Textured Yarn Technology
Prof. Kushal Sen
Department of Textile Engineering
Indian Institute of Technology, Delhi

Lecture – 11
Revision and clarification of doubts Session 1

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Revision and clarification of doubts

Session 1

So, this session is basically a revision session or session where there are some doubts which people have raised. And so we should take some time to clear those doubts. So, we call that a clarification session.

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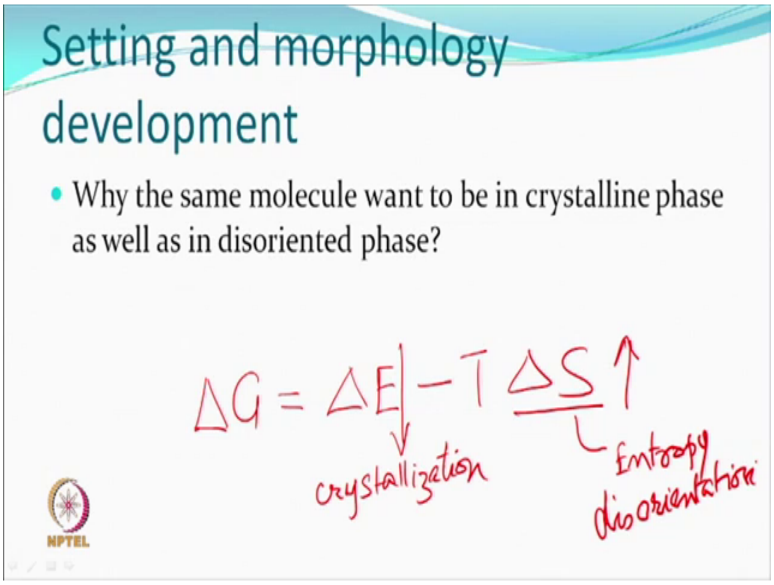

Setting and morphology development

- Why the same molecule want to be in crystalline phase as well as in disoriented phase?

$$\Delta G = \Delta E \downarrow - T \underline{\Delta S} \uparrow$$

crystallization

Entropy disorientation

So, this is was a question which says that why the same molecule wants to be in a crystalline phase as well as in a disoriented phase. So, obviously, the thing that we should be always aware is that this is going to be always holding good. And thermodynamically if delta S increases, it is also favorable; if delta E decreases, this is also favorable. So, these are the two things which if happen we would be getting a more stable state which we call as setting. And so this is if we consider delta E, then we are looking at this as if being represented by crystallization, and this as we said is like entropy so disorientation.

So, all the molecules generally would like to disorient. We will remain in a disorganized fashion increase the entropy of the system, and so that will be considered as a stable state. So, any molecule polymeric or otherwise if it goes into a disoriented state will be considered as a more stable state, because that means you have a complete freedom for movement, orientation, and anything else that the molecule may like to do at a certain temperature conditions.

On the other hand, when we talk about crystallization, what we are saying is that every atom in the molecule has found a specific place in a three-dimensional space which is completely ordered and that is what reflects the crystallization. So, more is the crystallization, more is the setting that means more release of energy has taken place. Similarly, if more orientation takes place, then also it is release of energy that is delta G is going to become negative, so both are good. So, question that remains was why a same molecule we say let us say polyester would like to be in a crystalline phase as also in a disoriented phase because these two are almost opposite as far as the nature is concerned, all right.

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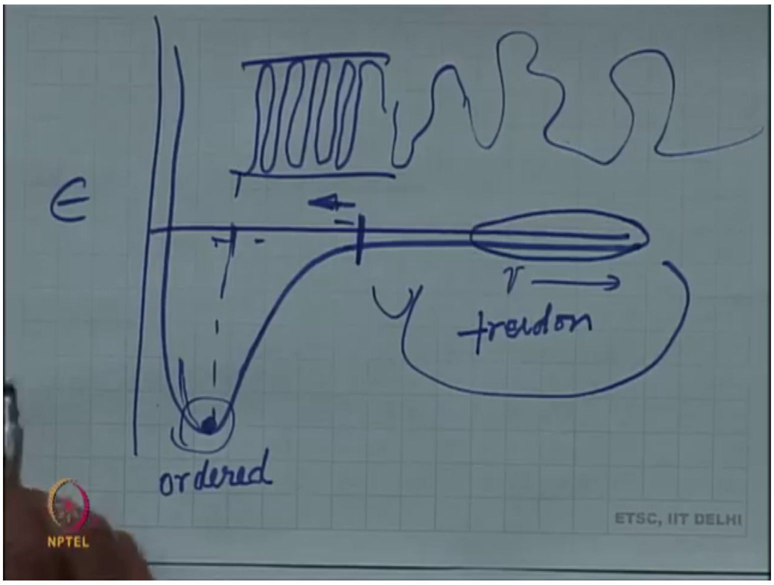

In this we had discussed one interesting curve which is the energy versus distance between the atoms. And this curve had a shape approximately of this type. There is when the distance between the two atoms to begin with are quite far, the atoms are far and distance is more, then the energy is approximately 0. So, they would like to remain in as far as the potential internal energy is concerned, they would be happy wherever they are. But when the distance becomes less than let us say a certain amount, certain value, then it will follow this particular curve and would like to take a position as at wherever the energy is the lowest.

And why this happens also we said that there are forces of attraction between any two particles, there is a force of attraction which brings them closer, and it comes to a position where the forces or repulsion become more predominant. Let us say there is a electron moving all around. So, negative, negative repulsion and so immediately the energy level rises. So, obviously, there is a well and so people would like to be there, but only if the distance is less than a certain value.

