Introduction to Mechanical Micro Machining
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Lecture – 23
Components of the machine tool (Contd.)

Good morning everybody and welcome to our course on introduction to micro mechanical machining processes. In the last class we started a new topic related to component of the machine and we have seen some of the important things that how the different component behaves that will be detected by the quality of the component which is coming out of the machine.

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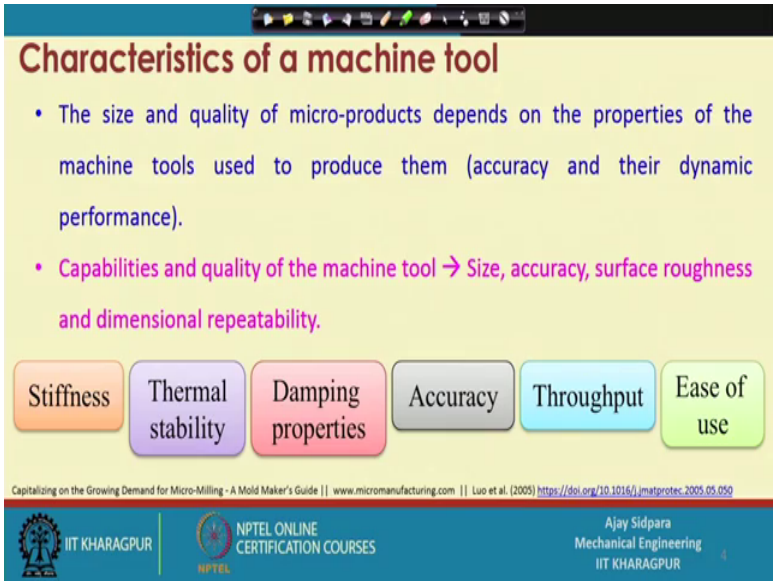

In the last slide we have seen that there are different properties or different characteristics should be met during the machining or the fabrication of the machine tool, those are the stiffness thermal stability, damping property, accuracy throughput and ease of use. So, getting this particular properties at what accuracy that will be detected by the cost of the machine; that means, if you want very very high accurate machine, cost of the machine will be very very high.

Thermal stability means even a 1 degree change in here your machine component or the construction component should not behave like very very soft material, then you have to use very very novel component or the novel material for making the different

components a cost will be very very high. Stiffness is important because if you want to reduce the number of joints then you have to create a monolithic structure, creating monolithic structure also play important role in the costing. So, these are the different properties so.

Now, let us go ahead in this particular topic. So, what are the major subsystem of the machine tool because machine tool has a different different components, but we have categorised a few components in one group and another in the another group.

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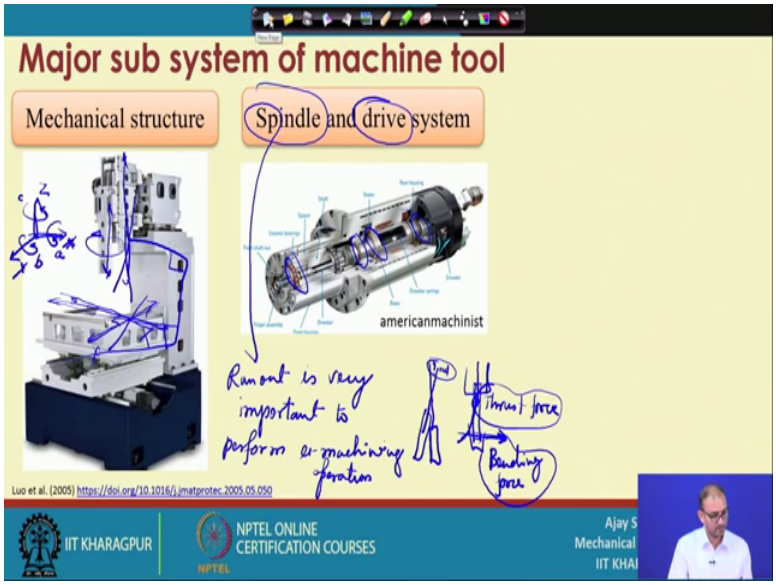

So, let us see what are the things fist thing is the mechanical structure. So, this is the mechanical structure. So, here you can see that this is just a box type structure after that you have to mount or you have to assemble many things here right. So, this is by z axis. So, in this z axis what you will mount?

You will mount a spindle axis and then you are putting a tools many thing on the top of it. See in this particular box in this axis your putting a y axis, in this line you are putting a x axis once these things are over then this are the you have to install motors everything to run this particular things you need one sliding axis for the movement of the z axis up and down also you have to mount spindle.

