Textured Yarn Technology
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False-twist texturing
Lecture – 07
Characterization and optimization

So, we come to this class and take the story further on the false twist texturing. Part of Characterization and Optimization; a part of characterization we have done. And this time we will try to complete some of the things which are left out. And how do we optimize? Optimize means then you got to have some parameters on which your properties depend. And so hopefully you will have some control on finding out how to change those and get to an optimum property. So, this is what we will try to see. May not be in this whole class we will go to the next class as well.

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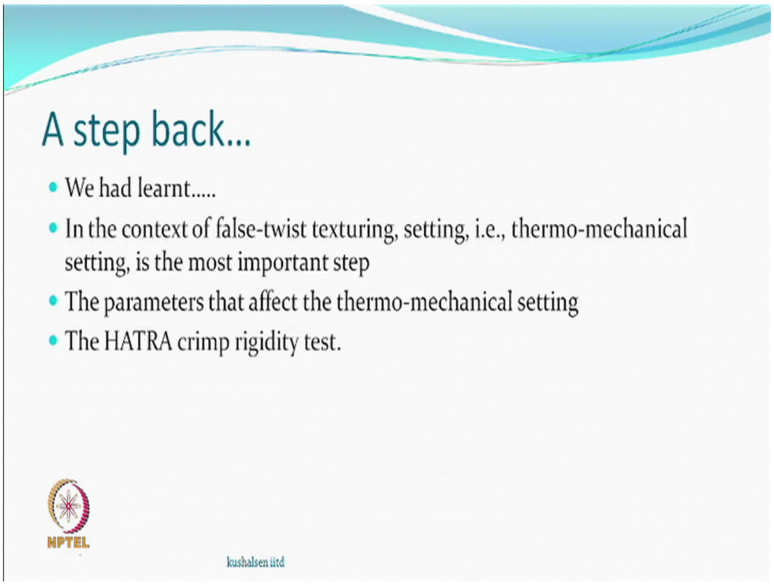

So, what did we do? We had learnt that in the context of false twist texturing setting that is thermo mechanical setting; these are all most important steps. And there are some things which we must control or if we can control, they would help to do better setting. And in thermo mechanical setting we understand; we are looking at release of energy.

Then also we looked into which parameters and we did talk about a crimp rigidity test method. And why we are talking about evaluation is that when you talk about optimization you know how to evaluate. First we should know, then only you will say well this is better or this not so good.

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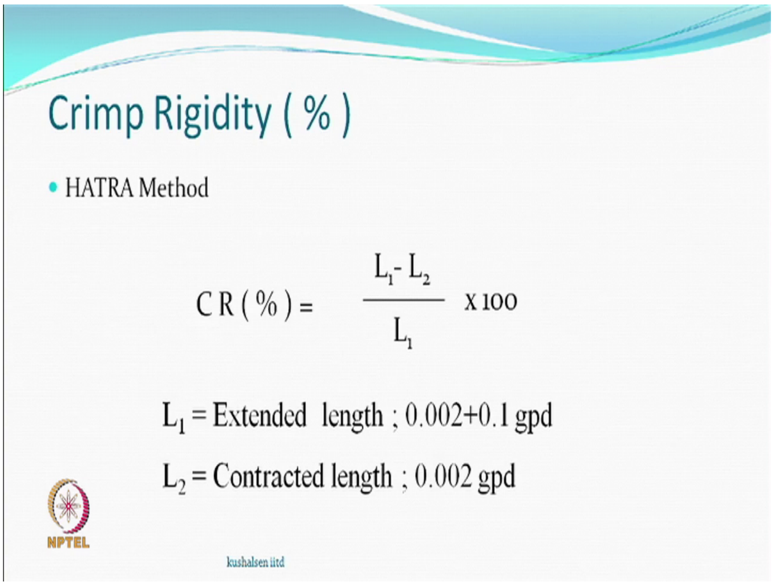

So, let us look at the characterization itself. We did talk about this method called the HATRA method. So this is called crimp rigidity. So, higher is the rigidity, better is the texturing we may at least conclude. What it means is that it recovers much more after the load. So, if it recovers less then; obviously, it is not so good. So, this is how we will work on.

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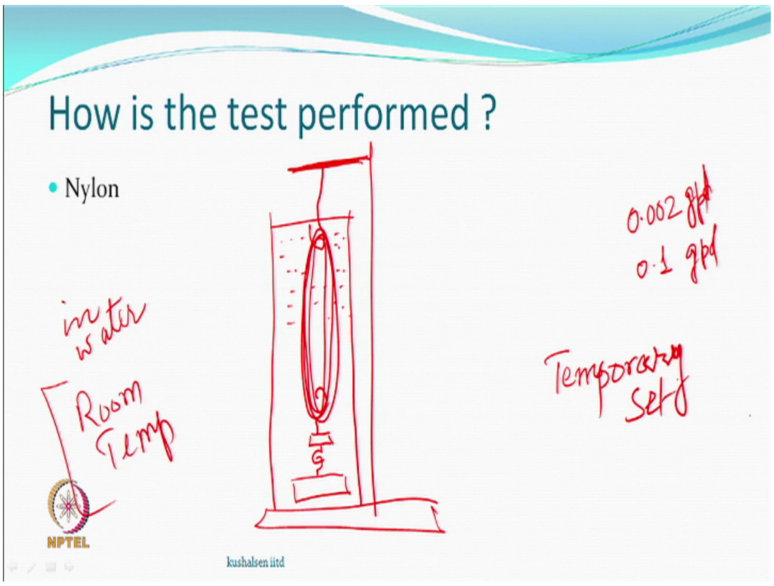

You remember the first fiber which somebody wanted to make synthetic fiber. Actually people who wanted to make polyester, but they ended up making nylon all right. So, therefore, the whatever happened on texturing also happened first on nylon and then on polyester. So, when it came how to evaluate the crimp characteristics of a textured yarn which was also nylon so, the initial method was designed for nylon. And what was the method? So, the test was conducted on leaves.

