New Spinning Technologies
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Lecture - 07
Significance of fibre and process parameters

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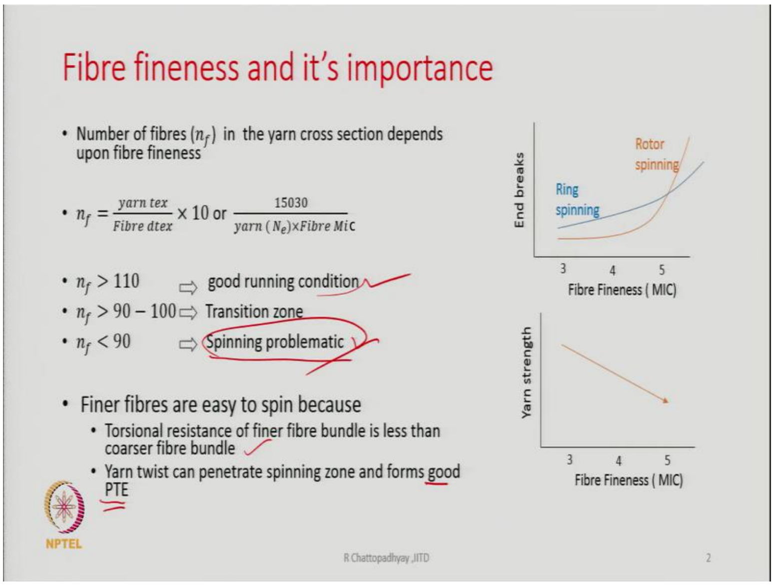

Today, we are now going to discuss Significance of Fibre and Process Parameters. We have already learnt about the rotor spinning machines, its working principles, and various parts or elements that makes this know particular machine. Now, we are going to discuss the importance of fibre parameters. So, first thing is you see the two diagrams are there on the right hand side. And the diagram shows fineness on one side and the other side end breaks fineness as well as yarn strength.

Now, what is the importance of fibre fineness in the case of rotor spinning? First of all irrespective of the spinning the number of fibres in the yarn cross section depends on fineness of the fibre for a given count of yarn. When the yarn count is fixed, now how many fibres are there in the cross section of the yarn will be decided by fineness of the fibre.

In that case, it is not dependent on which spinning system we use, whether it is ring spinning rotor spinning or any other spinning, does not matter. The number of fibres in the yarn cross section is dependent only on fineness of the fibre for a given count of the yarn.

In the case of rotor spinning, if we have more than 110 fibres, you will have good running conditions. So, you have to see that the fineness of the fibre is chosen in such a way that it should not fall below 110. Otherwise, the running condition of the machine will suffer.

90 to 100 is the transition zone, and less than 90, spinning is going to be problematic in nature. What does it mean problematic? That there will be too many very frequently we will encounter end breaks, and therefore, we should never allow the number of fibres in the yarn cross section to go below 90 at no cost. Because spinning will be almost impossible.

And the yarn will be too faulty because too many breaks will be there. This efficiency of the process will go down. It will not be cost effective at all. So, that is these are the important aspects. And here the fibre fineness is going to play a role.

Finer the fibre easy to spin because torsional resistance of the fibre bundle is less in comparison to coarser fibre bundle. The torsional resistance or torsional rigidity is dependent on the diameter of the fibre. So, finer fibre means their torsional rigidity are less and therefore, this will be easy to twist.

Yarn twist can penetrate the spinning zone and forms very good PTE. PTE we have already discussed earlier. PTE is Peripheral Twist Extent that is part of the twisted yarn that remains in contact with the rotor groove that is called peripheral twist extent. So, we need a certain amount of PTE to ensure stable spinning, otherwise the spinning becomes very very unstable. So, finer the fibres, better it is.

Now, it is shown in this diagram that as the fibre becomes coarser, the end breaks rates goes up, whether it is ring spinning or rotor spinning, in the both the cases. Coarser yarn, coarser fibres mean less number of fibre in the cross section, cohesion is less, the twist is not in a position to penetrate, the fibres which are there in the groove of the rotor. And as a result the end breaks will go up.

The other thing is that with the coarseness of the fibre, the strength of the yarn also goes down. There will loss in cohesion between the fibres. Therefore, fineness plays a very important role.

