Evaluation of Tensile properties of Textile Materials
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Lecture – 21
Evaluation of Tensile Properties of Textile Materials (contd…)

Hello everyone, so we will continue with the tensile testing and today we will start with the beam balance principle.

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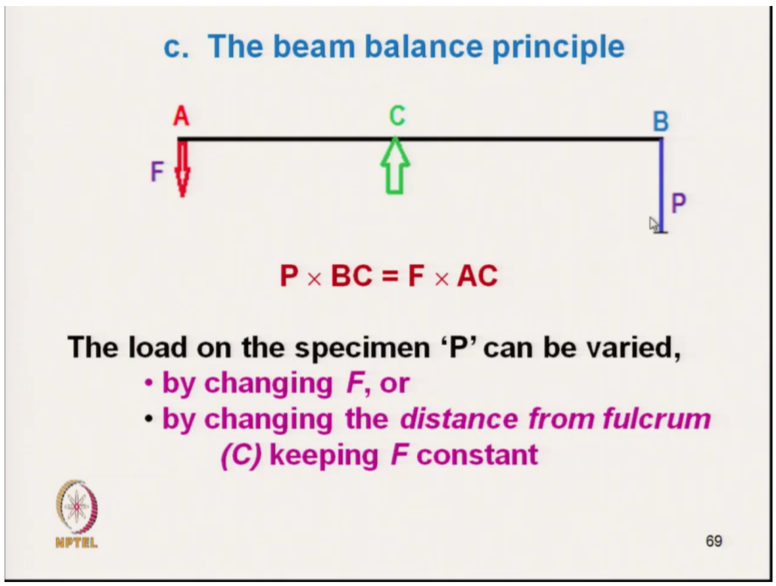

First let us see, what is the principle of measurement of tensile characteristics by beam balance? This is a basic principle; here it is a beam AB, where it is pivoted at point C now if we want to know the force ok, and the load on the specimen P. We calculate the load on the specimen P by knowing the force applied downward force applied at point F; at A, F force applied and if we know the distance.

So, PC is the distance from the pivot point to the specimen and AC is the distance from the pivot point to the force applying point ok. So, this is the equation simple beam balance equation P * BC = F * AC. So, the load on the specimen P can be varied by changing the F. This is the load so if we change the gradually, if we change the load, that means the P value can be changed.

So, that we can measure the strength up to the breaking point or by changing the distance that is distance from the fulcrum point C. The loading point is constant. So either you can change the load F, keeping the, AC distance fixed ok. Then we can change the load P, or if we can keep the load fixed ok F fixed. If, we change the distance AC, if we increase the distance AC gradually then the value of P will increase. So, P; BC is fixed, BC here it is constant if we keep constant, if we only increase the AC, then it will increase the value P.

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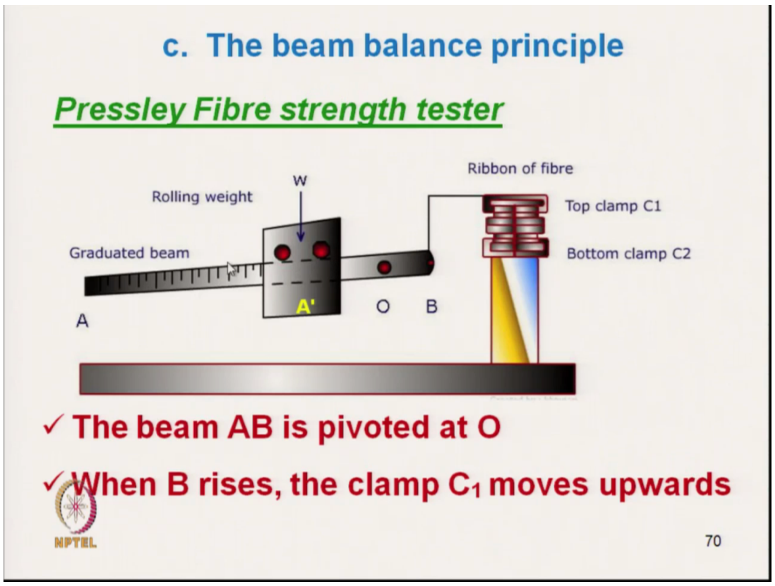

This principle is used in Pressley Fibre strength tester. Here, in this Pressley tester, we test the bundle strength and the same the jaw which we have used in stelometer. The same jaw can be used here and the same jaw which we have used and here it is the point O is the fulcrum point. So here we have seen this is the point fulcrum point C this point is shown here O, and point B it nothing but here, this is the point B and O, and the point A, the point A here changes here.

And here the mass; this is the mass of the weight it is the dead weight. It is fixed and in this instrument the beam, it is little bit inclined. So, that the mass slides down gradually so that the distance OA increases gradually. The beam AB, this is AB is the beam here, which is pivoted at O. When B rises, when B moves up that means the clamp C also moves up, so, this is fixed. This is connected and this applies the force on the fibre bundle here.

Because bottom clamp is fixed here and top clamp is connected with B. So, as the load is sliding down its increasing, so it will apply downward force and this B portion would always like to move upward, so it will apply force.