So, that it can rotate other than this 4 axis that is x, y, z and rotation around the z axis you have to mount some supplementary axis also to getting more results related to the 3 form

surfaces or 3 d surfaces. So, mostly we work with the 4 axis, 6 axis. So, this is you consider this one is the z axis this one is the x axis this one is the y axis, then the rotation around the x axis rotation around the y axis and rotation around the z axis.

So, rotation around x axis is called a axis, rotation around y axis is called b axis and rotation around z axis is called the c axis so many times machine is 6 different rotation and translation motions. So, that any different any complex components can be machine even at a micro skill level. So, machine structure or mechanical structure play important role because here.

Now, you can see if this things are not perpendicular it will create a problem, if this other than this perpendicular if this is not exactly at in the same plane. So, then if it is a theta then it is creating problem, this z axis is not exactly straight line then there is a problem, if there is a angle and it is a rotation and this old structure is not perpendicular to each other so this should be maintained right.

So, creating a structure itself is very difficult and when we are looking at micro scale machine we have to pay more attention in each and every aspect of this fabrication process. Another thing is a spindle and drive system because in micromachining we expect that this spindle should rotate to extremely high r p m to get the productivity at the reasonably good level because when rotating at a low r p m what you have to sacrifice, that you have to sacrifice the feed rate with low r p m at the time tool will not continuously remove the material the way you are forcing the tool inside the material.

So, your feed rate has the limitation because of the r p m desktop card is also limitation. So, if you increase the spindle r p m then you have a large flexibility in terms of deciding the feed rate and the depth of cut at a higher level. So, there are different, different spindles available some of them are belt driven spindle some of them are the electric spindle; that means, the motor is inbuilt within the spindle it seems you do not need a separate belt drive or some other pulley drive to rotate the spindle.

So, we will cover all this thing in detail, but what is important thing of this part is the run out because when you are machining at a micro scale run out is the major thing which we have to look into it run out is very important to perform micromachining operation, correct. So, run out means whatever is this is excess of that and then you have run out of this your tool is your expected tool is rotating here, but your tool is rotating at this axis.

So, this will be in a few micron of radius radiant few micro radiant, but that is still enough to create a bed component out of the machine parts. So, spindle and drive unit. So, what things you are using for driving this spindle that is also important; that means, the frequency response of that how quickly you can reach to the spindle there are vector control spindle available. So, that every time when you stop the spindle your tool is always in the same direction from where it is started.

So, those things we will see in the spindle system in different different spindle system, bearings are important that which step of bearings you are putting and how many bearings you are putting that the stiffness is directly connected with this particular things because we know that our tool is experiencing 2 forces, one thing is when it is going in the machine at the time it is getting a normal force and then you are moving in this direction.

So, at that time it will get a tangential force and your coupling is here at this location. So, when is moving in this direction there is a bending force comes into if direction and when it is plunging inside it at that time it is a thrust force and this is when it is moving this it is a bending force. So, whatever the assembly of this spindle it should be able to resist this thrust force and the bending force while doing machining operation.

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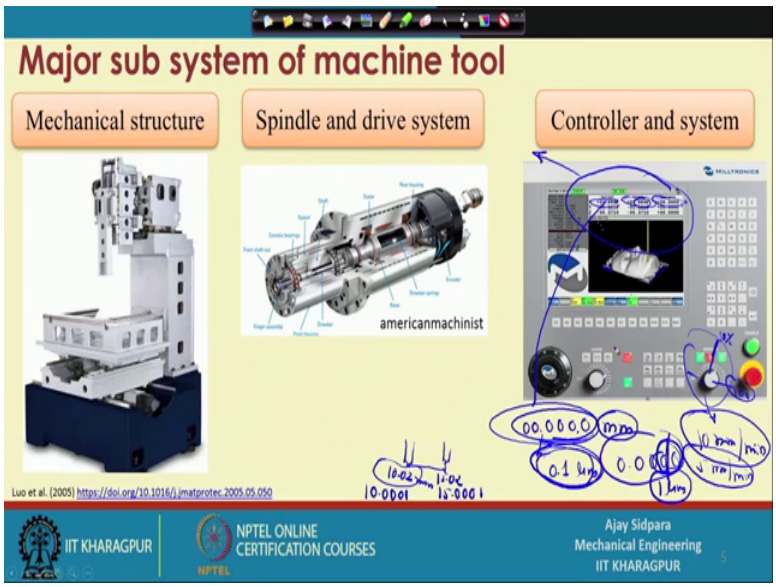

Another thing is the control and the system because we know that we are not operating any micro machining centre by hand because there are the controllers available and each

controller has a different, there are many machines available right now in the market which can perform the micro machining operation, but controllers are different for different machine many companies have their proprietor controller.