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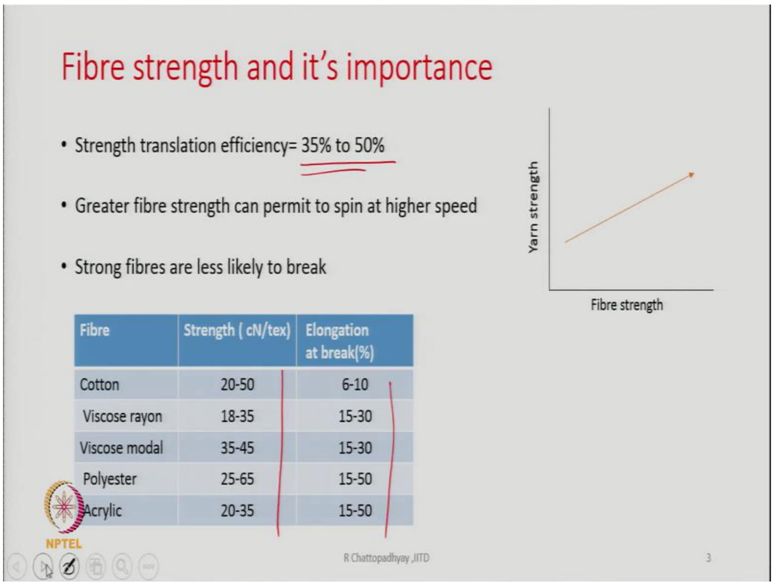

Then comes the fibre strength. Typically, strength translation efficiency in the case of corresponding yarn is 35 to 50%. That means, whatever the fibre tenacity that we get, 35 to 50% of that tenacity is actually realized in the yarn. So, if the fibre tenacity is 'x', the yarn tenacity is going to be 0.35x or maximum up to 0.5x.

So, there is a 50% reduction almost or even more than that could be in the tenacity translation. However, greater fibre strength can permit to spin at higher speed, higher speed and stronger the fibres, stronger is the yarn. That is in generally true, both for ring spinning rotor spinning. If you use strong fibre, then only we will get strong yarn.

Strong fibres are less likely to break also, because the action of the opening roller teeth on the fibres is very very aggressive and very very intense. And because opening roller is at very high speed and the end break breakage of the fibres can be avoided if the fibres are strong, less number of fibres will break.

Now, typically the strength of fibres; some fibres are stated here which are used for spinning cotton 20 to 50 cN/tex, viscose rayon 18 to 35, viscose modal 35 to 45, polyester 25 to 65, acrylic 25 to 35. So, these datas are anyway available in other text book also. So, typically the fibres which are used in the case of rotor spinning are stated here and their strength and elongation values are also quoted.

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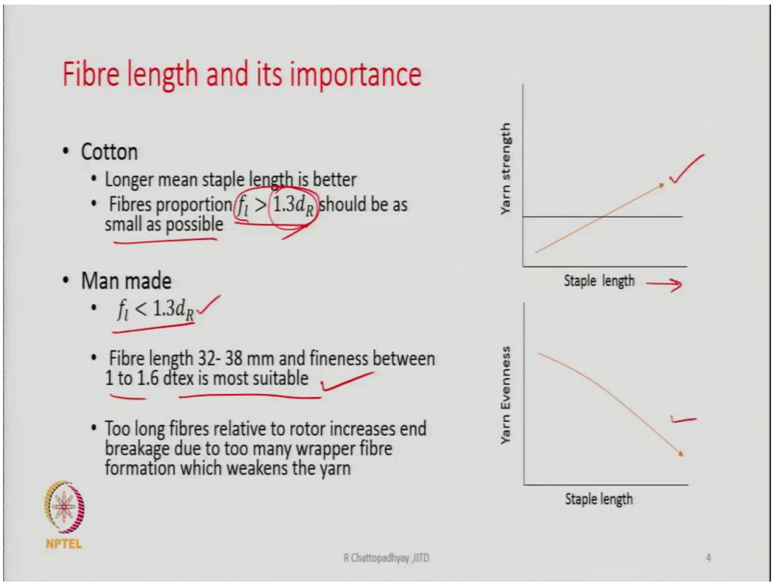

Next comes the importance of fibre length. So, what we see in the diagram is as the staple length is going to increase, the yarn strength is going to increase. That is the general behavior. So, short are the fibres, lower is the yarn strength; longer the fibres, more will be going to be yarn strength.

And with increasing staple length, yarn evenness goes down. This is something very different in comparison to ring spinning process. The ring spinning we do not find it. Longer fibres means always very uniform yarn. But in the case of rotor spinning, this may not be true. Longer fibres means much more uneven yarn.

We will see gradually that why the yarn becomes uneven when the fibres are long. But still shorter fibres are not really good for rotor spinning also. There has to be some minimum length and that way long fibres is always good, but too long may be bad. So, medium length fibres are best suited for rotor spinning.

Fibre proportions should be as small as possible. With fibres, fibres greater than $1.3d_R$, where 'd_R' is the rotor diameter. These fibres that means, 1.3 times the diameter whatever fibres are there, this should be as small as possible. And in the case of man-made fibre this is also true and for cotton also, for man-made fibre, this should be less than this for cotton. What it is saying? That this fibre proportion should be as small as possible fibres; that means, the very very long fibres.