If it is more, they would like to have more freedom, this is a freedom region, this is an ordered region. So, if you do a drawing kind of a process that means you are pulling molecule forcing them to come close or any other input that you gave mechanical, thermal or even chemical input, if there is a possibility of atoms or the molecules coming closer than this, then they would automatically allowed to be in this position, so this distance.

Therefore, you have the distance between hydrogen-hydrogen atom, carbon-carbon atom, carbon-hydrogen atom, carbon-hydrogen atom, they are fixed distances, they are not arbitrary, all right. So, if by any of your operations whether heat setting, stresses like drawing, you can bring the atoms closer ones you make them closer, then it becomes this process is facilitated; otherwise they will like to remain in a random configuration. When they come to a state where which is near then this possibly they may like to come closer to each other, fold on each other and make a crystalline region. Does it make some sense?

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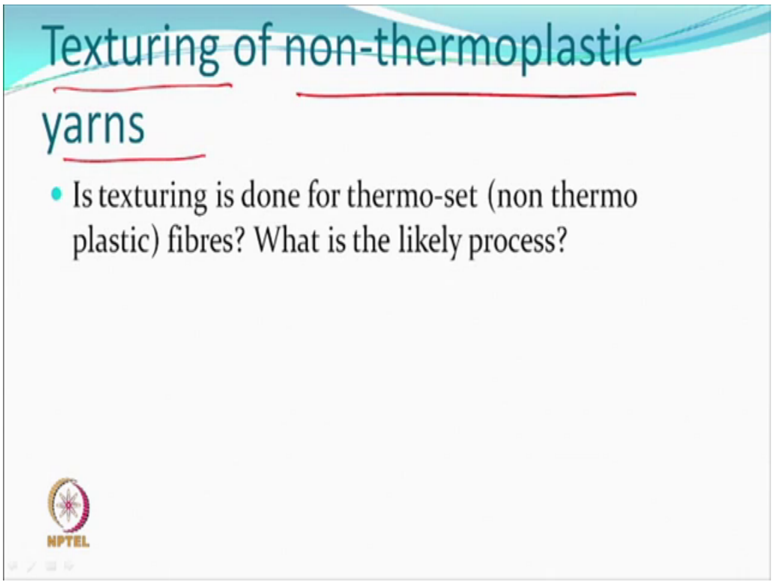

Texturing of non-thermoplastic yarns

- Is texturing is done for thermo-set (non thermo plastic) fibres? What is the likely process?

Suppose also something on the non-thermoplastic yarns. So, because we had said in the last few lectures that we shall be discussing fully drawn thermoplastic yarn, then thermo mechanical texturing. So, this question relates to thermo set or you say non-thermoplastic fibres. And what would you like to do to achieve texturing all right. You want texturing of a non-thermoplastic yarn.

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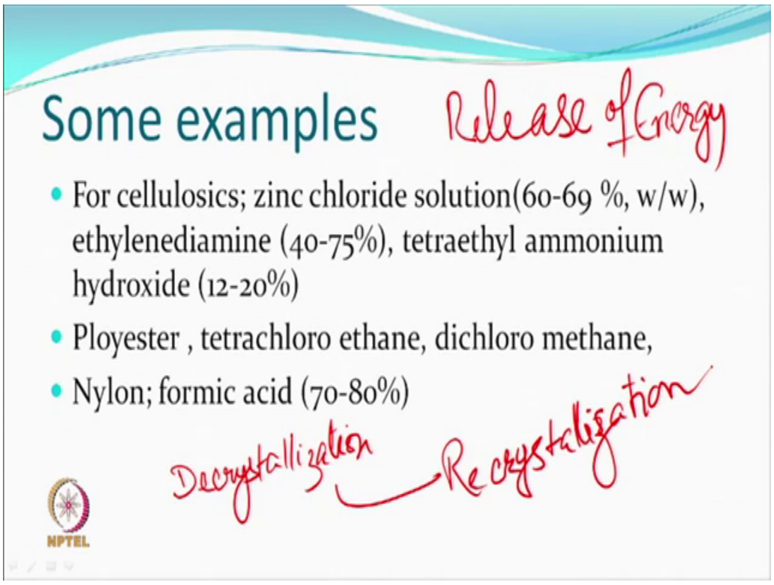

Some examples Release of Energy

- For cellulosics; zinc chloride solution(60-69 %, w/w), ethylenediamine (40-75%), tetraethyl ammonium hydroxide (12-20%)
- Ployester , tetrachloro ethane, dichloro methane,
- Nylon; formic acid (70-80%)

Decrystallization Recrystallization

So, what is likely to be the process? So, one of the processes that can be used even for non-thermoplastics is release of energy. So, there is a release of energy. For example, if you have cellulosic material if you know the cotton can be dissolved in (Refer Time: 09:06) ammonium hydroxide solution. And so there are many inorganic, organic compounds which can do a bit of a decrystallization and a recrystallization, beside it is a partial melting and recrystallization. If we use solvents, so you can probably say some people use this word also decrystallization. So, some partial decrystallization and then recrystallization.

So, what you can do, twist the yarn based on the approximate formula that you have, and then submerge the twisted yarn in a solvent for a certain period of time and a certain temperature, some of them may work at room temperature for some you may have to raise temperature little bit. But during that submersion where the solvent is going to diffuse inside the fibre, what will happen is exactly same as we were expecting breakage of intermolecular bonds. When you say some there is a solvent which dissolve what is a dissolution breakage of intermolecular bonds, so we are only saying decrystallization also partial decrystallization. It is not that you want to dissolve them completely therefore, they you do not want to melt a fibre.

