Textured Yarn Technology
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Principles of manufacturing textured yarns
Lecture – 04
Bulked Yarns

So, today we talk about again the Principles of manufacturing textured yarn. So, we have seen there are a lot of methods that we have and hopefully we should be able to actually cover whatever principles are there of manufacture.

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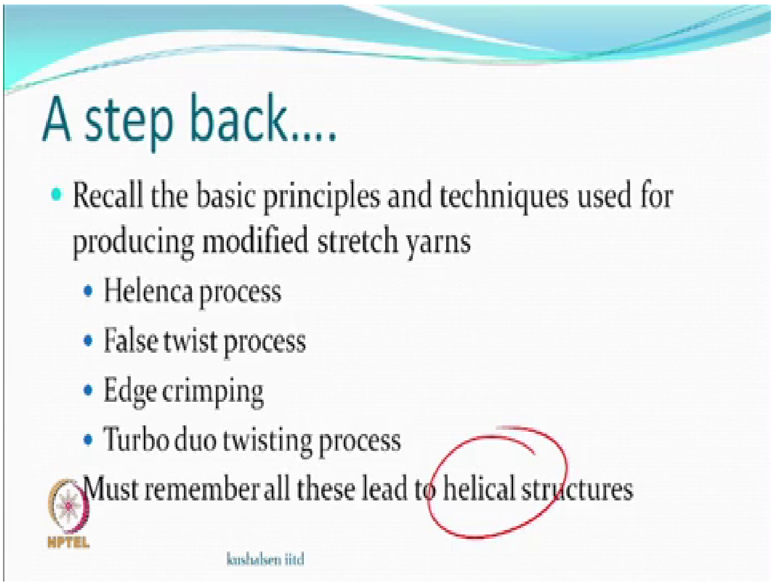

So, if you look back what have we done. We have seen that the four processes like, helenca, false twist, edge crimping, turbo duo; all of them can be used to produce modified stretch yarns and we remember that all of them gave helical structures.

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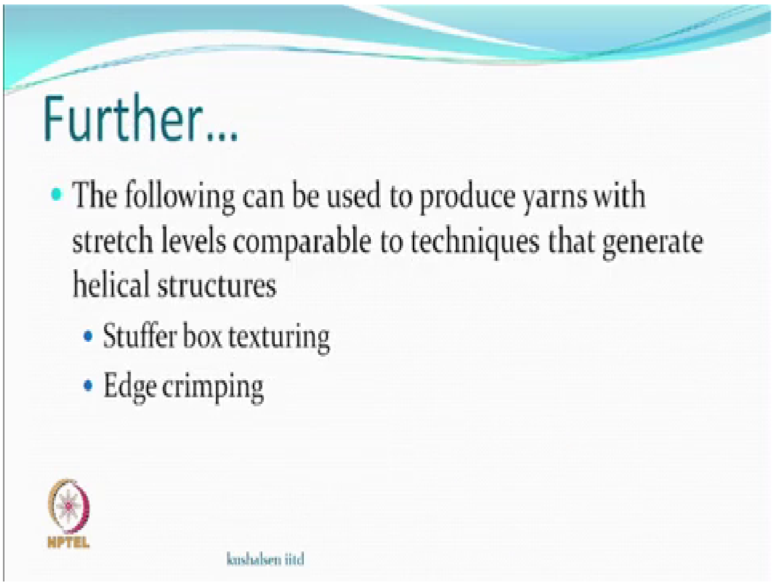

Further, also last time we talked about that we can produce yarns with comparable stretch levels which are generated by the modified stretch methods of the helical processes and these are stuffer box texturing and edge crimping.

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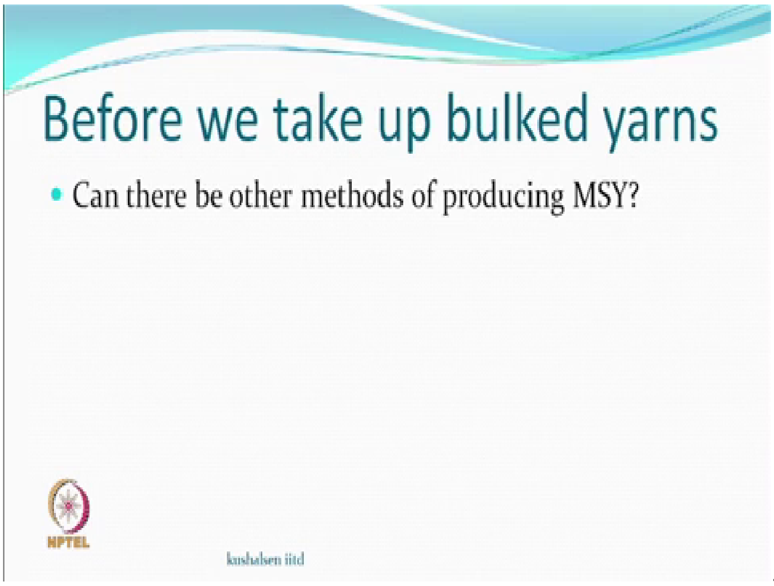

So, before we go to the bulked yarn, let us see if there are any other methods of producing yarns which are similar to modified stretch yarns.

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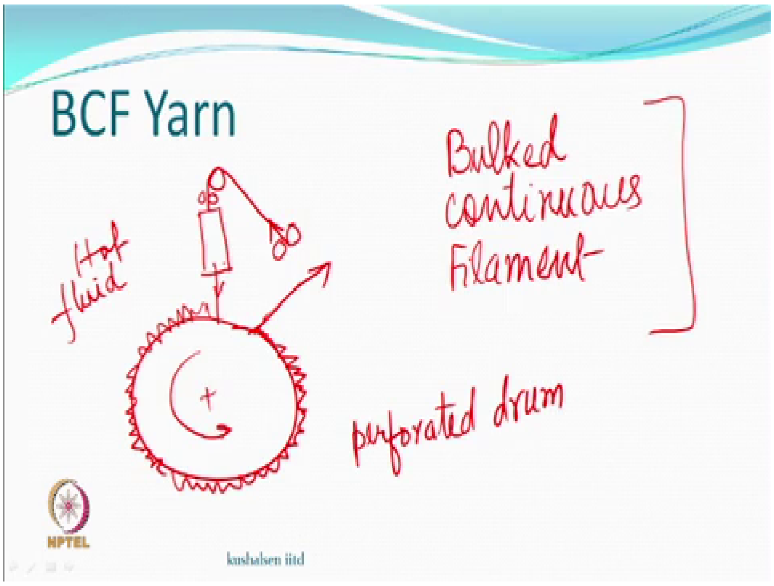

So, this is one process which is BCF. This is Bulked Continuous Filament call the BCF. So, this technology is now quite popular and we produce cribbed yarns which; obviously, give bulk the name here says bulk, but actually it has stretch also. So, therefore, we said that we are not actually at the moment talking about bulked yarns with name of the process has been given as the bulked continuous filament yarn; and this is a very interesting process because it is a very rapid process, simple process and so production levels are very high.

