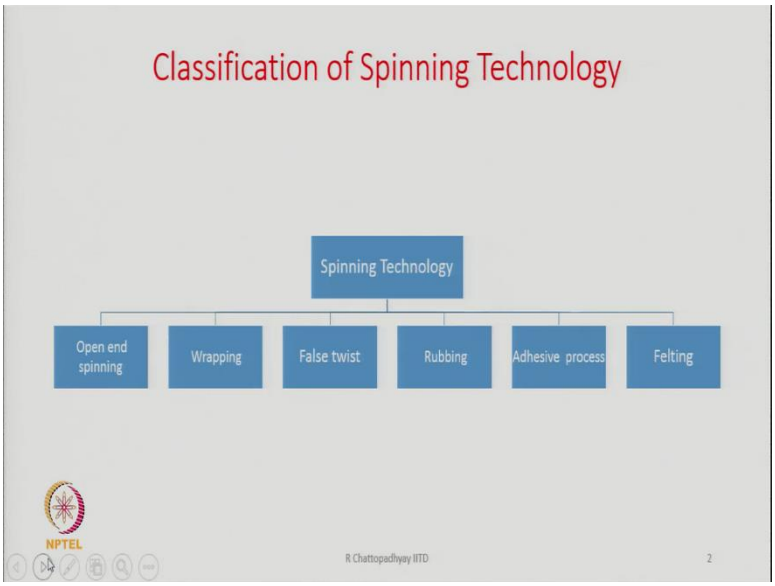
New Spinning Technologies
Prof. R. Chattopadhyay
Department of Textile and Fibre Engineering
Indian Institute of Technology, Delhi

Lecture - 01
New Spinning Technology

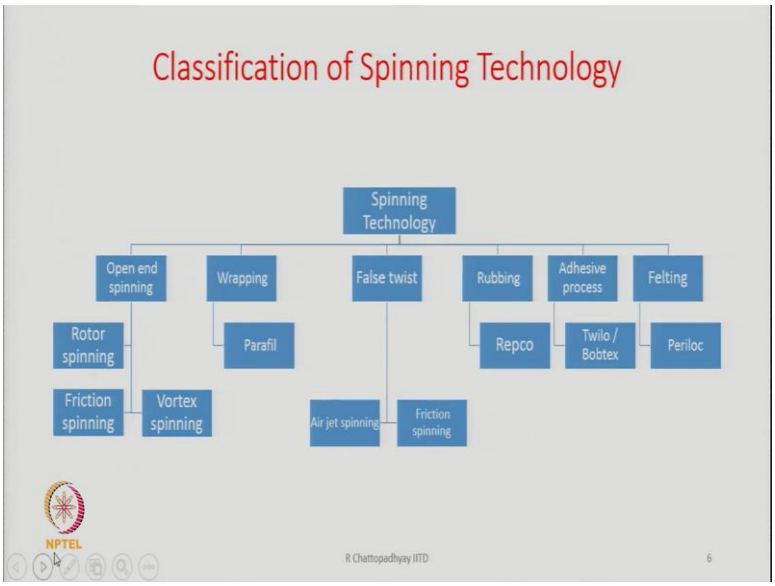
(Refer Slide Time: 00:35)



Now, in this particular course we are going to learn New Spinning Technologies. Let us first see, what are the different technologies that we have; first one is, open end spinning, the next one is the wrapping that is spinning a yarn by a process known as wrapping. The next one is false twisting; we produce a yarn by the process of false twist that is by generating false twist and making the fibres to wrap around the yarn.

The other one is rubbing; by rubbing action, we try to insert twist into the yarn. Then there is a process which is adhesive process; that is in this process we will be binding the fibres with the help of adhesive. And then the last one is felting technology that is a felting process is there through which the fibres will get stuck to each other. So, these are the various means which are used to produce yarns and the set of technologies that exist we call them new spinning technologies. we will learn each of them in more details.

(Refer Slide Time: 02:10)

