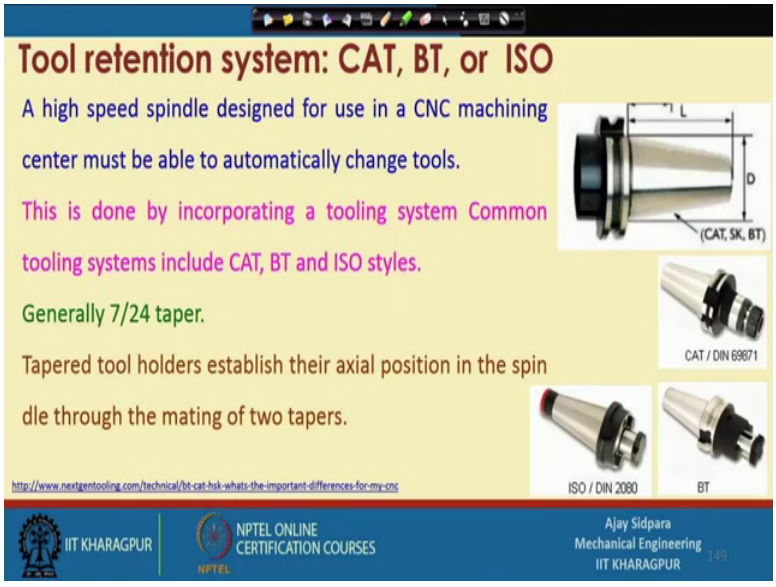
Introduction to Mechanical Micro Machining
Prof. Ajay M Sidpara.
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Lecture – 48
Components of machine tool (Contd.)

Good morning everybody and let us continue our discussion on the tool holders. So, in the last class we have seen two different topics that first one was the aerostatic spindle and we have seen that aerostatic spindle are a more appropriate for the micromachining application over where the load is a load is very, very small or medium load condition.

And then we started a topic that is what how to hold the tool in the micro machining centre, because there are different standards available in many standards are not actually suitable for or the many different type of configurations are not suitable for micromachining spindle because we are working with a only affections of micron or even a less than micron the tool run out and that is sometimes not achievable in standards which are developed before the micro machining technology came up.

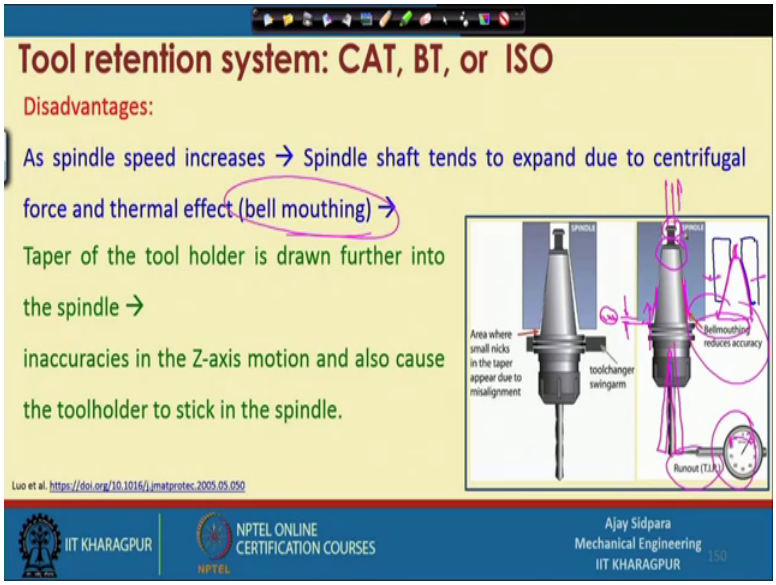
(Refer Slide Time: 01:05)



So, now this is the slide which we have seen that these are the three standard that the CAT BT and ISO standard and this standards are may develop before the micromachining came into existent or when there was not much discussion about that. So, these are the things, so let us see that what are the problem associated with this

particular standard. So, that we cannot use this thing for the micro machining applications.

(Refer Slide Time: 01:26)



And so these are the disadvantage because now we know that this is our spindle part and this is our tool holder. So, now, when the spindle speed increases what is having the shaft spindle shaft tend to expand due to centrifugal force and the thermal effect that is called the bell mouthing.

So, this is the thing is called the bell mouthing. So, now, you can see here let us discuss this thing first the now initially what was happening that our system was completely find. So, this was the initial thing let us see ok. So, this was the spindle part and this is the tool holder right.