And what is the simplicity of this for example, if you have something like a jet through which you pass the yarn there is a perforated drum and you; obviously, have a control has to how much yarn you want to send. So, a yarn which is to be processed through this process goes through this and is fed into a jet which has hot fluid. Now fluid does not mean liquid anyway, so it is a hot air or steam.

So, when you have hot air or steam two things happen, one that you feed more it becomes pliable the jet is there. So, there is an aspiration; so the yarn is actually sucked by the jet itself and then thrown onto a drum whereby the filaments which are coming out of the jet they strike the jet and bend; and what happens they get crimped and stay on the drum for almost the whole circumference and then they are withdrawn.

Now, this jet is hot fluid and therefore it softens the yarn, then it has got lot of velocity and therefore it throws the yarn; if it is a multi filament yarn not only it throws the yarn, but also it opens the filament. So, the filament bundle opens and then is sucked out thrown out onto a drum, the main role of a drum is to ensure that the filament gets cooled before it is taken out.

And so if perforated drum means you can be having a sucking mechanism inside. So, the filaments remain on the drum connected and do not fall off, because you do not want to give any tension; because if you give tension in a hot stage when the whole thing the yarn is filament is hot, then whatever the crimps have been formed they can be undone and so we know let us say particularly useful as we understand hot fluid for thermoplastic yarn. So, polypropylene, nylon etcetera are being subjected to this particular process. So, this also produces crimped yarn right. So, there are crimps are getting generated interesting.

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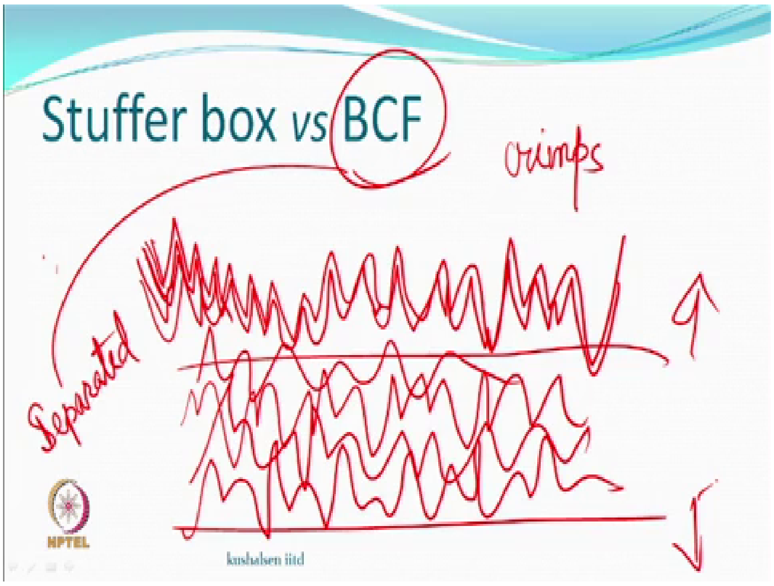

Now, stuffer box also generates crimps and the BCF also generates crimp. So, they will be giving modified stretch yarn levels. So, what is the difference between the two types of products? The most important difference is in the case of BCF, the filaments actually get separated before they are thrown onto the drum. So, if you look at the stuffer box the crimps are formed, but all the filaments more or less bent together, remember the stuffer box principle. So, they bent together third, the fourth, the fifth, the sixth all of them been together. So, the whole multi filament yarn is bent and then you get crimps.

In the stuffer box the filaments are separated in the BCF, the filaments are separated before they hit the drum. And so, theoretically each filament has its own crimp frequency and amplitude, the second one may have a different one, the third may actually have may not follow any path, the fourth may be something else. So, what do you see, the bulk increases. So, compared to the stuffer box the bulk of a BCF is much high because individual filaments have been treated individually and so that is an interesting part of it therefore, the technology becomes important.

The speed of stuffer box also could be very fast, not so fast as this. Because you are first softening the filaments, then you are separating them, then you are throwing them onto the drum where they get bent, the way they want to get bent there is no control and you get really bulked filament.

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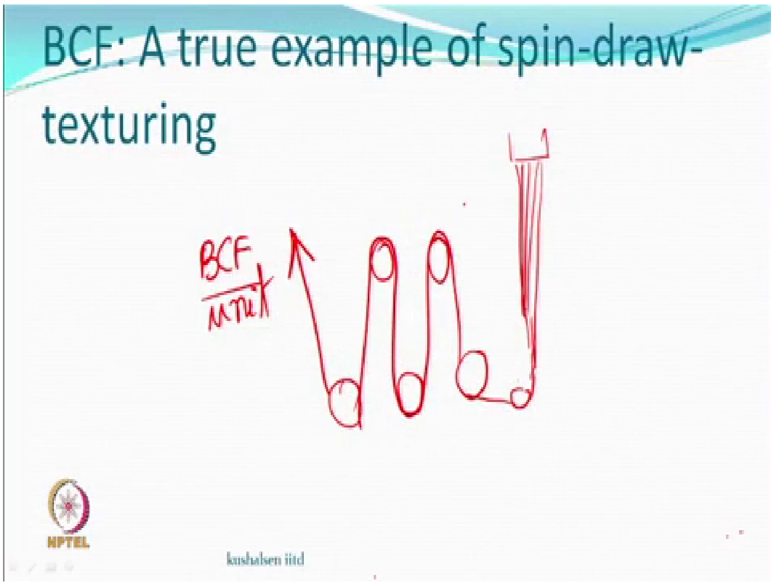

And this is the only technology that exist today which can be considered as a spin draw texturing process, it can be combined with spinning all right, have you heard of spin draw? Spin draw yarn have you heard of spin draw yarn, anyone who knows can say something about it? No, you see normal process of making a filament yarn is, that you let say you have melt, then you spin it, then you cool it, wind it and then draw it. So, a drawing is a process which is separate, then spinning process all right. In a spin draw process instead of winding the yarn after spinning it is taken through various godded systems where the drawing is done and at the end you get a fully drawn yarn ok.

So, that is called as spin draw technology for example, suppose you have this spinner it, the filaments are being spun, cooled and collected and after this you take this whole bundle to series of goddeds with the differing speeds. So, that as it moves from this direction to this direction to this, it keeps on getting drawn. So, not wound anything here and this number would be based on how much draw ratio that you want to actually achieve and then this yarn can be fed to the BCF unit the one we just saw before.

So, truly you can actually combine, spinning, drawing and texturing in this process. Why do we do that? Why we could do this with the other technologies? It because their speeds of texturing are close to the best of the best would be close to 1000 meters to 1200 meters per minute. The spin draw technology this one all right, this technology spin draw operates close to 4000 meters per minute around the time.

So, how do you combine a process which is running fast to a process with run slow and so, you could not do that. In this case the BCF can actually run at 4000 meters and so you can combine logical but interesting; 4000 meters per minute is not a less speed, it is a very high speed.