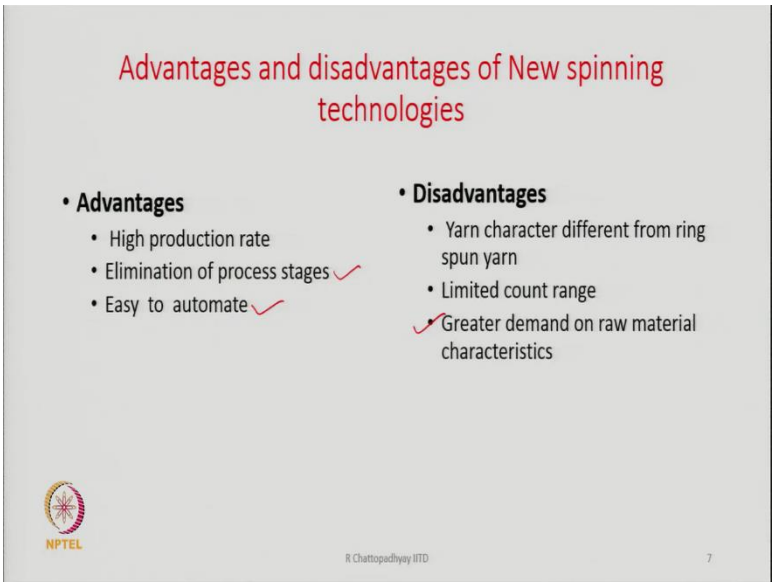


Now, in open end spinning we have rotor spinning, then we have friction spinning and we have vortex spinning. Under wrapping technology, we have a system which is known as parafil spinning system; we will learn about them in details later on. In parafil spinning, a filament is wrapped around a bundle of fibres. There is under false twist principle there are two methods which are available; air jet spinning and also friction spinning; so, you can see that friction spinning is here and friction spinning is there. As we go through the course, you will learn why friction spinning exist under open end spinning system and also under false twist spinning system.

Then by the process of rubbing the technology which commercially known as Repco spinning system mostly used for wool fibres. Then the adhesive process that has been developed is known as Twilo or Bobtex spinning system. And the felting technology that we have is known as Periloc is the name of the spinning system Periloc.

So, you see that spinning technologies can be really classified into one, two, three, four, five, six different groups, and you are going to learn about them in more details gradually. But out of all these some of the spinning systems are very very popular and commercially very very successful. So, the emphasis will be more on those systems which are commercially successful and also running in the industry.

(Refer Slide Time: 05:04)



Now, the question that comes to our mind what are the advantages and disadvantages of new spinning technologies? The general advantages are high production rate in most of the cases. This is in comparison to the conventional spinning system that we have that is ring spinning technology.

Then the next advantage is elimination of process stages. You are all familiar with the ring spinning process, ring spinning process is pretty lengthy process, there are so many machines which are used and the fibres have to go through a long chain of processes before they are converted into yarn.

So, if we can cut down few processes there will be great advantage in terms of saving of space, saving of capital, saving of labours, saving of energy; so, that is why any shortening of the process will be advantageous. And then the other one is that easy to automate, automation is has come in a big way and most of the machines are getting automated and these machines are easy to automate.

Against this the disadvantages are, yarn character is different from ring spun yarns that is the disadvantage. And we will see why if the yarn characters are different; why it will be a disadvantage, this will come to know as we go through the course. The second point is limited count range that is the count that we can spin on any of these systems is very very limited. Ring spinning is most flexible spinning technology from the point of view of range of counts of yarn that you can produce from very coarse to very fine.

But the new spinning technologies you will see that some of them are suitable for coarse count, some of them are suitable for medium to fine counts that is the you know disadvantage that we have with the spinning systems. And the third one is greater demand on raw material characteristics. Ring spinning that way as I say is very versatile spinning system, it can handle all types of fibres, it can produce you know a range of yarn counts and the character of the yarn also is superior in many respects.

Therefore, that is why the even though the ring spinning is slow in comparison to the new spinning system; even then the ring spinning is still most popular spinning technology till now. Now, in the new spinning systems you will come to know gradually that the demand of the raw material characteristics is quite high that some of them can handle shorter length fibres, some of them can handle long length fibres, or some of them may need little finer fibres, they may not be able to tolerate too much of dust. So, these are some of the you know limitations of the new spinning technologies; and therefore, there is a great demand on the raw material characteristics.

(Refer Slide Time: 08:46)

Now, shortcomings of ring spinning technology that we need to know, what are the shortcomings? The first one is under utilization of winding potential, what does it mean? we will discuss them in details. Second is a necessity to rotate a heavy package to insert twist into a tiny group of fibres.

In the Ring Spinning we will see that we have a big spindle which is quite heavy, then on the top of the spindle we put a bobbin; mostly nowadays, they are made of plastic material. And we need to rotate this heavy spindle just to insert twist into a tiny group of fibres, how many fibres are there in the cross section of the yarn?

It could be 200, 300, 400, or 100 in this range, but just to put twist we have to rotate a heavy package which includes the weight of the spindle also. Next is raising production speed, if we try to increase, leads to one is frequent end breakages. That means, we will not be able to raise the speed too much. We face this problem that is the breakage rate will go high; and therefore, there is a limit to which we can go.