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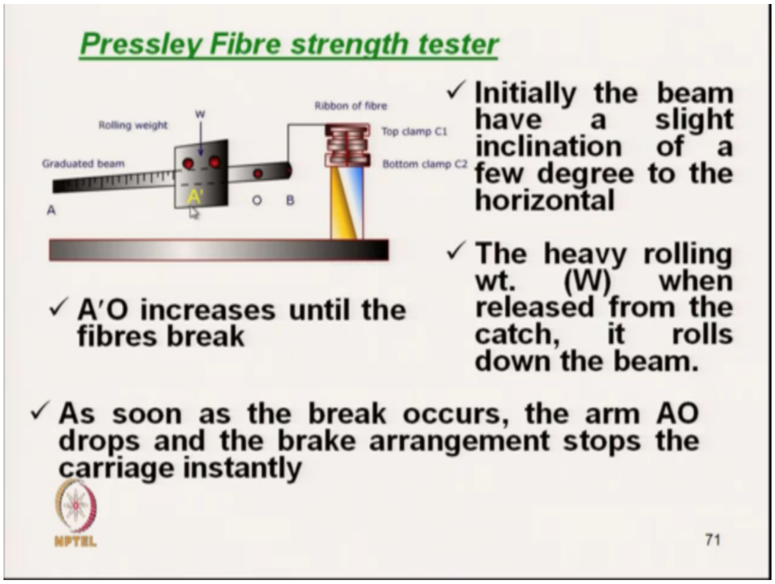

Initially the beams have a slight inclination, this beam it has slight inclination so that once this dead weight is released, its tendency is to slide down. So, it is few degrees. A heavy rolling weight, It is a rolling weight with the roller when released initially it is fixed when it is released from the catch the roller it rolls down to the along the beam. Now, as it is rolling down the force we have seen the OA is increasing.

So, gradually the force applied on the fibre bundle will increase and A dash O increases until the fibre breaks. It is a heavy mass. So the arrangement is such as soon the fibre breaks. The design is as this dead weight with the roller arrangement it will not move further. It will stop immediately that is the arrangement as soon as it breaks it will fall down and immediately. It will break it will stop.

And the arm AO drops this AO arm immediately will fall, on this platform and the brake arrangement stops the carriage instantly. So, why is it required to stop this carriage, because that otherwise, it will keep a wrong result and as we have seen from the earlier equation? This P, value that AC value when BC is constant and this F value is constant. BC constant, A value is constant. So, P, is actually is measured by measuring the AC value.

So, AC is the indicator of the force applied on the fibre so that is why if we see this, this beam is gauged, this is the distance but this distance is gauged directly the breaking load value. This is the directly breaking load value it is gauged.

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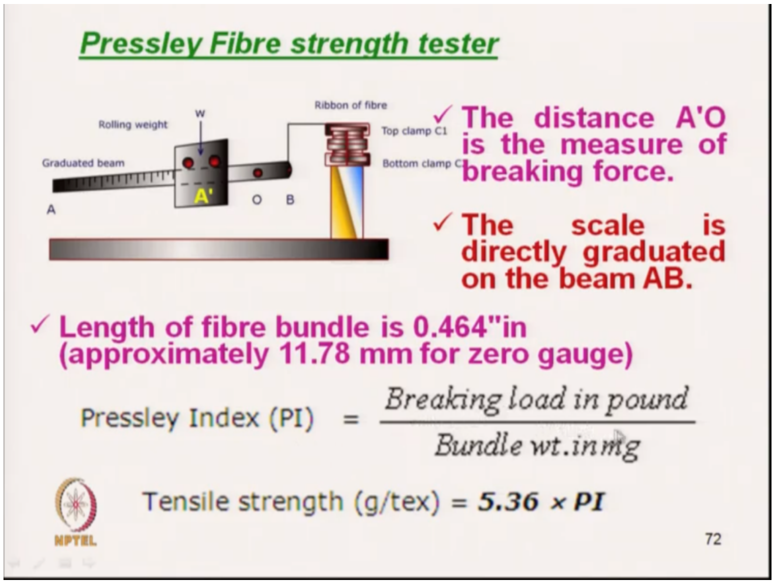

So, the distance A dash O, when it is breaking is measured of breaking force. It is a measure of braking force A dash O. The scale is directly graduated on the beam; here it is directly graduated in terms of say gram/tex and the length of fibre bundle here is .464 inch at 0 gauge, now, let us see at 0 gauge length.

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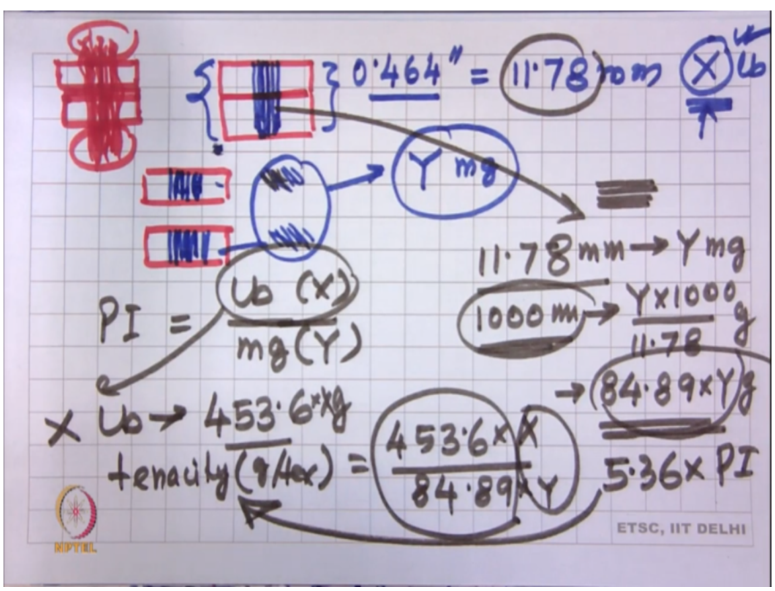

This is the clamp. This is top clamp and this one is bottom clamp. In bottom clamp among these two the fibres are the bundles are fixed and 0 gauge there is no gap. It can work in other, stelometer can work in three millimeter gauge length here the gauge length is 0. So, there is no gap. So, the arrangement is that we add the fibre bundles are gripped here, then after that this excess fibres are cut by knife. So finally, what we get this is one jaw, this is another jaw and fibre bundle is; we do not know the number of fibre bundle and this is the fibre bundle.

