Evaluation of Textile Materials
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Lecture-31
Evaluation of Yarn Evenness

Hello everyone, today I will start one most important characteristics we will discuss the characteristics which is important for textile material which is evenness.

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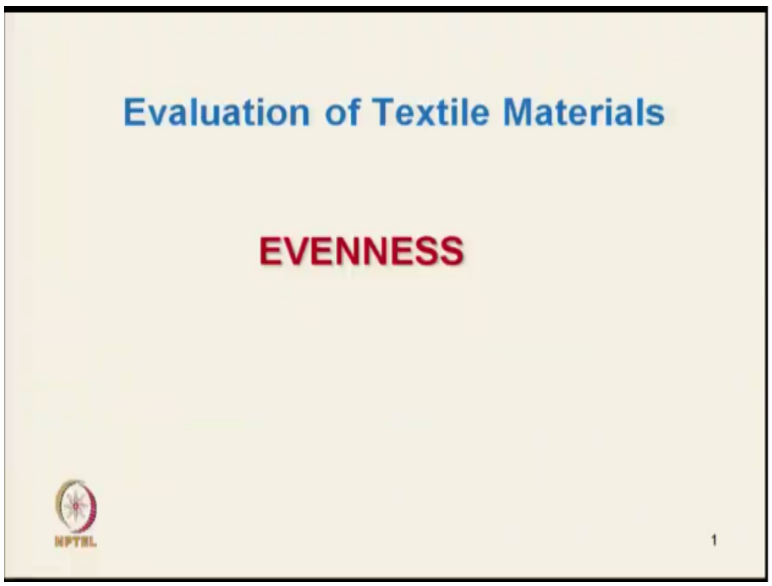

So, evenness means that whether there is the material is even or not there is a any irregularity is there or not. So, textile material particularly the staple yarn we cannot produce without any irregularity, so we will discuss all the aspects related to irregularity of textile material.

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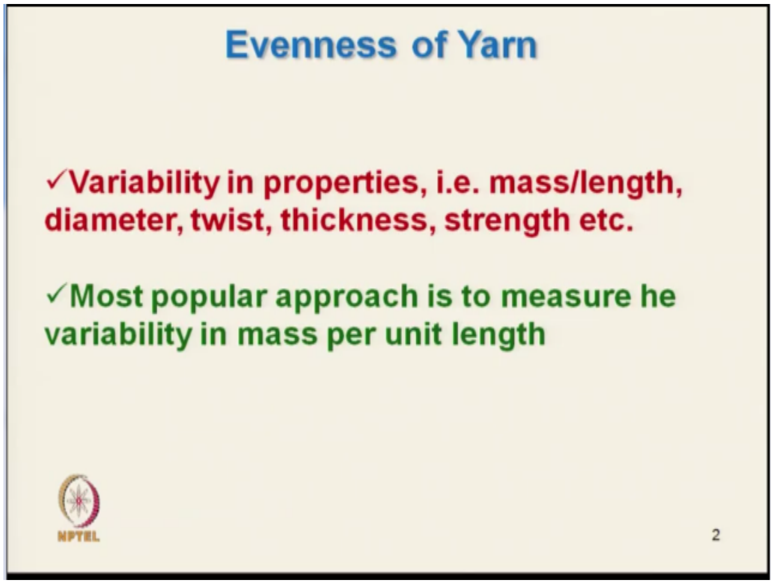

So, first we will discuss that the evenness in yarn what does it mean, so evenness actually mean that variability in property ok. That property maybe in terms of linear density that is mass/unit length, maybe due to the diameter variation in diameter, variation in twist, thickness that means it is diameter if it not circular then you can call it as thickness, strength. So there are wide range of variabilities. but most important variability which affect all other characteristics is variation in mass/unit length or in variation in diameter which are interlinked ok.

So, in our discussion here, in this topic we will discuss the variability in textile yarn particularly spawn yarn in terms of mass/unit length or in terms of diameter. And twist thickness strength are directly related with this characteristics with the variation mass/unit length. So, the most popular approach is to measure the variability in mass/unit length ok that is the most popular approach, so most of the testing instruments which measure the variability in yarn. They are in terms of either mass/unit length or in terms of diameter, so first let us see the variation in mass/unit area unit length, sorry.

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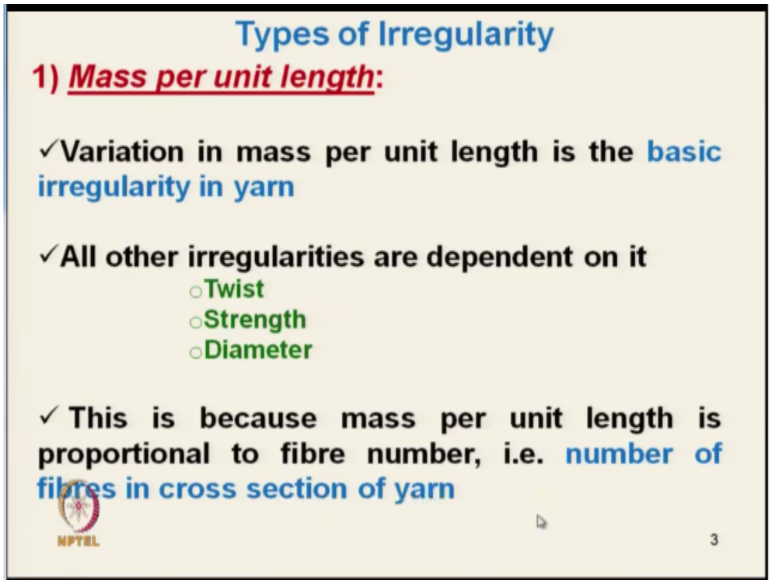

So, that is called the basic irregularity, so that why is it basic irregularity because all other irregularities are directly or indirectly related with the variation in mass/unit length. So, what are the other irregularities which directly depend on this mass variation these are twist variability, strength variability, diameter variability. Now if we see the variation in twist how is it related with the variation in mass/unit length.

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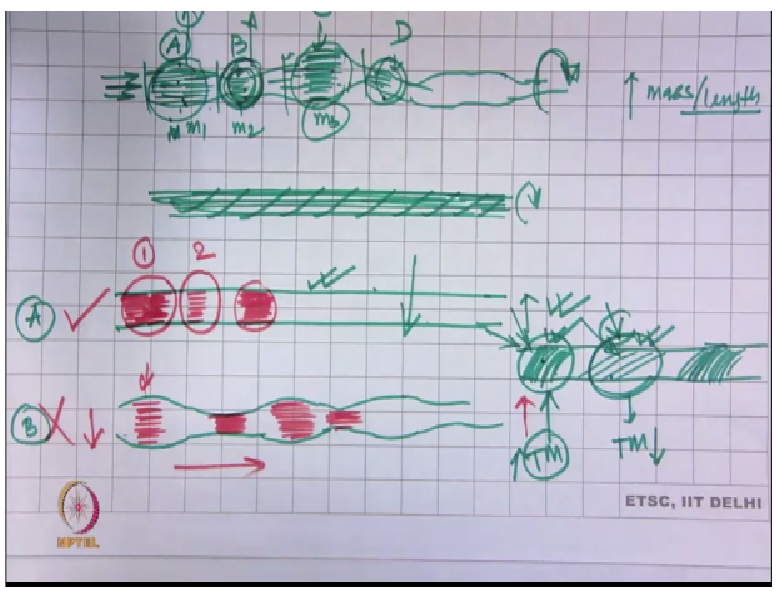

So, this is 1 yarn staple yarn ok this is a yarn strength, so it is a fiber strength it is coming out from the front roller neef of drafting system. Now when we impart twist so in this portion, portion A, this is portion B, this is C, D like this we can divide into different zones. So, in zone A the number of fibers in the cross-section is large number ok and in zone B number of fiber in the cross-section is less, that is why it has got mass variability.