So, that you perform a variety of task which is not available in the general purpose of the routine in available in the market. So, many company have customised the controller, what things are imported in the controller what things you can do here in the sense that suppose these are the programme. So, you can guide the programme and axis movement here there are function available. So, each and every function key has a different, different meaning if you change the controller, other than that what is more important that how up to what digit your controlling the thing.

Now, if you see the current position is given here target is given here and distance to go here now if you see this thing it is moving from 0 0.123 and 4 0 and mostly it is given in millimetre right. So, if you consider this thing working very fine then actually you are moving your component with a 0.1 micron correct. So, if you are moving here. So, this is the 4 point. So, you are getting a 0.1 micron of the movement. So, if you want to move your tools suppose your tool is here and if you want to move from this to this location correct.

So, this is you consider it is a 10.02 micron and you want to move from here to here 15.02 that is possible here in this case and. So, here that is the advantage that you are getting a different different feel of that if you, if this is thing in millimetre then what we are thinking of the 10.0001 that is starting point and your ending with a 15.0001 because that is what is showing that this is the precision of this part. But many times what happened that your controller, this is the digital controller that I will tell you in the next few slide that how this thing sometimes is not the correct way to represent the things.

Because, digital control can give value in terms of busy, even you can add more 2 0 also here, but whether you have to also see whether your system is actually giving the feedback at that level. Whatever is movement of this thing we have machine here in our lab we will see in the demonstration class that they are also giving the last 4 digit from 0 point you are getting a 4 0, but when you move the axis at that time it will not move last 2 0 simultaneously; that means, you cannot differentiate between these two things.

So, basically it has a movement resolution with a one micron only not the 0.1, even though it is showing the 4 0 after a decimal 4 0 decimal point. So, your digital control is different thing whatever it is showing in terms of this thing is different and when you are actual encoder is available there is a linear encoder or the rotary encoder what is the feedback accuracy of that thing that is more important that is the reservation of the feedback control is more important, how small change you can detect there.

So, that is important, other than that this is what are the some customise important thing is there that you can actually see you at the core component here because once you write a program you have to again verify that you have written a correct program. So, for verification of that many time there are 2 d simulator available, now machine controllers available where the 3 d simulations are available.

So, this is 3 d simulation were a face of a person is getting machine here and this is the tool. So, before you operate the machine you can actually verify your part program line by line that where your tool is getting more going to move and finally, what features you are getting out of the tool motion. So, this is very useful feature.

So, that you can actually reduce many other by chance if you have written something wrong here you can actually rectify before you start the machine and you have a chance to re look into the program efficiently. Then you can control the speed very efficiently because suppose this particular thing is very important because if you have set a feed rate of a 10 millimetre per minute and by chance if it is giving some type of fluctuation that your tool is not moving or it is creating something which is easy to inform the easy to get information, out of that then without changing the path programme what you can do that you can actually reduce the r p feed jet of this particular thing.

So, you can move from this is the 100 percent suppose it is 100 percent. So, whatever speed your rotating here it will feed your rotating it will go up to 10 millimetre per minute, but if you move it to 5 50 percent then what it will do it will be rotate it will move with a 5 millimetre per minute, right. So, without changing a part program you have a option or you have a flexibility.

So, that you can actually change the feed rate during operation. So, these things are mostly useful in the conversion c n c milling machine where we have a possibility to correct the things during operation, but we have seen in the introduction section that

hardly you can get any noise out of the machine and visibility is almost 0 you cannot see anything you cannot hear anything.

So, this type of change in process changing sometimes it is very difficult, but still it is useful when you can see the process there itself and you can by using of this machine you have some expertise and you develop some knowledge. So, this type of things are sometimes useful in the process and you have a emergency button. So, if you find that suddenly there is a fluctuation in the power or something you can press the lights out then you can avoid the further damage to the machine and there are some things available that is called compensation of the error compensation things those things are important.

Because when you do some type of machining you have a inherent error inside the machine that is a the expansion of the different different part that is an x direction, y direction, z direction. So, machine can sense those type of expansion and cause of the sensor inbuilt inside the machine structure and accordingly machine will take its own decision that what will be the situation of your tool if you are temperature varies and within plus or minus 2 degree 5 degree or 10 degrees. So, customise controllers are very very important for a specific machine, but it should have a reasonably good amount of general purpose function. So, that you can operate without any problem.

