New Spinning Technologies
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Lecture - 23
Wrap spinning (contd.)

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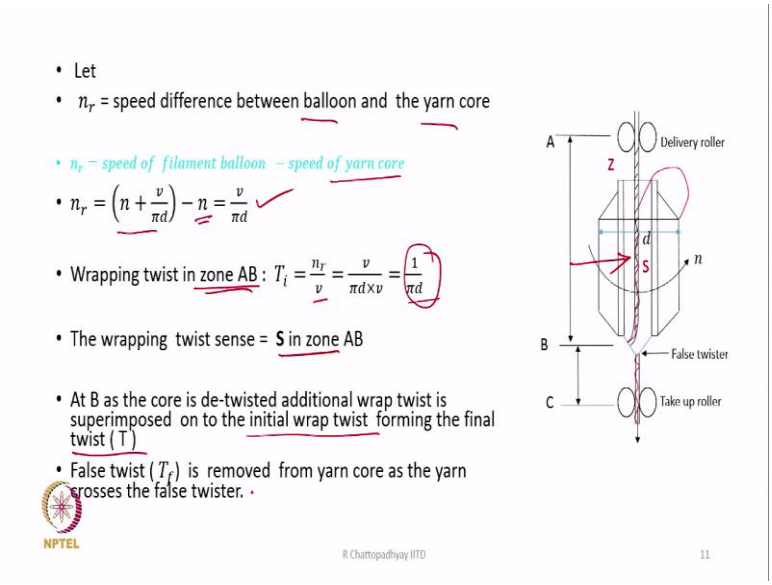

We continue, let n_r is the speed difference between the balloon and the yarn core. So, n_r is going to be speed of the filament balloon minus speed of the yarn core which is n; so, that is what is v/πd as I have already mentioned n and n will cancel and we will be left with v/πd. So, wrapping twist is going to be how much is going to be in the zone AB is going to be n r/ v and n r is v/πd and if we put this substitute the value of n r here, we will be left out with 1/πd.

$$n_f = \left(n + \frac{v}{\pi d}\right) - n = \frac{v}{\pi d}$$

So, the wrapping twist here in the zone AB here is going to be 1/πd. So, there will be little twist because the yarn is also rotating in the same directions and the balloon is also rotating in the same directions. So, they are both rotating in the same directions and the additional speed of the balloon is just 1/πd. So, that will be the wrapping twist in the zone will be going to be 1/πd or you can say wrapping rotation in this case.

$$Wrapping\ twist\ in\ Zone\ AB: T_i = \frac{n_f}{v} = \frac{v}{\pi d \times v} = \frac{1}{\pi d}$$

The wrapping twist sense in zone AB is going to be S. At B that is as the point of first twister the core is de-twisted and additional wrap twist is superimposed on the initial wrap twist forming the final twist that is T. And therefore, the false twist is removed from the core as the yarn crosses the false twister, we all know that the core will lose all the twist.

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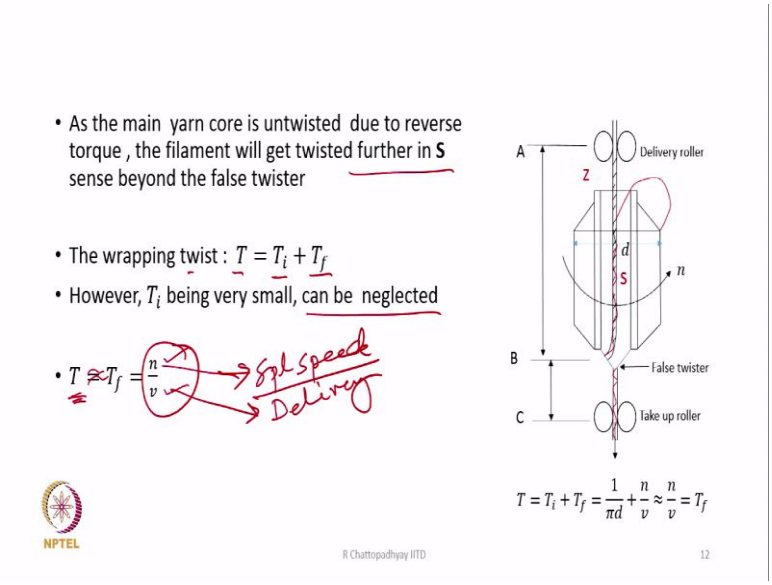

