Introduction to Mechanical Micro Machining
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Lecture – 35
Components of machine tool (Contd.)

Good morning everybody. Let us continue our discussion on the, linear motion or linear guideway that we have started in the last class. In the last class, we have seen their linear guidesway are more important or more suitable for the micro machining operation, compared to block ways type, because they have less contact point. So, if the contact point is less than your friction will be very less and you can easily move in a frequent axis travels in the opposite directions also.

So, let us continue that video, which was, we started in the last class. So, in the last class we have seen different-different type of definition service, rated service life dynamic capacity and all this thing and these are the two terms which are very very important in terms, in the bearing application; one is the preload another is a backlash.

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So, let us see then how these things are playing important role in the bearing or the linear guide way design. So, now consider, this is the one thing. So now, what is happening here?

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So, this is a thin person and he is sitting in a car, but now, if you see here, he is not actually fitting completely in that is, there are some space available. So, this is the space available. This is the space available and this is the space available at this location correct. So, now, what is going, when you are riding this car and you, when you stop it suddenly, what will going to happen? This particular person will move in to and fro direction.

So, it does not have any type of motion constraint right. So, see now, it is moving in this particular both the direction. So, it has some type of clearance and. So, there is a backlash, but no preload. So, the preloading, I will also again explain. So, this is what is happening in this case.

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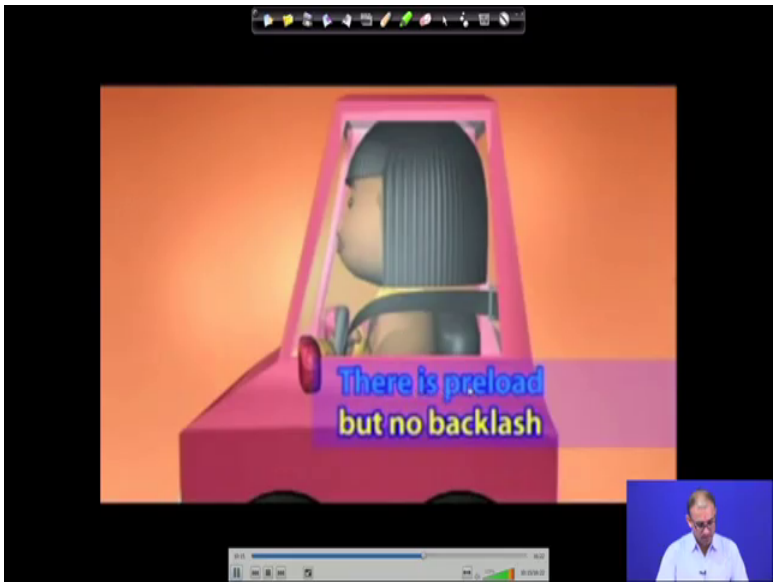

Now, considered the same car, but you are actually forcing one fat person or the big guy into the car. So, now, you can see that there is no space available, nothing is available here. So, everything is completely packed. So, when, if this car is moving and then suddenly, it will stop. This particular person will not get any type of motion in any direction, correct. So, there is a preload and no backlash. So, this is called the preloading of that part. So, that is also required in this particular care, because what is going to happen here.

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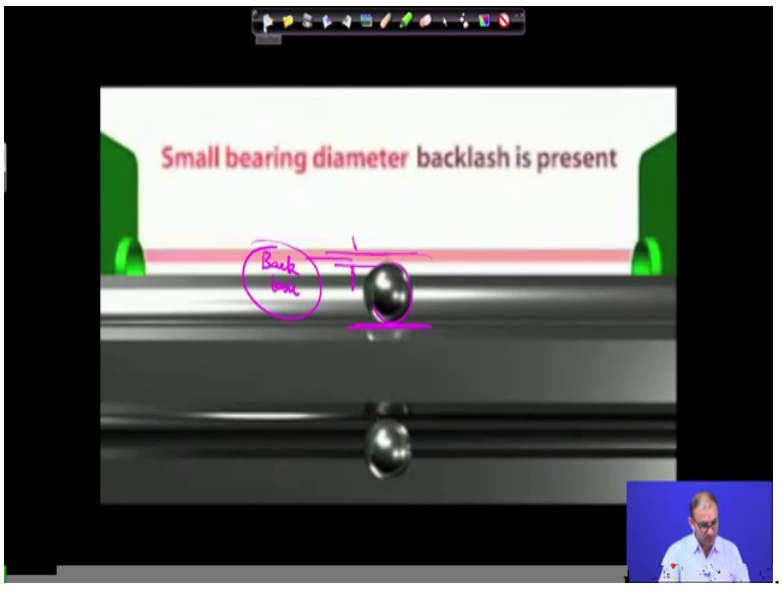

So, this is a situation, where the small bearing diameter and this is the length, where we have to keep our diameter. So, now, this is the thing that, this is the rail correct and diameter is your.

So, this is the particular backlash right. So, if that backlash is present, what is going to happen here, let us see? So, this is the motion of that part.

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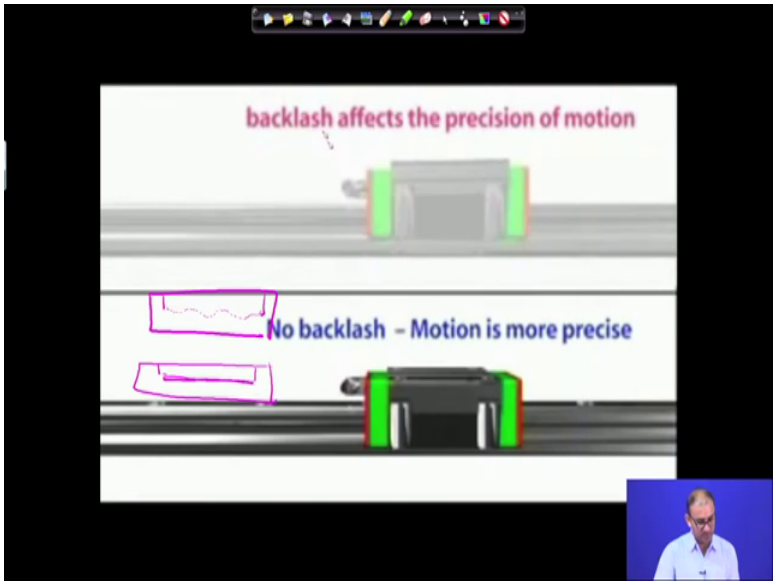

Because, now you do not have formed contact between the ball and the roller or that rail and because of that you are getting a type, wavy motion instead of a straight line motion.