If we take the mass of zone A it is m1, m2 if we cut this so the mass of zones will be different. Now here this yarn as got very high mass irregularity mass/length irregularity, now if we apply twist on the strength, so as zone A has got large number of fiber ok. The torsional rigidity of this zone will be much higher than zone B because they are number of fibers in the cross-section is much less.

So, when we apply twist at this point, so the twist will get will not be distributed even throughout the yarn. Suppose let us see another situation where it is a filament yarn, number of filaments are exactly same ok, this is filament yarn. Here if we apply twist as number of filaments are same the torsional rigidity of each and every point are almost same. So, the twist will get distributed evenly, so as mass variation is not there, so here twist variation will also not be there ok.

Now but the situation is different for staple yarn case with very high mass irregularity, so twist flow will be entirely uneven. That means maximum twist will be at the zones where number of fibers in the cross-section are less because of the high lower torsional rigidity. That means this twist variation will be there and if we measure twist it will have very high twist variation ok. Now the zone A or zone C will have soft twisted portion, so as this are soft twisted portion and this point is hard twisted portion.

That means rate of reduction in diameter due to twist will be much higher here than zone A that means the diameter variability will also be exaggerated. So, here this portion will have very high diameter and accordingly this portion zone B will have less diameter. So, diameter variability is also directly dependant on mass variation even if the twist variation is not there suppose twist variation is not there still the this portion A will have higher diameter than portion B.

If we assume there is no twist variation still A and C portion they will have higher diameter because of the presence of larger number of fibers, higher number of fibers ok. So, that is why the twist variation on diameter variation they are directly related with the mass variation. Still another characteristics the strength, so this strength of zone A will be definitely higher than zone B because number of fibers in zone B is much less than the fibers in zone A. That means the strength in the yarn is carried by the fibers, so as the number of fibers are less in zone B.

So, this zone B or zone D this zones will be the weak point ok, so and the yarn that breaks at the weakest point. So, the strength of the yarn will be lower if the mass variability is high, so the variability, mass variability it is the twist, strength, diameter they are directly dependant on the mass variability of the yarn, spawn particularly spawn yarn. So, this is because mass/unit length is proportional to the number of fibers in the cross-section ok.

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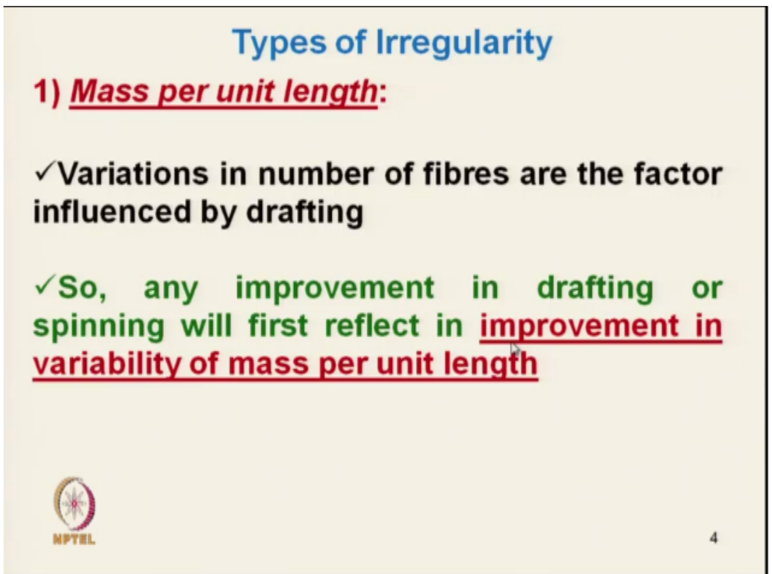

So, variation in number of fibers are the factor influenced by the draft, so due to problem in draft maybe due to eccentric drafting ruler or maybe any other problem, slippage in the drafting zone, so that causes the mass variability. So, any improvement in drafting or spinning system will improve the variability in terms of mass/unit length. So, if there is any variability, any mass variability, so we have to actually improve upon the drafting system or different spinning processes.

So, that the mass variability improves and as if we can control the mass variability in the strength then we can control directly the twist variability, diameter variability and also the strength variability, they are directly related with the mass variability.

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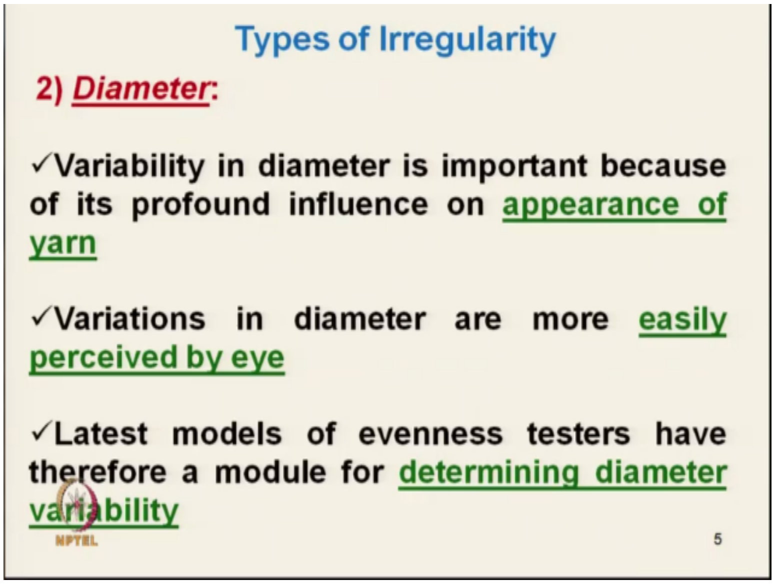

Next type of variability is that the diameter variability ok as I have already mentioned they are directly related with the mass variability and mass the diameter variability is extremely important as per as the appearance is concern. Now let us see another situation, so yarn A, yarn A has got mass variability, so suppose we have produced 1 yarn let us imagine this is 1 yarn. Now here the number of fibers in the cross-section the staple fiber I am trying to draw.

