Introduction to Mechanical Micro Machining.
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Lecture - 34
Components of machine tool (Contd.)

Good morning everybody and welcome again to our course on introduction to mechanical micro machining. In the last class we have seen some of the aspects of material for construction of different beds of the micro machining center and we have seen their polymer concrete is one of the solutions, one of the best materials which can be used for fabrication of the bed of micro machining center.

Then we can discuss about guide ways which can be used to move the table in the x y direction and the axis of tool; that is z direction that what are the different guides way we can use for making those type o components. So, let us continue this topic in the guides way.

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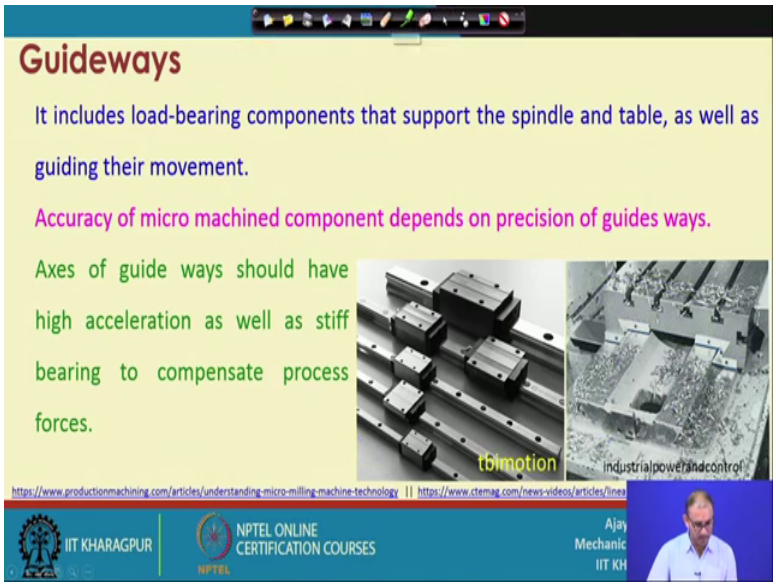

So, in the last class we have seen ah slide where we are, we have two different types of guides way, these are called the linear guides way and these are called the box type guides way. So, we will go through both the types, how these are useful and these things is not useful in terms of advantages and disadvantages of both the cases. And we have seen that these are used for loading of this [vocalized- noise], it will take the load of the

component or the work piece which we are putting. So, this are the guides way and this is the table on which your putting your work piece. So, this all thing will move to in fro. So, that is one particular axis, let us consider it is a y axis and the same thing is for the x axis also. So, you need two such type of guide ways for making a x and y motion, if it is a z axis, then you need one vertical such guide way, so that you can get x y z all the motion together.

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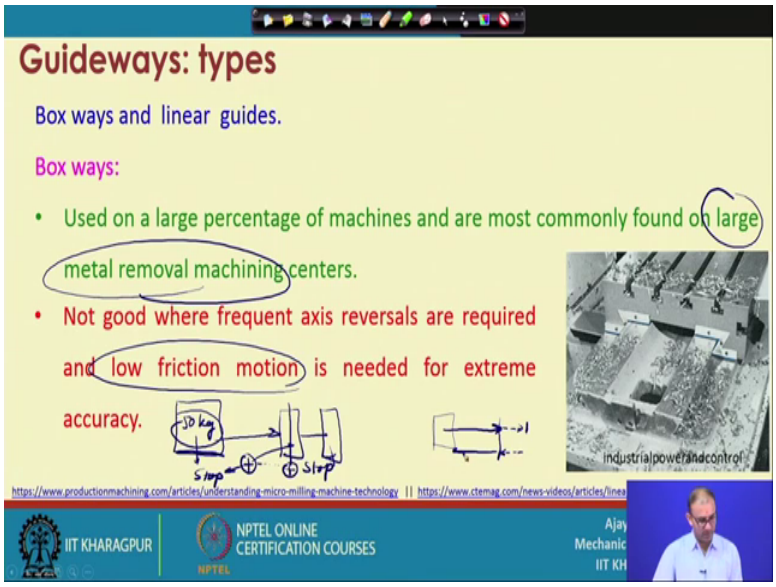


So, what are the types. So, we have seen that that two types; one is the box ways that is more conventionally used in almost all the machines and another one is the linear guides. So, these are the box way guides that we have seen in almost all the machine conventionally as well as c n c machines also. So, where it is used; it is used on a large percentage of machines and are most commonly found on the large metal removal machining centers, why it is so, because it has a large load carrying capacity, because if you see the size of this particular table which is moving on the top of this slide way it is very heavy and on the top of that, again you are putting a work piece and then you start machining.

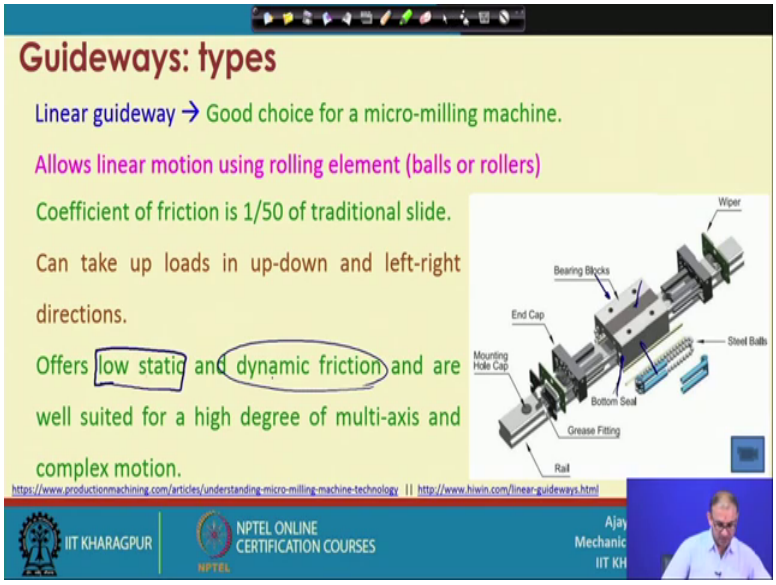
So, there are static loading from this work piece as well as slide and when you do machining at that time forces occurs, because of the machining also. So, it is mostly used for the large metal removal machining processes, where the size of this components and the machining process are very large. But why it is not good for this particular micro

machining, because it is not good where the frequent axis reversals are required and the low friction motion is needed for extreme accuracy.

Now you see the size of this, because everything depends on the inertia. Now if you consider that you your moving one object of a 50 kg and it is moving in this direction as suddenly you want to stop it here at this location, but it will not stop it, because it has inertia that weight is very very high. So, if you want to stop it here, you have to reduce the motion or you have to stop the motion here at this location, whatever the power supply you are using, if it is stop at this location then it will actually move slowly and it will permemes completely stopped at this location, if you stop this thing here and again it will move little bit, because of it inertia. So, that is the big problem with the heavy duty guides way or heavy duty machine slides way whatever we are using here.

So, if that is also problem, another is the low friction motion, because when the weight is more at that time you know the friction is also very high. So, in that case, so that is very problematic in that particular sense and other thing that we do not remove more amount of material and this is to be practically for the high material removal rate. So, we cannot use these particular guides way or the box ways for micro machining operation. So, that is the problem, because when you want to move axis from here to here.

Suppose it is a starting point is here and then you are moving at this location and instantly you want to move in this direction that that is not happening, because it will move little bit at this location and then you have to start this motion and then it will move to, because of this high weight of the component. So, that is not the right choice for micro machining applications.



Another one is the linear guides way. So, it is a good choice for the micro milling machining. So, how these things happens that it allows linear motion using the roller elements or the ball and roller. So, this is one schematic diagram of this ah linear guides way. So, what are the things are there. So, these are the bearing or there are two types of things; one you either you can use ball or you can use the roller, whatever is possible depending on the applications and then what these things are doing that, it will actually come into contact with this particular part.

So, basically what we are doing that instead of a two flat contact, what we are doing that we are putting roller in between these two correct. So, what is going to happen here the friction is very very less, because now here the contact area was very light, but here contact area is either point type or it is in case of ball bearing and if it is a roller, then it is a friction and are well suited for a high degree of multi axis and complex motion. So, why static friction, because now if it is in the stationary mode only the balls are in contact with this part, so you will not get.

So, much of friction here and dynamic friction when they are moving at that time, again there is no any change in the contact points. So, number of contact points which are in the static position, dynamic position that will not change. So, that is the very good example or very good advantage of using these linear guides way.

So, let see this particular video where almost everything is clear, what are the different components, what way you can define the different type of ah specification of the

machine and specification of the linear guide way and where these particular guides used in the different different application. So, let us go through that video and I will explain through that video step by step.