But here, the thing, which is known, is, it is the length of the fibre bundle. The length of the fibre bundle is 0.464 inch, which is fixed because here the jaw is fixed for Pressley tester. So, this ensures that length, which is equal to 11.78 millimeter this is at 0 gauge length the length of the fibre bundle. Now after breaking suppose, it is breaking at load of say X pound. At X pound it is breaking, after breakage we take out these jaws.

So this jaw will like, be this after, because this jaws will be separated. This is top jaw, because fibre bundle has broken and fibre bundle will remain like, is this at the top jaw and these fibres at the bottom jaw. Now we have to take out these fibres, we have to take the mass of these fibres so, from top jaw we have taken the fibres collected and bottoms of you have taken the fibre we have taken out the fibres and this and the mass of the fibre, we have taken as Y milligram.

This is X pound force is the force of the bundle braking force of the bundle. Here, it is Y milligram is the mass of the bundle. Now, here in Pressley index. It is nothing, but the breaking load in pound by bundle strength in milligram. So, this is gauged in terms of Pressley index. So Pressley index is breaking load in pound and bundle stength in milligram, so X we have seen pound, and Y milligram we have seen.

And we can convert this Pressley index in terms of tensile strength in gram/tex by multiplying 5.36 ok. So, Pressley index also shows the tenacity of fibre bundle and tensile strength is also gram/tex is the tenacity of fibre bundle. But their relationship is 5.36. Now, let us try to see how this 5.36 value. We can achieve. So, what it is showing the Presley index, it is nothing but breaking load in pound, which is X and the mass is milligram, which is Y.

Now, what is the length 11.78, so for 11.78 millimeter length the mass is; what is the mass? Y milligram and if we want to measure, the tex of this fibre bundle. So, we can takes of fibre bundle 1000 meter. So 11.78 millimeter the mass is Y milligram for 1000 meter what will be the mass in gram. So, it will be Y* 1000/11.78 in gram. So, this is coming out to be 84.89 * Y gram. That the mass of this material 1000 meter is this much gram this is the tex value ok.

Now, coming out to the; now let us see; coming to the stress value, force value in pound, the force is X pound. We have to simply convert the X pound into the gram that is 453.6 gram force, pound force to gram force. And now the tenacity in gram per tex, will be 453.6 * X / 84.89 * Y, that means X /Y. Actually, it is the Pressley index. Now if we see this value, this is nothing but 5.36 into Pressley index. So this is the tenacity.

So, this way we can calculate the relationship between the Pressley index and the tenacity. Now, one can try for 3 millimeter gauge length what will be the relationship between Pressley index and tensile strength, when in case of 0 gauge length, it is 5.36. What will be the relationship between the Pressley index and tensile strength in case of 3 millimeter gauge length?

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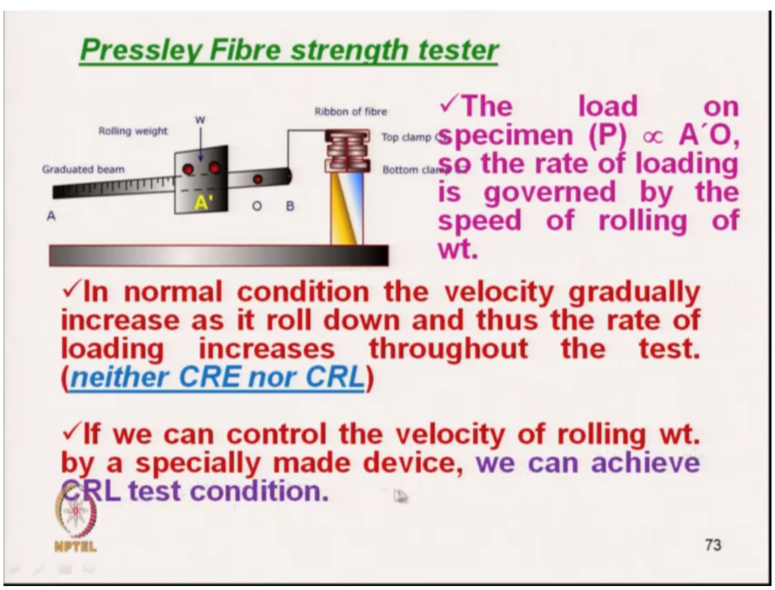

This we can derive the load on the specimen P is proportional to the A dash O, so that the rate of loading is governed by the speed of the rolling. So, speed of the rolling. So that is why this instrument is another work on CRE principle nor, it is working on the CRL principle. So, if the question is that you explain one method, which does not work on neither on the CRE principle nor on the CRL principle. So, that is Pressley index Pressley instrument is the example of that. Like, stelometer works one CRL principle. And if we can control the velocity of rolling weight by specially made device we can achieve CRL principle. That is basically difficult in normal case. It does not work.

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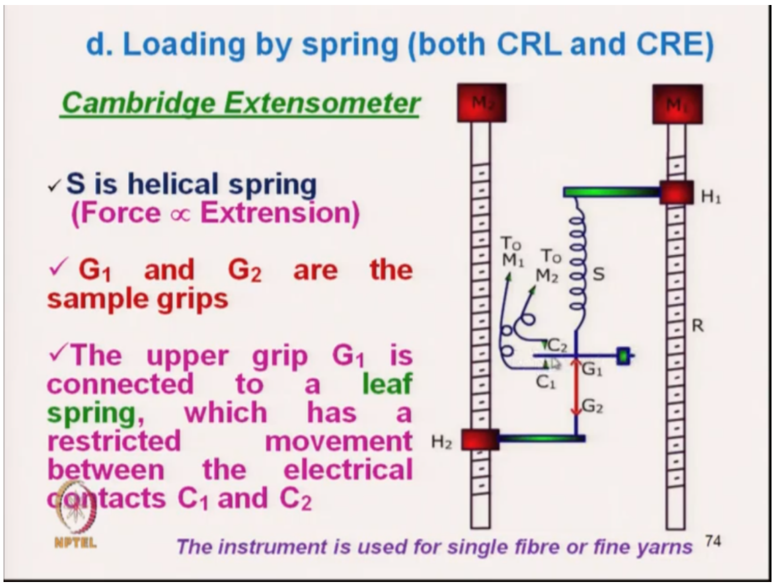

Next is the, instrument. It is called Cambridge extensometer. This instrument actually works on both CRL principle and CRE principle this is the unique instrument, which works in both principle both constant rate of loading principle and constant rate of elongation principle. Now this instrument is used for single fibre or fine yarns. It cannot actually tests very strong yarns single fibre with that at lower breaking load, because here, the loading is with the help by of extending the spring.