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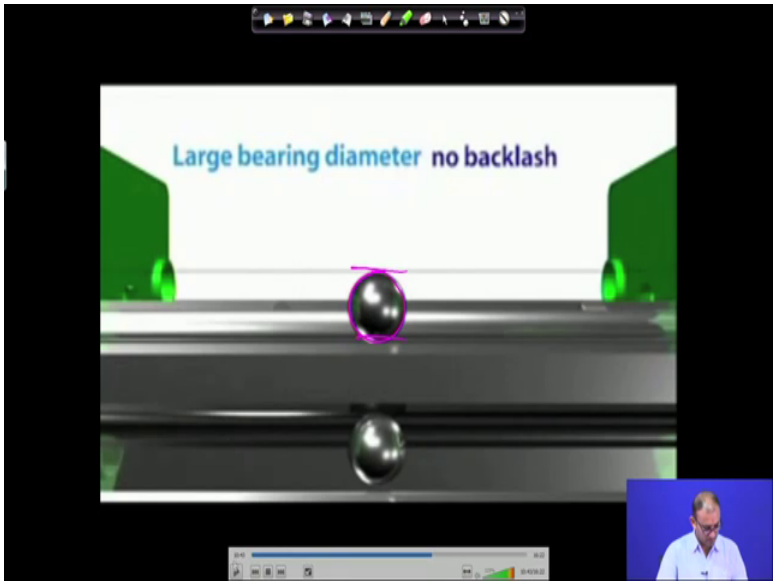

So, now, it is exactly fitting here. So, you do not have any type of contact. So, this is exactly matching with this part.

So, no any type of clearance between the, rail in the ball correct; so if you consider this particular motion then this is the bottom part, you can see that there is no backlash and motion is more prices. So, why this thing matters, because, what are we are looking at this particular location. So, those things are not exactly the, whatever weight it is moving up and down, it is highly exaggerated view, but if you see it in the micro level, that, that is also enough to destroy over workpiece geometry.

Because now, if you want to cut something like this straight line, this is your workpiece and you want to cut something, one slot here. In this case, if it has backlash here, then what you are cutting actually. So, this is the thing and you are cutting something like this right. You will not get a flat bottom surface at machining surface, because you are considering that your workpiece is moving in a wave view direction and because of that you are, you are not getting a precise movement of the cutting tool also.

So, that is what is going to happen, because of this backlash error. Now, what is the rigidity? Rigidity is mostly we can define that the deformation under the force. How much force your are requiring? How much is the deformation it is happening?

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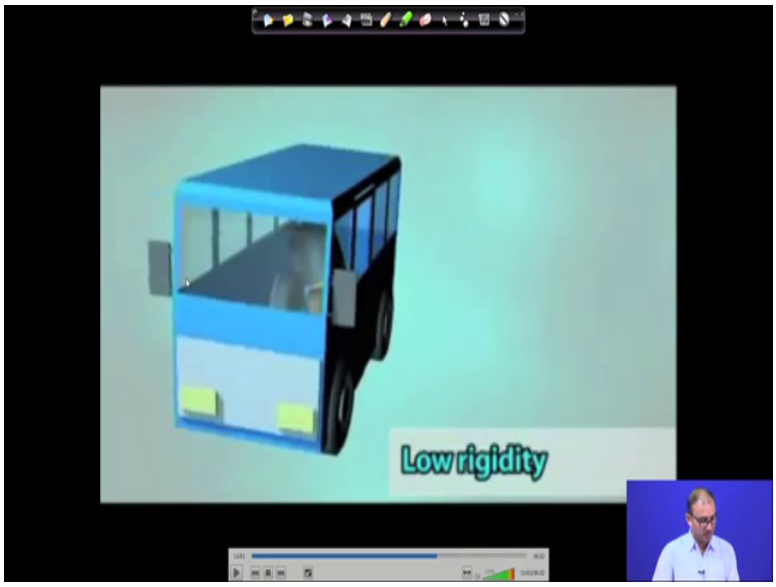

So, let us take this example that you have a very-very lightweight; that means, bus nobody sitting and one person is, come in suddenly, only with a some velocity in, he is jumping in on the bus. So, now, what is going to happen? That bus will actually displace here; that means, it will give some type of motion and that motion is called the, problematic things. So, that is called low rigidity, because when you are forcing something onto the component and if the component is not resisting that particular force then it is called the low rigidity.

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So, this is what is happening here. Now, consider that a, the bus is completely full and; that means, it has a little bit high rigidity. It is not deflecting be or deforming under the application of external load. So, now, the same person is coming with a speed. Now, you can see that it is not moving too much, compared to the earlier case. So, now, this is the way, we can define the rigidity.

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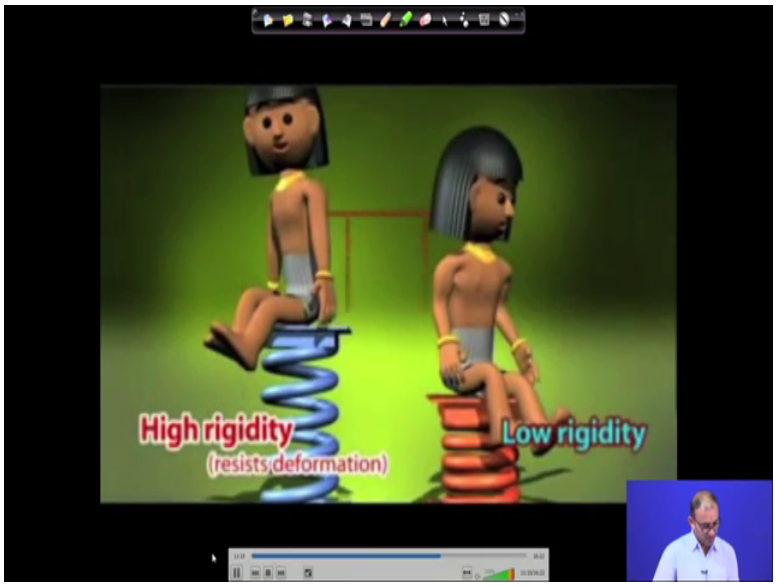

So, when you defined rigidity, a higher rigidity means less deformation or it will resist more deformation. So, this spring is not compressed more. So, it has a high rigidity and this one has a low rigidity, because it has compressed little bit more. So, why this thing is important? Because these things are important, when you are machining at a cutting tool, because when the cutting tool (Refer Time: 06:46), cut in contact with the workpiece tool, at that time there are force is occurs.