Somehow the number of fibers in the cross-section here in zone 1 it is very high, here it is a there is a loose packing although loose packing is there. But zone 2 has got less number of fiber but the diameter is same, so here higher number of fiber, so same diameter but mass variability is there. So, this actually this will not although there is high mass variability. But as the diameter is uniform in that case we can have fabric with uniform appearance at least in the grace date ok.

So, that diameter variability is also important suppose another yarn we can have another yarn where, so diameter variability is there ok, very high diameter variability. But number of fibers in the cross-section if we see say 10 fibers it is here and here also 10 fibers. So, this throughout the cross-section suppose I am having say 10 fibers in the cross-section you take that. Now if we measure the mass variability this yarn will give extremely excellent result very good result.

But if we measure the diameter variability this will be very inferior going to have, now if we see the appearance, appearance wise this yarn will fail, this yarn will pass. But as per as the mass variability, so this yarn will give excellent variable, so we have to see each which measurement we have to add up. So, that depends on various factors this things we will discuss ok, now although mass variability gives indication.

So, if suppose this yarn A, yarn B, so yarn B we can visually see it is variation ok, that we can always reject. But in this yarn suppose as per as mass diameter variability this is giving very good result, diameter variability is not there but the thing is that if we produce fabric out of that and after dying there will be total uneven effect uneven unevenness in the fabric, patchy dying will be there.

So, this will create problem in let us state although the diameter variability is not there in that case it is if we test in terms of mass variability then the that particular instrument will show this is the inferior quality level. So, that the weather should we go for diameter variability or mass variability we have to select depending on our priority. So, variability in diameter is important because of it is profound influence on appearance of the yarn.

So, appearance of yarn as well as the final product fabric ok, so it can be easily perceived by naked eye. So, latest models of evenness tester they actually test the mass variability along with the diameter variability also ok. So, that 2 types of approaches are there we can adopt any of the approach or both the approaches ok.

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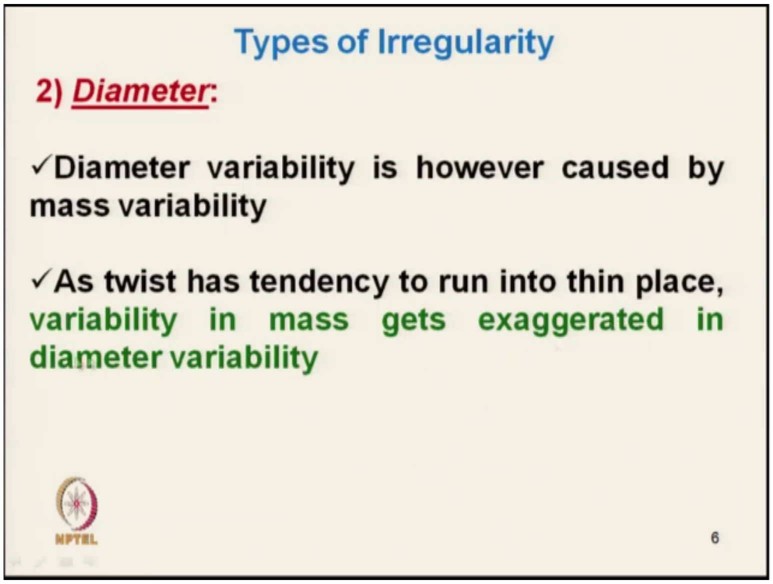

So, diameter variability as I have mentioned it is directly related with the mass variability, so if we test diameter variability we can have we can guess we can actually most of the cases diameter variability directly shows the mass variability. So, what I have explained earlier this those are the ideal cases, so but it is not it does not happen when mass variability is there that directly show the diameter variability.

On the other way if we measure the diameter variability that will show the mass variability also, as I have already explained as twist has tendency to run into the thin places the variability in mass gets exaggerated in the diameter variability. So, it shows of in the diameter, so if there is any mass variability means the uneven distribution of number of fibers, so that will indirectly show the diameter variability as twist will get distributed unevenly.

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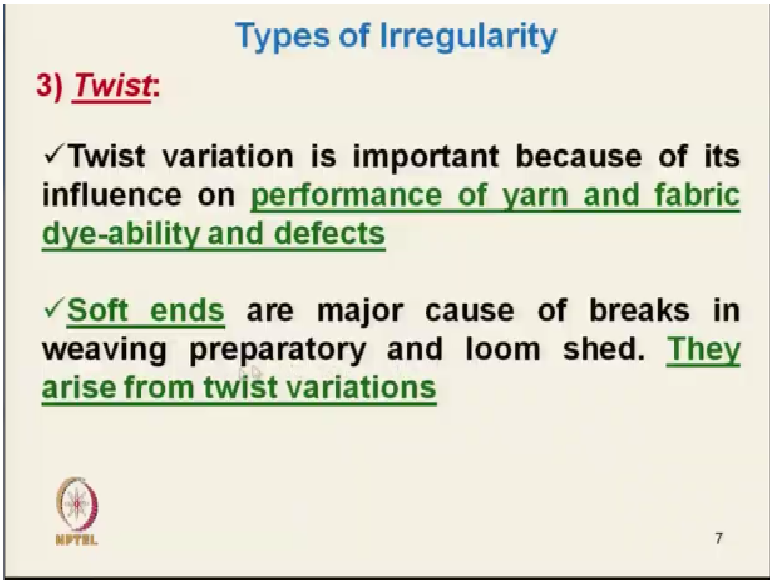

Next comes the twist variation, so twist variation is also an important aspect for measurement but normally in terms of at as the twist variation measurement it is a difficult it we cannot measure at very first rate. But if we have any idea about twist variation that will help us in actually predicting the performance or the quality of product like the performance of yarn and fabric dye-ability or defects directly influenced by the twist variation.

Because as twist variation is there the portion with less twist will have weaker place and soft in nature. So, from those portion with a low twisted portion fibers will start coming out and this fibers may form airs or peels in the fabric also those portions will be weaker in the strength ok. And also the dye-ability if the yarn has got high twist variation like suppose this is a yarn ok, in this portion it is high twist is there and in this portion the twist is less high twist.

So, as we have discussed earlier when we discuss the twist, so the higher twit angle this is higher twist angle, this is low twist angle say higher twist multiplier and this portion will have less twist multiplier. Higher twist multiplier means this portion will be compact and here this portion will be loose in nature, so what will happen the try to dye, dye will not penetrate in this zone easily.

And here in the same yarn other portion it will dye will be actually will penetrate at this portion will be dyed with the darker zone. So, the due to twist variation we have the yarn with uneven dye also the twist variation will affect in other way, that because this portion with high twisted will reflect light in different way than this portion. This portion with the less twist will have very shining in nature, so this affect the fabric appearance ok.

The soft are major causes of breakages, so that in the soft end in the preparatory process of weaving and loom shed. So, the low twisted portion will cause most of the breaking point there is from twist variation.