Therefore, you will be choosing concentrations and solvent such a way that there is enough mobility introduced, but not complete dissolution if there is no fibre there is no texturing. So, you can use release of energy mechanism also by using some solvent ok. So, cellulosic can be for example, I have given exa[maple] something, but thermoplastic material also can be texturized by a solvent process.

Because there again decrystallization, recrystallization can take place like we said there recrystallization takes place during heating also. So, during solvent uptake when the solvent is diffusing in also recrystallization we will take place/ And when you remove the solvent of course, you will have to remove the solvent like you remove the heat. So, you will do whatever processes have to be done, so that remove the solvent. When you remove the solvent, it will go back to the same process as the recrystallization and stabilization. So, all the three things which you require for setting can be done by solvents also.

So, whether it is a normal thermoplastic fibre or a thermoplastic fibre, any polymeric material can also be generally you can find a suitable solvent which may only do plasticization and not dissolution. So, if 100 percent concentration dissolves, you reduce the concentration add something like a non-solvent and suddenly you find that it will do the plasticization more than the dissolution, but it must go through the same process called the decrystallization, recrystallization process. So, solvent uptake and solvent removal like you heat and cool.

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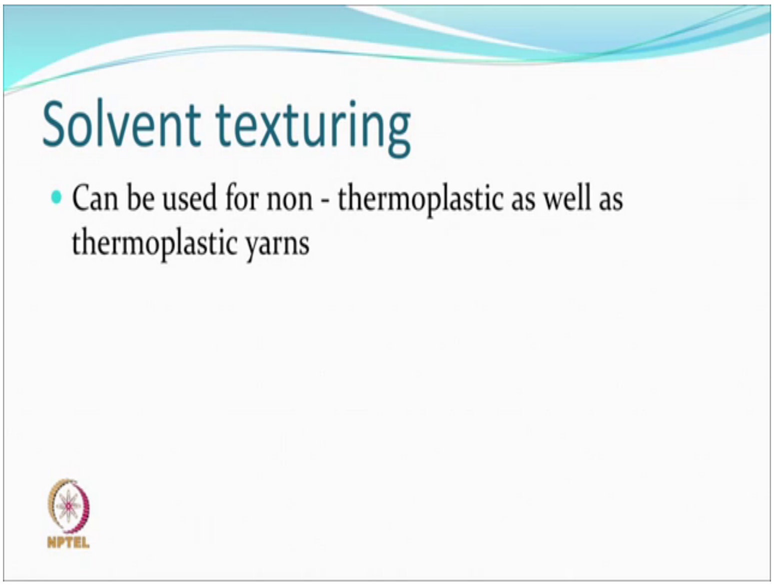

Solvent texturing

- Can be used for non - thermoplastic as well as thermoplastic yarns

So, as far as the solvent texturing for the non-thermoplastic and thermoplastic yarn is concerned, we just seen it can be used all right. So, one part is satisfying so answer to the question which was there before.

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Stabilization by freezing

- Good for non-thermoplastic yarns
- Can be termed as chemo-mechanical texturing
- Cross-linking agents

Bi-functional crosslinking Agent

Inter-molecular crosslinking

The other thing which can be done by the non-thermoplastic material is stabilization by freezing, not by release of energy. For example, you can use cross-linking agent for intermolecular cross-linking like for example cellulose you use d m d h e u, it is a bifunctional cross-linking agent or you can use trifunctional crosslink agent or hexafunctional crosslink agent. But you can appreciate if you have more crosslink by a same molecule the final structure is going to become more rigid like you have Bakelite, it is a cross-linked structure, but three-dimensional crosslink structure or melamine formaldehyde crosslink so you have various types of sheets which you generate which are very rigid.

So, most probably you will be happy with the bifunctional agent. So, a bifunctional cross-linking agent if we use some such agents then we can term this texturing as chemo mechanical texturing like we talked about the other one as thermo mechanical texturing because you are now using some amount of a chemical to do the job. And what is the principle of freezing that once you put additional cross links so whichever configuration that you have decided for yourself will be frozen.

So, what you do, you twist, after twisting, you go through a process where bifunctional agents are used and intermolecular cross-linking can be done. If that happens, then they will remain in a twisted configuration; when you untwist that was like to go back to the twisted configuration all right. So, non-thermoplastics can also be used, can also be texturized by either mechanism of [freezim/freezing] freezing or release of energy.

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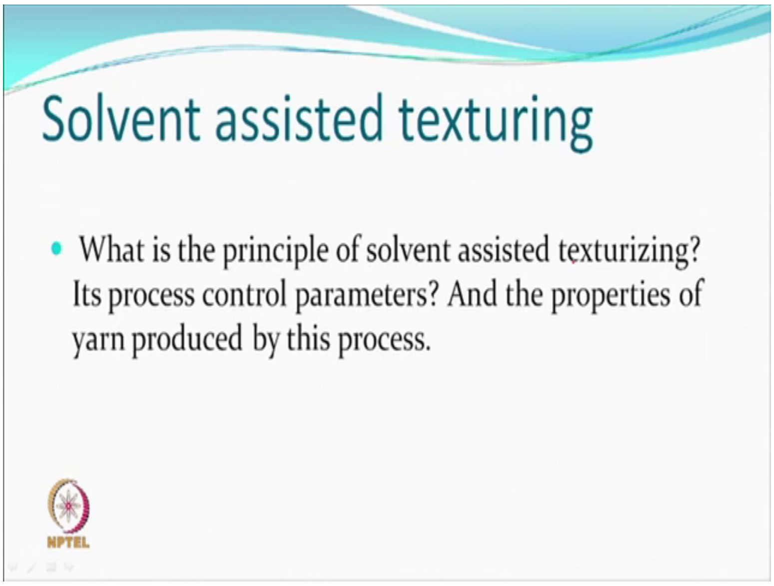

Solvent assisted texturing

- What is the principle of solvent assisted texturizing? Its process control parameters? And the properties of yarn produced by this process.