So, this is the initial condition, but what about the when you start rotating at extremely high rpm, beyond the allowable limit of this thing then what was happening that this particular shaft will try to spindle you try to expand in this case because of that what is happening that you are you are getting one opening here. So, this is called the bell mouthing that is the problem. So, now, what is happening that once this thing is there now you have a space to go inside because now you can see this particular face is also not in touch condition right.

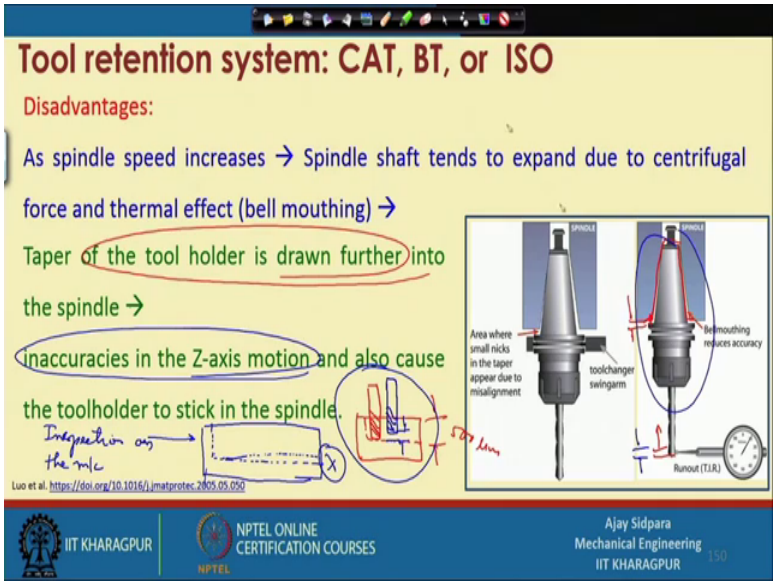
So, you have some clearance here, so whatever this clear that will be in terms of a fraction of millimeter to a 1 millimeter or 3 millimeter we will see that thing. So, because of that now because of this opening this whole thing will go inside, at that is the one way or if it is not going inside because now still there is a full contact here then this whole thing is verbal here.

So, this is the system now you are thing will be something like this or it is something like this. So, if you find this total indicator run out then this dial will move in this direction in this direction right. So, because of that you will get a run out, so you will get a bell mouthing a type of problem and because of this expansion of that.

Now, taper of the tool holder is do not further into the spindle because now what is happening that these are draw bar is there. So, draw bar is continuously holding this thing on the this direction because it is in pulling condition. So, if you are getting this part then what is happening that because of this pool your whole spindle will go for that; that means, your tool further will go inside it ?.

So, this is the actual position now after that what is happening that it will shift little bit inside right. So, if it is going inside right, so now, this is your one position it is touching and it is clearing this gap. So, this face is touching now, so if that whatever this gap this much amount of z is going inside it and that is actually note you are note in accounting this thing for the machining purpose.

(Refer Slide Time: 04:48)



So, what is happening your suppose this is your work piece and this is your features which you want to cut, and now consider this dimension is 500 micron depth and then you are cutting a slot out of it. So, when this thing happens here then what you actually you want to go up to this your cutting tool use this is the things which you want to reach to this location, but because of this things because now your holder is going further into the spindle than your tool is actually reaching a this location .

So, this is your tool zx is now correct, so whatever it is five here whatever this going inside; that means, how much is the inaccuracy in this z motion. So, that much in accuracy you will get in the machining feature. So, whatever features you want to create. So, what is problem here that initially when you are plunging it at that time you will get the same dimension right, because this is not happening from the starting correct.

So, initially, so this is the feature you want to create, but what you are getting it initially suppose because when you are rotating you may not get this thing instantly ; that means, after sometime what you are getting that you will get a this type of dimension.

So, this is the dimension what you are getting and then it will stabilize right. So, because of this problem what is going to happen that because of that you are dimension is first thing is not complete. It is not accurate as per your drawing other than that what is happening that measurement of this particular thing is also very difficult, because once you complete this dimensions then you have to measure this whole dimension by means of some high magnification.

Ah microscope or some type of non-contact profilometer and then what happened that if you are thinking that this thing is not correct and by chance if you have removed this component from the machine, because if you are doing this thing in line process monitoring; that means, on the machine is fiction on the machine.

On the machine then there is no problem because you are not changing the location or anything, but if you remove and do some type of line measurement then fitting again to the same location is a big issue because we have seen the fixturing also play important role how much force you are providing for fixturing and what is the location accuracy that creates a problem.

So, ultimately sometimes whatever it is better to reject this part instead of doing some type of repairing work on the top of big, because that will be much easier than finding out that location and doing the same thing. So, because of this what is happening that you are getting a problem here? So, in accuracy in the z axis motion we also cause the tool holder to strict to this spindle.