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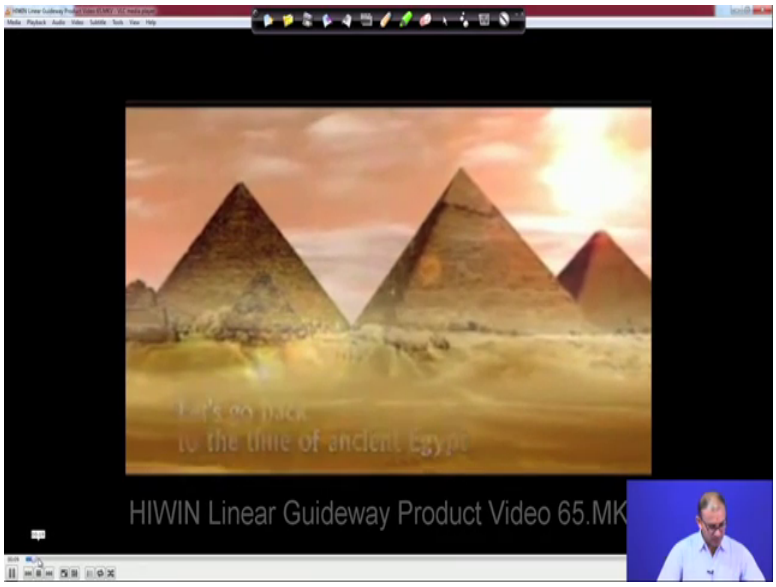

So, here what it is showing right, so this is the cases. Now you can see that if the rollers are there then you can reduce the friction of the components and these are the different different applications, where we can use.

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We are using these right now and so there are different type of instruments. So, these are the things where we need a sliding motions for the different type of operations in machine tools also available for movement of one component to another component, also we requires

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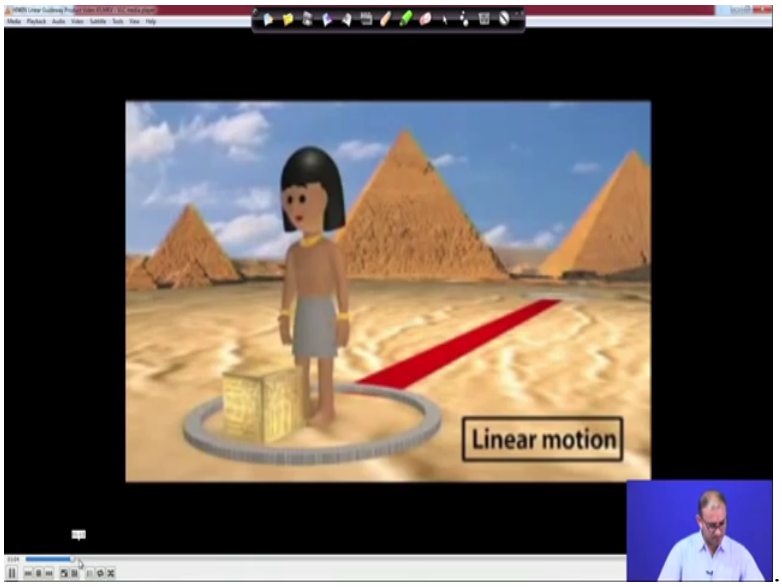

So, linear motion is that when you are traveling or transferring something in a straight line then that is called the linear motion right.

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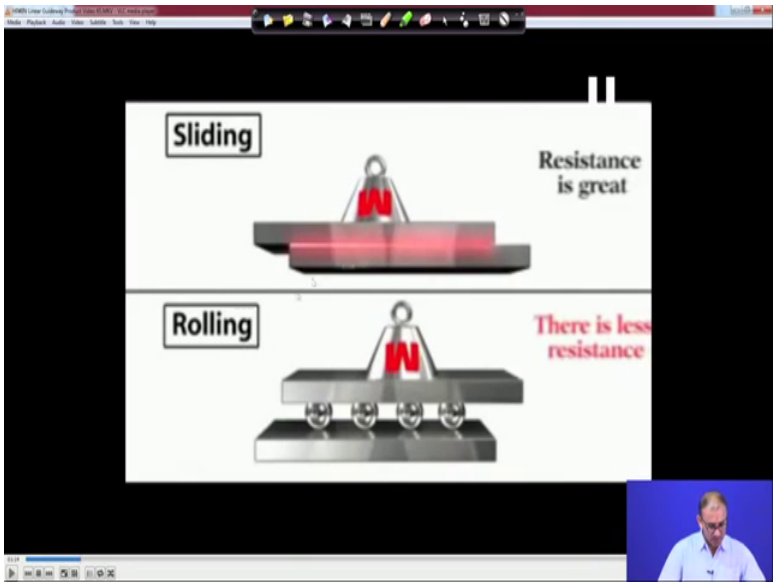

So, that is the advantage of these things. So, here it is the sliding. So, resistance is very very high, because your contact area is very very large here, but when you are adding a rolling aliment here, either ball or the roller then less resistances are there, because the contact contact points are very very less that apparent contact area between two surfaces are very very less. So, there are many applications. Now you can see these applications, where we need very very low friction motion, so that you can perform a particular operation without any problem. So, what is the, initially what was the thought that it was used as a linear bearing.

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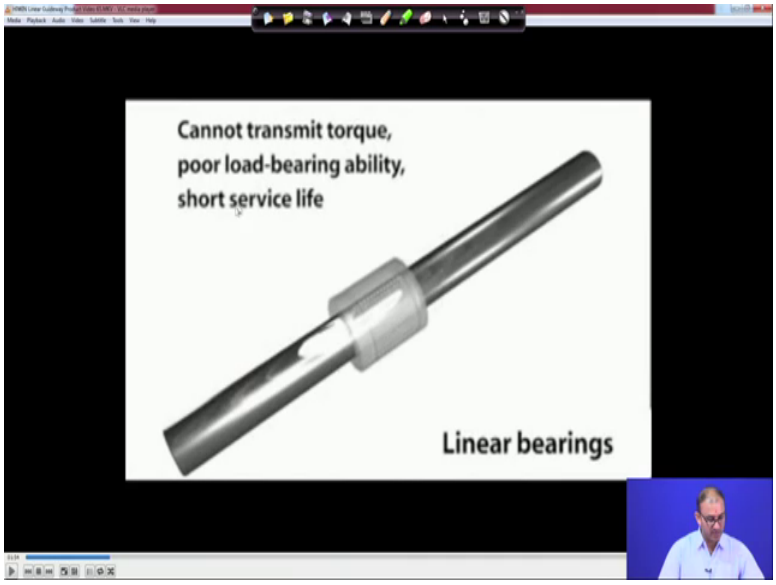

So, what is the linear bearing. So, linear bearing is that there are bolts available and this is the bush of that bearing and this is the shaft. So, here what is happening that balls are actually moving in a this way, only in this particular direction, not on to this particular circulator. So, linear bearings are not actually useful for torque transmission, because it does not have any type of restriction on the circular component, it will move in the forward and backward motions. So, that is the problem was the linear bearing, because you will not get any slots.

So, these balls will be scattered away when it is moving in the torsional part. So, cannot transmit torque and poor load bearing ability and the short service life, if you are using linear bearing as a linear mode at. So, what is the solution that instead if a ah shaft only you create one key wall in the on the shaft.

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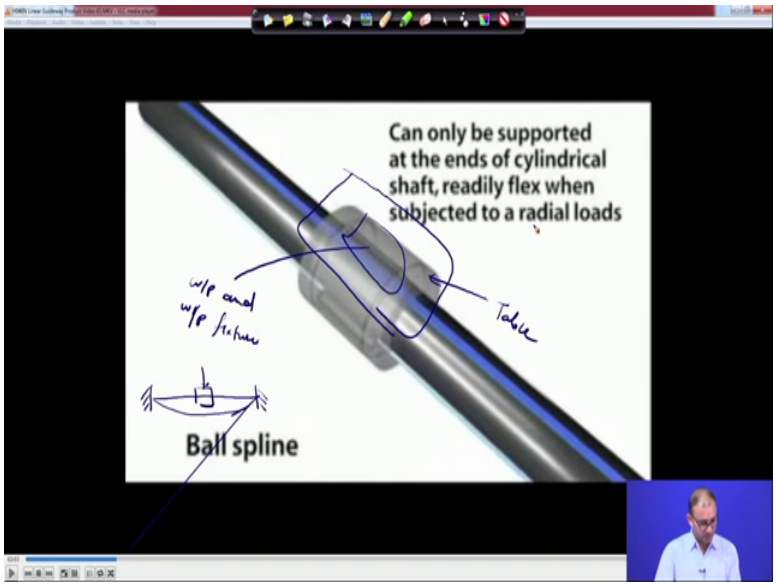

So, what is going to happen that, now this particular a key at that time you put the bearings on that is ball on the parts and at that time, it will create a motions. Now your bolts are restricted to move on the straight line; that means, in the linear direction only. So, when you are moving in terms of torque at that time, it will resist the torque, it is not the free to move, because now we have a constraints motion on these axel direction, so can only be supported at the end. So, what was the problem here that when you want to use this particular thing, your supporting points either this end or this end, so that is the problem.