And they become straight and parallel and as the core is reverse twisted, the filament will get twisted further in the S directions; so, earlier there were little wrap in S directions. Now, they it will receive more wraps in the same S directions now; so, total wrapping twist therefore, will be T is going to $T_i + T_f$. However, T_i is very very small, T_i is only $1/\pi d$ and therefore, it can be neglected for all practical purpose.

$$T = T_i + T_f$$

And we write that the total twist is basically equal to almost T_f which is equal to n/v. Therefore, for all practical purpose we say the wrapping twist is spindle speed divided by delivery rate, though actually to be very accurate we have to add that T_i value. But for all practical purpose we can neglect it because this value is very very negligible in comparison to the value which is n/v.

$$T \approx T_f = \frac{n}{v}$$

The same thing we do actually you know there is lot of analogy with the ring spinning also. The actual twist in ring spun yarn should be the ratio of traveller speed divided by front roller delivery. But we now in all twist we basically calculate on the basis of spindle speed by front roller delivery.

Though we know that spindle speed and traveller speed are not same, there is a little difference between these two, because the difference is there; therefore, the yarn is wound around the ring bobbin. But this speed difference between the spindle and the traveller in the case of ring spinning the difference is so low that we also neglect practically that. And we calculate the twist on the basis of ratio of spindle speed by delivery.

Because by doing so, the error that we make is too little and it has no practical significance and we ignore there. Here also we say that the wrapping twist is going to be therefore, n/v; where, n is the spindle speed this is with the spindle speed and v is the delivery that will give me the wrapping twist.

$$T = T_i + T_f = \frac{1}{\pi d} + \frac{n}{v} \approx \frac{n}{v} = T_f$$

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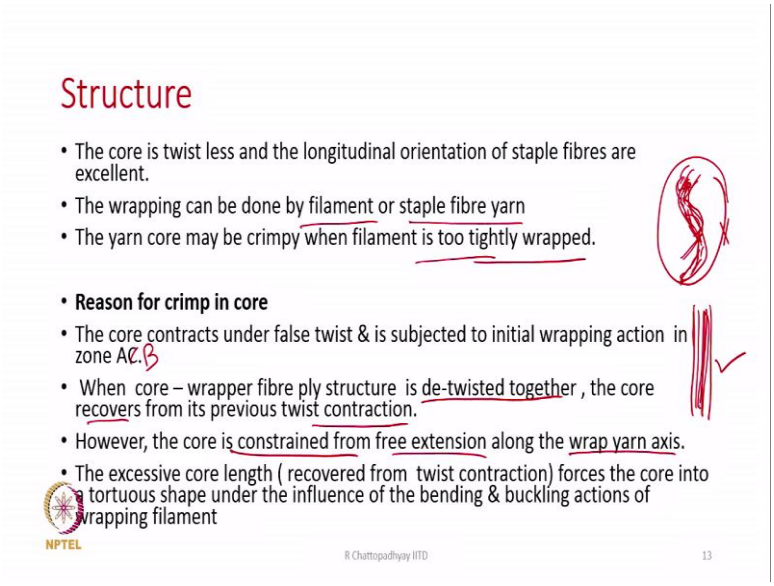

Now, the next topic is structure of such yarn and you can always automatically you can now visualize how the yarn will look like. In the core which will be almost 95, 96, 97

percent of the fibres will be forming the core and these fibre will be almost straight and parallel.

It is a parallel array uniform array of fibres and this will be wrapped by the filament, whatever filament we choose you will wrapped by that filament, even we can wrap it by spun yarn also; so, anything is possible whatever we want. So, the core is twist less and the longitudinal orientation of staple fibres are very very excellent because they are all straight and parallel.

Wrapping can be done by filament or by staple fibre yarn, it could be monofilament, it could be multifilament, it could be texturized yarn, it could be a staple fibre yarn. So, you have very very many options to develop different types of yarn using these technology also. The core fibres and the wrapping filament could be of similar nature could be dissimilar in nature also; all sort of possibilities are there to engineer different types of yarn structure.

So, it could be very suitable for development of technical yarns. The yarn core may be crimpy at times when the filament is too tightly wrapped, that is the core will be wavy, this possibility is there. Instead of being straight like this, this is what is required, this is something which we do not desire. And why it becomes crimpy or wavy? The reasons are the core contracts under false twist and is subjected to initial wrapping action in zone AC.

