Textile Finishing
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Lecture-03
Wrinkle Resistant Finishing Contd…

Welcome back to this course on textile finishing. You remember, we had earlier mentioned that, the chemistry of the fibres, as also of the chemicals, that we shall use is important to us. So, I shall not be mentioning this phrase, chemistry and its technological applications, but it is understood, that we will always keep this in mind, while we are going through this process. Is that ok?

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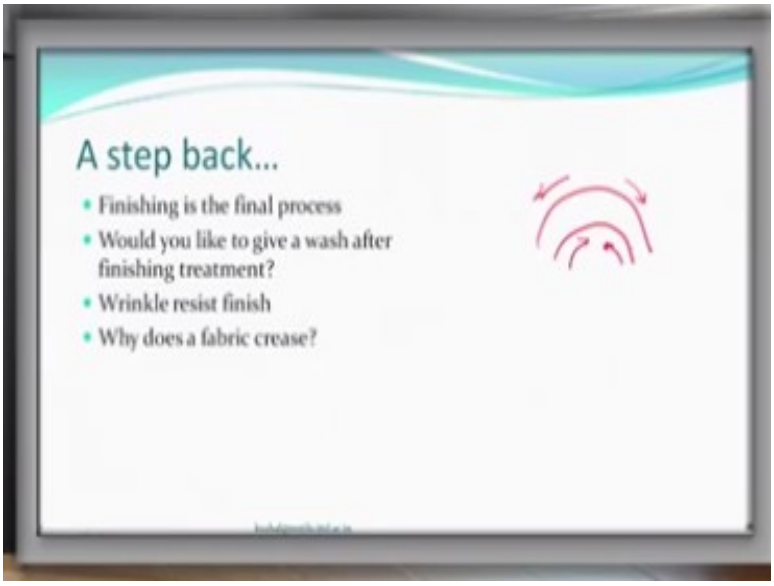

So, let us look a step back as to what we had done. What we had done is that, we said that finishing literally means the final process, that you have many unit operations, starting with singeing, scouring, bleaching, mercerization, dyeing, printing and then finally you want to give a finish and that is the reason, we say it is a finishing treatment, the last treatment. So, theoretically it is a last treatment. Let us say, if somebody asks this question, would you like to give a wash after any finishing treatment?

Actually, we should not. If we can, we should not. It is only when we find that, we may have used some chemicals, some monomers, some crosslinking agents, which may not have fully reacted, part of it is remaining on the fabric, and you think that part which is remaining on the fabric is not good for the consumer, let us say. Then you may have to give a wash. But then, after wash, you will have to do some other treatments, which will also come into the finishing treatment, the next treatment will become a finishing treatment.

So, we said that, we have chemical as well as mechanical processes, which in a way come under this umbrella of what we call as a finishing. So, literally it is a last final treatment, but in case it is required, another treatment may have to be given before, become so, in any case is a final treatment. Wat we did last time also, was a wrinkle recovery finishing. Right! We started discussions on them, on this particular topic, as to what is this wrinkle recovery finish.

And also, we realized to first understand, we must first understand as to why do a fabric creased? So, do you remember why the fabric creased? We said the fabric creases because, you are bending, whether the bend is sharp or not so sharp, that would determine many things. But a crease is generally sharp and what it means is, we said there are extensive forces, which are going to be applicable on the outer surface of the bend, there will be compressive forces, which will be applicable and working on the inner surface.

And accordingly, the material and the molecules, within the material are going to be affected, stressed or compressed, in any case certain amount of stress is being imparted during the bending.

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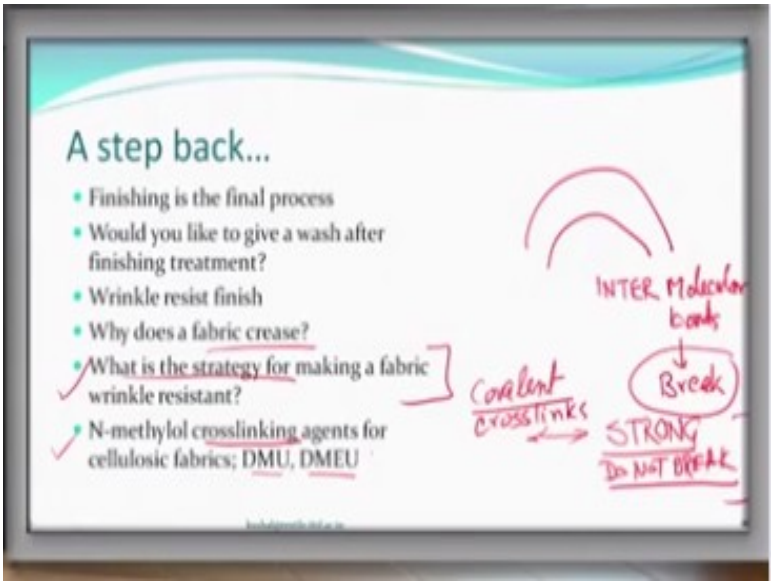

And, then what happens. The crease is formed, when let us say, there are intermolecular bonds, if they break, break as a result of bending, if they break as a result of bending, then the amount of energy that was required to recover, has already been spent in breaking the bonds. And therefore, there is no reason why the fibre, the material, the yarn and the fabric should come back to their original position.

Because, the energy which was imparted for bending, creasing, has already been consumed. So, what is strategy? We recall this strategy would be that, these bonds are strong, if they have bonds, are strong, that means they do not break, if they do not break, then we would be having a situation, where after bending the strong bonds can stretch, compress, bend, stressed, but will not break. And if they do not break, what it means, it means that the energy for bending has been stored already in this stretching distortion of the intermolecular bonds.

And because, they have not broken, this energy will be used to bring the material back into their original position. And so, what we require, is a strong bond and we said, if we can make a covalent bond, which sometimes we also call as crosslinking or covalent crosslinks. In such a situation we would be able to create strong bonds, strong intermolecular bonds and therefore, this can give us wrinkle resistant finish, because it wrinkles, it comes back, recovers. And some of the agents that we talked about last , where we call them DMU and DMEU. Alright!

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So, we are continuing with the same topic, wrinkle resistant finishing.

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We are also still looking at nitrogenous or, nitrogen based compounds, nitrogen based compounds.

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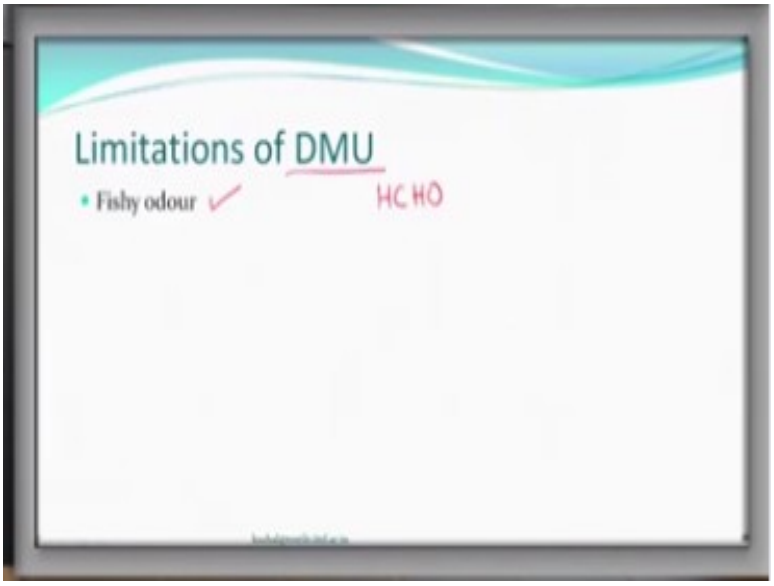

And, one of the compounds, that we talked about was DMU. Do you remember what is DMU? Dimethylol urea. Alright! If you remember one of the limitations, which we understood was the fishy odour. What is this fishy odour? These compounds were made by condensation of formaldehyde with urea. Now after it has been applied to a textile, there is always a possibility, because of the equilibrium reactions, the formaldehyde can be released during storage, during washing.

This whole link can hydrolyze, and it can break, and what can come out, is formaldehyde. If formaldehyde comes, then the odour of that formaldehyde which is been released is called, is called the fishy odour. Alright! So, it was seen that fabrics treated with DMU resulted in a fishy odour as well.