For a given know diameter of the rotor, the fibres which are 1.3 times more than diameter of the rotor, these numbers should be less. Minimum there, better it is. Because these fibres are prone to form wrapper fibres. We will see that how wrapper fibres are basically you know produced. I am I think we have already discussed this earlier. And therefore, very long fibres are not good.

For man-made fibres fibre lengths it should be 1 point, less than $1.3d_R$. Typically, fibre length for 32, 38 mm and fineness between 1 to 1.6 dtex is most suitable. For man-made fibres do not have any short fibres. Whereas, cotton fibres have short fibres. And see when man-made fibres are almost you can say hardly any short fibres are there, unless we generate short fibres while I am processing the fibres on blow room and card.

Because carding machines may generate some short fibres because of very intense carding action. Otherwise, man-made fibres will not have any shorter fibres, but typically therefore, the length of the fibres should be 1.3 times of the diameter less than that, because most of the fibres if it is exceeds this length most of the fibres are going to form wrapper fibres. Wherein, the case of cotton this is not true because cotton has a, its own fibre length distributions.

And therefore, you have shorter fibres, you have medium length fibres, you also have very long fibres. Too long fibres are in the case of cottons are bad. They are going to form you know the wrappers and wrapper fibres is something which is in nuisance for rotor spinning and we want to avoid them. So, too long fibres relative to rotor increases end breakages due to many wrapper fibre formation which weakens the yarn.

We will see that when we study discuss the structure of the rotor yarn in some other lecture, that the wrapper fibres are type of fibres which are wrapping the core part of the yarn. So, the rotor spinning we can say that you know it has a core and it has a sheath kind of thing. The sheath is basically formed by the wrapper fibres.

May be sometimes part of the wrapper remains within the yarn, rest of the fibre is actually forming wraps around the core part of the yarn. And these wrappers fibres more than number, there we can going to weaken the yarn because they do not participate in load bearing, when the yarn is actually stretched. So, when the yarn is stretched, how many fibres are supporting the load really matters and that decides the strength of the yarn.

In the case of rotor spinning because many fibres are simply wrapped over the main core. These fibres will not get tension, when you stretch the yarn. And therefore, they do not contribute towards the strength of the yarn. So, they are going to contribute towards the mass of the yarn only, not towards the strength. And hence lesser than number better it is always. So, we have to see that how to reduce the number of wrapper fibres which will otherwise spoil the yarn quality. So, you have to avoid them.

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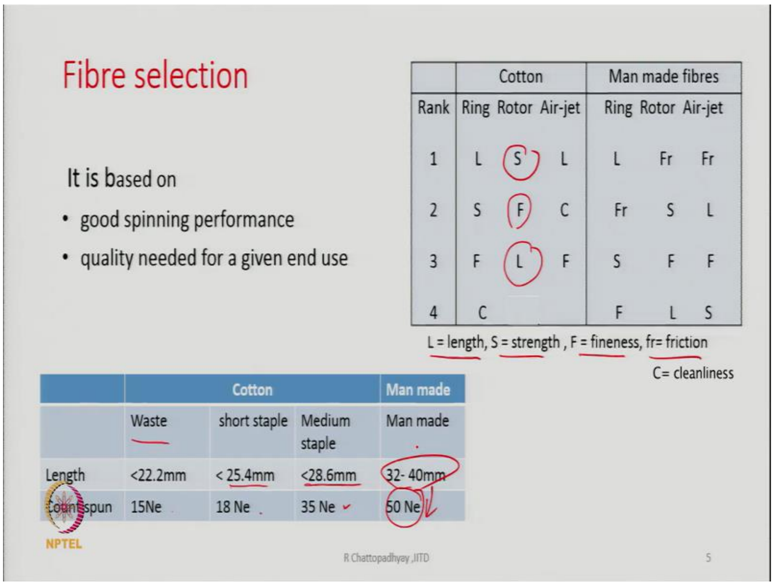

Fibre selection is based on spinning performance and quality needed for a given end use. Now, here a table where which is shown for different spinning system how the fibre parameters are important. So, for rotor spinning if we look at it for cotton, strength of the fibre is most important. That is rank one followed by rank two which is fineness of the fibre, the rank three is coming the length of the fibre.

That is how it has been shown by some author that in ring spinning length is most important in air jet spinning length is most important. But whereas, in rotor spinning the strength of the fibre becomes most important. And length occupies the third position. Because long length does not necessarily mean strong yarn in the case of rotor spinning because there is every likelihood that this long fibres may be part of the wrappers which will not contribute towards the strength.

So, some guidance is given here in the lower know table. That is typical length of waste fibres for cotton, short staple, and medium staple is given. And these fibre lengths are suitable for spinning count of yarn of 15, 18 and 35 or depending upon the basically the length of fibres.

For man-made fibres 30 to 40 mm fibre length can be chosen and we can go up to 50 Ne is very very fine count. We can make 36 Ne, we can make somewhere in 30s, it is possible to spin with 32 to 40 mm fibres. Because in the case of man-made fibre, if you choose a length between 32 or 38 or 40 almost all the fibres will be of same length. There is no short fibres in it. Whereas for cotton, this is not going to be true.

