New Spinning Technologies
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Lecture - 12
Air jet Spinning: Introduction

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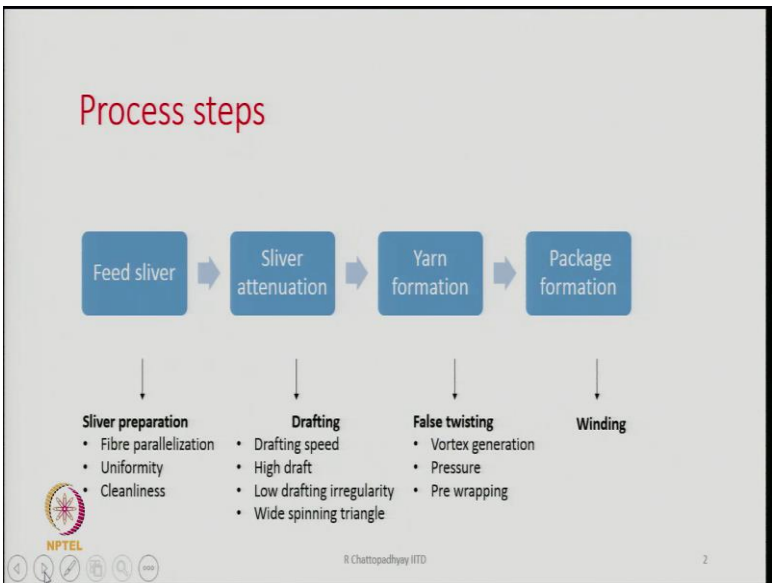

So, today we are going to start Air Jet Spinning. Let us look at the process steps. The first one is the feed sliver preparation followed by sliver attenuation. The next step is yarn formation and the last step is package formations. So, basically, in this machine, we have mainly 3 process steps.

The first one feed sliver is actually produced by the previous machines. But what we do in the previous machine to produce a sliver that suits this air jet spinning process also is very important to know. Therefore, we are saying that basically we have 4 steps that is pre-spinning stages where the sliver preparation is quite important and that is followed by the sliver attenuation, actual formation of the yarn and finally, formation of a package.

In the sliver preparation, what is important is parallelization of the fibres. It is very important that the fibres should be very very parallel with respect to each other. And we achieve parallelization by on draw frames. So, how many passages to be given on draw frame? What should be the draft? These are important.

The next is the uniformity of the sliver. That is also very important. And the third important point is cleanliness, that is the sliver should have minimum amount of trash particles and dust. So, these 3 are the important aspect with respect to sliver preparation. Parallelization of the fibres, the uniformity of the sliver, and the cleanliness of the sliver.

When it comes to sliver attenuation, it is primarily the drafting operation on the air jet spinning machine. See, from sliver, we are going to produce a yarn. Therefore, you have to go for a very high amount of draft. And not only that, the drafting speed is also very very important because the machine is capable to produce at a very very faster rate.

And hence, the drafting should be drafting should be capable to not only provide a very high draft, but also very high speed. So, high draft at high speed is something which is the requirement at the drafting stage. The other thing is that the even though the speed is very high and the draft has to be very high, we have to make sure that drafting irregularity generation is minimum because that will be reflected in the yarn irregularity.

Hence, there is a correlation between the irregularity of the drafted sliver and the irregularity of the yarn because whatever is the output of drafting operation that is going to remain in the yarn only. And hence, the irregularity generation during drafting operation on the machine is also important. And you will see that other important thing is the spinning triangle should be quite wide. So, why it should be wide? that we will discuss as we proceed further through the course.

Then, come the yarn formation, where the most important thing is false twisting. You have already learned that know ring spinning, there is no false twist, this is all true twist. In the rotor spinning also, the twisting is primarily a true twist. Whereas, in air jet spinning, the twisting operation is a false twisting operations. So, therefore, that is what is important here.

The other things related to yarn formations are the generation of the vortex which will actually twist the fibres. So, vortex generation is important. The pressures at which the vortex are generated, so that also we will learn. And the other aspects here is pre-wrapping of the fibres. Pre-wrapping of some fibres, what exactly it is. We will come to know gradually. But these are the things which will be important at the yarn formation stage.

Then, come the last one that is the package formation where winding is the operation that we do and this part you have already learnt while now discussing about rotor spinning. So, similar now winding principles are used to produce the package. So, there is nothing much in the at the winding stage.