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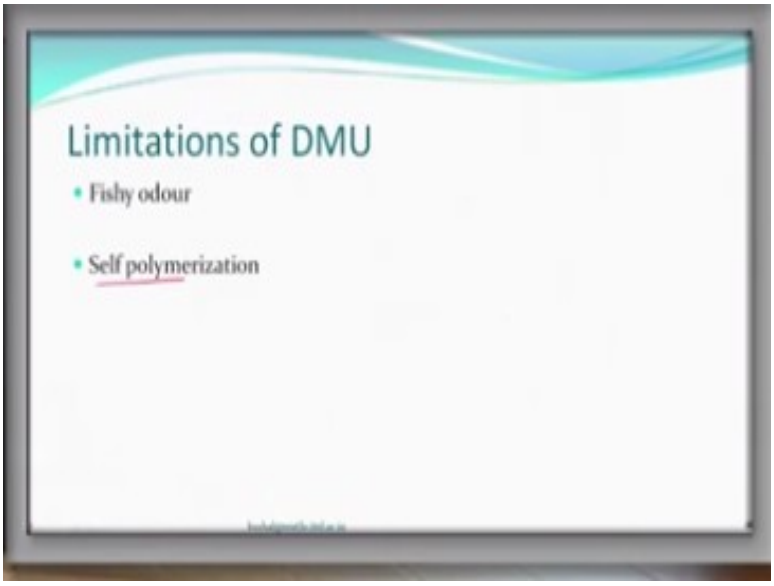

Then other thing which we remember and recall was that DMU could self polymerize. That is, it can react with itself to make a longer molecule, that means you would have a oligomer of polymer, polymeric material being generated, which will also get either attached in a covalent bond, covalent bonded structure or maybe just like a film formed on the surfaces of the yarn and that the fibres and so this can happen.

It is, how does it matter. One of the things is, if it becomes like a film, the fabric would become stiff. So, theoretically we just wanted crosslink, inter molecular crosslink, and not a film forming substance, which can create problems, is not that was self polymerization too much, but it was self polymerization that was one of things.

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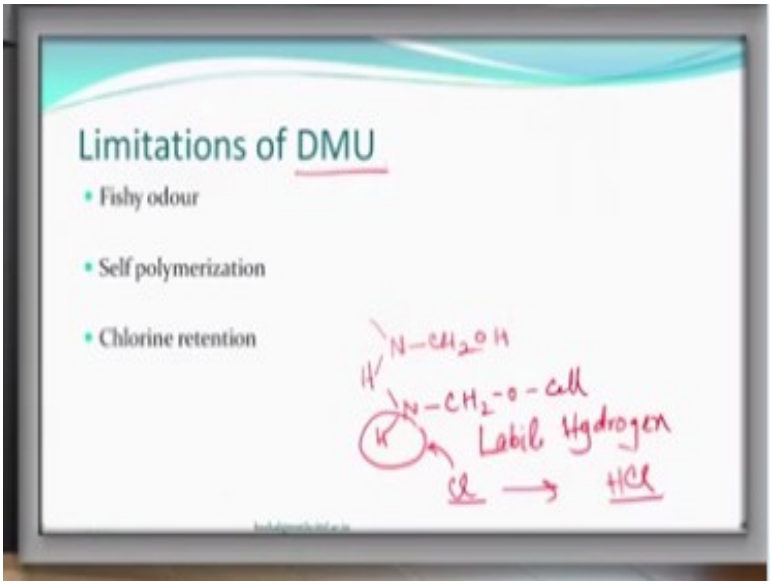

The other important problem which you can recall, we talked about was, chlorine retention problem and what is the chlorine retention problem? If you remember the reaction, this was the N-methylol group, after reaction with cellulose, you may get a reaction, which for example if there was H here in a case of a urea, the H stays there and then you have CH_2O-cellulose, so there is this hydrogen, which we call as a labile hydrogen, which can be replaced by chlorine.

If it is available, let us say in a wash liquors, if we have hypochlorite solutions in the bleaching systems and washing liquors, then or any other ways, in which the chlorine can come, then this chlorine can get attached and this is called chlorine retention. And later on, when we are using this material in the presence of heat, in the presence of moisture, the chlorine can be liberated and which will mean, basically an HCl can come and cause degradation, so these were the limitations of DMU**,** DMU.

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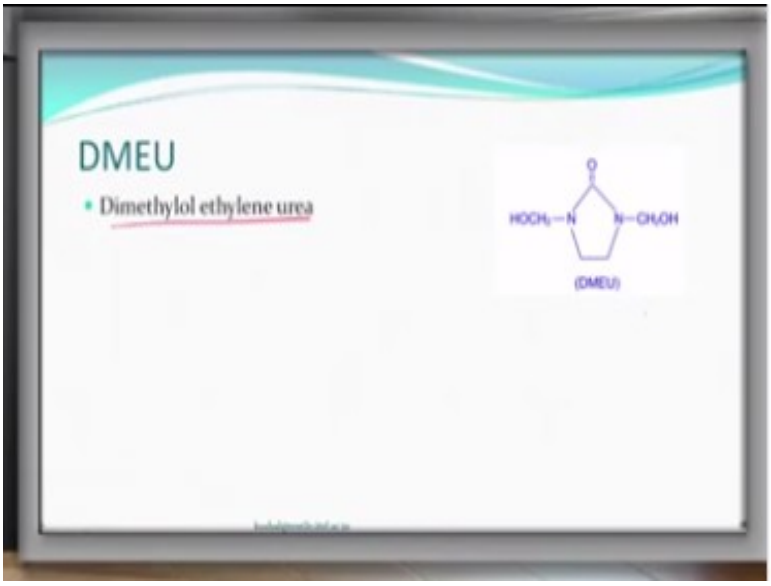

You remember immediately, that another compound which was similar, but cyclic compound, was dimethylol ethylene urea, so what do we have is a cyclic compound.

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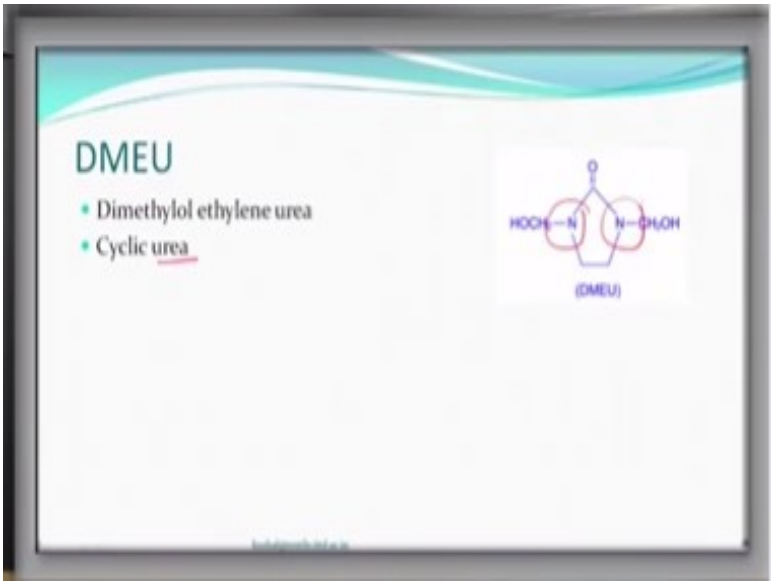

So, this is called a cyclic urea, what is important you can notice here is, in this case there is no hydrogen, which can be called as a labile hydrogen and therefore, we should not have chlorine retention.

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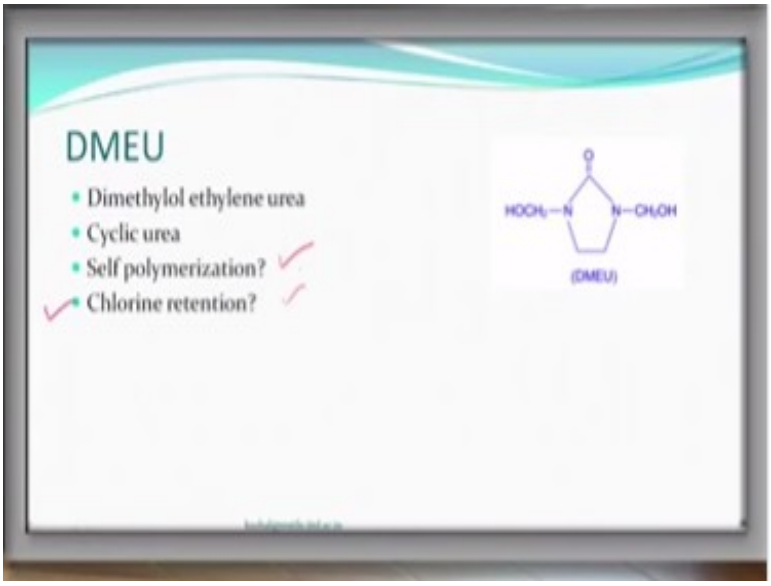

We do not get self polymerization to the extent because of steric hindrances, it is a cyclic compound, a bigger system and so, it reduces the tendency significantly that it does not self polymerize. So, by doing this, using this cyclic urea, you have done away with 2 important things what happens to.

