New Spinning Technologies
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Lecture - 15
Structure and Characteristics of Air-jet yarn

We will be discussing Structure and Characteristics of Air-jet yarns.

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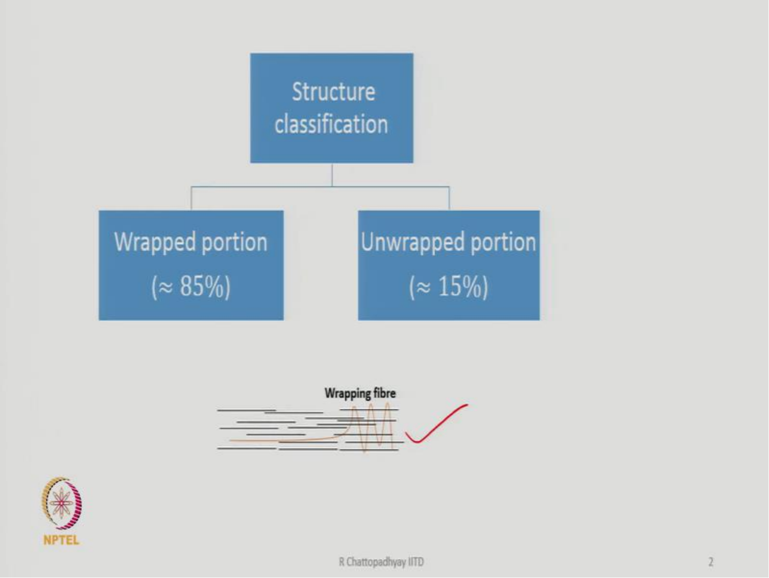

The structure can be classified into two first of all. One is the wrapped portion of the yarn and the other one is unwrapped portion. And wrapped portion on an average is almost 85 percent part of the yarn is basically wrapped by some fibres. The unwrapped portion is typically around 15 percent. And how a fibre is wrapping that we have discussed earlier by here in this particular diagram we are showing it typically fibre which is wrapping the core as well as is becoming a part of the core also.

So, in air-jet spun yarns there are many fibres which will be like this as shown by this orange colour that part of the fibre is actually wrapping the yarn. And there is another part which is inside the yarn. The same for same fibre part of it is forming wraps and part of it is forming the core part of the yarn. And therefore, these wrapper fibres are actually imparting strength to the main bundle of fibres which are fairly parallel with respect to each other.

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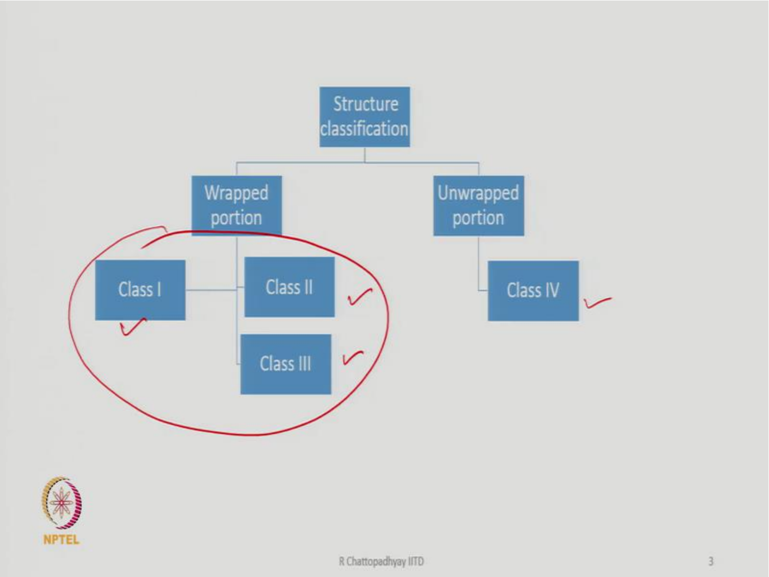

Now, we will further classify the wrapped portion into these three categories. Class 1, class 2 and class 3. The unwrapped portion will be called class 4. So, if we study the surface of the yarn, we will find that the wrapping portions are also not exactly same. There are different types of wraps and these are known as class 1, class 2, class 3 types of wraps. So, different people have classified them differently.

But generally, we can say there are three different types of wraps are there and some part of the yarn also is not showing any wraps and they will be known as class 4 type of you know part of the yarn.

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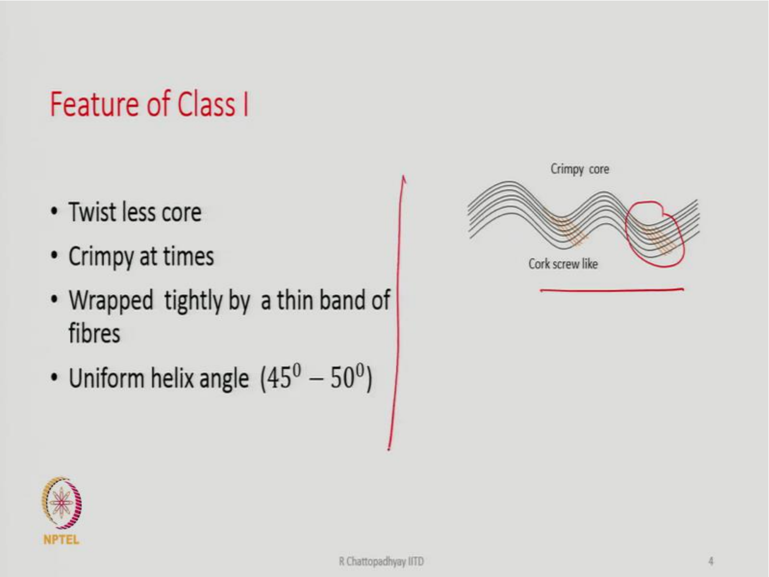

Now, what is the feature in class 1 type of wrap portions? The diagram is shown here and what are the speciality in this diagram? First is the core part if you look at it there are lot of parallel lines, I have drawn that indicates that the fibres are basically parallel with respect to each other and there is as if there is no twist into it also. So, the core is twist less. Then comes you can see there is a crimpiness in the core little wavy. So, this can be seen also that part of the yarn sometimes is wavy or crimpy.

