New Spinning Technologies
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Lecture - 20
Vortex Spinning

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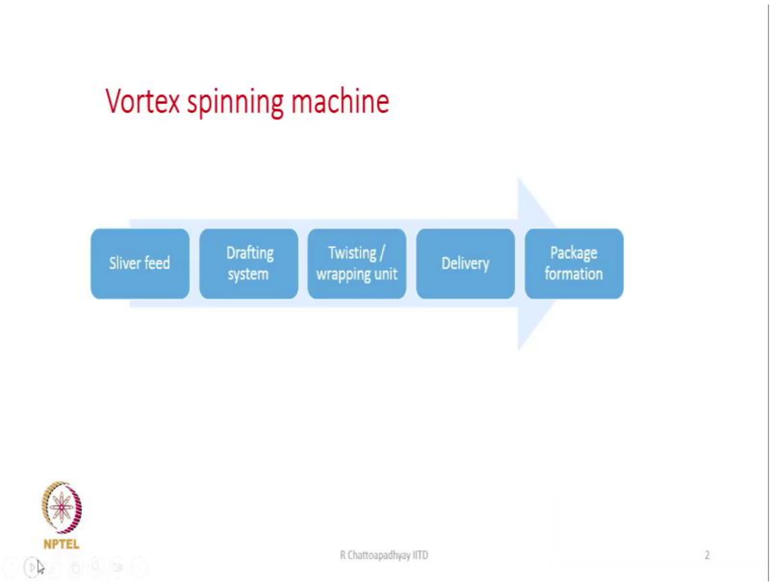

So, today we are going to discuss Vortex Spinning, in the vortex spinning machines what we have is a sliver feed system which is generally a can and this will be followed by a drafting system. And then we have a twisting or you can say wrapping unit followed by this unit we have a delivery, because by the time we have formed the yarn through twisting and wrapping actions the yarn has to be delivered.

So, we have that has to be some kind of arrangement of delivering or pulling out the yarn from the twisting unit. So, after delivery is obvious that we have to go for package formations. So, the most important part of this machine is the twisting and the wrapping unit.

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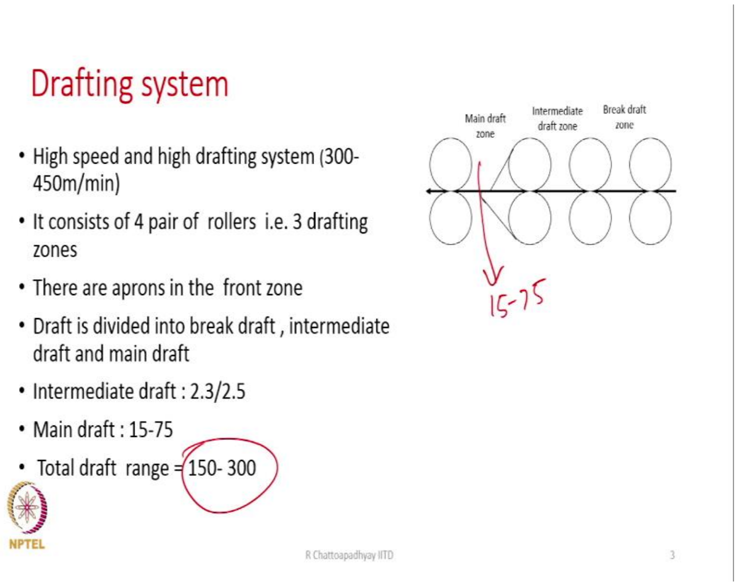

Sliver feed system is quite simple and you already know, the drafting unit is something is little we need to know because otherwise you also know it already, because the similar kind of drafting system is there in air jet spinning machine also. There is hardly any difference between the drafting system that is used on air jet spinning or the drafting system which is used in vortex spinnings.

The silent features of the drafting system is that it is basically a high speed and high drafting system that is delivery speed is high as well as the draft is also high. Why the draft is high? Because we want to spin the yarn from the sliver; so, if you want to convert sliver to yarn, we need a very high draft.

So, the drafting system should be capable to give us very high draft and the drafting system is here has four pair of rollers with three different drafting zones. And they are known as break draft zone, intermediate draft zones and the main draft zone; there are aprons in the front zone where the draft is maximum.

As already I have told the draft is divided into break draft, intermediate draft and main draft. Intermediate draft generally remains in the range of 2.3, 2.5, 2.8 to in this range and the main draft which is here it is varies between 15 to 75. So, major part of the draft is in the front zone and we all know that if the what whatever the draft is very high, we need a very efficient control of the movement of the fibres.

Otherwise, this drafting regulator will be there and that will be reflected in the yarn also. And hence we all know that the aprons are used mainly to control the movement of fibres; and therefore, the apron is placed in the front zone. The total draft is in the range of 150 to 300; so, depending upon the count that we want to spin and the sliver that we are feeding, we may need to have a draft somewhere in this range 150 to 300.

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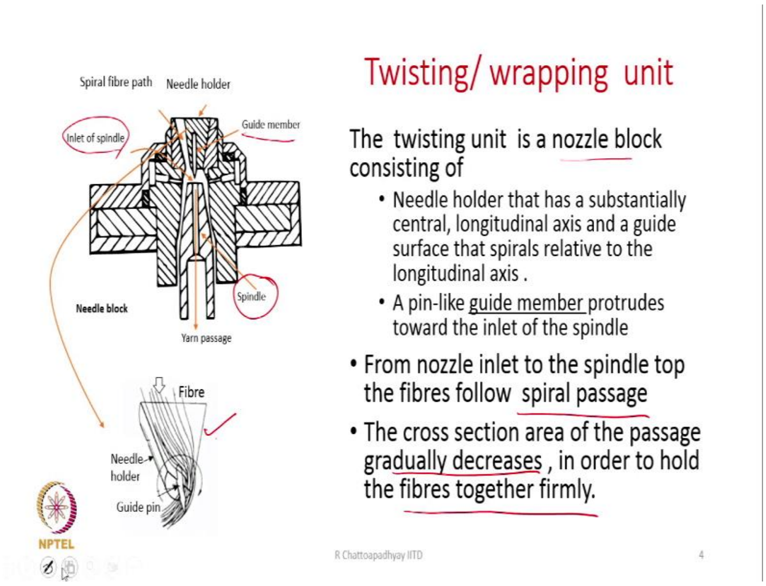

Now, we are going to discuss the various elements of the machines; as I said, drafting unit is one element and we have already discussed about the high draft and high speed system while discussing the air jet spinning machine. So, therefore, we are not going to know have any similar discussion on high speed, high draft system. Now, what is more important here is the twisting and the wrapping unit that we have a little bit of description we are going to know learn now or.