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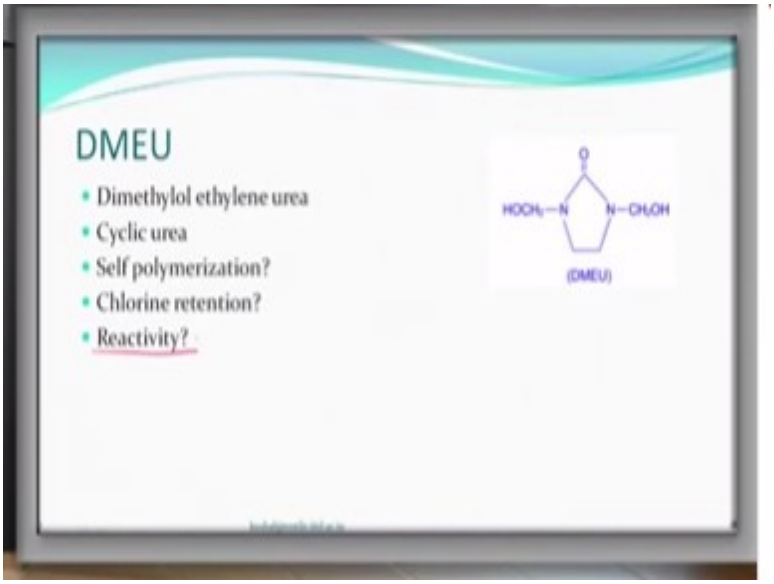

Let us say reactivity? What happens to the reactivity? Obviously, because the steric hindrances that this molecule would always have, the reactivity of this compound becomes low, lower than DMU. So, what is the disadvantage? Well, the only disadvantage you can think of, is that you may have to spend more time at the same temperature for any crosslinking reaction to take place.

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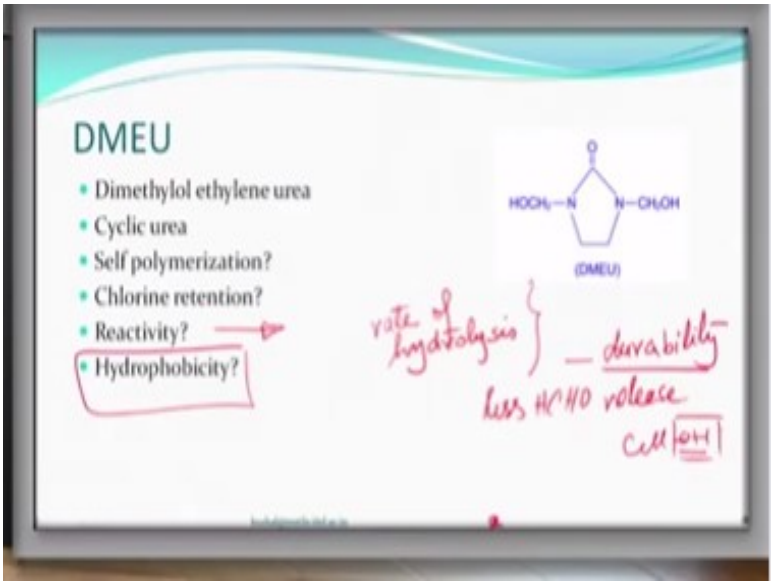

But what you get interestingly, is also that, because of the low reactivity, the rate of hydrolysis also is low, the rate of hydrolysis also is low, what it means? Therefore is, from the advantage point of view, that the fishy odour is going to be less. Because less formaldehyde will release during use. Ok, during storage, during washing, during ironing and so and so forth. And so low reactivity may expect a little more time, but time is not so important when you look at the durability part of it.

So, the hydrolysis is related to durability of the finishing treatment. It is therefore also, related to less, less formaldehyde release. Good for us. Ok. Another question which we may like to address is hydrophobicity, it was felt that the hydrophobicity of the textile, which maybe cotton or viscose or any such material would increase. Why? Because the reaction involves hydroxyl groups, so on crosslinking this hydroxyl group would be consumed, would not be available.

And therefore, based on how much reaction has taking place, how much add-on of the compound has actually happened would determine, how many hydroxyl groups have been lost. And therefore, you can think or assume that there can be certain amount of hydrophobicity introduced in the substrate in the textile or a substrate.

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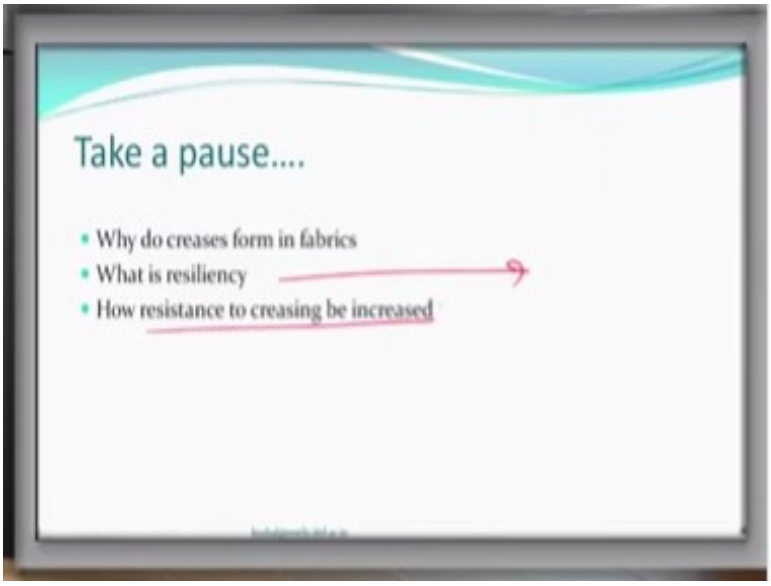

So, what have we learnt till now? We have learnt, why fabrics form creases, we would also learnt what is resiliency. Resiliency means resistance to deformation and recovery from the deformation. Right? Resistance to deformation and recovery from deformation. So, we have also learnt to make the fabrics creased resistant you have to do crosslinking.

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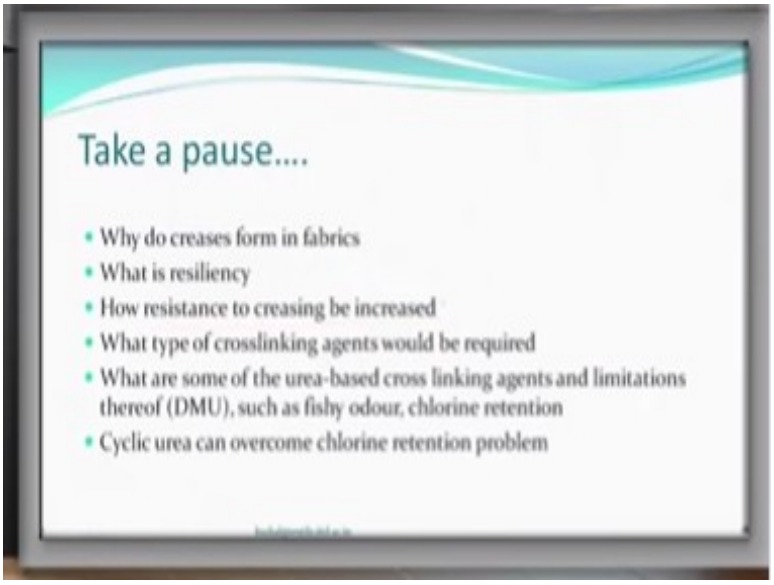

We also understood what type of crosslinking agents are required multifunctional or bifunctional, we said bifunctional. And also, some of the urea based compound like DMU and DMEU are the one which we have understood. We have understood why fishy odour comes, we have also understood why chlorine retention takes place. And, how cyclic urea can solve this problem to some extent, what more can be done?