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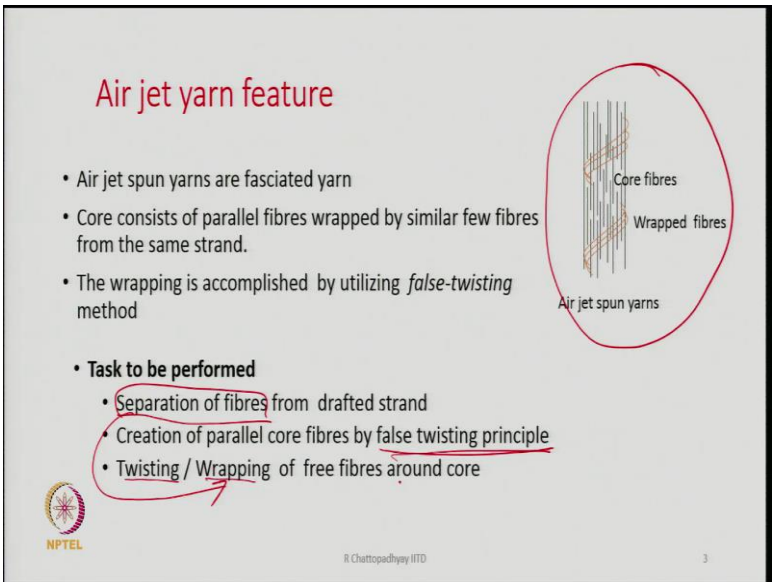

Now, we will discuss about these now steps one by one. But first of all, you should know how a yarn, what is the principle of the yarn formations.

So, on the right hand side, we see there is a schematics of the air jet spun yarn. And in the schematic what we see here, that the air jet spun yarns are basically fasciated yarns, where the core fibres are all parallel and they are wrapped by some other fibres. We are showing the wrapped fibre by the orange color, but the core fibres and the wrapped fibres are the same fibres.

It is not that is a different fiber to using that fiber we are wrapping the core. So, the same fibres are used to produce the wraps. And if this is what the structure of the yarn looks like, then what are the tasks to be performed? That is listed here; is separation of fibres from the wrapped strand to create the wrapper fibres, the fibres which will be used for utilized for wrapping the core.

So, if I have to use some fibres to wrap the core content, then I have to separate them out from the drafted strand. So, the separation of fibre or few fibres from the drafted strand

has to be accomplished by some means. Then, the other thing is I have to create a core fibres which are parallel with respect to each other.

So, creation of parallel core fibres following the false twisting principle. If I want to create parallel you know array of fibres by some kind of twisting process, then we have to go for false twisting. So, true twisting will not be able to produce a array of fibres, for all the fibres that straight and parallel.

And the third one is twisting and wrapping of the free fibres around the core, so the wrapped fibres. So, the fibres which are separated out they are actually utilized for this purpose. So, part of the fibres from the drafted strands are separated out and there utilized for twisting and wrapping around the core. This is what has to be done. So, these are the 3 very important task to be performed by the machine.

Now, we will try to understand how wrapping is can be performed. So, you see a diagram on the right hand side.

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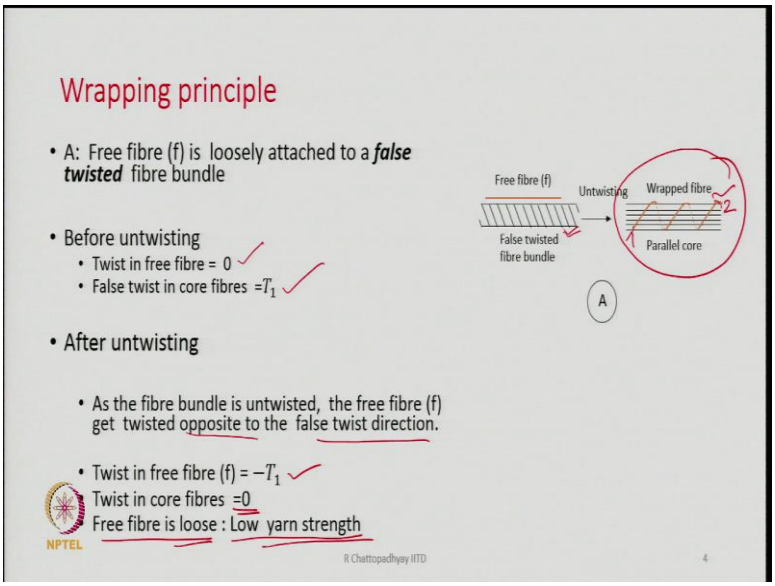

Now, let us imagine that we have a false twisted fibre bundle. So, you can see the twist over there. Now, there is a fibre, a free fibre ‘f’ which is lying pretty close to the false twisted bundle of fibres. So, the free fiber is shown by the orange color. An isolated single fibre is shown and it is very very close, I would say they are resting on the false twisted fibre bundle.