Then the wrapper fibres are shown by this orange color fibres, they are wrapping it tightly. It is a thin band of fibres. Few fibres are wrapping the core. Sometimes you may find that one fibre is also wrapping the core. So, it is little bit random in nature. Most of the time we will find a thin band of fibres is actually wrapping such portions of the yarn. And the helix angle of these wraps is fairly uniform that is 45 to 50 degree. So, this is the typical feature of class 1 fibres that is or class 1 structures.

The class 1 structure will be looking like this twist less core crimpy at times and they will be wrapped by some fibres based tightly wrapping and the helix angle is fairly uniform typically varying between 45 to 50 degree. That is the class 1 structure.

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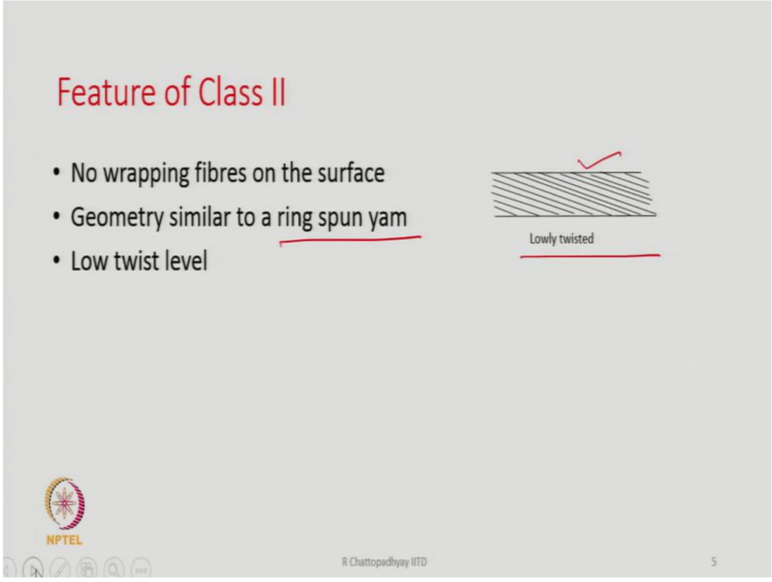

So, we now go to the class 2 type of structure of the yarn and a sketch is shown here. What we find here? That the fibres are slightly twisted and there is no wrapper on it. So, there are certain parts of the yarn which is devoid of wrappers. There is no wrapper on it. And the fibres there are slightly twisted. So, no wrapping on them, they are slightly twisted.

So, these parts of the yarn will be very similar to ring spun yarn. These there are certain zones where we will see this kind of structure of the yarn. Now, the other aspect is that there is a low twist level. The twist in this zone is low. And sometimes we will find that somewhere in the yarn the twist direction is S. Some other parts we may find twist direction is Z. That indicates that the core was false twisted. And the somehow the false twist could not get removed completely and they got trapped by the by the wrapper fibres.

So, the entire twist in the core could not get completely removed. Still some parts some residual twist is left there. And therefore, we find some little twist in the core and therefore, it looks like a ring spun yarn. But sometimes we will find it in S direction. Sometimes we will find it Z direction also.

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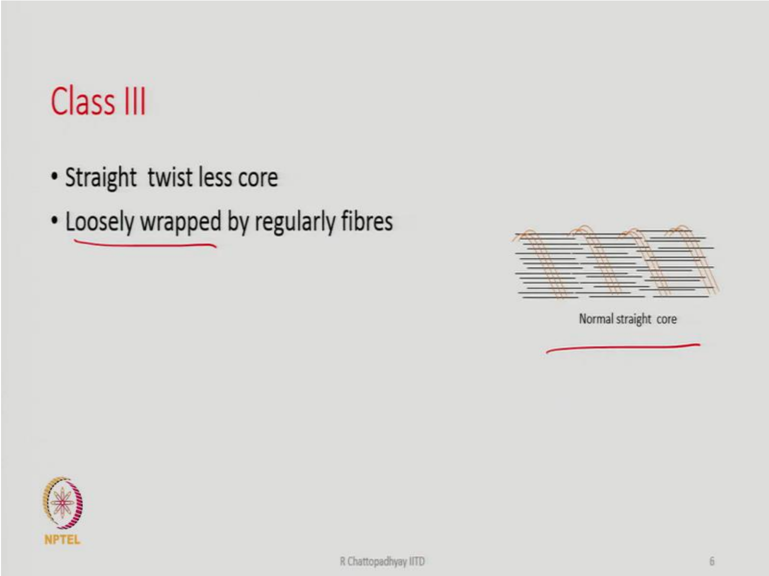

Then I come to the next part. The diagram is shown here. Normal straight core and there are wrappers also. So, the core is twist less. Fibres are parallel and it appears there is no twist. No twist is trapped. Only we find there are wrapper fibres at regular interval. So, and these fibres which are wrapping it they may be little loose. So, these kind of places can also be seen in the yarn.