The other one is shortening of traveller life; that is if we go for higher speed, the traveller is made to rotate also at a faster rate; and therefore, the traveller life is shortened. If it move at a faster rate there will be a lot of abrasion between the traveller and the ring, and the traveller will be pressed against the ring with a higher centrifugal force.

So, friction will be quite high and as a result the abrasive damage will be very very high and very quick, as a result the traveller's life is shortened. Then the other difficulty is, difficulty in manual piecing; in case, the end breaks we have to join the end with the fibres which are being fed from the front roller this process is known as piecing process.

So, if we go for higher and higher speed, manual piecing becomes more and more difficult that is the failure will be more and more. And hence, there will be loss of productions; so, this is another difficulty with the ring spinning technology. Frequent doffing of cops, in the ring spinning the package size is very small and tiny, and how much yarn it holds? It hardly holds 70, 80 or 150 gram of yarns, it gets filled up; so, the actual content of yarn in the cop is very very limited.

Whereas, you will find that in the new spinning technologies the package that we produce can really hold a large quantity of yarn which may go up to two kilo, two and half kilo; so, that is a big advantage. And if the content of the yarn is less; that means, the cops will gets filled up very fast; so, you have to stop the machine and replace the full cops by empty cops.

This process of replacing the full cops by empty cops is known as doffing process; so, frequency of doffing will go up and as a result the production loss will be there. Whenever

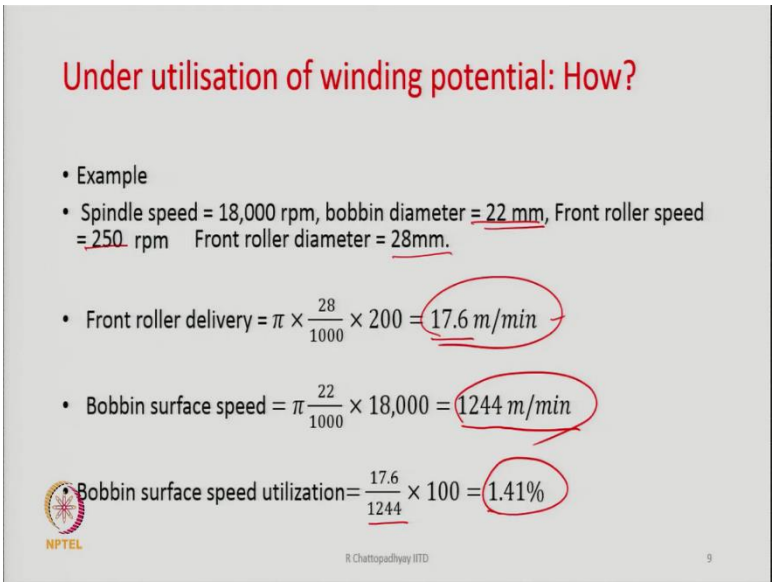
doffing is happening we have to stop the machine and remove the package replace it by a fresh package which is should take some time. And if the machines are quite long or so many spindles on which we have to work; as a result, the overall production loss is there.

And the last one is excessive fly liberations, this is also a serious problem that is fly mean very short fibres which will be coming out from the front roller nip will really increase in quantity. And the fly will contaminate the atmosphere and the second thing the fly will get picked up by a rotating yarn balloon and it may cause neps.

The fly will also fall and settle on the ring on the machine; and therefore, that every possibility that as the yarn is being spun, the balloon will pick up these fibres which are floating around and will this will going to create some kind of fault in the yarn; so, this is also a serious problem.

So, these are the problems with the ring spinning technology, and there was a always a thinking in the mind of the researchers that how to enhance the production speed and ultimately it was found that there are some inherent flaw in the very principle of ring spinning.

(Refer Slide Time: 15:13)



Would you see that now as it was written in the previous slide that under utilization of winding potential; so, how let me explain it now. Let us take an example in order to understand this spindle speed, let us say is 18000 rpm, bobbin diameter is 22 mm, front

roller speed let us say 250 rpm and front roller diameter is 28 mm. With this the front roller delivery is going to be 17.6 meters per minute that will be the delivery rate.

