New Spinning Technologies
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Lecture - 24
SIRO spinning

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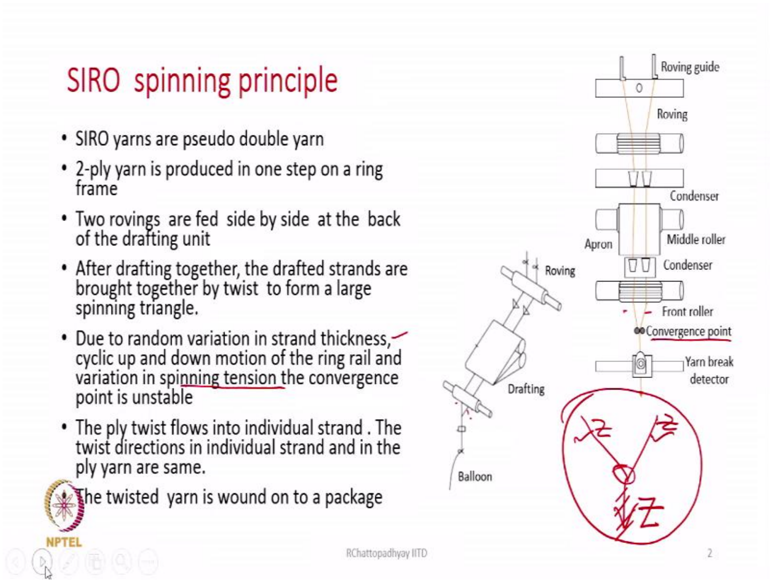

So, today we are going to discuss SIRO spinning. Let us start. SIRO spinning was developed in Australia by CSIRO. There is a research institute there and they developed this technology and the technology was developed to produce 2-ply yarn in a single step especially in the Woolen and Worsted industry.

See 2-ply yarn are superior than single yarn, but 2-ply yarn production process is quite lengthy and at the same time it becomes therefore, very costly. However, 2-ply yarns are definitely superior than single yarns in all respects and it is more important in the case of worsted yarn. So, in order to cut down the cost of producing a 2-ply yarn following traditional technique where we basically take single yarns and then convert them into 2-ply yarns and there is a process of winding and twisting.

So, these two extra processes make the manufacturing cost quite high and the other idea behind this to this formation of this SIRO-spun yarn in the production of a ply yarn in one step is to produce a 2-ply yarn which will be weave able on the looms. Without any sizing in the case of Woolen or worsted yarns.

Single yarns are not good for directly you know weaving operations because the abrasion resistance of the single yarns are poorer in comparison to a ply yarn. Now, the technique is very simple and we usually use a ring spinning machine to produce SIRO yarns. So, basically it is a 2-ply yarn produced in one step on a ring spinning machine or on a ring frame with very minor modifications.

Modifications are what? That we have to feed basically two roving simultaneously and we allow the rovings to be drafted independently in one drafting unit. So, if these are the two rovings being fed and they are going through the drafting zone, both the rovings are getting drafted in bundling and we have to maintain a certain distance between them and then once the rovings are drafted.

Now, they are brought together at a point which is known as convergence point and the two rovings drafted rovings are now twisted together by the normal ring and traveller system that we have on ring spinning machine. So, instead of one roving being fed, we are basically feeding two rovings and the two rovings are placed with little distance between them.

It is not that they will be placed side by side touching each other. There has to be a certain distance and people have optimized this distance will come to know a gradually how much distance we should maintain and what is the importance of this distance between the two rovings while they are getting drafted together.

Now, in this two drafted strand that we produce and then they are converging towards because both of them are then twisted together by the traveller and the ring combination of a ring frame the twist will flow in each of these strand, this strand and this strand both. And we will find a twist triangle getting formed in front of the front roller.

Now, there are certain variation that will occur, one is strand thickness in the two rovings will never be exactly same. There is a whether it is roving or it is a you know yarn or it is a sliver, there will always some variation in mass. Some random variation in mass will be there, they are not perfectly uniform.

So, some variation in thickness that basically means mass per unit length will be there in the both the rovings and there will be variation in spinning tension also because of the cyclic up and down of the ring rail. So, there will be tension variation here in the 2 strand with their ultimately coming together and joining.

And therefore, the convergence point here, this point is not really a very fixed point, it will keep on moving up and down because of the variation in tension and variation in the mass per unit length of the two strand which are coming together and joining at the convergence point or converging at a point.

Now, obviously, this point will keep on moving up and down because of this natural variation in tension and mass per unit length of the two drafted strand. The other thing which we will find is that the twist direction, if we apply if we let us say ply twist in Z that is twist here is Z, the twist in the two individual strand will also be Z. This is something which does not happen in classical plying.

In classical plying, if we want to produce a ply yarn, if the individual strands have S twist then the ply twist will be Z opposite or it could be vice versa. So, that is the one of the very important difference in the direction of twist in the individual strand and direction of twist in the ply in the plied structure.

There in this case they will both same, they will not be different from each other and there is a consequence of this which will come to know that what happens if the twist directions in the individual strand and in the ply remain same. Next, so once the both the strands are twisted together, they appears to be like a single strand and now they are wound on a package. Now, we will see later we will discuss about one thing that what is very important in this case is the trapping of surface fibres.

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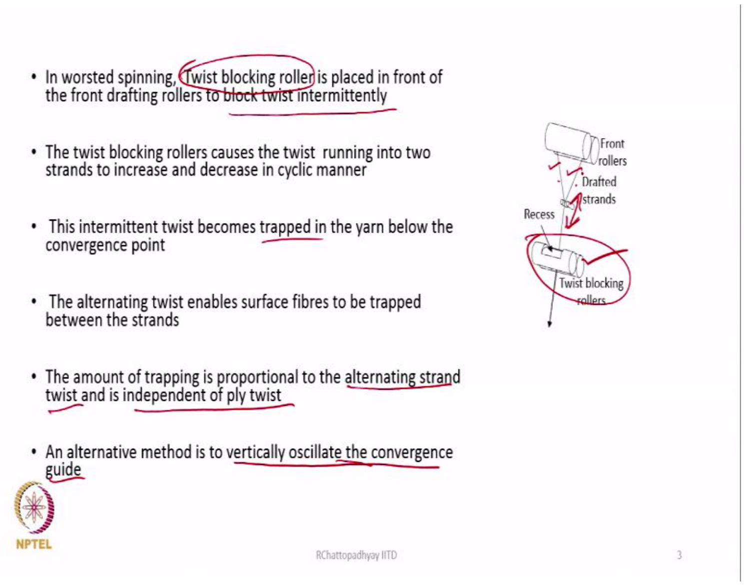

The surface fibres of the two individual strands must get trapped at the interface of the two strands which are getting twisted together. If the surface fibres are not trapped properly, then they can easily peel out and therefore, the abrasion resistance of the yarn will be very very poor.

Now, to enhance trapping which is more important in the case of worsted spinning, what can additionally be used is a twist blocking roller which is shown here that is in front of the front roller there will be twist blocking rollers and this twist blocking roller the top roller has a recess and the bottom roller is a normal roller.

So, when the recess part comes into contact with the bottom of the twist blocking roller, the yarn which is running in between them is not going to get gripped. If they are not gripped, the twist can easily flow. The twist flow is always in the upward directions. The yarn flow is towards the bobbin package. It is moving downwards, yarn is moving downwards whereas, the twist is always flowing up because the source of twist is the rotation of the balloon.