So, what if you are putting very heavy load here, because ultimately what we are doing that we want to put some work piece here. So, this is table, it is coming here on top on the top, it is a work piece, this is the table and this is the work piece and work piece fixture right. So, what is going to happen? So, these are the low this is the end to end point and this is our location and this loaded at this location. So, what is going to happen. So, this is going to bend depending on the load total load on the shaft. So, that is creating a very problem

So, at the ends of the (Refer Time: 12:10) readily flex, when the subject to a radial loads, so this is called the radial load. So, let us see how this is going to happen. Now see this is going to happen when it is subjected to the radial load. So, that is because of that loading from the that top part, this is also not the good way.

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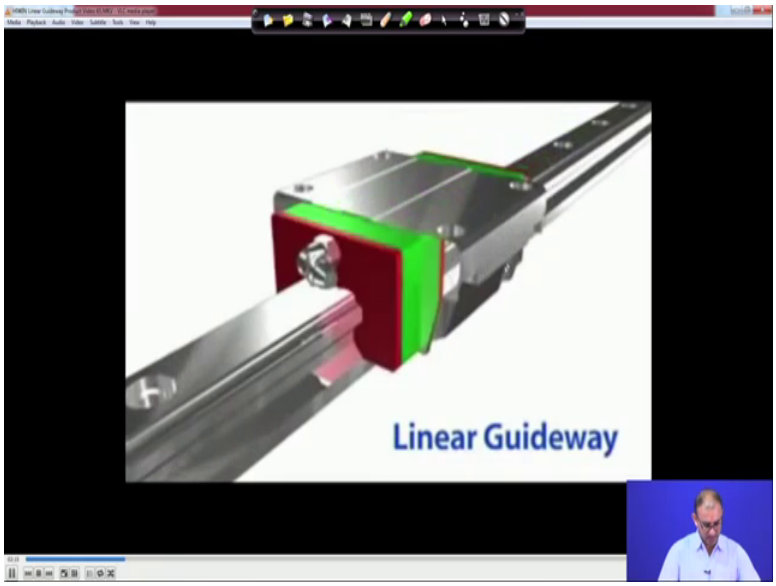

So, final solution is that instead of using a cylindrical shaft you actually go with the linear guide way. So, this is the guide way on which you mount all that subassembly like balls or rollers or different type of constraint motions. So, this is the advantage of that part.

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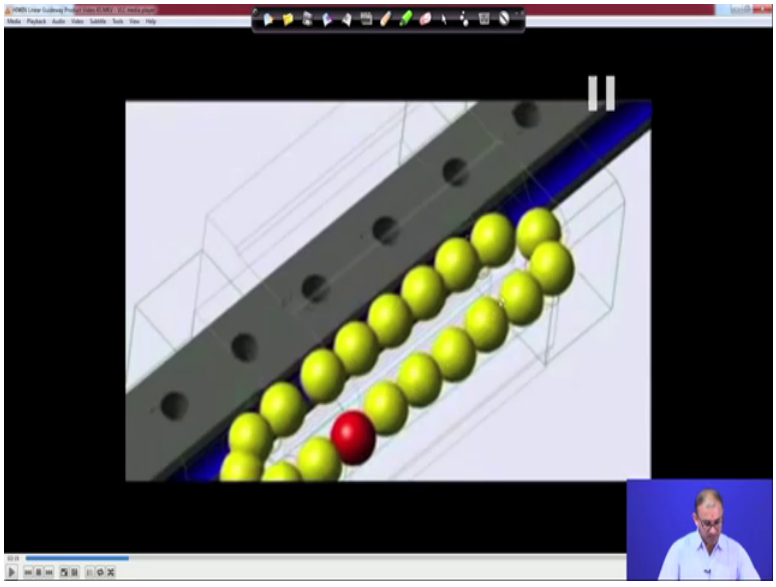

How this will work? You constraint the motions of the balls in such way that it will circulate continuously, when there is a motion between the drill and this particular ball.

So, contact points are here, here, here and all this pints only it will not create any problem at the later stage and we have seen that if contact is ball point.

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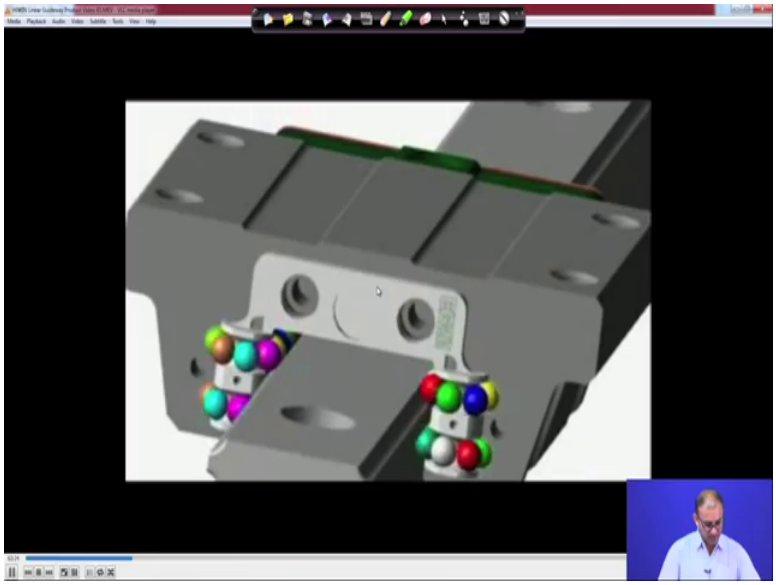

So, there is no any issue related to friction, very less friction is there. So, these are numbers of balls, we can use and these are the application by which you can get the things done. So, these are the sockets from where you can get these thing.

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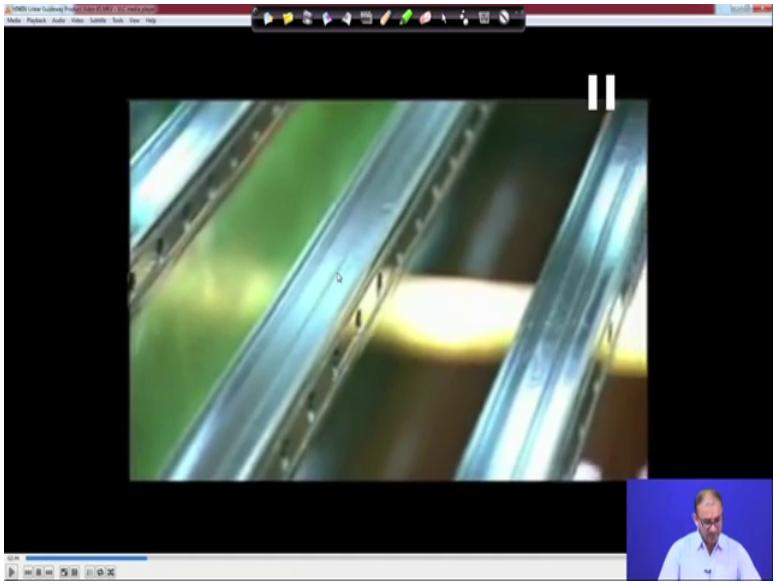

Another advantage you are using a box type of thing. So, the stiffness is very very high in this case, because whatever other cross section you are using like a circular kind of

thing at that time stiffness is less, but here it is a box type and it is a structure thing. That means, it is in some different type of ribs part kind of thing, so your stiffness is very very high in terms of the straightness and the load caring capacity. So, this is the vertical motion and if you transfer in other direction then you can get the different kinds of measures.

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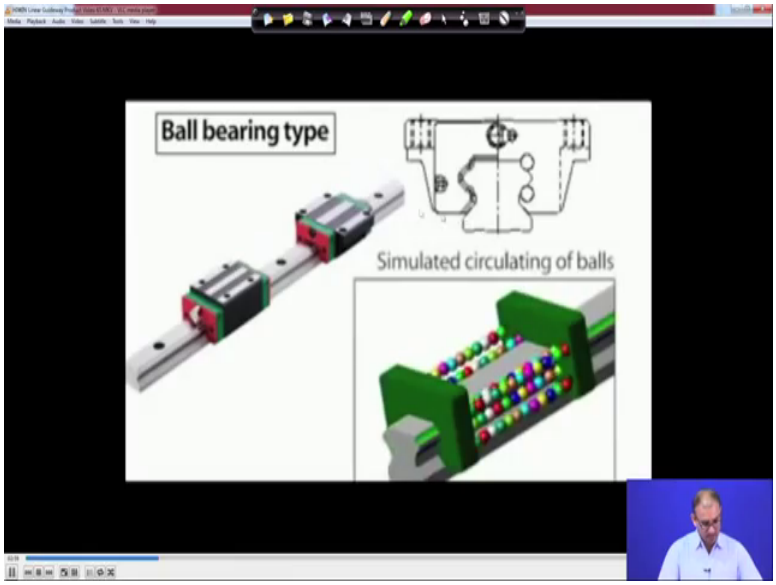

So, this is use for the ball bearing. So, now, if you are using a ball bearing then this particular motion will be something like this and other thing is a roller bearing.