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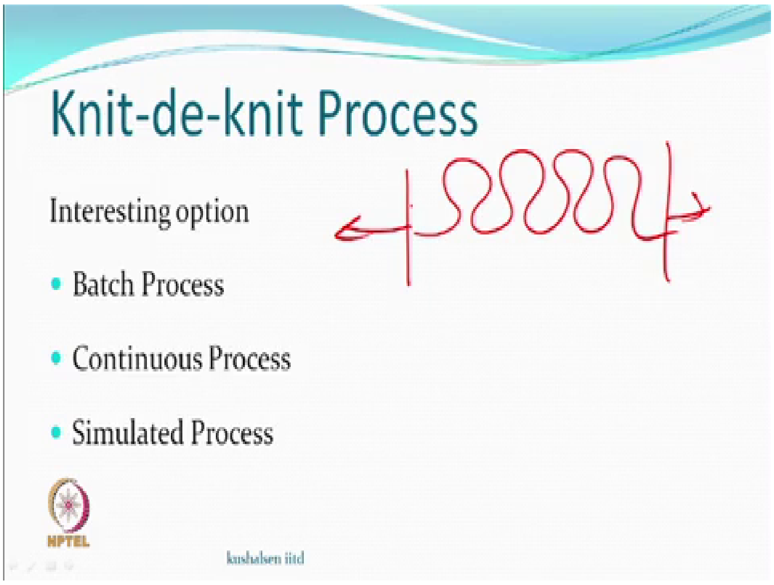

So, that was BCF, some people you know like if you are a design team, you are looking for new things to happen, always keep looking for more new things and so, they said well what are you doing? We are just deforming the structure of the filament. So, crimping you have done, twisting you have done, can you do something else? You said, yeah why not.

Let us see if we make a knitted fabric, we heat set the knitting fabric knitted fabric and unravel it, how will the yarn look? So, can you not stretch it and that it will recover? You say, yeah it can; it can recover based on how much setting you have done all right. So, this is imagination the way you try to work, the interest generated was quite large actually, then we said well batch process. What is the best process? Well, you need fabric somewhere else take it to an autoclave, set it, cool it and then unravel and wind. So, start from the package go to the another package and a batch process can be done, they said well if you are smart enough and you think this is a good process gives you nice structure which can be stretched and you can bring it back, can you not make it continuous. So, yeah we can make it continuous.

So, yarn is coming from certain size, some one end the fabric is going knitted instead of winding the fabric you are unraveling also simultaneously after setting and cooling. So, in a knitting system, if it is a flat bed it works in a different way. So, a flat bed knitting machine, starting from one end, you are making a fabric, there is a heater and then it gets cooled before you start unraveling and wind right. So, what you see from this is that if your imagination works and your logics are fine you can actually design any kind of a machine in any kind of process which will do approximately same job, all right.

And then somebody said well, why knit at all? Why knit at all? Why cannot we just simulate nothing process that as if the yarn is going through that particular route and I can be just going through being taken through a particular route that is it, but we do not knit because you may save energy and unnecessarily knitting, yarn friction, all those kind of things.

So, think of that some process called kni knit de knit process can also give you modified stretch yarn type of yarns by simple things you can think of many other things also, all right. So, we do not say this is the end of the game, but interestingly the people actually got so much interested started making machines also, that becomes interesting; an idea was not just in a classroom beyond that.

Although you may not find such processes and machines now, because others are going faster because theoretically knitting process is not a very fast process compared to a normal texturing process. So, one always would opt, but interesting options that is what more important, you should get excited whenever there are interesting options available and you can also keep thinking about what I can do, to do better things.

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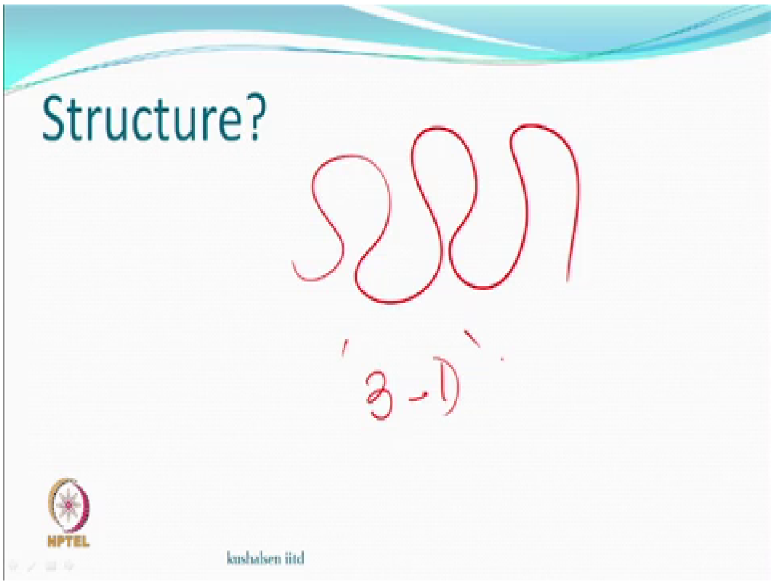

The structure would you call it a planar structure? Helical structure or what? Planar; so, what they found is key well this is not a planar structure also because the these type of structure that get generated actually is not in a plane, the yarn moves from one goes the other plane comes back and then goes to another plane and comes back. So, you cannot actually draw a plane as well this loop is you can see it is in the plane, you say no there is another plane.

That means they said well you know the way the structure gets developed. So, it is not in one single plane because it has been set also, maybe we can give it some term like it is actually in a 3-D structure on a looped 3-D structure, all right; that is ok. Does not harm us anyway because if you set it properly it will open and come back ok.

Now, only thing is the whole multi filament yarn would behave exactly in the same way, all right all of them will take the same shape, but that is ok. So, it will look a different type of a yarn and the product made out of this will also look different, then whatever you may have got, but that is it if stretch and bulk they will be definitely working around.

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So, in summary if you look at other than the twisting process no twist here, no helical structure, no helical structure. So, stuffer box, BCF, gear, knit-de-knit processes can be used; this is just to make sure that you keep remembering whatever we have talked before, is that ok?

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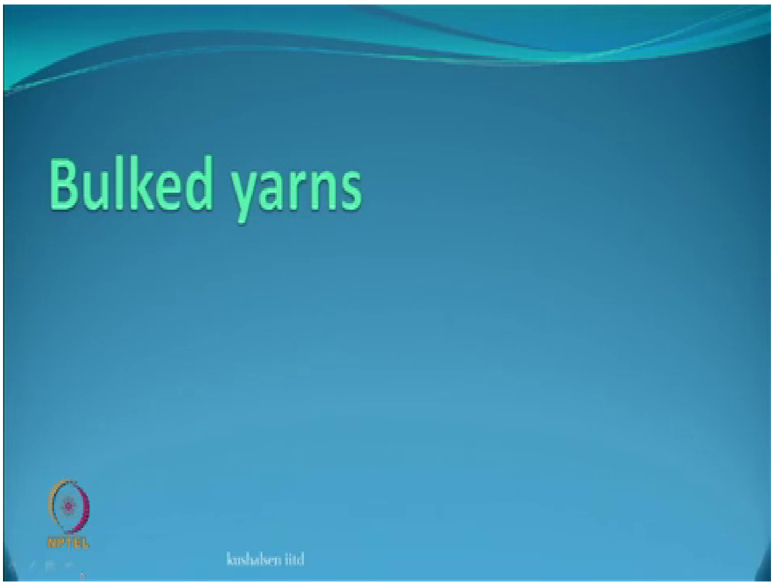

So, now we actually come to the bulked yarn which is the category which we have not touched till now, but we know what exactly we expect.