One question which was also there because what was solvent assisted texturing? So, it is something like a solvent texturing only assisted means only thing that one can think is well instead of going for a temperature which is very high you go for a lower temperature. So, you get assisted. And why will this type of a process be used because you may find that the material actually the thermoplastic, but if you go to a very high temperature losses are more than the gains ok. In that case, you say well we cannot work at high temperature, if we do not work at high temperature all the thing that you want to do will not be done.

What will not be done partial melting will not happen, reorganization, recrystallization will not take place, and so you would need assistance. So, when let us say you have a material like acetate, triacetate, so if you also use some solvent, you find that instead of going to very high temperature at half the temperature you can do the job. And at that temperature, the degradation will not take place, but it will be assisted all right. So, we still require some temperature which has to optimized, you will require certain amount of solvent which has to be absorbed adsorbed diffused.

So, processes can be designed as a batch process, processes can be designed continuous also, but then you have to take care. Wherever you use solvent and you want to evaporate solvent at higher temperatures depending on which solvent of we talk about, if it is an organic solvent you always have a danger of fire, and of course, vapours going everywhere else. In that case you will have to have a closed systems, where if the solvents vaporize, you are able to collect them, condense them, and hopefully reuse them, all right. So, we will not like the solvents to go out.

Process control parameter is obviously anything that you use what concentration of a solvent that have used, obviously, its boiling points will decide as to how much temperature can you go. So, time, temperature, tension, twist all of them are going to be there and in addition you have a chemical which also has to have a concentration and uptake. So, if you give less time, diffusion will be slow.

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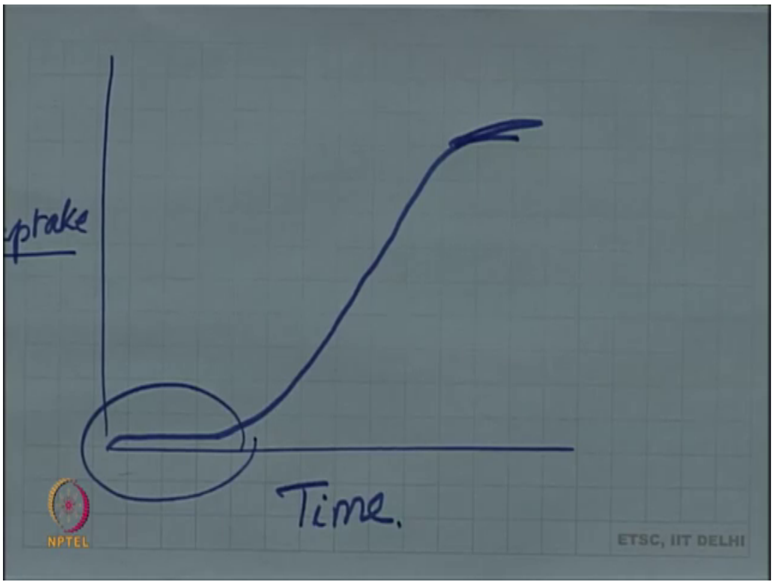

If somebody wants to measure the time of diffusion or uptake of the solvent which means so many grams per gram or milligrams per gram, then it will be very slow process, then will take up time, and then after some time it may take up a shape like this, no more diffusion, no more uptake, but this is the time when initially there is a resistance to penetration. So, there will be time which will required for penetration, diffusion, and then it will make space, and the solvent will go up. And if you are changing any property, then it will go and after that sometime a particular solvent also there maybe spaces are not there. So, it will the rate of absorption will also go down all right.

Unless and until, it is a solvent which can dissolve then there is no uptake left you know everything will be in the solvent the not solvent in the solid. As long as your concentration is such which are not destroying the fibre structure, then you are talking about uptake all right. And the properties of the yarn produced by this process well we are obviously interested in texturing say if we have properly done the thing that means, time temperatures have been taken care of, twist has been taken care of, tensions have been taken care of optimize based on this process. Whatever you have done optimization of a thermal process of the same fibre will obviously, not be applicable in this situation, we will have a different parameter.

And finally, crimp rigidity could be the same. As long as you can guarantee that by partial melting or partial dissolution or a decrystallization recrystallization process again gives you the same amount of crystallinity. If that happened, then you can say well the properties will be same. Some of things can be changed. For example, if because of the solvent absorption and diffusion, some of the oligomers may also come out, oligomers, then maybe or creating some more space, so maybe dye uptake and increase. But tensile properties will go down because this texturing disorientation was taking place, crimp rigidity should increase and so you should be happy.

The advantage with all these processes could be that you can actually if you go by this process, you may actually theoretically take a spun yarn or so we will do the same thing all right. But when you take a spun yarn if you twist more than what the twisted level it can say you can (Refer Time: 23:15) fibers. If you untwist too much, then you will have fiber separated out, you will have no yarn. So, instead of that people may say more than one yarn make apply yarn give apply to twist, and then apply and twist, and you will still get it and so you can gets properties which you want, which are the thermoplastic yarns which are not suitable for thermo mechanical texturing.