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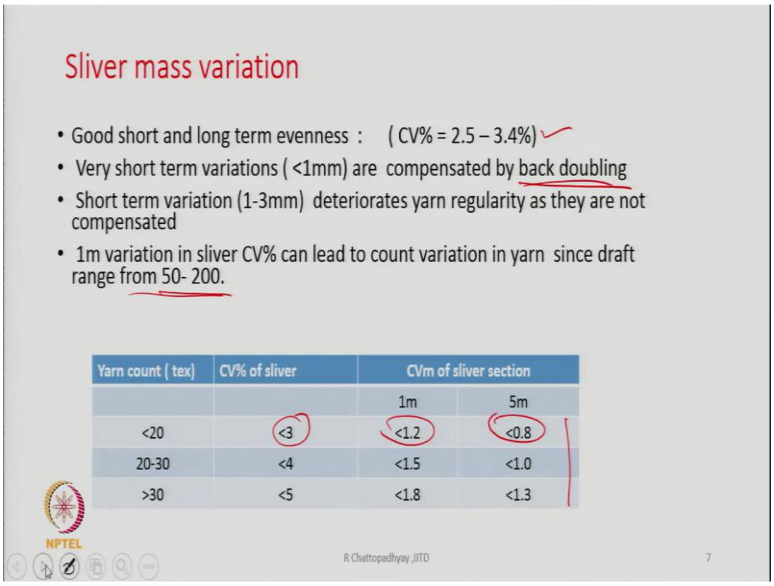

So, after discussing the fibres, now we are going to discuss the sliver preparation. First of all, sliver mass variations. For good short and long term evenness, the CV, mass CV of the sliver should be 2.5 to 3.4%. Very short term variations are compensated by the back doubling. I think we have also discussed this term back doubling earlier.

The very short term variations in the sliver would be compressed because of the back doubling which is happening within the rotor because fibres are actually accumulating within the rotor in the form of layer after layer. And there is a doubling action because of this. Which is going to suppress the very short term variations present in the feed sliver.

Short term variations which are 1 to 3 mm, deteriorates yarn regularity as they are not compensated. 1 meter variation in sliver CV can lead to count variation in the yarn since draft is in the range of 50 to 200. Depending upon the count we give a draft of 50-200 to the sliver to make a yarn.

So, 1 meter variation in sliver CV may lead to count variations in the final yarn. So, some typical values are also shown here, for yarn count less than 20, the CV of sliver CV, 1 meter CV of slivers and 5 meter CV of sliver. These are some kind of norm you can say which the industry follows.

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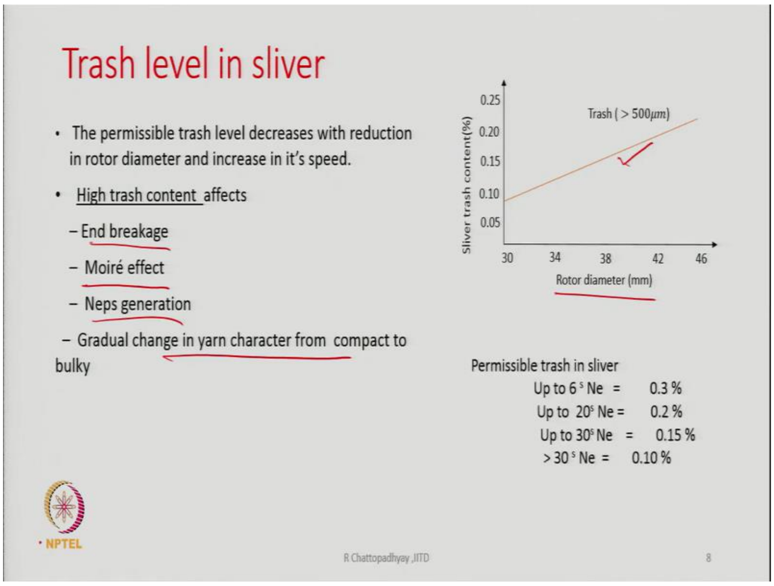

The other important fact is the trash level in this sliver, especially in the case of cotton. The permissible trash level decreases with reduction in rotor diameter and increases in its speed, and increase in its speed. That is if I go for higher speed my sliver should be very very clean.

And if I want to go for a smaller diameter rotor, the sliver has to be very clean. There will be very low trash content in the sliver. And if I want to spin faster using a smaller diameter rotor, we have to go for a sliver which is very very clean. That is what becomes important.

So, the permissible trash content versus the rotor diameter, there is a kind of graph as is shown is here that is trash content. The diameter is more trash content you can say tolerable trash content in the sliver is going to be higher. But larger rotor diameters can manage with little more dust content in the sliver. Or the smaller diameter rotors are very sensitive to the dust content and hence we need more clean sliver to process them; process on rotor spinning machines.