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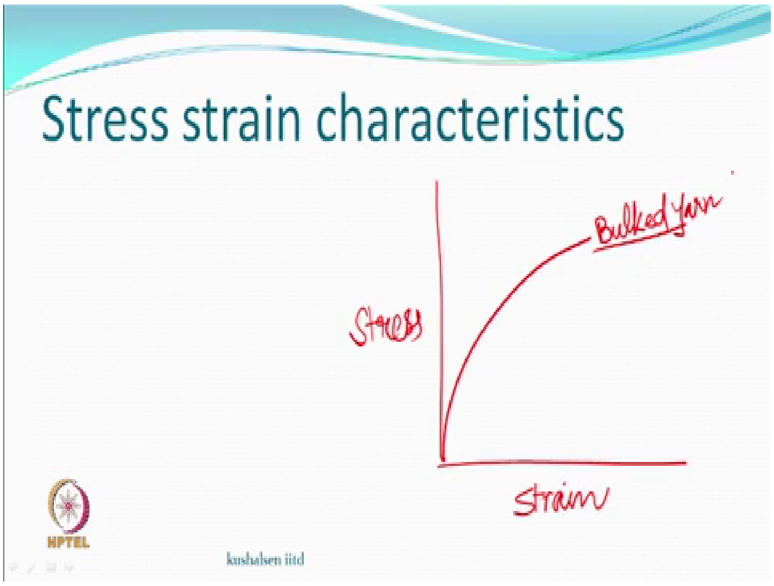

So, what we expect? We expect that this yarn is going to behave like this. So, remember your stretch yarns, so this is the stress strain curve of a bulked yarn. So, it is quite different from this stretch yarn, it does not have stretch; the moment you extend it starts the stress levels keep on increasing, till it breaks and depending on how you produced it. So, this is what do we expect from bulked yarn? Definitely it will have large amount of bulk, you can compress it literally, will get compressed and hopefully recover those type of things will be there.

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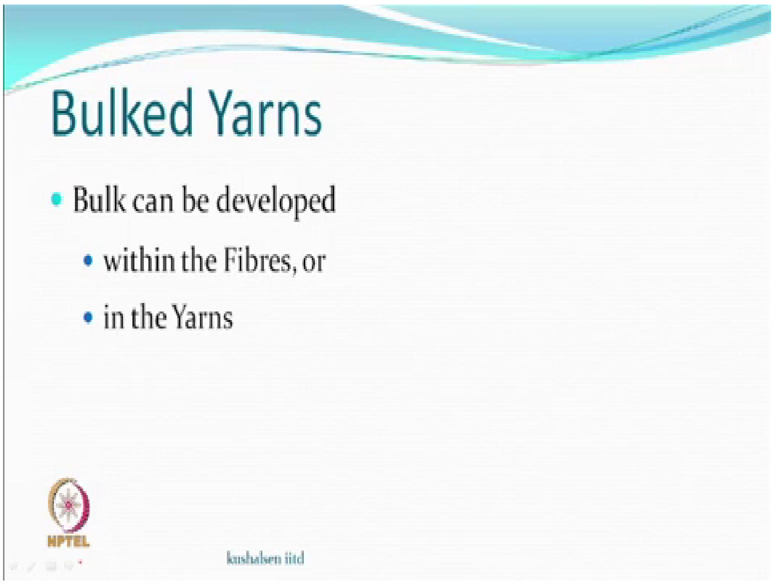

So, how do we produce bulk? Well, the fiber manufacturers are also interested in doing this and the textile technologists also tested in doing this. So, you can develop within the fiber. So, it goes into the domain of the fiber manufacturers. So, they have to do something, so that the bulk can be developed when it comes to the yarn you say well you give us the whatever yarn you have made will do the hard work to generate bulk.

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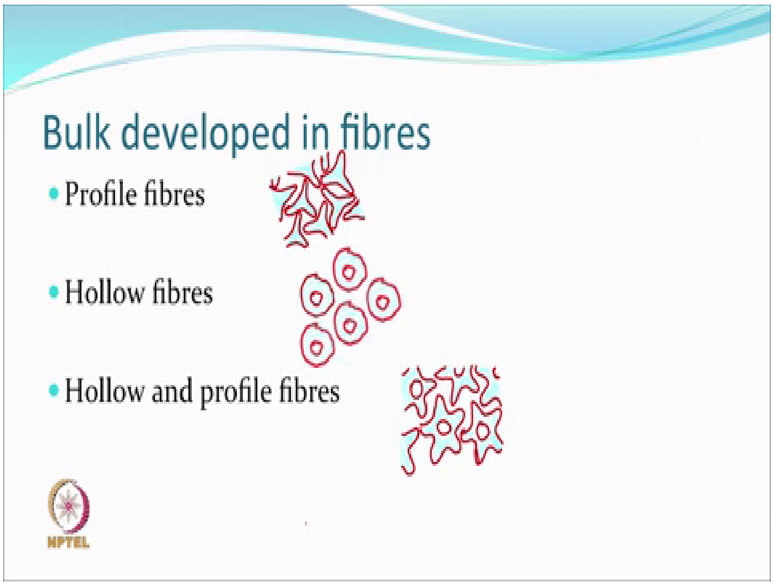

So, this we learnt in the beginning also that if you change the cross sectional shape of any filament yarn, the specific volume per unit weight, per unit mass will definitely be high. And so you can say we are developing bulk there is no stretch here you will see, but you will still be able to see that the same density of a material same GSM of fabric will appear bulkier. Just because, you have introduced a different cross sectional area; the cross section area could be whatever trilobal, pentalobe, hexalobal, octolobal whatever you want to do. And all of them will keep changing the whole bulk process; that is interesting part of it.

Then hollow fibers. They also are bulky in that sense you know their packing etcetera may not give you that feel, but if you look at the dimension of material the regenerator yarn, to steady on regenerate or a fabric that you make or a filling that you do. It will again appear that the volume is large, but the rate is very less. So, in some applications the hollow fibers there are many applications, but some interesting applications where hollow fibers have been used as a lightweight material do exactly same thing which you want. For example, if air is inside the thermal conductivity etcetera may also get affected.