Here S is the helical spring, and force in spring, we have seen force applied is proportional to the extension if we increase the extension, then force will increase and if we increase the extension at a constant rate, the force will increase at constant rate for spring. For G1 and G2 are the specimen grips, so red color, this one. This is the actually specimen and at the top jaw that is 0 and on top grip one leaf spring actually one leaf spring is there. The upper grip G is the connected with the leaf spring this is the leaf spring which has a restricted movement between two electrical contacts C1 and C2 ok.

This is the leaf spring horizontal and between C1 and C2 this can move. And the distance between C1 and C2 are very, very small ok.

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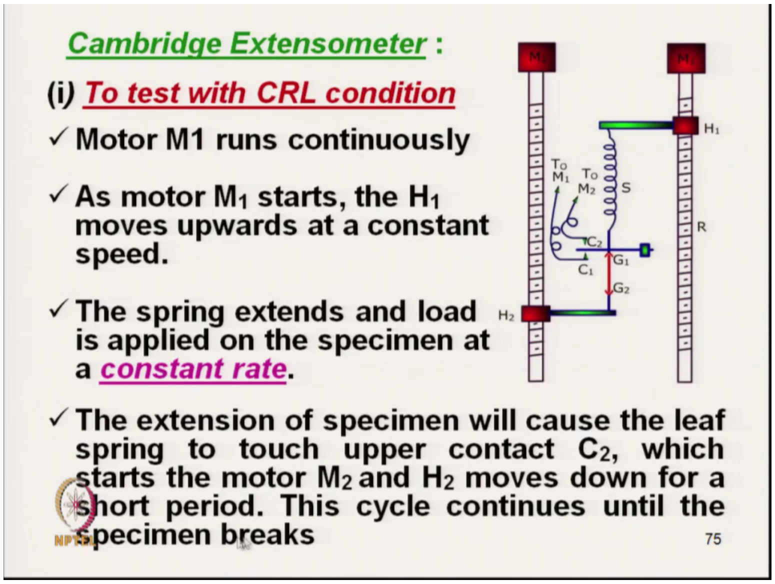

Now, it when it is working in CRL condition, constant rate of loading condition. Now, what happens? In Constant rate of loading condition and this two screw rods ok connected with the follower H1 and H2 the rods that are; so this rod is driven by a motor M1 and other rod is driven by motor M2 and this follower H1 is connected with this rod and follower H2 is connected with the other rod. When the instrument is supposed to work on CRL principle in that case, the motor M1 rotates continuously and motor M2 its normal case it will remain stopped ok.

Now when motor M1 starts moving the follower H1, so as motor moves, this H1 moves upward this one moves upward. And this motor is stopped, so this is the fixed jaw, this jaw is fixed. This is the jaw it is moving upward. Now, as motor M1 starts, H1 moves upward at constant speed. Then the spring gets extended as the spring gets extended at constant speed that means loading will increase at constant rate ok. So, at constant rate, spring is extending, that means the loading on the specimen is extending, increasing at constant rate.

As the extension of the specimen as the load is applied on the specimen between G1 and G2, so, as the specimen get extended that means this leaf spring will be in contact with C2 upper restrictor which is connected with the motor M2. As soon as this, there is a connection, it is touching. The motor M2 will get signal and it will start moving downward. That means H2 will start moving downward so that again, till there is a disconnection, and when it is moving downward again, lifting will move little bit downward.

So, with this again, it will be disconnected motor will immediately stop but the motor M1 rotates continuously it is rotating continuously, it is moving upward ok. So, the extension of the specimen will cause the leaf spring to touch the upper contact C2, which starts the motor M2 and H2 moves downward for the short period. This cycle continues until the specimen breaks. So, this for very short time it will move and again it will stop and again it will continue till it breaks.

So, what happens; what is there the movement of H1, the movement of the motor is the indicator of the load. Here movement of the; this M2 is the indicator of extension. So, as this one, this motor M1 is moving at constant rate so it is applying the load at constant rate.

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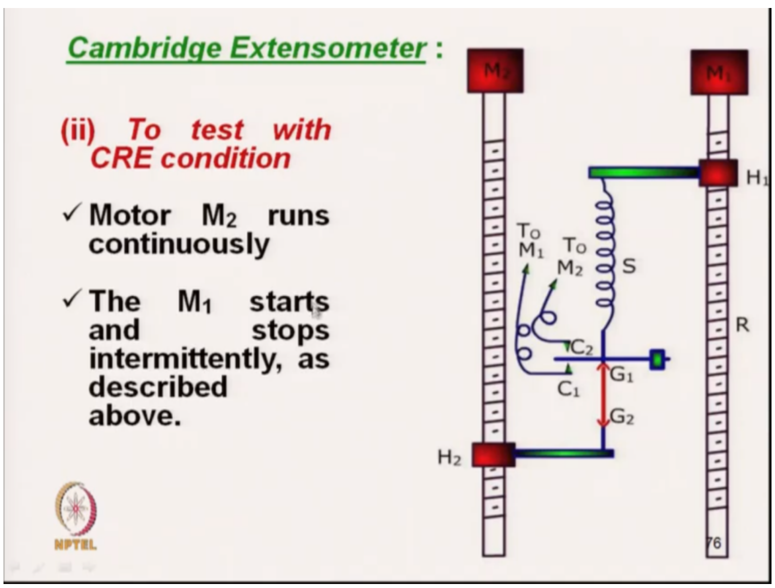

So, when it is working in the principle of CRE principle, constant rate of elongation principle in that case, the things will be just reversed. The motor M2 will run continuously and motor M1 only will start and stop intermittently as we have discussed earlier in case of CRL principle. So, that is how the motor M1 will run and stop intermittently. So, as the motor M2 moves continuously H1, so H1 will move down continuously.