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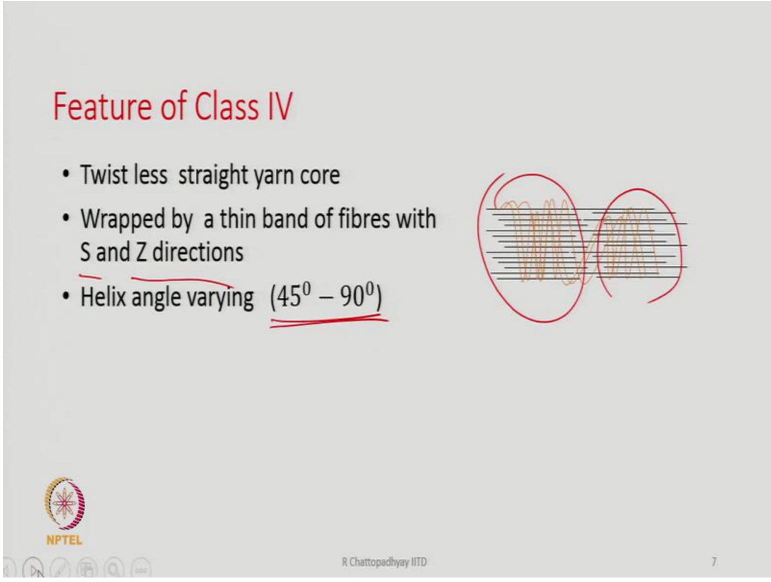

And there is another class 4 also. Some wrapping can also be seen where we find the wrappings are quite haphazard type. So, twist less straight yarn core is there.

But the wrapping part if we focus on it we will find that 3 band of fibres is wrapping it, but the twist direction is changing. Sometimes it is S wrapped, sometimes it is Z wrapped. So, this part if we see is wrapped fibres in one direction, they are the same fibres are wrapping in the other directions.

So, these kind of segments also can be seen. And this we can call them class 4 type of structure. So that means, we see that there are 3 different types of wrappings are there. And there is one class where it is not wrapped at all, just looks like a ring spun yarn structure free from wraps.

So, these are the 4 different classes that has been observed by different researchers. And in this case the wrapping angle that has been measured by many can vary between 45 to 90 degree. So, there is a wide variation in helix angle. It is not uniform. So, these disturbance could be there in the wrapping because the possibilities of air turbulence which is there within the jets high pressurized air are injected.

So, within the jets or within the nozzles we can say that lot of you know disturbance will be created by the vortex. And because of this the wrapping sometimes may not be very very uniform, at times because of the disturbance which is there inside the jets, there may be sometimes wrapping which is quite regular in nature and sometimes there could be wide variation in the wrapping angle. So, these kind of segments of the yarn also can be seen in these type of yarns.

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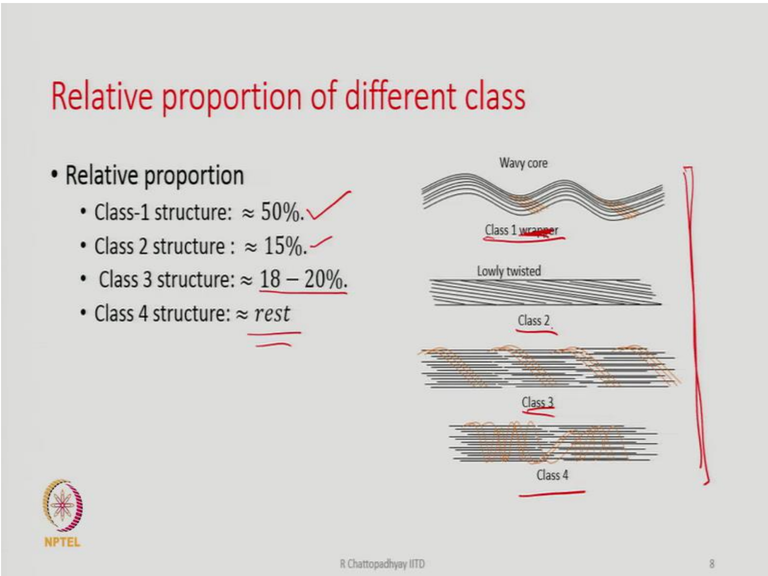

Now, relative proportion of different class or segments of the yarn. So, class 1, class 2, class 3, class 4. Class 1 type of structure, class 2 type of structure, class 3 type of structure, class 4 type of structure. Now, in class 1 type of structure typically this kind of structure is almost 50 percent of the yarn will have this kind of structure, class 1 type of structure. Class 2 type of structure will be roughly around 15 percent class 3 types of structure is 18 to 20 percent and class 4 type of structure is the rest.

So, some researchers have found out that typically these are the type of four different types of structures and these are their relative proportions. So, major part of the structure is look like class 1 that is core is twist less, but it is little crimpy and there are wrappings at regular intervals.

So, all these 4 types of structure will be visible to all of us when we look at the yarn under a microscope scan it over a certain length then we will probably find the structure to vary from place to place. Not like ring yarn where the structurally it is uniform even if we scan 1 meter of the yarn, we will find the structure is, but almost exactly same. But in this kind of yarn jet spun yarn this is not going to happen.

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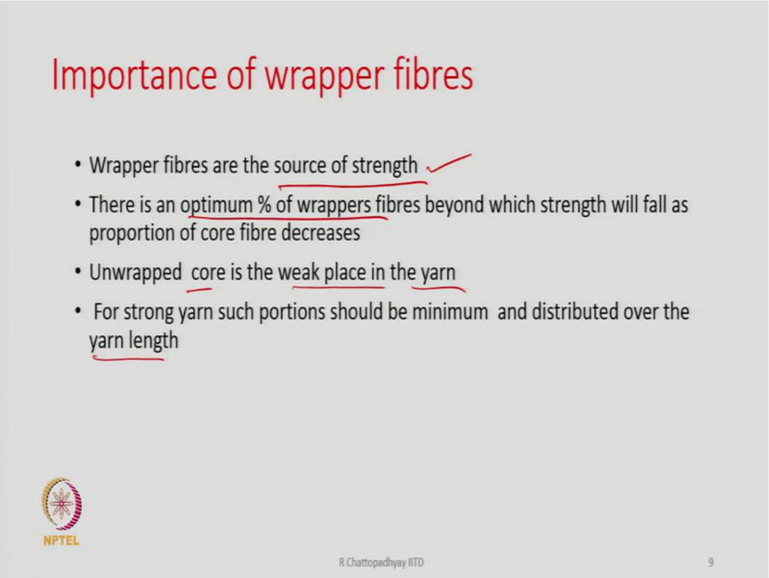

Now, what is the importance of the wrapper fibres in this case? As we have said that the same fibres part of it is forming the wrappers and part of it is basically a part of the core of the yarn.

