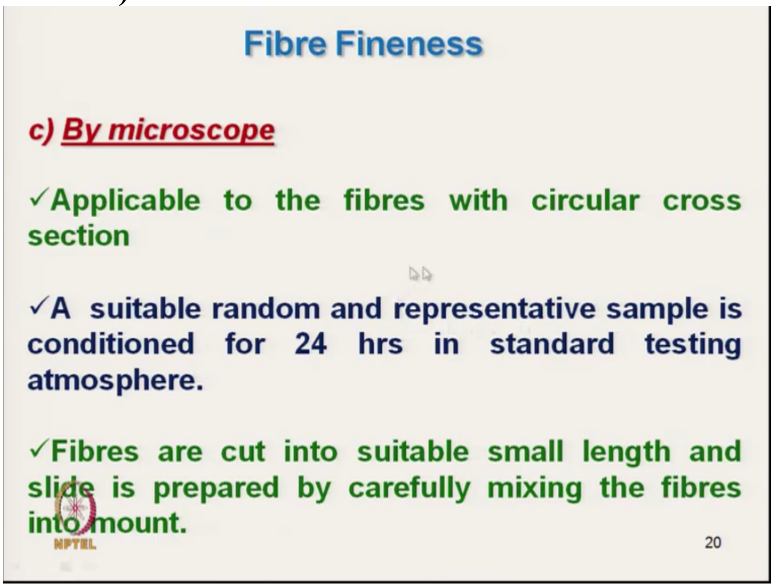
Evaluation of Textile Materials
Prof. Apurba Das
Department of Textile Technology
Indian Institute of Technology-Delhi

Lecture – 13
Evaluation of Fibre Fineness.(Contd..)

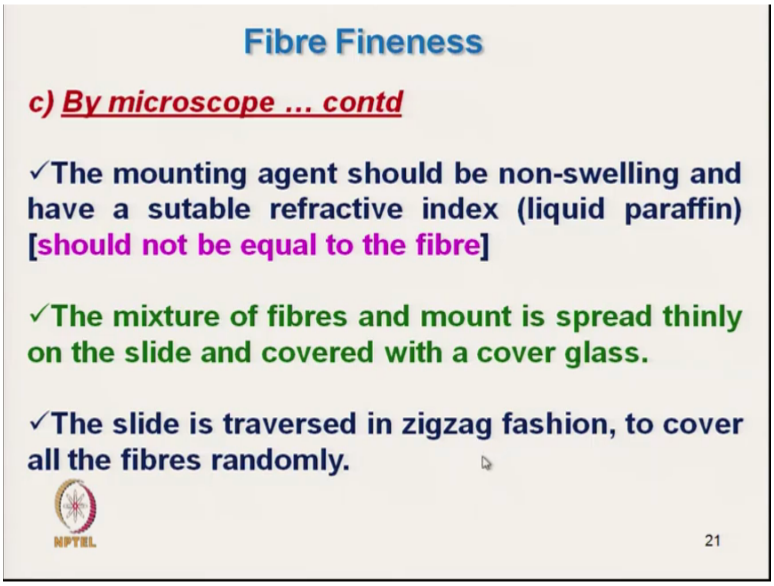
Hello everyone, so what we have discussing, is the measurement of fibre fineness. So in last class we have discussed, that fibre fineness, fibre diameter measurement, by microscopic method.

(Refer Slide Time: 00:36)



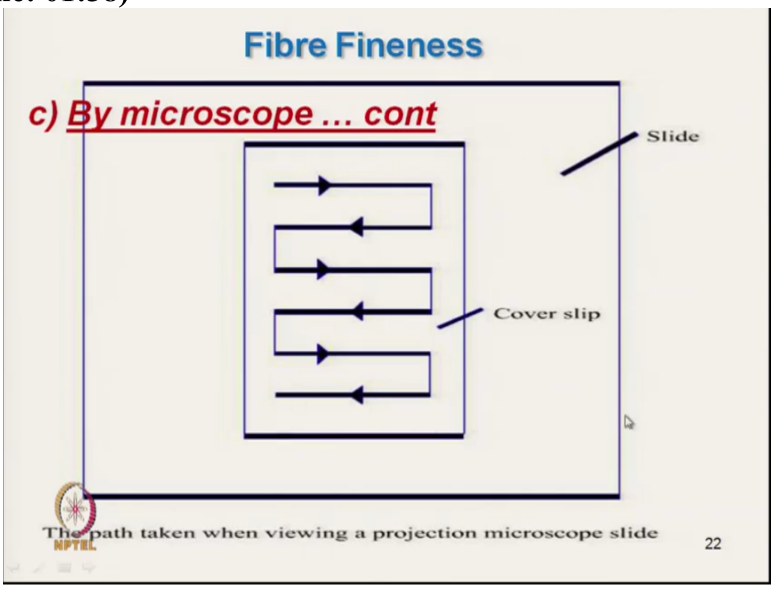
So, where it is a basically we have mentioned that, it is applicable for only circular fibre, where the cross section is circular in nature, and after proper conditioning, we have to put the fibre, we have to mix the fibre into the mount ok. And then we have to mix properly, carefully it is mixed.

(Refer Slide Time: 01:02)



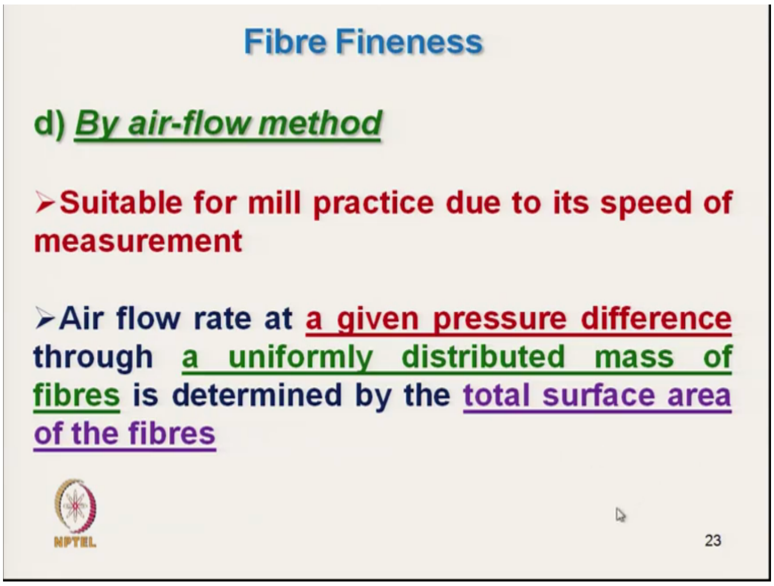
And mount, it is selected in such a fashion, that it should not, should not swell the fibre, and refractive index of the mounting agent should be different from the fibre and typically liquid paraffin is used. And the mixture of fibre and mount is spread properly, on the slide, and covered with the cover glass. And slide is moved in zigzag fashion so that to cover most of the fibres random.

(Refer Slide Time: 01:38)



So this is the way, the slides need to be moved.