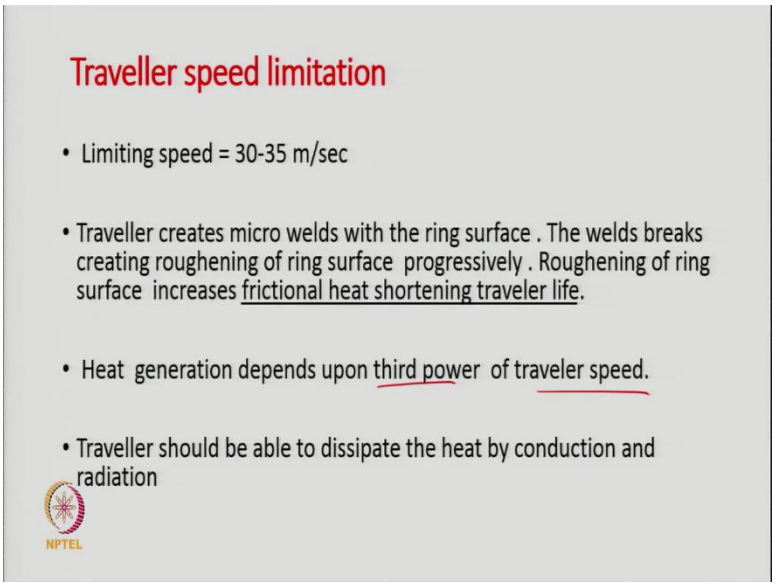
We know the bobbin we know the front roller speed and we know the diameter of the front roller; so, we can find it out typically. This is the typical delivery rate from the front roller of a ring spinning machines; it may vary between 15 to 20 meters per minute depending upon the yarn count and the kind of twist we are keeping in the yarn.

Now, for let us look at the bobbin speed now, bobbin surface speed is how much the spindle speed is eighteen 18000 rpm and bobbin diameter is 22 mm. The surface speed of the bobbin is going to be 1244 meters per minute; that means, the bobbin is capable to wind so much of yarn.

The surface speed is 1.2 kilometers per minute, in a minute it can actually wind 1.2 kilometer, but how much it is actually winding only 17.6 meter in a minute. So, what is the utilization of bobbin surface speed? 17.6 by 1244 into 100 that gives you a figure only 1.41 percent.

So, even though we are turning the bobbin at a speed where it is capable to actually wind 1.24 kilometer of yarn per minute. It is only winding 17.6 or close to 18 per minute. That means, the bobbin surface speed utilization is only 1.4 percent that is why we say that under utilization of winding potential.

(Refer Slide Time: 18:04)



The other problem is as I said traveller speed typically the speed of the traveller could be 30 to 35 meters per second limiting speed; some companies may claim that it can go up to 40 meters per second. But, generally if we go to the commercial level usually the speed that is kept is around 30 to 32 meters per second that is the typical speed of the traveller, this is the surface speed of the traveller.

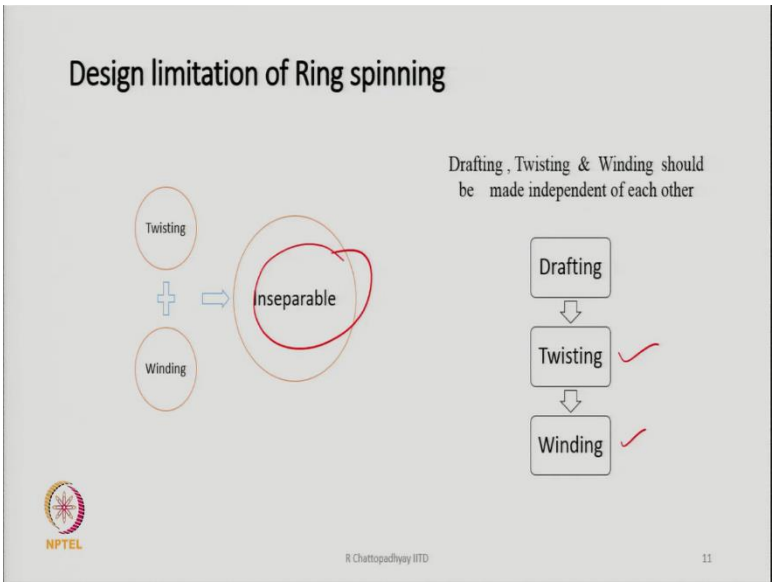
Now, what happens, traveller creates micro welds with the ring surface at it turns there is a metal to metal friction. The welds breaks creating roughening of ring surface, roughening of the ring surface increases frictional heat and therefore, the travellers becomes very hot. And that changes the very you know surface characteristics of the traveller; as a result the traveller life shortens, this is what is what will be happening.

So, heat generation depends upon the third power of traveller speed, a small change in traveller speed will increase the heat too much. Traveller are supposed to dissipate the heat, and what are the mechanisms that is available for the traveller for heat transfer is only conduction and radiation; so, conduction is between ring to traveller.

So, some conduction will be there and the radiation could be from traveller to the all the you know it could be through the air or to the all the machine parts. So, that is how the traveller can lose it, but point is the heat generation through the frictional heat generation is much more than what it can dissipate and as a result the traveller temperature keeps on rising.