So, from twist accumulates in the balloon and then it starts flowing upwards towards the nip of the front roller. Now, the twist blocking roller is going to block the flow of twist if the yarn is nipped between them. But if there is a recess cut, then whenever the recess is coming into contact with the bottom roller, then there is no hindrance to the flow of twist. So, twist will immediately flow into the part of the yarn which is beyond the twist blocking roller. So, towards the strands.

Now, by having this pair of a twist blocking rollers, what is done is that it will block the twist intermittently. At some periodicity the twist will be blocked and twist will be allowed to flow. So, twist is flowing, twist is getting blocked depending upon whatever is the speed of this roller we choose; obviously, the speed has to be little close to the speed of the front rollers.

So, cyclically the twist will be blocked momentarily depending upon what is the size of this recess. And as a result what happens that the twist in this two strand will cyclically change and this will have a very positive effect on the trapping of surface fibres. That is the additional attachment which is used especially in the case of worsted spinning.

So, with that also there will be some amount of trapping because of natural variation in the you know in the twist flow variation in tension, a variation in the mass of the mass of the fibres in the two strands. So, there will be some trapping even without twist blocking rollers. But with the help of twist blocking rollers we can enhance the trapping part.

And if we can improve the trapping then the abrasion resistance of the two of the yarn of the plied yarn is going to be better because the surface fibres are gripped. Trapping basically means trapping between the two component of the strand as they lie in the plied structure.

So, that is the advantage we get and the amount of trapping is proportional to the alternating strand twist and is independent of ply twist. It is not how much ply twist we are keeping, more ply twist does not mean more trapping. It is the variation in twist in the two strand right after the front roller.

That is what is most important. How much variation we are bringing there that is the main point or most important point for the point of view of trapping of surface fibres. So, we will discuss about the trapping in more details. And alternating method could be vertically oscillation or oscillating the convergence guide. That this guide which is here can be moved up and down.

So, that we change the geometry of the twist triangle as it moves up the triangle will be smaller as it moves down triangle will be bigger or longer. So, that way also we can bring we can change the level of twist in the two individual strand which are joining together to form the plied structure, ok.

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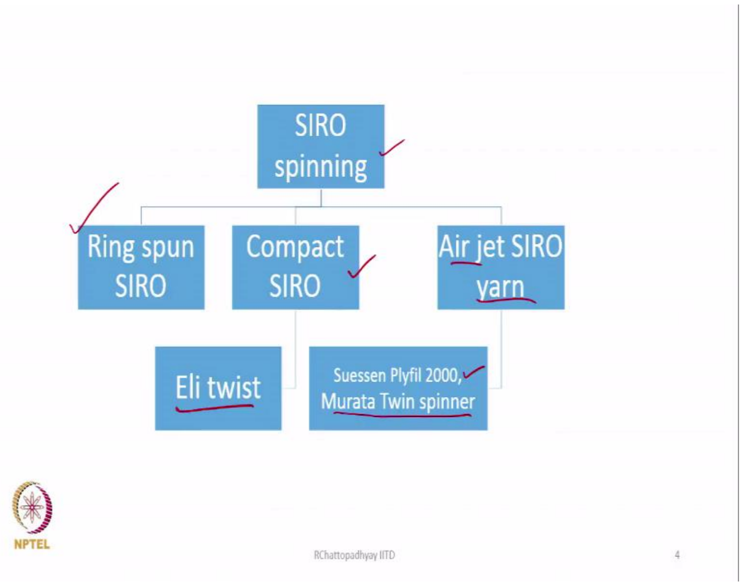

Now, SIRO spinning that is the two strand spinning you can see you are making a ply yarn in a single step. That could be lot of different types of application of this concept. One is what is traditional that is we use it on ring frame and produce ring spun SIRO yarn. We can also have compact spun SIRO yarn which is known as Eli twist.

So, compact spinning technology is there. So, same technology can be used for again we can feed two rovings in parallel and again make the two rovings they will be drafted simultaneously and independently and they will finally, join together to form a plied structure that is called Eli twist and also we can have air jet SIRO yarn. This is known as Suessen Plyfil technology and Murata Twin Spinner MTS.

So, the concept is same that is draft two rovings simultaneously maintaining a distance between them and allow them to join together after they get drafted and twist them together by some twisting mechanism.

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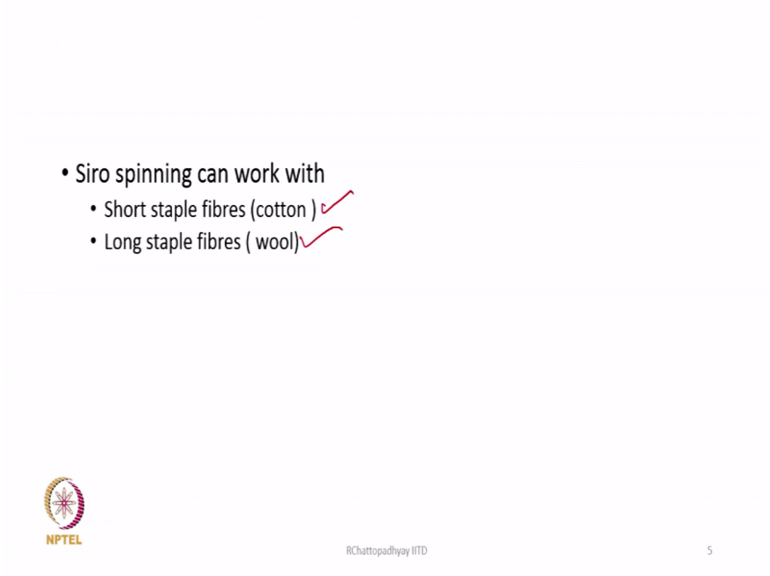

SIRO spinning will work with cotton and also can work with long staple fibres, but it is always better to use it for long staple fibres. For very short fibres it creates some spinning difficulties are there which will come to know gradually as we will discuss. But it can be used for short staple fibres like cotton or cotton polyester blend or viscose polyester blend or something some blends of cotton or even staple fibres.

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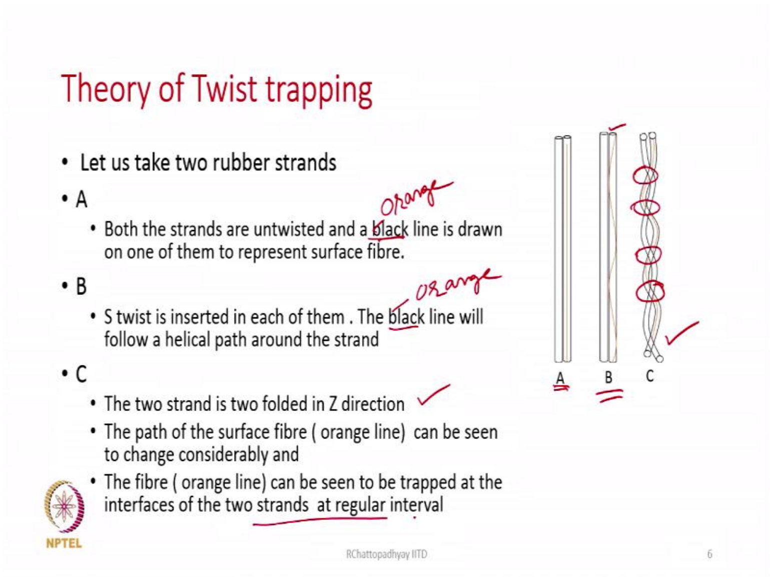

Now, theory of twist trapping we are going to discuss now. Let us take two rubber strand and in the diagram A one of the rubber strand on the rubber strand we are drawing a vertical line a black line I have written it here, but in the diagram it is shown as a orange line. So, some color line basically we need.