Now, before, like if the twisted part gets untwisted because this false twisted, I have said that means, if I allow it to untwist, now, what is going to happen? If it is allowed to untwist all the fibres which are false twisted will be finally, have zero twist in it. And because the free fibre was attached to it, the free fibre will get wrapped or twisted around the core.

So, before untwisting let us say the twist in the free fibre is zero, and false twist in the core fibre is 'T_1'. After untwisting, what will happen? As the fibre bundles untwisted the free fibre get twisted in the opposite direction to the false twist. So, twist in the free fibre is going to be '$-T_1$'.

Whatever was the false twist in the core, the same amount of torque will be now acting on the free fibre. So, free fibre had zero twist. And when it is the core get untwisted, it get untwisted in the opposite directions. And because of the untwisting action, the twist in the core fibres will be zero, but the free fibres will be twisted in the opposite directions to the original twist that was in the core before it was untwisted.

So, this is how we will be able to create a structure where the core fibres are straight and parallel, and the free fibres are actually wrapping the core. So, by this means we can say we have a bundle of parallel fibres wrapped by some other fibre. Unfortunately, if we follow this the free fibres will be very very loose, because both the end of the free fibre will be actually this end and this end. Suppose, this is one number end, this is '1' and this is '2', both the ends are actually staying on the surface of the yarn.

And therefore, this will be basically a kind of loose wrap that will hardly any tension on the on the fibre. And therefore, the this kind of wrapper fibres will be able to slide very easily on the core part. At the same time, it will not be able to grip the core fibres tightly because sufficient tension is not going to develop. Since both the ends of the same fibre are resting on the surface. So, it will lead to very very low yarn strength.

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So, so what to do? What we can think of to work on these situations? That is what is will be discussed now. That one end of the free fibre it has to be inside the yarn. So, that it remains gripped by the parallel core fibres.

So, if we can somehow insert the part of this free fibre inside the yarn, then it remains there tightly even when entire core fibres are untwisted. So, in this case, suppose by some means we have been able to put part of the fibre end inside the core fibres. In that case, because even after untwisting the end is going to remain within the bundle of fibres and the rest of the fibre n fibre is wrapping as it is shown in the diagram.

The fibre will be able to wrap the bundle pretty tightly and tension will develop in the wrapping fibres. Fibre will not be able to slide easily on the on the on the on the surface of the yarn, and this will be able to grip the core bundle of fibres quite tightly. Because there is a mechanism to generate frictional grip on the trailing end in this case of the free fibre which is inside the yarn core and then it is wrapped.

So, this kind of situation we have to create, otherwise the yarn will be very, very weak. That is something which we need to create. That is part of the fibre fibres which are going to finally wrap, at least part of the length of the fibre should somehow get inside the yarn.

Now, point is whatever we have stated earlier, by this mechanism even sufficient wraps are not produced. So, we have to if you want to increase strength further, if the wraps are not sufficient the yarn will be weak. So, earlier yarns, the first generation yarns used to be very, very weak.

So, therefore, they are not getting accepted in the industry, because the yarns are weak. And the yarns are weak you have to run the loom at a lesser speed. So, productivity is going to be affected. So, therefore, there are constant effort made by the machine manufacturers to enhance the strength.