So, very high speed we cannot attend; traveller life will be shortened, if the traveller life shortens, the end breakage rate will go up. And one has to stop the machine remove all the travellers and replace them by new travellers which is also a loss of production. So, that is the issue that we cannot go for very high traveller speed because of these reasons.

(Refer Slide Time: 21:04)



The design limitation on ring spinning; In the ring spinning, the twisting and winding operations are inseparable that is you cannot separate them out. The spindle is the prime mover, it rotates and it transmits rotation to the traveller and the traveller as a result runs on the ring. The traveller running around the ring is going to insert twist into the yarn and the traveller running around the ring also causing winding; spindle is rotating, traveller also is rotating, both of them rotates together.

The bobbin is on the spindle; that means, the bobbin speed and the spindle speed are exactly same. So, bobbin rotates at the speed of spindle, traveller also rotates at the speed of spindle not at the speed of spindle, sorry traveller will rotate at a lesser speed than this spindle that is the traveller will always lag.

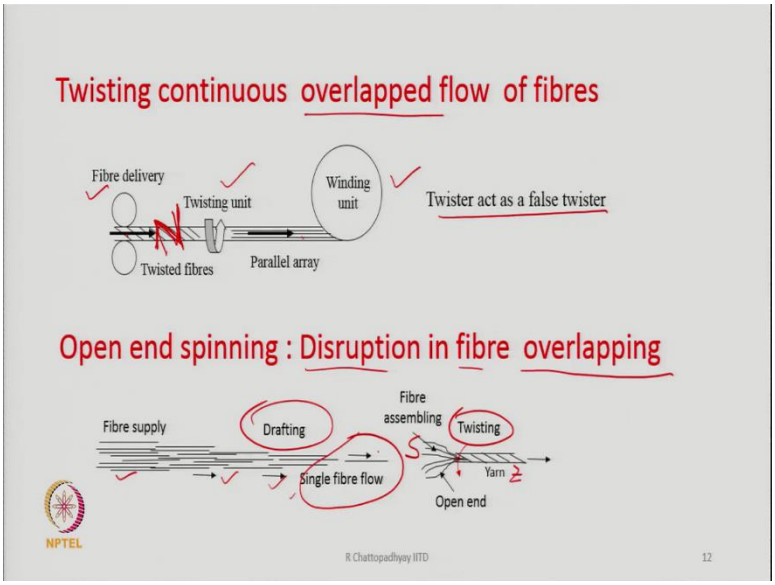
The lagging of the traveller is because of the friction between ring and traveller and the other thing is due to the continuous supply of yarn to the traveller from the bobbin and ultimately the yarn is going on the bobbin surface. The yarn is supplied from the front rollers and the same yarn is passing through the traveller; and finally, it is going on the bobbin surface.

Therefore, this friction as well as a continuous supply of yarn makes the traveller to lag behind the spindle or lag behind the bobbin, and this lag is the reason for winding the yarn around the bobbin, unless there is a lag, there will not be any winding. Fortunately the lag is just enough to wind the yarn that is continuously delivered by the front pair of rollers.

Anyway the twisting and winding process in the case of ring spinning are inseparable. They are happening together; drafting, twisting, and winding these are the three processes which are happening together. If we want to think that we have to go for high speed, then there is a need to separate out twisting and winding process that is they have to be independent of each other. On the ring spinning technology, they are not independent of each other.

The same element is responsible for twisting as well as for winding; so, the process these two processes are inseparable. If we can separate these two processes make them independent of each other, then that would be a possibility to raise the production rate phenomenally. Now, if we want to achieve that what we need to do?

(Refer Slide Time: 25:05)



Ok. Let us first see that if I want to have an independent twisting unit placed between the fibre delivery, which is here and suppose this side is winding unit we have. And from the left hand side the yarns the drafted fibres are being fed and there is a twisting unit over here which is twisting the bundle of fibres.

If we have a system like this what will happen, this twisting unit will actually start working as a false twister. If you are familiar with the false twisting process, then this is exactly will be a false twisting process. Because, there is a continuity in the supply of fibres from delivery point to the winding point and these fibres are overlapping on each other; so, there is a continuity and there is a overlapping of fibres.

As a result whenever the twisting unit starts putting twist, on the left hand side if we get ‘Z’ twist, on the right hand side we will get ‘S’ twist. But, then the yarn is flowing continuously the ‘Z’ twisted part of the yarn will go as soon as it arrives on the right hand side, it will cancel out the twist on the right hand side which is ‘S’ direction. So, ‘Z’ direction twist will nullify the ‘S’ direction twist which will be there on the right hand side of the twisting unit.