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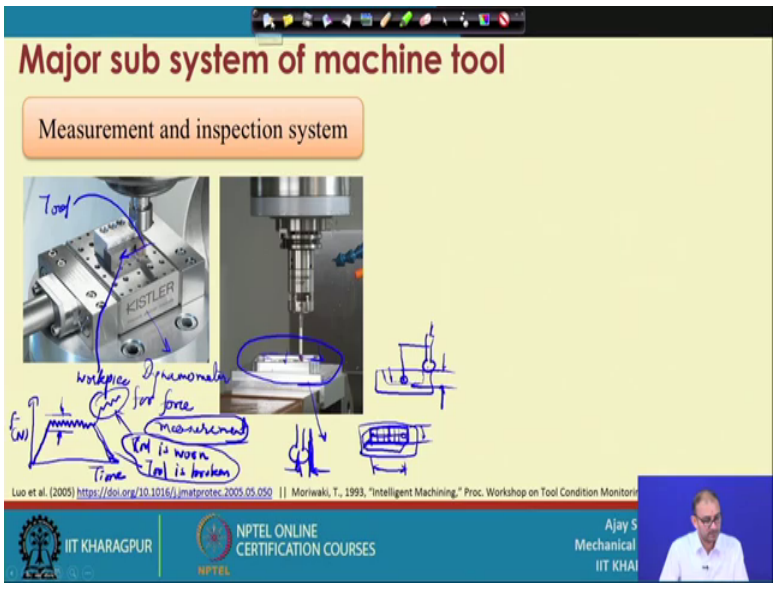

Another thing is a measurement and inspection system that is very important because we know that it is difficult to hear a difficult to see anything within the system. So, what we are getting that we are getting some type of indirect signals, what are the indirect signals that suppose you are putting something there. So, this is called the dynometer, for force measurement correct. So, what is the usefulness of this thing that this dynamometer is mounted on to the work table and the work piece is mounted on the top. So, this is the work piece and this is the tool, correct.

So, now, when these things are in physical contact and when you are doing a machining operation what happened that you will get a force signal. So, this is the force in Newton and this is the time correct. So, whatever is the situation; that means, sudden it is initially there is no contact and then you have started machine. So, force will increase and then stabilize it if it is a within a particular band; that means, your operation is moving uniformly and within the safe limited and suddenly if it is going up of it is going completed down, if it is going up there are different interpretation that your tool is one, tool is one and if it is suddenly going down and becoming 0 then tool is broken right.

So, this are one of the many interpretation by which you can actually understand what is happening inside the machine. So, this is in process measurement by means of dynamometer acoustic emission sensor or different type of accelerometer those things are very very important. So, that you can get the information of the real time machining because you do not have access to this location, but by the stuff indirect measurement you can actually monitor the process, what the status of the work piece and the tool second thing is the once machining is done.

Now, you do not want to remove this particular component because we know that we have fix this component after that we have decided that work co ordinate system and the tool co ordinate system and once you misplace is this thing; that means, once you remove it placing exactly at the same location you need again a very very highly precise fixtures. So, it is better the let us not remove this component out of this work piece, once the machining is done you put it touch pro that will do the calculation of the whatever things you have created inside that.

Suppose you have test plot this is the work piece and this is the a slot which is cut out of it then what you want to measure, you want to measure what is the dimension of this in

the lengthwise and the width wise another thing is the what is the depth of these components correct. So, this are the 3 components 3 things which you want to measure. So, this particular props there are many different companies who can who are selling this component this is one from the rainy. So, it touches the component at this location and then most to this location it calculate the what is the distance between these 2 including the diameter of the particular prop because prop is also the diameter.

So, this is the diameter of the prop and if this is the surface what is happing that this particular things should be compensated because whatever diameter 1 millimetre 5 millimetre or something whatever there you once it is touching that touch position it should give the reading from this location, not from this location correct. So, there is this is inbuilt inside that prop, but you should also know that where the measurement is being taken. So, it measures in this direction.

So, it record this diameter then goes to the centre of this then do the measurement in this reaction or suppose you want to see the what are the different different things at this location then you can take more than one readings in the lengthwise also and widthwise also. So, you can get one extra information that you have a perfectly square component or the rectangular component.