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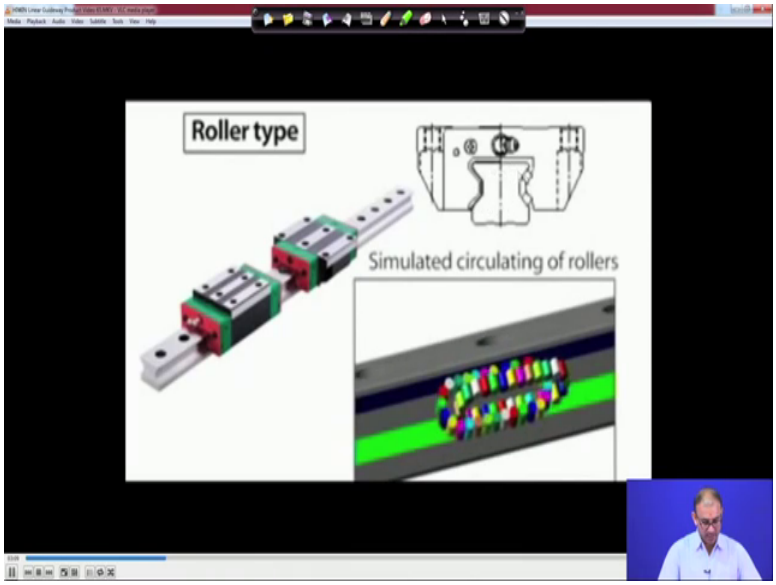

So, instead of balls what we are doing? We are using roller, so you get a like contact and you may get a more load caring capacity in this case.

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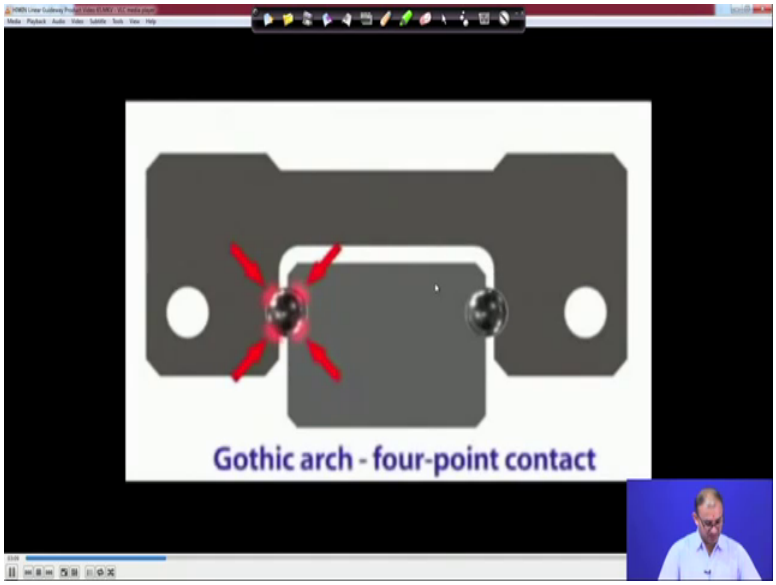

So, now what type of different, what type of contacts are required. Now we know that when you are loading something from the top and there is a chance of movement in this direction also, because now if your work piece is here and you are giving a force in this direction, your cutter is cutting this, then there are ways of getting motion in this direction also.

So, what is, what is thing that, there are four different types of contacts. This contact 2 3 and 4 and you are using a single ball on both the sides. So, that why it is called the 4 point contacts at this location, two balls are there and both the balls have 4 contacts; 1 2 3 and 4, 2 is on the real side and 2 is on this particular bottom fixture type. So, this called Gothic Arch 4 points contacts.

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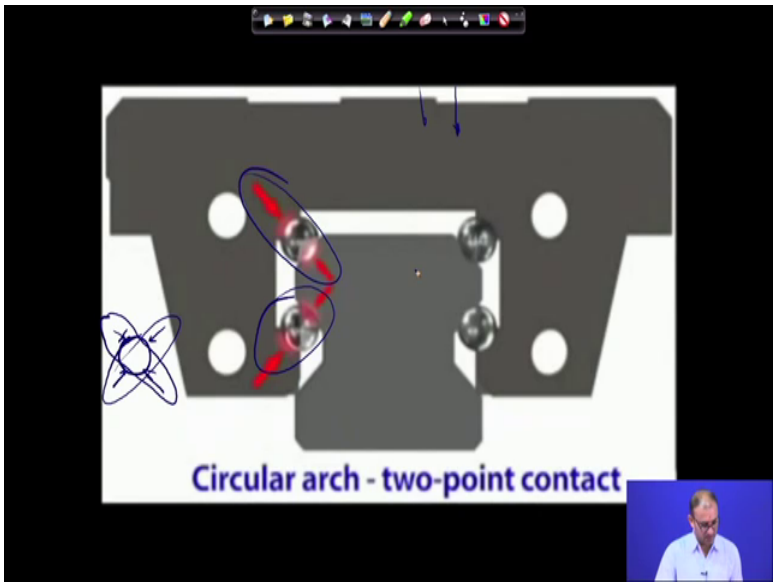

Now, there is another way. So, now, instead of 2 balls we are using 4 balls, but now what we have done that, we have actually converted that we have separated that contact points. Now earlier if you have seen there we had a single ball and it has a 4 contacts at this location, this location this and this location correct.

So, now, what we are doing here that we are separating out this coat, two contacts in a one bearing and these two contacts in the another ball. And now these are the two contacts and circular are two point contact bearing. So, these two bearings will help and will make sure that when you are loading from top, these whole thing will not move or displace very very seriously in that particular direction correct. So, its centers are contacting inside these part.

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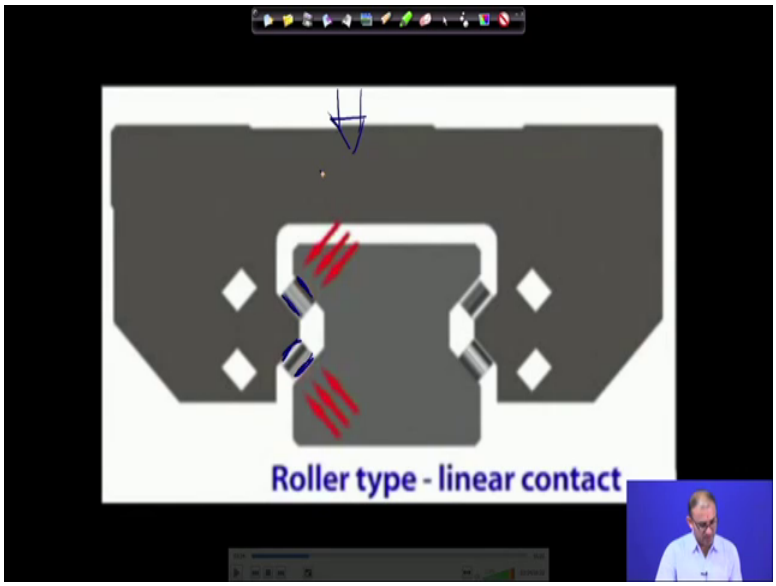

And now if you use a roller bearing then again it is the same thing here, but now you have a more contact jump points are here. So, it is a line contact now, because of the line contact your load caring capacity increases. Now you can add little bit high amount of load for machining or the doing a little bit aggressive machining at the micro machining center correct.