So, you consider those force is something like this, if you are guideways and other elements, which are not able to resist that force is and that deform; that means, your machine has a lower rigidity. If that deform, they do not deform, but it will at again the, this type of external forces is then, you can consider it as a high rigidity.

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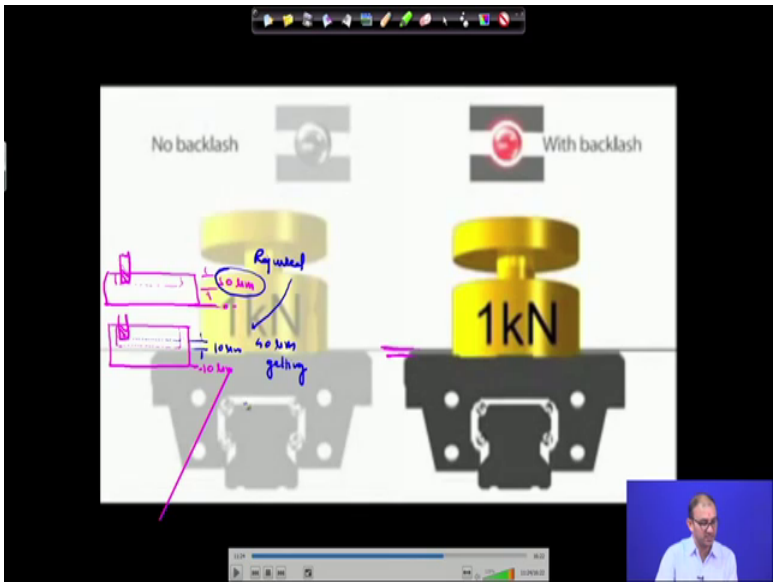

So, now this is considered a backlash. Now, under the backlash, what is going to happen that, when you add a 1 k g load now, they we have backlash. So, your old thing will go down and once you go, it will go down. What is happening here that, this is your reference surface and now, you are reference surfaces is shifted to little bit down.

So, now your whole machining is, going wrong way, because of this thing, because now, consider that again the same example that, you want to cut something, one slot and this particular depth, you consider. It is a 50 micron and, because of this problem, what is going to happen that, your tool will your workpiece, will go down. So, now, consider your tool initial position is this one. This is the initial position and you have given 50 micron of depth into the tool, but because when you are doing this particular thing.

This is your machine or this is your part program, by which you have program, this particular tool motion, but if that is the case, what is going to happen that, because of this backlash, your workpiece is, whole thing is shifted. This is the base surface right. So, this is 0 position and when you are going to do this, this, at that time there is a deflection going down little bit. So, consider the deflection is 10 micron. So, this is the minus 10 micron down.

So, what is going to happen that, you are, tool is still here and you assume that your tool has gone into the 50 micron from the workpiece top surface, correct. But your top surface is shifted here down. So, this you are actual things, which you want to cut, but

what is going to happen, because of this particular deflection, what you are cutting? Your cutting is this one right. So, you are getting a dimension difference of 10 micron; so your depth of cut, your required 50 micron.

So, this is required, but what you are getting, you are getting a 40 micron correct. So, 10 micron is moved down, because of this particular backlash. So, ever you, it is very difficult to get this thing, realised during machining also, but ultimately when you complete the machining and measure the dimension, then only you will find that there is error. So, it is better to avoid the backlash.

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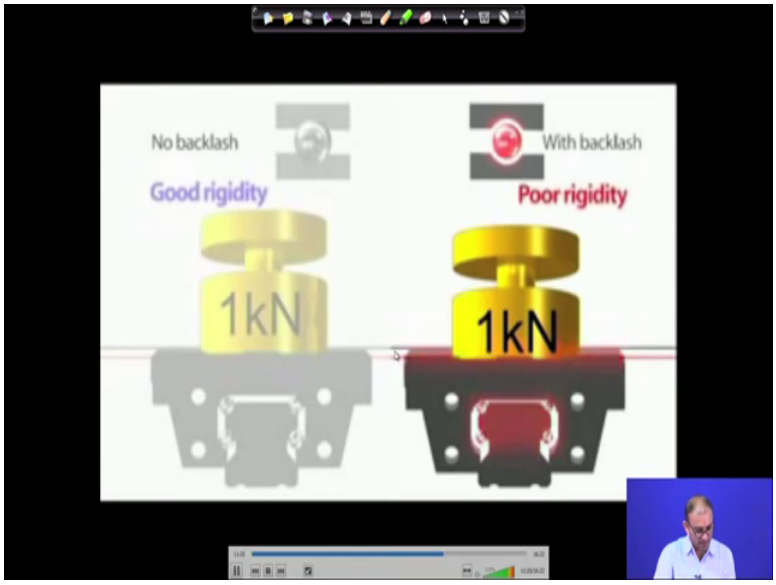

This is the deformation your lines reference line is shifted and it has poor rigidity. So, when it is no backlash at that time, what is going to happen that, your reference line will not shift there and all the things, whatever loading is that, it will be taken care by the parts the. How do you manufacture this particular linear guidesway? So, first thing is the recreation.

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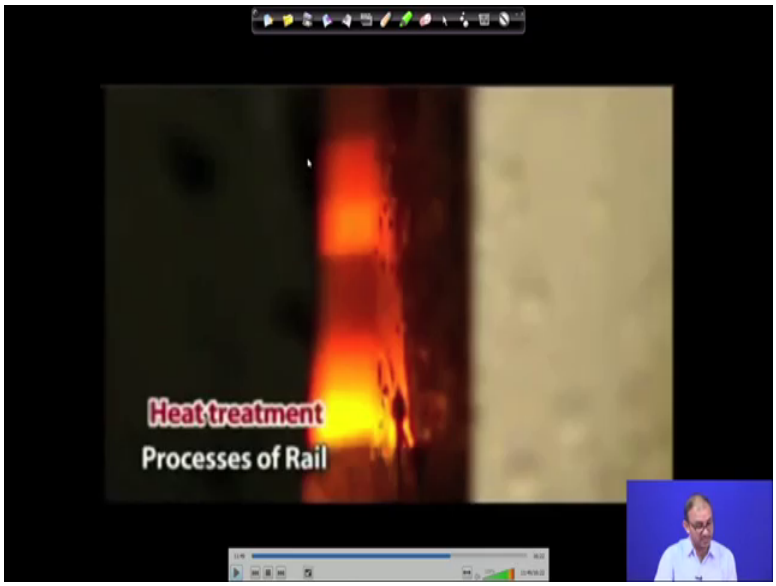

And what matters your maximum part is a straightness, because if you considered that we know that we want to move something in a straight line correct this is what is our required line, but if you are guide, when you are manufacturing it, it has some type of, problem in this direction. Let it be in few micron only, but it will create a lot of problem. So, straightness is more important. We will see that there are many different steps over the processing steps are perform, which are only to make sure that there is a straightness between the layers.