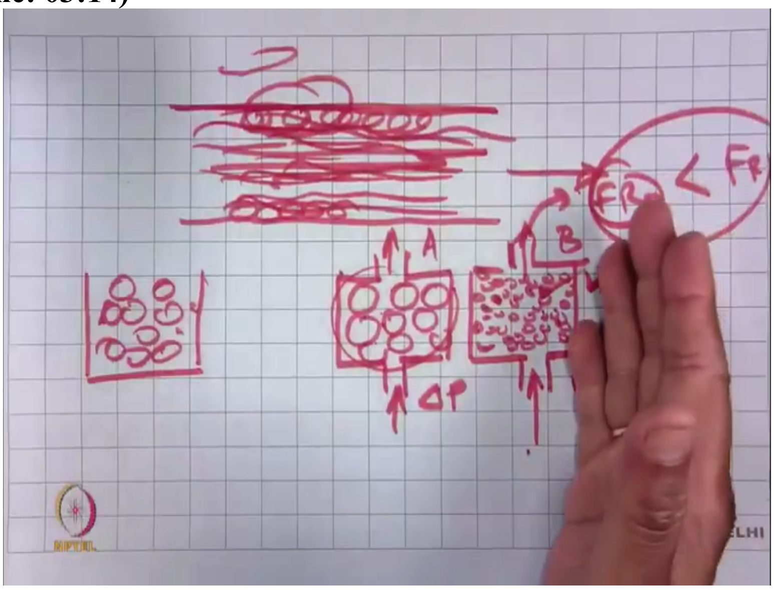
(Refer Slide Time: 01:46)



Next method is that, by air flow method. Air flow method, here we measure the fibre fineness, indirectly. It is total indirect method, and here, we do not measure the fibre fineness of individual fibre, it is the overall fibre fineness. Here we cannot measure the, the dispersion, that is the variation of fibre fineness within the, within the particular mass, ok. So what we get, we get a overall fibre fineness, of mass, ok.

It is basically it is a very fast technique; it is suitable for mill practice due to its speed of measurement. So we get the rough idea of fibre fineness, fiber mass per unit area, unit length, or its diameter, we can get rough idea. So basically air flow rate at a given pressure difference through a uniformly distributed mass of fibres is determined by the total surface area. Now, let us see the analogy here, we can make.

(Refer Slide Time: 03:14)



Suppose, it is a flowing river, ok, flowing river, so this is the water is moving here, water is flowing, ok, as water is moving, flowing, if we see, if we see carefully, at the bank of the river, the water actually flows in different fashion, here there will be some different type of movement will be there. But in the center, other side, it flows uniform. This movement here it is due to the drag of the surface. Drag of the bank of the river, ok.

That means, for any fluid flow, when fluid flows through the surface, it flows through the, any solid surface, that solid surface actually creates a drag here ok. This drag force, drag force is proportional to the area through which the fluid is moving, ok. Now with similar analogy if we see, the, this is a fibre mass. ok this is a fibre mass, now if we have say, an arrangement, of fibre mass, so this is the, suppose here, air is coming in and its outlet over here.

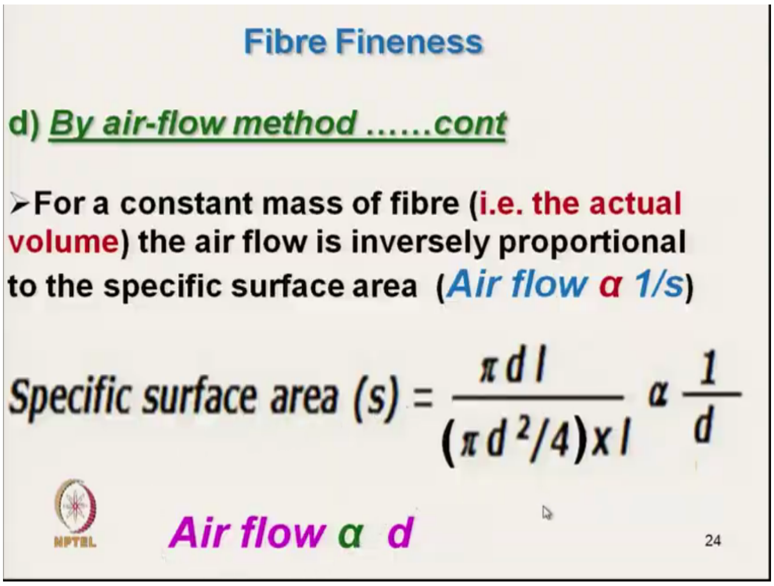
And such, two such arrangement we are making, here we are having a large number of, large diameter fibres. And here we are having smaller diameter fibre, so smaller diameter fibres, as we know, will have higher surface area, for same mass. Mass of the fibre in these two boxes is same. But smaller, this is A, this one is B. but mass, specific surface area that means total surface area, for unique mass is higher in case of B.

Now if we see, if we flow the fibre here, at same pressure difference, at same pressure difference, in both A and B, so as B has got higher area, higher area of drag, it will give, it will result, lower flow rate. Flow rate will be lower in B than flow rate of A. So that is how we measure here, we measure here the flow rate for same pressure drop. So indirectly we measure the; its measure the specific surface area and we are not actually measure the, measuring the specific surface area we are telling this A has got higher surface area than B.

And that we cannot tell the exact specific surface area, but from the large number of pre calibrated, pre calibrated, we can calibrate the machine, calibrate the instrument and from there, we can tell ok, this is the actual value. So using this basic principle, this airflow instruments works ok. Here in that instrument, here we can have constant pressure drop and we can measure the air flow rate or else we can do in the other way also.

We can have same air flow, but at then we can measure the difference in pressure drop. Then this 2 ways it work. So airflow rate at a given pressure difference, through a uniformly distributed mass of fibres is determined by the total surface area of the fibres. So that is the; that is actually proportional here.

(Refer Slide Time: 08:10)

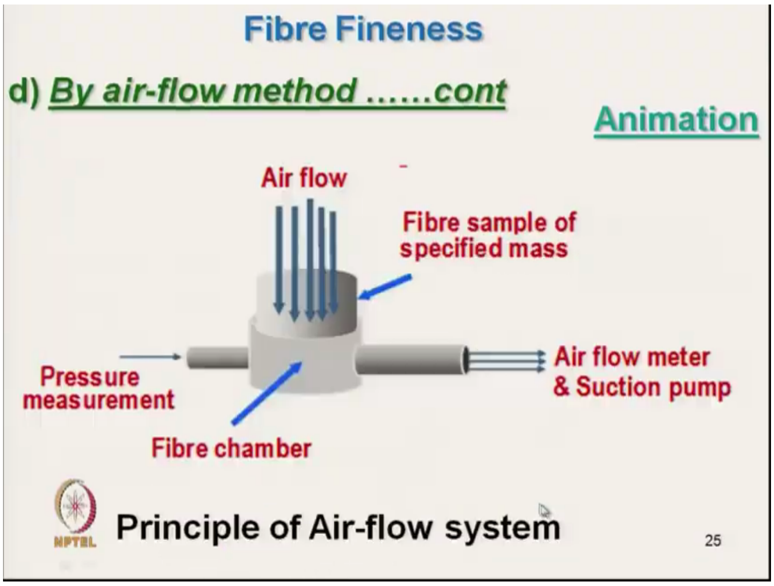


For a constant mass of fibre that is the actual volume, total mass it is proportional to the volume, because for a same density so for a constant mass of fibre, the air flow is inversely proportional to the specific surface area, that we have seen already. So air flow is inversely proportional to the specific surface area been the total surface area for unit mass or for unit volume.