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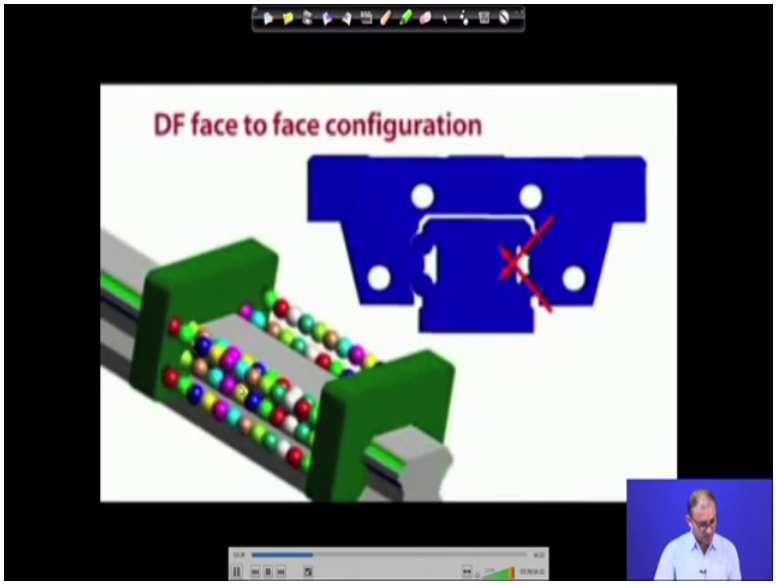

So, now there are different configuration that how we can define those things. So, it is called face to face configuration DF face to face. Now what is that thing that. Now if the

center of this both the balls, if it is going inside it then it is called the face to face configuration. Now you can see that contact points are here. So, these are the contact points of this bearing and these are the these bearing. So, it has the center point, if you are extend the line of the center, then it will, they will match at the inside the part not on the outer side. So, that why it is called face to face configuration. So, here this is the animation of that, how this will work.

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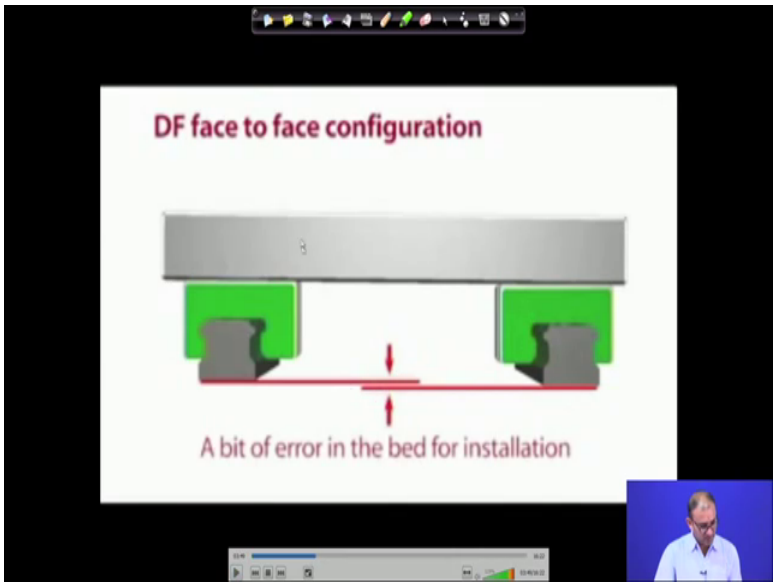

So, what is the advantage of these thing? That if there is a little bit of error in the bed installation, because it will be very very friction of micron, but that will also matters when you do machining at a 0.1 or 1 micron of depth of Kert and that time it will create a problem, but this political alignment will not create problem if you are using these type of face to face configuration.

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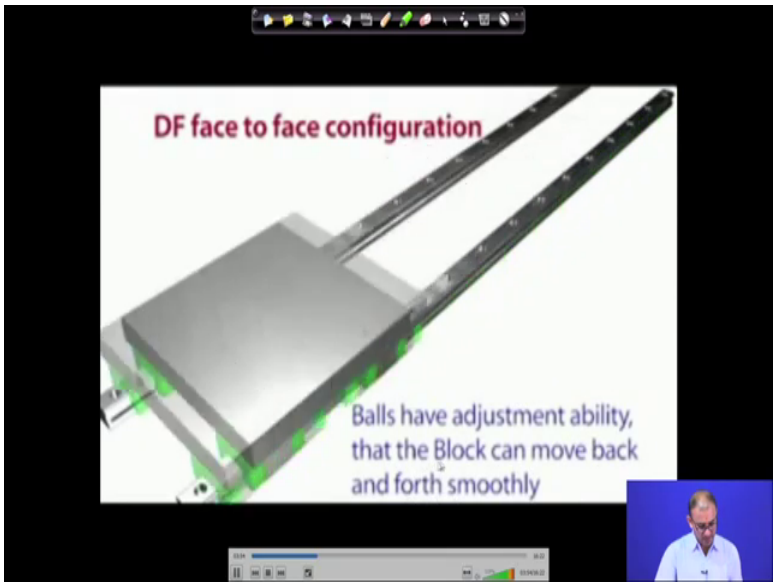

So, balls have a adjustment ability that the block can move back and forth smoothly, even though there is a there problem little bit kind of thing.

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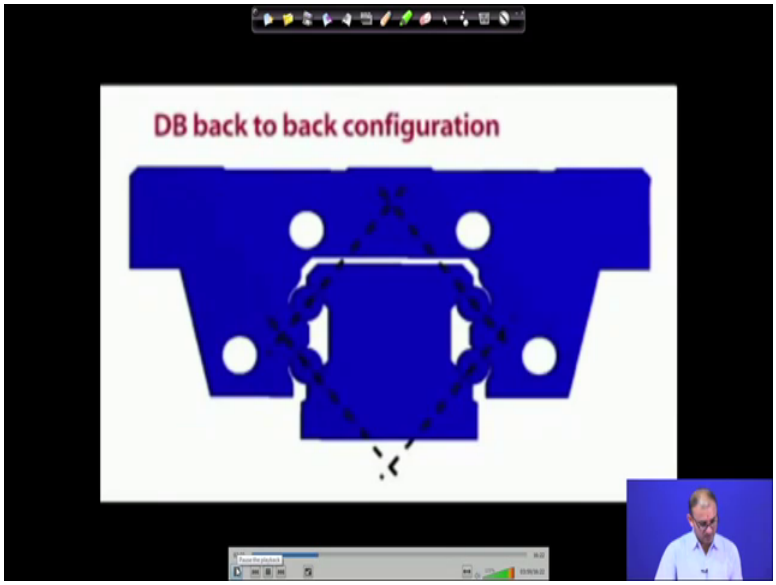

So, now this is called back to back configuration DB type. So, here now these particular balls have contact point; that means, center line moving in these particular direction that is called back to back configuration. So, its contact is outside of that part. So, what is thing this is simulation of DF configuration under the torsion part

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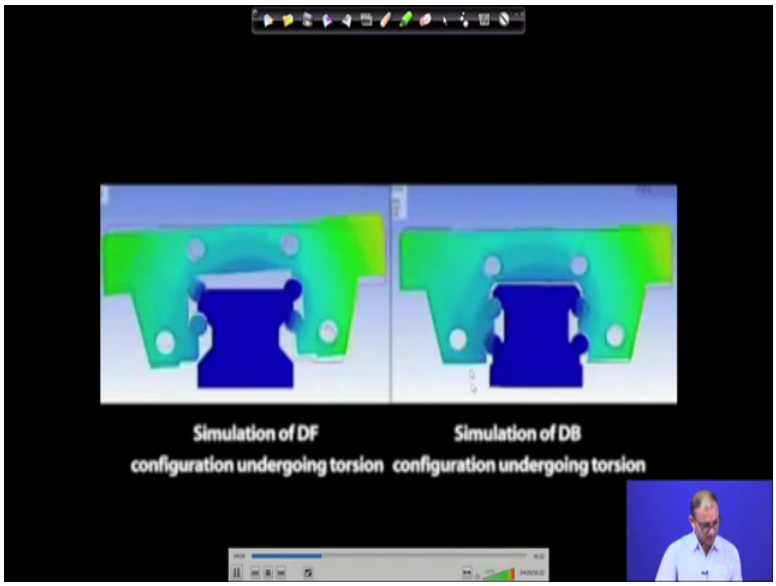

Torsion means; that means, you are moving in this particular direction and this is the same thing for the configuration undergoing the torsion; that is called DB type and this is called DF type. Now if you see this thing is moving little bit more in that particular sense, because now it is not able to resist that particular torsion motion comparative to this particular DB configuration.

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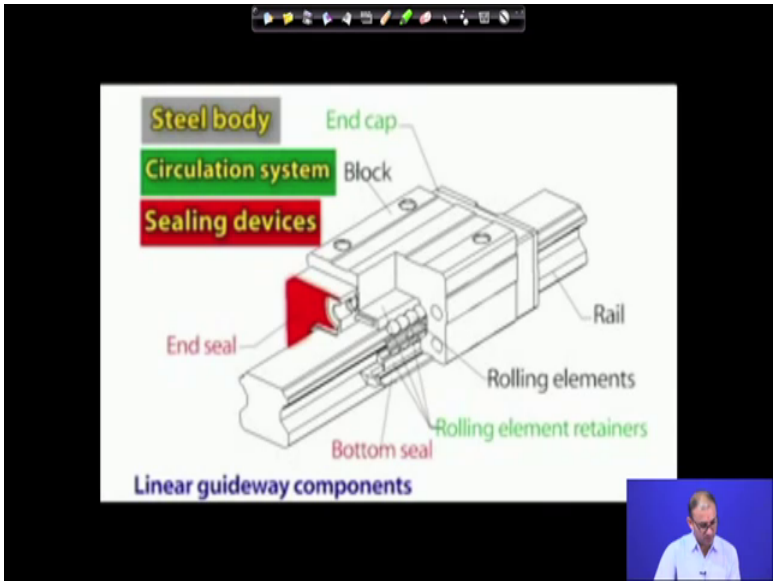

So, what are the components of this linear guides way. So, one is the steel body that is required, because on the top of that what we are doing we are mounting our work piece. So, that it can move in the x and y directions; that is the first component steel body.