Then third thing it will do that it will go inside first you have a height suppose this is the side view of this and this is the component or the socket which is cut down from this correct. So, first what will do the particular prop this go here and will touch the prop surface to the here and then take the reading and then it will be move here and then it will be go here and then it will take the reading.

So, whatever the difference between this 2 that will be the depth of the work piece or depth of the feature which you have created. So, this systems are very very useful and important because now once this thing is done that you do not need to remove the work piece by chance if there is some error then again you repeat the operation and get this thing done. If you remove the component your work is very very high because again you have to read and execute the same send location, if that is not possible then you have to do all the calculation again because; that means, you to find the work location.

You have to find that where you are going to start the operation you have to find the reference position and again you have to find out the what is the z axis comprises; that

means, you have to find the surface with the z 0 then only you can go into the depth wise correct. So, to avoid those type of reworking it is better that you finish all the operation without removing the work piece out of it. So, if that thing you have to do then you this type of measurement and inspection systems are very important and that will reduce the time and cost also.

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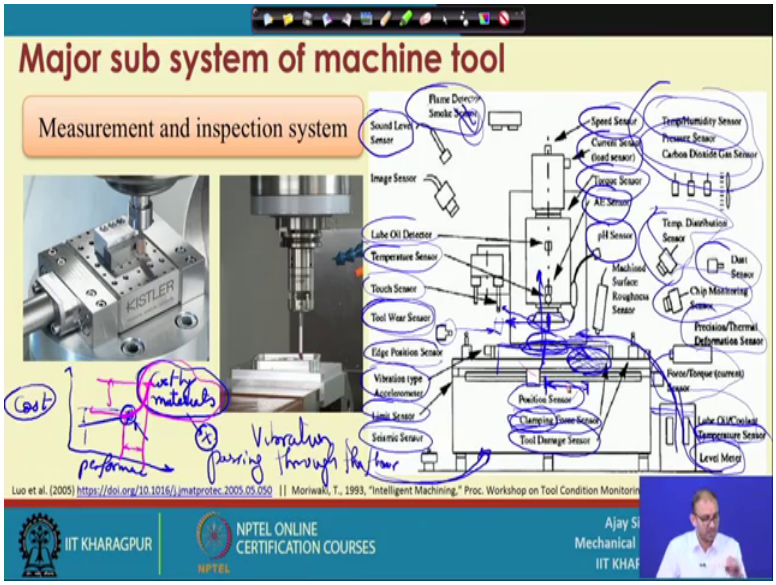

Now you can see here that how many different type of sensors you can put into the machining centre. So, this was from the very very old paper where it was means given in a very very generalised where what thing you can put into the machine. So, that your machine become very very intelligent now if you see the actual machining operation is here right. So, this is your cutting tool and this is your work piece right. So, this is a actual thing, but you can add many sensors here.

So, that your machine you can actually give a more and more reliability to the machine if you start from here there are the sound sensor available there are fume detector and smoke detector sensor available. Because if when you do machining operation at that time there is a chance is that that you are removing very very high rate, this is we are not talking about the micro machining, but this is we are talking about the general purpose machine all c n c machine in everywhere sometimes we are machining at high speed machining.

So, you are material removal rate is very very high. So, friction is very very high fumes are also coming up. So, this particular things will decide that with it should be within the permissible limit. So, when you are machining you have speed sensor, you have current sensor, load sensor; that means, if you are going with a very very depth of cut load on the spindle is very very high.

So, at that time you to provide more current. So, that it can counter it against the load torque sensor is available. So, that you can find out the enough torque is available to cut the material acoustic emission sensor p h sensor is available p h sensors important sometime because when using coolant inside this location then your to maintain, maintain or monitor the condition of the coolant also and once your operation of machining is over then you put a surface roughness tester here and do the surface measurement here.

So, without removing you can find out whether your surfaces pole is completely or without free from any type of birds or not, lubrication detection because your spindle is lubricated it can also tell you that this thing is temperature sensor is available. Because, we know the temperature in this spindle is also important because there are bearings available which are in physical contact with the races or other part. So, temperature should be within the limit.

Torque sensor is available because once your machining is over your tool will go to this location and this touch problem touch the tool and send the tool is available, it is not broken tool wear sensor available this are non contact that every time you once your operation is over your tool goes to this one particular location your camera will capture the image and then it will compare with the original captured image by this camera.

So, that you can get the difference between the used tool and the fresh tool whether there is edge blunting available, edge broken out is available, those things are possible edge position sensor is there vibration type accelerometer because when you do cutting operation here there is; obviously, vibration between the cutting tool and the work piece.