So that is the specific surface area, here, it is the total surface area, considering the fibre is the circular one, for calculation purpose, so that is the total surface area, that is Pi d is the perimeter of the fibre and it is the multiplied by length, total length of the fibre. So this is the total surface area and divided by the total volume Pi d 2 by 4 multiplied by length. So this is the total volume of fibre, so that means it is inversely proportional to the diameter of the fibre.

So that means if you see the air flow rate is inversely proportional to the diameter of the fibre. So that is the dia, so airflow rate will be directly proportional to the diameter of fibre. That means higher the diameter; the airflow rate will be high. So in that way if we can calibrate the machine, calibrate the instrument, we can directly get the diameter ok. So air flow is directly proportional to the diameter.

(Refer Slide Time: 10:03)



Now the principle here is that the specimen is actually packed here, in the fibre chamber. In the fibre chamber, the specimen is packed. Now with the air suction arrangement, the air is sucked ok, now, air flow with a pump, using a pump, air is actually, sucked. And then the air is flowing and creating certain air pressure, so for certain air pressure. This air flow rate, we can measure.

Fibre sample of specific mass we have to take, here we first take the mass of fibre and then we pack to it ok. And one thing is very important, a particular instrument is gauged, is calibrated, in for a particular type of fibre. Like, an instrument which is meant for cotton, in that instrument, in that gauge, fibre diameter may be the fibre diameter or may be fibre mass per unit length or directly may be micron micronaire value.

In that instrument we cannot test other fibre. Like for wool, wool fibre diameter, we can measure using air flow method. And it is cased directly in terms of micron ok. But if we use cotton in that instrument, whatever micron we will get, that will be actual micron, because the density of fibres are different. So that is why a particular instrument, particular airflow instrument, is used for a particular fibre.

(Video start: 12:12)

Now fibres are packed, correct, we are taking the fibre, we have taken the mass of fibre, and gradually fibres are packed. This is known mass of fibre. Now for a particular instrument, the mass is constant. So that is the gauge, this is the direct reading of this flow is proportional to the mass per unit length. So this is gauged either in terms of mass per unit length or in terms of diameter directly. And that is based on a specific mass of fibre ok.

Now the pump is, we have started the pump, air is been sucked and the air is and the rate of flow of air is measured by this float, ok this float height is indicating the rate of flow and this is this gauging is actually measures the flow rate but it is not based in terms of flow rate, it is in terms of directly diameter or micronaire value, or mass per unit length, ok. So that is why, here one thing is very important.

Suppose and the measure, it is a, we have to maintain this pressure. If the pressure is different then we have to adjust the pump ok, so to maintain certain pressure, for a constant pressure we have to measure the flow rate here, ok. And now, one thing is important, the mass of a fibre, so this is supposed for cotton fibre, cotton fibre of a particular mass, say 4g or 5g mass, once the particular instrument is gauged for particular mass of fibre, if we use, suppose the 4 micronaire or the 4g of polyester is to be placed in the chamber.

Suppose what will happen, if we take the 5g or 6g of cotton, what will happen? The 5, if we take a 5g of cotton instead of 4g, this will result higher specific surface area it will have higher surface area and the test flow, the flow rate will be less. And it will show as a finer fibre. Finer fibre, but which is wrong so that is why, it is very important, to maintain the mass of fibre, which we are packing, its exact mass of fibre ok.

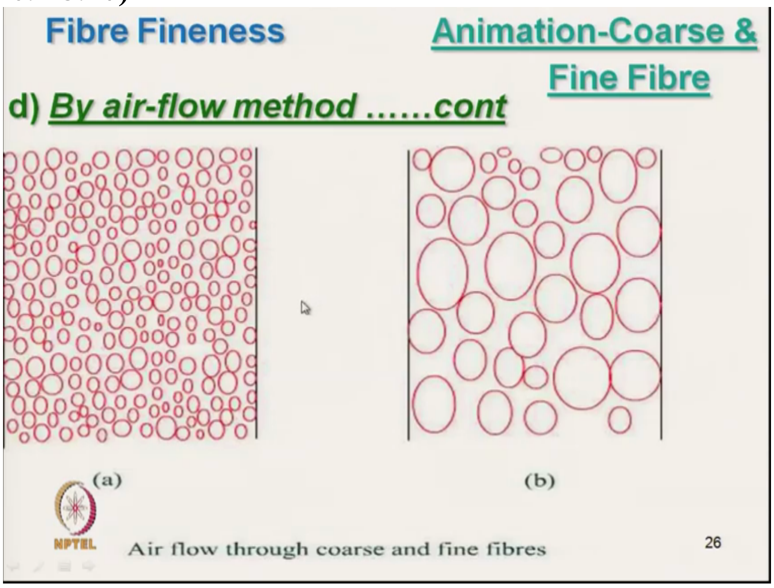
And also if we see, we are maintaining the same mass. If we use say, instead of cotton, if we are using polypropylene will have lower density, for same mass the fibre diameter will be same more, and its surface, specific surface area will be totally different. And it will keep wrong result, so it is very important, that air flow instrument. We have to maintain the mass carefully, we have to open the fibre; another thing is that we have to open the fibre, thoroughly.

If we do not open the fibre that means, let us see suppose here, we are, we have not opened the fibre thoroughly. Here suppose whether cluster of fibre, cluster of fiber, what will happen? The air will not flow through. So this, say, there are 10 fibres are there, 10 fibres will be actually behaving like a single coarse fibre, so that is why, it is very important that the openness of the mass should be total uniform.
And the individual fibre should be open. It is a thorough opening is extremely important ok. And also as I have mentioned here, the, this pressure difference has to be perfect, has to be constant, then, we can measure the flow rate ok.
(Video End: 17:01)

And this gauging, the gauge is actually, now let us see once again, this gauge, this is directly given the micronaire value. Say for cotton, it is giving micronaire value. How do you get this micronaire value? This gauge, this is based on the large number of known micronaire value. Then only we can get, so if we know the micronaire value, for a certain pressure, whatever suppose it is a 4 fibre, like it is a 4 micronaire, then if it is, if it is known, that is called calibration of the machine.

So if we know the mass of the, and for the mass if we know the micronaire, and if it is 4 then we can say, ok this gauging is alright. Now for a wide range of micronaire, we use the different types of fibre, different micronaire and we get accordingly ok.

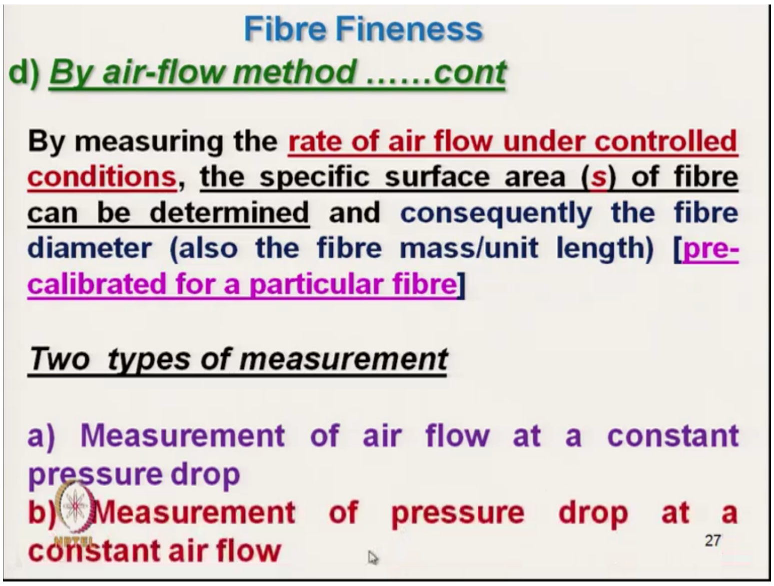
(Refer Slide Time: 18:17)



Now, so this is the air flow method. Now we try to see, if we change the micronaire value here, this is for finer micronaire and this one is for coarser one ok. This is for coarser fibre, we are packing it, and this was exactly same as earlier version. Now we are starting the process, its pump is started, now air is flowing, and the float is showing the micronaire value here, ok. Now this coarse fibre now has been replaced with the fine fibre. This is one particular fibre here, so we are getting this aloof float, ok.