So, both the strand to start with they are untwisted there is no twist in them and a line let us say in this case orange line is drawn and the line is going to indicate as if it is a surface fibre. So, untwisted and there is surface fibre represented by the orange line in the B S twist is inserted into it.

Now, what is going to happen this orange line will follow a helical path it is shown in one on the strand that basically means that it is twisted and we have given suppose some twist direction S in this case here. So, it will be like this. Now I in the third diagram we take these two rovings and Z fold them that is we give a folding twist or ply twist in the Z directions now.

So, we get a plied structure like this. And what we will find now if we focus on this orange line then we will see this orange line is visible and then suddenly it is coming in between the two strand at the interface. So, at regular interval the orange line will come in between the two strand and it will remain trapped there, this is possible because originally there was some twist in this two strand that we are basically going to ply.

So, when the individual strand is having twist already in them and then if we make a plied structure then the fibres will be will get trapped at the interface of the two component at regular interval. That is what going to happen. So, that basically means if it is not there then the trapping will not be there.

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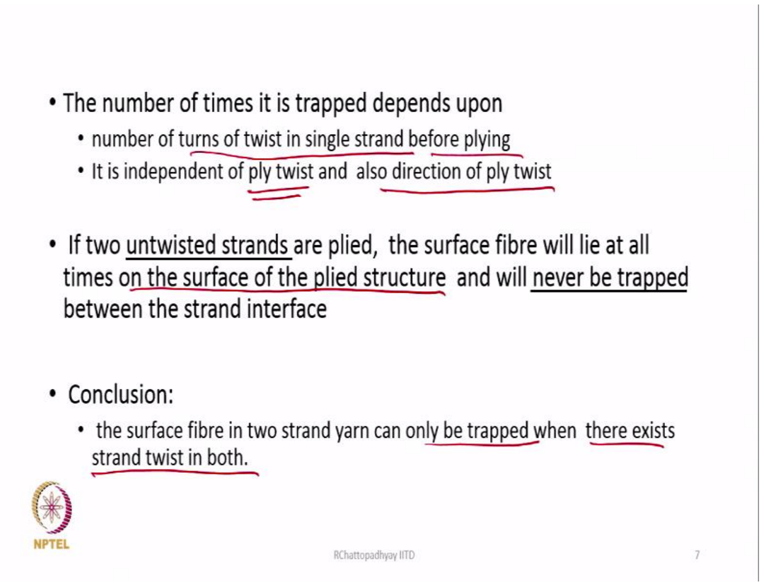

So, number of times it is trapped depends upon number of turns of twist in the single strand before plying what matters, how many turns are there in the individual strand before plying. It is independent of ply twist and also direction of ply twist it does not matter. If the two untwisted strands are plied the surface fibre will lie at all times on the surface of the plied structure will never be trapped.

So, if originally suppose these two strands have no twist in them 0 twist and then we ply them together then we will find that a fibre which remains on the surface of one strand will always remain on the surface and the fibre which was at the interface to begin with it will always remain at the interface.

But other fibres will never get trapped if the two strands which are going to be plied they have no twist in them. Therefore, conclusion we can draw from this particular experiment is that the surface fibre in the two strands yarn can only be trapped when there exist some twist in them. So, we have to have some twist in them.

Fortunately, when we go for taking two strand and then we are not twisting them together a twist flows into individual strands also.

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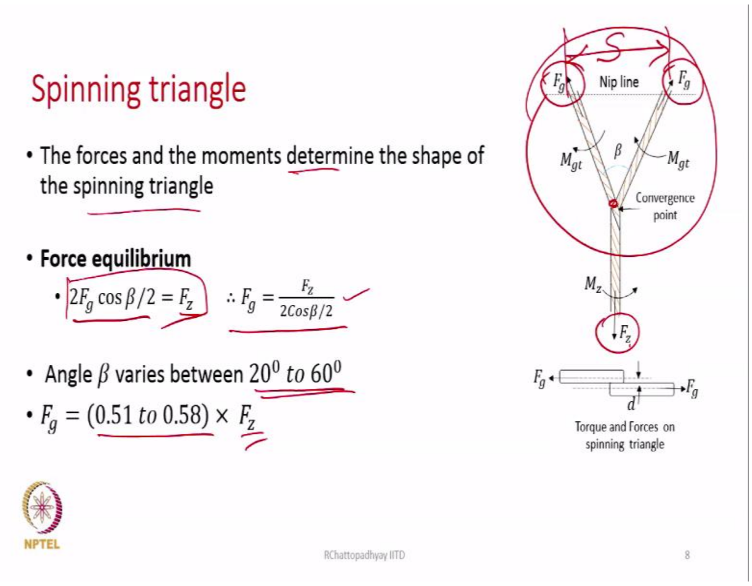

Now, the spinning triangle people have studied the mechanics of the spinning triangle the what the geometry of the spinning triangle. So, there will be forces and moments will determine the shape of the spinning triangle detail you know derivations and detail theories are there about this spinning triangle geometry and how the forces and the torques are balancing each other.

We will focus mainly on the force equilibrium here at any point of time the tension in the yarn F_z F_g and F_g are the tension in the two components and F_z is the tension in the plied yarn. So, at any point of time we can write that F_z is going to be 2 F_g cos β/2 or cos β is shown as the angle between the two strand. This convergence point where it will lie will all depend upon how much twist we are putting into the ply yarn.

$$2F_g \cos\beta/2 = F_z \qquad \therefore F_g = \frac{F_z}{2\cos\beta/2}$$

If I go increase keep on increasing the twist the convergence point will go up and up. If we reduce the twist the convergence point will go down and down. It will also depend upon the distance between the or the spacing that we are keeping between the two rovings that are getting drafted.

So, this spacing and the twist that we are using in the plied yarn they will decide where the convergence point is going to lie. If we look at the force equilibrium then this is the equations and F_g is F_z /2 cos β/2 Angle β has been seen to vary between 20 to 60 degree depending upon the process parameters.

And therefore, F_g is roughly 0.5 to 0.6 roughly let us say of F_z. So, whatever is the tension here the tension in the two are almost half or 0.6 of the tension.

$$F_g = (0.51 \; to \; 0.58) \times F_z$$

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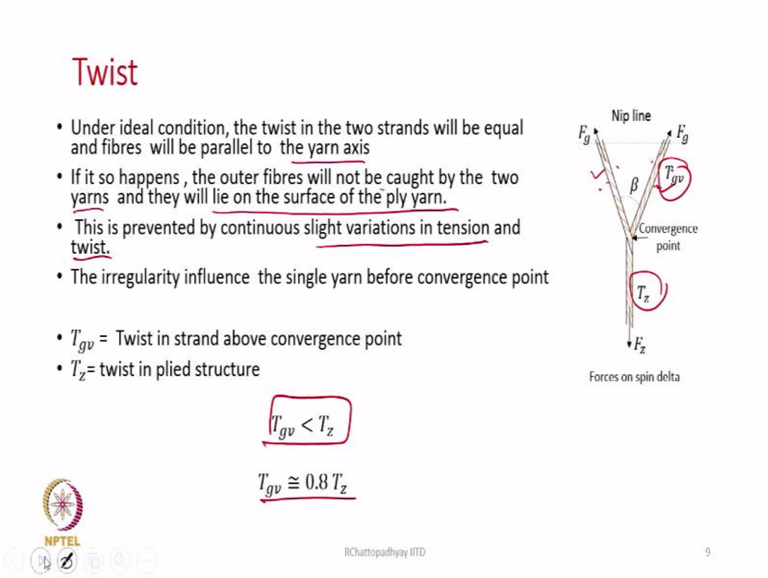

Now, we go to the twist under idle condition the twist in the two strands will be equal and will be parallel to the yarn axis. If it so, happens the outer fibre will not be caught by the two yarns and they will lie on the surface of the ply yarn. That is, if the twist happens to be exactly same then trapping also will not be possible.