The purpose of wrapper fibres here is the wrapper fibres are the source of strength. Because they are wrapped and because their one end is tucked in therefore these wrapper fibres can develop tension when the yarn is strained. That If I take a piece of yarn and stretch it the wrapper fibres are not going to slip on the surface of the yarn because one end is tied it has gone inside the yarn.

So, tension will develop and because of that the radial pressure will be generated. And hence most of the core fibres which are there which are most of the time they are parallel or having very little twist they are not going to slip easily because transverse pressure will be generated by the wrapper fibres.

Therefore, wrapper fibres are the source of strength in the case of air jet spun yarn. Then there is optimum percentage of wrapper fibres beyond which strength will fall. Because if wrapper fibres become more and more their automatically means core fibres will be less and less. So, there is a optimum value of wrapper fibres. Otherwise, more wrapper we form the less core fibres will be there. And if the core fibres are going to also support the load and wrapper fibres are going to generate transverse pressure.

So, it has been found that there is a optimum percentage of wrappers beyond which if we try to generate more wrappers fibres the yarn strength will go down. And that optimum percentage is around 15 to 20 percent not more than that. Unwrapped core is the weak place in the yarn.

If there are certain regions of the yarn where there is no wrapping that basically be those are the possible weak place or potential weak place in the yarn. Because when the yarn is stretched these portion will not get support from the wrapper fibres because there is no wrappers on them. So, they will simply slip and hence the yarn will quickly break.

So, unwrapped core is the weak place in the yarn. For strong yarn such portion should be minimum and distributed over the entire yarn length. So, there are similar to basically weak places and they are numbers or their frequency should be minimum. And if at all there they should be distributed over the long length of the yarn. They should not appear one after the other successively. In that case that part of the yarn is going to fail at a every lesser load.

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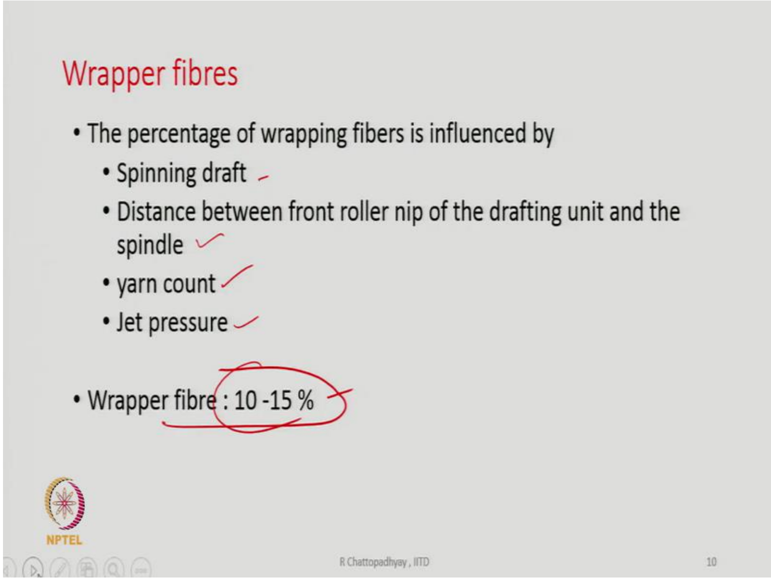

Next comes what are the factors that affect the wrapper fibre generations? So, the percentage of wrapping fibres is influenced by spinning wrapped, distance between front roller nip of the drafting unit and the spindle, that is the jet, the count of the yarn and the pressure of the jet how much pressure we apply. The vortex speed is going to depend on the pressure of the jet, at what pressure the air is injected that will decide the speed of the vortex and thereby the strength of the vortex.

Ultimately it is the vortex within the jet that is going to basically turn the bundle of fibre or trying to twist the bundle of fibres. So, wrapper fibre percentage as I said somewhere between 10 to 15 percent most of the time and we do not try to go beyond this because there is a possibility that the yarn strength will go down.

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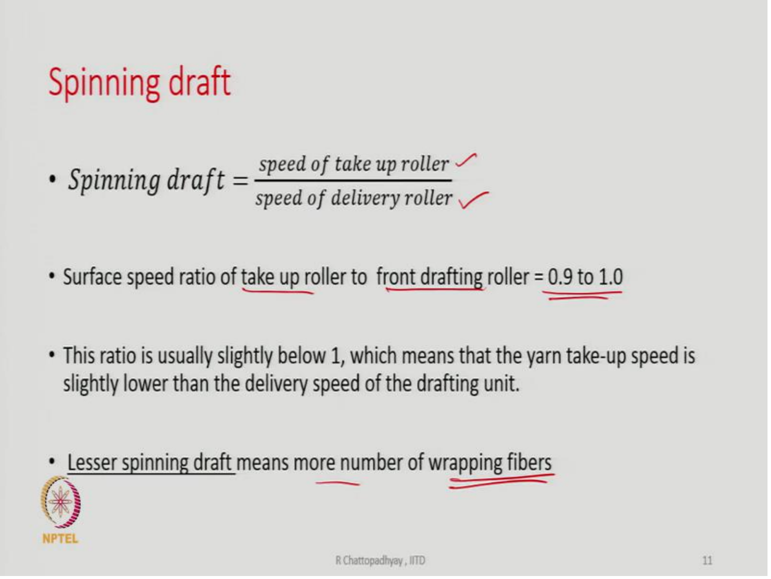

$$Spinning\ draft = \frac{speed\ of\ take\ up\ roller}{speed\ of\ delivery\ roller}$$

Now, spinning draft: spinning draft is basically is the ratio of speed of the take up roller and speed of the delivery roller, that ratio is called the spinning draft. So, this ratio is very very generally it is very close to 1. Surface speed ratio of the take up roller to the front drafting roller is typically 0.9 to 1. That is the generally kind of you know draft that we keep that is either 1 or slightly less than 1.