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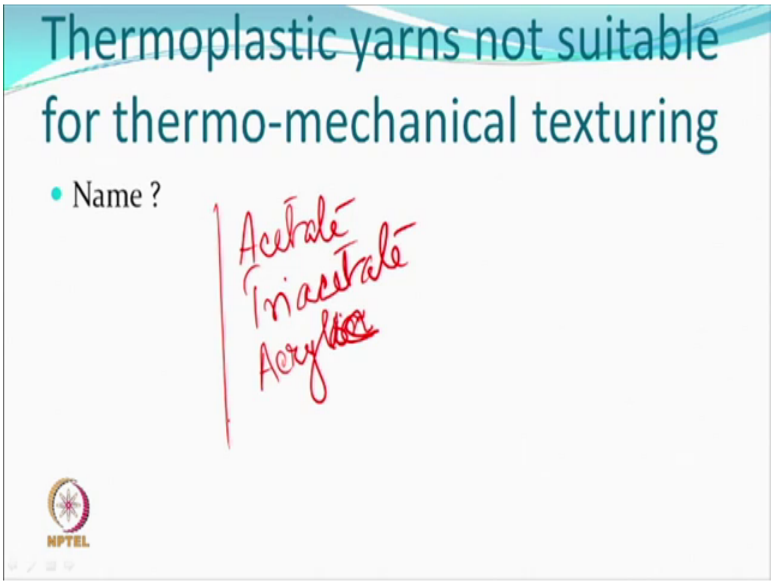

Thermoplastic yarns not suitable for thermo-mechanical texturing

- Name ?

Acetate
Triacetate
Acrylic

Any name where you want to give, yes, we said acetate, triacetate, and acrylonitrile or acrylic fibers. So, these are the textile grade material, which otherwise a thermoplastic, but you would like some assistance if you want that kind of a process or go completely solvent texturing, solvent assisted or solvent texturing can be used.

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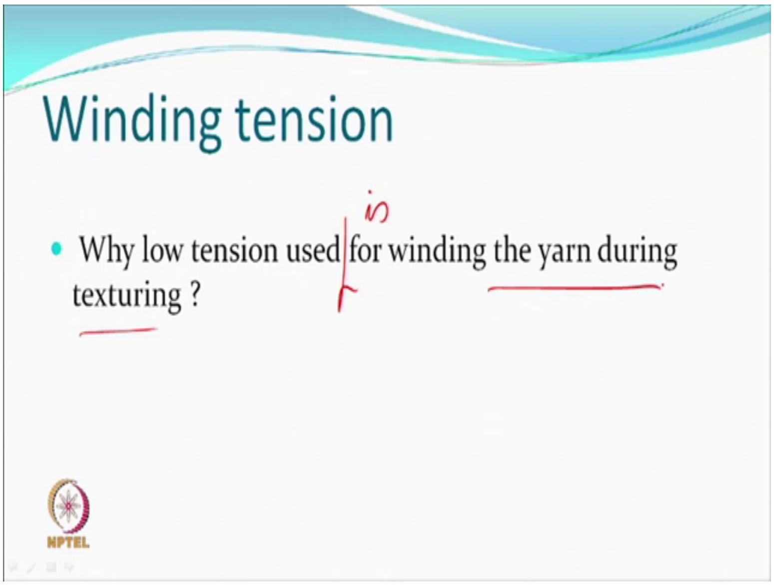

Winding tension

is

- Why low tension used for winding the yarn during texturing ?

One question which related to somebody is asked that why low tension is used for winding the yarn during treasuring. So, why this I hope what you meant was during the secondary heater treatment for the facilitating secondary heater treatment. When you only giving primary heater treatment and making a stretch yarn and not going for a modified stretch yarn; there is no real need for reducing the tension of the package right there is no need. Because point one gram per denier can completely remove the crimp and who would want to add tension of 5 gram per denier, nobody. So, you have tension is only, so that the package is good enough and does not slough off. So, you will be able to that. So, if you are not interested in going for a modified stretch yarn, so your tension, winding tension could be normal tension all right.

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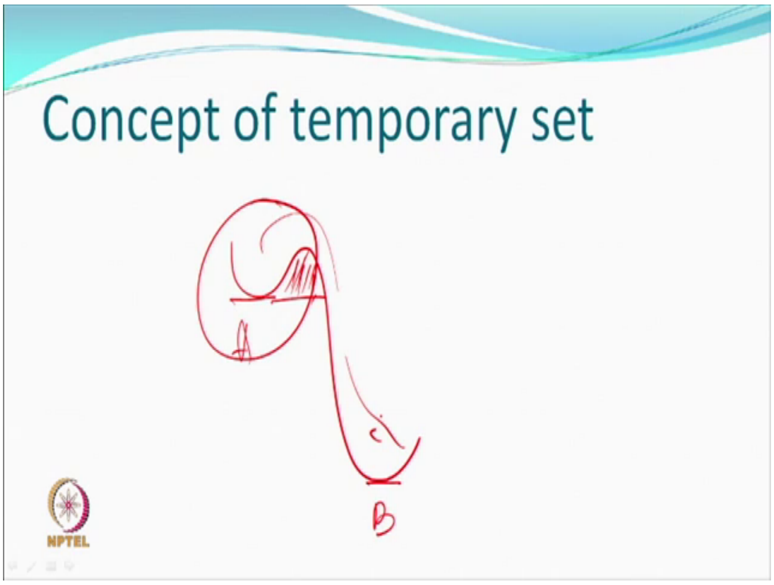

Concept of temporary set

If you are also wanting to know as to why this thing is done, but there is something called a temporary set. And we did talk about this temporary set as a minima at A compare to B, the minimum at A is also a minimum, but at a higher energy level than the minimum at B. So, for example, if you have bound your package under normal tension, normal winding tension let us say a nylon textured yarn. So, on the package, there is no crimp, you appreciate that because that is there is smaller tension is in good enough to remove the crimp, and then you store this material.