See in the zone, in zone, not in the zone AC; zone AB, if we look back the previous diagram, A is the drafting nip drafting roller nip, B is the spindle, whatever the your false twister is there that is the point B. And C is the point where the false twister is there, let us look back the diagram again; A is here, delivery roller, B is the false twister and C is the take up roller, we again move forward.

So, when the core is your when the core gets twisted, then there is chance of that it will be there will be some amount of contraction. So, core will be contracted when there is a false twist into it, and when it is getting this initial little wrap in the within the hollow part of the spindle, which is in the zone, we can say zone AB; not C, but it is AB. And then when the core wrapper fibre ply structure; so, it becomes kind of plying, you know, there is one component which is staple fibres; there is another component which is filament.

And now when it both of them are de-twisted together, the by the time they start crossing the false twisting zone. Then the core try to recover from its previous contraction. So, core initially was contracted because false twist was there. Now, when it is losing false twist; so, it will try to recover the length. And now when it is trying to recover the length, there is obstruction to this recovery, because filament wrapping has already started now, tight wrapping has already started.

The core is constrained from free extension along the wrap yarn axis; because as I said, because already wrapping has started at the same time. So, in this situation, what happens? The excessive core length forces the core into a tortuous shape under the influence of bending and buckling actions of the wrapping filaments. And therefore, the filaments are going like this, and because the core is trying to extend, but it cannot because there is a restriction to its longitudinal you know recovery of length.

So, it is forced to buckle now or forced to bend and as a result, the core start bending; so, this is what can happen and this has been observed also. Such kind of crimpy core also can be seen in the case of air jet spun yarn. There also sometimes similar kind of structure has been observed, we call it crimpy core.

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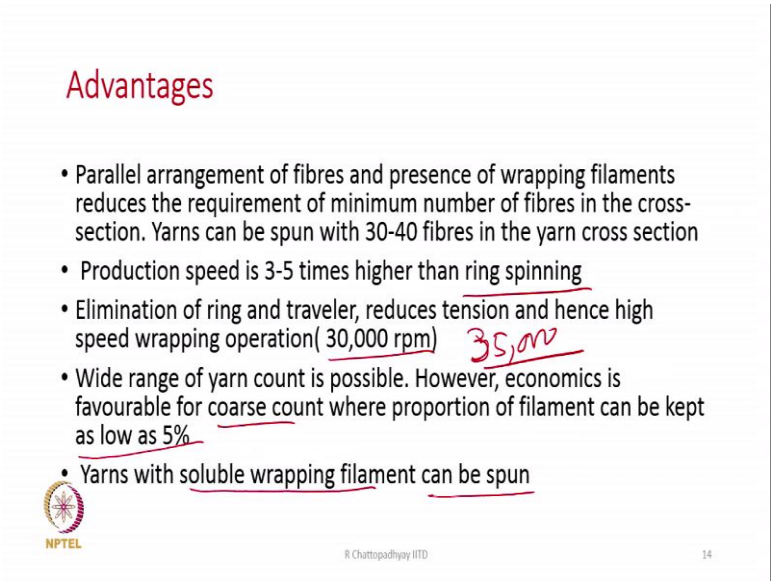

Now, what are the advantages of the spinning system and what are the disadvantages we will discuss. Advantages first is parallel arrangement of fibres and presence of wrapping

filaments reduces the requirement of minimum number of fibres in the cross section and yarn can be spun with 30 to 45 fibres in the yarn cross section.

This is something which is impossible with ring spinning, rotor spinning, friction spinning, address spinning, vortex spinning. Nowhere it is possible to spin a yarn with such a low number of fibres in the yarn cross section, in this technology, it will be possible.

Second is production speed is 3 to 5 times higher than ring spinning, productivity is high. Third thing is elimination of ring and traveler reduces the tension and hence high speed of wrapping operation. We go up to 30,000 sometimes we can go up to even 35,000 also, it can vary between 25,000 and 35,000. Wide range of yarn count is possible, not really too wide that sense.

We can go up to a 24s Ne at the most, but coarse yarn can be produced and up to 20s count can be easily produced. But economics is favourable for coarse count where proportion of filament can be kept as low as 5% or 4% or 3% that is the type of you know filament percentage that we keep in the yarn. So, we can take a polyester fibre in the core and wrap it by polyester filament; so, we have a 100 percent polyester yarn.