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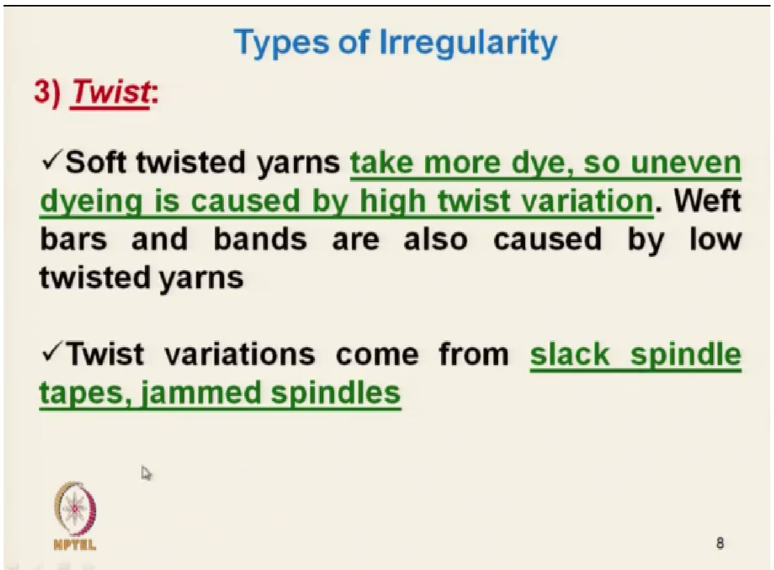

Soft twisted yarn takes more dye, so uneven dying caused by high twist variation as I have just explained weft bars and bands are also caused by low twisted yarn. So, if there are low twisted yarn and it is going in the weft, so that will cause, so if it is the twist variation is the longer length, so that will cause weft bars. Weft bars are visible for dyed yarn definitely because that low twisted portion will absorb dye higher quantity.

But in case of great quality without dye that also affect, so the weft bar because of the uneven reflection. So, the low twisted portion will reflect differently than high twisted portion. So, clear weft bar will be visible in a fabric and twist variation mainly in the yarn is actually generated from slack spindle tapes or jammed spindles. So, if there is any jamming in the spindle because the twisting comes from the rotation of spindle. So, spindle variation, spindle rotation is uneven that will directly create the twist variation.

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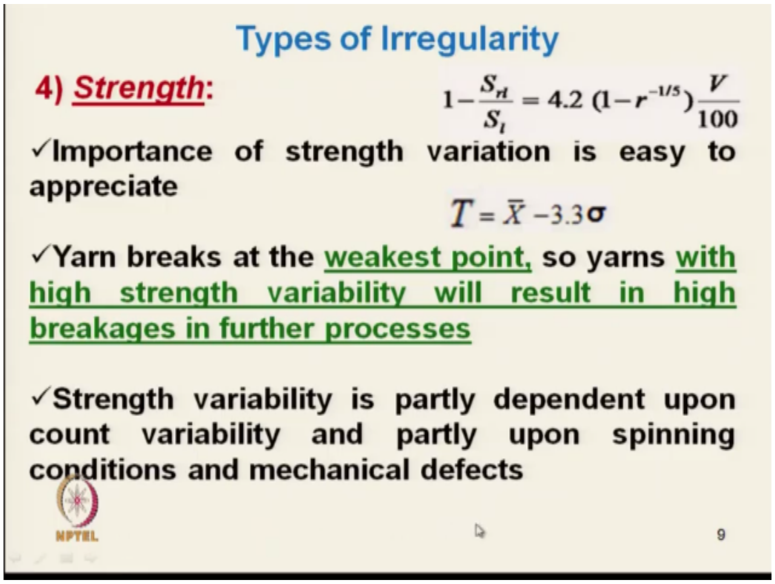

Next come the strength, so as we have discussed the strength variation is directly related with the diameter variation or mass variation ok. And higher unevenness of yarn that means unevenness in terms of mass variation or in terms of diameter variation will have higher strength variation. So, also on the other hand if a yarn has very high strength variation that will actually result in poor performance of the yarn because breakage rate will be high.

So, yarn breaks at it is weakest point, so yarn with high strength variability as we have discussed in detail in last segment where we have discuss the strength section. So, strength variability at higher strength variability will result the higher yarn breakage rate during processing. So, it breaks at weakest point, so yarn with high strength variability will result in high breakage in further processes like winding, warping, sizing ok.

And we have seen this 2 equations, we should remember this equation, in this equation which shows that the variability, this is the variability. This is CV%, this shows has the CV% increases the yarn strength keeping all other parameter constants r, constant r means the times the length case length increases. If we keep r constant, so in that case if we see as the yarn strength variability increases it is strength decreases ok.

Similarly for dynamic running in process, in say winding, warping process as we have seen the if say for a same yarn strength mean strength x bar is the mean strength of yarn in static mode. And t is the tension required for certain number of breakage per unit length of yarn, so if we keep x bar constant and the strength variability, this is standard deviation of strength the sigma if it increases then the tension required for certain number of break will reduce,

That means yarn performance will be poorer ok, so strength variability is partly dependant upon the count variable that we have already discussed count variability means the variability in mass/unit length and partly upon spinning condition and mechanical defects. So, in case of any mechanical defect when spinning condition is poor then also we will have eye strength variability like if due to spinning can poor spinning condition suppose the twist variation is there.

And twist variation if twist variation is high then it will affect the variability in strength, next variability is the variability in hairiness.

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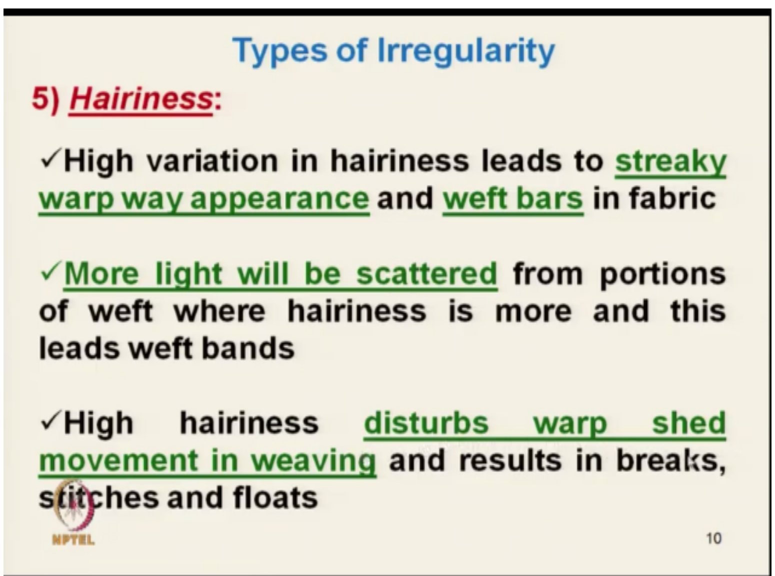

So, hairiness variability is high variation in hairiness leads to streaky warp way appearance or weft bars.