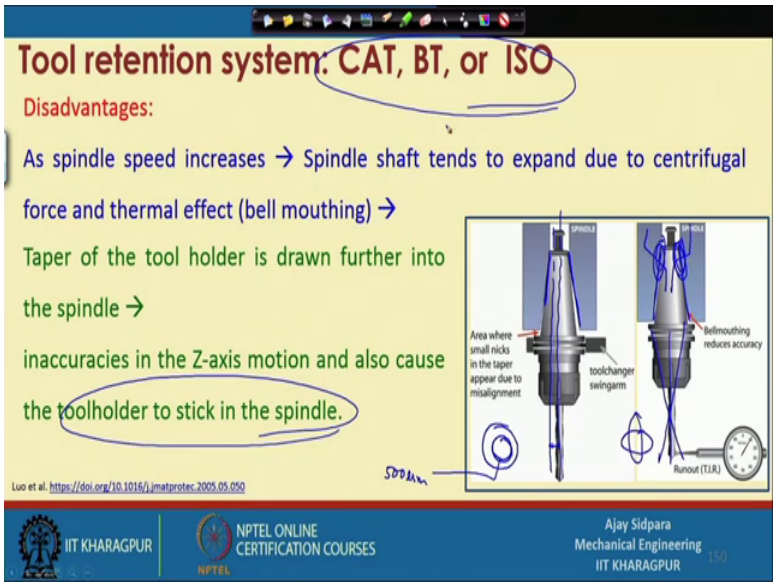
Because now you can know you see that initially there was a full contact correct right. So, this was the full contact here, so consider this was the full contact, but now contact is this location only right. So, now, whatever friction you are getting in the full surface now it is localized at one location only. So, whatever is the transfer of the motion from here to here it is taking by taking place at the very small location because of that all it will be generated here.

And you will get a tool holder sticking to the spindle at that is further damage the part because now you have to you have problem with the dimensional accuracy of the spindle to the nor. So, whatever taper you have maintained here that taper dimension is changed now and that creates a huge problem at the latter state.

This is the another thing that this is the area where the small nick of the taper appear due to misalignment. So, now, another thing is that by chance if your dimension is not exactly matching with this particular dimension because spindle has one taper and if you are dimension of the taper on the tool holder is not actually matching sometimes what happen that it is sticking to the one surface only not to the other surface right.

So, this is the problem when misalignment, so now, here the whole thing is shifted here right. So, here in this direction mostly you will get a tool alignment like this, but here this is the axis of the spindle and this is the axis of the tool. So, now, this is the parallel option this is the incline or consider there are incline offset. So, because of that what you are getting that now if this is the condition if you continue machining with this thing and by chance if it is the sustained that.

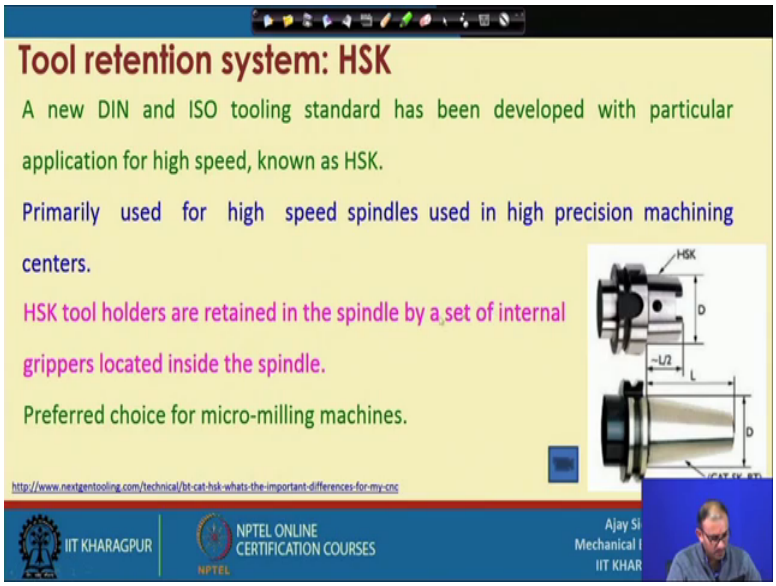
(Refer Slide Time: 09:17)



So, you want to do you want to get a dimension of this diameter, so whatever is a diameter consider the 500 micron is the diameter, but now you can see that here that you have tool is shifted to this location because this dimension was calculated based on the considering that the axis of the tool spind tool holder for the tool and the axis of the spindle shaft both are a coincident, but that is not happening here. So, instead of 500 micron what you are getting you are getting a bigger than that.