So, they made some leaves of the textured yarn all right. And now we say we are supposed to load and unload. So, we will be you can have some way to hold it the leaf. So, this could be some stand all right on which you can hold the leaf. And then you put some weight which you initially you have a light weight which we called at the [0.00] 0.002 grams per denier.

Then you also put a heavy load. So, which was let us say 0.1 gram per denier. And this whole thing this experiment was conducted in water. Experiment was conducted in water at room temperature of course. Well you can define the room temperature also as 25 degrees plus or minus 2 degrees in any setting testing environment.

But this whole thing was in a jar where this leaf was hanged into the water and then later after a certain time the heavy weight was removed is allowed to go and contract and then measure L1 L2 and get to your whatever value of crimp rigidity. So, question is why did they do in water? Because doing any test in any liquid is clumsy you know. Why would somebody do that? And here is one concept which we wanted to talk to you earlier, we had probably discussed earlier was called the temporary set.

That means, when somebody opened a textured yarn package and they took the yarn out, they almost saw this hardly any crimp there. And so what do you test and if you actually test that and there is no recovery or not as much recovery, it will give you a bad result anyway. So, one fear was that maybe we have lost everything during this storage period. But when they found that you do any kind of a stress thermal mechanical, it comes back.

So, this new condition where almost everything appeared flat was only a temporary condition. Automatically it was not going up contracting, but it needed help. And it was; obviously, when you put anything of nylon in water the glass transition of this polymer goes down. And so the molecular mobility also starts and suddenly you find that all the crimps which were seem to have been lost somewhere again come back and so, this test was designed in to be conducted in water all right.

But later on people found that there could be other methods also, you could actually make the leaf put it in a hot oven for some time then it would also recover. So, this was the test which was designed initially.

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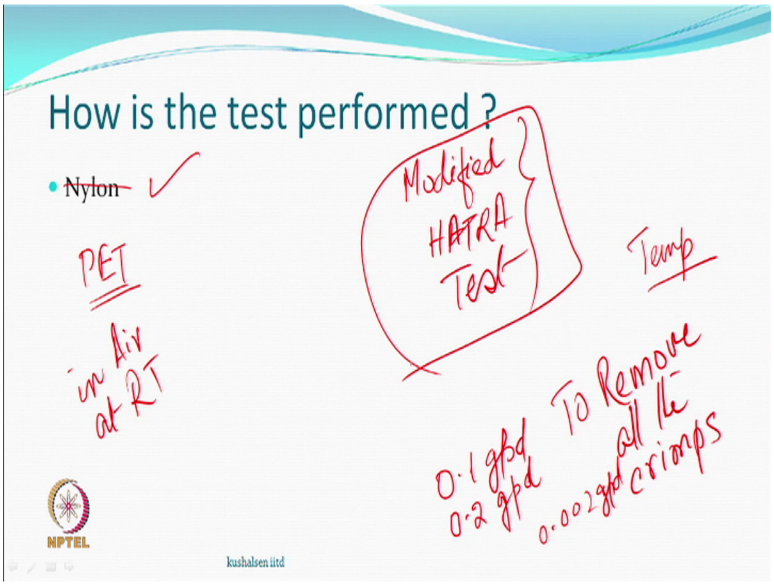

So, nylon we have understood. So, what about polyester? Will it be any different? So, two things people found that by putting polyester yarn textured yarn in water, it did not help. Because polyester is too hydrophobic and it is glass transition temperature does not get affected by water. So, if there was a temporary set, the temporary set remain. So, what you do?

So, either you raise the temperature of water or as I said you can put it in some hot oven at a temperature which is above the glass transition temperature and the glass transition temperature of the polyester will be 70 to 80 degrees. So, you try to get to that and suddenly you will find the crimp developed. So, instead of putting water putting the doing the test in the water, they said we will heat it up and then do the test. Because why go when we have why we heat the water which will be more difficult process while the test is being performed why not do it.

So, you make separate leafs whatever number of tests that you want to do, put them in oven they will; obviously, get contracted then you bring them up, then test them in air at room temperature without water right. So, that is called modified HATRA test. So, that is modified because the original HATRA was do it in room temperature water. They also found that polyester because of its aromatic rings in the molecular structure is relatively more rigid compared to nylon which has no aromatic ring is basically an aliphatic structure more flexible.

And so, to remove all the crimps you needed more stress. So, instead of 0.1 grams per denier suggested it was suggested that you can do 0.2 grams for this that is very low again it is not a very high stress. But it is double their double the previous one. So, they realized at least some of the researchers realized that if you do 0.2 grams use 0.2 grams per denier, then all the crimps are removed.

So, the first length that you measure is when all the crimps are removed and the second is just recovery which was still kept at 0.002. So, that is why this was called a modified HATRA test all right. So, we are locking PET only because that is the most popular textile yarn that you have although polyester as general there are many polyesters which are also useful and very nice.