So, same vibration will propagated inside the spindle system and some will go towards the fixture and then it will transfer to the x and y table and for the to the base, but everything depends on the which was the construction material of this thing; that means, if it is a damping coefficient damping property is very high then what happened it will

damp or it will diminish the this vibration within this particular local zone only, it will not propagated through system.

So, vibration type accelerometer will tell you about the vibration level of the limit sensors available. So, when your tool is moving in this reaction and unfortunately unluckily you do not remember the, what is the total travel limit of your table. So, your tool will this to this location and then limit switch will triggered and it will not allowed to move the spindle further in the direction.

So, that is advancer that you can actually work within the safe limit, seismic centre all sensor available. So, even some very very heavy machines is moving from here to here when your transportation machine along with this machine you have mounted and their conventional machine which is giving more vibration.

So, vibration passing through the floor, vibration passing through the floor that will also create a problem in our machine suppose our machine is working fine everything is going good, but you consider the just out of the outside of this machine installation there is a highway going on there are many heavy trucks which are moving very very high frequency high rate. So, that you can get vibration out of that role to this location also.

So, you have to make sure the location of the installation of this machine also that there should not be any other conventional machining or the machine which has a very high tendency of vibration it should not be installed there. There should not be any way any roads through which the very very large amount of the more amount of the work h vehicles and everythings are moving frequently.

So, you have to avoid the those thing, in this particular case temperature humidity sensor pressure centre. So, these things are related to climate control; that means, you have to also maintain not temperature, but you have to maintain humidity also because sometimes what happens the moistures is actually captured by the different different components of the machine structure and because of that there is a degradation of the part. So, temperature distribution sensor is available because.

Now, we know that when you do machining at the time temperature is distributed in 2, 3 different thing one is the within the tool also another is the work piece also and third one

is the chip right. So, work piece and the tools are located in some location chips are actually spread all over the surfaces in the round x table y table and the base also.

So, chip are also carry a very very large amount of the and when chips are falling at the same location there is chance that that particular location will be heated beyond a specified limit. So, you have to find out the temperature distribution also that what is the total distribution of temperature within the system, chip monitoring sensors available dust sensor is available because many times we have seen that dust particle size few tens of micron and part geometry or what features we want to create it has also the same dimension.

So, when dust comes in contact with the tool and work piece interpret that it is considered as a one of the defect or some type of impact force from the external element and that will create a problem precision thermal deformation sensor. So, here what it will do the what is the deformation because of the thermal effect that will because of the temperature variation what is the deformation in the machine tool or the work piece of the tool.

Force sensor and torque sensor that we have seen here that dynometer accur then the strain gauge type of things also you can measure position sensor available position sensor are mostly linear encoder and rotary encoder. So, we want to move from here to here this location the sensor will give a feedback that actually tool has moved from one location to another location within the required part clamping force is important because where you are holding a work piece here and then it is machining. So, machining will create a vibration. So, if you are clamping is not perfect or very very firm at that time your clamping will be little bit loose after some cycle of operation then this particular sensor will tell you that.

Now, there is a loosening in the clamping or the fixturing of the work piece, tool damage sensor is available you can get continuous monitoring. So, there are few sensors which will give you the same reading, but more sensor useful because we are not sure about the reliability of the one sensor. So, if you are getting the same data from 3 different sensor, by 3 different principal and all are showing the same result; that means, you are in good shape; that means, whatever the tool you are using that is reusable for the next operation

also, then there are some other sensors available that is called the lubrication, coolant temperature, sensor level metre.

So, we know that we have to use coolant for that to reduce the temperature of on the tool as well as work piece also and the chip also. So, when you are using that first thing you have to maintain the temperature of that particular coolant also because when you are re-circulating the coolant because of it is also absorbing the temperature from this working zone. So, it has also one temperature. So, if you continuously use the temperature coolant at the time temperature also will rise from the cooler, you have to maintain the particular level also because beyond a particular level your the motor or pump will not pass this coolant to the working zone. So, you have to maintain does thing. So, you can see here that there are different about tens or 100 type of sensor which you can mount on to the system.

But now, question is that how many sensor you really need for this correct because there must be a cost tool the performance thing because now if you see here. So, this is the performance graph and this is the cost correct. So, now, first thing we have to decide that what are the sensors which are important because without that you cannot operate a micro milling machine.