Here in this particular case what you are you are getting the mostly you will get a oval shape of wall. So, that is creating more problem in this case, so both the way ultimately actually you are not getting the part as per your dimension. So, this is the problem with the CAT BT or ISO type of standard right.

(Refer Slide Time: 10:08)

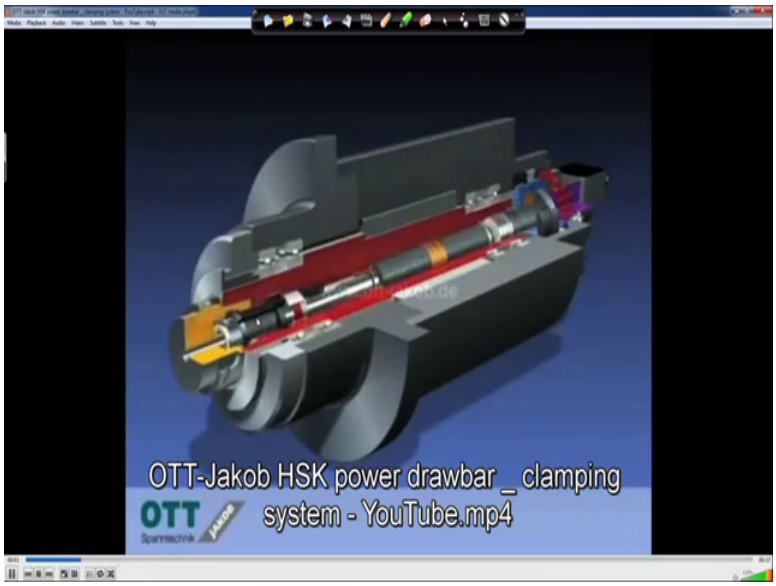


So, now there is a one system that is called HSK now. So, it is a new din note new, but comparatively new compared to this ISO standard the other standard which we have discussed just before a new din or ISO tooling standard has been developed with a particular application for higher speed known as HSK. So, it is equal to hollow shaft hollow shank shaft something like that it is a German name, but it is considered that to be shaft is hollow and it is hollow shank shaft.

So, this is the system and now we can compare this both the think the how this things are different than the earlier case, now difference is are many because first thing you can see that the, this much dimension is not present. So, it is almost half of the length of the this conventional that is cat b t or HSK type of standard, other than that thing is that that once it is then the taper is also very less here if you consider this both the things taper is less and there are some things which is very, very important or very, very different compared to this part that there it has a different, different type of contact surfaces not only one contact surface.

So, let us see that what things are there right. So, it is particular used for high speed spindle used in the high precision machining centers and HSK tool holders are written in the spindle by a set of internal gripper are located inside the spindle.

(Refer Slide Time: 11:48)



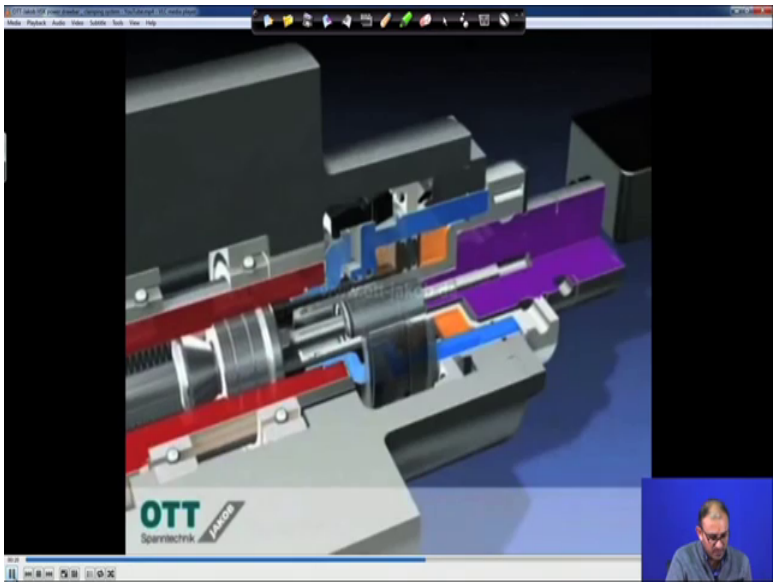
So, what this thing is there, so let me show you that video where, so this is a HSK type of spindle now you can see here. So, this is this yellow colour is the HSK tool holder now this is the set of inter gripper or a let me show you that let me finish this part.