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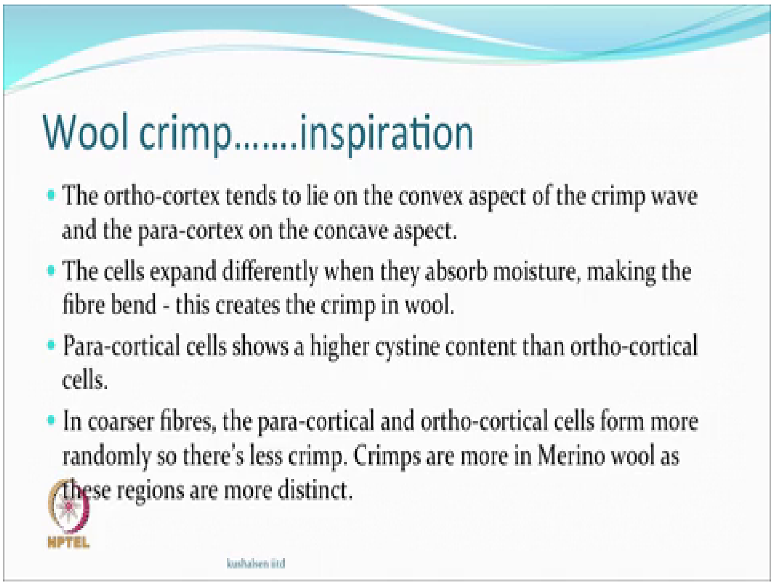

Then combine both of them hollow and profile. So, this is the domain of fiber manufacturers and not the textile technologists. Before we go further, let us say the wool as a fiber is always considered a fiber which is warmer, when we never wear wool in winters all right; sorry, you always wear food in winters right not in summer. And why do that? You see there is some crimp and because of the crimp which is natural, you are not able to pack the yarns and the fiber or you are able to pack them in a lighter configuration, open configuration, so that you can compress them.

So, all the woolen yarn that you may have seen somewhere they have this characteristics. Of course, you can twist high, if you have a high twisted to the bulk will reduce, but if you have appropriate is there will be enough bulk, but if you try to stress this yarn does not stretch; it behaves exactly the way this behaves.

So, one could think of wool as an interesting material because it has crimps. So, this you may have studied in your under graduate that in the structure, it has got the main part which is called the cortex has got two types of core tech, particular cells which is one is called ortho cortex and the other is called the para cortex. And there is a crimp and if you see the crimp, the ortho cortex is seen and found on the convex part of the crimp and the para is found in the concave part of the crimp, wherever the crimp is; all right.

So, every time somebody says that this may be just general, somebody wanted know as to why this happens. So, this is what was found. So, very interesting is that, when the cells absorb moisture after there is moisture anywhere, everywhere and wool anyway being very hydrophilic. So, it absorbs moisture in different going different seasons or when you put it in water also. So, they will absorb moisture, but interesting is they absorb moisture and then expand differently.

So, the one portion which ex absorb more water; obviously, has more pressure and wants to expand more. The one which absorbed less is less pressure and wants to get less. And so it is something like two bimetallic strips if you understood them, you heat them. So, one expands more the other expands less the one expands less, goes inside becomes the concave part of it the one expands more is. So, no thermal in the same it just say that will absorb moisture that also can do swelling.

So, the one which swells more; obviously, expands more the one which swells less. So, the interesting is that, for whatever reason these two types of regions have different characteristics. So, lot of studies have been done on that and this is what happens. It also understood by some hard work that the para cortex have more crystine content than the ortho. Now, what that means is? So, there are cross links all right.

So, the cross links; cross link means stability ok, we can all work on the one which is less cross link is more amorphous more flexible a more ready to change the dimensions, the one which is cross link would not change the dimension so easily. And so you have created the difference. So, when some moisture goes in something will happen on one side, the other thing will happen on the other side all right.

So, there is a difference. So, that difference is one can lead to the formation of crimps. And like coarser, fiber, wool I am talking here again for example, the wool found in india generally has less crimps. The Merino has no crimps and that again that these two regions are very nicely defined, they are distinct. In Merino wool compared to be other rule where not only their difference may be less, but they are also randomly there you know, somewhere on this side, somewhere other side it is not there, but in the fine wool they are quite nicely defined they almost say on 50 percent, one of them is the other 50 percent of the cross section the other is there and therefore, crimps also become more.

So, that is inspiration you know these days people take a lot of inspiration from the nature and then try to do exactly same thing.

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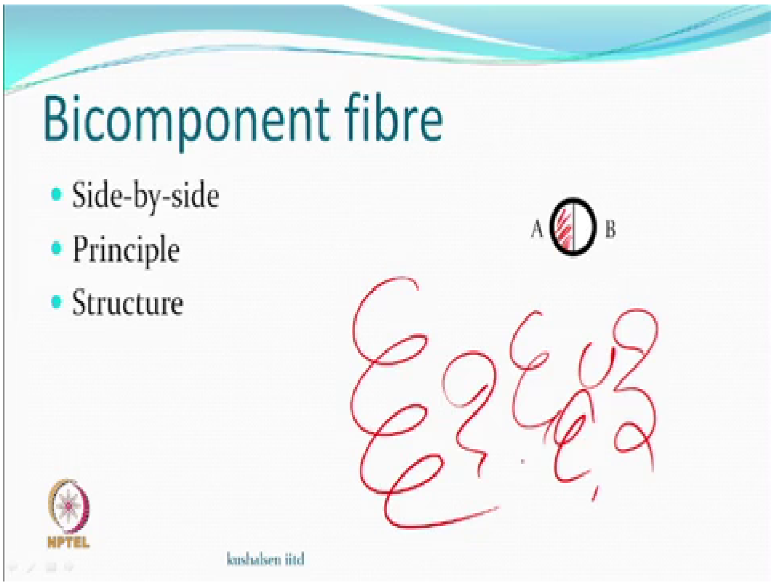

So, although this is the job of fiber manufacturer, so you have something called Bi-component fiber. So, bi-component fiber if you have side by side kind of thing or bi-component fibers could be sea island structure, you could have split structures is up to you what you want to make. So, do different kinds of polymers if you do side by side, polymer A is let us say of one type and the B is of a different type. Different type means well either because of the thermal input, they may expand differently or because of the solvents, moisture or in the solvent they may expand differently and the movement they say they are going to be having this difference then you will see crimps generated.

So, if you have the crimps generated. So, principle is very clear you got to have two different polymers side by side is the best way to do it and then you get crimps. So, principle is clear like bi-metallic strip which is used generally used for what, bi-metallic strip is it useful or is just a principle and thank you very much, does it have any use anywhere.

Student: (Refer Time: 29:49).

Right. So, they are sensors; they can be used as sensors, so whenever there is a heat generator you will see they are behaving differently and you can sense something happen. So, the same principle in a bi-component fiber if you use then theoretically, what kind of a structure we will likely to get, what kind of structure we likely to get, if suppose this was these two polymers had different coefficient of x thermal coefficient of expansion. What kind of structure we will likely to get? Yeah.

Student: (Refer Time: 30:34) helical.

Very good. So, you can get helical structure by bi-component fibers by choosing suitable polymers with different properties. So, it does not have be thermally different, it could be swelling capacity could be different for various reasons you can always get to this type of thing. So, you may say well this is a helical structure this will be stretchy and where we actually working on a you know under the bulked yarn category. So, It what happened? That people were not able to get the kind of helix and the number of helices per unit length, but not so high for it to be considered so nice, that it is going to replace a stretch yarn, right, but they would cut into staple and then use them and they say oh this looks like a crimp.