So, first you finalize those sensor only. So, then what happened that your cost will increase slightly with respective performance, that you are getting a performance very very large here, but you are increasing the cost is very very small. Then you find out that what are the auxiliary sensors which are also important and it play important role in getting some type of very very costly component, sometimes what happened that you are machining a very very costly component and this particular sensors suppose you are reaching to this level this is the consider reasonably good point through which get the more performance with respect to cost.

Now, you are using a very very costly component or costly material materials right. So, now, what is the problem that even though you are using a reasonably good amount of sensors for getting a high performance you do not want to create any type of problem with this costly because you have something happens to this material or during machining operation what is the only way that your to scrape this component and that cost is even very very high.

So, what is the thing that you have to again add some more sensors here right. So, now, what is happening that now cost will actually follow a exponential curve. So, now, you are adding some more sensor out of that. So, that you can actually monitor the costly component machining, but still you are getting a reasonable amount of performance. So, now, if you see this thing then your performance or cost or almost same amount of 10 percent increase in performance your getting a 10 or more percent of increase in the cost of machine.

So now, what you have to do in this particular case that now it depends on case by case you have to find out that which particular work is your cutting what is the cost of this cutting and what is the cost of the sensors which you are additionally mounting on to work is surface. So, this things are very important in understanding. So, because you cannot mount each and every sensors into the machine tool because machine has also limitation and there is a space correct.

So, whatever it is showing here it is showing schematically, but it does not mean the location is the same whatever way it is showing here. It may be very very claim within the one location putting 5 senses and then you are not able to understand that which sensor is giving good result, assembly is also important you have to claim many things at the same location.

Again it should not create any problem during machining because even if you put many sensors here and some of the sensors are obstacling the machining operation then you cannot do a good job out of this thing. So, measurement and inspection systems are important that we have seen here.

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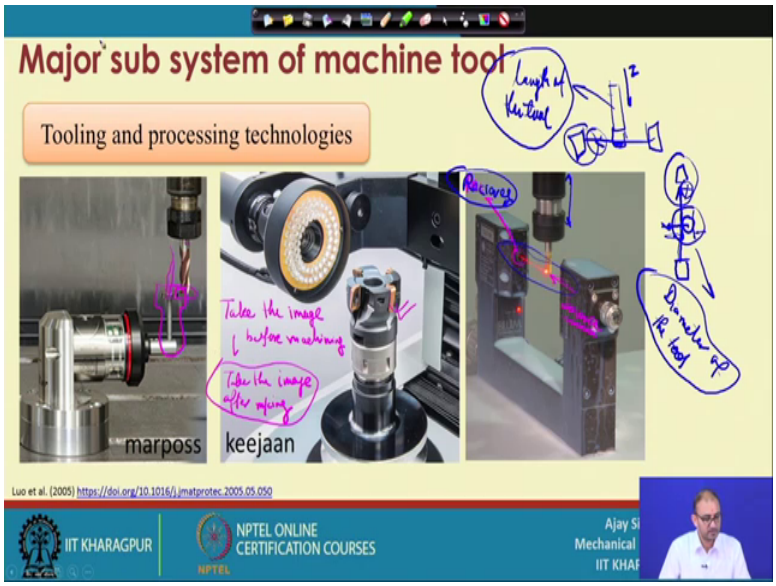

Then tooling and processing technology. So, till now what we have seen we have seen about the monitoring the machine tool operation in the machine itself. Now, tool is also important because we have to understand that how to monitor the status of the tool, when you are working with a micro tool or micro dimension we know it is a difficult to detect the tool we are and the tool breakage.

So, we need some sensor elements or some type of technology. So, that you can get information of the tool without removing tool from the spindle. So, this is one of the tools. So, this are that this particular things will give you one type of information about the tool edge. So, this is one type of lever kind of thing and when it is touching the surface at the time it will be triggered one location.

So, you can actually find out if there is any edge is broken or not if you are putting this tool exactly from the top at that time you can actually find out what is the height of the tool. So, in that way you can find out different, different properties or the specification of the tool without removing tool out of this particular system. So, these are some type of contact type thing; that means, tool is coming in physical contact with the sensors and then sensor is getting the data for the further processing.

And then there cameras are available because once you complete the operation what you can do that you take the image before take using this particular tool. So, take the image before machining and once machining is over you keep the tool in the same orientation

and then take the image after machining and then compare both the thing. So, at that time you can actually understand the how much is the tool wear what things are. So, this camera will give you a very very nice pictorial view of the visual information. So, that you can get information whether you can use these tool again or you have to replace the tool.