And if it is there is a said nylon in the moisture which is generally there, there can be some mobility, because the glass transition temperature in a wet state or a moist state and nylon can go down very low. And you have seen that earlier curve that there is possibility of mobility above the glass transition temperature how so where less it is not 0.

So, if you actually take a nylon textured yarn normal winding, keep it for let us say 3 months, you did not deal it, and then you open you might find that it is opening as if is a normal multifilament yarn without any crimp right, because it has somehow gone to this state. It is not been able to go it was here, but because you have kept it in a stressed condition not really stressed, but crimped open and then stored for a long period where some possibility was also there that you can have some molecular rearrangement howsoever small, it may not be having crystallization, but may have disorientation which also a setting is not it.

In fact, people have found the other thing also in the case of nylon. If you instead of giving very normal tension, you give let us say double the tension or triple the tension and wind it, and then keep it in the package, normal un textured yarn also. You might find there a modulus etcetera change, because some molecular arrangement is taking place even at room temperature because you have ensured that the glass transition temperature goes below right. So, some properties can change also, so that is the temporary set.

But in case we get this kind of set in textured yarn, the testing method as I suggested either you go for a hot environment all this will come back. So, by either solvent or by temperature, you can overcome this barrier, energy barrier, then this material will come here, and then you can see there is a textured yarn still exists all right. So, if that question meant that to be answer, this is the answer.

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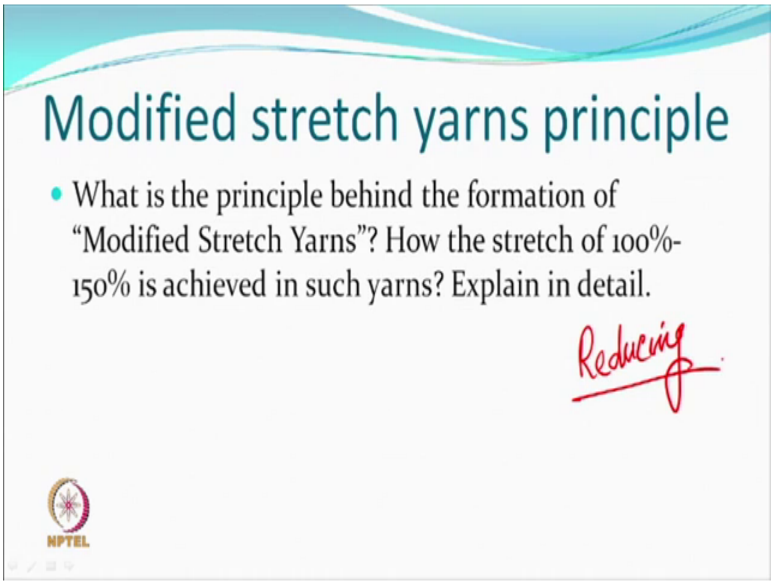

Modified stretch yarns principle

- What is the principle behind the formation of "Modified Stretch Yarns"? How the stretch of 100%-150% is achieved in such yarns? Explain in detail.

Reducing

What is the principle behind the formation of a modified stretch yarn, how the stretch of 100, 200 percent is achieved in such yarns. Well, whatever details. So, the process of modified stretch yarn meant you have first making a stretch yarn and then modifying it. So, if you make first stretch yarn, then we are expecting in a ideal situation 350 or more percent of stretch is going to be there. So, you are only supposed to reduce the stress, where you say modified stretch we are reducing, reducing the stretch to whichever level that you want. I can make it 0 stretch. I fully extend the yarn and reheat and.

If I reheat to the same temperature, the temperature at which we had textured everything will be finished, there will be nothing like a crease you put it on the thing in the same temperature crease can go, it is a reversible process, because partial melting recrystallization full melting everything can take place. So, it is a temperature dependent phenomena and condition at which you are doing this process.

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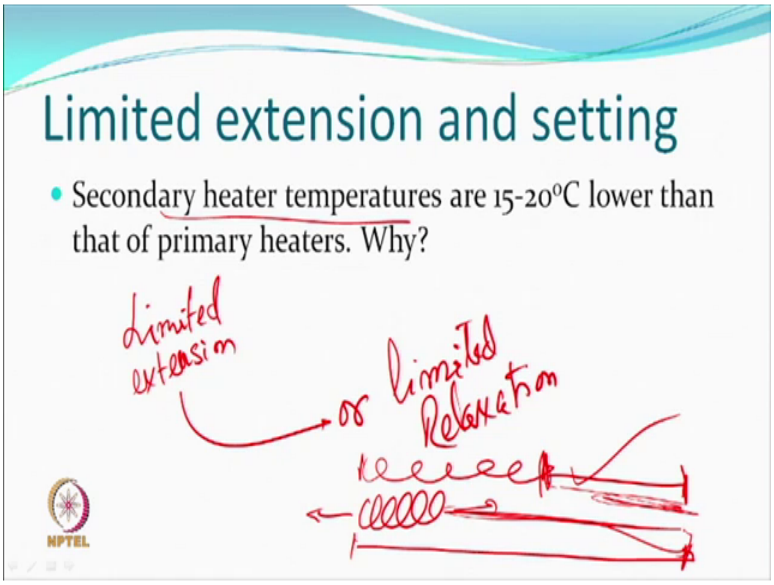

Limited extension and setting

- Secondary heater temperatures are 15-20°C lower than that of primary heaters. Why?