Now this is the removing of this part now this is internal gripper now if you see this particular part. So, this is the internal gripper and when it is going inside at the time this particular this particular draw bar component it will actually expand and it will it will try to push this thing at this location right.

So, it is a contact here this is the contact this is the one contact and not only pushing after pushing actually it is doing inside it. So, you will get another contact here right, so it is a dual contact. So, this particular HSK has the dual contact and that is the advantage that even if there is some type of misalignment here you are tool holder it will lot penetrate inside because it has a contact with the face also.

So, this face contact will not l allow it to go inside right. So, it is going down, so when it is moving it is compressing at the time you can remove this particular part away of from that and then again it is now first it is going inside and then it is expanding. So, you will get a perfect conduction between the two parts.

(Refer Slide Time: 13:15)

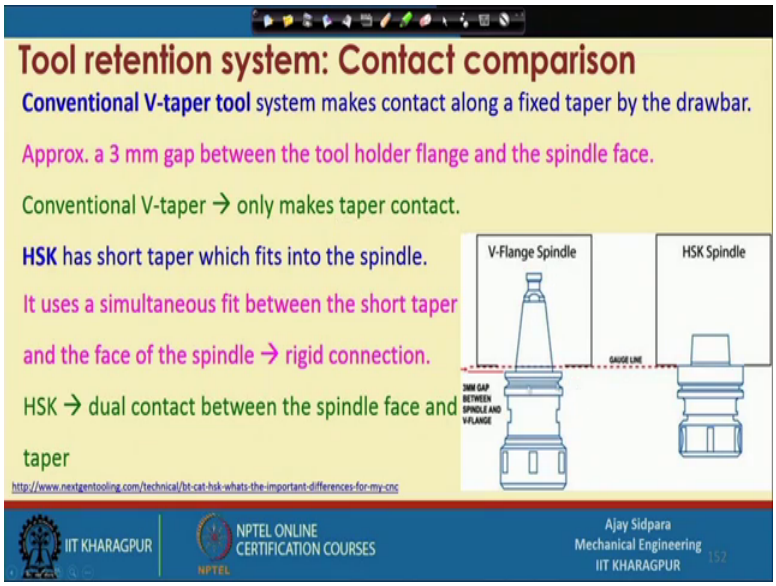


So, this is the mechanism by which you are putting. So, either it is a numerically operated or hydraulically operated. So, so that you can easily get the displacement whatever you required without any problem, now this is what essence when it is pushing down at the time this particular thing is actually getting compress.

So, when it is compress it is old thing you can remove this thing away from the system and then it is pulling back again. So, at that time it is pulling this tool holder also and after pulling actually it will expand. So, it will touch the surface of the spindle system.

So, this way actually you can get this thing done. So, let us the how this is important means how which we it will create a good joint. So, that is the because of this inter gripper you are getting a good acceptance in the micro milling machines.

(Refer Slide Time: 14:22)



Now, compared to contact let us see the how the contact happen that is what is important. So, now, this is the things between the v flange and the HSK spindle, now you can see that we have seen in that animation that it has a two contact here. So, this is the one contact and this is the another contact, but in this particular case we know that this stud will be pulled a by this draw bar.

So, when it is pulling that you have to create one gap here that is mostly it is consider the three millimeter gap between the spindle in the v flange, because if that gap is not there then this pulling has actually no effect; that means, by chance if this particular when it is pulling in this come this thing is coming into contact first before it is matching this particular taper then you will get a obling motion in this direction and this direction right.

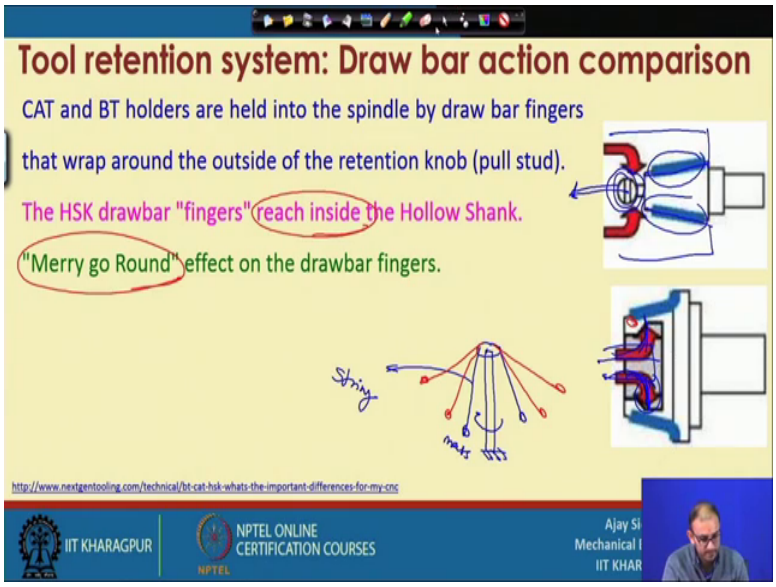
So, this gap will ensured that it is a full contact all over the taper direction. So, that is the advantage of keeping this part, but this 3 millimeter gap will create a problem because now when this thing will expand this 3 millimeter gap actually try to reduce and then all system will go inside of it.