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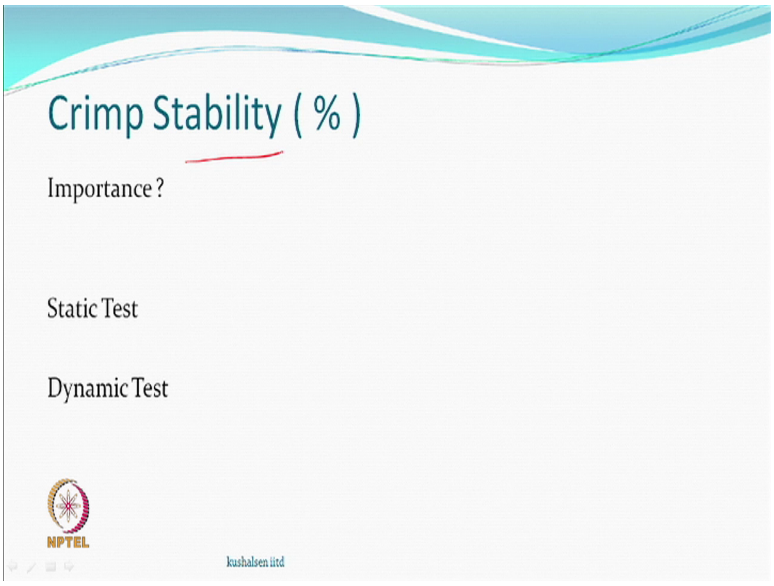

So that is about that was about the crimp rigidity. The other test you may be interested in is the stability of whatever crimps that have been generated. Whatever texture as we made how permanent it is one test you do is gets a value. Then you go to the next leaf give it do another test you get another value average amount. And get to the value, but let us say in a normal condition let us say somebody who is wearing a textured garment textured yarn garment.

And then he is sleeping in a certain posture and the yarn from that area has been stressed for a long period ok. If it is stressed for a long period then this is at condition which is most stressful then the condition of a test which is stressed to only 1 minute and then recover. In this case maybe depends on who is sleeping 6 hours, 4 hours, 8 hours or more. Then you are expecting this to recover from that.

Now what happens is if suppose your material for whatever reason creeps, creep is a test under stress is not it. So, if this material creeps, then you will have a different situation all together. Now somebody may be interested; I want not only want the initial test I want to know what how will it happen. So, that kind of a thing could be called a static type of it like stressed in an approximate static condition of a long period other the dynamic test you may like to conduct where for example, athlete it is jumping.

And you have a frequency at which it is stressed and recovered stretching and recovering. So, you can do a dynamic test of stretch and recovery you do certain some number of cycles and then see how good or how bad it is ok. So, you may be interested in something called crimp stability; which also means a combination of the properties of the material that you are handling texturizing versus the stress levels that you give or the setting that you have done.

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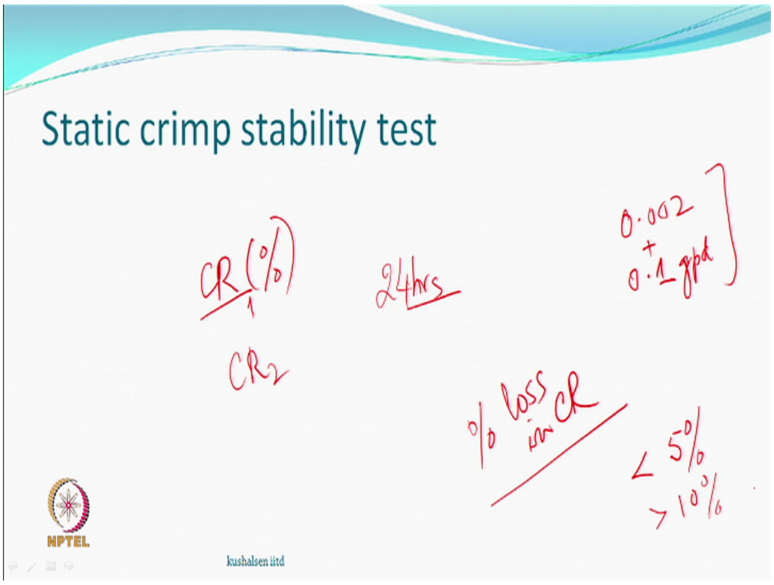

How can we measure these static crimp stability test? We can I mean this is there. So, you do the crimp rigidity without stress. Then you stress put a stress which means the 0.002 plus 1 gram per denier let us say in the case of nylon or 2 grams per denier. The stringent test could be you load it for 24 hours which is really it is stringent at room temperature And then you remove this, let it recover maybe depends what kind of tests you can design maybe for 1 hour better to recover.

This also too much of time people who like it to recover within few minutes. But let us say and then do crimp rigidity test again. So, we will find that if some there is a loss in crimp rigidity. So, how much is the loss percent loss you can calculate. So, the percentage loss in crimp rigidity will give an idea that whether the setting was good or if the material that you chose to texturize responds differently to the stress levels right.

So, this test can be performed then you can say if the loss of this is less than 5 percent should be quite happy that it is not bad. But if it is more than 10 percent you may start giving advice do not do this, do not do that right. You got a care advice you know do not wash in 80 degrees wash it room temperature etcetera. So, or tell the guy that this is not good enough we have to do something else all right. So, this is one of the ways and you can evaluate your material.