So, what are we doing, we are having a secondary heater or another autoclave where the temperatures are lower than the primary heater temperature that means, you do not want to wash off completely what you did before, that is one part. But 15-20 degrees also quite above the temperature where partial melting can take place (Refer Time: 31:42). So, all such entities within the fiber which can respond to this thermal input, they will respond and so there will be molecular rearrangement again. But in a configuration in the geometrical configuration which is different than when you actually did the texturing.

And how is it different? Different is in what we call as limited extension or limited relaxation. If it is are fully relax state, then I am giving some extension and reheating. Let us say this is fully relaxed state. So, I give extension. So, this can become this fully extended. or this can be extended in this manner up to this point. If I am efficient enough, I fully extend the material and then heat. And heat also to the same temperature you will get a flat yarn.

If I do the this part limited extension ok, if I do limited extension, then and also use temperature which are lower, there will be change, but a new configuration is the one which you are trying to set. It is still helical while you are setting is not fully extended. And so if this structure becomes stable, then you want to fully extend, it can go up to this point only because the main length of the yarn has not changed not significantly. And so when you measure the crimp rigidity, this will be here the recovery. Recovery will be this, and not this. So, your crimp rigidity will go down, because a new structure has been stabilized, so that is how the modified stretch yarns are produced.

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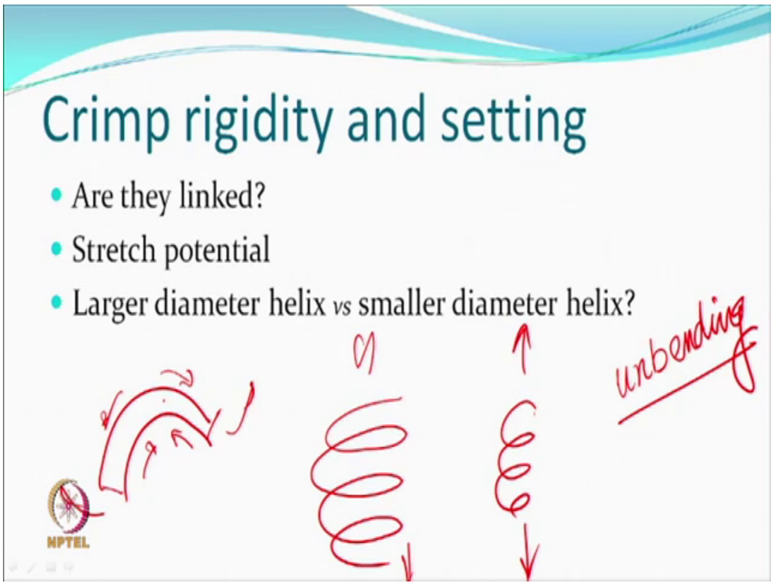

Crimp rigidity and setting

- Are they linked?
- Stretch potential
- Larger diameter helix vs smaller diameter helix?

Some question about the diameter of helix etcetera. Is the crimp rigidity and setting are they linked? Yes or no? So, there are linked because the better set means more crystallization, more disorientation favorable and that means setting that means crimp rigidity. Crimp rigidity also is related to stretch potential that which we have measured and so in some sense setting crimp rigidity stretch potential are linked. So, more is the setting better is the setting stretch potential is going to be high, crimp rigidity going to be high.

Then there was a question related to larger diameter helix versus smaller diameter helix, which one will give you higher stretch potential? You see there is if this is the situation versus this is the situation. When you want to open the crimp, what are you doing, you are doing at least we can call it unbending, unbending. So, in which case I want to open up by pulling unbending stresses will be more everything wants to remain is position because you have set it, you want to make it flat.

In which case the unbending stress would be more, where the curvature is more, where it is more curved or radius of curvature is less. Why, because in a let us say one single filament which is got a curve like this compressive forces, extensive forces are the ones which have been in a way released, all these stresses were released during texturing.

Now, we want to do the reverse. So, you have to do unbending. And therefore, this must expand inner thing must expand, outer must compress. Now, the more is the difference between them, and the more is this stress difference the more you have to apply additional stress. So, in an larger diameter, the curvature, radius of curvature is large, but the curvature is small. So, you do not have to do too much of unbending. And therefore, you have to apply less stress. And therefore, less stretch potential, and therefore you can give a less crimp rigidity. Make sense?

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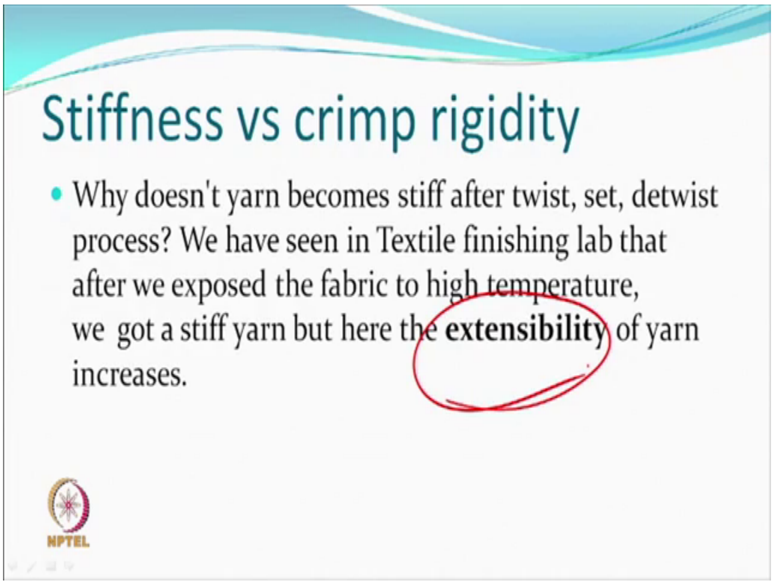