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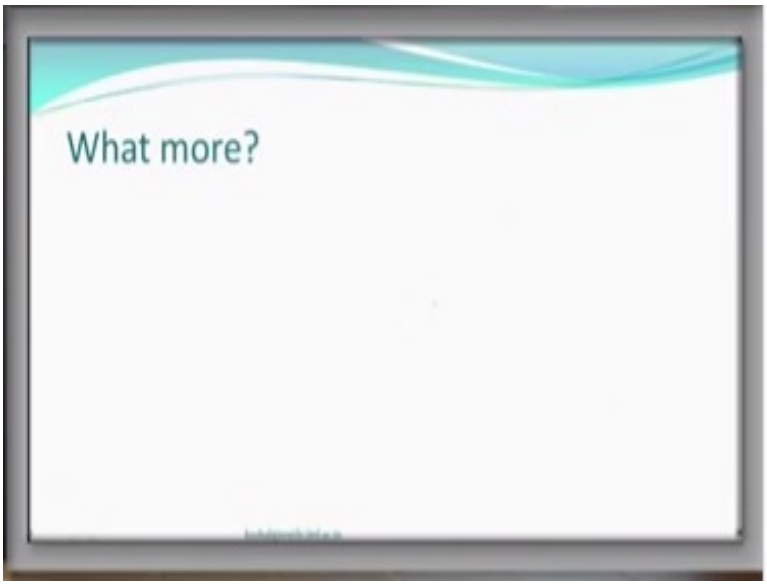

We have learnt that hydrophilicity is reduced or hydrophobicity is increased as a result of this crosslinking.

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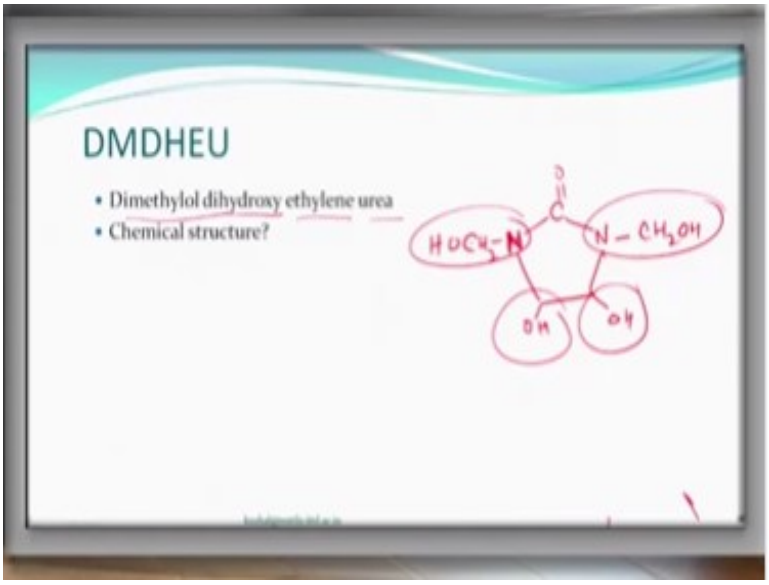

So, another compound which became a commercial success, is known as dimethylol dihydroxy ethylene urea or sometimes referred to as DMDHEU, what is the chemical structure and how is different from the previous one? Let us say it is still urea, so you have this, this compound is also cyclic, so you have this, so this is nitrogen and we have methylol groups. So, 2 methylol groups and so dimethylol, so if you do not do anything this is the DMEU.

So, what they also introduced was 2 hydroxyl groups here. Now if you have 2 hydroxyl groups introduce the one thing which you can appreciate is, if these 2 functional groups react with cellulose, that means hydroxyl groups of cellulose which obviously, after reaction do not participate as a hydroxyl group. But at the same time this compound itself has 2 hydroxyl groups and therefore the advantage, if you look at it would be that, we have not blocked any hydroxyl groups of a cellulose in literal sense. Because whatever has been blocked, new hydroxyl groups have been created.

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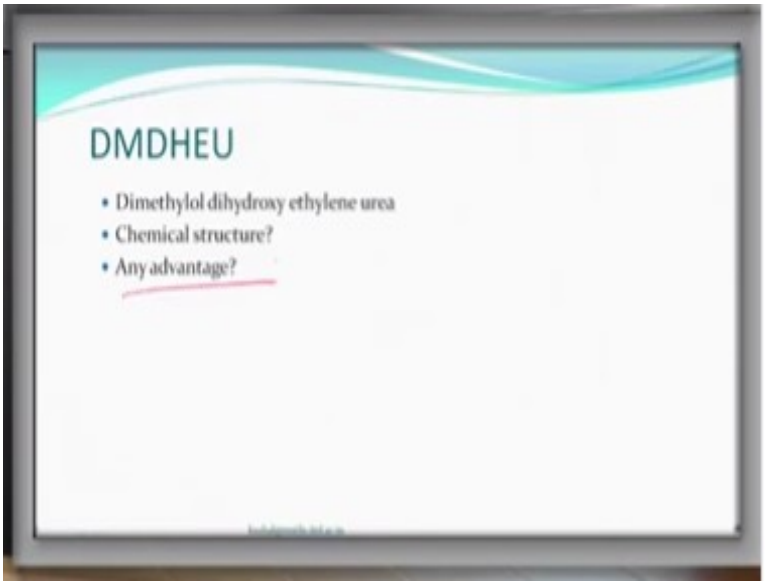

That is the biggest advantage, and what it means is that, the fabric will not be reducing in its hydrophilicity, it will not become more hydrophobic, because of the crosslinking reaction, so it is an advantage.

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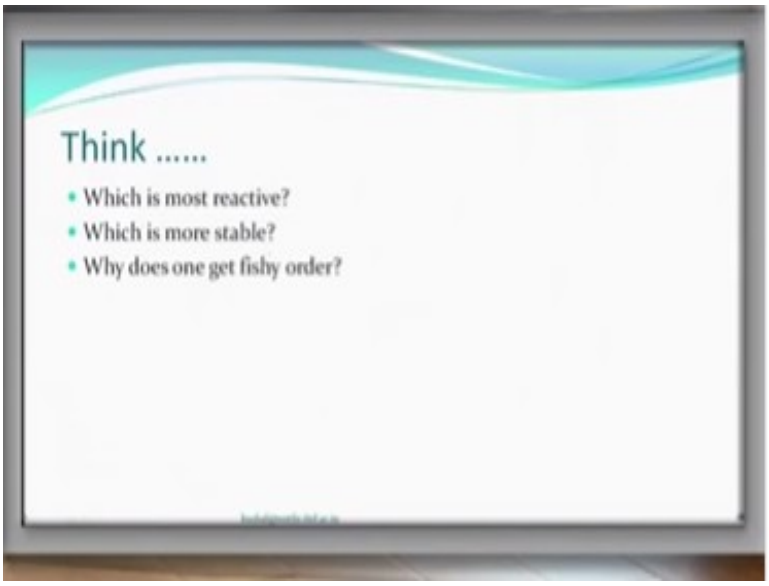

So, think, which is more reactive out of the compound that we have talked about? Which is more stable, will give you more durable finish and which would have less fishy odour or more fishy odour? This you can think, contemplate and write it down in your own notebooks or whatever methods that you have of remembering.

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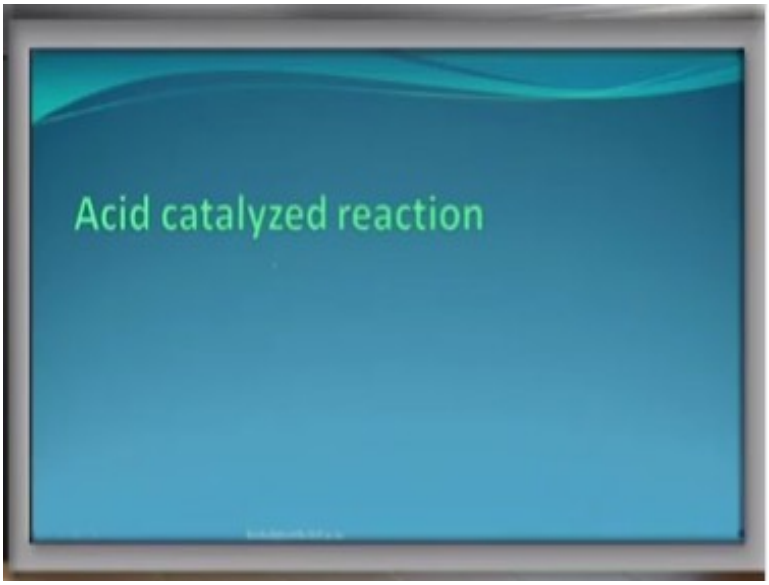

Here, we will just talk and spend little time on as to how the reaction takes place. This reaction takes place in the presence of a catalyst, which is the acid, that is we need a proton.