Now this coarse fibre, replacing with the fine fibre now it is fine fibre. Now what happens, the flow rate is dropped, which is the change in flow rate. So from there we can get idea about how the flow rate is changed ok.

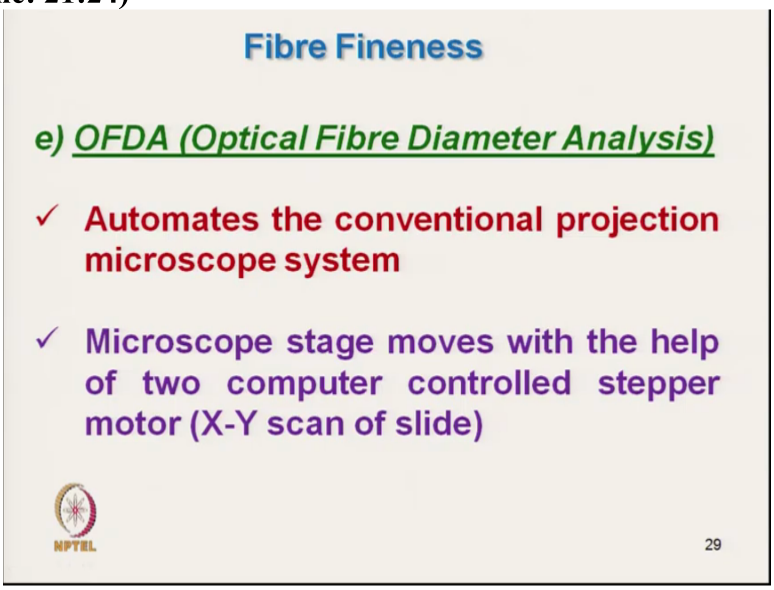
(Refer Slide Time: 20:09)



So, by measuring the rate of air flow under controlled conditions, controlled condition means that which we have discussed, that is proper opening, same amount of fibre, ok, the specific surface area of the fibre can be determined, we can actually direct, gauge the fibre, it is as per the specific surface area also, ok. And consequently the fibre diameter, we can measure, we can gauge in terms of fibre diameter, or in terms of mass per unit length.

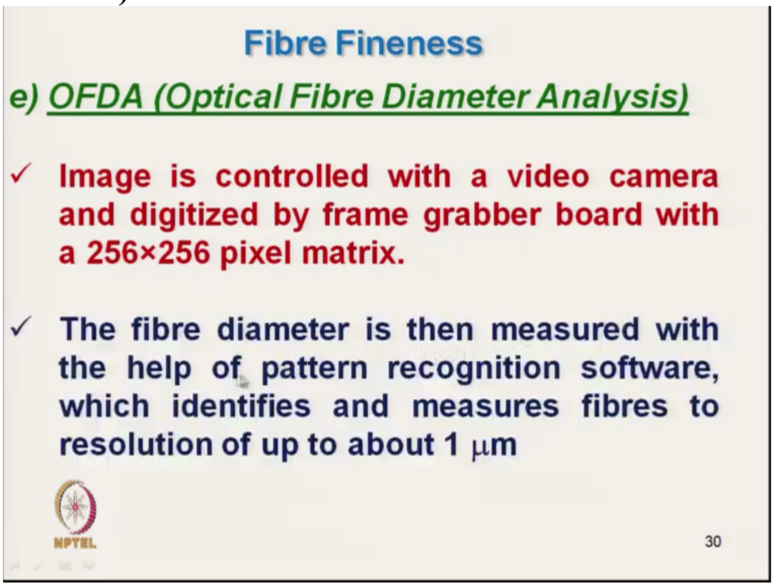
Fibre diameter is actually gauged for wool and for cotton it is a mass per unit length or it is pre calibrated for a particular fibre so that, for a particular machine or instrument, it is pre calibrated. So, 2 types of measurement are there, one is the measurement of air flow at a constant pressure drop; another is that measurement of pressure drop at a constant air flow. The two pressures, two ways of measurement is that. So this is the method we have discussed.

(Refer Slide Time: 21:24)



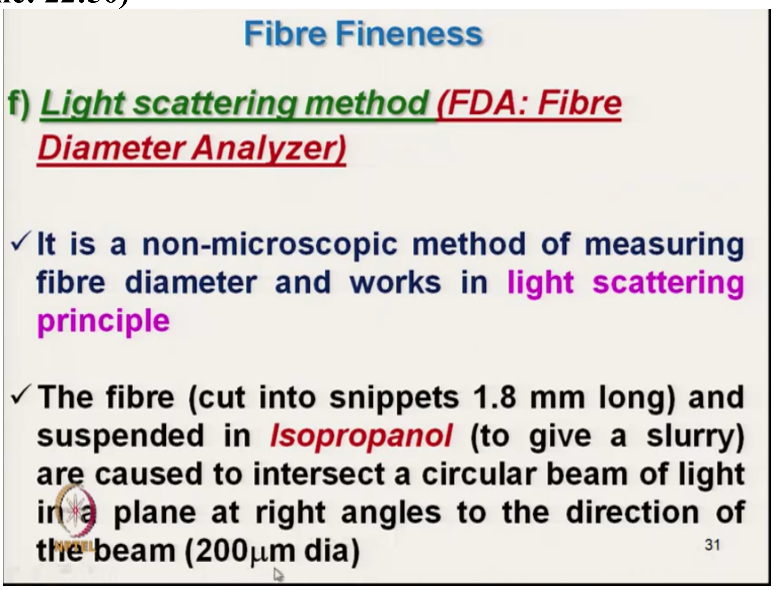
Now, next method is that, Optical Fibre Diameter Analysis, this is very simple technique, it is a, basically it is a automated action of the projection microscope, as we have discussed, where the fibres are placed on a slide and its manually moved in zigzag fashion and measured the fibre diameter. Here it is simply automatic. Microscope stage moves in, with the help of two computer controlled stepper motor, XY direction, so it is a randomly moves and we can program. That way it moves and accordingly and the image is captured.

(Refer Slide Time: 22:19)



Next is that the image is controlled with a video camera, it is captured with a video camera and digitized by frame grabber so that image processing we can get, ok. The fibre diameter is then measured with the help of pattern recognition software, so that we can measure ok. Light scattering method, this is the, it is called Fibre Diameter Analyzer ok. Analyzer it works in a light scattering principle.