So, the a cross sectional view of this twisting or the wrapping unit is shown on the left hand side of the diagram. This twinning twisting unit is basically a nozzle block, the entire twisting unit is shown; it consists of what? A needle holder that has a substantially central and longitudinal axis and a guide surface that spirals relative to the longitudinal axis this is the if you look at this, this is the needle holder, which is basically this one this area is shown here, this is the needle holder and the path of the fibre is spiralling.

So, that way a path of the fibre has been designed, but whatever fibre are being delivered from the front rollers, they will follow the path, the path is not straight, it is following a spiral path. And then there is a guide pin which is clearly visible here, the guide pins are also shown here in the name of guide member. So, in some books or some you know papers you may find it is written as guide member or guide pin, basically a kind of pin.

The pin is also a guiding element, guiding for the element for the fibres. Because the fibres are flowing through this zone and they have to arrive at the tip of the spindle and the spindle is shown here. So, a pin like guide member protrudes towards the inlet of the spindle. So, you see the spindle is here and this is the inlet of the spindle is shown here. So, the fibre has to finally, arrive at the exact you know central point of the spindle.

And to make sure that they arrived right there, the pin acts as a guiding element. Then from the nozzle inlet to the spindle top, the fibres follow a spiral path; as I have already mentioned, this path is spiral. The cross section area cross sectional area of this path gradually decreases in order to hold the fibres together firmly. So, if the area of that path gradually reduces, then there will be fibres will be held against this path more tightly.

And hence this is what is done that is cross sectional area of the path is gradually reduced; so, the fibre strand which is flowing through it becomes very very compact. So, this is the way how we make the strand of fibres which is flowing right now compact by gradually reducing the area of the path for the spiral path.

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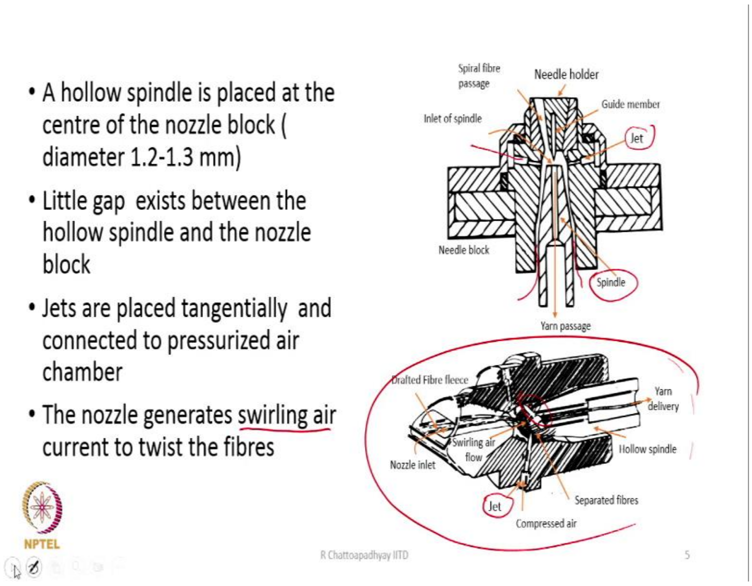

Next, a hollow spindle is placed; so, we have already seen that this here is the spindle. So, the spindle you see it is hollow and it is placed at the centre of the nozzle block. So, this entire part is the nozzle block, this is another view of the same nozzle block. Here is this is the spindle; spindle is placed at the centre of the entire block. And this is the nozzle inlet through which the strand of fibres from the front roller nip will pass through and they are trying to arrive at the tip of the spindle.

Now, there is little gap that exists between the hollow spindle and the nozzle block. See, look at this gap, this little gap that is existing here between this and this side also there is little gap. So, the diameter of the inner part of the block and the spindle there is little bit of difference; so, there is a little gap between them. This gap is required, why it is required will come to that when we will discuss the yarn formation mechanism; so, little gap exists between the hollow spindle and the nozzle block.

Now, there are jets which are placed tangentially and connected to a pressurized air chamber. So, jets are here is one jet which is visible there is another jet over here and jets are also shown here in this diagram and also shown here there is another jet. So, there are normally there will be four jets which will be placed tangentially. And through these jets are connected to a pressurized air chamber; so, that the air can flow through the jet and create a vortex that is the purpose. So, jets are required, and jets are placed tangentially.

At the same time the jets are also inclined at an angle, they are not perpendicular with respect to the spindle axis; so, they are placed a little angle at the same time. The nozzle or through which the air is flowing is generates swirling air current; that means, a kind of vortex which actually twist the fibres. We will discuss about them with little more details later on.

So, the purpose of the jet is finally to create some kind of swirling current of air or a vortex of air and this vortex ultimately trying to wrap the fibres around the axis or around the core part of the yarn. So, these are the different term the entire system of the twisting unit is shown here, these are the two different cross-sectional view.