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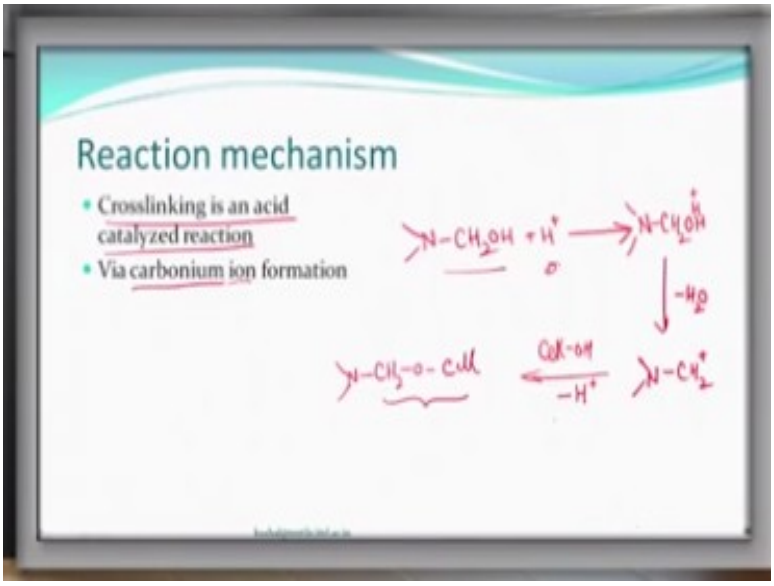

So, this crosslinking is an acid catalyzed reaction and how do that happen? Let us say this is my functional group N-methylol, in the presence of some proton, this will be going through an intermediate step. Then we would have dehydration and you get a carbonium ion formation, so in these steps what we have seen is a proton get added, an intermediate product is formed and then water molecule is released and then you have a carbonium ion formation.

This carbonium ion in the presence of the hydroxyl group which are available on cellulose. Let us say this is what we have talking about would release the proton back and would form a crosslink of this type. Alright! So, this is the crosslink which gets formed, so what is happening you have N-methylol group, reacts with a proton and then an intermediate product and from there dehydration, formation of carbonium ion and then reaction with cellulose,

And this proton again comes back. So, which will be like a catalyst, again react with reaction and finish the whole thing. Right?

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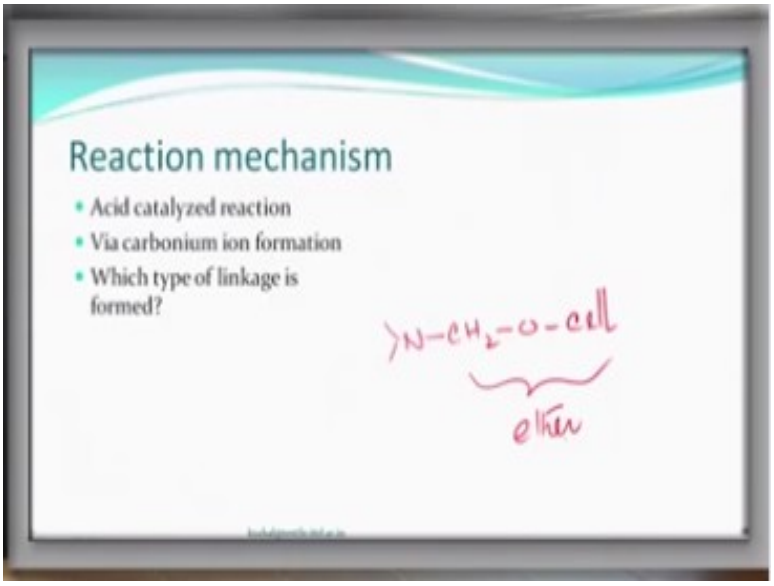

So, acid catalyzed reaction via carbonium ion formation, which type of a link is formed, what is the link now, we have talking about? We are talking about this new link, what is this link? This link is ether. Alright! So, it is a ether link which has been created. This is briefly the mechanism of reaction of N-methylol compound with cellulose.

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Now we come to another interesting part and which is application process. How do we apply, what do we have with us? We have, let us say, the crosslinking agent, we have some catalyst which can donate proton and we have fabrics. So, all of them generally are expected to be water soluble, if they are not soluble in water, we will have to take another medium. But generally, whatever commercially we are using in the kind of compounds, that we talked about, they are

going to be water soluble. So, we will make an aqueous solution of, we will make an aqueous solution of the crosslinking agent, and the catalyst, and then apply.

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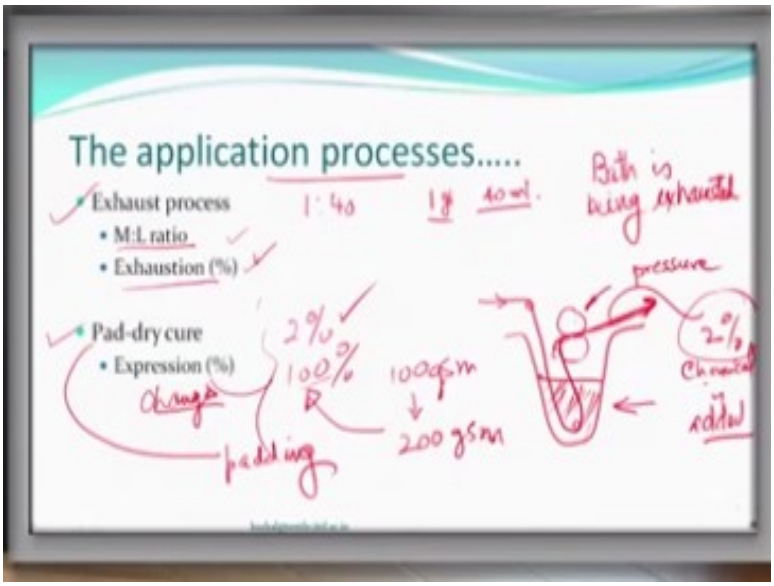

So, there are 2 types of processes, which are used, one is called the exhaust process and the other is called the pad-dry-cure process. So, in the exhaust process the components that are important to us or the parameter that one may like to control in one way or the other is, material to liquor ratio, and what is the exhaustion percent. Actually, what exhaustion process means? Exhaustion process means that we have a solution,

And, we expect, when we introduce into the solution under suitable conditions a fabric, all the chemical are going to go to the fabric or the substrate. And, slowly there will be almost nothing left in the solution because most of it would have been absorbed, adsorbed, reacted with the fabric. So, bath, the finish bath is being exhausted, that is why it is call the exhaust process. What is ML ratio? I hope you are aware, if 1 gram of fabric and let us say 40 ml of liquor is used, 1 gram of fabric, 40 ml of liquor, this will be considered as 1:40 ML ratio, that is one.

Now why this important is? Because you could take 1:20, you could take 1:5, you can take 1:100. If you take 1:100 and concentrating that our chemical is also water soluble, let us say, then the equilibrium can shift towards the solution. If we take less ML ratio then the equilibrium

will shift more towards the fabric. Obviously, our interest is what, that should go more to the fabric, so, ML ratio becomes important.

Then the next thing which we said we will talk about is the exhaustion percent. What is the exhaustion percent means? If all the chemical, whatever you have taken in the solution, all of it goes to the fabric, then it will be called 100% exhaustion, that means nothing is left back in the solution, everything is gone, that is 100%. But in general, it may not be possible even in this process, because all reactions are equilibrium reactions.

The equilibrium can be in the favor of fabric, but it is not necessarily 100%. So, one may like to know, what is the exhaustion percent? 95%, 90%, 80% how much get exhausted? Rest would not be exhausted. The other process is called the pad-dry-cure process, in this you are not dependent upon how much exhaustion takes place, you want to apply by a mechanical process, the amount of chemical that you want to, actually apply.

That means if you want to apply 2%, then you do whatever you want to do, to apply 2%. So, what is the process. The process is, you have a pad bath, this is the pad bath, which is got the required solution, you have a fabric which gets immersed into the solution and then it goes through a mangle, where the squeezing takes place, excess liquor flows back. And whatever you wanted, if you have a control it will go onto the fabric. Alright?

Let us say, if you have 2% chemical in the solution and you have an expression which we say, let us say, we have 100% expression, what it means is, 100% expression means? That the fabric, if it was weighing, let us say, 100 grams/square meter, then if it becomes 200 grams, at the end of this squeezing process, then the expression will be 100%. Now whether it should be 100% or not this would depend on what you want. This expression can be changed. How? By increasing or decreasing the pressure.