We can have viscose yarn fibre in the core; wrap it by viscose for a yarn filament also. So, we will get a yarn of these counts, but produce at a very very faster rate. Yarns with soluble wrapping filament can be also spun that is also another advantage. Sometimes we need it; we can wrap it by filament which will soluble in water.

So, with that particular type of yarn we can make some fabrics and then we can get rid of the filament. So, we will have a fabric where the yarns interlacing each other and the fibres are basically all straight and parallel with respect to each other. And there is no twist in it that is what is possible.

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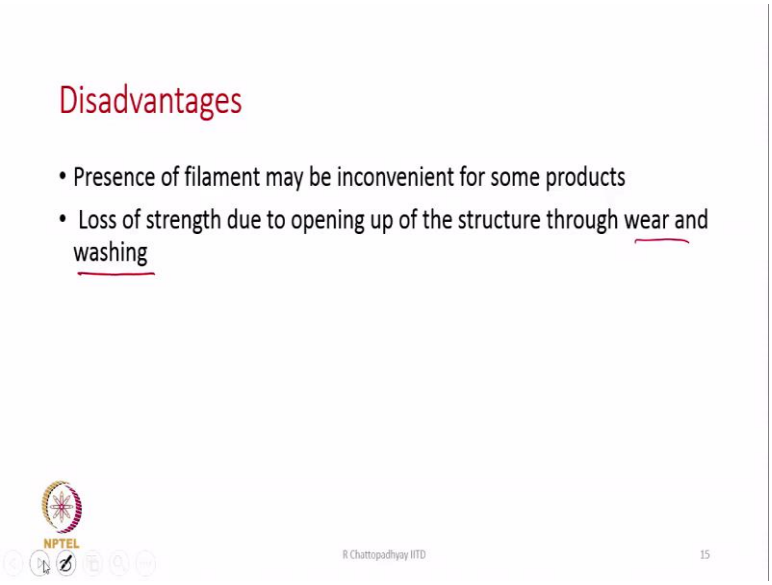

What are the disadvantages? Presence of filament may be inconvenient for some products. If I want 100 percent cotton yarn, then we cannot have a filament of polyester or viscose yarn or something. In some products it may not suit, because the filament whatever we choose may not be you know adding value to the quality of the product, it may happen sometimes.

Loss of strength due to opening up of the structure through wear and tear and wear and washing. Repeated you know washing can cause this; that is, the structure becomes loosen, because the 90% 95% of the fibres which are core fibres, they are not really there is no interlocking mechanism to hold the fibres together other than the filament.

So, the filament surface filament gets ruptured due to any reason; suppose, it is a fabric as say some abrasion and the filament has got ruptured. In that case, the core fibres are now exposed they are free to move out or peel out from the fabric surface. Because fibres are not really having any other mechanism through which they are bound to each other. In ring spun yarn, because the migration that happens between the fibres, we create a interlock structure.

Fibres are somehow there actually there is a mechanism that is because of migration, there is interlocking mechanism between the fibres which hold the fibres together. This is something which is absent here the fibres are straight and parallel. So, if the in the

absence of the protecting filament, core fibres are simply exposed, there is no twist in them. They are all straight and parallel, they can easily wear out that is the difficulty.

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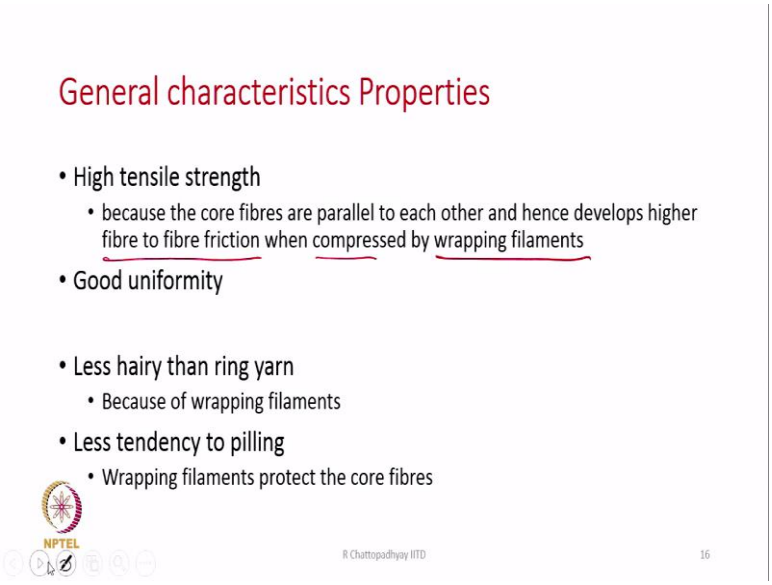

So, now the general characteristics and the properties; first of all, the high tensile strength because the core fibres are parallel; so, there is no obliquity effect. The load bearing core fibres are straight and parallel; so, they can take the full load still the rupture if we produce a proper yarn.