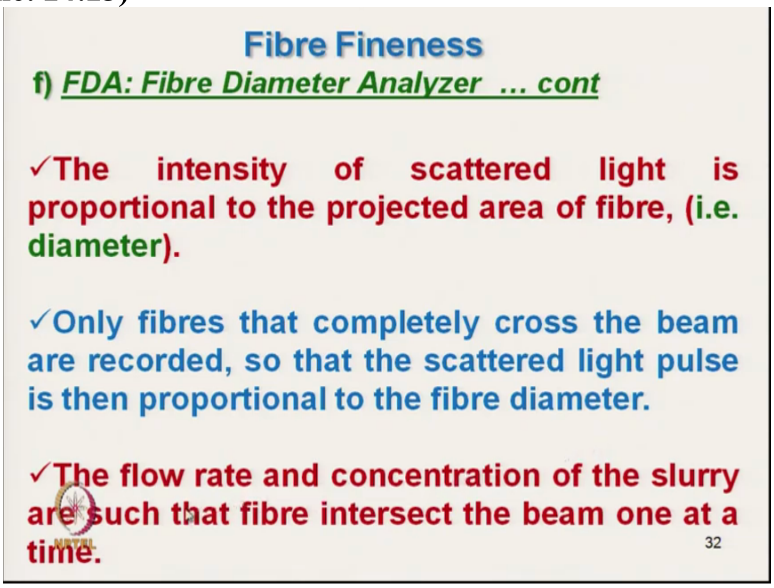
(Refer Slide Time: 22:50)



This is not a microscopic principle, as light is used it is not microscopic technique, it is a non microscopic method, of measuring the fibre diameter, it is by light scattering technique, ok, works on light scattering principle. The fibre cut into snippets with a very small length, typically 1.8 mm that is specified, and suspended in Isopropanal, to give slurry, so this Isopropanol is used because it is a, non swelling chemical caused to intersect a circular beam of light in a plane, which is at right angle to the direction of the beam.

So that means that light is actually projected on slurry. The slurry its, it contains the fibre, small fibre; it is actually, it is in the form of slurry, it moves at through the tube. And the light is projected on that, ok. And the beam, light beam diameter is 200 micron. 200 micron of clean light beam diameter, light beam is projected and the fibres are moving in a channel.

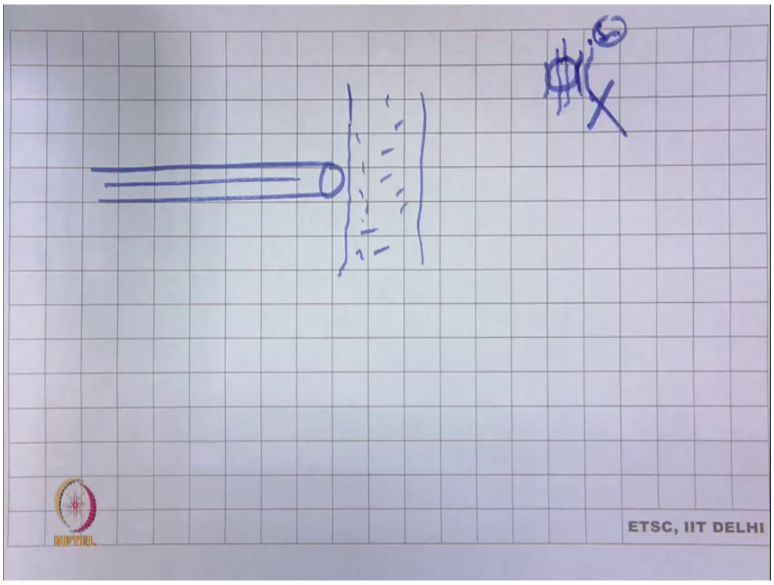
(Refer Slide Time: 24:23)



Now let us see, the intensity of scattered light is proportional to the projected area of fibre. So that means the fibre, that is, diameter, more diameter, higher the diameter, higher will be the intensity of light, scattered. So 200 mm, the most of the, all the fibres are less than, what we are measuring is less than, the 200 mm diameter, but what we are measuring, the scattering of light, the scattered light quantity, quantity of scattered light.

So the quantity of scattered light is proportional to the diameter of fibre. So higher scattering means higher diameter of fibre. And another arrangement here it is made, only fibres that completely cross the beam, there will be some fibre, few fibres, which crosses the beam partial, so the 200 mm diameter, 200 micron diameter of beam, circular beam is moving, and the slurry is also moving, ok. So if the fibre is not crossing 100%.

(Refer Slide Time: 25:34)

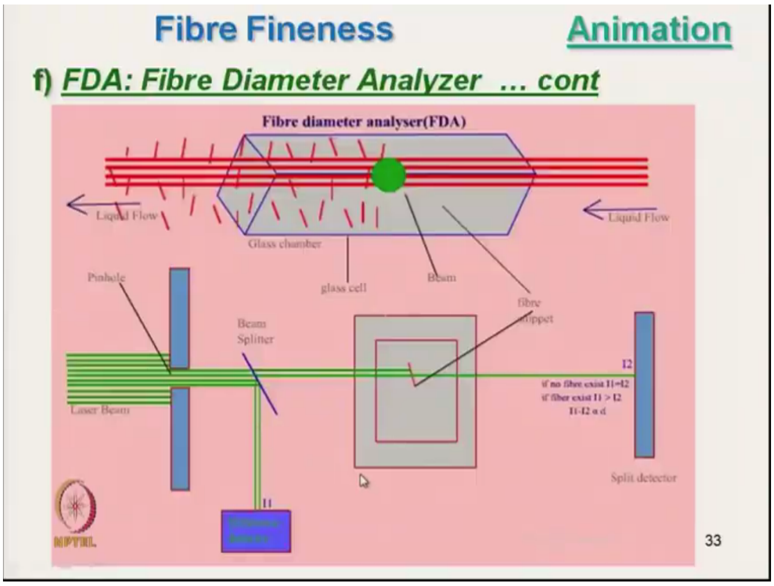


Now let us see, suppose, this is the beam, beam of light, ok, now, here there is a flow at right angle, fibres are moving with the slide, there will be few fibres, now this is beam, few fibres which are not crossing completely, in this way, partially it is crossing, it is also scattering, so that if it is scattered, partially, actually, that it is a projected fibre, scatter, so it will scatter, the less quantity. So that means, this fibre, it is scattering, that means it will keep a wrong result.

It will show that there the fibre is smaller in diameter. That fibre we have to discard, ok. That fibre and only fibre which crosses completely, those fibres we have to take. Now, there is a technique, that I will explain, So the fibres, only the fibres that completely cross the beam, are recorded. So that the scattered light pulse is then proportional to the diameter of fibre and the flow rate is such, flow rate and concentration of the slurry is meant in such a fashion, that one fibre at a time is intersected.

That means, if the flow rate is very high or the concentration of the slurry is very high, that means the number of fibres will cross the light beam at a time, so it will keep wrong result. So from the light beam, one at a time, ok. So that means, such is that, fibre intersect one at a time. So that will keep the correct result. These are the pre conditions.

(Refer Slide Time: 27:35)



Now this is the arrangement here. See this is the light beam of 200, now here it is a, this is the fibre here, ok. The sensor here, this one is the sensor. And this is splitter, this is splitter, light is splitted in 2 equal part. So here we know the actual intensity of the fibre, actual intensity of the light here. And the fibres are moving. This is with the slurry ok with the liquid flow, with the slurry, with the fibre. It is snippet. It is moving in this direction.