So, increase or decrease the pressure, you can change the expression, so let me just go through this process again. If this solution has 2% chemical and the expression is 100% then at the end of this process 2% chemical is added. So, this pad-dry-cure process therefore, does not depend on

exhaustion, it just allows the liquid to be absorbed on the fabric to an extent that you want. And based on this extent which is the expression here you will get the amount of chemical this is there, so in this example this is what it is. Alright?

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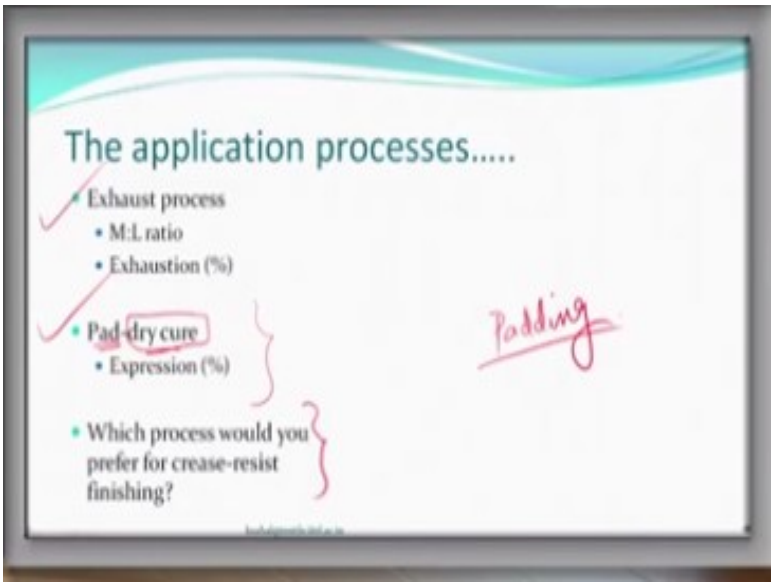

So, if somebody says, well, these are the 2 processes we understand, which one should we prefer for finishing? Exhaustion process or pad-dry-cure process? So, as of now we have talked about padding. Alright? This whole thing is only representing padding. Alright? We still now talked about this process as of now, is only first application. The other 2 therefore, represent something else. So, which process one would like to use for crease resistant finish, as we said finishing is almost a final process.

The fabric should be in a creaseless form, if you want a plain fabric, nice looking fabric. All the reactions must happen, when there are no creases. Because, if there are creases there, then those creases will become permanent after crosslinking. Do you understand? Say, if there are no creases it will become creaseless fabric, if there are creases, then it will become a creased fabric. So, if you have no control on the dimensions, which is generally may happen, in an exhaust process, many exhaust processes would not have any control on the dimensions.

Then, whatever dimension is there it will be get fixed. If it is in a rope form, its crosslinking will be formed in a rope form, if the conditions of crosslinking are met. But for finishing being a final

process and we are interested in dimension control also, therefore, we would be using a padding process. Is that right?

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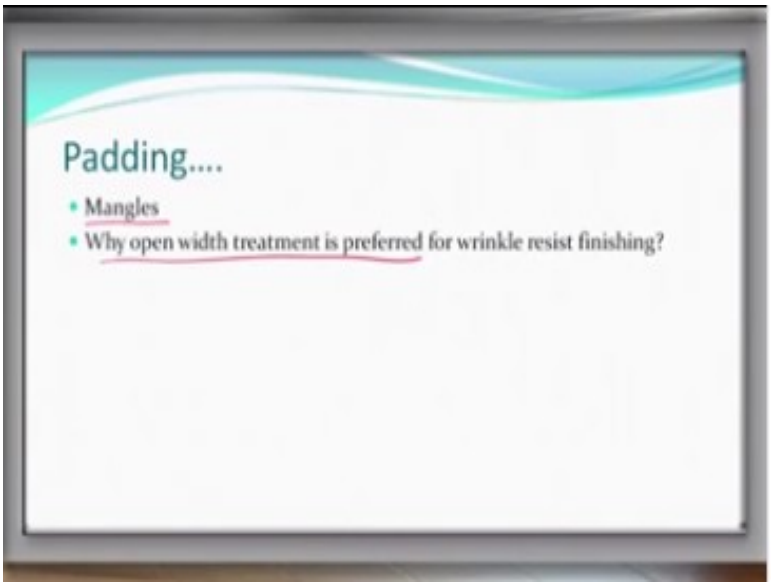

So, what is this dry cure? So, what have we run is padding sometimes are called as mangles. We understood why open width treatment is preferred for wrinkle recovery process. Why do we prefer open width? Because, we do not want any creases to be fixed, so that is one.

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So, we talked about this padding process, uses something called a padding mangle and we did in one of the diagrams, looked at this process, these 2 rolls are also known as bowls. Ok?

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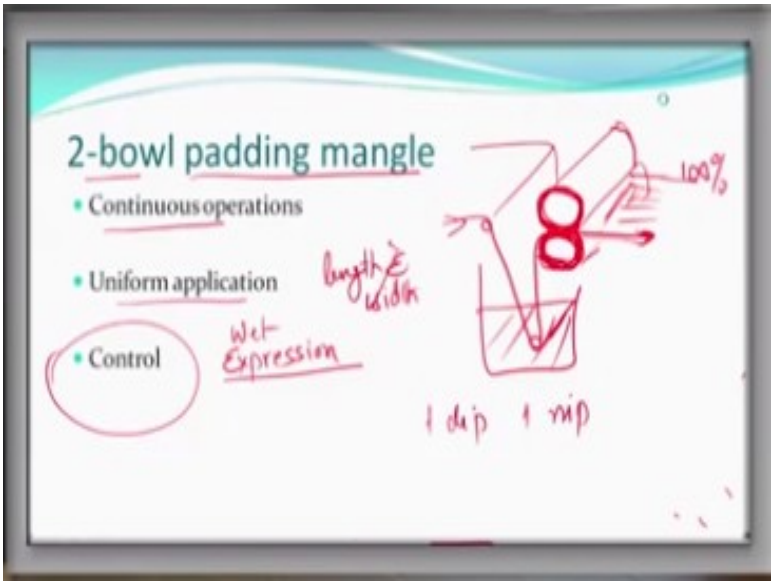

And so, if you use 2, then it is called a 2-bowl padding mangle. So, that we already saw, this is how we pass the fabric in squeeze. So, it is 2 bowl padding mangle. Ok? What is the advantage? It is a continuous process. So, fabric can come from one side, enter, gets merged and then gets squeezed and come out, based on what is the expression, let us say 100% expression or whatever value that you have.

The other advantage that we think, is gives a uniform application along the width, because these bowls, obviously, have dimension like this and the fabric, obviously, also will be wide enough to go through this process. So, along the width and along the length of the fabric. Alright? This sheet of the fabric goes in, comes out, goes in, comes out. So, uniform application along the length and width and also, we have a control and what is the control?

By increasing or decreasing the pressure, we can control expression, sometimes is also known as wet expression because at the end of the day, fabric is wet and what is been added is a liquid, solution. Alright? And so, it is a wet expression. So, that is a 2-bowl padding mangle. It is also known as sometimes, 1 dip and 1 nip process. So, it is dipping once and then this is nipping, so this bowl is a metallic bowl with a rubber sleeve.

The hardness of rubber would obviously, be controlled, so this is got 2 advantages, the fabric is directly not being pressed by metal, but it is coming between 2 rubber sleeves, which are put on

the metal cylinders, rollers, so they are there. So, you control your pressure, you will control expression, you have uniform application and you have a continuous process, is good to have continuous process.

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So, this is what we just talked about.

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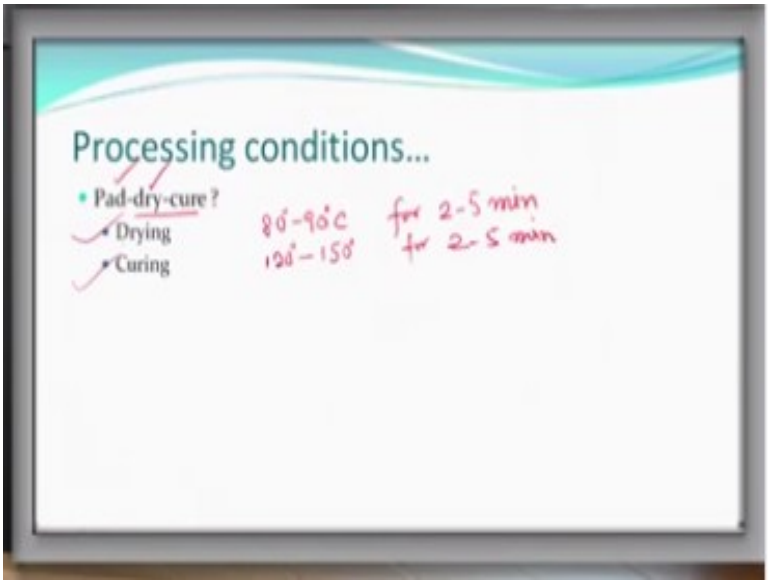

Then we look into what we understand as the dry and cure process. So, we said the whole process is called pad-dry-cure, padding is by the mangle and now we have to see what have we done? In the padding process, let us say we had added large amount of medium, which is could be water and certain amount of chemical, which is required by us. In most the cases you are

talking about 95 to 98% of liquid, which is water, which has to be dried, it was just a carrier, it must be removed.