But this is what is prevented because of always there is a variation in tension and twist and also in the mass of you mass per unit length of the fibres which are getting you know after getting drafted these the mass of fibres here and here are also not same at any point of time.

So, there is a continuously disturbance is there in terms of fluctuation in tension fluctuation in mass per unit length that is number of fibres present in the two individual strand and twist also may fluctuate ply twist because the traveller lag is there and traveller speed is not constant it is continuously changing.

So, there is a some natural disturb disturbance is always there and that will actually will make sure that the two strands are not having same level of twist. T_{gv} is the twist in the strand and T_z is the ply twist then T_{gv} is always less than T_z and typically it is 0.8 of T_z. Then the twist in the strand is 0.8 times the twist of the twist in the ply that is ply twist is more than the strand twist.

$$T_{gz} < T_z$$

$$T_{gz} \cong 0.8T_z$$

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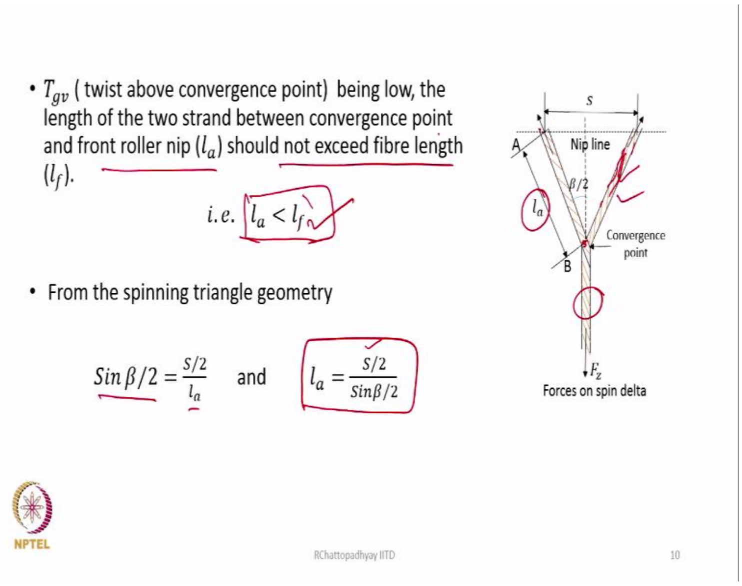

So, the twist T_{gv} being low the length of the two strand between the convergence point and the front roller nip should not exceed the fibre length. Now, twist here is less than twist here. So, if it is less; that means, this part of the yarn is weak. Now, this distance that is l_a should always be less than less than l_f. l_f is the fibre length. So, that we can expect a fibre to be simultaneously gripped at the convergence point or twist point and by the front roller.

$$l_a < l_f$$

So, when this is less it is better, but if it exceeds then there is a chance of drafting of the fibres in the twist strand. So, in the twist strand in the twist strand you can say that there is no; there is no support here and the twist is relatively low and therefore, there is a possibility of fibre slipping within the structure in this zone. That possibility is always there some uncontrolled slip could be there.

All depends how long the arm length is l_a with respect to the fibre length. The longer it is the better it is. And we can from the geometry you can write that sinβ/2 = S/ 2 l_a and therefore, l_a is this the value of l_a is depends upon S/2 that is whatever is the spacing between the rovings by 2 and sin β/2. So, the length of the arm can increase if we increase the spacing between the 2 rovings and we also depend upon the angle β.

$$\sin\beta/2 = \frac{S/2}{l_a} \qquad and \qquad l_a = \frac{S/2}{\sin\beta/2}$$

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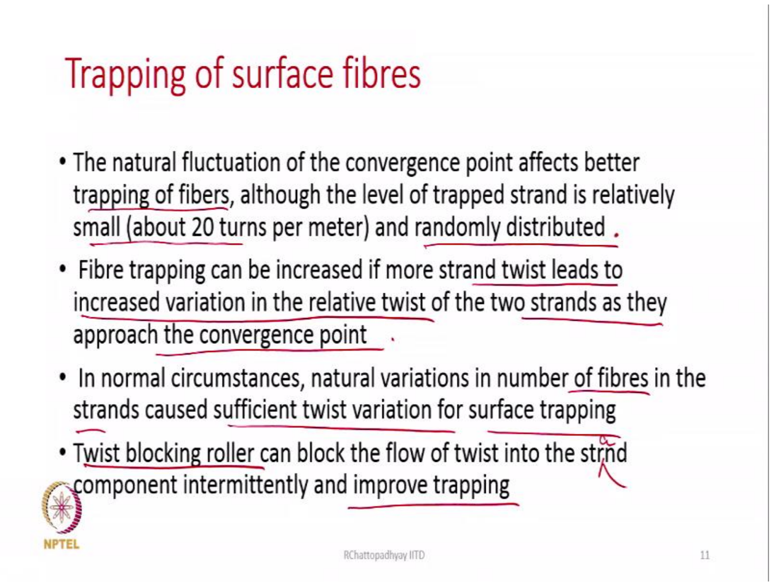

So, if we discuss about trapping of surface fibres. So, the natural fluctuations as I said earlier the convergence point affects better trapping of fibres although the level of trapped strand is relatively small and randomly distributed. So, because of this natural you know variation in tension as I said earlier there will be some trapping of fibres always. And fibres trapping can be increased if more strand twist leads to increased variation in relative twist of the two strand as they approach the convergence point.

If we have to increase trapping then there has to be more variation in the strand twist before they join the convergence point. In normal circumstances natural variation in number of fibres in the strand caused sufficient twist variation for surface trapping. So, which I have already told you that because of the variation number of fibres because of the tension variations also there is always the twist variation exist between the 2 strand which are which are joining finally, to form the plied structure.

And therefore, some trapping will be always happening. We can further improve this trapping effect if we go for twist blocking roller. This can block the flow of twist into twist strand and can improve trapping. And therefore, we can use this kind of twist blocking rollers also and that is mostly used in the case of long staple fibres that is especially worsted spinning system.