And then there are non contact of things available. So, this non contact type of things here we are using a contact type of, but here it is a non contact. So, how this thing will work right. So, now, there is a source of a laser. So, this going in this direction and there is a receiver source and this is the receiver correct, now what it is doing the tool is actually moving in between this 2.

Now, consider that your tool is here and your laser beam is moving in this direction, now when tool is at this location when is gradually going inside it then you receiver will not get the signal. So, once it is not getting the signal it understand that at which particular instant of the z movement, this is the z moment that particular instant of z moment your receiver is not getting the signal.

So, that particular moment because everything is synchronous it does not mean that this is independently working spindle moving up and down independently working everything is synchronous within the control of the machine. So, when you are not getting the signal then it will note down that particular time that when it is reaching that particular location. So, at that time you can find out the length of the, length of tool correct now after that what it is possible that now it is inside of this thing. So, this the length of the tool.

Now, let us the see from the top view. So, now, this is the supply and this is the receiver and laser will be going this direction then what tool does the tool is right now located at this location, it is already inside it depth wise is already inside it, but little bit is moving in the sidewise. So, again we are getting this signal on the receiver side then tool will pass through this location.

So, when it is passing through at the when it is touching then this will not get the signal when it is completely passed it will get the signal. So, whatever the diameter of this tool that much amount of time that your reciever is not getting the signal. So, by this way you

can measure the diameter of the tool correct. So, length and diameter of the tool we can measure by this.

Now, question is how small diameter and how small change in the length you can measure. So, there are different, different sensor system available which you have to select suppose you are measuring with a less then one more than one millimetre then most of the system will work when you go down to the 100 micron or 50 micron or 20 micron tools at that time the specification of this laser in this system changes, but systems are available where you can do measurement of the online system.

Now, coming to mechanical structure of the machine tool.

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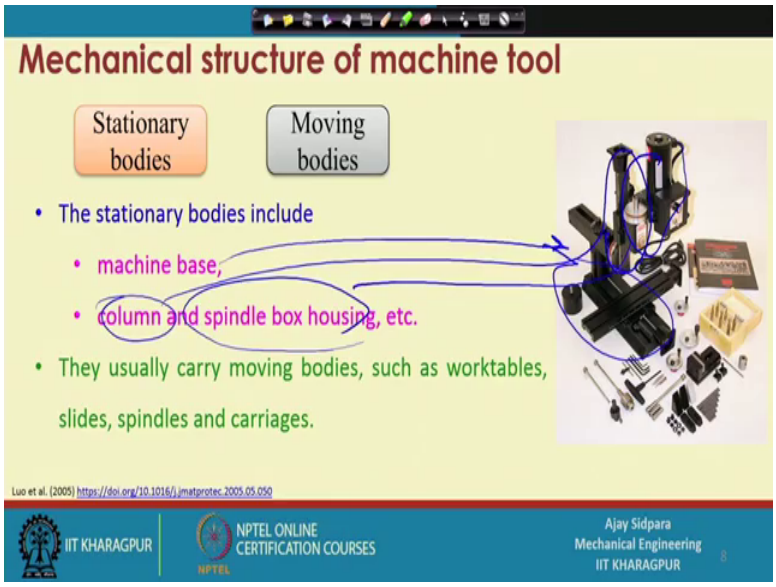

Now, what things are there there are 2 different compounds available one is a stationary body and this things are available. So, these are called stationary body that we have seen in the structure part that what was the machining stuff machine tool structure was there those was the stationary part and there are moving bodies available moving bodies are the x, y, z axes and the rotation around xyz axes and those things are moveable component.

So, that you can get the required geometry machine on to the different, different components. So, stationery component what things are included in this the one is the

machine base. So, this you consider the machine base correct column and spindle box housing. So, this particular thing is the base part, then this column is this one this is a column and the spindle box housing. So, this is a spindle box housing whatever is available here this is the spindle box housing.

So, in that way you can find this are the few main component, but there are many auxillary component depending upon the total specification of the machine you can get the different different things out of it, then they are usually carry moving body. So, once you install this stationary body then what we are doing we are putting a different different movable thing that is we are putting the servo motor and stepper motor for x and y motion then you are putting the same motor for the z motion your putting a carriage also on the top of it and then you are putting a different rotation around axis also.

So, those things are the movable components. So, you are stationary bodies is important for carrying out this thing and then you also make sure that old things are in a perfectly assembled. If it is not that thing some loose connections are there is a (Refer Time: 40:05) parallelism, flatness those things are not there then it will create a problem at the later stage.

So, let me finish this lecture from this slide we will continue this topic in the next slide or the next lecture.

Thank you very much.