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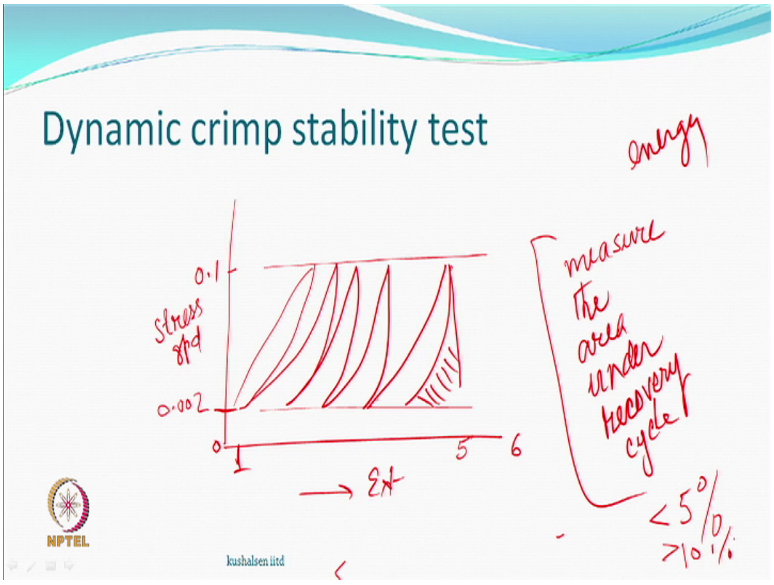

The dynamic crimps ability test what it means is that you will be doing some cycles of loading unloading right. So, one of the ways will suggested is let us say on this time this side I am plotting stress. So, loading means there is a strain also. And from where to where, you say well 0 is here there are levels. I am fitting 0.002 and let us say 0.1 grams per denier ok.

So, these are the two levels where I may write to the cyclic loading. Let us say you for whatever you get a curve, then you do unloading, then loading then unloading then loading then unloading. And what do we do? We can measure the area under recovery curve. So, this is the thing and this is the recovery. So, you measure the area under the recovery curves in each cycle all right.

So, you may start with a cycle 1 and let us say you have cycle 5 sometimes people may go to cycle 6. So, recovery the energy so you are measuring the area means the energy. So, this of course, is extension. So, you get; obviously, some hysteresis every time you go up whichever is curve it follows depends on what you are putting on it follows a curve when it comes back you find it is coming differently that is the hysteresis all right.

So, if the change happens too much then the hysteresis will be more if the change is less then hysteresis is less 0 hysteresis will be the best, it may not happen. Because what happens is this test can be performed let us say on an instron tensile tester where the jaws keep moving up and down at a certain speed which you fix. So, many centimeters per minute all right. This is the way you will do the extension part of it, but limits are set by stress the moment the stress becomes 0.1 start, coming back.

When it become 0.02 start going up so this cycle can continue. So, you are going up to the fully decrimped state to a recovered state and that is the way you can test. So, the loss of energy that is the under the recovery cycle percentage loss of energy and the recovery cycle can be considered as the measure of crimp stability. If loss is too high then; obviously, stability is low if the loss is less stability is high. Is this clear what am saying? So, on an instron machine you can load your textured yarn or a bundle of textured yarn where they are loaded up to let us say 0.1 denier.

So, fully loaded then you allow them to recover up to 0.002. So, this cycle can do this kind of cycle can be done where you can fix the extension levels, but because the crimp rigidity test says that we work in two stress levels. So, this is the stress level you can fix it up all right. Here also if the difference between the 5th cycle and the 1st cycle loss is less than 5 percent, you can still be satisfied or more than 10 you should be dissatisfied. And so there is a range you can work around. So, this is the dynamic crimp stability test.

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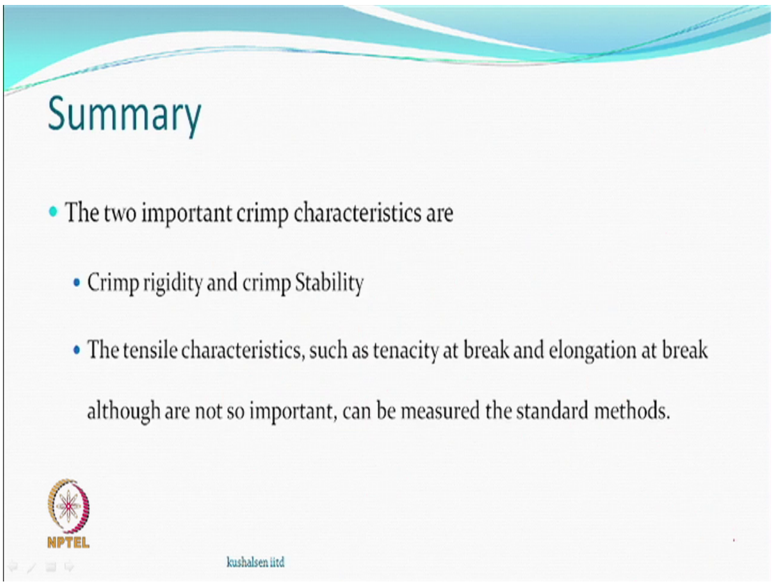

So, important crimp characteristics therefore, are crimp rigidity and crimp stability. We mentioned the tensile characteristics as a tenacity at break and elongation at break although are not so important because generally during use your yarn is not going to be extended to that level. You know if it extends 300 percent 400 percent your stretch at any given point of time in a garment may be 30 percent 50 percent.