And as a result what will happen on the right hand side we will only get parallel array of fibres. And if this is a parallel array of fibres this will have no strength; so, there is no winding possible at all. So, if we think of a process like this, this system is not going to work at all.

So, what is the way out that is what heard exactly been done in open end spinning, that is the fibre supply which is there that is fibres are supplied may be by a pair of rollers. We have to give a very high draft, and the draft is so high that the fibres number in the cross section will keep on reducing, and it will reach to a stage theoretically which will be almost single fibre flow at that stage we have to reach.

So, that a very high draft we have to apply, hoping that the number of fibres in the cross section of the fibre flow will keep on reducing and it will reduce to a level which is close to almost single fibre flow. And if we have a twister placed here at a distance as is shown here, the twister rotates what will happen? If the twister is putting let us say ‘Z’ twist in this directions the twister will put ‘S’ twist in this direction only.

But in this direction as soon as the fibre will arrive, the fibre will get assembled at the twisting point. And once the leading end of the fibre is picked up by at the twisting point the trailing end can rotate freely, and whatever ‘S’ twist is could be there on the trailing end that will be lost. So, on the right hand side the fibres will be ‘Z’ twisted, on the left hand side as soon as the fibre arrives and get picked up at the twisting point the front end is picked up, the trailing end of the fibre is free to rotate now.

So, the torque which the left hand side of the fibre is receiving is actually getting released, because it is free to rotate. And therefore, we will not find any twist on the left hand side of the twisting point, because the fibres will be trying to freely rotate and release the twist; whereas, on the right hand side the fibre bundle will be twisted in ‘Z’ directions.

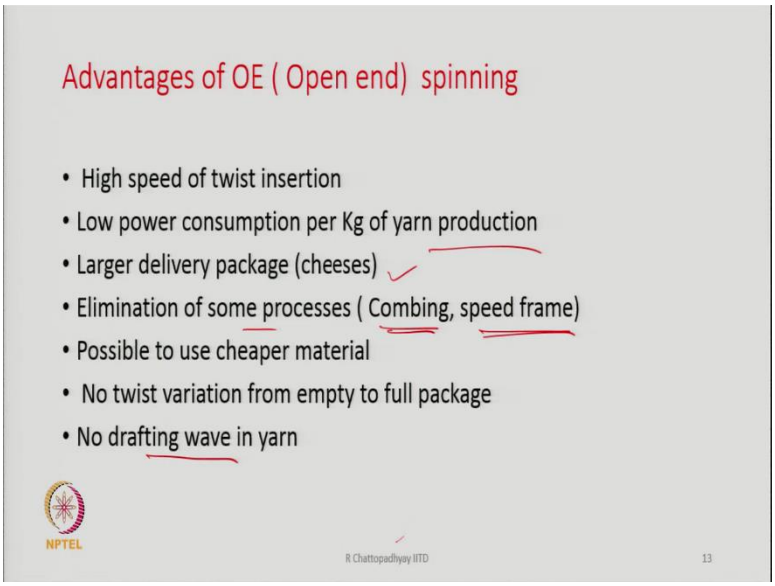
So, what has been done? disruption in fibres overlapping; that the fibres are not really overlapping on each other that much amount of draft we have to provide. Here many fibres are overlapping on each other by drafting, by means we are stretching the number of overlapped fibres is gradually reducing. And when we come to this stage number of overlapped fibre is nil, almost single fibre flow is there; that means, there is a break in the continuity of fibre supply this break is very very necessary.

So, fibres are moving at a high speed and then at the twisting point they are arriving and this they have to arrive they have to slow down. Because, we need to have let us say 100 or 200 fibres in the yarn cross sections. If there is single fibre flow, the velocity of the incoming fibre and the velocity of the twisted yarn should be so balanced that at any point of time there will be 200 fibres available at the twisting point; so, that we can produce a yarn of the desired count.

So, fibres have to be slowed down they will incoming fibes will be coming at a higher speed the break will be there in the continuity of the fibre supply. And then fibres will be reassembled at the twisting point that basically means, whatever number of fibres are required in order to produce a yarn of a certain count that many fibres will come and arrive there and then all these fibres will be twisted together.

The right hand side will get the desired twist and in the desired directions, on the left hand side the fibres end because they are free to rotate they loose twist and they will remain untwisted, this is the basic principle of open end spinning.

(Refer Slide Time: 32:52)



So, as a result of this what are the benefits, one is high speed of twist insertion. The twist insertion unit or you can say the twister can be rotated at a high speed; we can have a small twister, not like a big one like a spindle not so heavy. We can have a very small unit which can rotate at a very high speed and consume much less energy. Then the other advantage is low power consumptions per kg of yarn productions, because we are not rotating a heavy twisting unit.