Therefore, you need a drying process, curing process you require, because this is the time where actual crosslink will be formed. So generally, the drying conditions could be 80 to 90 degree centigrade for 2 to 5 minutes, depends on the thickness of the fabric, very thin fabric will require less time to dry, very thick fabrics would require more. So, that optimization will have to done, the curing temperatures could be depending upon the chemistry of the crosslinking agent.

And that of the catalyst, would require different temperatures, again for 2 to 5 minutes. Now remember, this is just a figure, the optimization will have to be done based on chemical, catalyst and the expressions, also what is the GSM of the fabric. But purpose of this is drying, purpose of this is crosslinking.

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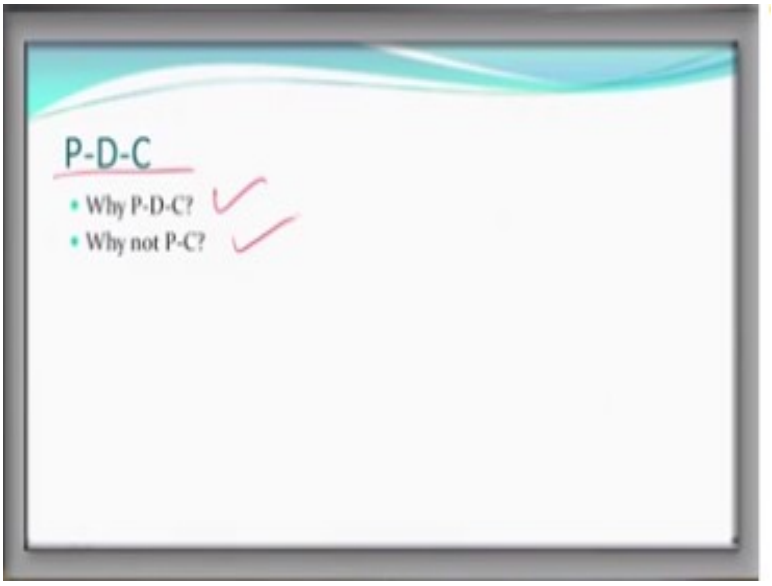

Somebody can always ask this question, this P-D-C that is a pad-dry-cure process why P-D-C and why not P-C means just pad and cure? One is pad, dry and cure and the other is pad and directly cure, the argument is, that curing temperatures are always higher than the drying temperatures. The drying takes place because of the difference in the temperature, because of the difference in the temperature of the fabric, which obviously has water and also the environment which has let us curing environment which has 150 degrees, 160 degrees, the difference.

So, if we do directly pad cure, drying will obviously take place first and when the temperature comes, the curing will take place, why should you go for a process which is pad, dry and then cure? Why should do that? Why cannot we do it in one step? So, there should be a reason for that.

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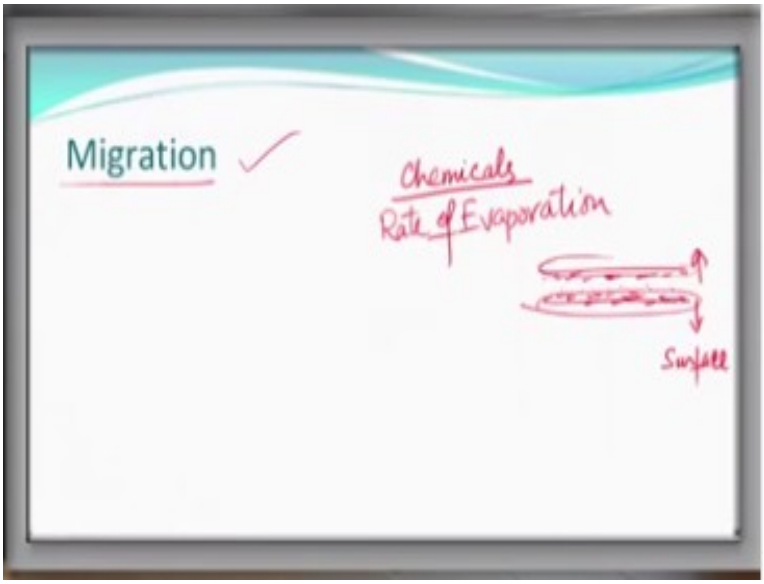

And the reason is something called migration, what you understand by migration? why do you do the padding? Our aim was that the chemical is applied, obviously, through a medium across the length and the breaths of the fabric, which could be 1000 meter 10,000 meter, uniformly. Here one must remember, this crease-resistant finish is change in a bulk property of a material, what is a bulk property?

That is across the length, width, thickness of the fabric. This reaction the crosslink formation is uniform, and it changes the property of every part of the fabric, at least we want that. If it does not happen then it is called the nonuniform crosslinking. If the crosslinking happens more on one side, less on the other side, if the crosslinking happens more in the first lot, first few meters, first few 100 meters, and then less in the next few 100 meters, nonuniform.

If it happens more on 1 side and less on the other side it is nonuniform, but our aim is to do uniform that is why we did padding. But if migration takes place, what is the migration?

migration of chemicals, if the migration of chemicals takes place from one position to another then non uniformity will be created. Why does it happen, why would it happen? If the drying takes place let us say, you throw hot air onto the fabric, the surface will first get dried.

Then the liquor, which is inside will come out and then it will dry and if this is the process that happens, the migration therefore, would depend on rate of evaporation, rate of evaporation. If the rate of evaporation is high, then the water will come out faster from inside to outside and during this process the chemical also along with it will come out because it is water soluble. And so, it may happen that, in a fabric after drying process or after drying of water, if this is thing, there is more chemical on the surfaces, near the surface,

And, less inside which means the chemical has migrated towards the surface, that is migration. So, what? So, what it means is, there will be more crosslink here and less crosslink inside the fibre let us say, or the yarn, that means non uniform crosslinking can take place. If crosslinking is nonuniform the properties also will not be very good, we must uniformly change the bulk property of the textile. Right?

Then only we will get the good result and so instead of drying at a high temperature, I will like to dry at reasonably low temperature. So, you have a pad, then you dry at a low temperature, then once you say most of the waters gone out, then we raise the temperature to a higher, where the crosslinking will take place. Ideally one can say, well, it will be very nice if we can dry only at room temperature, because that will be the slowest drying,

And, therefore very very low amount of, zero migration we can almost say, but then time consumed will be very high. So, you have kind of a compromise that will raise the temperature to an extent, that the rate of evaporation is higher than the room temperature, were not so high and so migration if at all takes place, is very very low and so, we go through to step process in fact 3 step pad, dry and cure.

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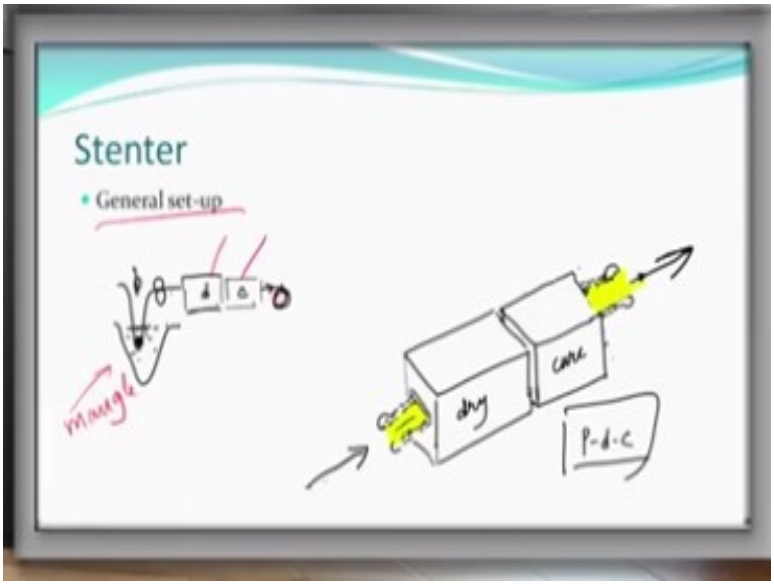

This is done in some general setup like this, you understand this? This is your padding mangle, the wet fabric from here enters a chamber which is called the drying chamber. And then it enters the curing chamber and then of course you can wind it. So, this could be 1 chamber, 2 chamber many more chambers, based on what is the width, what is the GSM of the fabric, what is the expression that you have, how much water therefore you want to remove,

And, at what speed that you want to do your production. If you want higher speed of production and you want this time and temperatures are optimized already, then the only way you have a more number of chambers, more number of drying chambers, so that drying time taking care of more number of curing chambers at the curing temperature is taking care of. So, you can have many more chambers in line and this could be a very very long machine, which can give pad dry cure and finally a finished fabric.