So, heat treatment is over required, because now, you want, you do not want to a, this particular things to deformed during the operation. Let it be static deformation or the dynamic deformation.

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So, these are the straightening, first straightening, because initial you to straighten it and then you have to do drilling, because we have to mount many things here.

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That straightening process to after each and every operation, you too again perform the Straightening operation, then after straightening over, you have to create a reference surface here.

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Now, what does it mean? Now, considered that you have one block with a very-very over say; now, this is the surface. Now, what you want to do? You want your objective is to create a perfectly rectangle out of this. So, what we generally do that. First, you do machining operation and remove this layer and then you do grinding operation, once grinding operation is over then what you have to do that you have to mount this thing, upside down correct.

So, now, we have created this reference surface. So, all the dimension, whatever you want to machine suppose, it is a 10 millimetre then 10 millimetre count will be done from that location. So, now, this is your reference surfaces, you have reached to this location. Now, mount in ups and down. So, now, your surface is something like this. Let it be again the very-very on even on the top surface, but your bottom surface is completely failed, because you have taken as a reference surface. Now, what we have to do now that; now you apply that 10 millimetre. So, now, you measure that from here to how much is the 10 millimetre? Again do the one machining operation and one grinding operation; so that you can get that 10 millimetre.

So, when you are surface is not, you, when your surface does not have any type of a shape then at the time, you to create one references at, from that reference surface then you continue all the operation, with reference to this part. So, that is criticized, is called the reference surface. So, your calculation for the all the dimensions; let it be a depth,

also what the width, also what the length, everything will be taken care by this particular surface reference. So, that is, it is required for this operation also right.

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So, this is the processing of the rail, in same thing you to do for the block.

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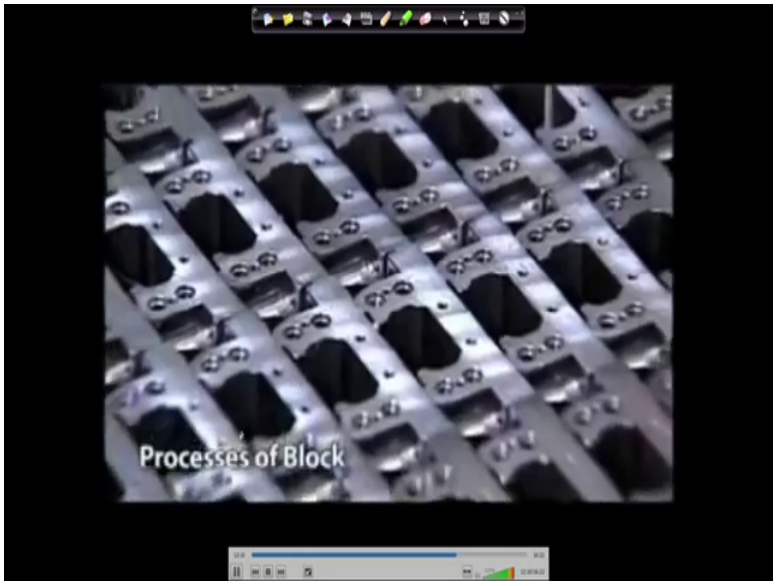

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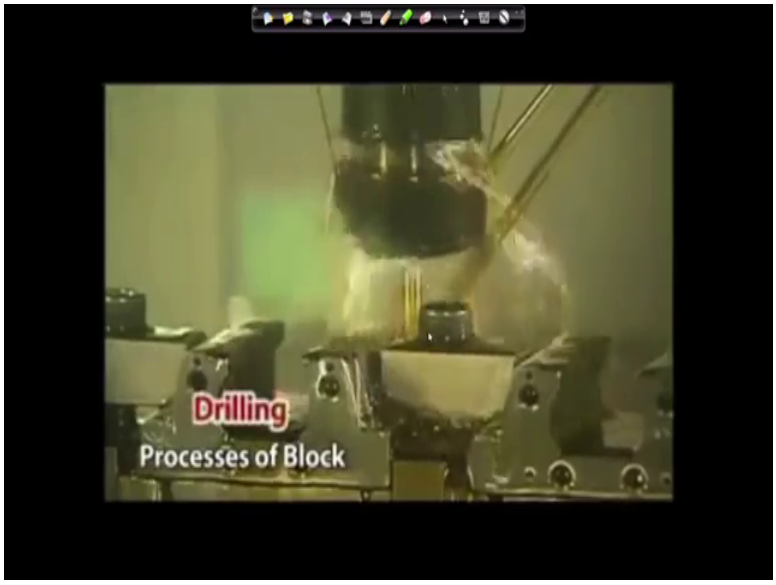

Also, because we have to mount one block also on the top, then again the drilling and all the operations are same and again you to create the reference surface, because both things are in the matching part.

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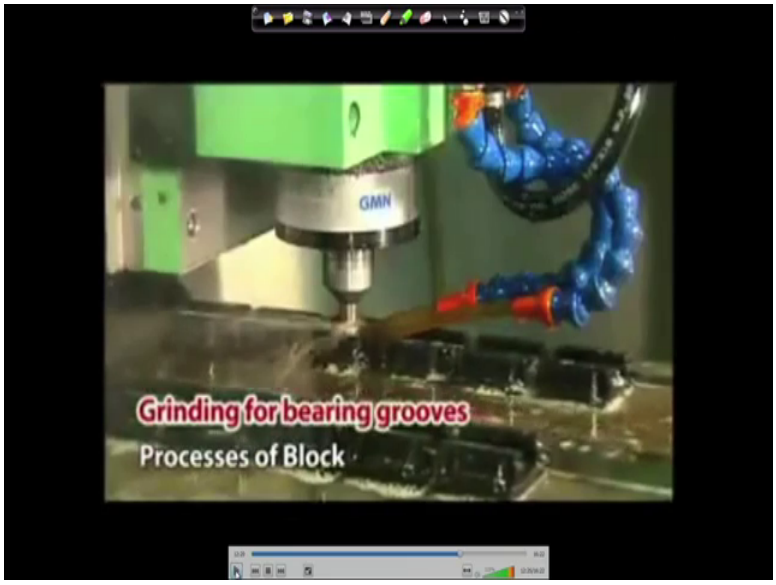

Because, earlier what we have discussed, it is for the single component, but if you have two component, which are coming into contact with each other, then you to create a reference surface for the another one also, after that operation you have to grind the bearing groove also, because you have to make sure, there is no any type of dimensional, problem torrents and should be as tight as possible, so that you will able any problem, at the latest stage.