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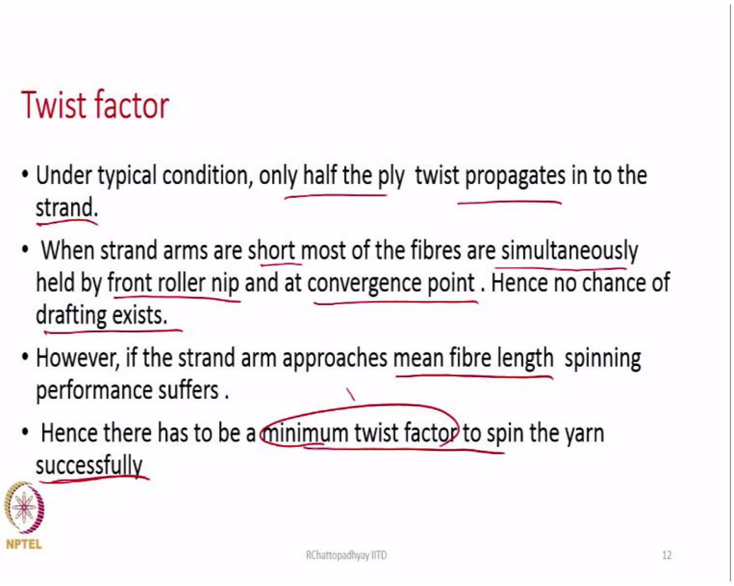

Twist factor under typical condition only half the ply twist propagates into the strand. Though in some you know some investigation it has been shown to be almost 80 percent twist propagates. Whether a some reports where to it say then only half the twist propagates into the individual strand. So, therefore, when this strand arms are very short most of the fibres are simultaneously held by the front roller nip and convergence point. Hence, no chance of drafting exist.

So, if the arm length is less in comparison to the fibre length then possibilities of fibres getting drafted in the strand itself because of the tension whatever is there will not be there that possibility will be less. Is something like you know roving if a roving if I stretch it can easily fibres can easily slide and they can be thinner.

Similarly, here if this two strands if the length of the strand length is less then most of the fibres will bridge the gap in between the front roller nip and the convergence point. That is where the two strands are basically getting twisted together and in this cases possibilities of slippage between the fibres will be less.

So, uncontrolled drafting is not going to occur and opposite will be true if the arm length increases especially when it approaches the mean fibre length and this will be happening more. So, in the case of cotton or short staple fibres because there will be many fibres which will be lesser than mean length also. So, that is the you know importance of the length of the arm. Hence there has to be a minimum twist factors to spin the yarn successfully.

If we think that we will produce a yarn a soft yarn by reducing twist multiplier then the arm length is going to increase and therefore, there will be uncontrolled drafting of the fibres in the yarn arm or in the strand and that uncontrolled drafting of fibres in the strand will lead to a yarn which will be inferior in terms of quality. There will be thin regions will be coming and yarn will be non uniform also because that drafting which will occur there will have no control on that.

So, there has to be a minimum twist factor to spin the yarn successfully and there is a possibility of breakage as well also.

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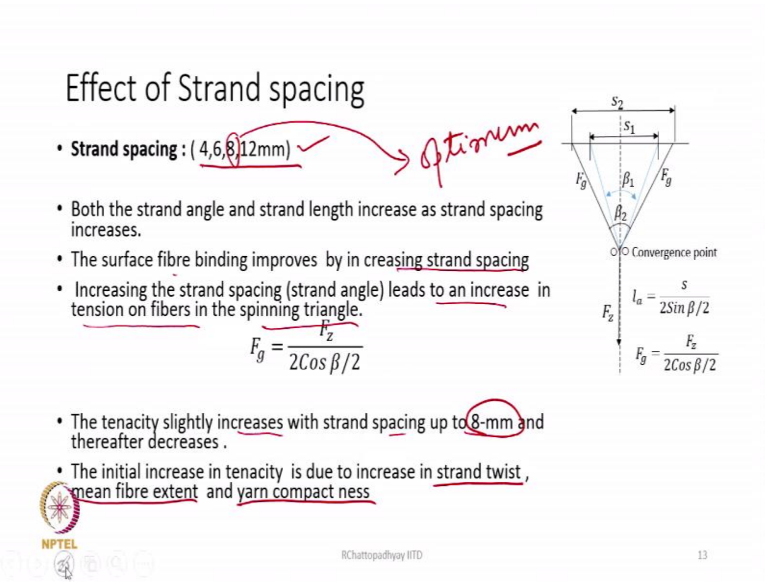

Now, effect of strand spacing typical spacing which has been 10 for cotton or short staple spinning system is 4, 6, 8, 12 people have studied that and mostly people have ultimately shown that 8 millimetre is the optimum for short staple fibres. Strand angle and strand length increase as strand spacing will increase which is very obvious.

Surface fibre binding improves with increasing strand spacing. Increasing strand spacing leads to an increase in tension on the fibres in the spinning triangle. So, fibres will be better aligned also that effect will be there. The other thing is tenacity therefore, slightly increase with strand spacing up to 8 millimeter it has been seen that there is a increase improvement. But thereafter tenacity may decrease.

So, the initial increase in tenacity is due to increase in strand twist mean fibre extent and yarn compactness. Because, the tension if F_g going to increase the fibres will be more oriented that advantage will have. And with increasing spacing the convergence point will go down. So, the value of β is going to change also.

$$F_g = \frac{F_z}{2\cos\beta/2}$$

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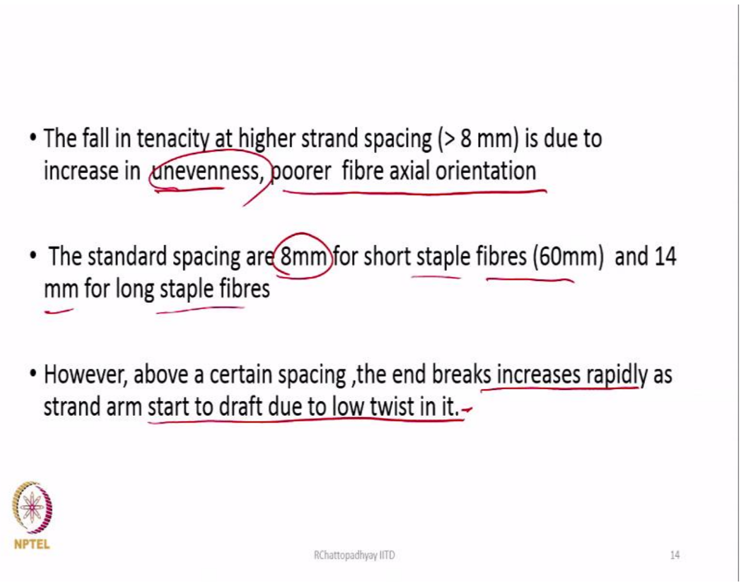

The tenacity reduces beyond the certain spacing mainly due to increase in unevenness and poor fibre axial orientations because yarn becomes more uneven because the length of this strand or yarn arm we can say a strand arm. Strand arm I mean the part which is above the convergence point. So, that length is going to increase when you go for from 8 to 10 mm or 12 mm and therefore, especially for cotton or short staple fibres unevenness is going to increase because of uncontrolled drafting in the strand arm itself.

So, this is 8 millimetre is the optimum that many studies has shown and 14 millimetre for long staple fibres. Short staple fibre up to 60 mm and for long staple fibre 14 mm has been seen to be optimum. However, above a certain spacing the end breaks can increase rapidly as strand arm start to draft due to low twist. So, not only that yarn will be uneven the breakage possibility is also going to increase.