High trash content affects, what else it affects? End breakages, it increase Moire effect, it will create neps generations, and it can gradually change the character of the yarn from compact to bulky. If we do not you know bother much, then we see that the quality of the yarn is suffering from beginning to the end of the package because of high trash content and is presence in the groove.

Whatever trash is left in this sliver, then trash cannot be taken out. Some trash will be left in the sliver or always even if we go for combing, still there is some you know trash particle left. And these trash particles will always go inside the rotor. But from the rotor they has no escape route for them. So, they will be generally staying within the rotor and they will accumulate within the rotor groove.

And that becomes a source of problem, especially Moire effect, it can lead to end breakages, neps generation, and gradual change in yarn character. Because of accumulation of dust in the groove itself which will affect the flow of twist and. That is why the problems will arise.

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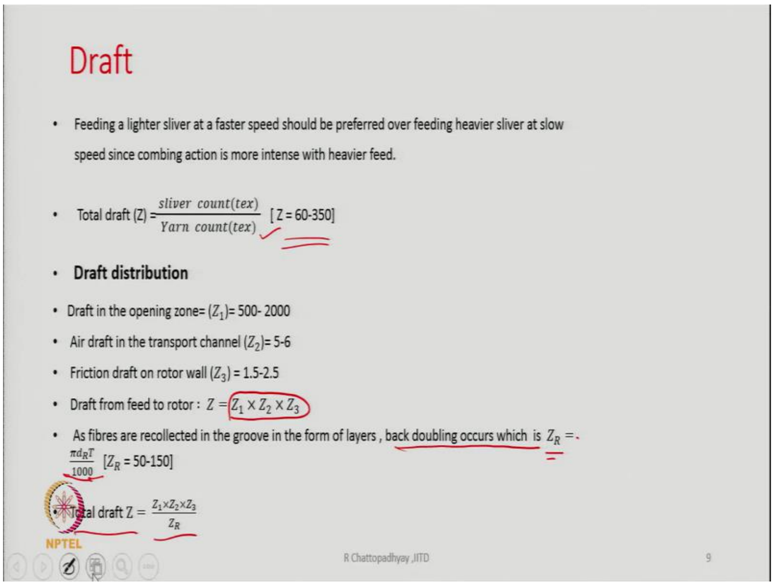

Next one is draft. How much draft we should keep on the machine? This question always comes, that is for a given count what should be the sliver count. Feeding a lighter sliver at a faster speed should be preferred over feeding a heavier sliver at a slow speed since combing action is more intense with heavier feed.

So, you have a choice, that is finer sliver higher speed or coarser sliver and slow speed. In these two cases, it is better to go for a lighter sliver and feed them little faster. Then, using a coarser sliver and feeding it slower, that is not preferable.

$$Total\ draft(z) = \frac{Sliver\ count(tex)}{Yarn\ count(tex)}$$

And that varies between 60 to 350, depending upon the count of yarn I am going to produce.

Draft distributions, draft in the opening zone is around 500 to 2000. The transport channel it is 5 to 6. The friction draft on the rotor wall around 1.5 to 2.5. And draft from feed to rotor would be the multiplication of the individual draft 'Z_1', 'Z_2' and 'Z_3'. If we multiply these 3, we get the total draft in the opening zone.

As fibres are recollected in the groove in the form of layers, back doubling occurs, which is how much is back doubling in this case. Z_R is '$\pi d_R T/1000$'. It can be shown or proved that the back doubling that occurs is dependent upon diameter of the rotor and the twist, both of them are responsible.

Now, we go to the next slide. So, total draft if we try to find out it is,

$$Z = \frac{Z_1 \times Z_2 \times Z_3}{Z_R}$$

What is Z_R? 'Z_R' is the back doubling occurs which is 'Z_R'. That means, several layers of fibres are again getting sandwiched within the rotor groove. So, that also has to be taken into account. Therefore, total draft is '$(Z_1 \times Z_2 \times Z_3)/Z_R$'.

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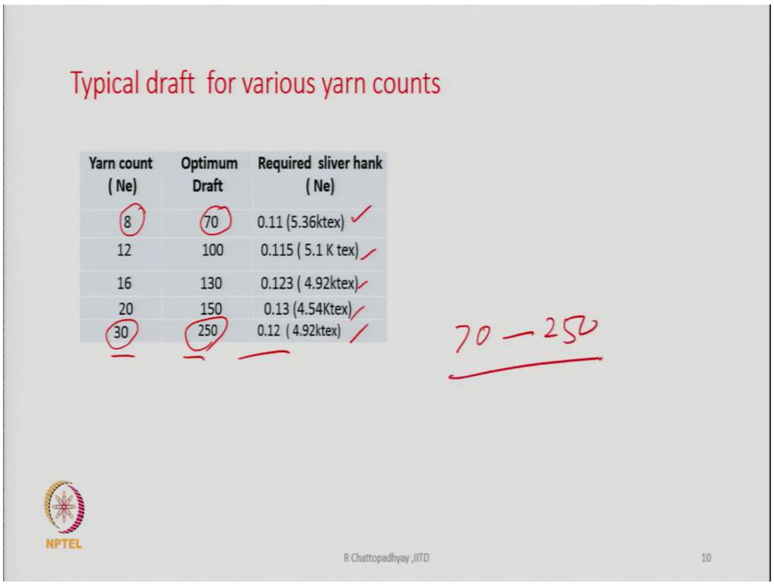