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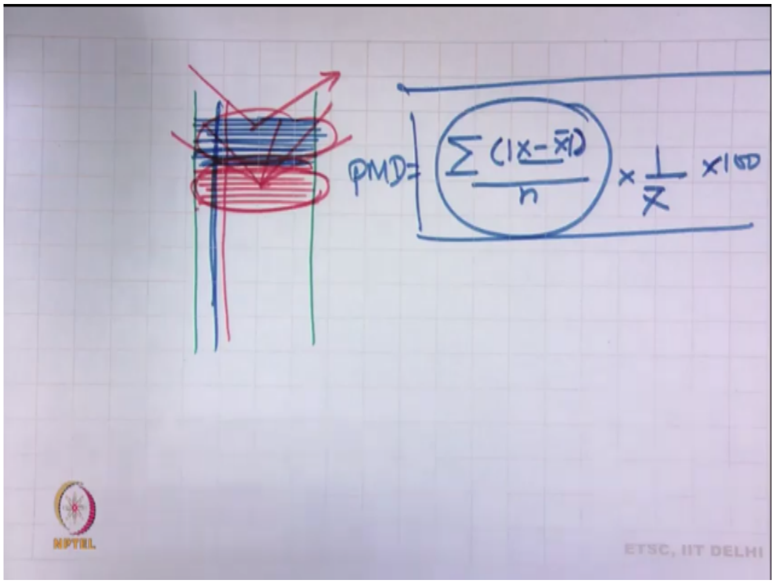

Like suppose this is a fabric and it has been produced by yarns with high variability in hairiness suppose this portion this is weft. This portion the hairiness is good, there is no hairiness or less and this portion when it is weaving it is high hairiness. So, that means this will give clear weft bars because this portion with low hairiness we will have proper reflection, regular reflection. This portion will actually scattered light and this potion will look dull so that band will be there due to the variability in hairiness.

So, weft bar, clear weft bar will be there and also if it is in the warp there will be sticky bars will be there, so that is clearly visible from the fabrics. So, more light will be scattered from the portion of weft where hairiness is more and this leads to weft bar. And high hairiness disturb weft shade formation during weaving, so that also result poor quality of fabric and breakage will be there and stitches and floats will be there ok. Now we have to express, we have to now measure the hairiness.

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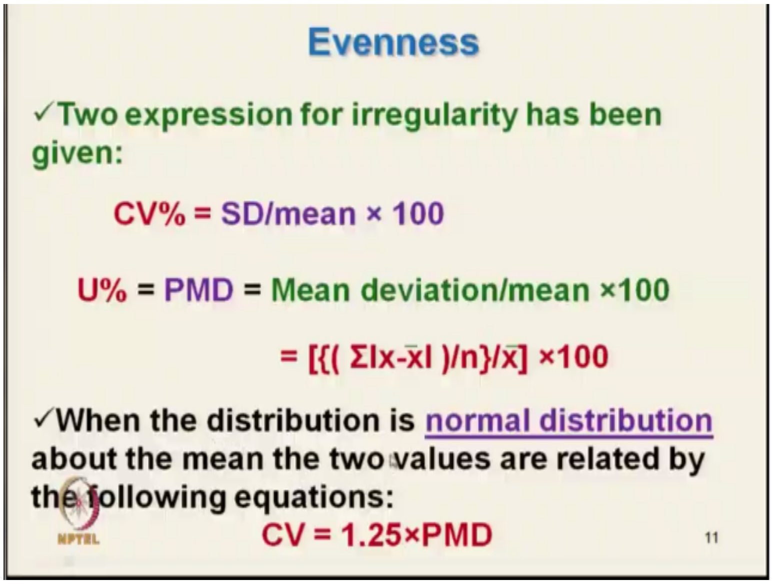

So, normally in yarn staple yarn we express the hairiness, sorry we express the evenness in 2 by 2 terms 1 is it is a by sewing coefficient of variation which is nothing but standard deviation by mean*100 ok. That is in terms of coefficient of variation we express another way of expression is the percentage mean deviation which is nothing but it is u% commonly known as u% it is a mean deviation by mean*100, so this is the expression in terms of percentage.

And this one is the mean deviation that is x-x bar, so mean deviation what is that this is the mean deviation. So, it is a x-x bar within mod so though we will take the positive part ok, this you will be and divided by n, so this is called mean deviation. And if we take the percentage of that percentage with x bar mean, so that then it will call it it at say percentage mean deviation.

And this is one of the most popular way of expression of yarn evenness in terms of %mean deviation ok. When the distribution is normal, so in case of normal distribution if we assume the distribution in mass variation is normal in that case the relationship rough relationship between CV % and U% is it is a CV=1.25*%mean deviation. So, if we know the U% if the instrument measures the U% then we can convert it CV%.

And if the instrument measures both U% and CV% we can see check that it is approximately close to 1 to 5 it may not be 1.25. Because this distribution the data may not be normal distribution ok but the data definitely it will be close 1.25 ok.

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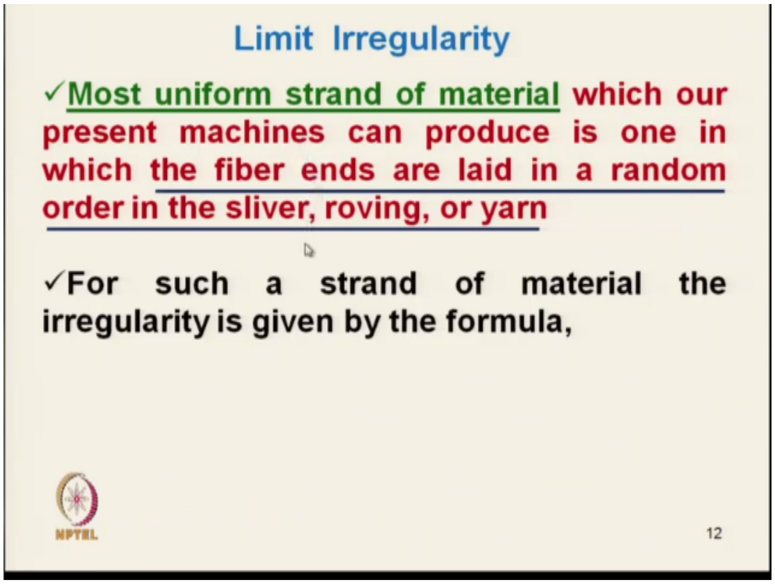

Now coming to the concept of limit irregularity, so we must understand the concept limit irregularity. So, in staple yarn this concept of limit irregularity is there in case of staple yarn production ok, yarn production from staple fiber.