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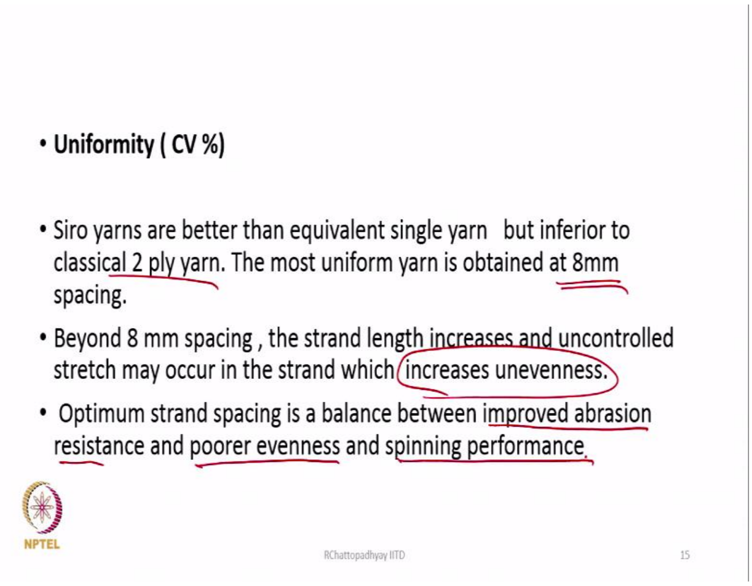

SIRO yarns are better than equivalent single yarn in terms of uniformity, but inferior to classical to ply yarn. The most uniform yarn is obtained when 8 millimetre spacing is obtained is a 8 millimetre spacing is maintained and beyond 8 millimetre as I said the unevenness is going to increase the reasons have been already told.

Now, optimum strand spacing is a balance between the improved abrasion resistance and poor unevenness and spinning performance. So, trapping of the fibres will be better if the spacing is increased and therefore, abrasion resistance is going to increase, but the yarn quality in other respect are going to suffer. So, we have to strike a balance at where we should how much spacing we should maintain.

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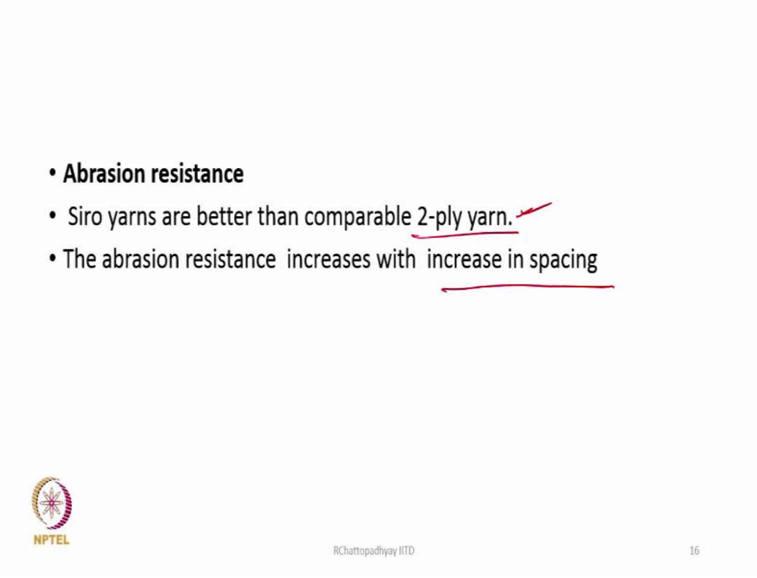

SIRO yarns are better than comparable 2-ply yarns in abrasion resistance some of people have reported and the abrasion resistance increases with increase in spacing. This is probably because both the yarns the individual strand as well as the ply twist directions are same. So, therefore, abrasion resistance of the yarn, SIRO yarns could be better than the 2-ply yarns. The 2-ply yarn, classical 2-ply yarn, the twist directions of the single and the ply are different.

So, when I am plying then I am removing twist from the single yarns in the case of classical plying techniques. Single yarn twist is gets reduced by the ply twist because single yarn twist and ply twist directions are different. They are opposite to each other, but in this case single yarn twist directions and ply yarn twist directions are same. So, binding of fibres are better and therefore, it gives better abrasion resistance.

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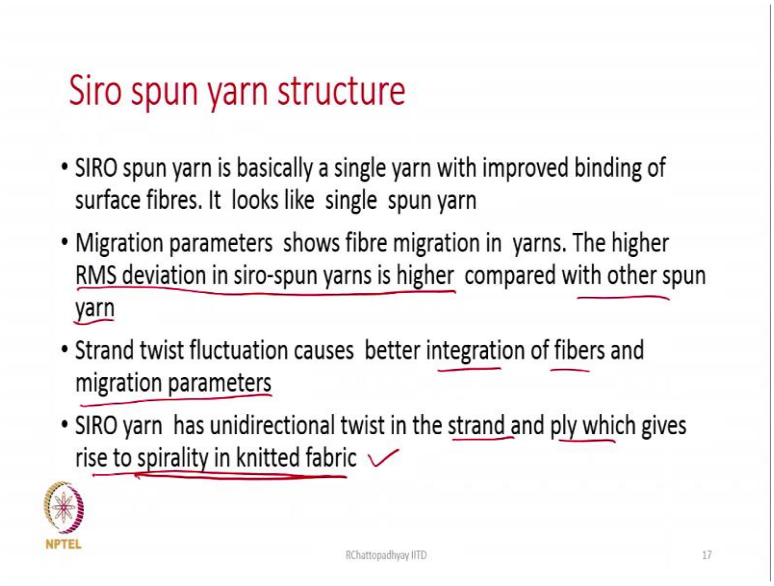

Structurally, the yarn looks like a single yarn, ring spun yarn type look. Migration parameter also people have studied and it has shown that RMS deviation in SIRO yarns is quite high compared to other spun yarn. So, regular migrations will be happening because individual strands are actually getting twisted.

So, there is a small twist you know twist triangle will be there and the way migration happens in ring spun yarn same thing will happen here also. And strand twist fluctuation causes better integration of fibres and migration parameters. SIRO yarn has unidirectional twist in the strand and ply, this is what is different and as a result of that there is a chance of spirality in the knitted fabric.

That means, the yarns will be more twist lively. In the in strand twist directions and ply twist directions are same, then yarn will be more twist lively and therefore, it can show spirality in the knitted fabric. That means, we need to go for twist setting is more important in the case of SIRO yarns.

Where in the case of classical ply yarn we can produce twist balance yarn or torque balance yarn.

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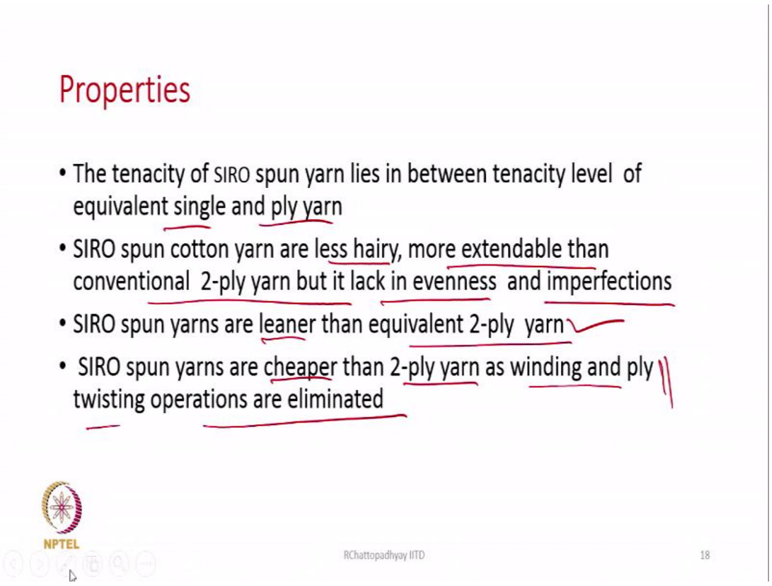

Properties tenacity of SIRO yarns lies in between tenacity level of single and ply yarn, normal single and ply yarns. SIRO spun cotton yarns are less hairy, more extendable than conventional 2-ply yarn, but lack in evenness and imperfections. SIRO spun yarns are leaner than equivalent 2-ply yarn. Why? Because the twist directions in the single strand and in the ply are same so, compactness is more.