This is the rail on which your rolling element will slide, this is the rolling element and the circulation system because the circulation system are required in between these two. These are the end caps are required, because you want to restrict the motion, you do not want to extend this particular thing beyond a particular limit. So, this is for end cap.

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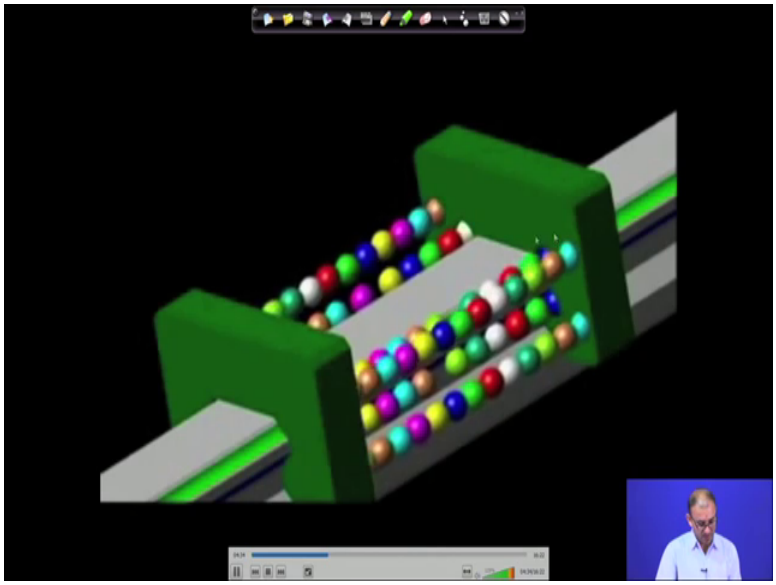

So, that is for keeping this particular ball within the limit zone.

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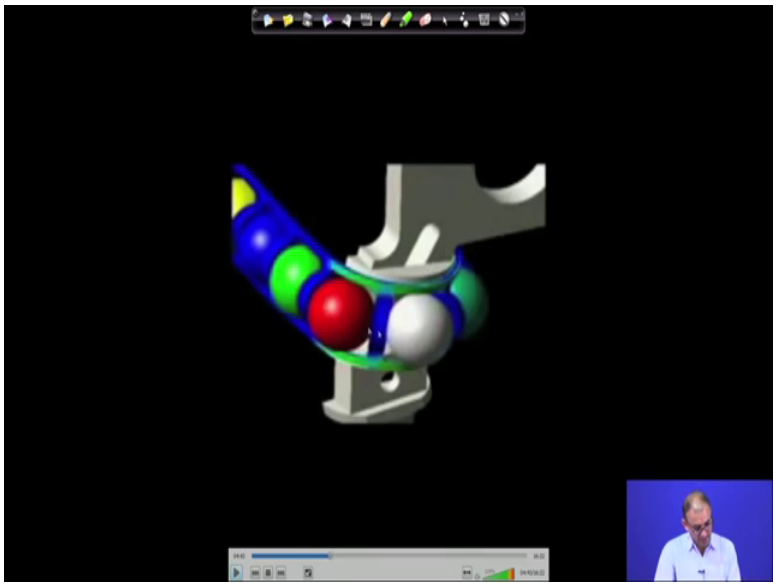

So, once you get this end block at that time, it will it will circulate from this to this only, it will not create any additional motion. So, these are the things. So, it will move in a particular confined motion only correct. So, this is the way this particular ball will move in the direction and this is the rolling element retainers. So, retainers are required, because these particular retainer will make sure that balls are not actually moving in a other direction.

Sealing devices are required, because this is called bottom sealing, because we know that machining operation may encounter the different type of the cutting fluids other than the cutting fluids. There are other different types of chips are available also if you want reduce the contact of those things dot chip and cooling to the bearing element, then what you have to do? You have to seal this component. So, bottom sealing will make sure that no type of dot or any other type of impurities are entering into the bearing zone and other than that and other that that bottom zone, we have one this particular end cap also and this particular part.

So, this is called end sealing end sealing also function with same, but it will prevent all these thing to enter from the end part and this is from the bottom part. So, first thing is basis static load rating. So, what is that basic static load carrying that. Suppose a lift man is lifting a particular load then, so what is this, the initial position so.

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Now, if you are adding more and more load on this, what is going to happen, your hand will be going down and down. So, this is the next position when you are adding more weight. So, what is happening? So, this is the initial load where it was a this location and then if you are adding load continuously, your next position will be this one. So, this is your next position. So, when LGO minus LGO is oneth of, it is a 1 of 10,000 of these points. So, that is called load bear static load bearing capacity. So, right now we are not moving it. So, this is in the static location only.

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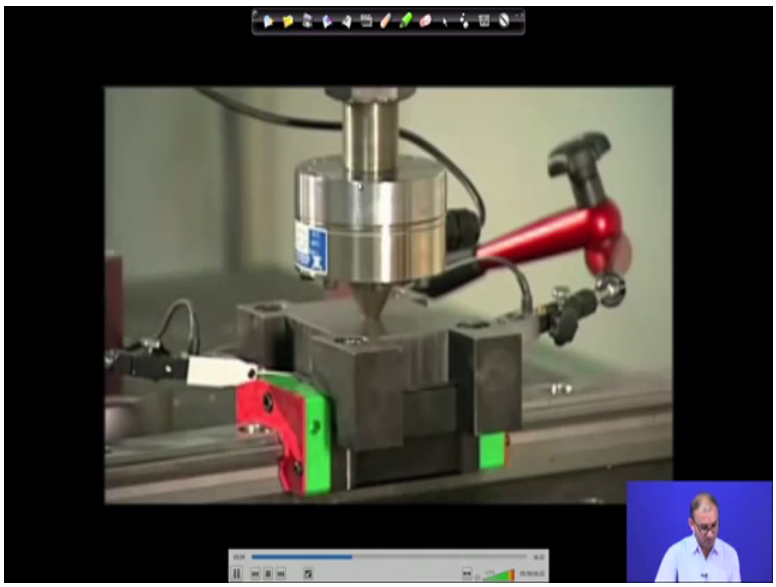

So, this is how we can actually calibrate these things that you put a load from the top.

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And when it gives load verses displacement curve on this particular (Refer Time: 22:34), if it is permanently deformed; that means, it has very low static load caring capacity.

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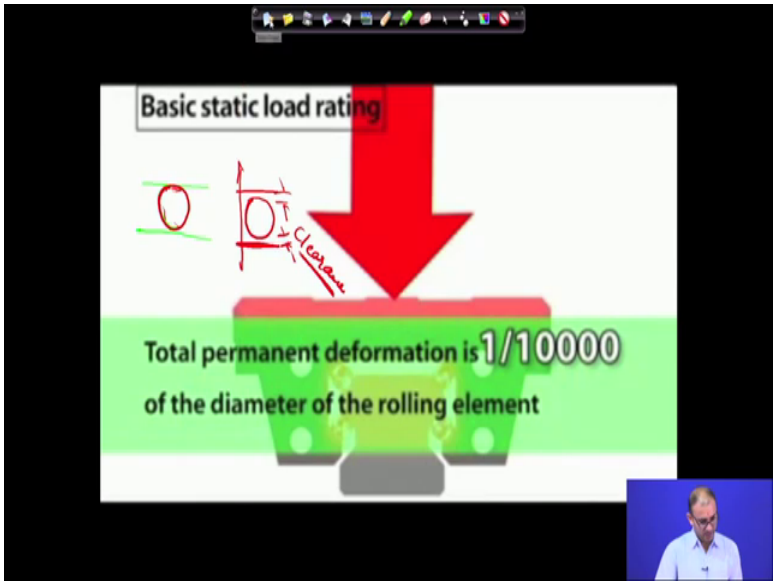

So, this is what it is, it should not deform permanently and so that is whatever load is happening, that is the load bearing capacity. So, total deform permanent deformation is 1 of 10000 of the diameter of the rolling element. Why we consider this rolling element

diameter, because we know here that this is the ball which is playing important role here, that it has everything here.

So, this is the ball and now this thing, it will deform. Deform means there is something deformation; either it is not circular now or it has own components from any other location. So, now, what is going to happen that your ball is something like this. So, it not completely in the contact with this part. So, whatever is this part is there. So, that will create a clearance. So, this clearance will create a problem in the adjustment in this particular direction, when you are moving in the when you are calculating the distance at this particular location, it will not create problem, but this location it will create problem.