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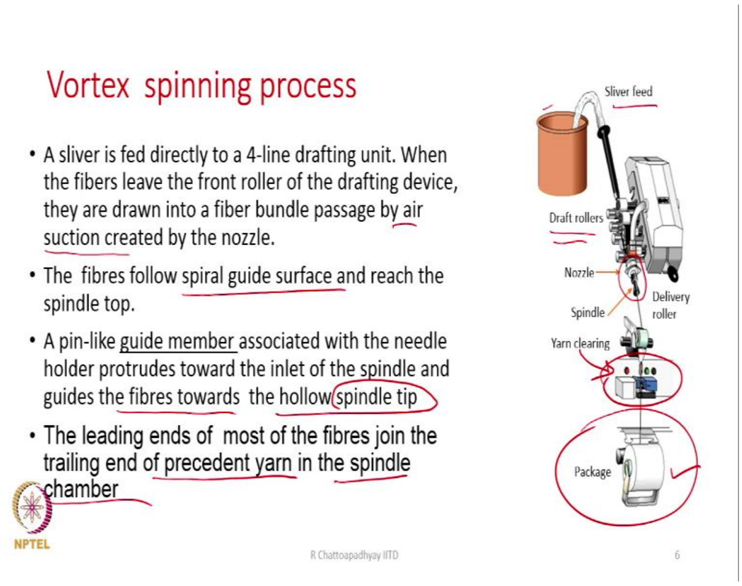

Now, we will discuss the how the system how the process works, a very you know simplistic know description will be given now. First of all, from a can we will be feeding a sliver that is what is shown here. So, the sliver will be fed to a four roller drafting units, this is the draft rollers and then here we have the nozzle and the spindle. So, after drafting the fibres as soon as they emerge from the front roller nip, they are actually sucked by the air.

So, the air within the nozzle will find that they have a negative pressure and because of that the fibres will be sucked from the front roller nip. So, fibres are not going here and there, because of this suction the fibres will move towards the spindle. And within the nozzle block there has to be some kind of no negative pressure otherwise how they will be sucked; so, we will see how the negative pressure is generated.

So, and now once the fibres arrive within the nozzle block, they as we have discussed earlier, they follow a spiral guide surface and then they reach the spindle top. A pin like guiding member associated with the needle holder protrudes towards the inlet of the spindle and guides the fibres towards the hollow spindle tip which is important. The fibre has to be released right on the top of the spindle tip; so, there has to be very good alignment between the pin and the axis of this hollow spindle.

So, that the fibres can be really you know released right at the tip of this spindle. And therefore, that needle is there; an needle is acting as a guiding device here, it is giving support to the fibres and directing them to arrive at the tip of the spindle. The leading end of the most of the fibres join the trailing end of the precedent yarn in the spindle chamber. Within this spindle chamber, here the spindle is you know shown every in a very small in size.

We will discuss about the exact details of it in you know few once we go through this set of slides we will come and see how they look like and how the fibres are moving. So, the trailing ends the leading ends will join the trailing end of the yarn being formed within this spindle. So, that is continuously in the flow of fibres and there is a yarn formation within the spindle. So, this flowing fibres is joining the trailing end of the yarn that is getting formed continuously and then being withdrawn that is what will happen.

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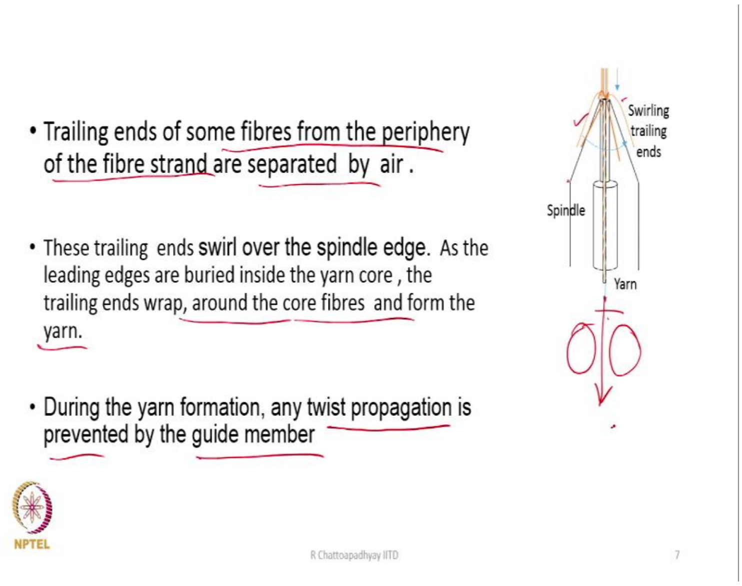

But while the leading ends are getting connected to the trailing part of the yarn. Now, what happen trailing end of the some fibres from the periphery of the strand are separated by air. We will discuss them in more details that is continuously the leading ends of most of the fibres are joining the trailing end of the yarns.

But, while doing so, some fibres it happens with some fibres their trailing ends get detached. Leaning end is connected to the trailing part of the yarn, but the trailing end of some fibres somehow get detached, some of get detached means there must be some reason why they will get detached we will discuss them. But, for the time being say the some of them get trailing ends get detached and once they get detached these are what is shown as the trailing end of some fibres which are detached from the rest of the fibres.

So, this is the flow of fibres, here inside the yarn is there and the yarn is moving out and these fibre trailing end is hanging over the surface of the spindle. Now, these trailing ends swirl hanging; they are not really hanging, they are at the same time revolving around the tip of this spindle. So, this is this spindle of the tip of this spindle you see that this arrow indicates that there is a swirling air current which causes the trailing end to continuously rotate around the conical surface of the spindle.

So, if they rotate around the conical surface of this spindle and at the same time because the leading end is in connection is already buried in inside the yarn, they are pulled out at the same time they are going to actually wrap the yarn. So, there will be wrap around the core fibres and the yarn will be formed.

So, during the yarn formation any twist propagation is prevented by the guide members, there is no chance for the twist to propagate up. Because, the guide members will prevent it, because there is a metallic the pin is there the path is also spiral in nature. So, they will not allow the any twist to propagate towards the nip of the front rollers that will be always prevented.