Whereas, the classical plying techniques because the you know the ply twist direction in the opposite to single twist single yarn twist directions and therefore, there will be some opening up of the fibres within the single yarn. And therefore, two ply yarn diameter will value to be more than SIRO spun yarn diameter. SIRO spun yarns are cheaper than 2-ply yarn as winding and ply twisting operations are eliminated.

Obviously, that is the main purpose for going for SIRO spinning. So, avoidance of processes will mean yarn will be cheaper.

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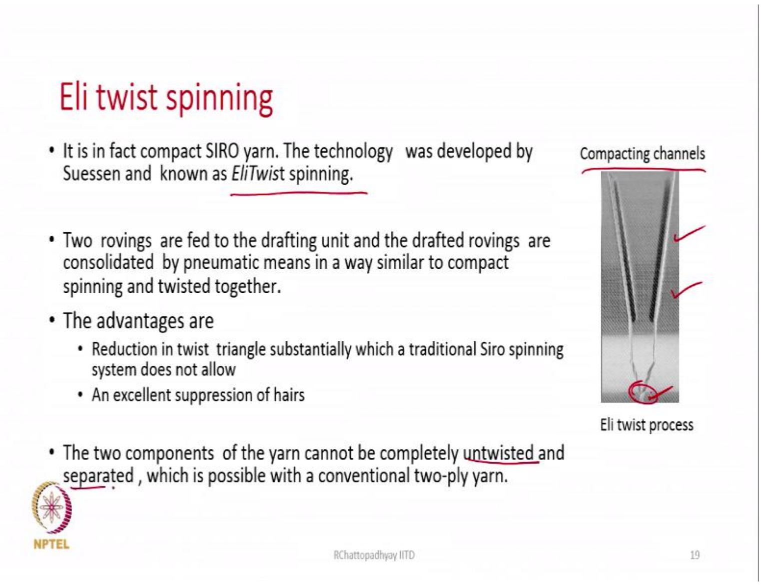

Eli twist spinning as I said we will discuss about compact yarns. So, basically it is the extension of ring spinning where the fibres, the drafted fleece of fibres are compacted before we twist them. So, here also what is the same technology can be used where two rovings can be compacted together by the compaction unit and then we can make them, we can get them twisted and we call it Eli twist.

So, Suessen Eli twist spinning system is available two rovings are fed. So, if they exactly same the only thing which is extra here is a compacting unit. Normally this is we suction systems are used for compression of the drafted fleece. Idea behind this we will discuss about them is to reduce the spinning triangle size. So, that the hairiness of the yarn can be reduced.

So, if we already compact the two fibres and then make them join the yarn is likely to be better because compact spun yarn also superior than ring spun yarn. But if we go for if we need to go for plied compact yarn then this technology could be quite helpful. But still we have to remember that this strand twist directions and ply twist directions are same. And because of that whatever you know difficulties or possessing problems we can encounter same thing will be happening here also.

But anyway we can have we have twist setting techniques by steaming the yarns. So, if at all the yarns are twist lively then liveliness can be reduced. Two components of the yarn cannot be completely untwisted and separated which is possible with a conventional 2-ply yarn. The yarns are twist lively.

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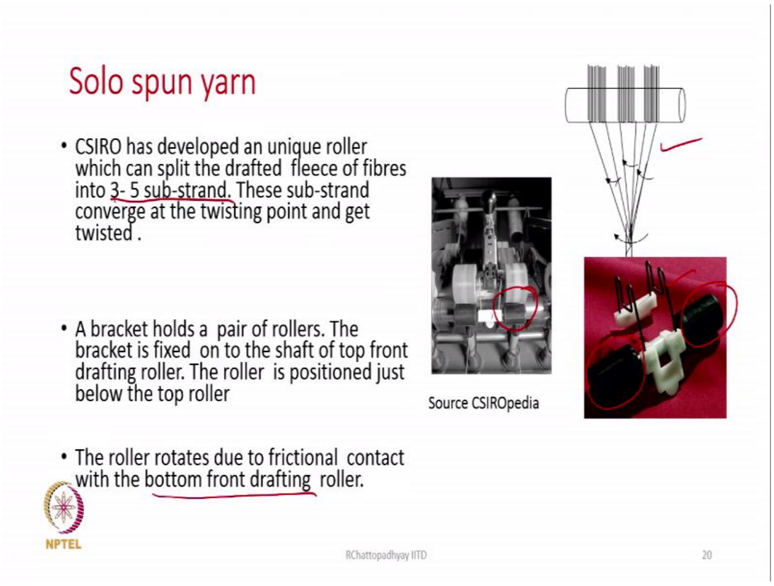

Solo spun yarn now we will discuss it is also basically an extension of SIRO spinning. The concept is same this was also developed by CSIRO that in Australia that is they had developed a special roller which will split the drafted fleece into few segments. Now, earlier SIRO spinning through drafted fleece are basically twisted together.

Now, here the drafted fleece is splitted into many parts as it is shown in this diagram that could be 3 to 5 sub strand that can be produced and they individually they will be twisted as if they is strand. So, instead of two strand we are actually forcing 3, 4, 5 strands to come together at the convergence point and then get twisted. So, this is the technique of solo spinning and for that what we have they develop they have developed a special bracket with these two solo spun rollers which can be fitted on the existing machine.

And these rollers will rotate like here the it is shown here because of frictional contact with the bottom front drafting rollers. So, it is also a kind of attachment rest of the part of the machine remains same.

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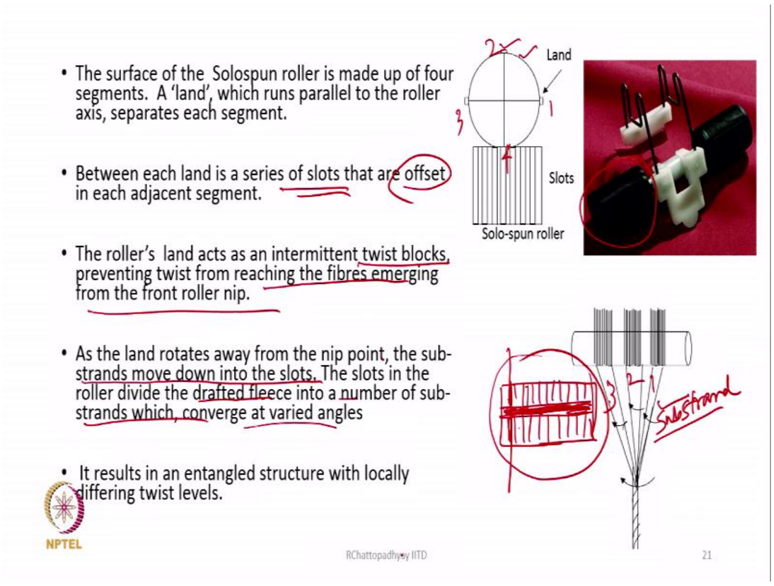

The interesting part is in the design of this the solo spun roller which is shown in black color here this rollers the surface of the solo spun roller is made up of four segments a land which runs parallel to the roller axis and separates each segment. See like this is the roller and here this is the land. The land goes from one end of the roller to the other end.

