, and the whole thing like you had jigger you know upon one roll there is first the fabric, then it passes through some liquor and goes the other one and you want to repeat the same cycle.

This type of thing can go twice at least on these decatising machines, which obviously finally will give you a flat surface, creaseless, smooth surface. So depending upon what kind of fabric you have, the surface could be more smooth or little fluffy, but dimension control will be there, it is not likely to shrink very easily because you may have done other process also which is called the anti-shrink treatment and this is the setting, so they are two different things.

In the anti-shrink, you have something to do with the scales, in the setting, you have something to do intermolecular, not just surface, intermolecular thiol exchange. Thiol interchange if takes place, then you will get this setting okay.

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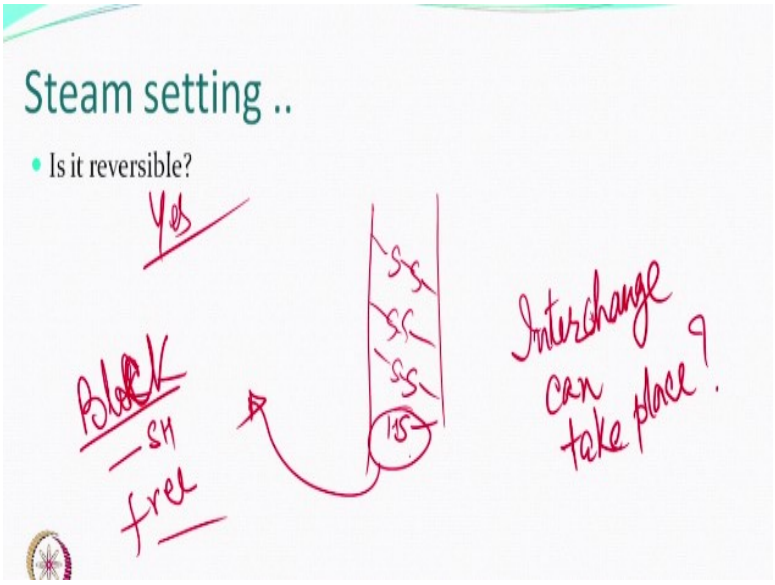

Now this question somebody may like to ask, is this steam setting reversible or is permanent? So, the question of permanency now is coming here, is this steam setting, where what has happened, the covalent bonds which are the disulfide linkages have exchanged their position with the other thiol groups which may be free and new condition has been created, is this process reversible or permanent? What do you think? So, the process is reversible if you steam it again, you make a pleat, steam it, press it, it is good, you wash it, you will see there.

If you next time flatten it out, again steam it, and press it, the pleats will go, why? Because again you still had something called a free thiol group somewhere, remember at the end of setting, you still had some free thiol group. If you do the reverse, this exchange or interchange can still take place, true, so is it reversible? Yes. So, what do we do? People suggested many things, one of the thing people suggested was if suppose we block thiol groups which are free, so if we block free thiol groups by some reaction, by anything, by mean, by compound, aryl or alkyl compound, then this will be blocked.

If this group gets blocked, then it will not be available for interchange, that can lead to some additional permanency because if breaking all the bonds and then doing exchange will be requiring more energy and so you may actually think that well this is not it, so you can block, right if you block.

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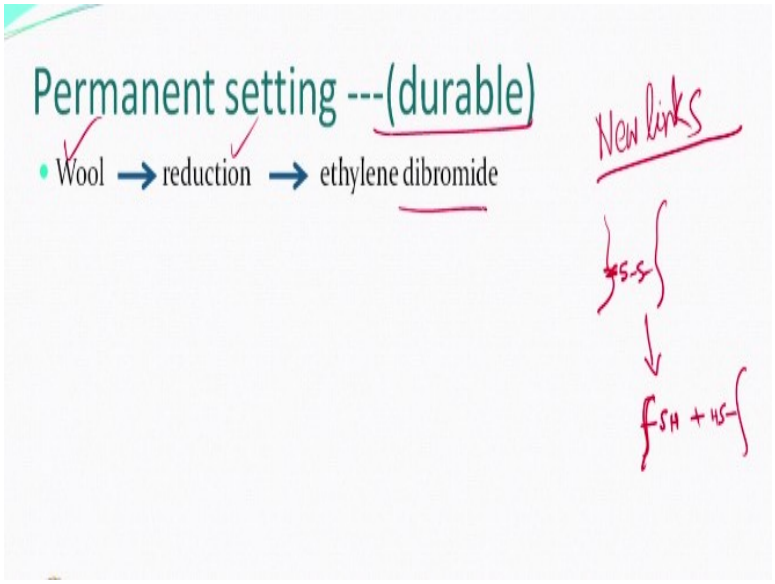

Other interesting thing which people also talked about was can we create new links. New links means like in cotton we created those ether-based links by the crosslinking agents. If you create new links which are not the same, then maybe you can do something. So, one of the things people suggested was that you take wool fabric, subject it to a reduction process. So, what the reduction process will do? If you have wool and this is the disulfide linkage, by reduction process, you will convert it to free thiol groups by using reducing agents.