And the light beam, this is the other type because we can see this is the light beam, this is the light beam at right angle. Now the fibre has, as fibres are moving as on from these, and this will be counting, this fibre went its moving, crossing this light beam, it get its refract, it actually scatter light and the intensity of the light is recorded ok. And it is compared with this, this is reference type, referable, the intensity of the light is recorded and that is proportional to the diameter.

Now the technique here is that, here there is a beam splitter, this is the actually, split detector, now the split detector here, its function is that, it will actually detect any fibre, which is fully crossing or not, that it will detect, ok.

(Video Start: 29:24)

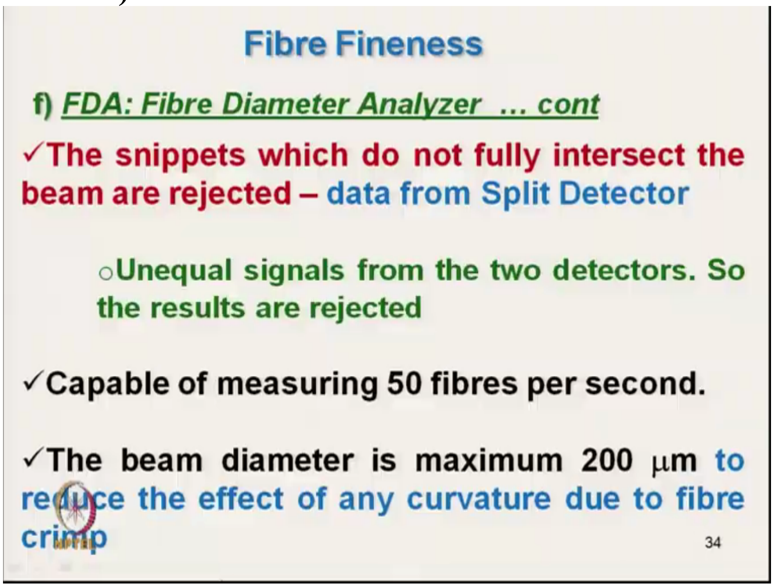
Now see here, these are the fibres in the series move, now light beam is passing, the same light ok. Beam splitter, splitting into two parts, and here it is fibre, fibre snippet. And if it crosses properly, fibre is crossing properly, then this is the split detector, here it has got 2 parts, upper part and lower part. The intensity of these 2 parts should be exactly same. Whether it is low or high does not matter. The intensity should be exactly same, and then only that particular data will be taken.

Suppose the fibre is moving partially, then intensity will be different, ok. It is the upper side, higher side or lower side, will be different.

(Video End: 30:56)

Or it will detect, it will tell that, ok, this fibre has not crossed the beam properly, ok. That is how this split detector will indicate. This is the principle of measurement of fibre diameter.

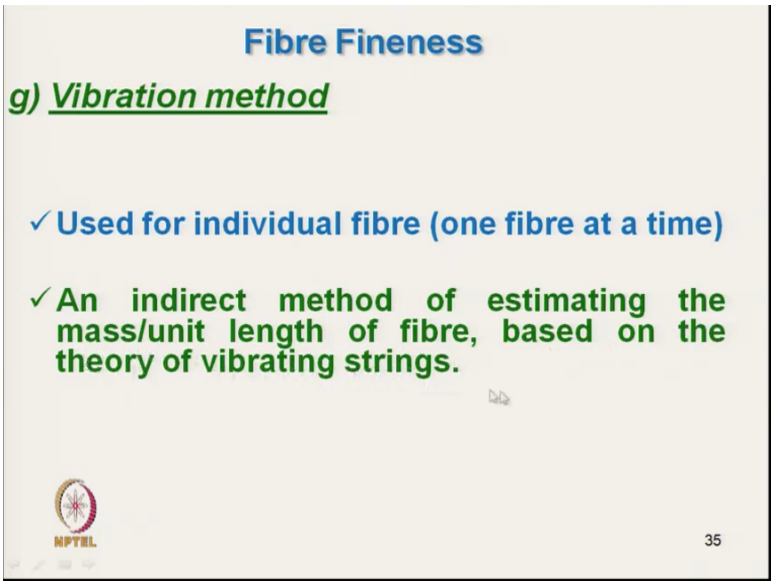
(Refer Slide Time: 31:13)



The snippets which do not fully intersect the beam are rejected, data from split detector. Split detector will tell, it will automatically get rejected. Unequal signals from the two detectors will be there, so the results are rejected. If the signals are same, then the particular result will be taken. Capable of measuring 50 fibres per second it is a very high measuring technique, ok, high speed measuring technique.

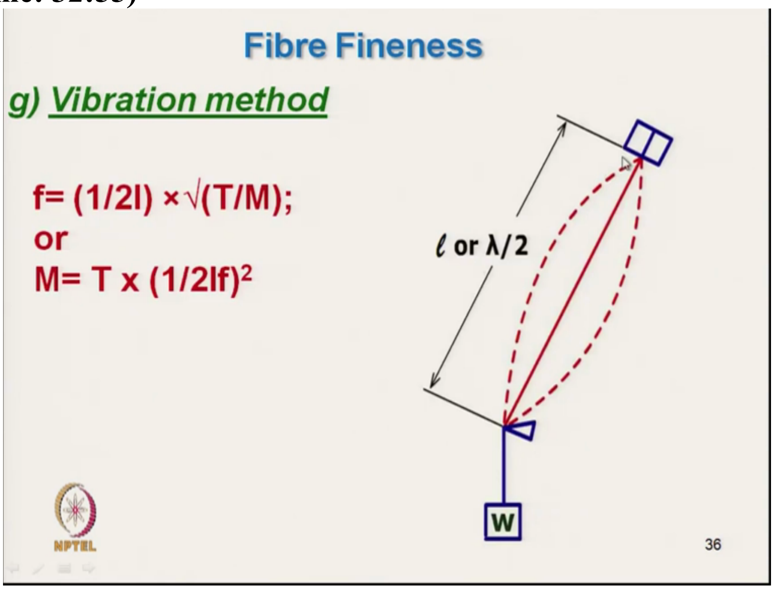
The beam diameter is maximum 200 mm; can we have a larger beam diameter? We can definitely have. Why 200 mm because, to actually accommodate to reject any crimp of the fibre, to reduce the effect of any curvature, due to crimp of the fibre. So that is why we have to use the very fine diameter of the beam.

(Refer Slide Time: 32:15)



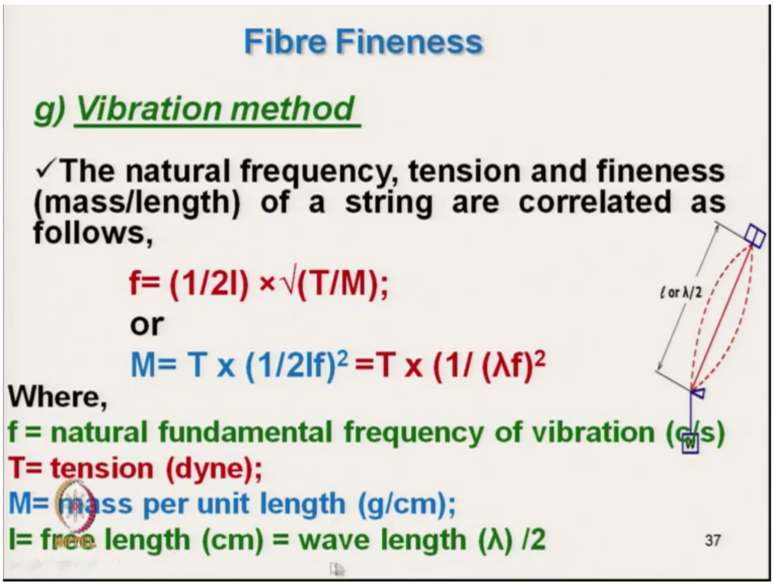
Next method is the, it is the vibration method. Here we use the basic principle of vibration of rod. And this method is used for individual fibre one fibre at a time ok. Earlier method we have seen, it is a mass of fibre, ok. Now it is a, this is the only method where we use the single fibre, for measuring the mass per unit length. Here we directly get the mass per unit length an indirect method of estimating the mass per unit length, by using the actually basic theory of string vibration ok.