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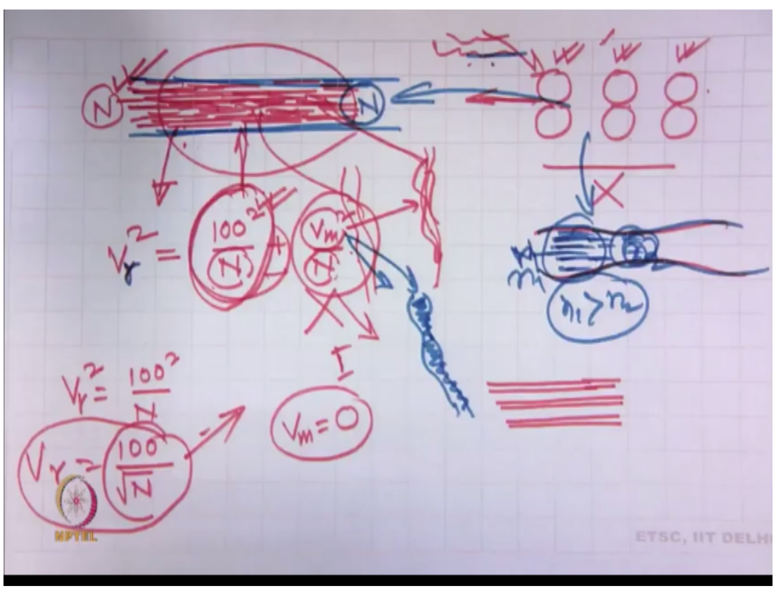

So, suppose this is 1 strength, this limit irregularity is valid not only for yarn for other form of material continuous material that is the sylver it is valid for roving also ok what is this the fiber staple fiber these are distributed inside the structure ok. Now if we assume the distribution of staple fiber within the structure like yarn, sliver, roving those are perfectly uniform, so we are actually distributing the fibers whatever maximum possible even way, possible, that we are distributing, ideally we are placing the fibers.

We cannot make more even than this state, theoretically you are placing perfect, so if we are doing this thing. Then the whatever irregularity will be getting that irregularity is it is called limit irregularity where we assume our spinning machines are running exactly ideal like drafting, these are the drafting rulers. In spinning we have seen large number of the material goes through large number of beans drafting rulers.

So, this drafting rulers there is no problem at all no problem, they are perfectly circular there is no slippage running perfectly, setting is exactly perfectly ok. In that case whatever fiber strength it is producing it is perfect but the individual fiber like cotton fiber it has got unevenness wool fibers unevenness in diameter. Those variations this machine cannot do the spinning machine cannot make the individual cotton fiber even, this is the nature of the fiber ok.

Now this type of irregularity will be there ok due to the variation in diameter in inherent mass/unit length variation but the spinning machine has done it is job there is no such defect. Even the environment whatever environment is there humidity or temperature they are exactly perfectly maintain. In that case whatever the yarn whichever yarn we are producing that means we cannot produce better than this and that and still this will have certain irregularity.

Because it is staple fiber it has got random arrangement of fibers, so we cannot produce better yarn than this. So, this and whatever variability this yarn has got it is called limiting irregularity ok limit irregularity. That means by definition it is a most uniform strand of material which our present machines can produce theoretically is one in which the fiber ends are laid in random order in sliver, it is not the preferential order.

The order of arrangement will be exactly random there is no preference, no unevenness, so that in the order in the sliver, rowing or yarn that irregularity is known as limit irregularity, it is a based possible product ok. So, it is fibers ends are late in random order ok, for such a strand of material the irregularity is given by the formula. So, this is the definition of irregularity and now we have to know calculate the irregularity, limit irregularity.

This is the formula where Vr, Vr is the limit irregularity in terms of CV% so Vr=so this is the irregularity of this portion it is a Vr square=100 square/N where N is the number of fiber. Suppose here it is a N number of fibers are there because why N as we have seen that the variation in number of fibers are there in yarn cross-section. So, variation in number of fibers are there in normal case, normal yarn, so here higher number.

This defect the distribution is due to the problem in spinning machines, spinning machines could not distribute the fiber evenly. That is why it has distributed here say N1 fiber say N1, N2 number of fiber, so where n1 is more than n2. But our assumption is that spinning machine is running perfectly, so it has distributed the fibers evenly, it has done it is job. Because spinning machine can do this much it can actually distribute the number of fibers in the cross-section ok.

So, it has distributed because our assumption is that spinning machine is running perfectly, ideally. So, here throughout the cross-section the number of fibers are in, so in that case, so limit irregularity Vr=100 square/N+Vm square/N what is Vm. Because it has done it is job n number of fibers it has actually led on the surface but this Vm is the variability in fiber itself as the individual fiber say like cotton fiber it is a mass variability mass CV of cotton fiber.

So, mass CV of cotton fiber it is a Vm it has got 2 term 1 part is straightway based on the number ok based on the number and the arrangement ok . It is perfectly arrangement is there but due to the this discontinuity and all this it has got this portion and second portion is basically due to the individual fiber variability ok, individual fibers mass variability.

Now can we have a fiber with least mass variability because we have seen natural fiber will have very high variability definitely we cannot control, can we control this, yes. We can control that if we take say synthetic fiber manmade fiber like polyester cot polyester fiber where the fibers diameter or mass variability we can assume as almost 0, there is no mass variability. So, in that case this Vm for synthetic fiber Vm will be 0.

So, this portion will be 0 in that case Vr square=100 square/N or Vr=100/under root N, so this is for synthetic fiber or synthetic fiber the limit irregularity is 100/under root N. Because why is it 100, this portion as I have already mentioned this is the system because it is a this one is the discontinuous fiber and discontinuous fiber whatever we arrange there will be little bit unevenness, so this unevenness is this is called limit irregularity.

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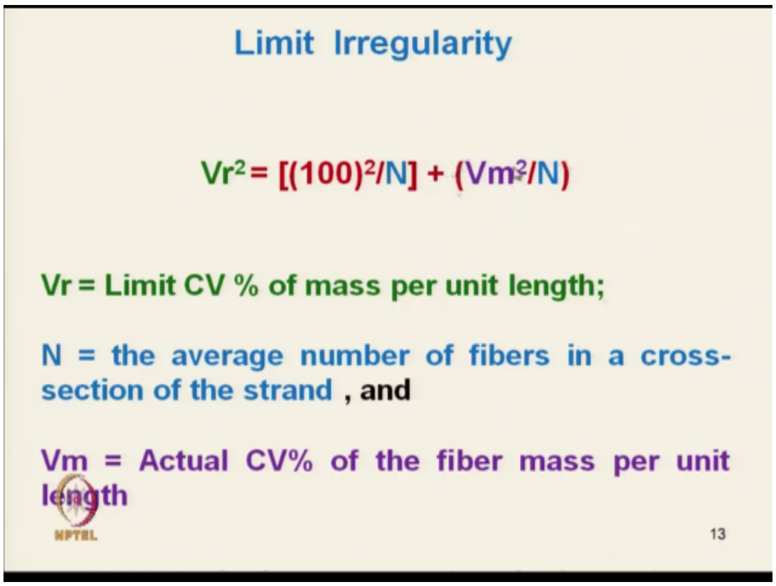

So, this is the portion as we have already discussed here and Vr is limit CV% of mass/unit length this is Vr it has got 2 components. So, N is the average number of fibers in the cross-section of the strand ok this is the average number of fibers in the cross-section. So, that cross-section in the cross-section ideally there must be n number of fibers everywhere but the there will be definitely some variability that is why mean number of fibers are taken here.

And this second part as I have mentioned it is the actual CV of fiber mass per unit length, this Vm. So, if we can make it 0 that is for say synthetic fiber this portion will be V0.