Any contact with a stationary surface means, the torque flow will be resisted; it happens in ring spinning also, like lap head guide will resist the flow of twist towards the nip of the front rollers. So, there is always a twist differential in the spinning zone of the ring frame and in the winding in the say the balloon zone of the ring frame also ring spinning process. Because there exists this lappet guide, lappet guide is stationary metallic surface.

So, the yarn remains in contact and therefore, entire torque is not flowing towards the nip. So, any contact with a stationary surface means the friction is there and there will be frictional resistance to the flow of torque that is why even if twist will never flow towards the nip of the front rollers. So, this is a brief description; so, the yarn moves out now and if I want to take out the yarn, we must need two pair of rollers to pull them out.

And then most of it in the what we have now is a yarn clearing unit, there is a sensor which is placed over here and the sensor will continuously monitor the diameter of the yarn. So, if any if in case if defect is getting created, the obviously spinning will be stopped; so, there is a another I have shown it I think in the you know in the previous slide.

So, that is there and so, if I go back, it is here, this is yarn clearing unit. It sense the diameter and if the diameter is too much or it is too less there is thin region or thick region accordingly the spinning process will be interrupted. So, that you can always produce a very fault free yarn; after that obviously what comes with the winding unit and package formation; so, we have already discussed about this.

So, if there is no difference between the way we form a package whether it is rotors pond, yarn package or a adjust spinning yarn package or friction spinning yarn package. The principle of package formation is always same, we make big packages and the principle of forming the package is not going to change their dimension; so, there is no need to discuss about the package formations.

Here what is this part is again the fibre path as you said that the fibres are going to follow a spiral path. So, moment they follow a spiral path more tension will develop in the yarn you know in the fibres also, because they are not following a straight path they are following a spiral path.

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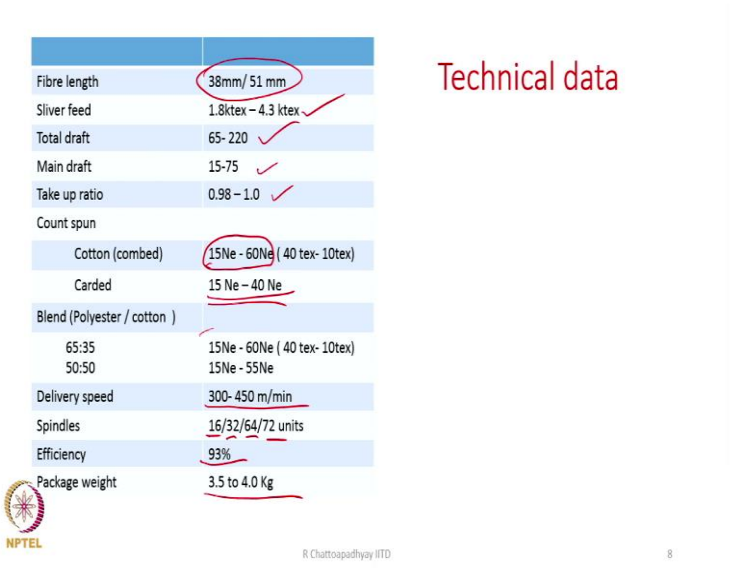

Some technical information about the machine fibre length which it can process easily is 38 or 51 millimetre in this range, sliver counts is given also 1.8 kilo tex to 4.3 kilo tex. So, fibres a little finer side or the total draft we have already said it is 65 to 220 that is the range in some machines.

Main draft take up ratios 0.92, 1.0, count spun typically 15 to 60's Ne that is the typical count that we spin very coarse count less than 15 to 10, 8, 6 this technology is not suitable, it is good for medium to fine count yarns. Carded count also this is typically the range of count blend also can be possessed and the count range remains practically same.

Delivery speed is 300 to 450 meters per minute; so, it will be 15 times or 20 times more than what we find in ring spinning, even it is much more than air jet spinning machine also. The spindles in the machines could be 16, 32, 64 or 72, the efficiency typically could be to the order of 93 percent and the package weight can vary between 3.5 to 4 kg; so, we can really produce very big package.

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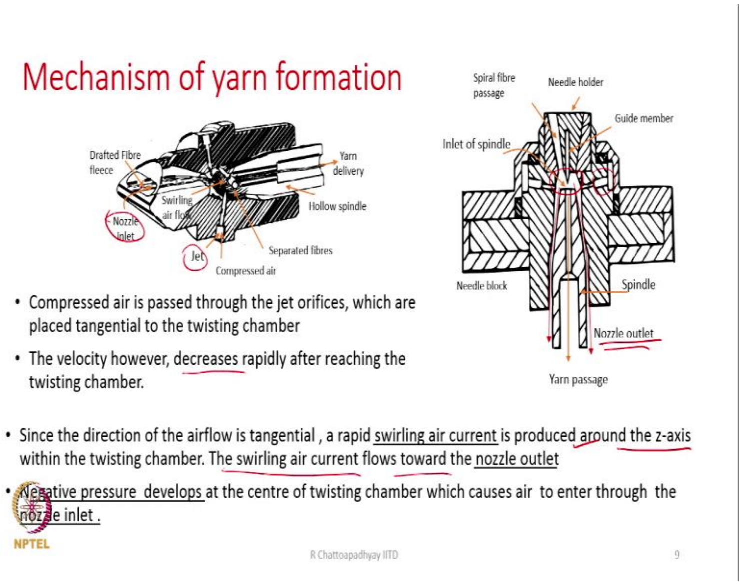

Now, we will give little more attention to the yarn formation, the nozzle block is the heart of this vortex spinning system. Compressed air as it is passed through this jets this jet or you can this side this is the jet. The velocity near the jet is going to increase, because it is very very narrow.

But once it enters the area that is just above the spindle top the velocity decreases rapidly. Once it enters the twisting chamber, because you see here there is little bit more volume where the air is initially coming through finer jets. So, there is sudden change and therefore, velocity will decrease there.