So, conventional v taper tool system makes contact along the fixed taper by a draw bar right. So, approximately a 3 millimeter gap between the tool holder flange and the spindle face is given here. So, only makes a taper context, so that is the problem here, so it is a contact in the taper only and that is creating problem, but HSK the short taper which fits into the spindle.

So, this is the only thing which is going inside the spindle right and here you can say that is a very large amount of mass which is going inside the spindle. So, it uses a simultaneous feet between the shorter taper in the face of the spindle because of that you will get a rigid connection. So, now, it will note movie any direction it by the it will not go into the this direction also because now this particular face will prevent this motion to be happen and when it will not move in this direction also because now this is also in perfectly aligned condition.

So, in radial direction or the axial direction you will not get any type of movement right. So, it has a dual contact between the spindle face and the taper. So, that is the things because here you will get a only taper contact, but here you have a face contact and taper contact both the things .

(Refer Slide Time: 16:47)



Now, you can compare the draw bar mechanism that which where you are draw bar is holding this part, because if you see this our conventional that conventional holders are held into the spindle by a draw bar fingers that wrap around the outside of the retention knob in full stud. So, now, you are draw bar mechanism is located at these location. So, when you your clamping is then this whole thing is actually moving inside the system. So, because of that moment you will get a contact with the spindle face here. So, this is the context surfaces whatever this two surfaces are given that is the context surface right.

And HSK is the different thing now you we have seen in that case that it is not like there it is not pulling any sides of first thing that your all that gripper is actually going inside it then actually it is pulling and then it is expanding. So, it has a internal gripper here.

So, here it is a external griper because water it is pulling it is pulling through the student study is located outside of that part, and here what is happening that it is a inside of this part and then it is expanding after going inside then it is expanding out of it. So, it is called the hollow shank, so because of that name that hollow shaft hollow shank shaft, so that is the HSK part.

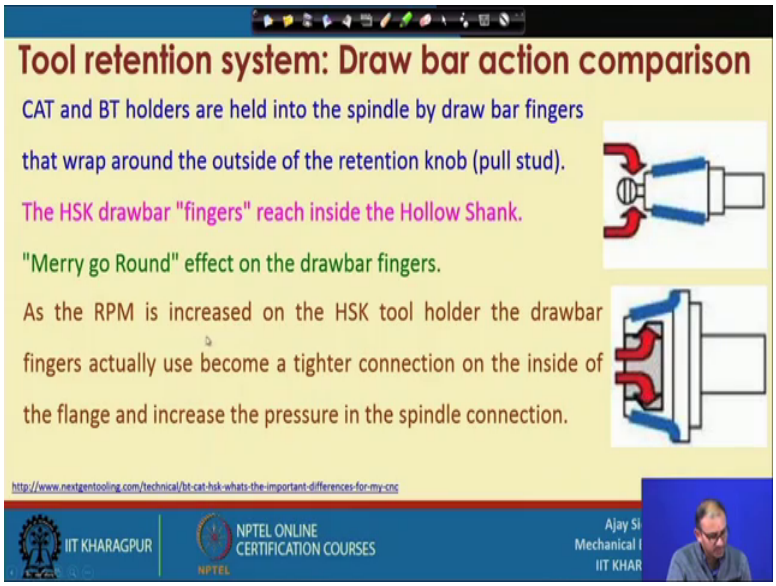
So, it is a finger which reach inside the hollow shank, and because of that what is happening then you will get a merry go round effect in the draw bar. So, what that thing now considered that you have a mass here and this is the string right. So, this is the mass and this is and now you rotate this thing.

So, when you rotate this thing this whole thing actually go in to the outer dimension because now this thing will go here that depends on the rpm and then it will go away and away, so that is called the merry go round effects. So, here, but merry go round effect is very, very good here in this particular case because it is actually doing from inside this because this word is very important because if it is going in merry go round then what is happening that actually you are wasting whatever is here .

Now you can see that your contact is here correct, so it is a inside contact. So, what is the advantage that if you whatever the rpm your rotating your contact actually firm further it will actually steak to the surface it will not x men, but here things are exit a different.