So, there will be a continuous; it will extend at a constant rate. So that is why this process is constant rate of elongation.

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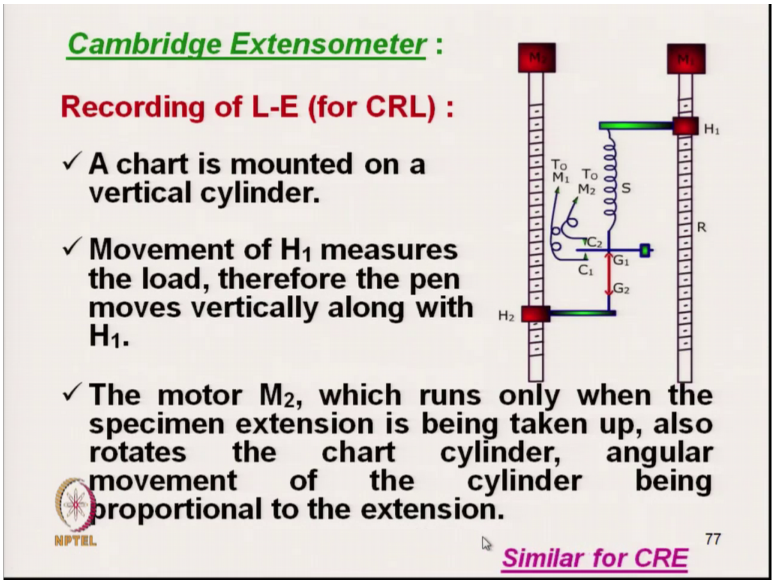

Now how to record? So, we can record the load elongation curve CRL principle. A Chart is mounted on vertical cylinder and the movement of H1, its movement of H1 that is a recorded by a pen. So that the chart is mounted; suppose the chart is mounted on a cylinder and cylinder is getting drive from Motor circular motion it is getting from the motor M2 ok and the pen is fixed suppose on H1.

So, vertical movement of the pen shows which basically shows load movement of H1 measures, the load, therefore the pen moves, vertically along with the H1 and the rotation of the cylinder. The chart is mounted on cylinder vertical cylinder the rotation of this cylinder will actually show the actual extension of the material, so if we make a cylinder, like, this suppose, this is a cylinder now here it is a graph paper is there.

We are placing the graph paper. Now, the rotational speed rotation is getting from by M2. M2 is giving the rotational motion and the vertical motion is given by the M1, so M2 is moving, when there is extension and loading is there when it is a vertical motion. So, ultimately the resultant, there will be a total plot of load elongation curve. So, this will give us the load elongation curve for constant rate of loading.

Where motor M2, which runs only when the specimen is extended, is taken up and also, it rotates, the chart cylinder, angular movement of the cylinder being proportional to the extension. And in case of CRE principle, we can similarly we can get plot.

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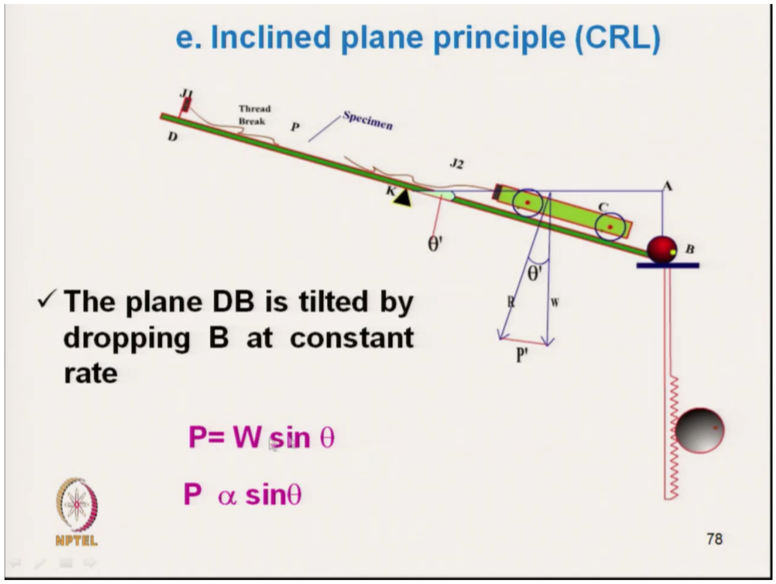

Now the next principle is that constant; it works on constant rate of loading principal and this principle is known as inclined plane principle. The plane DB ok this is the DB is the plane it is tilted by dropping B at a constant rate. So, there is a; it can be dropped at constant rate and then is a carriage here which is actually responsible for loading. It is a weighted carriage of mass W. Now this side it is a B side is dropped at constant rate we can control by any arrangement like that rack PL arrangement, or screw arrangement. The plane DB is tilted by dropping B at constant rate. Here if we see the P, is the force applied on the material and specimen is equal to W, W is the mass of the carriage.

So, W sine theta, as the sine theta increases the W; the P, will increase for a same mass. So, P is proportional to sine theta here, W is known, so if we can change the loading that increase in sine theta at constant rate, and then can we achieve the constant rate of loading. So, P is the loading on the load on specimen. Now, if we see the triangle here triangle, the K is the fulcrum point KAB it is a triangle where this is the; theta is the angle AKB is the angle theta, which changes, which increases with the dropping of the point P and if, that is the sine theta is proportional to AB.