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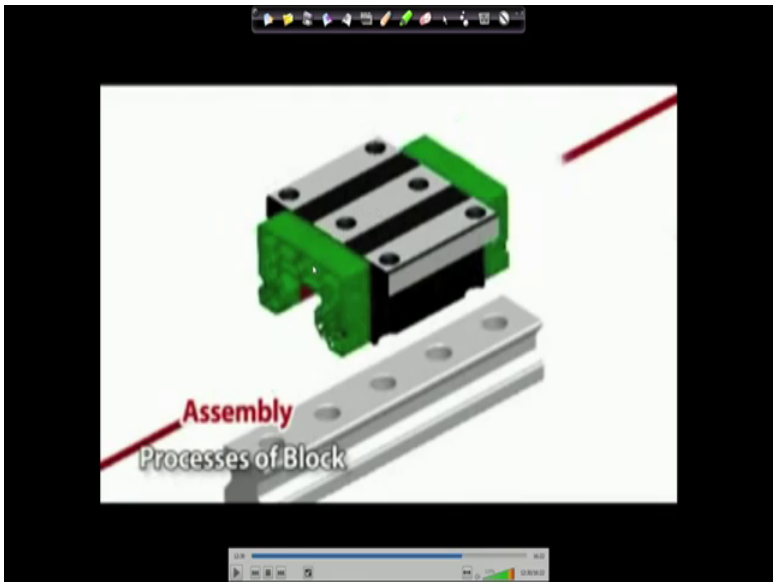

Then finally, assembly once you guide everything ok. Then this is the assembly of the processor. You are putting all the things, guides and everything, ball also together and then mount everything from this also. This is the final part. So, these are the different-

different about all the thing. Now, where you are using this thing, we are using at wherever we need a very-very highly precise motion. Mostly, it is for pick and place type of thing moving one component to other location, where few microns of difference also play important role. So, those are the application of the process or this particular linear guide way. So, let me finish this video now here and we continue with the lecture correct.

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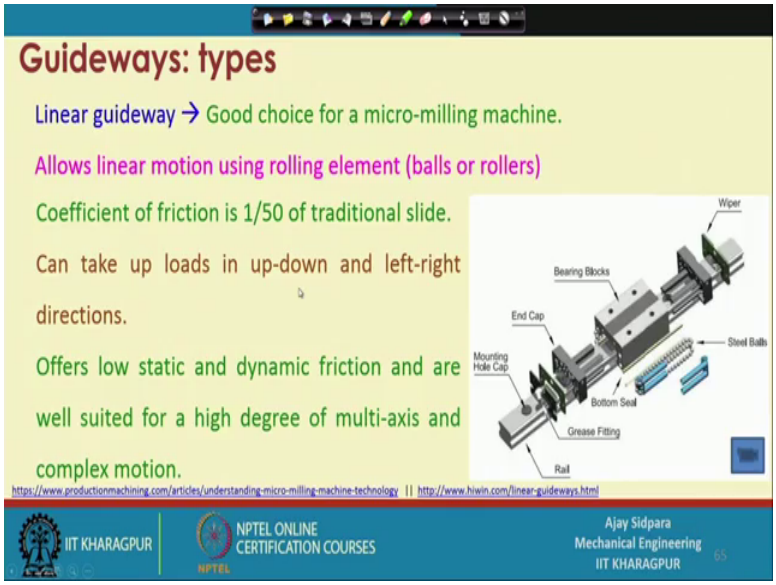

So, we have seen the, all the thing that these are the different components and how this is better than the other kind of things, linear guideway after the, that is called hydrostatic guideway.

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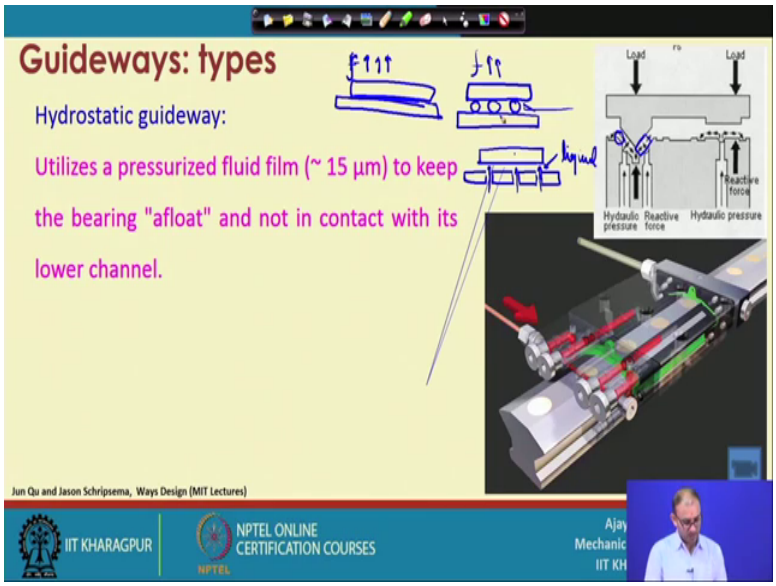

So, what is this hydrostatic guideways? So, what is happening here than? Earlier case, we have seen that this is a moving component, we are putting balls here or we are putting rollers here correct. So, that is to reduce the contact point between the two surfaces, when they are in motion; so now, considered that we have situation; so this is the one thing, where there is a fluid surface contact. This is another thing, which we have seen recently. This is the, these are the balls and this is the third one and what is happening here? This, some liquid is coming from this and then it is creating one film.