Twisting unit can be made very small now; and therefore, lot of saving of power and therefore, power consumption will be much less. Larger delivery package, package size can be quite big, because now in the ring spinning the package size is limited because the package has to stay within the balloon.

So, and we cannot if you want to have a big package, you have to increase the ring diameter that will create, if we have increased the ring diameter the balloon tension will increase the yarn will break. And if you increase ring diameter the number of rings that we can accommodate in a given length will be much less.

So, number of production positions will go down; the main problem will be the breakage of the yarn, because larger ring means lot of tension in the balloon, balloon the yarns will break. So, large package we cannot have in ring spinning whereas, here there is no such limitations. The package size which is cheese, I can make it 1.5 kilo, I can make it 2 kilo,

I can make it 2.5 kilo whatever is convenient we can have it, and we have no problem there.

Elimination of some processes, we will see that we do not need combing operations, we do not need speed frame that is roving frame, these two processes are not required at all. Possible to use cheaper material, especially in rotor spinning system we can use cheap material that is material; that means, fibres which are shorter in length, this is only true for rotor spinning. No twist variation from empty to full package, in ring spinning in the ring cop this possibility is there.

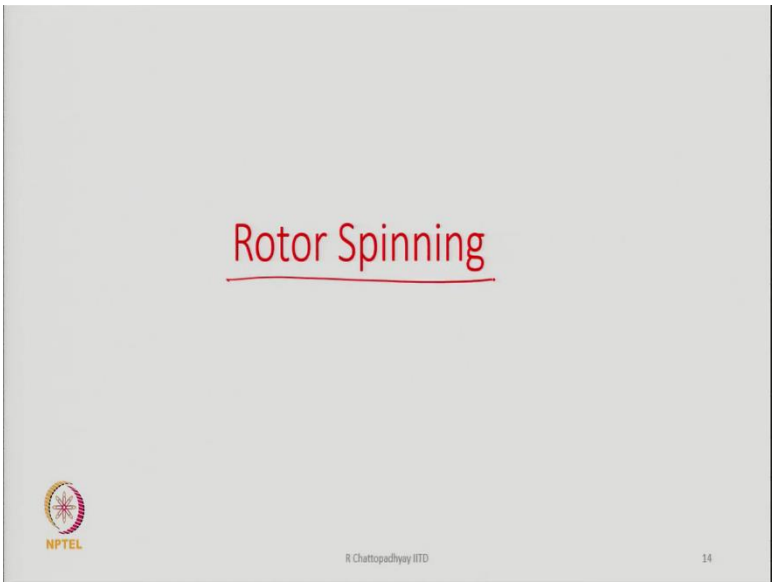
Twist may vary from empty to full package there is a chances of twist variation could be there, here this is not true. Because, there the traveller speed is not constant it is continuously changing, and hence twist can vary in ring spinning, but it will not vary in rotor spinning systems.

No drafting wave in the yarn, because the roller drafting will not be there, we will see that how the material are this sliver is drafted. We have eliminated the roller drafting unit and hence the drafting wave generation is not there which is otherwise possible in the case of ring spun yarn.

Drafting wave can be generated on draw frame, it can be generated also, it can generate on your roving frame also possible on the during ring spinning itself the drafting system; so, at different places the drafting wave can generate. Here, this possibility is almost nill though we will be feeding a drawn sliver.

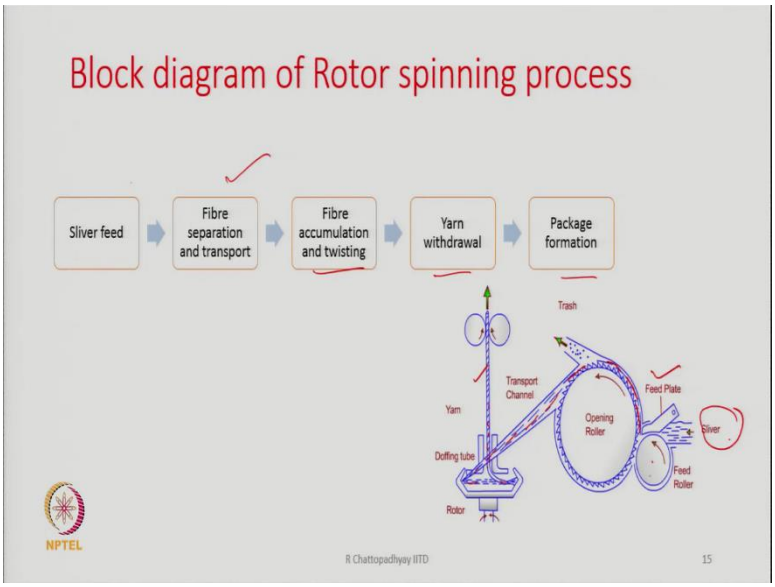
So, card sliver when we draft them on the draw frame there is a chance of development of drafting wave there. But, beyond that in the spinning process there is no scope for generation of drafting wave. So, with this we now come to the open end spinning as we have discussed earlier that we will see that this principle is used in the case of rotor spinning.