Now, the jets are inclined and the same time the air is actually entering the inner wall of the twisting chamber tangentially. So, because of this swirling air current is produced that is a vortex gets created. Around the z axis that means, as well the vertical axis of the this nozzle block. The swirling current flows towards the nozzle outlet and the nozzle outlet is shown here.

That is it will pass where the in between the gap that exists between the spindle and the nozzle block through that gap this swirling air current is going to escape to the outside. Another important thing is the negative air pressure develops at the centre of the twisting chamber which causes air to enter through the nozzle inlet.

So, nozzle inlet is shows you see it here, a negative pressure is getting generated here, because of negative pressure means there is a suction. So, it is sucking the air from outside at the same time and that air is entering through this nozzle inlet. And at the nozzle inlet where the fibres are actually from the front roller is approaching them approaching the nozzle block. So, the nozzle inlet because suction is there the fibres are simply dragged and they are they will easily enter the twisting chamber.

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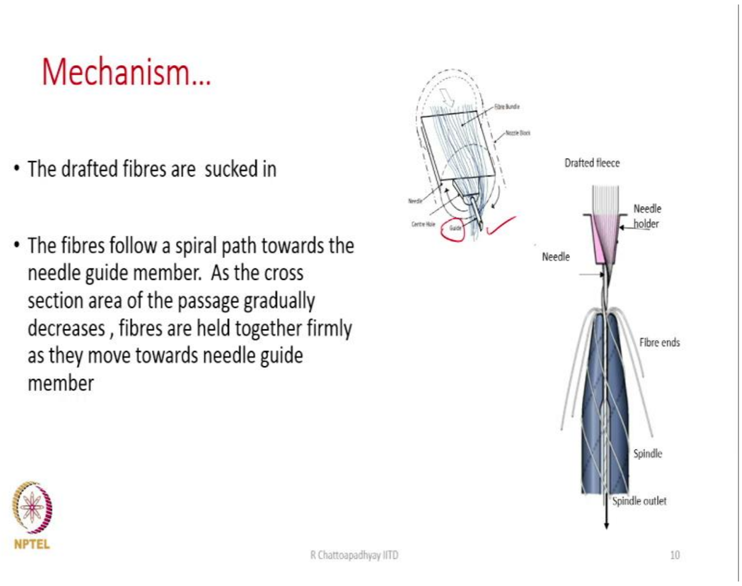

Because of this negative pressure the suction the drafted fibres are sucked. So, drafted fibres know is not going here and there once they are you know moving out of this front roller nip, they are automatically coming towards the inlet that is a nozzle inlet.

Now, the fibres we have already discussed following a spiral path as it is shown here towards the needle guide member or towards the pin either you will call it guide or pin, pin acts as a guide as also stated that the cross-sectional area of the passage gradually decreases fibres are held together firmly as they move towards the needle guide member.

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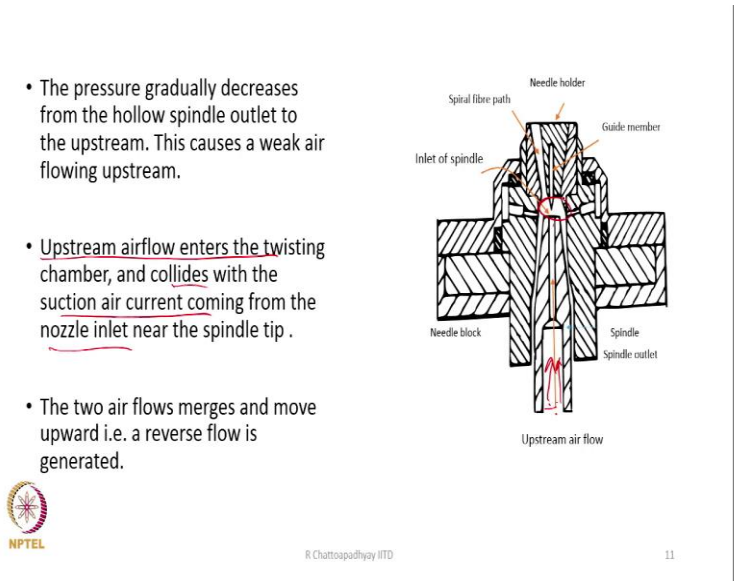

The pressure decreases from the hollow spindle outlet to the upstream; this is another interesting part of it that from here to upwards, see this is the hollow part of the spindle through which the yarn is running. But the pressure at the bottom is more than the pressure at the top within the hollow part. If there is a pressure difference, the air is going to move towards the tip of the spindle.

So, upstream air flow therefore, generated and it goes from bottom to the top of the spindle through the hollow part ok. So, what happens that the air pressure is more here at the bottom of the spindle, but less at the top; therefore, air will flow through this. So, air is entering also from the top, air is also coming at the centre point through the jets.

The this air flow upstream air flow collides with the suction air current coming from the nozzle inlet, from the nozzle inlet some air is coming and this air is moving up. So, what happens that there is a collision between the two stream of air. Because of this collision the reverse flow is generated somewhere here and that reverse flow is causing some fibres to get detached from the main stream of fibres, which is arriving at the tip of the spindle.

Because there has to be some kind of you know disturbance to be created to separate out some fibres from the rest and if they are separated out, then the trailing end of few fibres actually gets separated. The leading ends are remain with the main flow and this is the reverse flow that is generated because of the collision between two stream of air is actually causing detachment of the trailing end of the fibres. And these trailing ends after detachment they are inverted as it is shown here.