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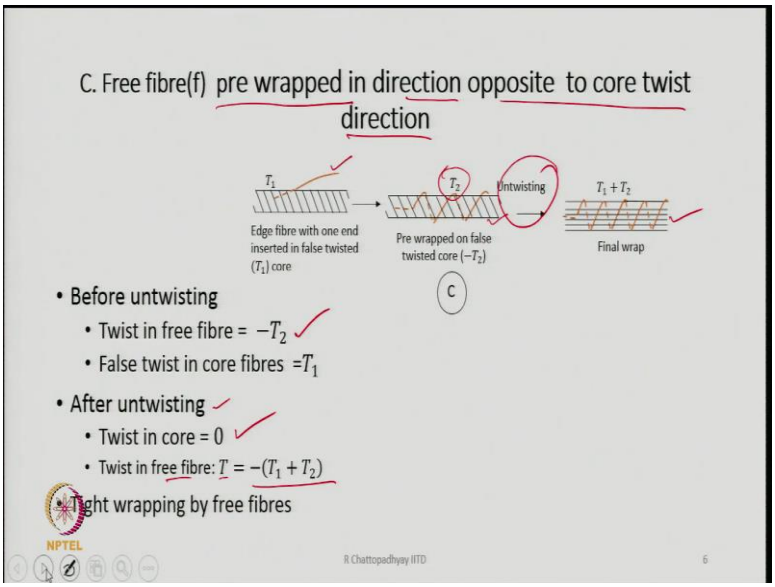

So, one solution to that is the free fibres if it is pre-wrapped in the direction opposite to the core twist direction. That is in this case, if you look at the diagram, the same free fibre this is the free fibre the orange color fibre, we are suppose by some means I am pre-wrapping it. That is the core fibres are twisted and the free fibres in advance they have been wrapped to some extent.

Let us say, they have been wrapped by to some extent and that twist level is 'T_2' and in the opposite directions, they have been wrapped. Because we know that after wind untwisting all these free fibres are going to receive torque in the opposite directions. So, in advance we wrap them in the opposite directions.

In that case, so before untwisting the twist in the free fibre is '-T_2', '-T_2' indicates that it is 'T_2', but in the opposite direction. So, in the core is in the 'Z' direction, the twist in the wrap wrapper fibre or free fibres in the 'S' direction. So, the plus or negative or positive sign indicates the sense of twist.

Now, after untwisting, the twist in the core will be zero. As it is shown here, it will be zero. All the twist will be lost and twist in the free fibre 'T' is not going to be '-(T_1+T_2)'; because '-T_2' was already there and it will receive another '-T_1' because of untwisting action of the entire bundle at the untwisting stage.

And hence, it will be able to increase the wrapping intensity. And as a result, the yarn is going to be stronger because you will be able to generate more wraps, wrapping frequency is going to increase. So, that is the way to enhance the strength of the air jet yarn.

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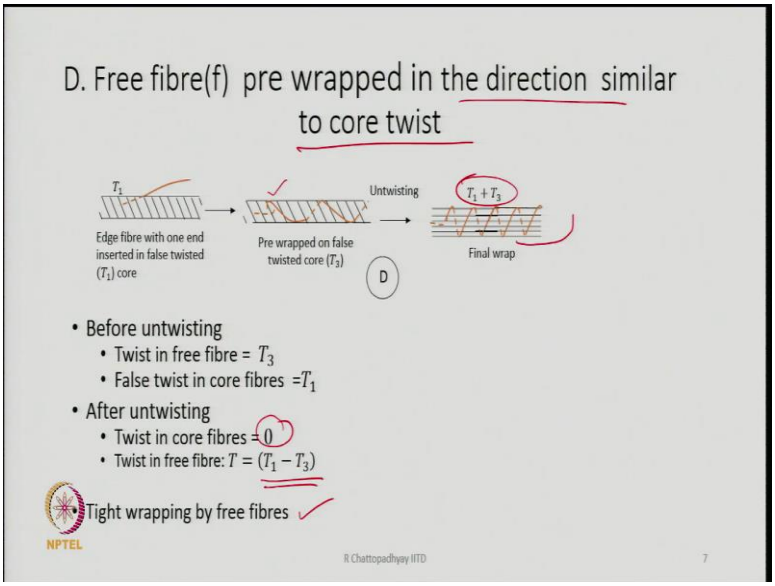

The other mechanism which was also suggested is that the free fibre will pre-wrapped in the direction similar to the core twist also. That is their wrap, but wrapped it to a different degree. If you look at the twist directions, they are similar. The core fibres and the orange colored fibres they are inclined in the same sense. But the twist or wrapping twist that you find in the orange colored fibre is much less.

So, there is some amount of wrapping could be there. In that case, after untwisting, the twist in the core is going to be zero and twist in the free fibres is going to be 'T_1-T_3'. So, this way also the wrapping will be possible. But the final wrap is going to be less than even if I had the earliest one when we had zero twist, that will still be better in comparison to this.