(Refer Slide Time: 32:55)



Now this is the, this we know, so frequency that is the natural frequency, is equal to 1/2l , multiplied by under root T/M, ok, where T is the tension on the string, f is the frequency, l is the length of the, free length, here, between the 2 point, and M is the mass per unit length ok. In this way using this formula, we can measure the mass per unit length.

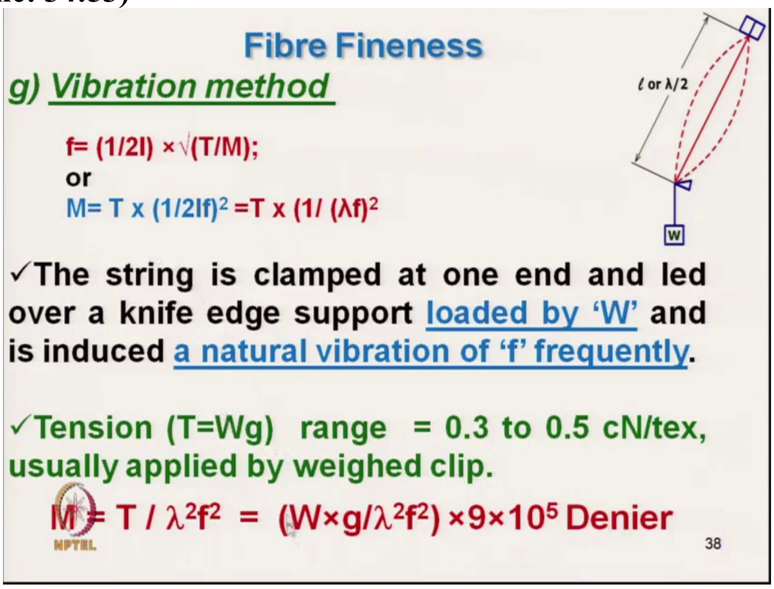
(Refer Slide Time: 33:43)



So the natural frequency, ok, tension and fineness, mass per unit length of the string are correlated as this formula, as we have seen. So mass per unit length, we can measure using this formula, if you know the tension in the screen, in the string, length and the frequency. We can measure the frequency, then we can, this is the natural frequency, ok. Natural frequency, f is the natural fundamental frequency of vibration, t is the tension in dyne, and frequency is in hertz cycles per second. Mass per unit length is in g/cm ok.

This is the g/cm we can get, and l is free length in cm, and wavelength is that the lambda by 2. This is, so we can convert into in terms of wavelength also.

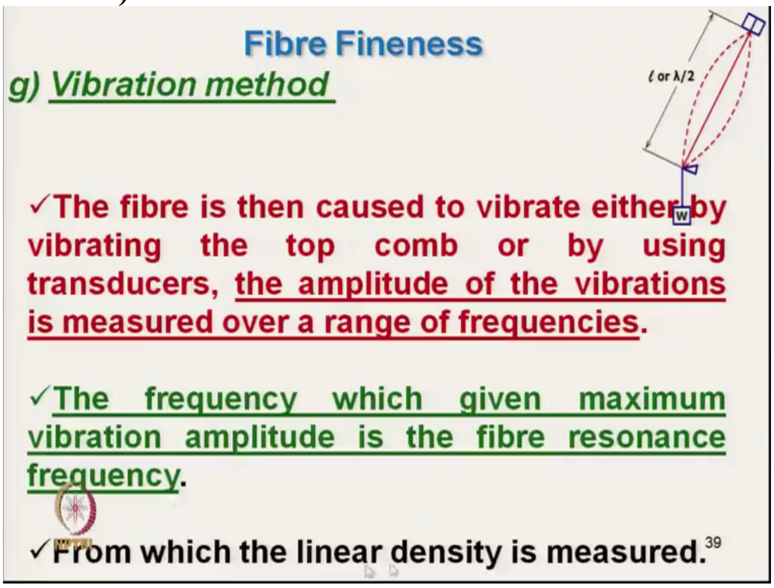
(Refer Slide Time: 34:53)



So the string is clamped, this string is clamped between two ends, one end and led over the a knife edge support, ok, at this end it is clamped and other is its supported by knife edge, knife edge and lone mass is loaded by W, and so the tension on the string will be Wg ok, and is induced, a natural vibration of frequency f. So that we can calculate if we know the natural frequency of vibration, then we can calculate the mass per unit length.

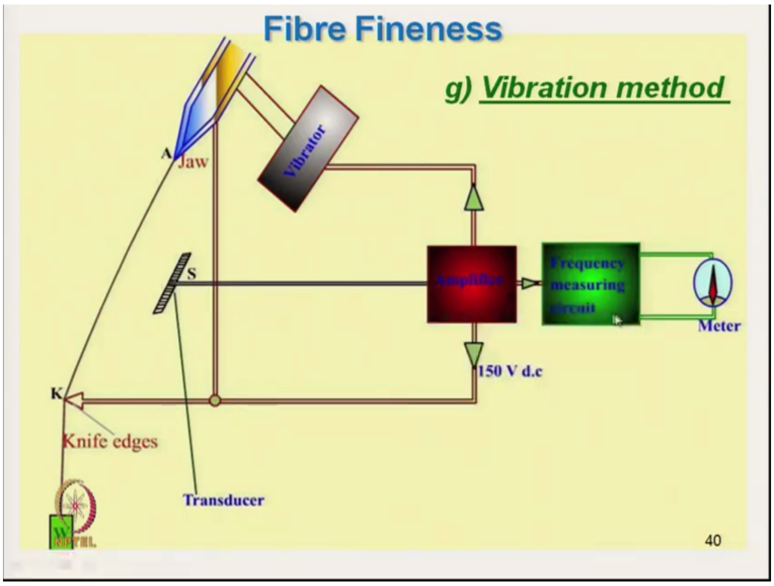
So, how to get the natural frequency? So we have to vibrate this string with wide range of frequency, series of frequency. And in one particular frequency, it will have very high vibration that is why, that frequency is the natural frequency. And Tension, T=Wg, it is the range between 0.3 to 0.5 centimeter/tex, that is the tension we have to apply here. And we can convert this mass per unit length in terms of denier by simply multiplying by 9, multiplied by 10 to the power 5. This is the direct typical to measure the denier, of the fibre.