So, one fiber, the other fiber and so on so forth so, they made the yarn. So, one of the interesting product which we had the acrylic bi-component spun yarn system where you would say it is a bulky yarn all right, but if you are very smart and the difference between the swelling capacity are so large between A and B, that they actually make a beautiful helix which you can see that, if it is a there, you see the helical section is not there it is here a little bit of a difference ok.

So, you cut them into staple fibers and then mix them and use to make a yarn out of it like a wool you see the inspiration from wool; wool is also a staple fiber. So, it makes staple yarn, you say this is a like wool, you cut it up and then make it stable yarn out of it any problems there is no problem, go ahead do it.

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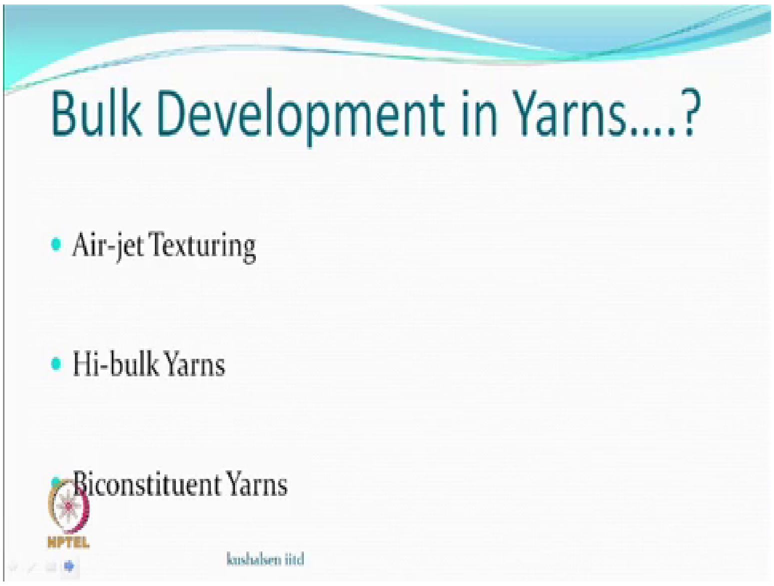

The next thing is that, we get something from the fiber manufacturers and then we say well now we are developing bulk in the yarn. So, three interesting techniques have been used they are you know Air-jet texturing where you have filament yarn, work on a compressed air jet and you get something which is interesting enough to produce a textured yarn which is in the category of bulk yarns. Then Hi-bulk yarns which have again a staple fiber based on staple fiber the air-jet texturing in the filament right generally; generally filament, but not necessarily. Hi-bulk yarn we talked about they are basically staple yarns made from staple fibers you know.

So, and the other is called the bi-constituent yarn, there are two fibers and hi-bulk there may be same fiber with different properties and bi-constitute could be two different fibers with different properties.

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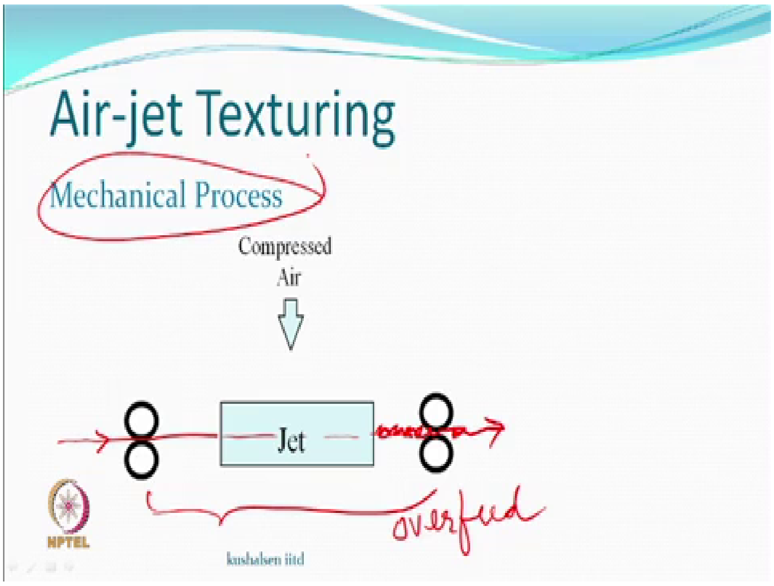

So, let us take the air-jet texturing like the false twist texturing, this is also one of the very popular techniques, all right and so, commercially a success. So, what do we do? So, there is something called a black box, all right which is called a jet where the compressed air is being fed, once this is there and you feed your yarn it goes into the jet and from the black box when it comes out it gets texture. So, how this kind of a thing comes to loops; various kinds of loops are generated. How does it happen, details we will learn later, but one interesting thing is between those two sets of rollers you give over feed.

So, I give over feed between these two sets of rollers. So, that you have enough length of the filament between this zone, where lot of entanglements will take place and then you get entangled yarn. If you do not have any over feed the filaments will not be able to move from one side to another they will not be able to make a loop bend or whatever. So, you give over feed and good amount of over feed, 20 percent 40 percent; that means, the length of the whole thing will reduce by 40 percent, it will be a 40 percent over feed, but then you want bulk to be developed.

So, if you want more bulk, more loops have to be formed, more entanglements have be formed and therefore, you give over feed that is the controlling factor, other controlling factor of course will be the pressure of the compressed air and the most important controlling factor with the jet itself the design figured.

So, it is not that anything that you feed and everything will come out nice something interesting has to be done, but the most important thing is called a mechanical process. Mechanical, you know so, you do not have to worry about the chemical structure because you are saying in the other thing there has to be something called a heater, then heating, then cooling and setting does not matter it is just a entanglement process; if it is entanglement process this course can be processed, acetate can be processed, polyester can be processed, nylon can be processed does not matter. So, the basic fundamental process does not require any chemistry not concerned, we do everything mechanically handle optimize mechanically and get a nice yarn at the end of the day.

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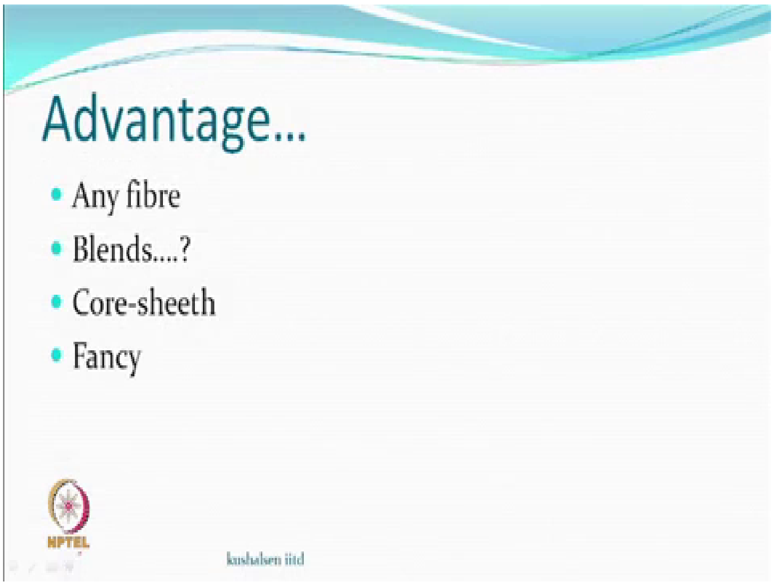

The thing which it actually attracted quite a lot of interest, but any fiber can be thrown into it something will come out; thermoplastic, non thermoplastic no problem, circular cross section, profile cross section, hollow it does not matter; whatever you want to throw in something will happen. So, what you have to bother, that is an optimization process.