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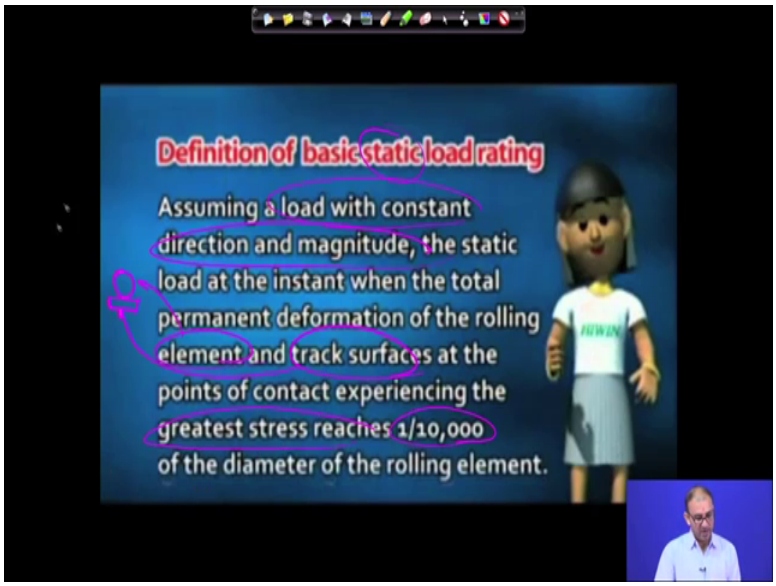

So, how you can define this basic static load rating capacity. So, it is assuming a load with a contact direction and magnitude the static load at the instant, when the total permanent deformation of the rolling element and the track surfaces at the points of contact experiencing the greatest stress, reaches the one tenth oneth of 10000 of the diameter of the rolling element. So, what does it mean right. So, this is the when you are putting a load on the constant direction and magnitude; that is more important, because that is why we are considering as a static load. So, there is only one direction, we are not moving in a other direction. So, it is mostly considered load from the top normal direction.

So, what is happening that we have a ball here, this is the rail. So, we consider these this thing is the rail, the total permanent deformation of the rolling element. So, this the rolling element and the track surfaces, this is the track surfaces, because we have to consider both the thing.If there is V R of the track, then there is again it is a problem.

There will be a little bit of clearance if there is a V R of the rolling element, then again there is a V R of that part track surfaces, any type of contact experiencing the greatest stress reaches oneth of 1 of 10000s of the diameter of the rolling element. So, whatever is the diameter we have to consider the greatest stress should not reaches to that location. So, that is the basic state, basic static load rating at. So, second thing permissible static moment.

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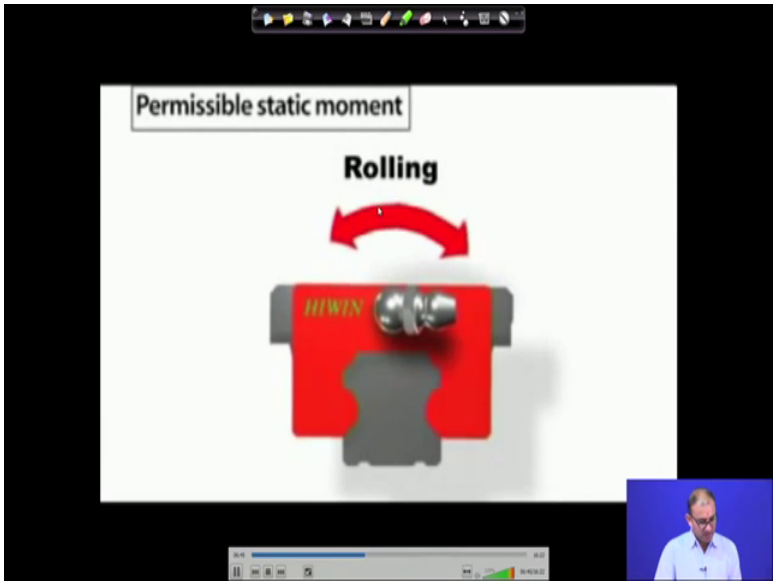

So, now these are the different different movements. Earlier it was load only, now it is a movement, so it is rolling movement. So, this is your vertical direction. So, it is moving on left and right at.

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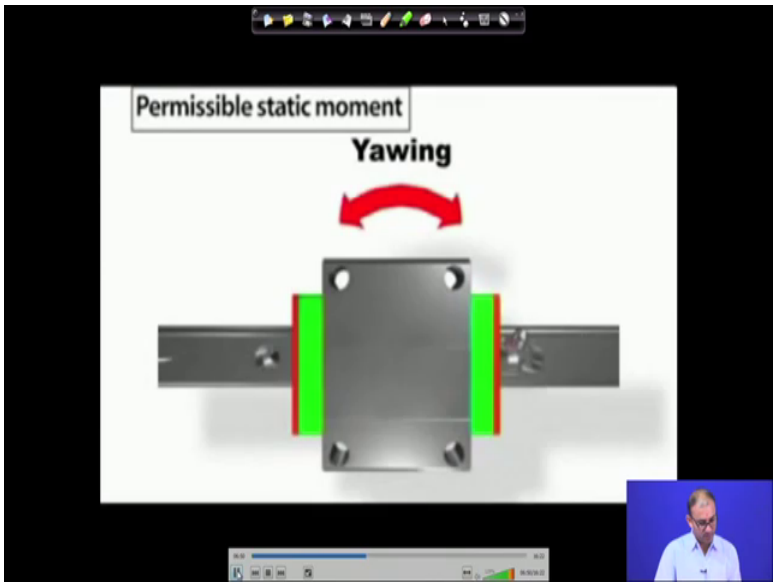

So, when you see from the top and that is called yaw motion that these things we have seen in that geometric error in the machining.

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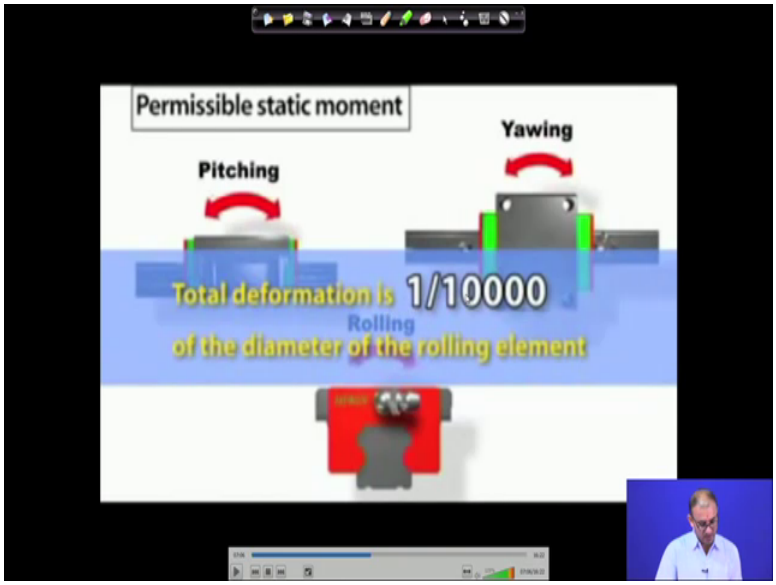

And this is called the pitch motion; that is looking from the left side or right side. So, these are the motions. There is mostly happens when you doing machining of the side cutting or something slot cutting, something like that. So, if under these condition also same thing the deformation is 1 of the 10,000s of the diameter of the rolling element.

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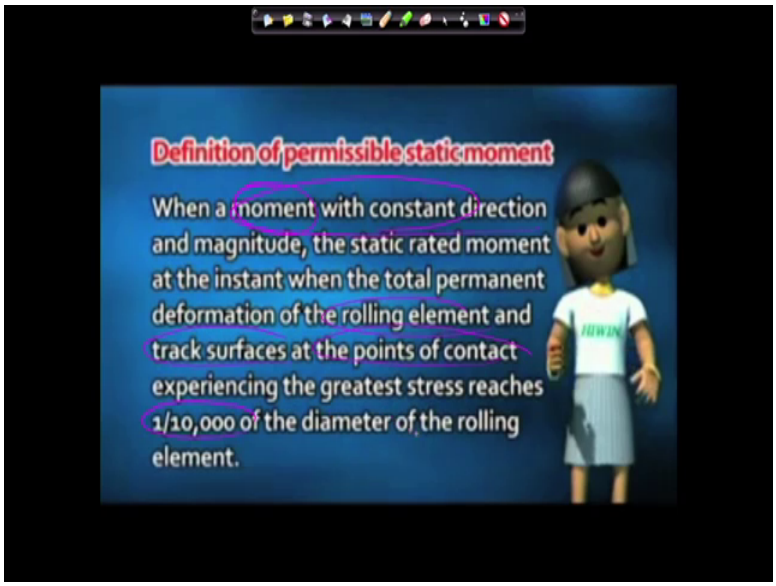

At the same thing here, but here instead of that constant direction load what is happening, we are we are considering the movement of the constant direction and the magnitude. So, now, it is constant to the movement under this particular condition, if the total deformation of the rolling element and track surface at any point of contact experiencing the greatest stress, reaches the 1 of 10000 of the diameter of the rolling element.