So, it is much below, but we still measure and we can report also I have done this texturing. This has happened that has happened and which also could be important in some cases. Now we go to the next part of this discussion whether the parameters which will affect the texturing. Texturing means we are looking at crimp rigidity we can look at crimp stability.

So, we are talking about that which in turn also means whether you have done good setting or a bad setting it is not that independent of that setting twisting setting. And the de twisting is part of the whole process, but this type of a behavior that we call a whether is good nicely set or not. So, nicely set would be determined by the crimp characteristics.

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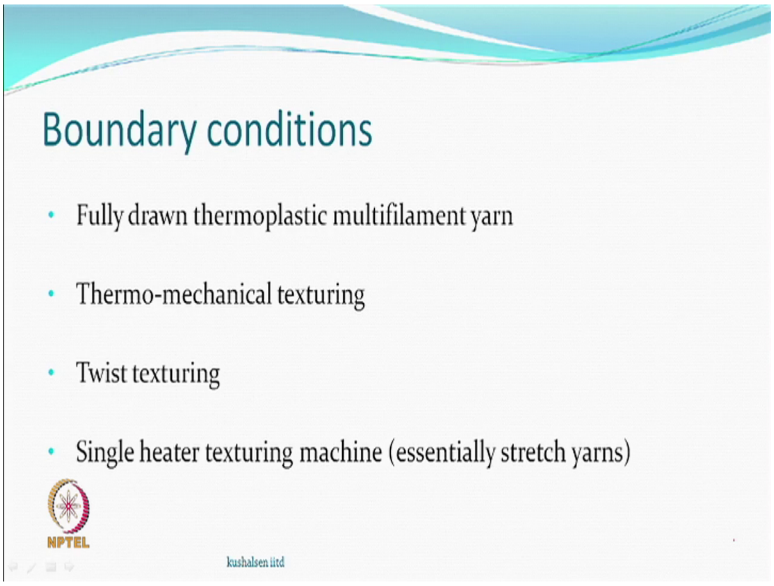

So am just repeating again that when we visualize whatever discussion that we are having. We still in the under these conditions that fully drawn thermoplastic yarn thermo mechanical texturing. And it is twist texturing no other texturing and at the moment we are looking at single heater texturing machines ok. We are not even looking at double heater texting machine. So, we are basically saying stretch yarns and not even modified to stretch yarns.

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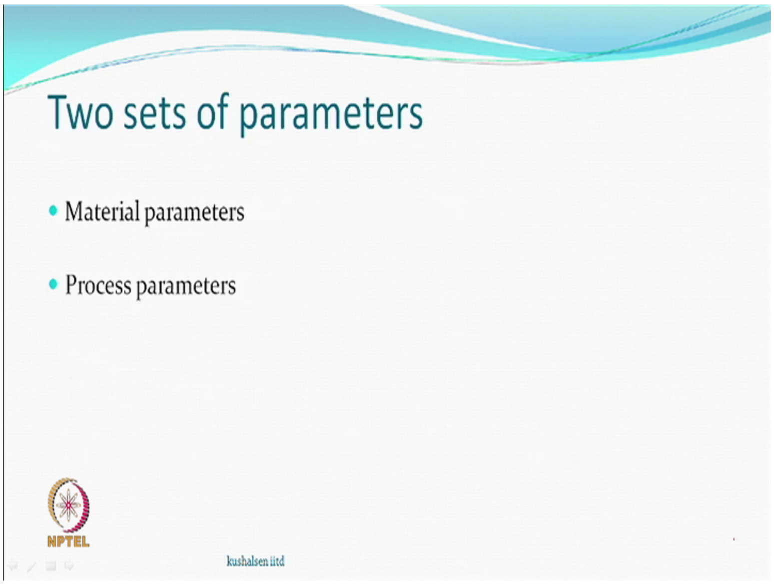

So; obviously, there are two types of parameter that you may like to discuss one is the material related parameters other is the process related parameters. So, material parameter which type of a fiber that you are actually wanting to texturize what are the dimensions of the material. How many number of fibers it has in the filaments all those kind of things will be important the material characteristics and the process means we know it is a thermo mechanical process.

So, that is temperature is important time is important. How much twist are you giving that could be important and also may be how much stress that you want to put while you are texturizing. What is the stress level? You know what last time we said that if you have a stressed yarn. And this process of setting is a relaxation process where the molecules can take up certain positions. So, that can be restricted if you put stress. So, so those will be the process parameters and then we have the material parameters.

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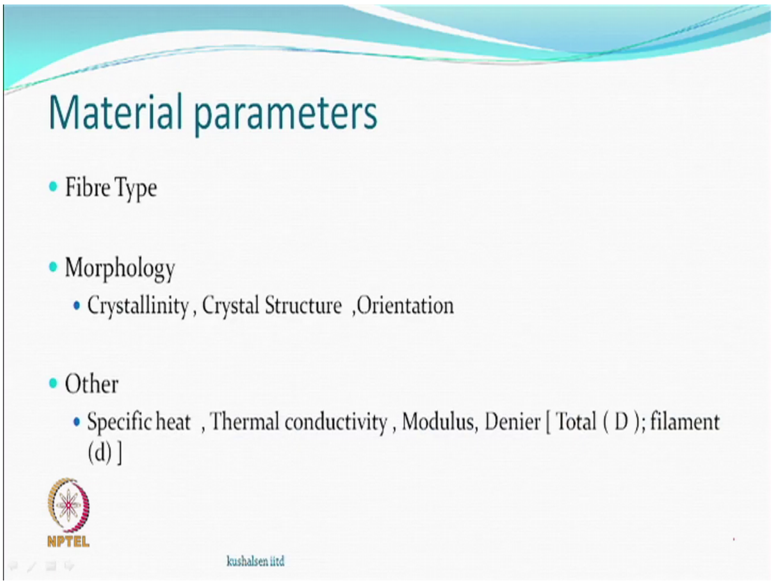