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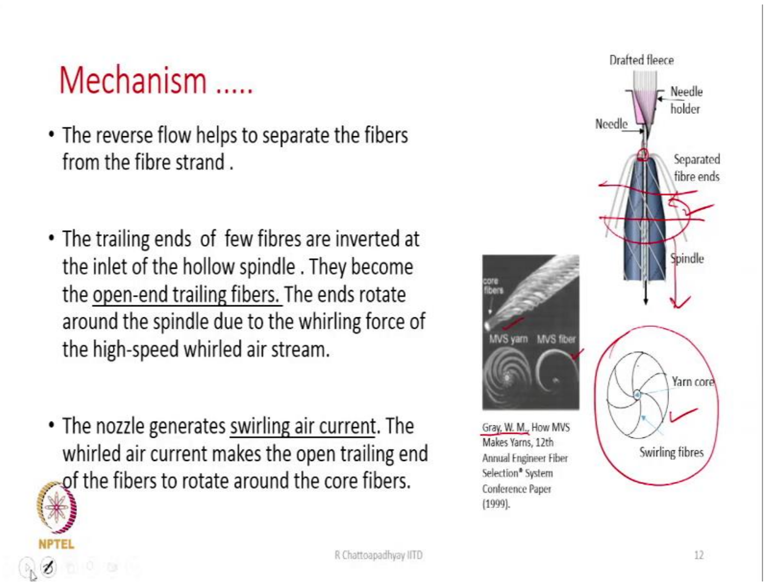

So, the leading end is actually inside they are part of the yarn, the yarn trailing end is existing somewhere here. But the trailing end of the separated fibres have started swirling around the spindle, because the swirling air current exists here. The swirling air current which is surrounding the spindle it has been generated by the jets and they are going down and down the swirling air current.

And the swirling air current picks up the trailing end of these fibres trailing end of the separated fibres and make them go round and round around the spindle tip. And when they are going round and round around the spindle tip at the same time if they are pulled, because their leading end is a part of the core of the yarn; hence, the trail again will get wrapped around the core fibres.

So, if we look say this diagram is in a way is trying to show the same phenomena that this is the core of the yarn. These are the fibres which are actually the trailing end of the separated fibres which are swirling around the spindle tip. So, these fibres and you know if we cut the cross section in this plane and try to see how the fibres are going or from this part of a plane which is you know around the cross section of this if we try to see we will look at the fibre look like this they are swirling.

And therefore, they will get wrapped around the yarn core, the same diagram has been visualize this kind of diagram visualize first by Gray W M. Here it is shown in the MVS yarn how these swirling fibres will look like from the top. This is one fibre which is swirling it is following as spiral and this is the core part of the yarn.

So, the core part of the yarn is consisting of large number of parallel fibres, part of the trailing end of these fibres are made to wrap around the core. So, the fibres which are wrapping around the core we expect that part of it will be the core and the rest will be forming wraps around the core that is how the yarn is formed.

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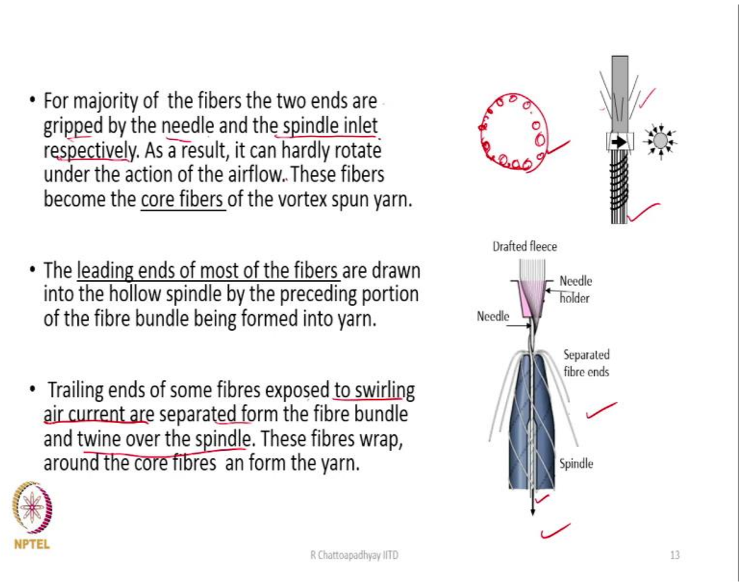

So, for majority of the fibres the two ends are gripped by their needle and the spindle inlet respectively. As a result, it can hardly rotate under the action of the air flow, most of the fibres this is going to happen, because they are held at two ends one is gripped by the needle and it is wrapped. So, it is acting as a kind of nip though there is no positive grip, but because it is wrapping; therefore, it is acting as a as if they are gripping the fibres and at the same time the other end of some these fibres is also is part of the core.

So, therefore, both the ends are gripped in some way and this result this main bundle of fibres cannot really rotate; and therefore, we see the parallel array of fibres at the core. The leading ends or most of the fibres are drawn into the hollow spindle by the preceding portions of the fibre bundle being formed into yarn.

Trailing ends of some fibres exposed to swirling at air current, first of all the trailing end has to be detached. So, the detaching mechanism is because of the collision of the two air currents that results into some kind of upward air flow which will cause the fibres. If these are the suppose, this is the yarn cross section if we imagine and the fibres at the periphery of this bundle of fibres and cross section means it is not twisted yarn cross sections.

Suppose this is the bundle of fibres is going to form yarn; so, the fibres which are placed at the periphery of this they are going to be affected by this upward air current or reverse air current which is generated; and therefore, these fibres are likely to be detached. So, as long as the fibres which are the core, possibility of detachment is almost nil.

These air current will be only able to act on the surface fibres of the bundle and their trailing ends will be easy to be detached. So, like these fibres are shown from the surface for all around, these are the trailing end of the fibres they are detached and once they are detached this will be twining or swirling and who is doing that, it is done by the swirling air current generated by the jets.

So, that is how the yarn is formed, this diagram shows also that these are the fibres trailing end of some fibres. Most of the fibres are at the centre and they are both the ends of these fibres are part of the core, but some fibres which have got detached. Now, they start circling around the spindle tip and because the other end is gripped within the yarn as the it is moving and the same time it is rotating it is forming the wraps and that is how the wraps are formed; so, this is how the yarn is made here.