That is this AB where KB is constant this is a fulcrum point is constant. This beam length KB length is constant. So, this sine theta is proportional to AB here. Now if we can change if it is dropping at constant rate. So, AB is changing at constant rate, so sine theta is changing at constant rate. So we are achieving the CRL condition. If AB, is increased at a constant rate sine theta will also increase at constant rate. So CRL condition is achieved. So, this principle, we achieved CRL principle and here one arrangement is there this side B is simply placed on a platform here. It is not fixed because as its sliding, it is adds that it is moving down inclination is increasing this B portion point.

This point of contact will little bit slight left side towards left side that there will be simply sliding ok that is why it is not fixed. It is only placed the; this end is only placed on that the platform ok.

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So sine theta is AB that we have discussed AB by KB, now it is moving down so we can this is not with this little bit it slides ok. It is moving down and the carriage is little bit coming on the right side. It is getting extended load is increasing at the constant rate and then it breaks. At that point, as soon as it breaks we have to stop the machine. And then we can calculate the breaking load.

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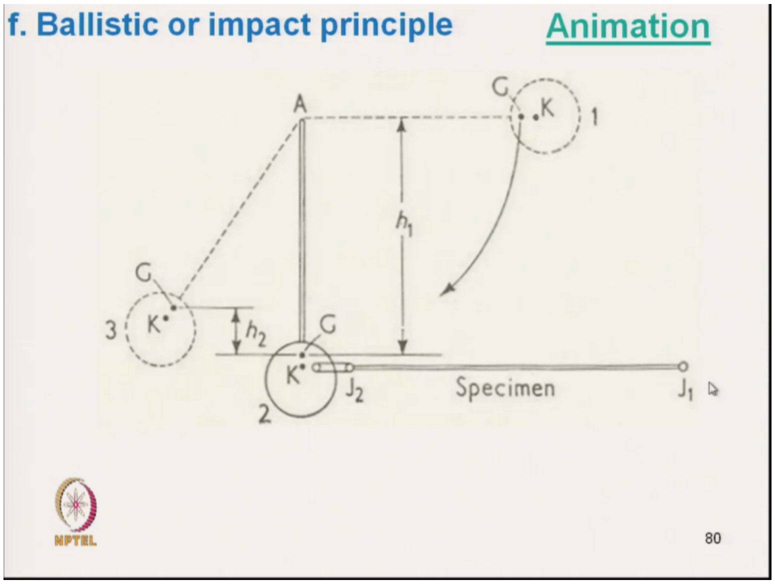

Next principle is that Ballistic or impact Principle. Here, there is a pendulum and the specimen is connected with jaw one J1 and J2 this is the specimen. And after that, this pendulum is actually lifted to the horizontal point here and with height H1 and when it is released pendulum will actually try to move to reach to other point. When it is lifted, the potential energy is actually stored here, then we just and this is the height and when with the material with the specimen attached. It has the least the height up to H2.

Otherwise, if there is no material, it should reach at the other side so the potential energy was up to the height H1. So, it measures, the work of rupture, what is the work done of the specimen, instead of maximum breaking force. So, in this principle, we can measure the, the work of rapture. It does not measure the, braking force.

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Now you can see the animation. So, in the first step when there is no material ok without material, we are trying to test. Now, it is coming down free swing is there. Pendulum is swinging ideally it should swing up to the extreme point ok. This is free swing ok. Now, we have fix the material ok. When the specimen is attached to the pendulum and it is begins to pull the material for breaking ok.

Now again the pendulum is lifted here and now we have to release the pendulum, the pendulum is being released here and pendulum is moving along with the yarn, which is fixed at one fixed jaw. And now the yarn is getting extended. After breakage, the pendulum will not move up to that point initial point. Now, after breakage the pendulum will not reach up to that the point initial point. It will stop somewhere and that height; this is the height H2. Now this H2 height and now break the specimen at the position, which is H1 and at the position point T.

And the work of rapture, we can calculate W* H1 - H2 that is the work of rapture. What is the work required to rupture the material ok, so initial work was their initial and energy was there and up to this energy it is going. So that is why we can calculate the work of rapture.

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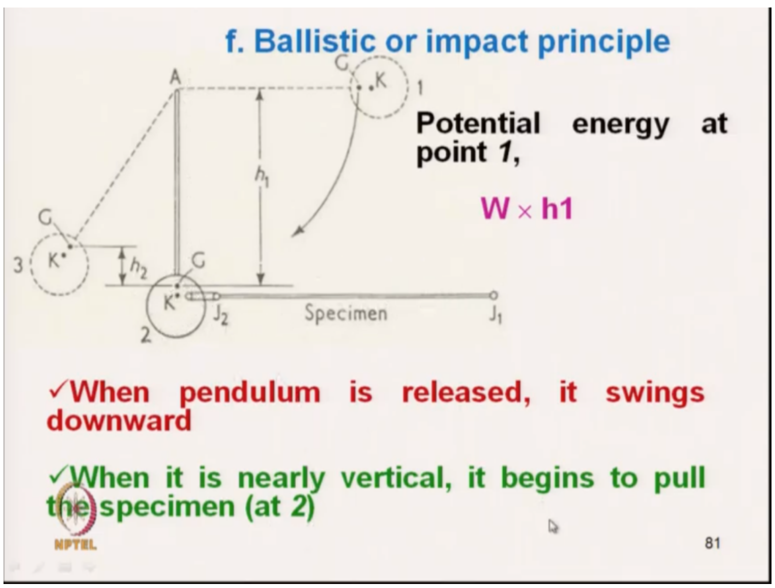

So the potential energy at point 1 is Wh1. So, when pendulum is released it swings down, when it is nearly vertical it begins to pull the specimen at 2 point. So, here, it will start pulling the material.