The obliquity effect that you have been know you must be knowing that is there in the case of ring spun yarns, it is absent here. The develop high fibre to fibre friction when compressed by the wrapping filaments. This is possible only when the wrapping filaments are tightly wrapping the structure.

In that case, we can expect very high tensile strength of the yarn. Uniformity is good, is not it as good as know ring spun yarn? Less hairy than ring yarn because the hairs, part some of the hairs are getting suppressed by the wrapping filaments. Less tendency to pilling for the same rising wrapping filaments will protect the core fibres and now allow it to you know pill out easily, these are the general you know characteristics.

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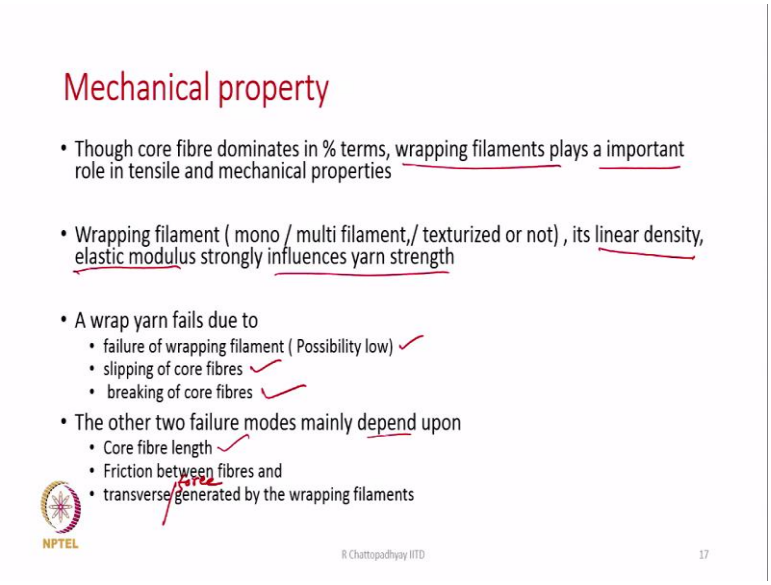

And if we look at the mechanical property, the core fibre dominates in percentage terms. Wrapping filament plays an important role in tensile and mechanical properties. So, the core fibre will actually dominate the mechanical property of this yarn, but wrapping filaments must play an important role.

Because the filaments are not developing enough radial pressure, the assembly of fibres will have no strength. And the running filament; see, type of wrapping filament is linear density, its modulus, its tenacity will strongly influence the yarn strength.

So, we have to choose the filament yarn, keeping in mind that there are many parameters of the filament yarn which can influence the property of the wraps spun yarn. The wrap yarn fails due to failure of the wrapping filament whose possibility is generally low, but it can happen the filament ruptures when such a structure is elongated. The filament may rupture and the filament ruptures the entire structure will immediately fail.

The other is slipping of core fibres, this might also happen and the other one is breakage of core fibres finally. The other two failure modes that is slippage of core fibres or breaking of core fibres, this will mainly depend upon the length of the core fibres, longer the length, more is the surface area of contact; so, more will be the frictional resistance to slippage.

So, therefore, length of the core fibre will have a very you know great influence on the overall strength of the yarn, friction between the fibres. Because ultimately it is way up to frictional resistance has to be built up in order to avoid slippage between fibres.

So, frictional resistance or coefficient of friction between fibres will be definitely very very important. And the third one is a transverse force generated by the wrapping filament; transverse force generated by the wrapping filament. That is how much radial pressure the wrapping filaments are generating on the core fibres that is also very important.