So, we expect that fibres in the core remains parallel the simple flow of fibres. Within here you have to remember this that the yarn within this hollow spindle axis is not rotating, it is simply flowing from top to bottom. The trailing end of the fibre has simply rotating around and they are getting wrapped then they are wrapping the main body of the yarn.

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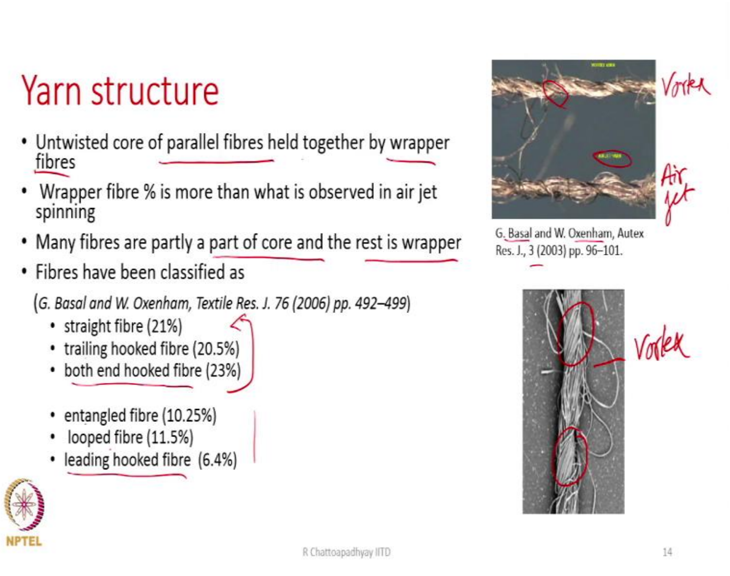

Now, we will discuss the yarn structure, if you look at the yarn structure is a comparison this was done by Basal and Oxenham one paper, this is the air jet yarn and this is the; so, this is vortex and this is air jet, this is also vortex. So, you see that these are the fibres which are wrapping; here, these are the fibres which are wrapping. So, typically the yarn structure is like this untwisted core of parallel fibres held together by wrapper fibres.

Wrapper fibre percentage is more than what is observed in air jet spinning that has been reported by most of the researcher that percentage of wrapper fibres usually is more than what we observed in air jet spinning. In air jet spinning it is 10 to 15 percent, here it is more. Now, when you say it is more how much it is there are reports where some people are suggesting that it could be 50 percent, some researchers suggesting that it could be 25 percent.

So, many fibres are partly a part of core and the rest is wrapper; so, some fibres entire fibre will be part of core, but for some fibres part of it will be core, part of it will be wrapped. So, fibres have been classified by different researchers, I have you know classified them in different way. In one research paper it has been stated, the straight fibres trailing hooked fibre, both end hooked fibres, entangled fibres, looped fibre and leading hooked fibre.

These are generally more in number, straight fibres, trailing hooked fibre and both end hooked fibre, entangled fibre, looped fibre, leading hooked fibre are little less. So, the fibres within the yarn it has been classified depending upon their shape. So, the classification of fibres according to shape within the yarn and their relative percentages have been given.

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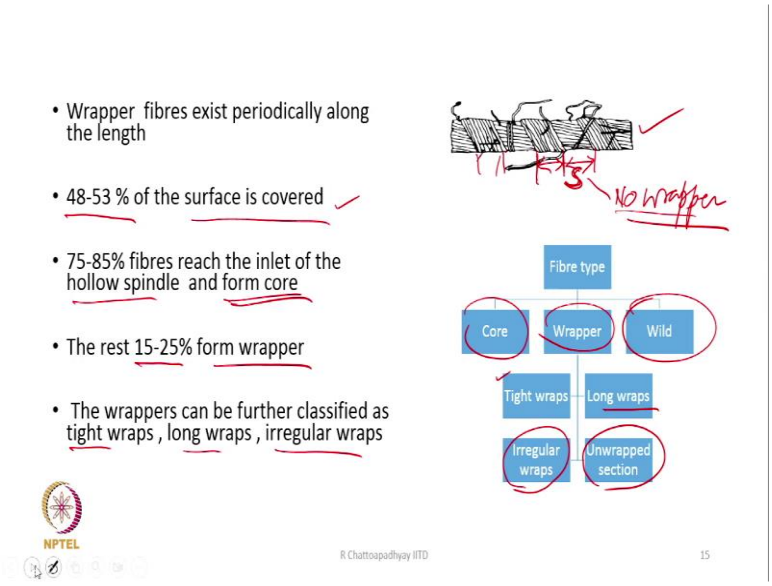

Now, there is another classifications where fibre type has been classified in the yarn as core fibres, wrapper fibres and wild fibres. And wrappers are being also classified as tight wraps the nature of wrap, by wrapper we mean simply wrapper, but then the wrapper fibres can be further classified as tight wraps, long wraps and irregular wraps.

The other one is unwrapped sections, sections where there is no wrapping at all only parallel fibre exists, this is schematic diagram of the yarn; so, wrapper fibre exists periodically along the length. So, here you see from here to there the wrapper is there, then from here to there wrapper is there, there is a portion from here to there no wrapper.

Wrapper fibres are actually giving strength to the bundle of fibres, if the wrappers are not there all the fibres are straight and parallel, the yarn will have no strength. So, some reports suggest that around 50 percent of the surface is covered by wraps. Some portions there is no wrapper let us it is seen it here, but non wrap portions should be short in nature.

If the long wrap portions are long, then that will be the weak place in the yarn; so, wrap portion is fine there will be wrappers are there; so, that part of the yarn will be strong. But it is important what is the length of the no wrapper zone. If this zone is let us say we defy that say it is S. So, what is the value of S? If the S is too long, then that part of the yarns is only having parallel fibres. So, if you put some load all the fibres will slip the yarn will be weak.