So, this is called liquid fluid. Now, considered all these three situations in this one, very large contact is that a friction is very-very large correct. Second one, what you have done? We have reduce the contact. So, now, our contacts are at the either, it is a point contact. What is a line contact, depending on the use of ball or the roller, but still, they have contact right. So, fiction is little bit less, but now, if you avoid this thing completely that there is no any type of mechanical component in between the two surfaces.

So, what we are adding here? The, we are adding a liquid film here. We are pressurizing in such a way that whole thing will be lifted. Now, consider, this is the hydrostatic pressure and this is the load. So, it always balance this particular thing that when you are 0 adding the load, more your hydrostatic pressure will increase. So, everything this will be in the stable condition. So, in this case now, what is the advantages that, we are not getting any type of mechanical component between the two surfaces.

So, that is very-very good advantage and now, friction is completely avoided only thing will matter different, is a, what is the viscosity of this particular liquid, which we are using here? So, it is more convenient or more useful then this particular case that is a fluid contact over. It is a roller about the ball contact. So, that is called a hydrostatic guideway, because hydro, they are using some liquid static means, we are continuously providing. So, it is in static loading not in a dynamic.

So, there is another thing in hydrodynamic guideway, where when you rotate a verticular component that is caller rotor. At that time, it will create the film depending on the rotation of that part that is in dynamic condition, but we are looking right. Now, here is hydrostatic guideway. So, it utilizes is pressurized liquid film about 15 micron to keep the bearing afloat, bearing afloat; that means, this is the part and not in contact with the lower channel. So, this lower channel is the, this one, this is the lower channel.

So, this particular fluid, whatever we are using, oil was any other type of liquid then it always make sure that there is no direct or physical contact between the two surfaces. One is the stationary channel, another is the things, which are moving up and down. So, this is one of the, in as schematic of the diagram of that thing that how you have to provide this particular part. So, now, you can see that, this is the oil supply whatever, from where you are supplying the oil and that oil is actually equally spaced or distributed in between the two surfaces, which are in contact.

So, this is the lower one and this is what it is moving on the top. So, this is the top one correct. So, this way you can actually increase the comfortability or what you can say that reduce the friction between the two contact points and then you can easily move freely without any type of more friction. So, let me show you this video also here has. So, this is a hydrostatic part.

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Now, you can see just by putting one finger, you can actually moving this whole things, because it wait maybe 10 5, take 10 k g also, but you can say that just by finger, you can move, because now, we know that there is no any physical contact between the two surfaces or whatever liquid is present here. This particular liquid is creating film between the two surface and you can easily get the low friction part.

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Now, this is the thing, which is mounted on the part. Now, you can see even, it is loaded with a very-very heavy component, still the same motion. You can get by this particular frictionless, hydrostatic bearing correct, correct.

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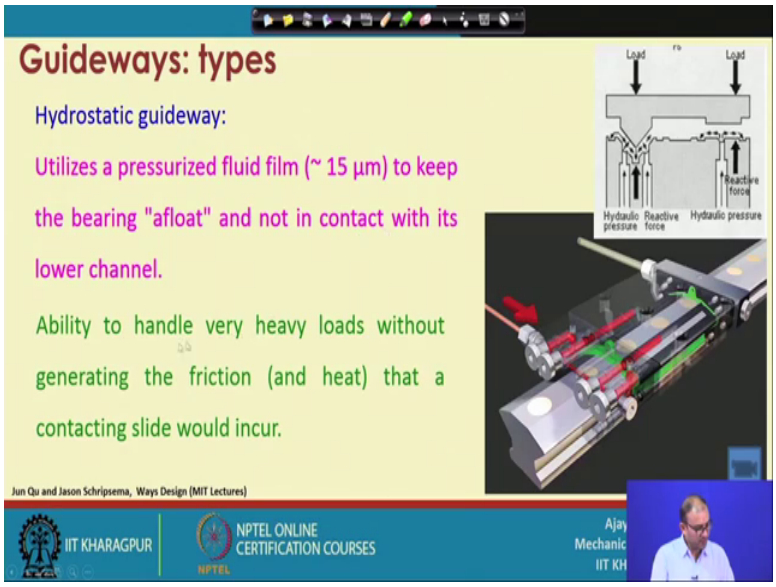

So, what are the advantage. It has ability to handle very heavy loads without generating friction heat, that are contacting slide would incur. So, in this particular, it will because now, we are using a liquid here. So, it will, it load, carrying capacity is very-very high in this case.

But what is going to happen that we, we know then micromachining. We are not working with a very-very heavy loads here. So, it may be used for some of the application, but exactly we are not a getting this particular application in the, micromachining also.

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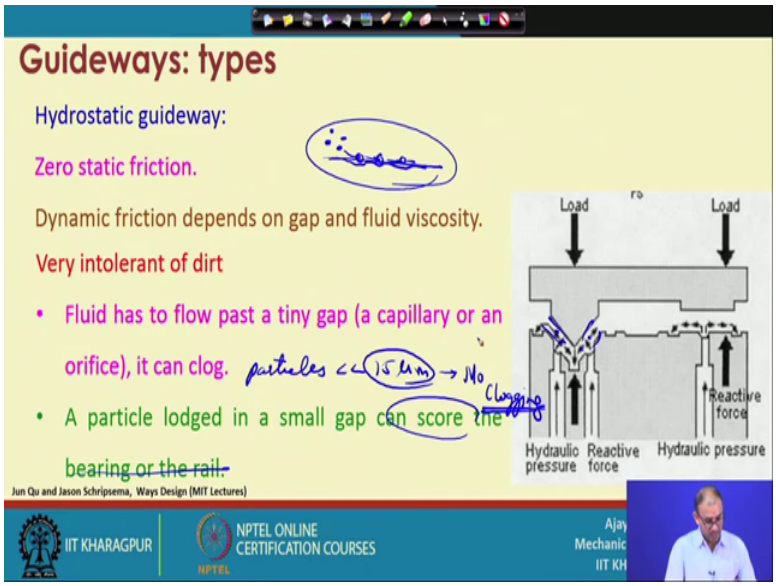

So, what are the advantages of this hydrostatic guideway, it has a 0 static friction and the advantage of 0 static mean, we know that we are not getting any type of resistance, because of the motion, a dynamic friction depends on the gap and the fluid viscosity, because we know that if the fluid viscosity is very-very high then you are getting more friction.