Stiffness vs crimp rigidity

- Why doesn't yarn becomes stiff after twist, set, detwist process? We have seen in Textile finishing lab that after we exposed the fabric to high temperature, we got a stiff yarn but here the **extensibility** of yarn increases.

This question was also there. Why does not the yarn becomes stiff after twist, set and detwist process? We have seen in textile finishing lab that after we expose the fabric to high temperature, we got a stiff yarn, but here extensibility of the yarn increases. First question which has to be answered is does it become stiff, do you believe that the modulus of the yarn the fiber is going to increase if your crystallinity increases? Yes or no? So, in that sense, it will become stiff. So, whether you do texturing or you do not do any texturing, if your modulus increases that is stiffness, but the problem is the definition of extensibility, extensibility versus stretchability.

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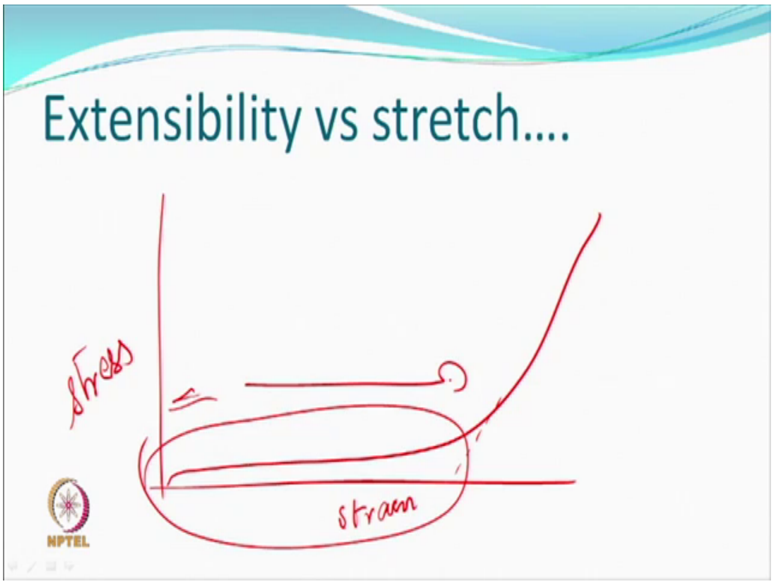

Extensibility vs stretch....

They are two different terms. So, our textured yarn behaves like this. If you are looking at a modulus here, fully decrimped yarn so, the modulus of the decrimped yarn will change. And if more crystallization let us say 15 percent crystallization or 5 percent crystallization to 50 percent crystallization you take, you will see stiffness will increase, but this is a different story. This is stretchability is nothing to do with that modulus it has something to do with the modulus, but what we call is extension increasing is we have created a structure like helical structure which has helping this. When this you look at the decrimping zone from here to here complete decrimping zone, yarn has not extended, the length of the yarn is same is only unbend. So, the stress that is there is an unbending.

This is a low deformation phenomenon not a high deformation phenomena. They are hardly in a deformation from the length point of view just unbending deformation. And therefore, this has to be differentiated with the normal extension at break. And so when if you are looking at this being very low or stress condition, it extends quite a lot, yes, it does because only crimps are opening which are only taking care of the unbending part of it and not stretching the yarn, not extending the yarn in length. And therefore, you see a lot of extension I hope this is what was the question which was intended

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Hi-bulk yarns

- Polyester *vs* acrylic yarns?

Differential Shrinkage Principle

Freezes Amorphous orientation

And hi-bulk yarns by differential shrinkage principle. So, you have two fibers, generally (Refer Time: 41:40) fiber environment. One of them shrinks quiet a lot, quiet a lot means 30 percent or more actually when you heat; other one is closed to 0. So, difference between the shrinkage that is one part. Polyester hi-bulk yarns are not easily available in the market. Why, because it is very difficult to produce, polyester yarns with such large difference of shrinkage, because the moment you stretch, draw, heat, polyester crystallizes immediately, crystallization means stability, stably meant no shrinkage.

We were lucky the acrylic fibers do not crystallized the way the polyester does or the way nylon does or the way polypropylene does. It goes to a meta stable state. And what we have said is it in a way freezes amorphous orientation, freezing of the amorphous orientation without crystallization. So, when you have oriented structure, if you give a chance, it shrinks like all textile fibers. But in between if you have done crystallization it done shrink. In normal state, I do not want my shirt to be shrinking 30 percent in everywhere right. So, I do crystallization for stabilization, but this is thing. I can do it is possible in the acrylic fibers to have amorphous orientation frozen.

And also go further heat setting to make sure that this orientation also in a way go to meta crystallization form which does not then shrink. So, you can make two types of fibers because got highly polar nitrile group all over the molecules and so that polo-polo attraction is good enough to get to the amorphous orientation freezing. And so it can shrink and therefore you can produce such yarns. I think for today is ok. Next time when we meet for this type of a session, we will have more questions and doubts later.