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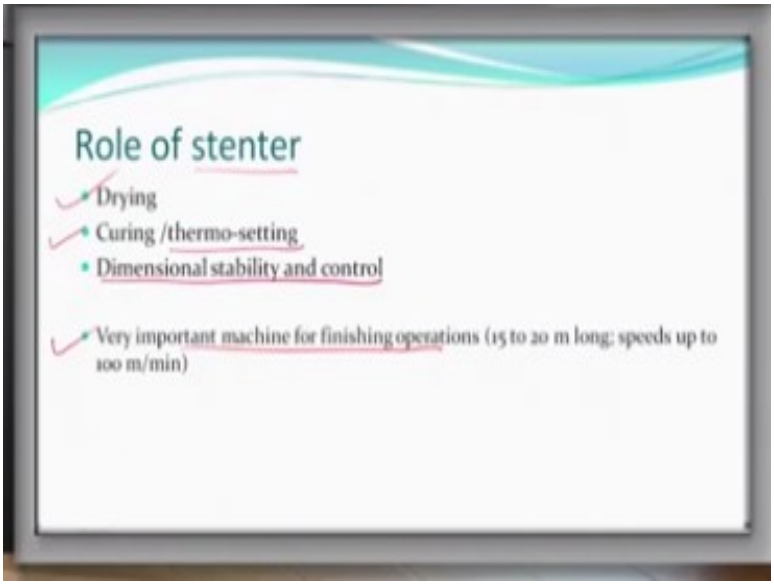

So, stenter. What can be done in this stenter? The stenter obviously, can have chamber which are at low temperature fixed and therefore they will do only drying. You can do curing because some next set of chambers could be at higher temperatures, which could be gradually increasing from 1 chamber to another, control is yours. And, so crosslinking reaction can take place. Also, it can be used for thermo setting or heat setting if you remember, we talked about which is generally to control the dimension and shrinkage of synthetic fabrics.

Because synthetic fabrics are generally thermoplastics and they do respond to any thermal input that we give and so the stenters can be used to do dimension control or heat setting of the fabric. So, the other important thing is dimension stability and control that we said, whether you are doing finishing or you are doing heat setting. Finally, you would like to know what is the width of the fabric, if we want to allow it to shrink, we allow it to shrink,

we do not allow it to shrink, we can stretch it, keep it which have position. In our case for example, in the crease resistance finishing, we would like to keep their control on the dimensions across the length. If you , let us say, 90 centimeter width, 140 centimeter width, you make sure that the 140 centimeter is actually maintain throughout the length of the chamber, where drying initially and then curing will take place.

So, there finally, dimensional stability will be there. These machines are most important machines from finishing operations, can be 15 to 20 meter long, based on number of chambers and the requirement that we have. And, the speeds can be pretty high also, upto, up to 100 meters/minute but optimization will have to be done whomsoever is responsible for this.

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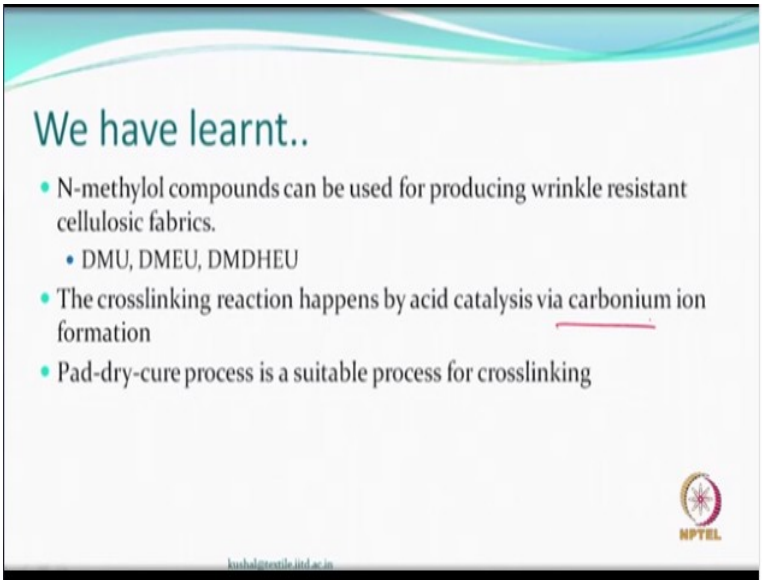

So, what have we learnt, we again learnt, in this lecture, there are N-methylol compounds which can be use to produce wrinkle resistant finish, wrinkle resistant finished fabrics. Some of the examples we discussed were DMU, DMEU and DMDHEU. We also learnt that the, their mechanism of crosslinking is acid catalyzed and it happens via a formation of a carbonium ion right carbonium ion.

Pad-dry-cure process is more suitable for finishing process because the fabric remains in a creaseless form, dimension controls are there. And because of the intermediate drying process the migration is less and because the migration is less uniform crosslinking can take place and give a better fabric.

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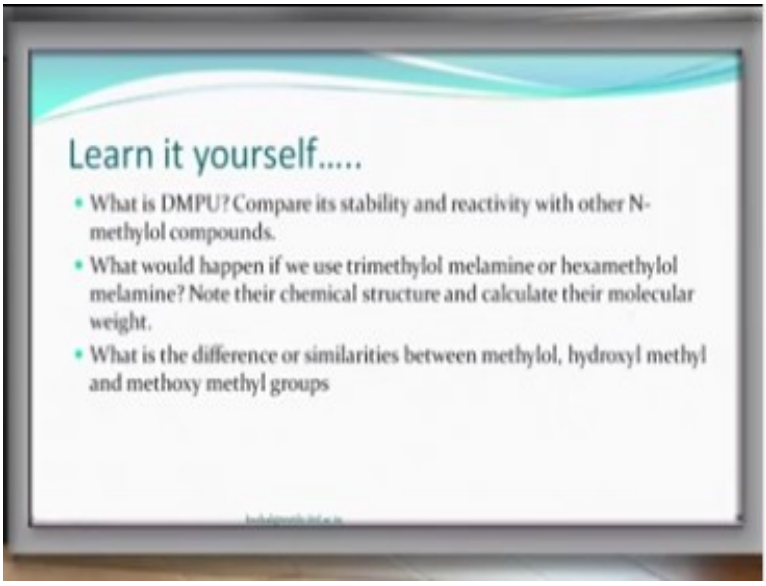

At this stage I will encourage you to do and learn something on your own. Find out what is DMPU, try to argue, compare it hydrolytic stability and reactivity versus the other compound that we just studied. Try to find out if instead of this compounds if we have trimethylol compound what would happen if we have hexamethylol compound like the trimethylol or melamine hexamethylol melamine what would happen try to find out what are the chemical structures.

And calculate the molecular weight just check if you can understand what is the difference between if at all or similarity between methylol group hydroxymethyl group or methoxymethyl group, is there any difference. If suppose we use methoxymethyl groups instead of hydroxymethyl groups will there be any difference in reactivity will there be any difference therefore in the stability.

Remember a general thumb rule highly reactive compounds can give you some advantage in terms of time of curing but that is not what a consumer will be interested. The consumer will be interested in a stable product, product we does not change its properties that time which does not break down and release, let us say formaldehyde. Because they have been made from the formaldehyde which gives fishy odour which is also not good.

So, instead of reactivity one can opt for stability alright, higher the reactivity, less is the stability generally. Because it is very reactive therefore it also has a tendency to hydrolyze also fast.

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So, we stop here and next time when we meet will take this discussion further alright, thank you.