Ammonium thioglycolate, sodium bisulfite, some of these are reducing agents and reduction can be done actually at room temperature also. If you use that, then you can create free thiol groups. After that if you react it with this compound, then you create a new bond.

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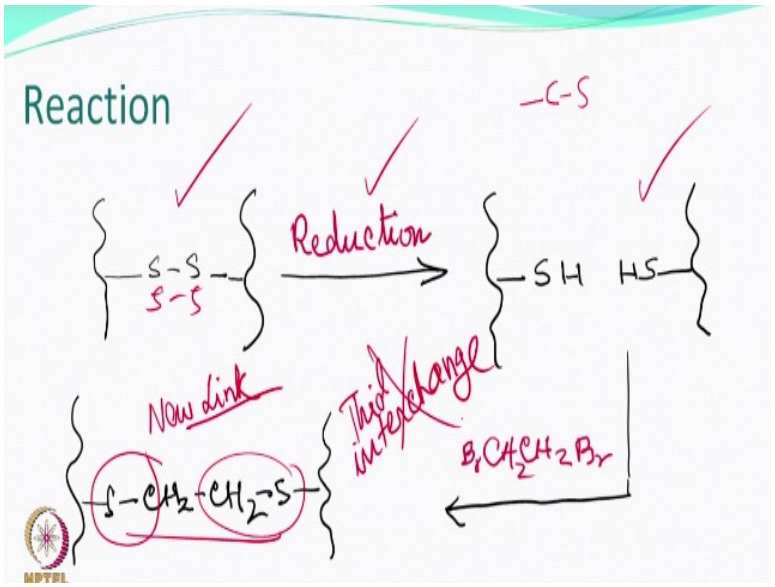

What is this, you had disulfide linkages, you do the reduction, you get free thiol groups. If you react with a compound like ethylene dibromide, you create a new link. How does it help? This new link is not between S sulfur and sulfur okay, the S-S bond is weaker compared to C-S or S-C s or SC bond. The carbon-sulfur bond is stronger than the sulfur-sulfur bond, both are covalent okay. So, this bond is now new bond, this bond is now a new bond, and **so** in between of course there is carbon-carbon, so they are stronger bonds.

So, when you now subject it to let us say further steaming, this bond will not break, it is not going to participate in whatever called the thiol interchange, thiol interchange will not work. So, in some sense, by either blocking the free thiol groups or by creating new links, you may be able to do a more durable permanent setting of wool okay, does it make sense, okay.

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So, something you may like to learn yourself okay, at your own leisure, try to learn more about what is hercosett process, little more detail if you have interest. There is something called carpet wool, obviously it is a coarser wool, you might like to learn about it, what kind of wool, what types of wool are called the carpet wool, what is different in them compared to let us say Marino wool, where are they grown, something you may like to understand.

This I am sure you know, but maybe you like to revise why are the woolen warm? Is it because of their thermal conductivity or something else, you may like to talk about it? Keratin for that matter has got two structures, alpha and beta structures of the keratin, what exactly they are, and you may like to say and why do they have these kinds of structures that also you may like to revise or learn on your own, is that okay.

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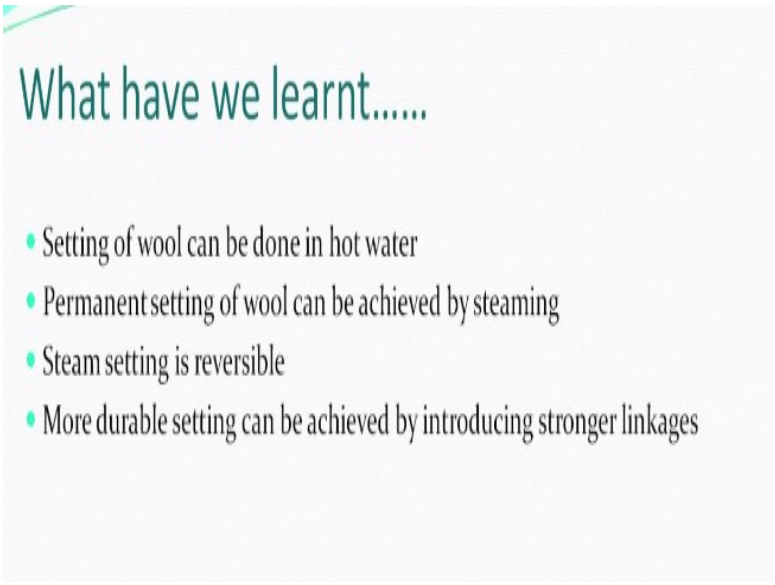

So, what have we learnt today? We have learnt today setting of wool. This can be done in hot water which is stable in washing in the cold water, hot water, cold water. Permanent setting in some sense can be done by steaming because steam temperature and energy is at higher level and washing can be done at lower temperature, so it can be permanent in that sense, but steam setting is reversible, this also we learnt, but if you want to make it more durable, then what we do, create new crosslinks, new type of crosslink even using the so-called disulfide linkages.

So, we finish this class. In next class, we take one more topic on wool, which is the moth proofing of wool. Till then, all the best, enjoy. See you in the next class.