Then you can actually generate blends throw viscous and polyester together. Here something will come out which is entangled, not separable; you cannot separate them very easily otherwise not a good yarn. So, you made blends, think of how do you make blends, what difficult process, fibers coming from here, fiber come mixed in a certain blend keep doing all kinds of carding, then all operations and then you get some yarn. It is a throw filament from one side, the other filament from the other side, you will at the end you will get a blend, you say that else.

So, we can make a core sheath structure; that means, one yarn is actually in the core, the other is forming a sheath and how do you that? You just control a row feed, the one you want on a sheath give more over feed, the one you want in the core give less over feed and you get a different yarns and if they are colored also definitely, you will say something else.

For example, you may be interested polypropylene in the core viscose on the surface, possible, strength coming from somewhere else, bulk coming from somewhere else, beautiful structure fancy yarns; all kinds of fancy yarns can be made; that means, there is a lot of advantage that is why you have interest in such technologies. Simple, but works more, a complex technology which may cost more can also work if the product is so much in need; if you just find well the purpose to be served is only this, then why come make the technology very complicated. If you make it complicated of course, you will pay more and the product also will cost more, this is one interesting technology. Everything is not hunk hunky dory we will learn about it later.

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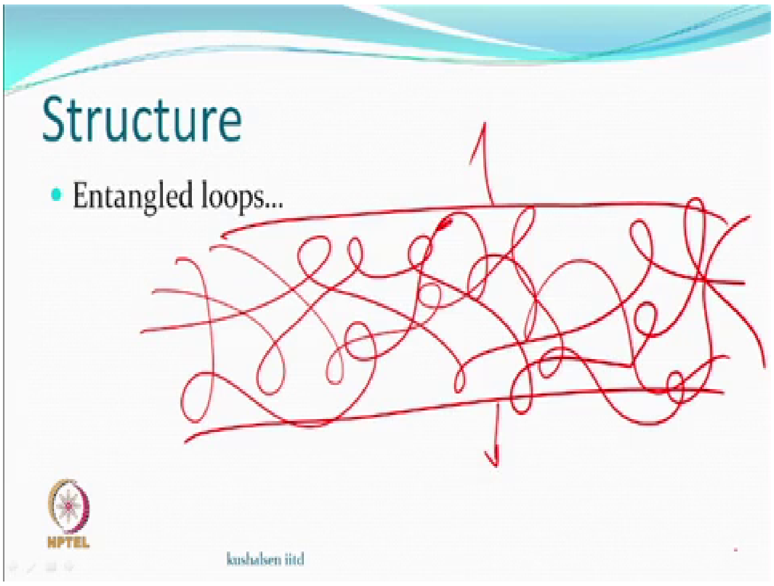

So, what kind of a structure well valuable, you know each filament may actually keep making loops, the second one may make loops, may make more loops, may cross over bend and go the fourth third one may do something else which you may love or not does not matter, the guy is going to behave the way it has behaved. And certainly if it negative it is good you see, what is the dimension of so called yarn versus what is the dimension of the bulked yarn? So, it depends on what you do and how much you do the bulk will need.

But here also entanglements are so nice, very nice, that you do not have any stretch. In fact, if you stretch this yarn and it extends it will actually not come back, it will remain in extended home because all this is be by friction into fiber friction and once you applied something and because of one some slippage is gone to a different position and because the friction wave will come back, there is no reason for the filaments to come back. So, they can change shape that is a challenge.

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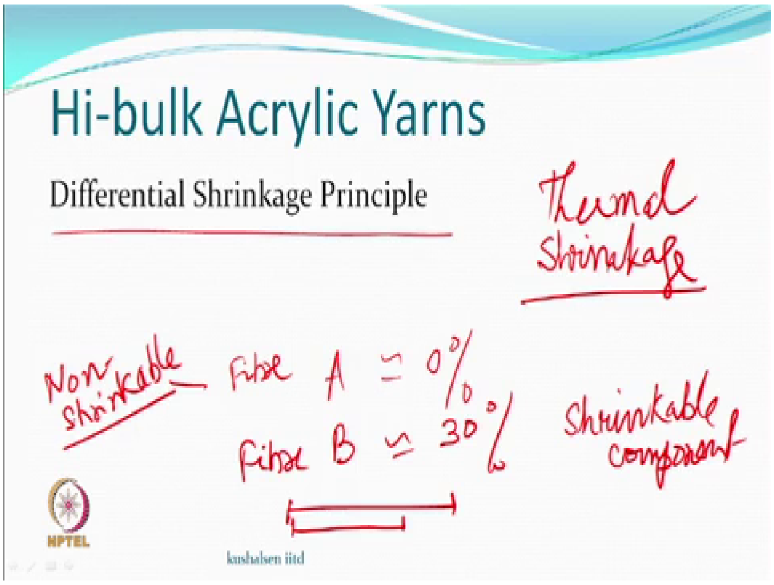

So, in the hi-bulk category the most popular product is hi-bulk acrylic yarns; hi-bulk acrylic yarns. In fact, when the acrylic fibers came and this is the kind of product which came in it just replaced wool, it gives you same feel, again staple fiber yarn we just replaced wool, today you go anywhere in the market and say I want a woolen yarn the 99 percent chance they will give you an acrylic and you will be happy with oh it looks very nice and exactly the same.

It works on the principle called the differential shrinkage again. You remember we said in the case of bi-component yarn also it is the difference between the two types of things. So, here you can make one fiber let us say acrylic fiber which has let us say shrinkage on heating let us say, thermal shrinkage. One yarn let us say yarn A has close to 0 percent shrinkage and yarn B or a fiber B let us say, fiber B is close to 30 percent. This is called difference; that means, you heat one fiber, it will approximately is dimension will be remain same after heating other fiber is dimension will reduce. And, what do you do? You mix them up and let us say 50-50 percent make a staple yarn.

And then subjected to thermal treatment; if you subject to thermal treatment, what will happen? The one which is the fiber V; B is called shrinkable component, it will shrink, let us say fiber B it has length this after heat treatment the length is this, then the other one is a more important candidate called the Non-shrinkable. So, it cannot shrink so, what we do in a compact situation in which everybody, every fiber is entangled so, it will crimp, it will bend, it will make loops to accommodate itself.