So, front roller delivery speed and the take up roller speed the surface speed of these two. This is also a very you know this is, but also critical this draft. The ratio is usually slightly below 1 which means that the yarn take up speed is slightly lower than the delivery speed of the drafting unit.

So, if I delivered x length of yarn at x length of drafted fibres the yarn take-up speed will be 0.9x it will little less. That is how we maintain it and we know that as the fibres are delivered from the front roller, they are they are delivered in the form of a thin fleece of fibres without any twist.

When the same fleece is going through the chamber of the jet chambers, they will be getting twisted, when they are twisted there will be some contraction. So, yarn the length of that fleece is going to shorten because the configuration is changing from parallel bundle of fibres to now, they are becoming a twisted bundle of fibres finally. Due to that there is going to be some contraction always.

So, the contraction is there you can make it up to some extent by having a draft which is less than 1 not more than, if we keep draft more than 1 tension will be too much in the yarn, the yarn may break during formations. So, we keep a tension value which is little less than 1 because we know that these fibres as they get twisted their axial length is going to reduce.

Axial length means axial length along the yarn axis is going to because they are going to form follow a spiral path a helical path finally. And therefore, the overall length of the yarn is going to be little less than the length of fibres being delivered into the twisting zone. Lesser spinning draft means more number of wrapping fibres it has been same, that if the spinning draft is less more wrapper fibres will be formed.

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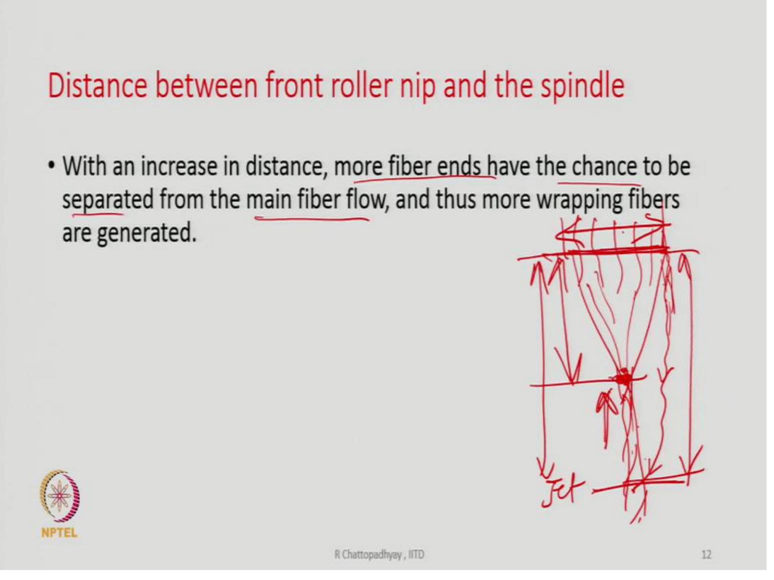

Distance between front roller nip and the spindle: with an increase in distance more fibre ends have the chance to be separated from the main fibre flow, and thus more wrapper fibres will be generated. So, that is a very also important distance. The distance between the front roller nip and the entry to the jet this distance is very important. A higher distance means we will be able to generate more edge fibres.

And edge fibres as I have said earlier that the from the twist angle the fibres which are lying at the edges these are the fibres which will escape twisting actions and they will join the main strand little later. And because of this phenomenon they will be twisted differently than the main body of the yarn. And because of this reason we will when they get both of them get untwisted as they cross the both the nozzles or jet we find that they are twisted in the opposite direction now and the core part of the yarn because they are first twisted they will not have any twist left in them.

So, the edge fibres are in a way the source of wrapper fibres. So, more their number is the better it is. And the later they join the main body of the yarn longer wraps will be formed. So, if this is my twist triangle and let us say this is the yarn. So, the fibres which are coming from the edges some other fibres will escape twist action and they will go move forward and they will join later.

So, the size of this triangle; this is important, how for the twist thing point is reaching the front roller nip and what is thus width of the thin ribbon of fibres both of them are important.

So, from the edges some fibres will escape twisting actions and they will join the main strand later like this fibre and the later they join the longer wraps they will form finally. And their numbers can be increased if we increase the width of the triangle from here to there, this width if this is increased from here to there more edge fibres will be formed.

Therefore, we will see that the draft also becomes important, draft in the drafting in the drafting system also becomes important. And how for the apex point this twisting point is moving ahead that all depends upon the power of the jet two which is more powerful. That is actually twisting the main bundle of fibres and forcing the twist to move ahead towards the front roller nip. But finally, all these fibres will lose twist because they are basically false twisted.

So, if this if this distance we increase like this distance we are talking about at the jet could be somewhere here maybe jet is here. So, this is the distance, that distance is actually going to effect. Because you will have fibres will be delayed as to fibres which will be escaping twisting actions and they will join late. So, they will have space to travel. So, if I create a larger space for the edge fibres to travel and reach the main body of the yarn and hence, they will ultimately lead to longer wraps formation.