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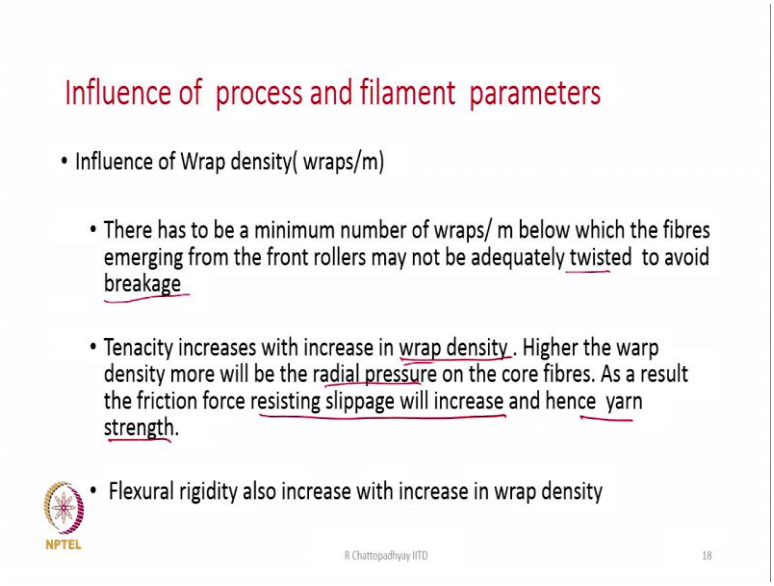

Influence of process and filament parameters we will discuss the lot of research work also has been done. I will only you know discuss about two important parameters, one is the influence of wrap density that is the wraps per meter or wraps per inch whatever we say. There has to be a minimum number of wraps per meter below which the fibres emerging from the front roller may not be adequately twisted to avoid breakage.

This is what we have to remember that unless we have a minimum wraps per meter; the yarn will break at the nip of the front pair of rollers, because sufficient false twist is not getting generated. And therefore, the yarn right after the front roller nip is going to be so weak that it will break there itself; so, we have to have a minimum amount of wraps.

Then the tenacity will increase with the increase in wrap distance density, more wrapping means stronger yarn. Higher the wrap density more will be the radial pressure on the core fibres, as a result the frictional force resisting slippage is also going to increase and hence yarn strength. So, more wraps mean more pressure mean more resistance to frictional slippage and therefore, more strength.

Flexural rigidity also increases with increase in wrap density, because if the fibres themselves core fibres cannot really slip or they become difficult to slip bending also will become difficult. So, bending rigidity of the yarn is going to increase as we keep increasing the wrap density. So, the we make the yarn stronger, but also same time we will make the yarn more and more difficult to bend as we increase wrap density.

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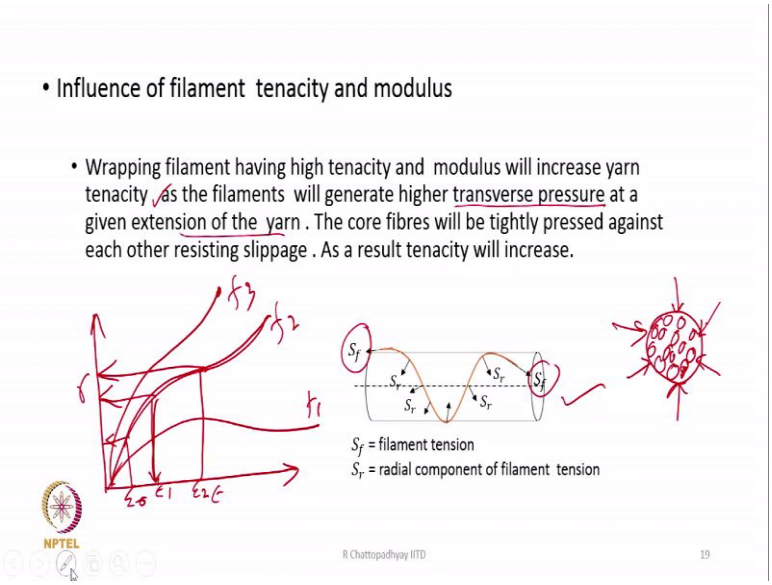

The other one is filament parameters where the tenacity and the modulus are the most important parameters. There could be other parameters also the fineness of the filament could be other parameters or the breaking extension of the filament could be also another parameter. But here the filament tenacity and modulus wrapping filament see here a diagram has been shown where the cylinder is representing the core bundle of fibres and the orange color the line is indicating the wrapping filament.

So, the wrapping filament is when it is wrapping it is under some amount of tension which is there that is what is S_f let us say. And it is generating radial pressure and therefore, because if we look at this if this is my constructional view of the yarn and

these are the fibres, then radial pressures are getting generated. There are mathematical models where people have tried or people have already developed models to predict the strength of such a structure.