But point is even if I can it gets wrapped in the same direction, but there is a differential amount of twist in the core and the pre-wrapped fibre, it will still give you a yarn and there will be some wrapping by the free fibres around the core of the of the yarn.

So, this is also possible and the mechanism of wrapping when it has been researched by many you know many authors, researchers, they have shown some of them has proposed this that some of the fibres actually remain wrapped initially in the same directions. At the same time, some people who have suggested you know they are actually wrapped in the opposite directions.

So, point is the whatever directions are they are wrapped ultimately there will be some amount of final wrapping on the, around the core of the final yarn. The important thing is the frequency of the wraps and how many fibres are participating in wrapping. These two are most important. So, that will decide the ultimately the strength of the yarn. And you have to remember that no separate filament or fibres are used to wrap the core part.

From the same fibres, part of the fibres are taken out and actually utilized to produce the wraps. So, false twisting is something which is most important in the case of air jet spinning. And therefore, we will little bit discuss about the false twisting process.

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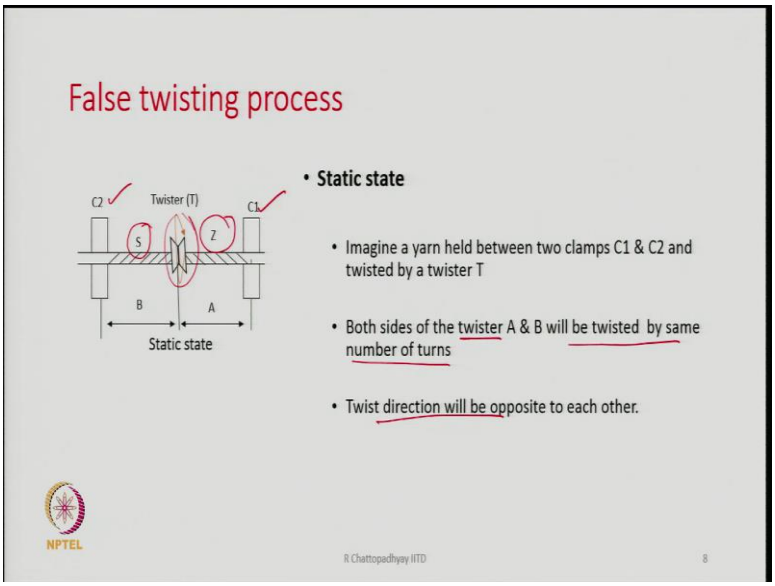

Now, the false twisting is suppose we have a yarn held between two clamps, ‘C1’ and ‘C2’ and the yarn is there is a bundle of fibres between them. And if I there is a twister placed at the middle. Now, initially the yarn had no twist, let us it is filament yarn. So, to start with, there was no twist into it.

Now, they are gripped at the look at ‘C1’ and ‘C2’, and the twister is placed in between, and the twister rotates. The twister rotates both sides of the twister ‘A’ and ‘B’ will be twisted, by the same number of turns, but the direction is going to be opposite. So, ‘B’ side is having ‘S’ twist, ‘A’ side will have ‘Z’ twist.

So, this is quite similar one can even do the experiment itself and we can find it out that if I take a length of yarn and put it between the fingers and ask someone to twist at the middle. You will find that the twist directions the two segments are opposite to each other. In a static state, this is what is going to happen. If I remove the twister will again find that all the fibres have become parallel to each other because the ‘S’ and ‘Z’ twist will cancel.

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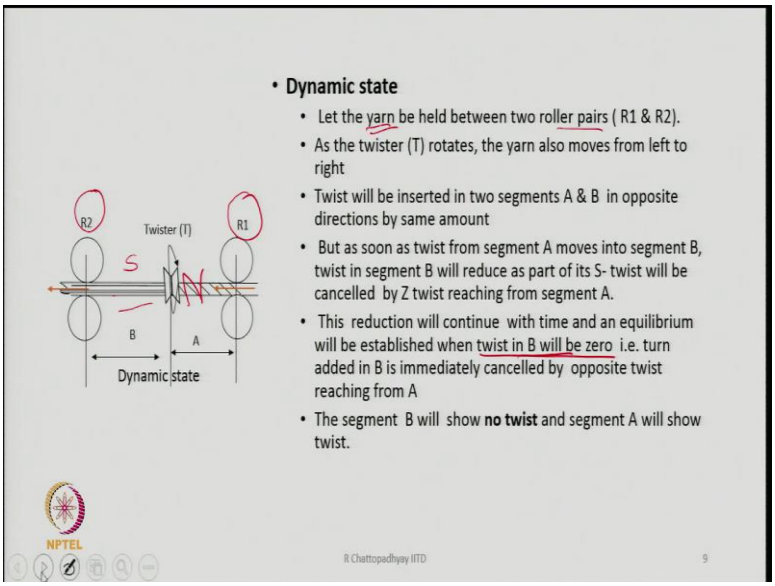