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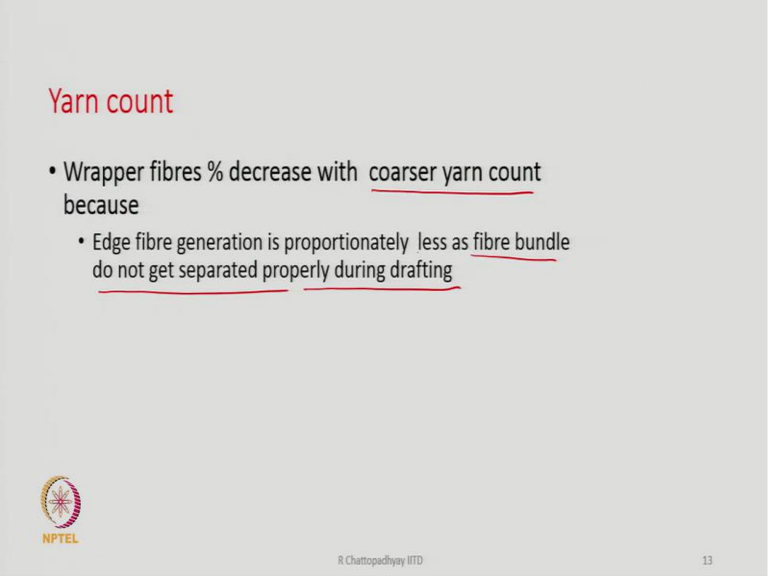

The next is the count of the yarn. Generally, wrapper fibres will decrease with coarser yarn count from the same fibres if we produce finer yarn counts, we will get overall the wrapper fibre percent is going to increase. If we go for coarser count from the same fibre the proportion of the wrapper fibre is going to decrease. Because edge fibre generation is proportionally less as fibre bundles do not get separated properly during drafting operations. When the bunch of fibres are more the cohesion between them is also more.

So, the fibres which will really get separated and fibres which are located near the edge and will get separated from the rest of the fibres that depends actually also what is the level of cohesion between the fibres, either many fibres to support them if they then they may not many of them may not escape twisting action.

So, when the bundle is thin; that means, the when I producing a thinner yarn or finer yarn fibres can be easily get disturbed especially fibres from the edge. And therefore, they will form wrappers. So, proportionally less number of fibres will be disturbed when I am going for a coarser count. This is in comparison to the finer count.

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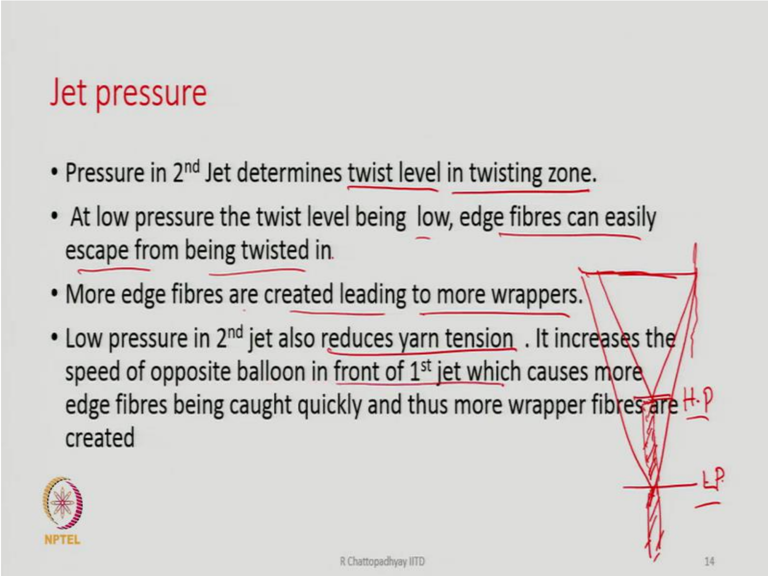

The other thing is jet pressures another parameters. Pressure in the second jet determine the twist level in the twisting zone that is in the spinning triangle zone, how much twist is there in the spin triangle zone will be determined by the pressure of second jet.

That is the jet which is more powerful, that is actually trying to false twist the main core of the yarn and it is deliberately kept the pressure kept on the higher side in comparison to the first jet. So, that it actually twist the main bundle of fibres and the twist flows near to the front roller nip.

So, the twist level there is determined by the pressure in the second jet. More pressure, more powerful vortex and therefore, more twist. At low pressure the twist being low the edge fibres can easily escape from being twisted in. That is when the pressure is low, edge fibres can easily escape from being twisted in and more edge fibres are created leading to more wrappers.

So, at low pressures that basically means that the spinning triangle if we think like this. When the pressure is low, suppose the this is the apex point of the triangle. When the pressure is high the twist will reach here at this point, when the pressure is low the twist will reach this point.

So, this is for high pressure and this is for low pressure. So, low pressure means elongated twist triangle. So, fibres can easily then escape twisting. And therefore, a lesser pressure of the jet 2, this is respect to jet 2 will lead to more wrapper fibre generations.

But also, you have to see there has to be a pressure differential between jet 1 and jet 2. Because we have to make sure that jet 2 remains always more powerful than jet 1. Low pressure in second jet reduces yarn tension. It increases the speed of the opposite balloon in front of the 1st jet which causes more edge fibres.

So, low pressure in second jet will also reduce the yarn tension. When the tension reduces the balloon speed increases. See in the front of the first jet the yarn balloon formation is there. See the yarn trajectory within the jet house is not a straight path, the yarn is actually following a spiral path within the jet also.

And outside the jet in front of the first jet and the front roller the yarn will be seen to rotate forming a balloon, small balloon. So, this balloon speed depends upon the pressure of that particular jet and also depends upon how much tension is there in the yarn. If the tension is high, the balloon will be smaller in size and balloon speed also will be less.