Now, typically the draft for various yarn counts typical values are quoted. These are can be practiced. That is what we see here if the count becomes finer the draft becomes high, when the draft is actually coarser the draft is also low. So, this kind of you know draft that exist it could be 70, it could be 130, 150, it can go up to 250 also.

And if that is the draft to use then we can find out what is the type of sliver that we need to manufacture the rotor yarn. So, total draft range if somebody ask how much draft is normally used, you can say the range is between 70 to 250.

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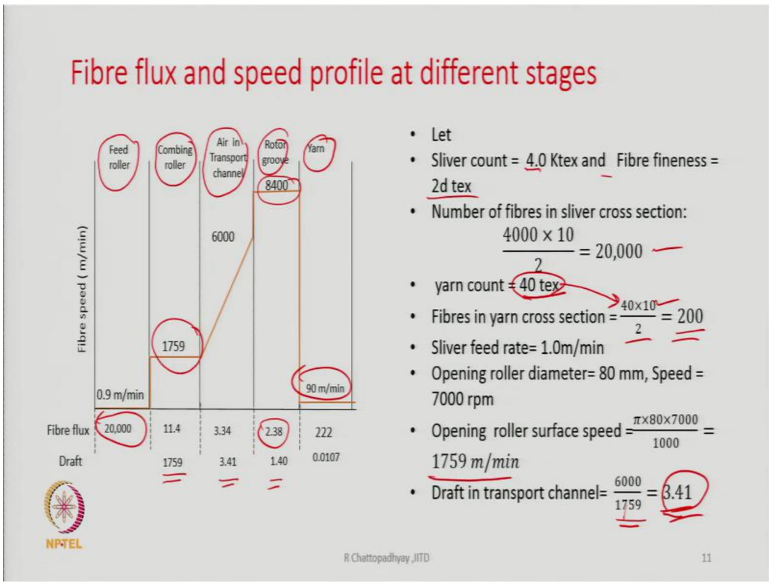

Now, fibre flux and speed profile at different stages. A diagram is shown here and now I will do some calculation to show it how these figures or a figure close to this are coming. So, this is different zones feed roller zone, feed zone, combing roller zone, or opening roller zone, air transport channel, rotor groove, and actual yarn formations. So, I have 1, 2, 3, 4, 5 different you can say sections of the machines and we want to find out what is the fibre flux.

Now, first let us look at this small numerical just to find out what could be the values. Sliver count is 4 Ktex fibre, fineness is 2 dtex. Number of fibre in the sliver cross section, we can find out is going to be 20000. Then, the yarn count is 40 tex and fibres in the yarn cross section is going to be '(40×10)/2'.

Yarn count is 40 tex, so this 40 comes here. I make it convert into dtex by multiplying by 10 and divide by the fibre fineness which is given in dtex which is 2. And therefore, the total value is coming 200. Fibres in the yarn cross sections therefore, is going to be 200, sliver feed rate is 1.0 m/min. That is we feed this sliver at a very very slow speed, hardly 1 m/min.

The opening roller diameter is suppose it is 80 mm and speed is 7000 rpm, then opening roller surface speed we can calculate which is going to be 1759 m/min, almost 1800 m/min.

Draft in transport channel is we can find out '6000/1759', that is 3.41. This is the draft within the transport channel. That is the fibres are leaving the surface of the opening roller and through the transport channel it is landing on the rotor wall. So, I am travelling, travelling this small distance, opening roller surface to the rotor.

There is a draft, because the air is accelerating continuously and the draft in the channel could be to the order of 3.41. So, that is how the drafts are shown and if you look at this diagram, the speeds are shown at different stages, the how the fibre is flowing through the machine, and at what speed, that fibre speed we can find out from this diagram.

And second thing that we can find out is how many fibres are there in the cross sections. So, that data is also given depending upon the sliver count, and the sliver or the yarn count, the sliver count in actual practice and we can find out these values. The fibre flux in the beginning which 20000, it comes down to 2.38 which is very very low.

And the draft different stages are also shown here. The combing roller, opening roller is very high, then it is coming down 3.41, further down to 1.40. So, these are the fibre flux and draft values at different stages of production. That is what is given here. And the transport channel draft is shown to be 3.41. Its transport channel draft is only because of accelerating air current.