So, this is also important that is the length of the non wrap zone and what is the distribution of the length of the no wrap zone? 75 to 85 percent fibres reach the inlet of the hollow spindle and form core; that means, 75 to 85 percent fibres are part of the core. And the rest will be wrapper 15 to 25 percents wrapper, though some people have suggested that it can go up to 50 percent.

Probably it all depends to what parameter combinations was chosen to produce the yarn process parameter combination. That is why probably there is a possibility that there could be some variations in the observations of the researchers. The wrappers can be further classified as I said in this already told tight wraps, long wraps, irregular wraps.

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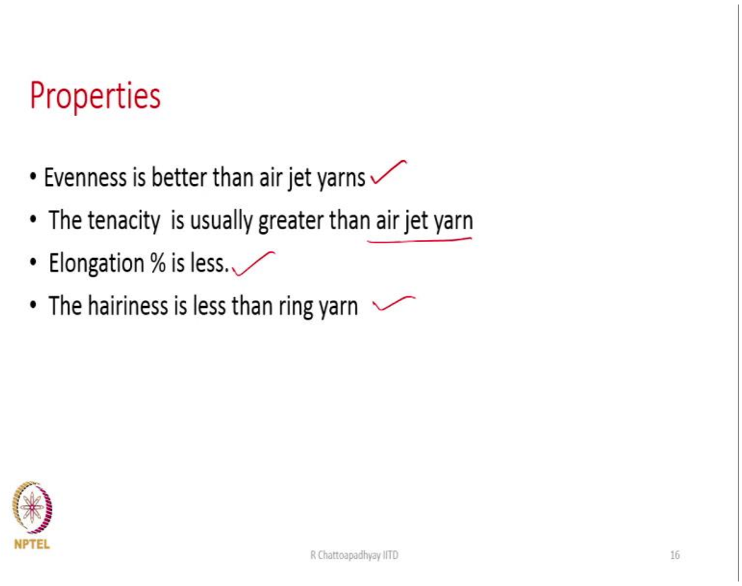

Because tap wraps will make the you know yarn strong and long wraps means a large part of the yarn is covered by these fibres. In a way this wrapper fibres can also protect the yarn while it comes to abrasion and the irregular wraps is something where it is not good for the yarn from this you know strength point of view. And for the unwrapped portions as I said the size matters, short unwrapped portions are ok. But the long unwrapped portions are there their potential weak place in the yarn.

Some properties evenness is better than air jet yarns; genericity is usually greater than air jet yarns; elongation is less the hairiness also less than ring yarn, because of this wrapping is there. So, many of the fibre projecting ends are basically get suppressed by the wrappers; so, ultimately numbers of projecting ends are less.

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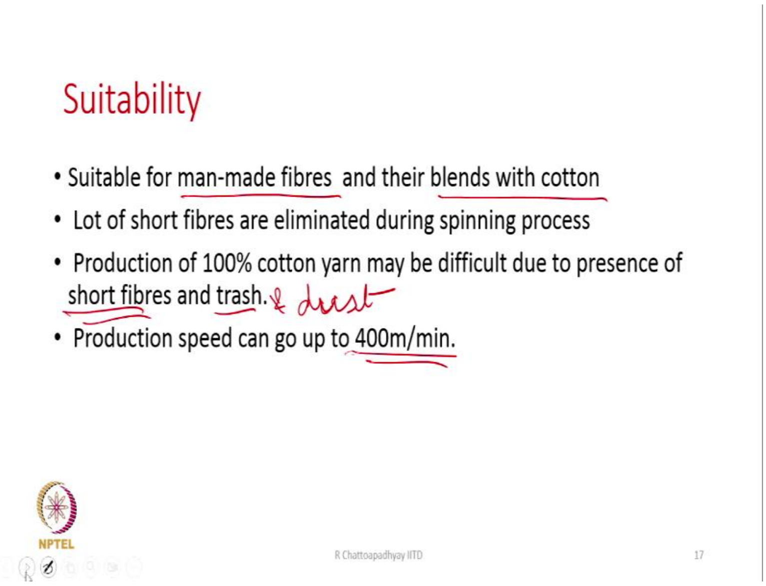

These yarns of this technology is suitable for manmade fibres and their blends with cotton. 100 percent cotton though it is not suitable as combed cotton can be processed, because ultimately what happens cotton basically means dust. And dust basically means there is a possibility of choking the jets, the twisting unit here. And therefore, blends are more preferable in this case; if we need cotton polyester yarn otherwise 100 percent polyester 100 percent viscose is better, because there is no dust in that.

100 percent cotton means one has to face the problem of the entire nozzle block getting choked with dust after processing the you know or making the yarn for maybe few hours.

Sufficient amount of dust to be accumulating and it will mainly to jamming; finally, the breakage or the quality of the yarn will also will go down.

Otherwise, the other problem is that presence of short fibres, trash and also the dust we should also write dust. Short fibre means they will not be able to form proper wraps, production speed is very high 400 450 meters per minute and that is the end of this particular session. So, what we have discussed if we summarize the heart of the spinning system is the twisting or wrapping unit.

This wrapping unit is very intelligent design is there I mean there are the vortex has to be generated there are jets, then there is a spindle which is also hollow there is an entry of fibres. So, if we look at each and every part of the design aspect it is a very very complex and very intelligent design. And finally, we are making a yarn structure we have little bit we have discussed.

Mostly it is basically a kind of fasciated yarn where the fibre themselves are wrapping and it is giving you a yarn which is any time it looks like very similar to ring spun yarn. Because the proportion of you know wrapper fibres are more and the wraps are also quite uniform.

Wraps are there in rotor spun yarn also, but that those wraps are basically very regular type of wraps. And therefore, rotor spun yarns are very harsh, but vortex yarns are not really that harsh, ok with this we close this particular session and

Thank you.