So, in the material parameters; obviously, we should be concerned about which type of fiber. We are using we should also be concerned about the morphological characteristic of the material does it crystallize what kind of crystallinity, does it have, is it oriented structure not. So, much oriented structure and crystal itself can have different structures crystallinity is one part.

But within the crystallinity you may have a different type of crystals present. So, different materials; obviously, respond differently and then other properties characteristics. That you may be interested in a specific heat thermal conductivity modulus of the material the denier total denier and filament denier which is individual filament denier right. So, total linear is a 300 denier material, there you are texturing or 80 denier material you are texturing.

Does it have 36 filaments or got 15 filaments? So, all that is part of a material some of it you may have control oh I will not texturize 35 filament yarn. But your client says you have to so only thing that you have to understand with it will have some impact and based on that you may change something all right so.

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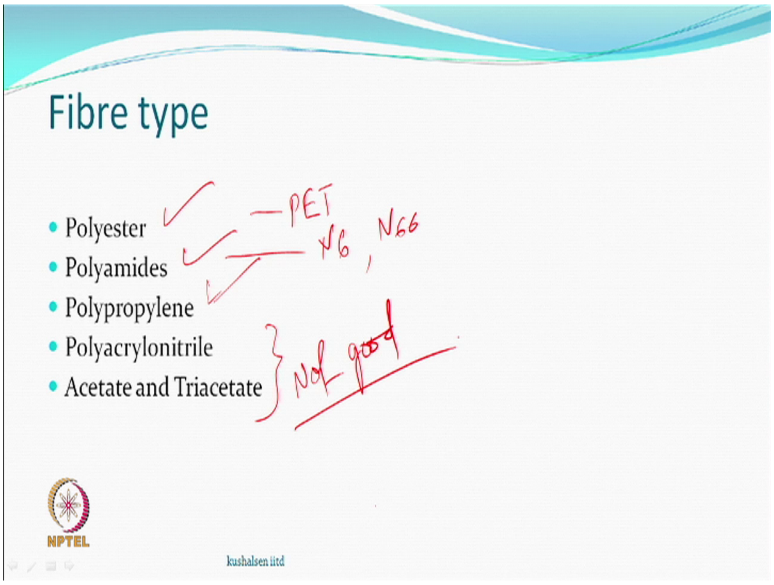

Polyesters, polyamides, polypropylene, polyethylenenitrile, acetate, triacetate. Which one of them is not a thermoplastic? Which one of them?

Student: (Refer Time: 27:29).

So, most of the people are saying acetates are not thermoplastic right, but that is wrong.

Student: (Refer Time: 27:38).

They all thermoplastic and theoretically all of them should respond to thermo mechanical texturing theoretically. So; obviously, in this whole thing it is the chemistry of the fiber which should be responsible for how does it respond to any thermal input. And what do you want ultimately we said these molecules should be freed they should be allowed to take up positions within the fiber in a crystalline region or in the amorphous region whatever they want and we cool them cooling is our thing heating is our thing.

But what happens within the molecule is spontaneous you cannot guide each and every molecule do this. And therefore, the chemistry of the material is; obviously, important therefore, polyester behaves differently than polyamide. And the polypropylene other than the things which you call as optimum temperatures which will be different for different polymers because they melt at different things different temperatures, they soften at different temperature the glass transition temperature different. So, there the chemistry is playing a role ok.

Among these things as we now understand all of them are thermoplastic they should respond. The ones which people love are these two definitely and here this also another way talking about textile grade material which is available. Because when you heat these three first of all you remember they are all melts one material and so they do very nicely respond to thermal input. What it means is that they would also crystallize very easily.

Of course, the rate of crystallization each one of them is different. The fastest crystallizing will be polypropylene then the polyamides which is the nylon. For example, and then polyester being a rigid ring you know polyester here is we are let us say we are not talking about all polyester. And not poly amides we are talking about let us say all polyester which is the poly ethylene terephthalate. We are also talking about let us say nylon 6 and nylon 66 polypropylene.

So, these are the commercially available material which are for the textile applications. All three are good. They consider good texturiable. Texturizable material because they do respond to heat and do change morphology you know during this process. These two are not really considered very good material for texturizing which texturizing, we are talking about false twist texturizing. We are not talking about general texturizing you know this part.

You know constrained the boundary conditions of discussion polyacrylonitrile which is otherwise a beautiful material acetate and triacetate they are thermoplastic. Because the hydroxyl groups have been replaced and the new group of the acetate does not form that type of hydrogen bonding you see. Otherwise the cellulose the cotton viscose forms lot of intermolecular hydrogen bonding. And therefore, when you heat it does not melt such intense is the hydrogen bonding that the main chain degrades before the intermolecular chain start separated.