So, what is the air velocity at the entry? And what is the velocity in the entry in the exit? If you know this take the ratio, that will give you the draft in the transport channel.

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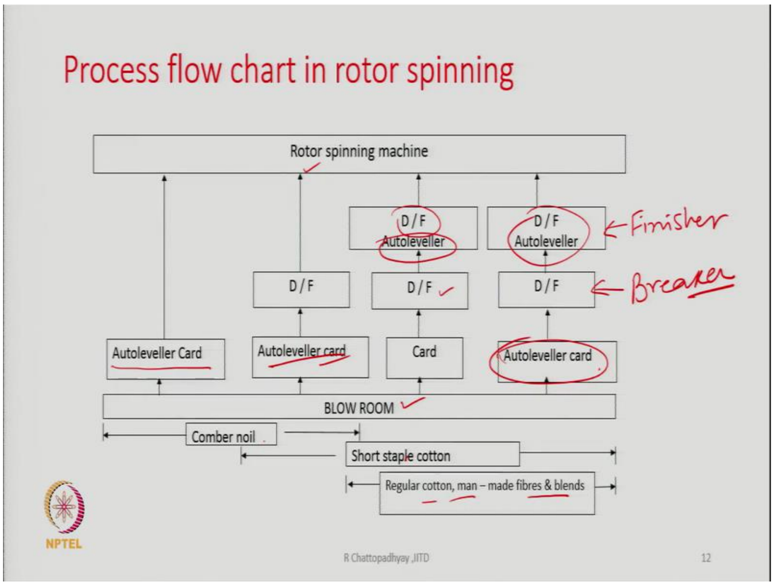

This gives a flowchart of the rotor spinning process you can say. So, the rotor spinning process flow chart is shown here that we start with short staple fibre or comber noil whatever we get or also we can take regular cotton man-made and fibres and blends. These are the 3 different types of machines also.

So, what we see here there are various practices in the industry. One is you take the fibres in the short stable form or comber noil or mix them together, whatever we want and then the first operation is the blowroom operation, where we will further open and clean it.

And then from the blowroom it can directly go to the autoleveller card, and it finishes there. From there, I get sliver directly which we can feed to the rotor spinning machine. This is one options of the process flow chart.

The other one is that you from the blowroom you feed it to the autoleveller card and then from there it goes to a drawframe which do not have any autoleveller. So, give one passage to the drawframe, make this sliver little bit parallel to each other and then we feed it to the rotor spinning machine for subsequent spinning operation. This is one process.

The other one is normal card we take, we may not take autoleveller card, we pass it through a drawframe and now we have a second passage drawframe, we autoleveller are available. So, we can go basically are giving two drawframe passages with autoleveller as in the drawframe itself. You will get a quite uniform sliver and this can go for spinning on the rotor spinning machine. That is another process.

The other one is its card itself autoleveller. After autoleveller card sliver goes to drawframe and from drawframe breaker drawframe, it goes to the finisher drawframe. So, these are you can write finisher and this is breaker. So, breaker drawframe and then finisher drawframe.

So, breaker drawframe passage and finisher drawframe package. So, finisher drawframe package that is finisher drawframe we try to keep the autoleveller. Autoleveller will even out the mass variation which is present in the sliver. So, the advantage is there of having autoleveller in the end. Because whatever faults are mechanical faults are generated by the card or by the very fast drawframe, all of them will be then even out because of the autoleveller drawframe that we have as the last process.

Fibre orientation is going to improve. And at the same time the mass variation is going to be evened out, by having this thing. So, whatever process flow chart that we follow that depends upon what is the yarn count I am going to make, and how good quality yarn I want to produce, which is also dependent upon the buyers need, and his paying capacity. What is the buyer need, how much he can pay, depending upon we have to choose the processing sequence.

So, we have 1 processing sequence, 2, 3, 4. There are 4 processing sequences which have been you know described here and as I said depending upon the quality of the yarn, the count of yarn, that the buyer is looking for and the payment he can make, we choose one of them.

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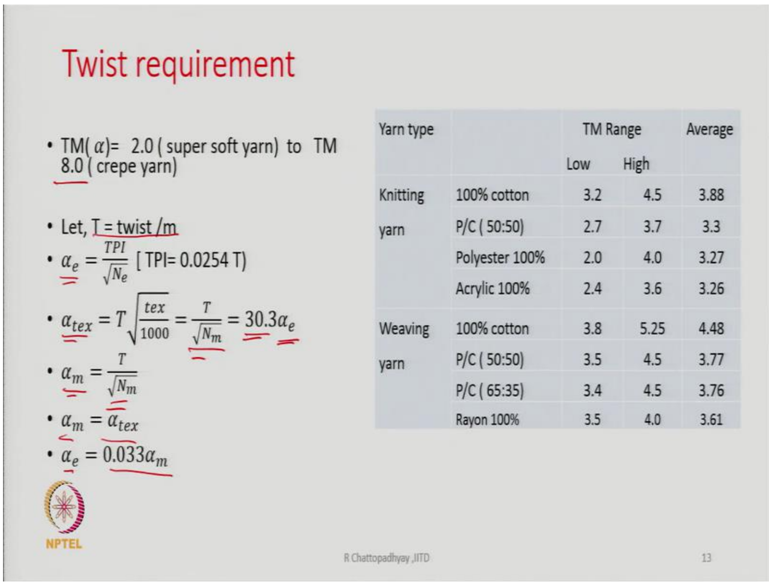