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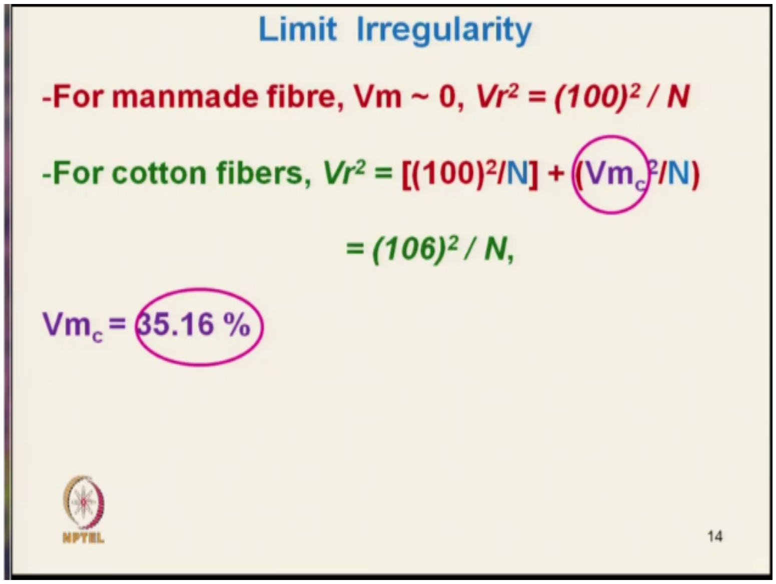

So, in synthetic fiber a manmade fiber Vm is 0, so this equation this relationship has been reduce to 100 square/N. now what will happen to cotton.

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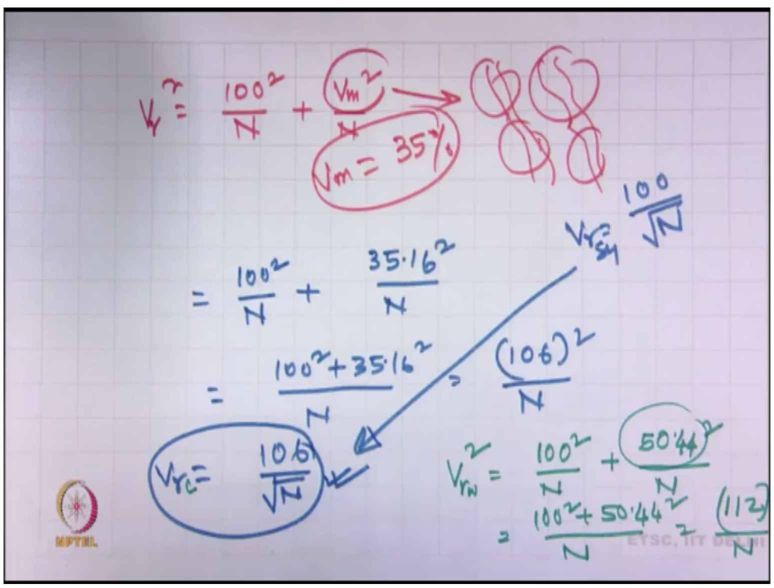

Cotton we can say Vr square=100 square/N+Vm square/N ok, now for cotton if we can measure the mass variability, mass variability if we can measure then we can get the this value. For and this mass variability for cotton it is a it is very high, here if you see the mass variability of cotton it is basically around 35%. So, this mass variability cotton has it is natural fiber in it is natural fiber.

So, if we see the CV% if we measure the CV% it is a approximately 35% here and see that is why for cotton this is the for cotton 100 square/N Vmc square/N. And this is the mass variability of cotton and the typical formula for normal cotton for typical cotton the formula is the it is Vr square=106 square/N, so this is the formula for cotton and how this 106 has been achieved as I have mentioned from large number of experimentation.

It has been observed that cotton has got average the mass variation is around 35% and if we use if we put 35 here then this total value will be 106 square. So, if we see we have measured so that means for cotton if we see it is a 100 square/N+this is 35.16 square/N. So, N 100 square+35.16 square this will be this will come out to be 106 square/N this value will be approximately 106 square %.

So, Vr for cotton will be 106/under root N this is the general formula we can remember this one. So, for calculating limit irregularity for synthetic fiber we have to use the formula Vr=Vr for synthetic ok 100/under root N and for cotton it will become 106/under root N. So, this difference from 100 and 106 it is mainly due to the variability of mass variability of cotton ok. Now what happen to wool, so if you see the wool fiber variability, mass variability is much higher than cotton. So, wool's fibers variability is around 50, 55% ok, this is the variability of cotton.

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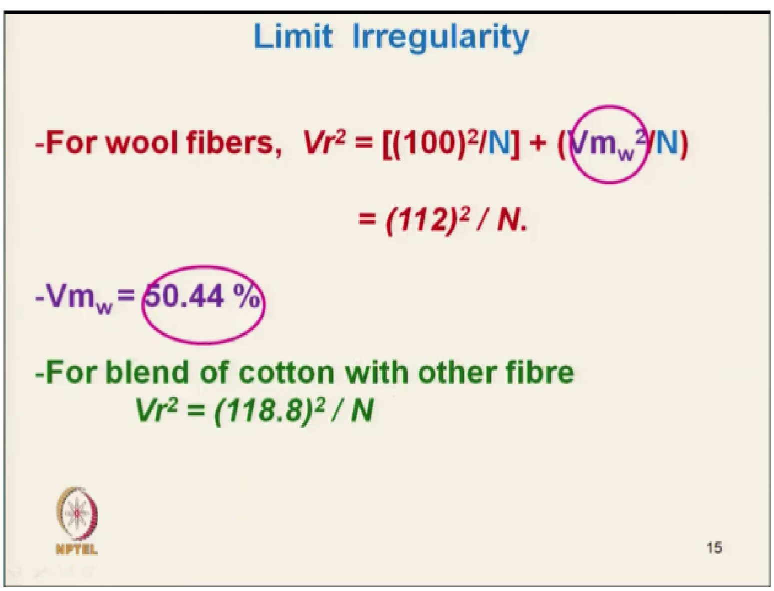

Now for wool this mass variability of wool due to that the equation become 112 in case of cotton it is 106 for wool it has become 112. This is mainly due to high amount of high value of variability mass variability of wool it is around 50%. So, if we see for wool Vr wool, so it was Vr cotton, /vr wool square=100 square/N+50.44 square/N. So, if we take N=100 square+50.44 square ok=112 square/N.

So, that means this value comes from this condition, so this is this 50.44, 50, 51, this variability mass variability of wool is at this range. We will see in next slides the diameter variability can also be measured for wool. It is coming out to be around 25%, so 1 can remember the around 25% is the diameter variation of wool I am talking about individual wool fiber and mass variation of wool is around 50%.

So, from that assumption this value comes, so one can directly use this formula, now what will happen in case of blend. In if we blend polyester and cotton. For polyester we have seen the limit irregularity is 100/under root N. For cotton it will become 106/under root N, so apparently people may think that if we blend the irregularity should be in between 100 and 106.