And start can do whatever they feel like doing right. So, these materials are not melt spun they degrade ok. And because they degrade, then how can you do texturing so the degrade. So, you do not want the degraded material and say now I have got a textured yarn be happy about it cyclic fibers are very sensitive to heat something will happen, they become yellow very quickly.

And similarly acetate and triacetate are also thermoplastics because the in the capability of formation of intermolecular hydrogen bond it reduced drastically in tri acetate all the hydroxyl groups have been taken care of in the acetate at least 2.2 to 2.7 out of 3 have been taken care of. So, they do not form hydrogen bonding. So, they would respond to heat all right. So, you understand what I am saying, but still not considered good for texturing. And again I am reminding the texturing we are talking about thermo mechanical texturing.

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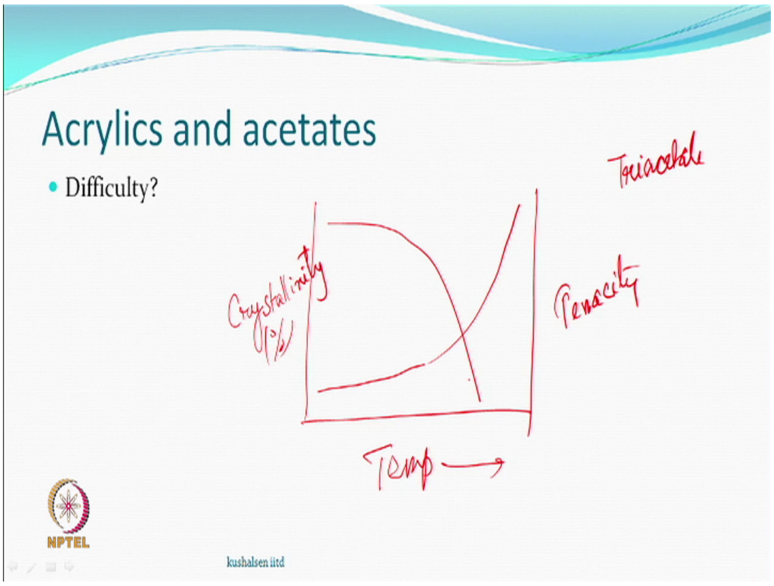

So, difficulty level for example, if somebody wants to say well I am temperature. And here let us say you are measuring crystallinity. And you want to plot for let us say a triacetate. The crystallinity does not develop very easily and then it develops. So, it can be sure oh crystal is developing no problem. That means, we can get setting by release of energy, but if you have this tenacity as another measure.

So, the tenacity and dips like this. So, when the crystallinity starts rising the tenacity starts falling also badly. So, while it is thermoplastic material and still cannot be very easy so, what can we do to this? Well if you really want a twist texturing, then you may have to get help by an external agent other than thermal other than the heat that is the solvent. If you can do the same thing in the solvent things, the solvent assisted texturing can be done at a much lower temperature where solvent does exactly the same as the heat does.

What does the heat do increase temperature kinetic energy of the molecules increases that energy becomes. So, high that the intermolecular bond; obviously, break and then the molecules are free to do what they want to do. In the case of solvent the solvent diffuses inside the fiber and then whatever little associations that they had intermolecular associations it breaks. When somebody said that nylon glass transition temperature goes down in water.

So, water is doing what the nylon molecules form hydrogen bonds water and these bonds are like contracts ok. It is it is not like an Indian wedding you know for the whole not life this life many lives so this is a contract. So, when the two atoms come close to each other so they can exchange certain things. And therefore, they say well we are making a covalent bond or ionic bond or a polar bond or a hydrogen bond.

So, it distances because they are they like that part. If hydrogen hydroxyl groups here and hydroxyl groups come hydroxyl groups from the other side come together it is fine well the water can also go and make they do the same thing. So, it can break that anyone similar any other solvent will also go and break other bonds and you have a new contract signed and suddenly you will say well.

Now the motion molecular motion can take place at low temperature because solvent is assisting it. A lower temperature could be room temperature it could be 70 degrees based on what solvent what fiber we are talking about. So, theoretically all fibers with the self solvent assisted systems can work. So but we are discussing what thermo mechanical texturing. So, they are bad candidates for this.

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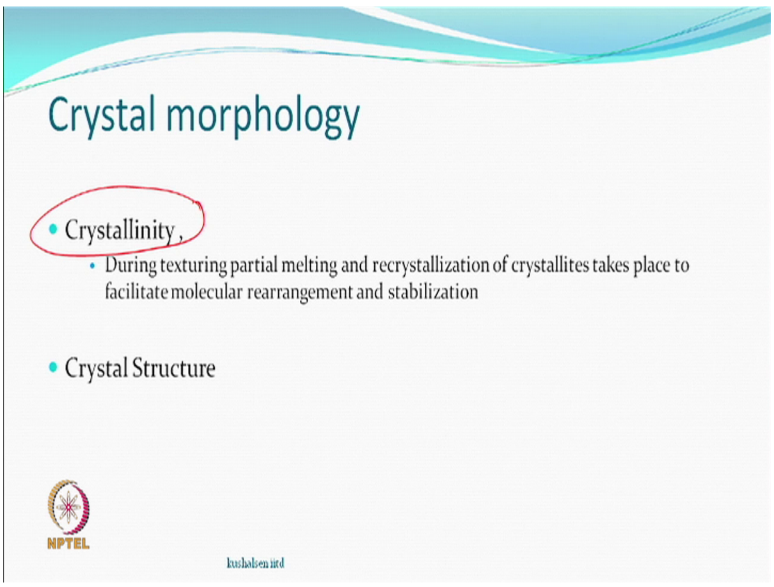

The next in the material configuration material parameters that could affect texturing we said morphology crystal morphology. So, one of them is called crystallinity. So, you understand crystallinity. How do you measure crystallinity? How does one measure crystallinity? X ray diffraction, very good. So, you can note this statement and what is the statement says during texturing why we talking about thermo mechanical distribution.