Whatever things are here, so if this is your spindle part. So, if this thing is expanding then what is happening that you will get a loose connection, but here if it is expanding you will further get a strong connection here? So, that is the big advantage of this thing; that means, you want you more you got the highest speed more it will actually written or more it will firmly grip with the surface. So, that is the advantage and that thing is called the merry go round effect in the draw bar finger right.

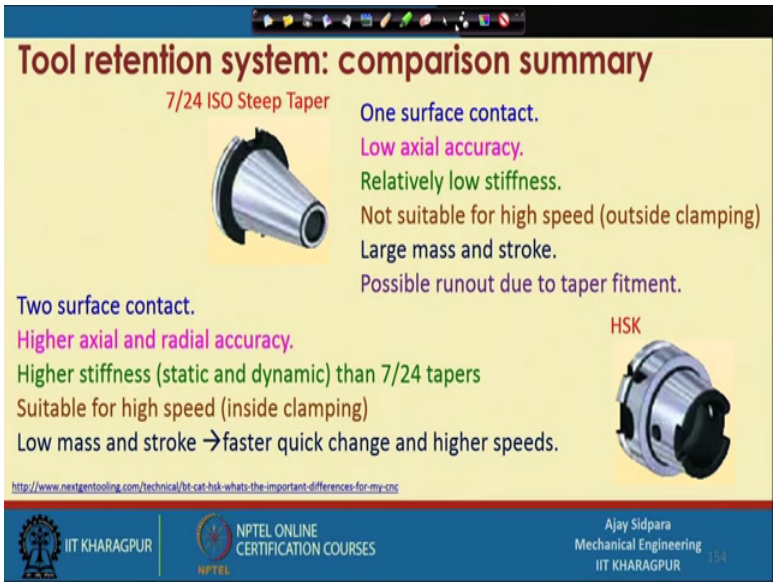
(Refer Slide Time: 19:50)



So, is rpm is increased on the HSK tool holder the draw bar finger actually use become actually use become a tighter connection on the inside of the flange and increase the pressure on to the spindle connection. So, this is the advantage of using this particular part because whenever you will get a higher rpm your draw bar will push this particular part and whatever is wherever it is a centrifugal force reaction or the thermal expansion.

Everything will actually make this thing more string and here those type of a thermal expansion or centrifugal force, that will actually adversely effecting the conventional tool holder. So, that is the difference between these two different systems right. So, now, what are the comparison summary between this two systems.

(Refer Slide Time: 20:38)



So, this is the taper ISO BT standards whatever we are thing and this is the HSK tool holder. So, first thing is the one surface contact here and here you will get the dual surface contact. So, that is the big advantage low axial accuracy because now we know that we are getting a shifting in the z direction. So, whatever is the problem because of this misalignment everything will be reflected mostly on to the z direction?.

And if you compensate with the z direction then again it will create a problem in the x and y both the things, but here you will get the higher axial in the radial accuracy because you have a dual contact on two surfaces, relatively stiffness here because whenever you are putting a load on the axial direction or the radial direction, what is problem that you are getting a deflection or because the whatever is the contact here that is fiction contact only that is also on the one surface.

So, because of that you will not get the high stiffness on the part. So, here you will get the higher stiffness because it has a static and dynamic both witnesses high compared to this particular system not suitable for high speed and because it has outside clamping that what we have discuss is just now that whenever is outside clamping what is happening that at high speed the centrifugal force and the thermal expansion both thing actually adversely affect there, but this thing is actually suitable why should because it is a inside clamping.

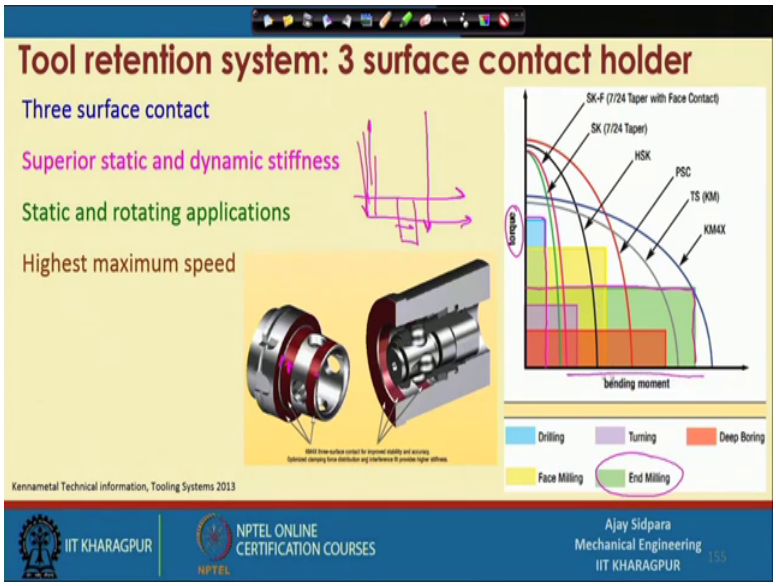
So, this inside clamping you will actually make your system more and more strong, when it is rotating at a high rpm and the another thing is as a large mass in the stock is there. So, that is also creating problem because you have to remove this particular thing very quickly and that is also you may be a higher speed also because when you are mass is high then rotating at high rpm it is also creating problem and every time you have to provide more amount of stroke here because when you are automatic tool changer is removing the things from here and you are putting something different.