But still that friction is much less than the physical that is mechanical contacts, type of surfaces then very intolerant to the dirt. Now, that is very serious thing is here, because we are using liquid here and we know that this particular gap is 15 micron or. So, something like that. So, if you are dirt, you are not filtering this liquid, very-very perfectly then what is going to happen? This dirt will create some type of problem here. It may close this particular spaces and then you have to find somewhere to remove those things. So, filleting of this particular oil, whatever oil over the liquid you are using, that should be perfectly fine, a without any type of impurities correct. So, fluid has to pass through a tiny gap, a capillary or a orifice it can clog.

So, that is, what is going, happening here in, this case, a particle lodged in a surface. Small gap can score the bearing or the rail. Now, there is another problem, because by chance, if the particle sizes smaller than the 15 micron considered that is the thing. So, first thing that, it will not clog right. So, a particle smaller than 15 micron and this is the case then no clogging correct, but what is happening here that, if it is a small particle.

Now, considered, these are the small-small particles and we know that this whole thing is a closed loop circuit.

So, this particle may again come into contact with this time and then it will actually contact these particular surfaces. So, when you consider the, this is the surface and one particle or more than one particles are contacting this particular surface and they are rubbing with this part. So, note in a short duration, but after a long period of usage, what is going to happen. This particular surface may create some type of deformation or some type of removal of the abrasion, abrasion wear and, because of that.

There is a scoring of the rail and once the scoring of the rail is there, then the gap by maintenance is very difficult, because now, you have uneven surfaces and whatever calculation you have done with respect to load with respect to the, hydraulic pressure. How to maintain this both the things, that is, calculation is? Now, note applying here, because your surface is now, different than the earlier design surface.

So, this is the problem. So, you are filtering a process, should be very-very is strictly monitored, otherwise there will create some problem at the particular stage right.

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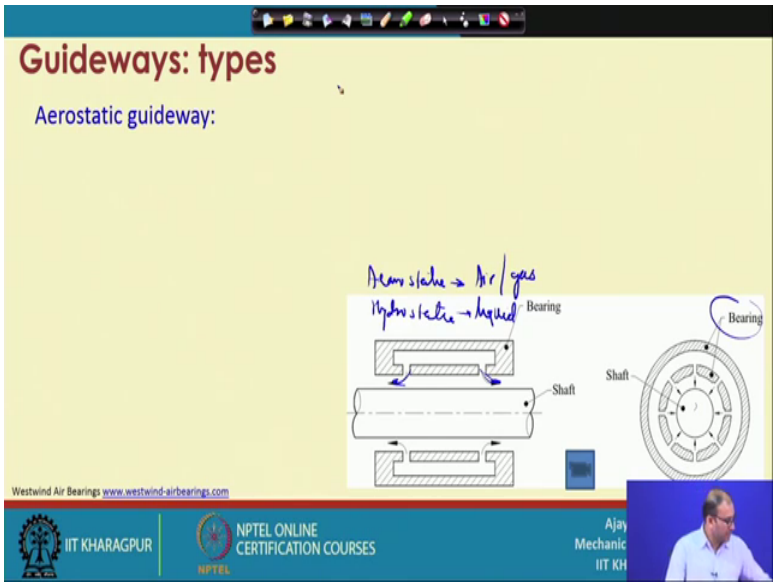

Now, coming to the aerostatic guideway; so what is the aerostatic guideway. So, only difference between the hydrostatic guide and aerostatic gateway is that you are using air in place of liquid right.

So, this is the same thing. Now, consider, this is the shaft and this is the bearing and this is the same way. So, here what you are putting, you are putting air earlier, case in the hydrostatic. What we are using liquid and in a aerostatic. We are using air for gas right. So, this is the different, but now, there are many other advantages also for hydrostatic guidesway. So, before that let us see this video that we can get more information by animation that how these things are important.

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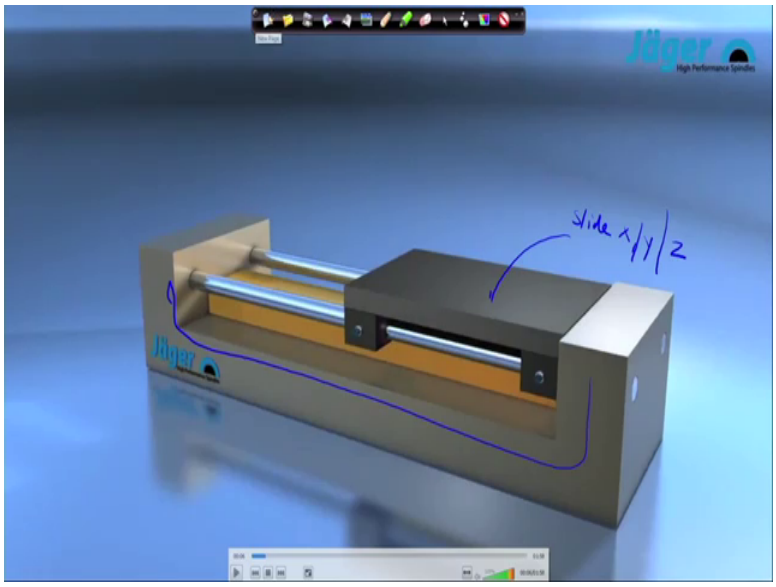

So, what is this thing that here, what we are doing that, this is a table and on the top of these, this is the slide. So, you consider a x or y, or it is mounted in vertical side, then it is a z axis right. So, we need a frictionless, this particular part. So, how this thing will work here?.

So, where we are mounting our air bearing, we have to mount air bearings here and this is the air supply, through which you have to supply the air from this part right. So, it is moving in this way. So, let us go more into detail of these parts of this is a bushing and from here, what we are providing? We are providing air in this particular interface.

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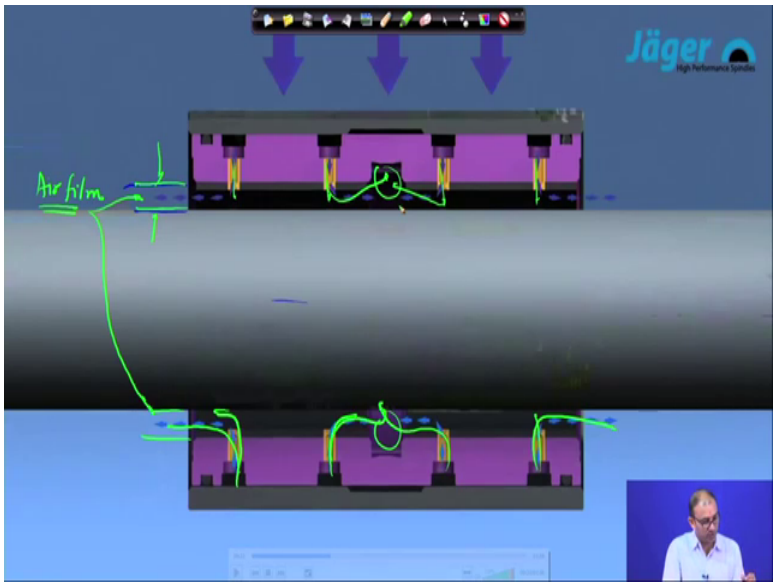

So, now, this is the interface. So, this is the shaft and this is the bearing and in between, this is the fluid filled. This is called air film and that is the same way, in this direction also correct, because we have to keep in this shaft, in the central position of this particular part. So, air is supplying from this part also, this is also and this way also.