So, this is the land is there and then; that means, it is something like this that if I say this is my roller and here is suppose I say land then I have channels or groups like this on this side on this side. So, there are 4 lands 1, 2, 3 and 1 is here 4 lands are there and the and in between the lands the periphery of the roller will be having grooves fine grooves.

Between each land is series of slot or groove whatever we say and these slots and grooves from one segment to the other there is a little offset between them offset between adjacent. That means, this particular slot and this slot will not be exactly on the same line they will not fall on the same line it will be certainly on the left hand side or right hand side of the previous one. So, they are little offset the roller's land acts as an intermittent twist blocks.

So, whenever the land will come the entire nip is going to be blocked preventing twist from reaching the fibres emerging from the front roller nip they will not allow the fibres to reach the front roller the twist flow will be temporarily blocked when the land because the land is there when land is there means a raised portion on the surface of the roller and when this comes into contact with the bottom roller the yarn is in between them how the torque can flow torque will not be able to flow.

So, momentarily there will be interruption to the flow of twist or torque it is something similar to twist blocking rollers. So, as the land rotates away from the nip point the sub strands move down into the slots when the land moves away now, ideally the fleece of fibres will settle in the slots. So, there are so many slots are there they will settle because fibres are coming randomly.

So, they will settle in different slots and as a result the drafted fleece will be divided into number of strands and then this strands which are divided into as a shown is here, they are divided like 1, 2, 3 it could be 4, 5 also they will get now the twist will be flow to there and they will get twisted and these division 1, 2, 3 may not be exactly same you know same in terms of mass per in the or the number of fibres which are there in 1, 2, 3, 4, 5 each of the sub strand.

So, these are basically we can write sub strand and sub strand 1, 2, 3, 4, 5 may have different numbers of fibres in the cross sections because this roller which is solo spun roller is known as we will not be able to really divide the fleece into equal parts. So, it could be there will be some variation in some sub strand fibres may be more in compared to the others, but that does not matter the twist will flow there and each sub strand will be twisted and then they are going to converge and as a whole they will now get twisted and form a plied structure that is how it is going to work.

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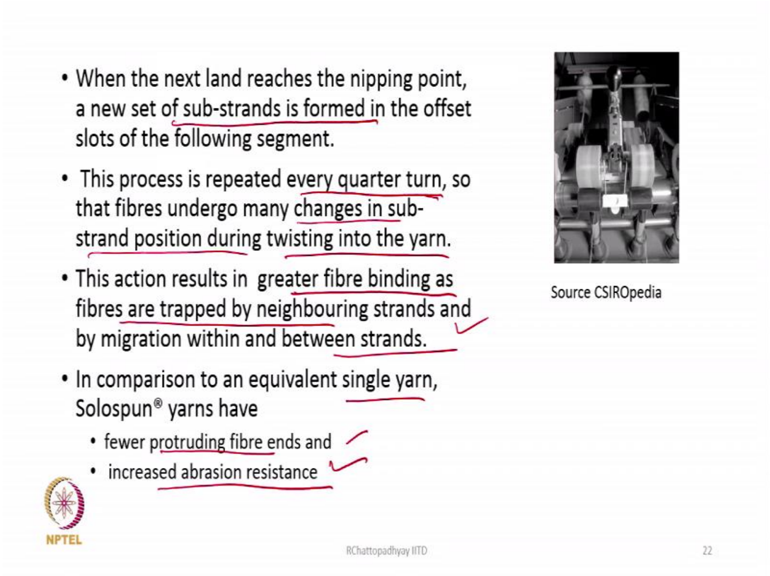

So, when the next land reaches the nipping point a new set of sub strand is formed. So, one sub strand gets formed the twist flow is interrupted because of the land is coming there and now again the land moves away another set of sub strand will be formed and because of the offset the previous and the new sub strands may not be exactly matching there will be different between them.

And this process is repeated every quarter run every quarter turn. So, the fibres undergo many changes in sub strand positions during twisting because every rotation means 4 times the sub strand formation will be there and the sub strand formations will be different from each other. So, as a result what happens this as gives in a greater binding of fibres and better trapping of the fibres.

So, instead of two we can say simply say there are many sub strands many means not 10 or 12 could be 3, 4, 5 because too fine a sub strand may break also, but for long staple fibres they may not break as well. And instead of two strand getting twisted in the SIRO spinning where having multiple strand getting twisted together and this gives a better binding of fibres.

So, in comparison to equivalent single yarn, solo spun yarns will have fewer protruding fibres and increased abrasion resistance because of better binding of surface fibres.

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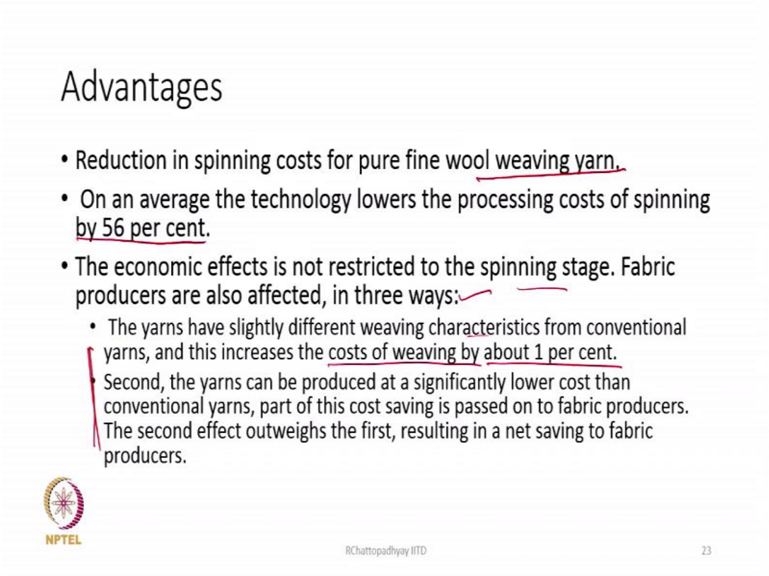

Advantage is reduction in spinning cost for fine wool which can be directly woven into fabric. The processing cost goes down as estimated to the extent of 56 percent. So, it may vary from country to country. The economic effect is not restricted to the spinning stage fabric producers also get affected in three ways. The yarns have slightly different weaving characteristics from conventional yarn and this increases the cost of weaving by about 1 percent.

Second the yarns can be produced at a significantly lower cost than conventional yarns. Part of this cost saving is passed to the fabric producers. The second effect outweighs the first resulting in net saving of the fabric. This is some, you know in terms of a commercial point of view. Someone has studied the you know feasibility from the point of view of commercial angle that these yarns, you know if you use these yarn probably there will be a final advantage to the fabric producers.

And that is the last slide. So, we have discussed the SIRO spinning and solo spinning conceptually both are same. And we tried to actually cut down the lengthy porocessing sequence of producing a plied yarn by following this technique where we can produce a plied structure in a single step. And the same concept has been extended to air jet spinning also. And accordingly machine has been developed and also it has been expanded to compact spinning as well.

So, same concept is used in ring spinning process, in air jet spinning process also in compact spinning process. Idea is to produce a yarn directly. Produce a yarn means produce a ply yarn directly instead of following the classical procedure or classical technique. So, that we get a better quality yarn and it may be or may not be as good as, there are lot of studies still going on.

Maybe may not be as good as two ply yarns, classical 2-ply yarn, but it will be close to that. But the cost saving is so much that it is a very attractive proposition for the industry. And therefore, the Murata twin spinner as well as the grid system of compact spinning are becoming quite popular in the industry ok.

With that we close today's session.

Thanks.