So, but now if the situation is like this that we make the yarn move that instead of clamp I have a pair of rollers ‘R1’ and ‘R2’, and the yarn is gripped between these two pair of rollers. There is a twister in between and the yarn is no more static, but it is moving from, in this case it is moving from right to left.

So, the yarn be held between two polar pairs. By the yarn here we means let us say filament yarn not that the you know twisted yarn we put it. As the twists are rotates, the yarn will also move from left to right. In this case, as twister is has started generating twist, the yarn also has started moving from right to left. So, twist will be inserted the two segments ‘A’ and ‘B’ in opposite direction as told in the previous slide.

But as soon as the twist from segment ‘A’ will reach segment ‘B’, twisting segment ‘B’ is going to reduce. Because if ‘A’ is having let us say in this case ‘Z’ twist, the moment the twister rotates the section ‘A’ receives a twist, but section ‘B’ will receive twist in the ‘S’ sense.

But as the twist is flowing, as the so in the twist, but the yarn is flowing the yarn is taking the ‘Z’ twist along with it into the ‘B’ part or ‘B’ segment and there the fibres are twisted in the opposite sense. So, ‘Z’ and ‘S’ is going to nullify each other. So, twist in the segment ‘B’ is going to reduce and equilibrium will be established when we will find that the segment ‘B’ will have zero twist. This is what is going to happen finally.

And therefore, no twist will be finally, seen in B. So, we will have a situations where one part will have twist and the other part or other segment of the yarn will have lower twist. So, I have such an yarn moves out from the system, the core part or all the fibres in this case will be showing you no twist at all.

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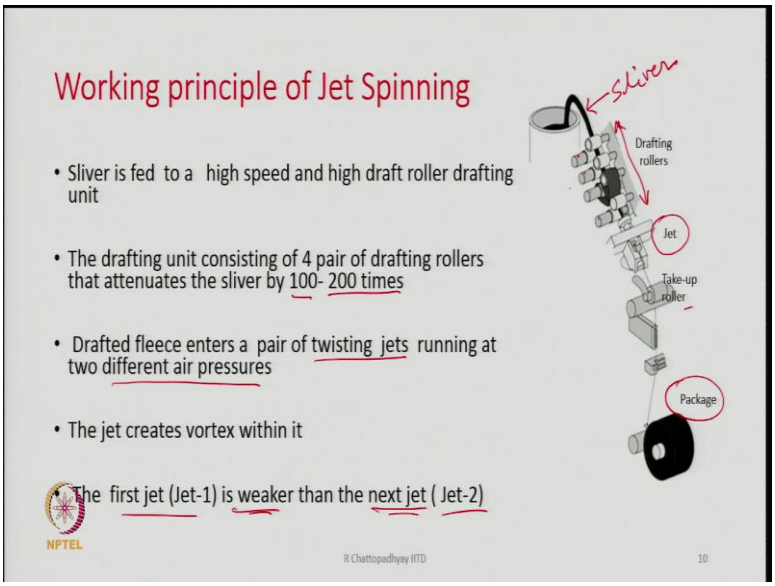

So, this is the principle which is actually very much used in the case of air jet spinning. And also, we will see similar principle is used for vortex spinning as well. Now, we will just go to the working principle. Just a briefly we will just let you know how the a jet spinning machine is going to work in very simple terms.

So, you can see the image on the right hand side that, here we have this sliver, then we have the drafting rollers from here to there. Here we have the jet and then we have take-up rollers followed by the package formation unit. Here is the package formations. So, sliver is fed to a very high speed and high draft roller drafting unit.

So, roller drafting unit we can see here it is consist of 1, 2, 3, 4, four pair of rollers. It is a high drafting system. There are 4 pair of rollers. In some machines there could be 5 pair of rollers also. But usually, 4 pair of rollers are there, and out of that 1 pair of rollers will be having aprons. You see here the aprons.