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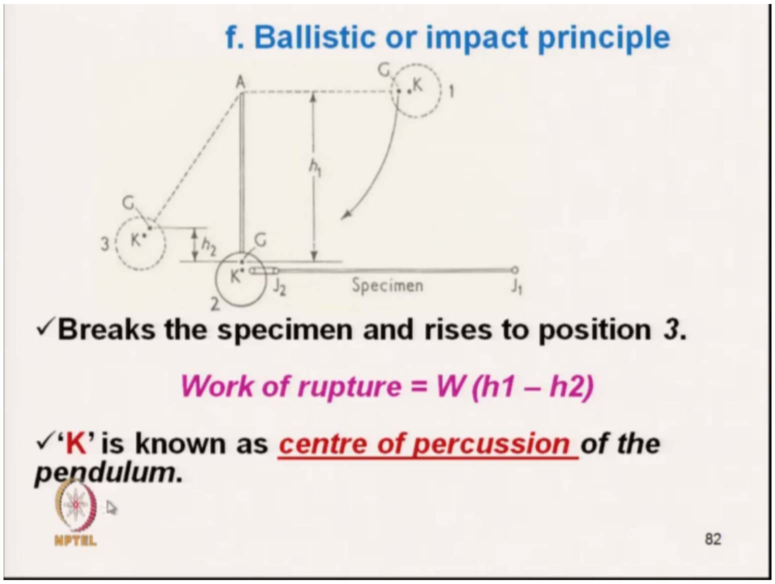

And breaks the specimen, and after breaking it rising to the position of the point 3. So, from there, we can calculate the work of rupture and K is known to be the center of percussion. So, this is key of the pendulum so what is the importance of center of percussion is that it is point a where there will not be excess jerk on the other side on the handle, in a cricket bat the point of percussion is the point where the batsman will feel the least jerk ok so that is the point here. So that point it is actually connected because otherwise, pendulum will have different uneven movement ok. To eliminate that uneven movement we have to fix the pendulum at that point.

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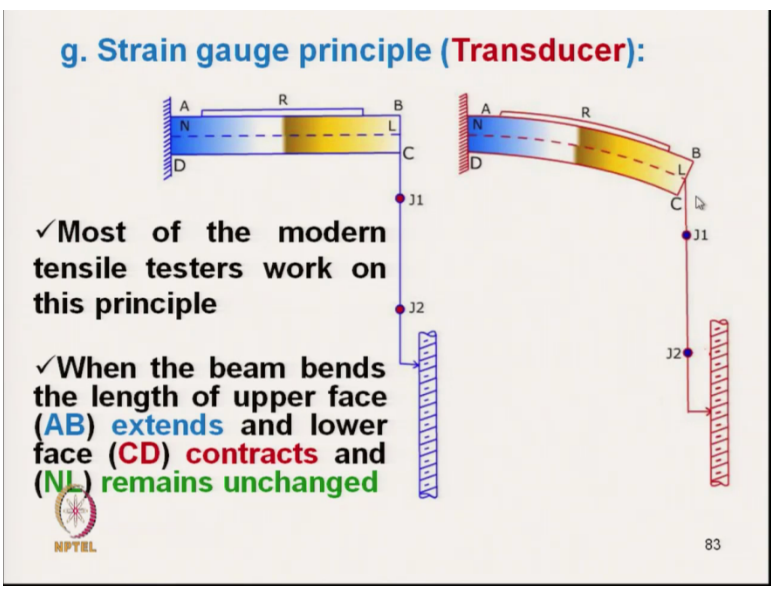

Now strain gauge principle: the strain gauge principle most of the modern machines, the works in strain gauge principle. The strain gauge actually here the movement of the other jaw is almost negligible that is why we can call. We can term this movement this actually principle as CRE principle, because whatever movement is then it is negligible here it is shown, although it is bent, but this bending is very, very negligible.

In, most of modern tensile testing machine work in this principle ok. When the beam bends, it has got three layers layer upper layer, middle layer and bottom layer ok. For any bending, the top layer gets extended and bottom layer gets contracted and middle layer there is no change. So it is remains unchanged. Then how to convert this value so here what happened, in this in top layer and the bottom layer that resistance wires are fixed ok. Now we want to; that the deflection, whatever deflection due to the load we want to measure.

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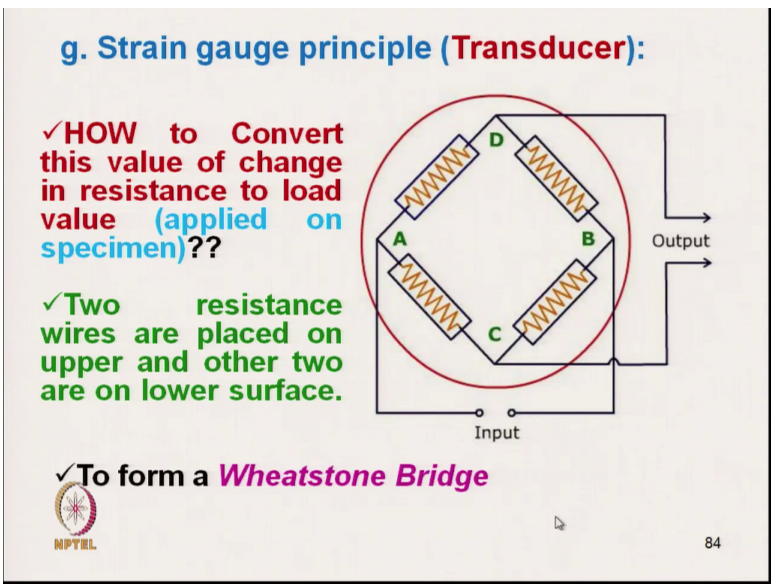

So, how to convert value of change in resistance to the load value that resistance changes due to the extension and contraction of the resistance. So, this is done by the Wheatstone bridge. Two resistances wires are placed on the upper layer and these are the resistance and other two on the lower side. Upper surface is 2, lower surface there are 2 resistances and which forms the Wheatstone bridge.