(Refer Slide Time: 37:58)



Rotor spinning is one machine where the spinning actual yarn formation principle is open ring spinning. So, we first take up this and this is one of the most successful spinning technology.

(Refer Slide Time: 38:16)



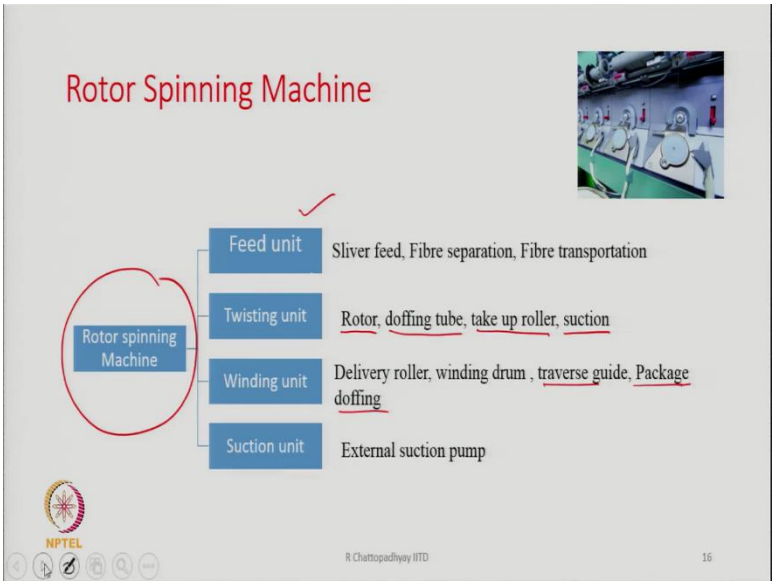
Now, block diagram of rotor spinning process; so, if you look at the rotor spinning process first there is a sliver feed, some arrangement by which sliver will be fed. Next is fibre separation and fibre transport. We have to as I said we have to stretch this sliver; so, that we have to introduce a break.

Then comes fibre accumulation and twisting, after that we will have yarn withdrawal; very twisting means, the yarn is forming at this point. Now, we have to take out the yarn; so, yarn withdrawal has to be there and then we will have a package formation that we have to form a package.

So, this is the you can say the various units of the rotor spinning, sliver feed, fibre separation unit and fibre transport, fibre accumulation and twisting by a twisting element, then yarn withdrawal, and then package formations. Here a diagram is shown here you can say cross sectional view of the open end spinning rotor spinning especially here.

We will discuss about them in more details gradually that sliver is here we are feeding. Then the feed roller is here, feed plate the sliver is drafted it is going like this is here, this is the passage of the fibres, here is the yarn will. So, a simple sketch of the spinning process is shown here; sliver, feed roller, then there is opening roller; the opening roller is actually acting as a drafting unit, we will discuss about them.

(Refer Slide Time: 41:01)



So, rotor spinning machine if we see, we have a feed unit where sliver is fed then from the sliver fibres are separated and then fibres separated fibres are transported. This is the part of the feeding unit is doing this job; it is pulling the fibre feeding it, then fibres have to be separated from each other and then the separated fibre needs to be transported, the entire feed unit actually doing these jobs.

Then comes the twisting unit, twisting unit consists of a rotor which is a twister. A doffing tube, a take up roller and a suction system, these are all there in the twisting unit. In the winding unit, we have delivery roller, a winding drum, a traverse guide, package, doffing. Then you go to the suction unit where we have external suction pump to draw air. Fibre transportation is done by the help of air, so, it is all pneumatic transport of fibres we will also look at the pneumatic transport in details.

So, you can say the machine has three, four units feed unit, twisting unit, winding unit and a suction unit. And with that we close the very first lecture on this topic, and in the we will see that in the next lecture we will take up each of those units one by one and discuss them in more details. So, you have a hope you have understood why what are the main shortcomings of ring spinning technology this is very important to know.

But, what are the strength of ring spinning also you should know. The second thing is whatever weakness is there; if we want to get rid of this weakness what we need to do and that is exactly what has been done by developing this rotor spinning technology. And then; obviously, we have just I have just introduced you to the rotor spinning technology you know in the coming lectures we know more and more about rotor spinning.

Thank you.