So, it cannot say independently ok, that I remain as long as I was before. So, theoretically yes the length of the fiber will remain the same. B has actually shrunk thermal shrinkage, in the other case there is no shrinkage. So, either it has a possibility to remain at the same level. So, length remains same, but others around the thing are contracting. So, it has to bend and then get in and if your twist levels have been optimized in nice manner, you will study design the bulk of the yarn is increasing. So, differential shrinkage principle; interesting and this is commercial. So, this principle is commercially successful products are there, there is a bulk yarn.

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Very interesting thing is, that only acrylic hi-bulk yarns are available in the market you (Refer Time: 45:08) and say I want acrylic hi bulk polyester yarn, they are not there. This is also very lucky, that you actually had something called acrylic, the same thing does not happen with polyester that you can make acrylic fiber one which shrinks up to 30 percent or more other can be stabilized.

So, here there was a concept which we can say, that you can freeze amorphous orientation. Freeze, what do you mean by? Normally, what you do? I draw take it to the heat setting and expect the heat setting would help me to develop crystal crystalline regions and the fiber will not shrink that is what I normally want, that my things must not shrink. And by heating, some of these materials like polyester, polypropylene, nylon they immediately start crystallizing and so (Refer Time: 46:29) some becomes stable.

Very interesting in acrylic, that they actually you can go through a certain temperature system extend it, it does not crystallize very nicely, but it can make large number of polar bonds which is because of the nitrile group, there is many nitrile groups there and they can make polar bonds. And so when you stretch so new polar bonds have been created because of the so many nitrile groups and you leave it there it does not want to come because of this, but it still not crystallized.

So, this thing is not possible in other fibers, they immediately crystallize that is you can actually freeze amorphous orientation, you see anything which has been oriented has a tendency to shrink; the one which is not oriented and shrink so much right. So, oriented structures polymeric structures will have tendency to shrink. So, you that is what you are doing stretch it so you have given a potential that will shrink, but if it crystallize it cannot shrink.

In this case you can actually freeze amorphous orientation and so you can actually create fibers which are only oriented without crystalline, others you actually go to more thermal conditions where some crystallization take place stability will be there and 0 percent shrinkage is never there, maybe 1 to 2 percent shrinkage and so there is a difference is quite large and then you get what you call as acrylic hi-bulk yarn.

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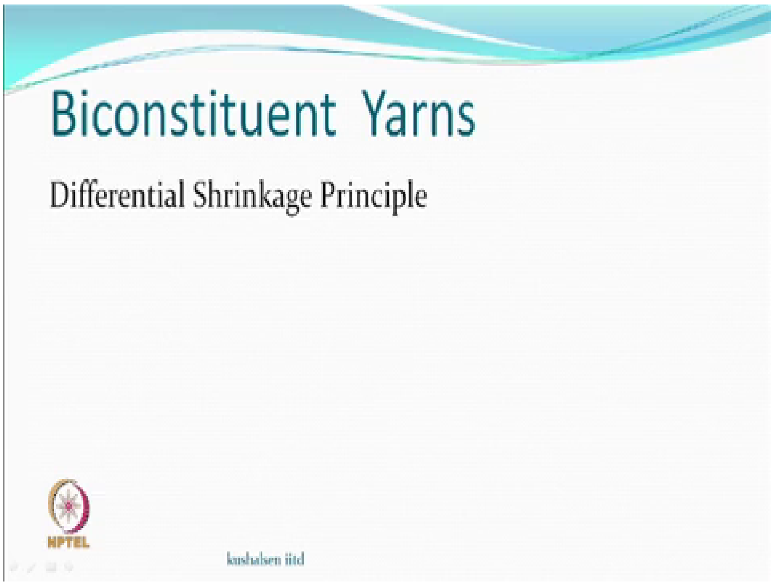

Alright, so, the other one is bi-constituent means that you have two different fibers, if they have differential shrinkage you can get it. So, people have used various type of things blend of acrylic and polypropylene acrylic shrinkable fiber, polypropylene non shrinkable fiber people have said well I make jute and wool mix and I give some chemical treatment. So, that one of them shrinks the other does not shrink so certainly get bulk no, right. So, this is how people have been working around to use different kind of thing using the same principle and get bulked yarns.

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So, we take one or two minutes and say beyond the classification right.

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So, there is no whatever classification we have done stretch yarn, modified stretch yarns, bulked yarns this beyond that, you will still get bulky fabric the bulk can be developed and stress can be developed in the fabric itself you know. For example, the crepe bandage, you see the crepe and it is a fabric nothing is being done at the yarn level to give the stretch, what you are doing is very high twisted yarn have been woven and in light you know GSM kind of environment and whenever they get a chance they because of their energy reduction you want to go to a stable state. So, the cribbed yarn or the twisted yarns want to come back.

So, one can make crepe on fabrics is one of the things where one set of yarn has got one twist, the other side have got another twist and you get beautiful effects, bulky effects can be done. Other is interlacement which is not a bulk development, but it has some motivations, some inspiration from whatever is happening in the bulked yarn, but part of the filament industry and part of texturing industry interlacements can happen.

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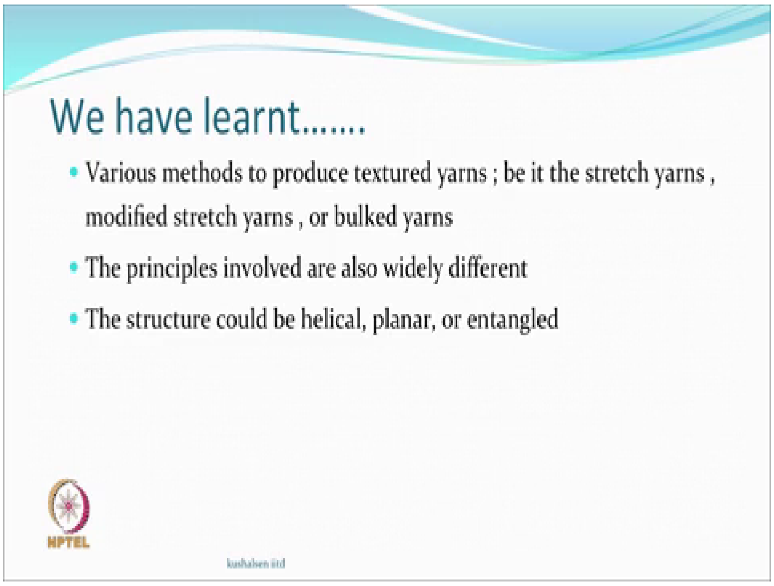

So, we come to the end of this today, that various methods which can be used to produce textured yarns we have learned whether it is a stretch yarn or a modified stretch yarn or bulked yarn. The principles involved in producing such yarns are also very widely different. The structure that is produced generated also is very different could be helical, planar, 3-D, entangled structures so on and so forth, all right.

So, in summary what we have learnt is there are the large number of methods that can be used and some of them have become commercially success. So, as we move further we will talk more about the commercial commercially successful technologies and we will keep appreciating the principles people have generated at time to time.

Thank you all the best.