So, same definition, but there is a difference in the content; so, here we are talking about movement and earlier case we are talking about the static motion. Now, coming to the dynamic load carrying capacity; now consider the these are all the ball. So, they are all carrying little bit of weight and they are running around a circle. So, this is what is generally happening in our ball bearing also.

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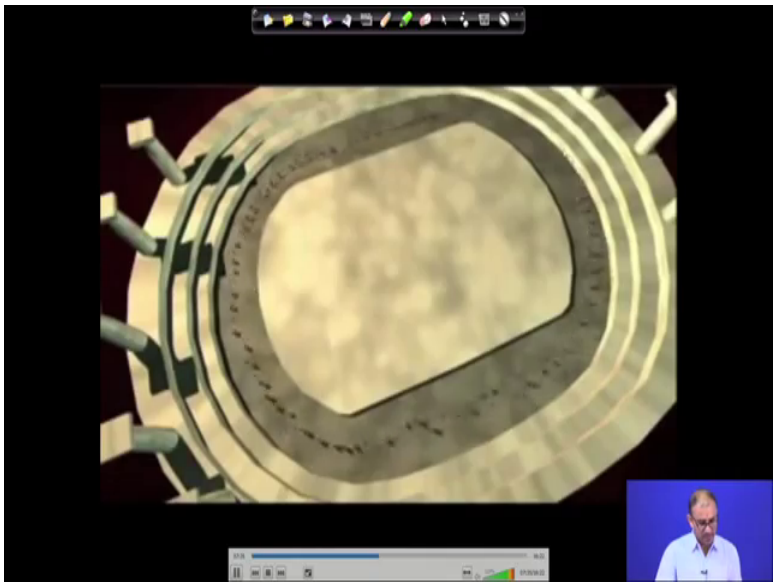

So, now under this condition the 90 persons complete the whole marathon and they are rotating the direction 10 persons are drop out. So, these are the problems in the bearing and weight on everyone carries at this time, termed as a load carrying capacity.

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So, how can you define these things that after a batch of ball type linear guide ways, with a identical specifications have completed their service life.

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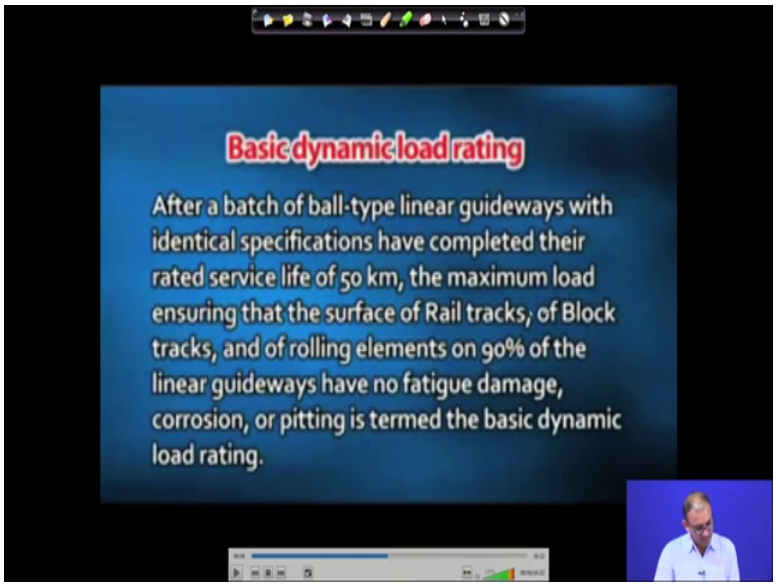

So, consider the service life is 50 kilo meter. So, and the maximum load ensuring that the surface of the rail track block tracks and rolling elements on 90 percent of the linear guides ways have no fatigue damage corrosion or anything. So, you consider that you your whole system is running; that means, all that particular guide way have completed 50 kilo meter of run that is particular specification for this part only.

And if you find that 90 percent of these all the components does not have any type of these damages, then that is called the dynamic load carrying capacity. So, there should not be any problem of that 90 percent. If there is 10 percent problem that can be a consider as a this particular dynamic load carrying capacity.

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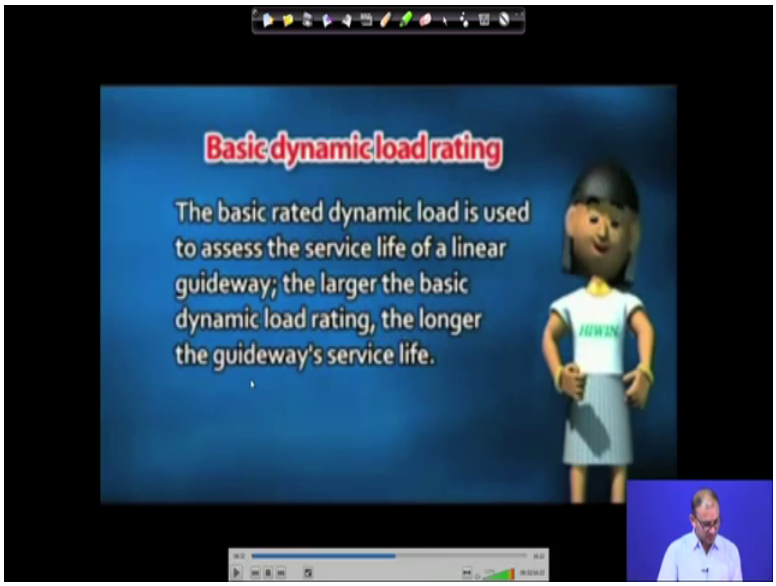

Basic dynamic load rating capacity that will ensure the rated dynamic load is used to assess the service life of a linear guide way larger the load bearing capacity, then the longer is the service life, because we know that if it is a 50 kilo meter, if it is reaching more than 50 kilo meter then actually our life is increase, because now 10 percent of that particular deformation or the defect, it will occur after 70 kilometer also 100 kilo meter also. So, in that case it higher is the dynamic load rating capacity longer is the service life of the component rated service life again.

Let us define that part again. So, again we are rotating these all balls in that same direction and there are hundreds of these runners or balls and when what is going to happen that one by one, if they are going down and down then 90 persons of runners are still in the marathon. So, that is 90 percent of balls are still working at that particular location. So, this is how we can define that part; so, this is the under operation part.

So, when you are working with this particular part and if you find that 90 percent of the things are still working in that system, then that is called the service life of that component.

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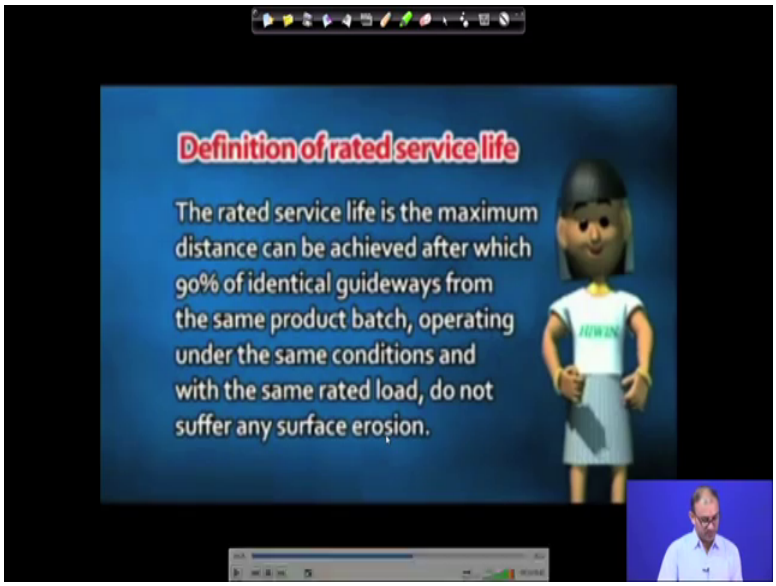

So, maximum distance can be achieved after which the 90 percent of identical guides way from the same product batch operating under the same condition and with the same rated load, do not suffer any surface erosion. So, what is our objective that what is the distance it can cover within 90 percent of the guides way without any deformation. So, that is the way; that means, the higher is this particular thing, more is the service life of the component. So, this is how we can define different different type of thing. And let me finish this lecture here, we will continue this video further in the next class

Thank you very much.