So, air is coming continuously in this particular ways correct and these are the opening; that means, exhaust of this air will pass through this. It will go away, here it will go from this direction. This direction again, this is a process it will go from this way.

So, it is now in environments. Now, you do not need to worry about, what is going to happen after release of the air correct. So, now, what is going to happen that now, it is in a free motion after that what we had doing that we are adding workpiece. We are adding the tool and doing machining and everything.

So, your displacement, this whole thing will go down, because of that what is happened? The earlier, it was balance the force right, force at this location, at this location both were same, but when you are putting this thing down, what is going to happen that space is available, here is less, if the space is less, your pressure is more and here space is less, you are is more. So, your pressure is less.

So, after once this thing happens at that time, what this particular bearing will adjust itself; you do not need to see that how it is going to happen right. So, after in this

location, this is a red color that means high pressure. Again, this both things are maintained. Now, both the things are in blue colour, again, it will go down, this becomes less, high pressure, and this is a low pressure zone again it will mess the part. So, in this way what is (Refer Time: 27:52). This is a self adjustment bearing. So, wherever, there is a pressure difference, it will maintained that pressure reference by pressure regulator of this particular air bearing.

So, this is way how it is useful and once there is a no contact of this part then, you can easily actually move this shaft to and fro or you can move the table to and fro, that is up to your application, which one you want to make a stationery, which one is movable component correct.

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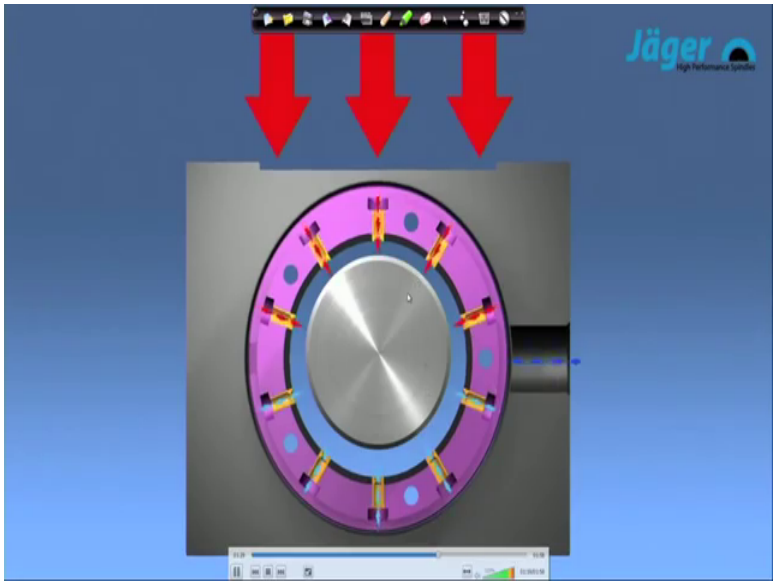

So, this is from the side view. So, now, this is the way you can actually mess over you are shaft is always at the centre he is pick took the loading. So, only thing you to make sure the loading is within the permissible limit of the pressure of this particular Bulverde hydrostatic bearing correct.

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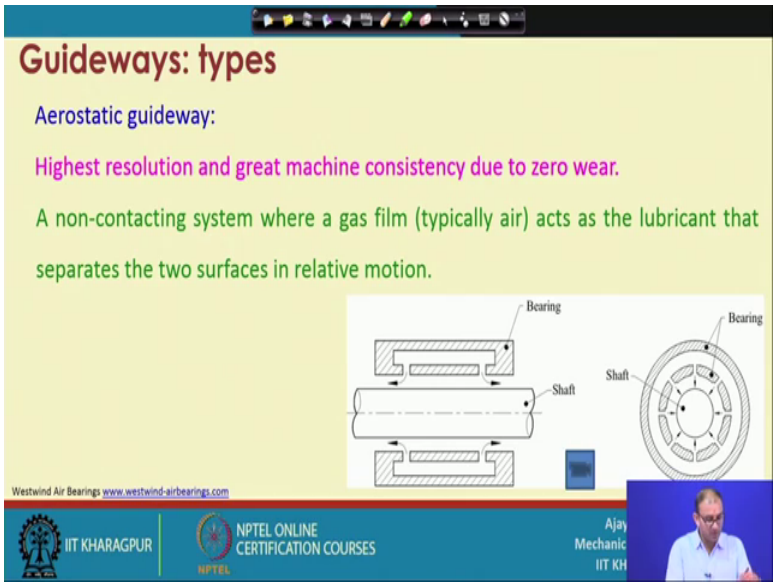

So, it is the high raise highest resolution great machine consistency due to 0 wear. So, compared to that hydrostatic, what is going the hydrostatic thing? There are hydrostatic pressure, was creating a problem, because the viscosity, what we are using fluid viscosity, if the high viscosity fluid is used then there is a problem in this particular case. So, you are getting a little bit more freedom in terms of the wear of the component and the friction correct.

So, a non contacting system, where a gas, gas film typically, mostly where using air act as a lubricant that separates the two surface in the relative motion; so this is what is happening in this particular case. So now, we have seen that we have a different-different kind of bearing. One is the bush bearing, where there is a surface contact, then there is a ball bearing and then hydrostatic bearing and when there is a aerostatic bearing and, we have all a things, we have a separate-separate application, because we cannot say the, this is a best on, it can be used for everything.

But there are different ways by which you can find out a specific application, where these are applicable, because this is not universal. That one is also not universal. Every application have some limitation. So, you have to find, which particular bearing or which particular guideways are more important or suitable for your application too.

Let me finish this class here. You will continue this guideway topic further in the next class.

Thank you very much.