Now, it is requirement of twist. How much twist is required in the yarn? Or how much twist multiplier is required in the yarn? Twist multiplier can vary from 2 to 8, huge range. 2 is for super soft yarn and 8 is for crepe yarn. If the 'T' is the twist per m, then α_e, 'α_e' indicates here the twist multiplier in English system is,

$$\alpha_{tex} = T\sqrt{\frac{tex}{1000}} = \frac{T}{\sqrt{N_m}} = 30.3\alpha_e$$

The twist multiplier in English system 'α_e'. So, 'α' indicates twist multiplier and the letter the subscript indicates the system, the counting system we are using. And

$$\alpha_m = \frac{T}{\sqrt{N_m}}$$

where 'T' is indicating twist per meter, and 'TPI' indicates twist per inch.

$$\alpha_m = \alpha_{tex}$$

$$\alpha_e = 0.033\alpha_m$$

And here is a direct table that gives you an idea typical twist multiplier which is chosen for different types of yarn.

For knitting yarn, the TM range is 3.2 to 4.5. For PC yarn that is polyester cotton yarn, it could be 2.7 to 3.7. So, a kind of know guideline or suggestion is given which are generally practiced in the industry. And one can follow this. And we can generally say from this table that for weaving on, the yarns which are meant to be woven the twist multiplier is on the higher side, in comparison to the yarn that is meant for knitting or hosiery. Because for weaving we need strong yarns.

For hosiery, we do not need so much strong yarns. And hence, the if we keep more twist we expect the yarn to be stronger. And that is why we keep higher TM.

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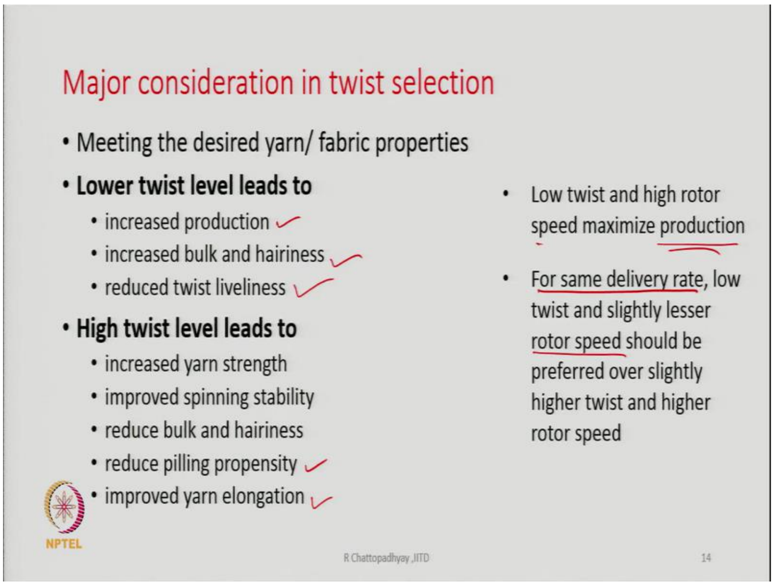

The major consideration in twist selection is meeting the desired yarn and fabric properties. That becomes the most important consideration for twist selection. Do we need a? Because generally we need know that lower twist level leads to increased production, increased bulk and hairiness, and reduced twist liveliness.

So, these are the advantages we can say to keep low level of twist. And high level of twist, on the contrary, will lead to increased yarn strength, it will improve spinning stability, reduces the bulk of the yarn. The yarn will look now little thinner because diameter will go down. It will reduce pilling propensity, and it can improve yarn elongation also.

So, advantage is also stated here. And depending upon that we should choose the twist. Low twist and high rotor speed maximize the production. But also we have to keep in mind that how low we should go. If we go for high twist, how high we should go. That will all depend upon the kind of product we want to make from that particular yarn.

For same delivery rate, low twist and slightly lesser rotor speed should be preferred over slightly higher twist and high rotor speed. If we have a option between these two, for the same delivery rate, there are two possible options.

Low twist and slightly lesser rotor speed or higher twist and higher rotor speed. The preference will be given to the low twist and slightly lesser rotor speed, because this will reduce power consumption because the rotor speed is low.