But the basis is that basically as I stretch such a yarn the filament will get stretched. If the filament gets stretched one component of the filament tension will be acting radially inwards and this radial inwards force will actually hold the fibre together.

So, wrapping filament with high tenacity and high modulus will increase yarn tenacity as filaments will generate high transverse pressure at a given extension of the yarn. See the filament if we plot the lowered elongation diagram of a filament which is used to wrap it typically it could be diagram could be like this, this side is elongation or strain and this side is stress.

So, as we keep on increasing the yarn from here, we go to let us say here we go there; the pressure the force that we generate on the filament is going to increase. How much force will be generating all depends, at what level of extension we are. As we go from ε_0 to ε_1 to ε_2 more and more stress will level up on the filament. And therefore, more and more radial pressure will also develop and hence the fibres core fibres will be pressed with a higher force.

And therefore, it will be difficult for them to slip easily; they will resist more and more slippage; so, how much force will develop depends upon the nature of this curve. This curve or if you say another curve like this, or another curve like this; this is one filament 1, this is filament 2, this is a filament 3, filament 3 is having higher initial modulus than filament 1.

So, filament 1 will generate less force, filament 3 will generate more force. And the other thing depends what is the tenacity, what is the tenacity, what is the failure at the time of failure what is this value. If the tenacity is high the strength of the yarn is also will be more as a whole, if the modulus is high the yarn is going to be very strong as well.

So, the nature of the curve is going to decide the magnitude of this radial pressure which will be generated. And therefore, how tightly the fibres will be held together will also be decided by the nature of this filament, especially their stress strain behavior or load elongation behavior.

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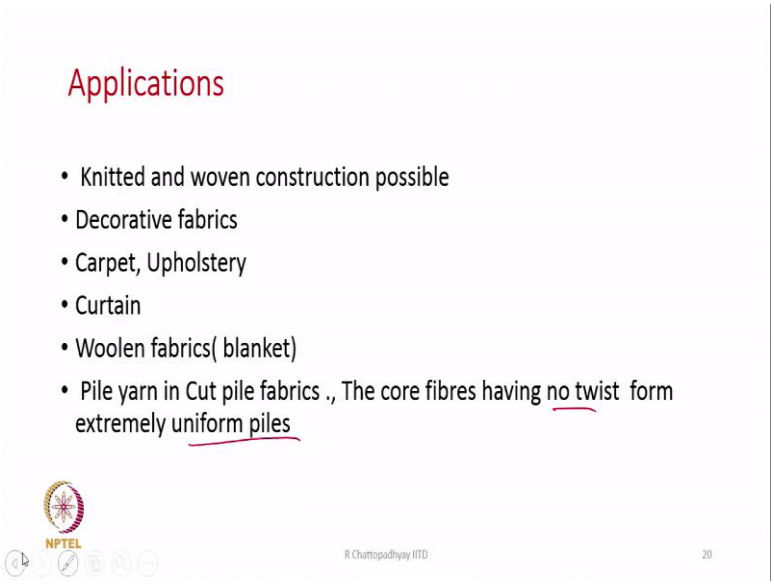

Applications of these yarns, knitted and woven constructions are possible can be used for decorative fabrics, carpet, upholstery, curtains, woolen fabrics that is blankets. And carpet also they are made from you know could be from wool also, pile yarn in cut pile fabrics the core fibres having no twist form extremely uniform piles. So, these are the different types of applications, which are possible and also, we can think of application in the area of technical textile nowadays.

So, we have a means to produce a yarn where we can have core as well as a wrapping filament. We can have many types of combinations of core and wrapping filament and these yarns can be then used either in some you know you can say home textile products or they can be used in case of technical textile products also.

And lot of possibilities are there to play with the fibres, they are blends, in the core or in the on the surface and we can take two of these yarns and further apply them, lot of possibilities are there to expand its use in different fields.

So, with that we come to the end of this particular session and I think most of the you know technologies which are non conventional in nature actually they have been covered. Now, we will I will take few more you know sessions on others, which are not really that says unconventional, but there you can say an extension of the existing technology that we have with little modification in some times.

We can use it to enhance certain properties and especially certain properties of the yarn these technologies is used to make earlier. So, we will discuss about them in the coming you know one or few more sessions which are left.

Thank you.