The drafting unit generally consist of 4 pair of rollers, but as I said some case it could be 5 also. And it attenuates the sliver by 100 to 200 times. So, the draft range can vary from

100 to 200 or sometimes can go up to 250 also. So, that is the range in which we can keep the draft.

So, that we sliver from sliver to yarn. We will see afterwards we you know; we have done some calculation in some other lecture we will discuss about it in more details, how much draft is required. But typically, requirement of draft could be anything between 100 to 250 to convert a sliver into a yarn.

Probably, depending upon the count of the yarn and count of sliver, the draft will change. Now, drafted fleece enters a pair of twisting jets. So, jets here are actually 2 jets are here, one after the other. Running at 2 different air pressure, the 2 jets the pressure of air inside the jets are different from each other.

Now, the pressurized air is released inside the jet in order to create the vortex and because the vortex is what is going to actually twist the fibres. We release the fibres inside a vortex and vortex is going to actually twist the bundle of fibres and thereby it is going to produce the yarn. The first jet is weaker than the next jet that is jet 2. Two jets are there successively, Jet 1 and Jet 2. What is Jet 1? Jet 1 is close to the front roller nip. And Jet 2 is the next one.

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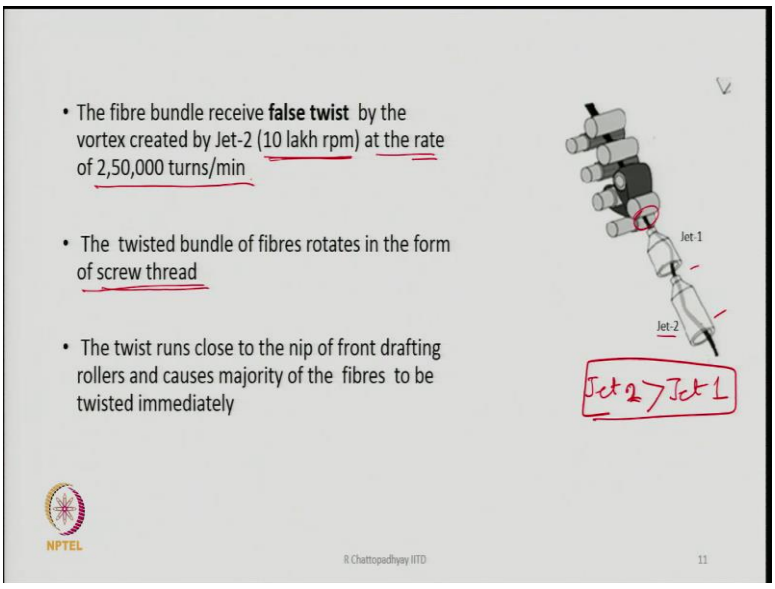

Now, the fibre bundle will receive false twist by the vortex created by Jet 2. So, Jet 2 is usually more powerful. So, the pressurized air, the air pressure is more on Jet 2. And Jet

2 as a result is more powerful than Jet 1. So, Jet 2 will twist the bundle of fibres and the vortex could be to the order of 10 lakh rpm that is the speed of the vortex. And the twisting rate goes to the order of 250000 turns per minute. So, the vortex speed is 10 lakh rpm, but the speed of the fibre bundle is 250000 rpm.

But that is the you know; that means, the twisting rate is very, very high. The twisting rate in the case of ring spinning is only at the most 20000 turns per minute, 20000 rpm. When you go to rotor spinning it can achieve 100000 to 120000 rpm at the most. Here it is almost double of what is the twisting speed on rotor spinning machines.

So, that is the rate at which we can turn the yarn and therefore, we can produce at a very, very faster rate. The twisted bundle of fibre rotates in the form of screw thread. Because when the bundle of fibre is passing through Jet 1, Jet 2 as it is shown here. The path of the yarn, if you look at this inside it is not a straight path. The yarn path follows a spiral because balloons are created within.

Because high centrifugal force which will be acting on the yarn it will cause the yarn to bend, and it will create small balloons. So, therefore, we are saying that the twisted bundle of fibres will form a screw thread. Basically, means the spiral balloons will be generated. Because Jet 2 is more powerful that means, Jet 2 is more powerful than Jet 1.

The twist runs close to the nip of the front drafting rollers. So, Jet 2 vortex is more powerful. So, the twist that the bundle of fibre receives because of the vortex of Jet 2 that twist will run upto the nip of the front pair of roller that is somewhere here, the twist will move. And you will cause majority of the fibres to be twisted immediately.