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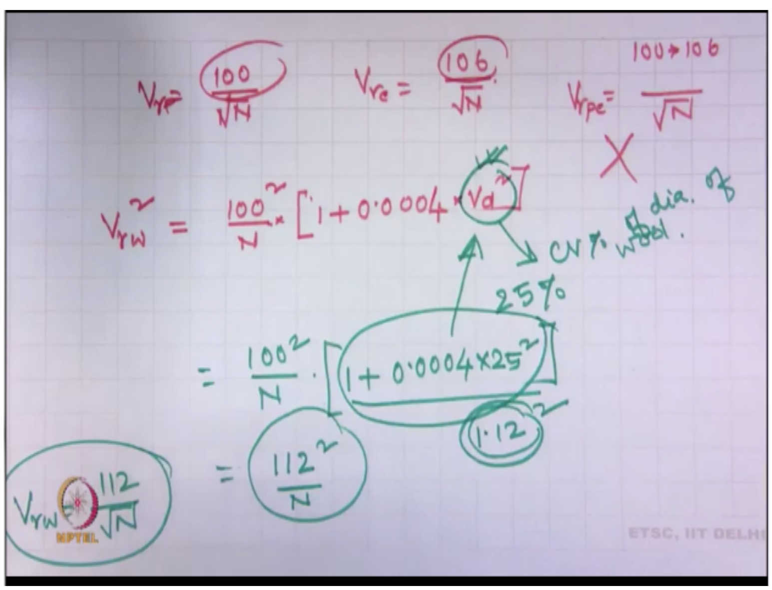

So, for polyester it has Vr=100/under root N, for cotton Vr polyester Vr cotton 106/under root N. But if we mix in Vrpc it is it between 100 and 106/under root N no because when we blend to entirely different types of fiber that means there are other problems will be there. That means quotient between fibers clustering will be there, movement through the drafting ruler due to the frictional contact between fibers.

So, this will affect the variability adversely that means the variation the limiting variation will be higher than much higher than this ok. So, for blended yarn for blended say polyester cotton yarn this will be typically 118 that has been actually observed. So, this is the limit irregularity of polyester cotton or any fiber blended synthetic fiber blended with that is these are the formula one can directly use to get idea about the limit irregularity.

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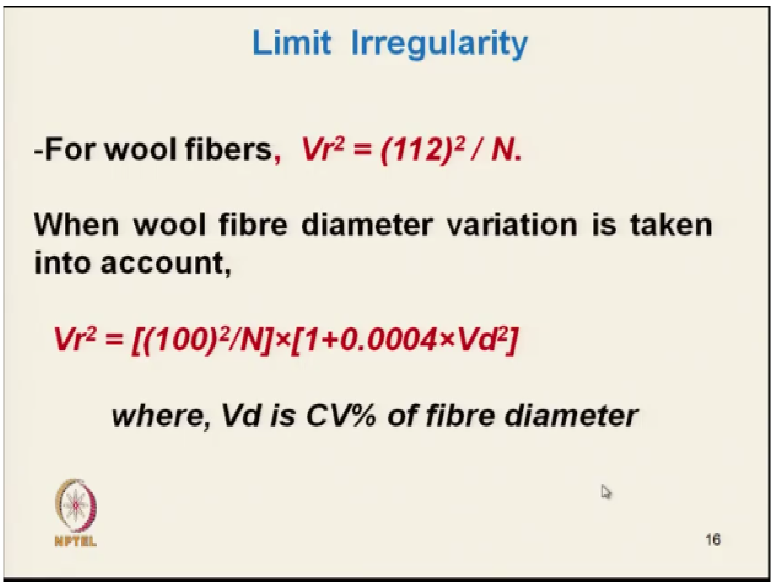

So, for wool the limit irregularity as we have seen from the mass variability of fiber that fiber mass variability was around 50% 50, 51%. So, this has come to 112 square/N also we can get the limit irregularity for wool in terms of diameter variability. So, when wool fiber diameter variation is taken into account. So, if we take the wool fiber diameter into account in that case the variation we can calculate, we can measure the variability of wool fiber the limiting irregularity.

This that this standard formula we must know ok, so for Vr ok Vr square of wool=100 square/N and then *1+0.0004*Vd square. This Vd, Vd is nothing but CV% of diameter and it has been observed that CV% of diameter of wool is approximately 25% ok. So, diameter CV is approximately 25%, so that diameter CV for wool if we actually replace here by 25%, so 100 square/N 1+0.0004*25 square.

This total value will be typically around 1.12, this value will be come out to be 1.12 approximately. So if we take 1.12 square this value so then it will be actually 112 square/N, so this value will be 1.12 square, so it will come out to be 112 square/N. So, Vrw is coming out to same, so from the mass variation of wool fiber or diameter variation of wool fiber we can get the same value of 112.

So, one may ask a question, so if the equation 112 square/N is given then what will be the mass variation of wool fiber, so one can calculate by back elimination. So, Vd is the CV% of fiber diameter.

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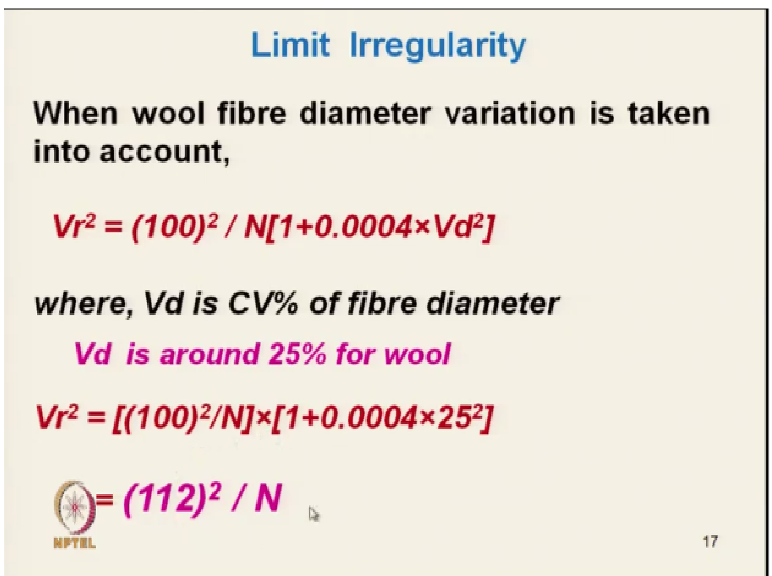

And when wool fiber diameter variation is taken into account, so this is the formula and CV of wool fiber diameter in approximately 25% and if we replace this, so this will come out to be 112 square/N ok. So what we have discussed I have discuss the limit irregularity or what our machine can produce ok for synthetic fiber or cotton fiber or wool fiber or from blends ok.

So, with this concept we will we can calculate many parameters many ethics are the performance of machine spinning machine individual spinning those we can all we can calculate everything.

So, in next class we will discuss the all this calculation how we can actually judge the performance of different spinning machines till then thank you.