(Refer Slide Time: 36:38)



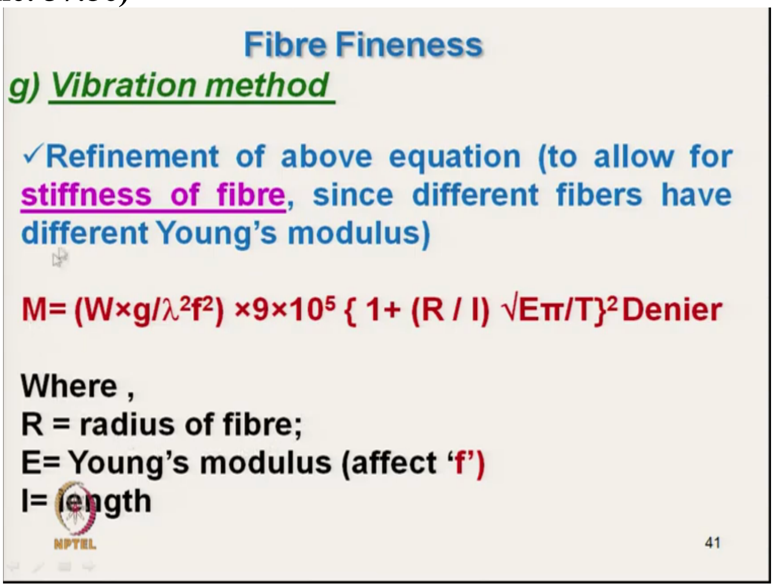
Fibre is then caused to vibrate either by vibrating top comb or by using transducers, ok we can allow the fibre to vibrate and the amplitude of vibrations is measured over a range of frequencies. We can actually vibrate at different frequency and the amplitude we measure. So the frequency, where amplitude is maximum, that frequency is taken, ok which gives, the frequency which gives maximum vibration amplitude, is the fibre resonance frequency. That frequency is f, ok. That is taken for calculation, from which linear density is measured.

(Refer Slide Time: 37:32)



Now this is the technique, here this is, actually the vibrator is there. And here it is vibrated with the wide range of vibration, and where the maximum frequency is there, that value is taken.

(Refer Slide Time: 37:56)

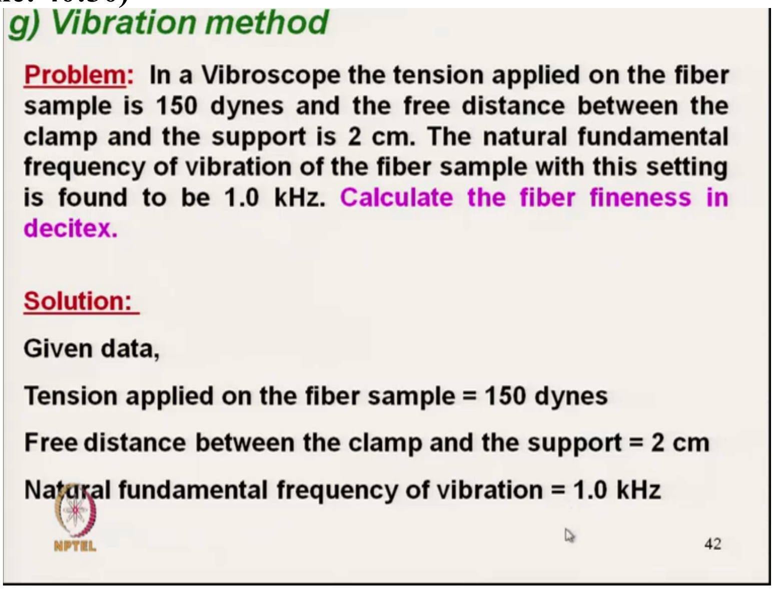


Now actually there will be different fibres of different initial modulus, Young's modulus, this fibre, this method is normally used for manmade fibre and manmade fibres like polyester, polyester will have say different length, same length, same everything even same. But will have different say young modulus. And this young modulus difference in young modulus will lead to different amount of frequency. So if we change, if the keeping all other parameters constant, if it is then for same diameter, same mass per unit length fibre, if the young modulus of two fibres are different, that will affect the frequency, fundamental natural frequency value.

So, how to correct it? So if the dia, our idea is to measure the mass per unit length, but if it changes with the young modulus, then we get wrong result. So to counteract this value, so this is the modified refined formula, is used, considering the Young's modulus theorem. So here if we use the Young's modulus, if we take Young's modulus here and if we use it, then we will get the actual mass per, corrected mass per unit area.

It is a fineness of fibre, so refinement of above equation to allow the stiffness of fibre, so if the stiffness of fibre increases, if it is high, then this value will be, will also be high. So that is why, if it increases, so this value will also be, will be different, so accordingly we can, modify the equation. We can, we can get the correct result ok. So earlier equation was this one, so this portion have been added ok for correcting the different stiffness.

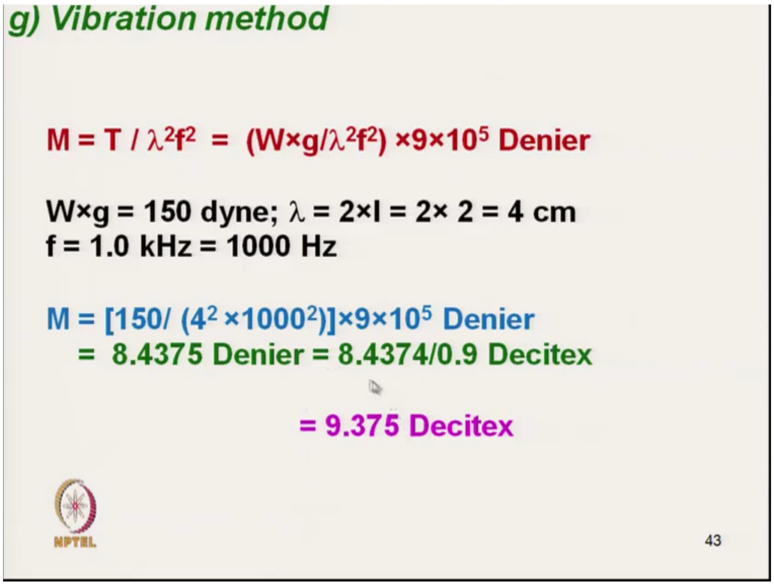
(Refer Slide Time: 40:30)



Now one simple example, is that, in a vibroscope that is the instrument which measures the; what is the principle of vibration principle, in a vibroscope the tension applied on the fiber sample is 150 dynes, ok that is the tension applied, and the free distance between the clamp and support is 2 milli, cm, that is the free distance. The natural fundamental frequency of vibration of the fiber sample with this setting is found to be 1 kHz. Calculate the fineness in decitex.

So this data, directly actually given, in such a fashion, so we can use the formula, the given formula directly. So, here tension applied is 150 dyne, free length of support is 2 cm, and natural fundamental frequency is 1 kHz, that is 1000 hertz, and fineness we have to measure.

(Refer Slide Time: 41:45)



So, this is the formula. It is the formula for Denier. So this Wg is nothing but the diameter. And this is the length so we can get, this is dyne, lambda frequencies which is 2l, twice l, so it is 4 cm, and frequency f is that 1 kHz, 1000 Hz. So we can simply replace this value and use this value, 150/4 squared, 150/4 squared multiplied by 1000 squared, into 9 multiplied by 10 to the power 5. So if we use, if we get this value it is coming out to be 8.4375 Denier, this is denier and from denier to decitex, if we want to convert, it is a divided by 0.9, so what we are getting, the decitex of the fibre, 9.375.

So this is, this way we can actually calculate the decitex, or we can measure the fineness of fibre, ok. So we have discussed all the methods of measuring the fibre fineness. It is the decitex, and thank you.