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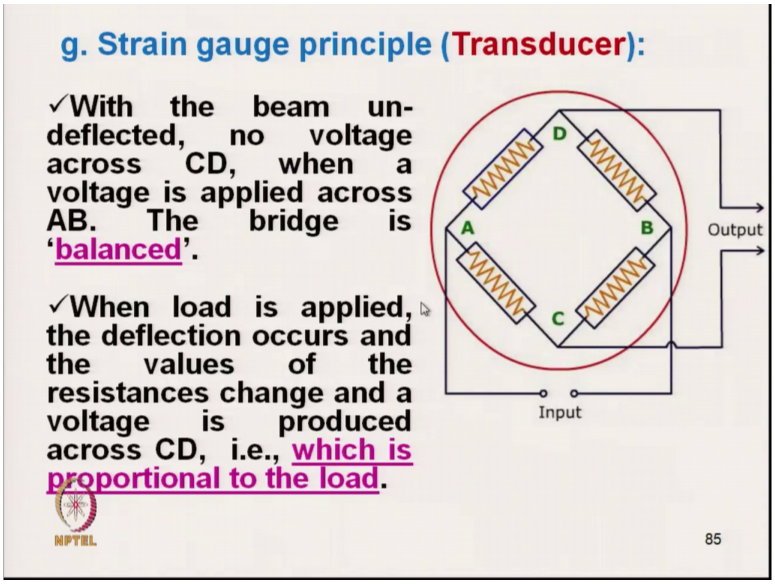

With the beam undeflected that is when the beam is not deflected no voltage across CD, there is no voltage. So, it will not show any voltage and when a voltage applied across AB so, across AB the input voltage there would not be any output voltage, because it is the Wheatstone bridge is balanced. When load is applied, the beam will get deflected and the resistance value will change and there will be output voltage across CD and this CD value this voltage value here is proportional to the load value whatever load is applied on the specimen this will be measured by this application from this output voltage value.

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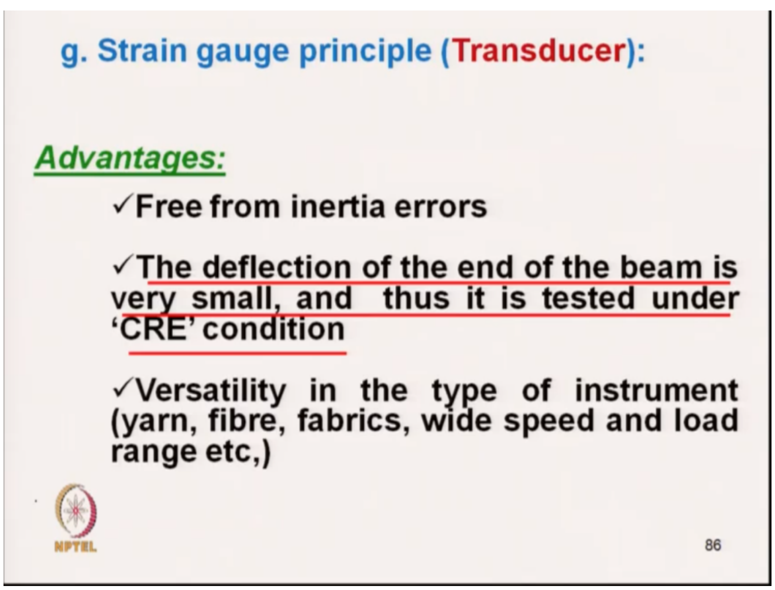

The main advantage of this instrument machine is that it is free from Inertia. So we have seen in other machine other techniques like pendulum technique or many other things the inertia effect is there this is actually free from Inertia. And the deflection of the end of the beam is very, very small and we can neglect that one. Thus, it is tested under CRE condition. Although there will be deflection. If there is no deflection the load value cannot be measured, but deflection is negligible and this technique is this principle is versatile.

Here, we can test yarn, fibre, fabrics at wide speed limit and with wide load range. So, that is why this strain gauge principle is used for most of the modern tensile tester with wide range of load requirement.

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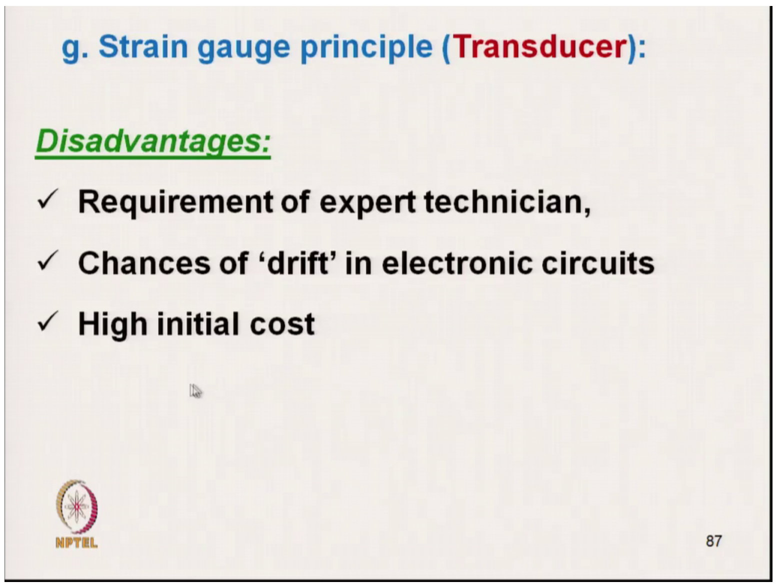

Main disadvantage of this system is that it is requires expert technician because lots of electronics are there chances of drift in electronic circuit. So after repeated extension, repeated loading there resistance wires may get extended permanently or contracted so that may lead to wrong results. That is why this type of instruments need recalibration with after specific interval, and another disadvantage is that it is cost is very high. So in the next segment, we will discuss few other techniques, so like constant rate of winding tester, so that we will discuss in the next class. So till then bye, Thank you.