Partial melting and recrystallization of crystallites takes place to facilitate molecular rearrangement and stabilization recrystallization you see partial melting and recrystallization. So, you must appreciate your material which is called a textile material to begin with is not amorphous. It has crystalline regions it has also amorphous regions and so when we were talking about intermolecular bond breaking. So, that molecules can take you know positions based on the best position which means you have to handle the crystalline portions also not just amorphous portions which will respond easily.

So, you have to go beyond that. So, there is always a energy barrier to be crossed because it is already crystallized we said why the crystallize because of fully drawn yarn. A fully drawn yarn had been stressed enough, so it can have stress induced crystallization. So, you have a crystalline material already and then you have to partially melt. So, why do not you fully melt because if fully melt you will not have the fiber.

So, you are partially melting and then doing enough; that means, giving enough temperature giving enough time for it to recrystallize. Because sometimes smaller crystals can come together make a larger crystal all that is there. But what it therefore, means is that it is not just the molecules in the amorphous region which are going to rearrange themselves the material or the molecule within the crystalline regions also will have to be handled which is this must be happening.

Then this also has something called a crystal structure some fibers are very good like polyester. They have only one type of a crystal whenever they crystallize they crystallize only in one form. But there are fibers like nylon, they have at least 2 form. Then you have polypropylene they may have at least 3 to 4 forms; that means, it is a different crystal structure. So, when you say crystallize, then means it can crystallize into any form. So, that is the structure part of it.

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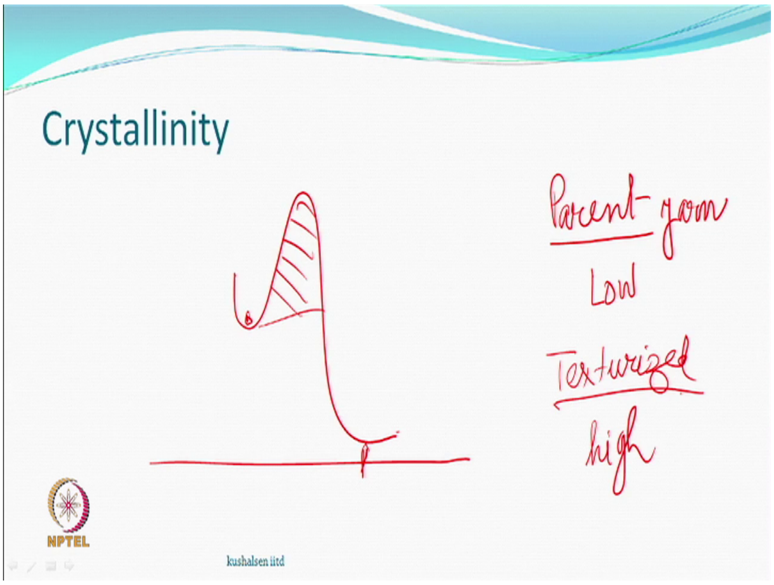

So, let us first look at the crystallinity itself. So, if it has certain amount of crystalline D and you want to go to a different thing you have twisted the yarn. And now you are heating it up and want a stable structure. So, what you have to do is; you may have to before any rearrangement take place you may have to cross this barrier. There is an energy barrier that is why you have to heat. If this barrier was not there then automatically it would go to the lowest energy state it cannot go because this may not be temporarily set.

We said temperature set also has a minima, but that requires very less energy to cross that barrier and go to wherever it wants to go. But in this case it is already a crystalline material. So, because there is crystallinity on the 20 percent 30 percent whatever you have to overcome some of it only when you overcomes this barrier then the molecules will become free to go to a state which may be this state. Where you will say I am not satisfied right. So, if somebody asks a simple question; you have given you have been given a choice and what is the choice that there are five materials with you or three materials with you can choose any one of them for texturising.

One of them has low crystallinity other has high crystallinity which one you choose? Low crystallinity, see parent yarn there is something called a parent you know very important things. So, similarly we have parent yarn parent yarn the parent yarn crystallinity should be low is that right. Same question I repeat I have texturized the yarn.

So, I can measure the crystallinity of a parent yarn take a call after I have texturized again. I measured the crystallinity of the textured yarn then I ask a question.

Whatever process you have chosen, if the crystallinity of the textured and measured one process has given you low crystallinity, other has given you high crystallinity which one you prefer? In the case of parent yarn we had to choose the parent yarn which had to be texturized. After texturization same question is being repeated. Now I have a textured yarn I have done some processing on it I have measured crystal in D and I have got certain values. Which process would you approve? The one which gives you high crystallinity or the one where you have found crystallinity is low?

Student: High crystallinity.

High crystallinity very good.

So, what we have learnt here is that if choice is available I will take a parent yarn with low crystallinity to texturize. But at the end of texturization I like to have as high crystallinity is possible that would mean more stable structure all right. So, this how we will do. So, we can stop here today and next I will pick up from here and move further.

Thank you.