And if the tension is low balloon is going to be little bigger and speed is going to increase. The balloon in front of the first jet is basically rotating in the opposite directions because the two jets which are there the design is such that the jet close to the front roller that jet will turn the yarn in opposite directions. And jet 2 which is more powerful and away from the front roller they rotate the yarn in the other directions if one is clockwise the other one will be anticlockwise.

So, because tension is decided by the one is this you know the spinning draft the other one is the pressure of the jet 2. So, if the pressure of the jet 2 is reduced, tension in the yarn will reduce, but that will cause balloon speed to increase and thereby it will cause more edge fibres being caught quickly and thus more wrapper fibres. You know they will not they will edge fibres being not quickly.

They will be delayed. And as a result, more wrapper fibres will be created. So, there are quite a few different types of hypothesis which are there proposed by different researchers.

Point is what is important is how much upper fibres, how much edge fibres I am generating. And am I creating a situation that they get caught quickly or they get caught late? If they get caught quickly the wrapping length will be shorter. If they get caught late by the main body of the yarn the wrapping length will be larger. See the all matters when these edge fibres are ultimately getting caught by the main body of the yarn.

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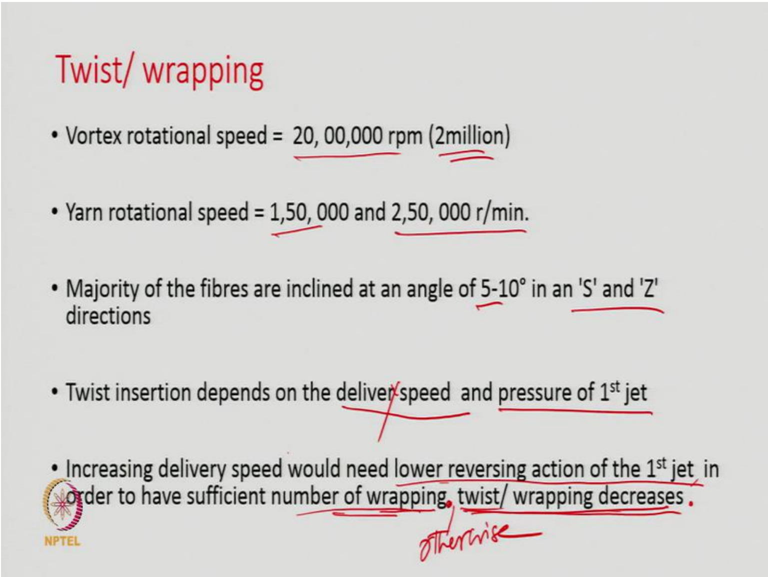

The next one is the this is there is you know twisting or wrapping because we see on the surface of the yarn some fibres are wrapping at different angles. So, we call it wrapping or twisting whatever you want to say. Typically, vortex rotational speed is 2 million rpm. The yarn rotational speed is 1,50,000 to 2,50,000 revolution per minute.

So, there is a huge drop vortex speed and the yarn speed. So, yarn speed is hardly 10 percent of the vortex speed. Majority of the fibres are inclined at 5 and 10 degree in ‘S’ and ‘Z’ directions. Twist insertion depends on the delivery speed and pressure of the first jet. So, delivery speed is increased, the twist or wrapping is going to be less wrapping angle.

So, to counter that what we do? We want to lower the reversing action of the first jet in order to have sufficient number of wrappings twisting or wrapping. Wrapping otherwise the twist and wrapping will decrease. See if the delivery speed is increased twist and wrapping is going to decrease.

And if we do not want the twist and wrapping to decrease then what we have to do that we need to lower the reversing action of the first jet in order to have sufficient number of wrappings. Otherwise twist or wrapping is going to decrease. So, that is see more delivery speed means more production.

So, generally the productivity of the machine is in is measured in terms of what is the delivery speed. But if I go on to for high delivery speed the twist and wrapping is otherwise going to decrease and if you want to counter that, that basically means that my yarn strength is going to suffer.

So, high delivery speed means yarn strength will be low. So, to counter that what we can do? We have to lower the reversing action of the reversing action of the first jet that is balloon speed has to be taken care of. Otherwise, the wrapping is going to decrease and the strength is going to be less.

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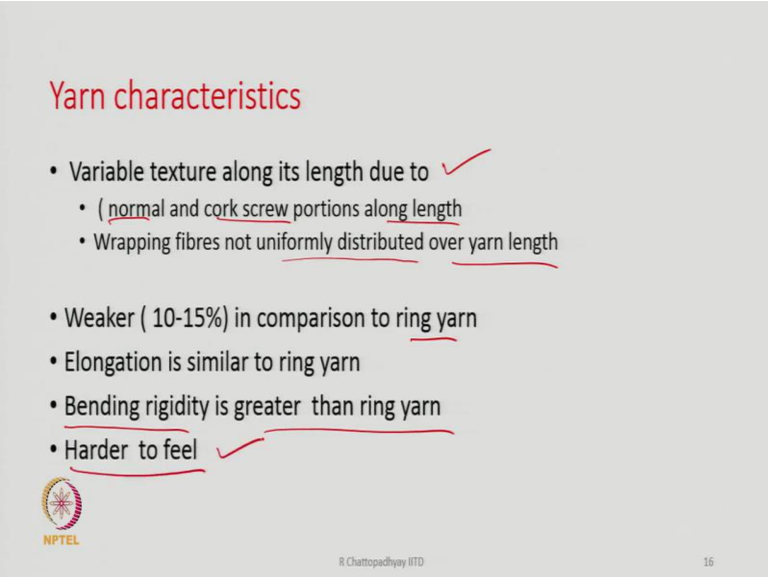

Yarn characteristics the texture of the yarn is variable due to normal and cork screw portions along the length. Wrapping fibres are not uniformly distributed over the yarn length. So, we see that texture which is highly variable in nature. The yarns are weaker in comparison to ring yarns.