At the time it have to pass through a very large amount of distance in the z direction, but that is not the case here because we have seen in that to figure that the length is almost a half of the length of the normal this conventional think part. So, that is that you can actually get the faster change as well as the higher speed both the things are possible in the HSK tool holder.

On the problem you are the possible run out due to the taper fitment because when you are making this thing at the time you have to make sure that the machine the spindle taper is exiting matching with the tool holder taper if those things are not matching even a fraction of micron here and there that will create a run out directly to the tool.

So, because first thing is the we have three connection we have seen that from spindle to the tool holder and tool holder to the tool. So, if any of this things are not actually making perfect connection then everywhere you will get the run out. So, there are the difference is between the two system and mostly because of this particular difference is we have you can think that only HSK is the best suitable for the particular application in the micromachining.

(Refer Slide Time: 23:48)



So, now we have discussed you know that there are one is the taper contact that is in conventional thing and HSK it has a two contact right, one is that the taper surface and another is the flange surface, but there are some very, very customize tool holder available where there has surfaces three contacts. Now if you see this particular system now it has a three contacts here as the one contact is; obviously, the face part another there are two contacts at two different locations, so there are the three things.

So, what happens because of that you will get a three surface contact for improve stability and the accuracy. So, that particular things will optimize the clumping post dissipation interference with provide the highest stiffness. So, when this is mostly use when you are doing a very, very high speed machining and the under the high load; that means, when you are machining hard material with a high depth of curve or something; that means, it is an aggressive machining part of thing.

So, HSK still useful or it is still fulfilling all our requirement for the micromachining, but this slide is showing here because there are no only there are not only two surface available three surface contacts holders are also available and that is one of that particular part .

Now, what are the advantages here that it is a three surface contact and we know that more the surface contact more it will become a stiff. So, here it as a very, very high static and dynamic stiffness because now you do not have any chance of moving in x y or any

z direction and static and rotating application mostly wherever you are using this particular a part it has a very, very high demand for this part and it has a highest maximum speed.

So, whatever rpm you are rotating still it will fulfill that requirement. So, that are the these are the advantages of using three surface contact, but this mostly is very useful when you are doing a stock machine; that means, when you are we doing a high speed cutting or when you are doing a normal machining operations where the material is very, very hard and you are not able to get those things by that kept bit your high ISO standard.

So, that is the advantage here now here if you see this particular chart it is it a torque was the bending moment; that means, how much torque you are providing and what is the bending of that particular tool holder. So, here these are the different, different tool holder showing and these are the different, different operations. Now if you see this particular things also gives you many, many things then now if you see this is the drilling area right.

So, now, equation the building you will not get in the train because we know that in draining we are just mostly actually pushing into the things. So, your torque requirement is very, very high, but you will not get bending at all, but if you see this particular end milling operation.

Now, we know the in n milling what you are doing we are pushing it down and then we are moving in this direction right. So, when your tool is going down at that that I will get first force and when you are moving at that end depending on your federate and the depth occurred you will get the different, different bending moment. So, end milling has the highest area that is in terms of the bending moment.

And now what is important here that you can see that this, but whatever we are discussing here that is actually here at this location now you can see that it is a very, very large amount is area through which it is creating a bending more. So, it can sustain for a longer period of time and these are mostly what you are we are talking here there is say one by four taper in first contextual it has a very, very small thing that is my building moment at this location.

So, by this way and our HSK whatever we should discuss it is falling at this location, but still it is useful in this because these are very customize thing and mostly it is used for the high speed machining and the very, very hard machining where the material hardness is very, very high at that time you have to actually maintain the bending moment and the stiffness into the machine tool.

So, this is the third contact. So, let me finish this lecture here because our part related to the component the machine tool is mostly over by this particular time we will see that what things we will discuss in the next class.

Thank you very much.