The torque will flow, like in the ring spinning. The torque is generated by the rotation of the balloon which is done by the traveller. But that twist flows from balloon zone to this spinning zone that means, near the front roller nip.

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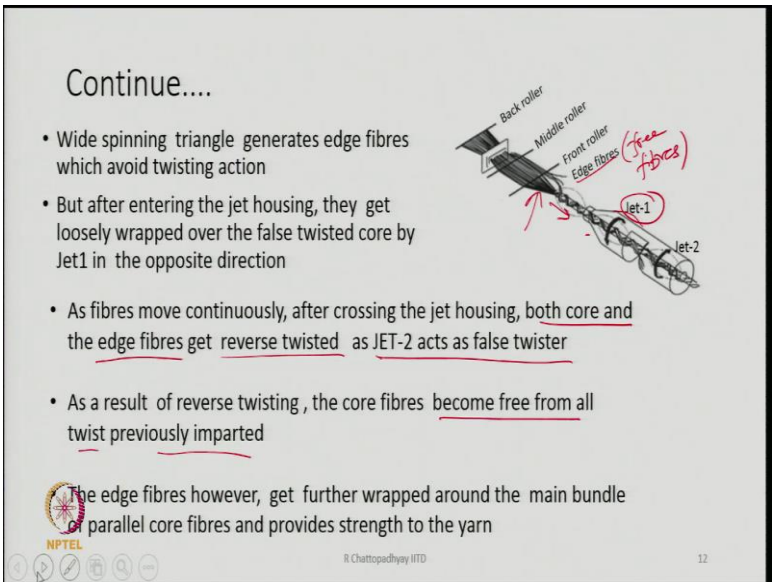

Here also the twist that the fibres receive that torque will flow or the twist will flow right up to the nip of the front pair of rollers. And this is going to be very very fast. What happens that when it flows close to the nip of the front pair of rollers, some of the fibres from the especially from the edge, so here is some fibres we call them edge fibres. Edge fibres are also basically what I was initially discussing that is free fibres.

The some of the fibres from the edge of this spinning triangle, this is your spinning triangle. From the edges some of the fibre will escape twisting action. And that is what is going to help us. So, some of these fibre edge from the edges they will escape twisting action and, but they will be moving along in this strand of twisted bundle of fibres and both of them will enter the jet. After entering the jet housing these fibres which are close to the main bundle of twisted fibres, they will get wrapped by the vortex of Jet 1 now.

So, as soon as they enter and reach the Jet 1, Jet 1 is not very powerful and Jet 1 is rotating in the opposite directions; is vortex is in the opposite directions. Jet 1 is not rotating, the vortex with the Jet 1 is rotating in the opposite directions. So, the power of the Jet 1 being low, it will not be able to do anything to the core bundle of fibres. These bundle of fibres have been twisted by the vortex of Jet 2.

So, the loose fibres which are now resting close to the twisted bundle of fibres. So, these fibres cannot penetrate. Their ends will be wrapped by the vortex of Jet 1. And that is

what will be pre-wrapping of the edge fibres or free fibres around the twisted bundle of fibres, false twisted bundle of fibres.

And then, fibres are moving continuously because they are not stationary anywhere and the fibres moves continuously after crossing the jet housing, both core and the edge fibres will get reverse twisted because Jet 2 acts as a false twister. So, they will be reverse twisted finally. And as a result of about twisting, majority of the all the all the core fibres we can say will become free from all twist that was imparted previously. So, twist in the main core bundle of fibres will be zero.

And the edge fibres which are pre-wrapped by the vortex of Jet 1 will get further wrapping because of because of their connection association with the main bundle of fibres and main bundle of fibres are now rotating in the opposite reactions. So, these edge fibres will be now tightly wrapped around the core bundle of fibres.

And these wrapping will be tight enough which will give the yarn certain amount of strength, so that they are processable on, subsequently on winding machines and also on looms. So, this is how the yarn is met on the air jet spinning machines. So, today, we have just discussed the basic principle that we follow to produce the yarn, basically how to generate the edge fibres or free fibres, and then how to utilize those free fibres in wrapping the main bundle of fibres in the core.

After this, we are going to discuss in more details about the drafting system. And also about the designs of these two jets and the role that the you know the pressures in the jet is going to play in deciding the structure of the yarn and finally, the structure decides the property of the yarn. So, all those you know discussions will be held in the future lectures.

Thank you.