Elongation is similar to ring yarn. Bending rigidity is greater than ring yarn; it is stiffer yarn because wrappers are going to hold the main bundle of fibre core fibres are going to be tightly wrapped. So, as a result the bending rigidity is high. Same as the situation for rotor spun yarn also.

Bending rigidity is slightly higher than ring yarn because the presence of wrappers there also. And as a result of this is harder in feel because bending rigidity is more.

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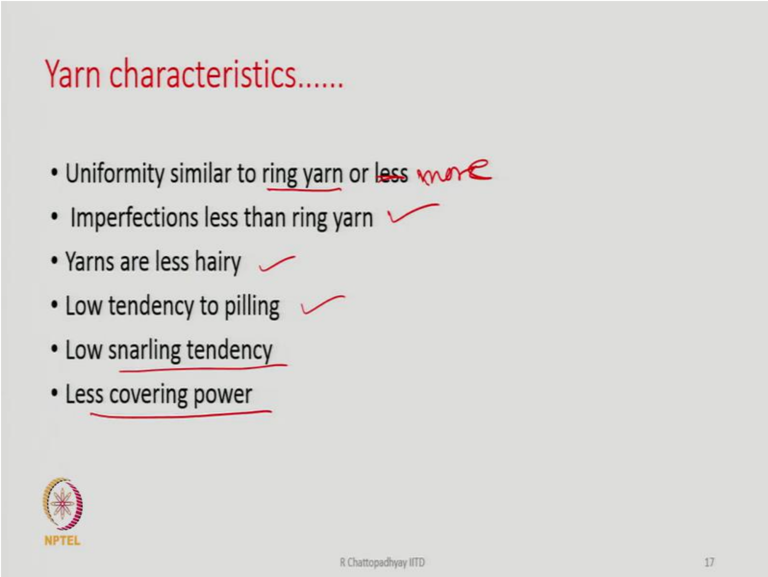

Other important aspect is uniformity of the yarn is similar to ring yarn or in fact not less, in fact uniformity will be more, either similar or more not less. If the uniformity is better in terms of U percentage, then it will be less. U percentage value will be less. Imperfection also is less than ring yarn. That is thick, thin places and neps are also less than ring yarns.

Yarns are less hairy because wrapper fibres are there. So, projecting hairs are much less. Some hairs which are there get suppressed because of the wrappings. Low tendency of pilling also reason is same. Wrapper fibres are actually tightly you know gripping the core and therefore, the projecting hairs are not there.

See projecting hairs are the source of pilling and the projecting hairs are few with pilling also will be less. Low snarling tendency. This is another good point, but less covering power. Yarns are not very bulky. Yarns are quite lean. In comparison to ring yarn also their diameter is little less. They are more compact.

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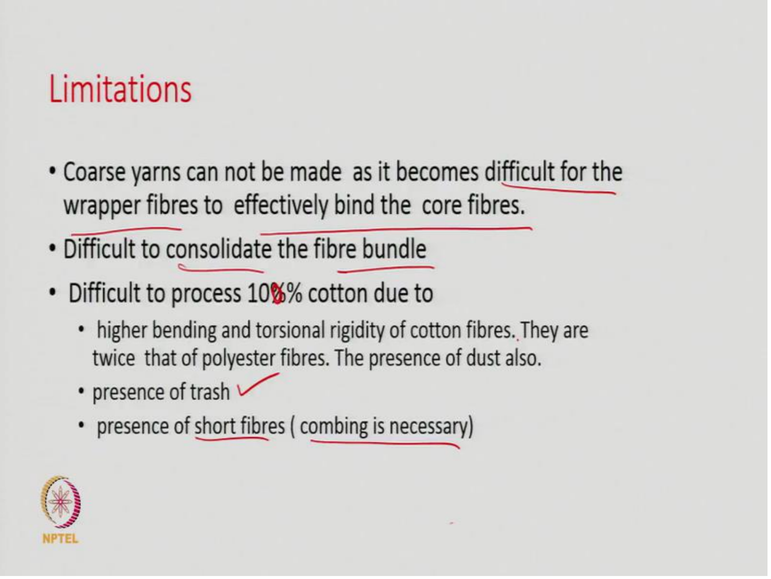

And what are the limitations of this technology? Coarse yarn cannot be made as it becomes difficult for the wrapper fibres to effectively bind the core fibres. The when the diameter of the yarn increases coarse yarn basically means diameter is more. So, the same fibre will now give less wraps because fibre lengths are not going to change. Using the same fibres, I have to make coarse yarns. So, that is one difficulty we will face and therefore, spinning coarse yarn is very difficult.

Other thing is difficult to consolidate the fibre bundle. Difficult to process 100 percent cotton. So, 100 percent cotton yarn is difficult to process here because higher bending and torsional rigidity of cotton fibres in comparison to polyester fibres or viscose rayon. The bending rigidity and torsional rigidity of cotton is more. The other thing is presence of trash and dust and presence of short fibres. So, if it is there, we have to go for combing always. And even then, 100 percent cotton processing is difficult.

If you want to have you can go for blend cotton with polyester, cotton with viscose or we can go for PV polyester viscose blend processing will be easy. The trash will be always there and some dust particle will be there. So, this dust particle is going to choke also. They will go and accumulate within the jet. After some times the yarn will break.

And therefore, this technology means you either produce 100 percent polyester, viscose, acrylic yarns or you go for blend of synthetic fibres or you mix with cotton up to a certain percentage. Maybe 50 percent polyester, 50 percent cotton processing will be easy, but that cotton has to be very clean cotton. It should be combed.

So, with that we close this particular lesson where we have discussed the structure part of the yarn. Structure has been classified into class 1, class 2, class 3, class 4 type and then we have discussed the different characteristics of the yarn in general in comparison to ring yarns, ok.

Thank you.