**Introduction to Mechanical Micro Machining**

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**Lecture – 06**
**Introduction (Contd.)**

Good morning everybody and welcome to our course on Introduction to Mechanical Micro Machining. In the last class we have seen some of the difference between the conventional micro machining center or conventional micro machining processes. And there are two different processes one is the MEMS based processes, another one is the precision processes. So, now, we have seen that how those differences are there and those differences are mostly related to the; so, there is the difference between.

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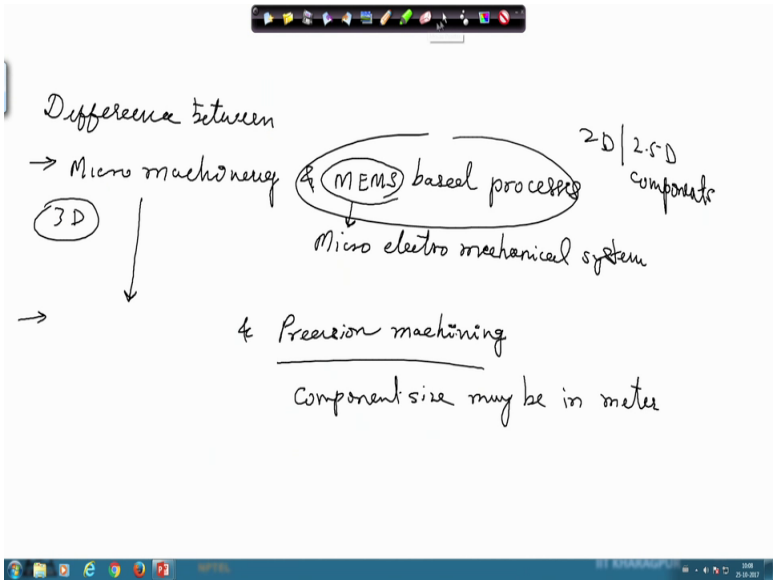


Micro machining and MEMS based processes and this MEMS means Micro Electro Mechanical System Micro Electro Mechanical System. Another difference was same micro machining center and precision machining.

So, basic difference here that these components are mostly 2 D components and 2 D or 2.5 D components while here you can create a pure 3 D or the actual 3 D components. Here the size of the component was very large may be in meter, while here it is mostly in the tens or the hundreds of the micron. So, that thing we have covered in the last class.

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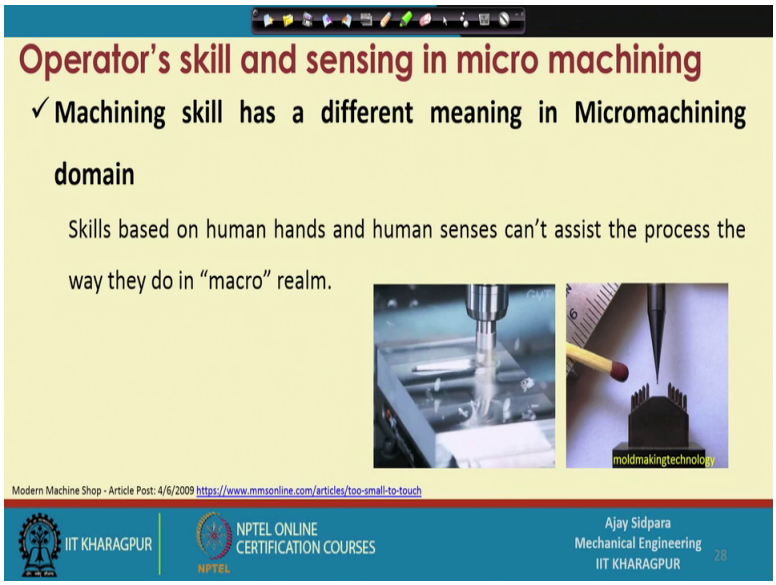


And then we move to the what other operator skill and sensing in the micro machining required. Because when you operate a machine at a micro scale or at a conventional scale, there are lot of differences available. So, we have to understand that what things you have to consider when you operate a micro machine.

So, it was the skill based human hands and human sense cannot assist the process the way they do in the macro realm. Because when you operate a micro machine; that means, conventional machining at that time, you can here lot of noise also a process is not working fine, you can understand by voice that something is going wrong, but that is not possible in the conventional processes in micro machining processes.

So, here you how to understand processes in terms of some basic idea that if you said this speed feed and depth of cut; with respect to conventional tool or the material property that which material you are machining and which tool you are using for that depending on that you have to you trial and error then find out what is the reasonable lead; particular range by which you can do proper machining. Because your ear and eye will not help you in understanding to find out the; what are the problems in the machining zone.

So, here we have seen some of the things that how these things are different.

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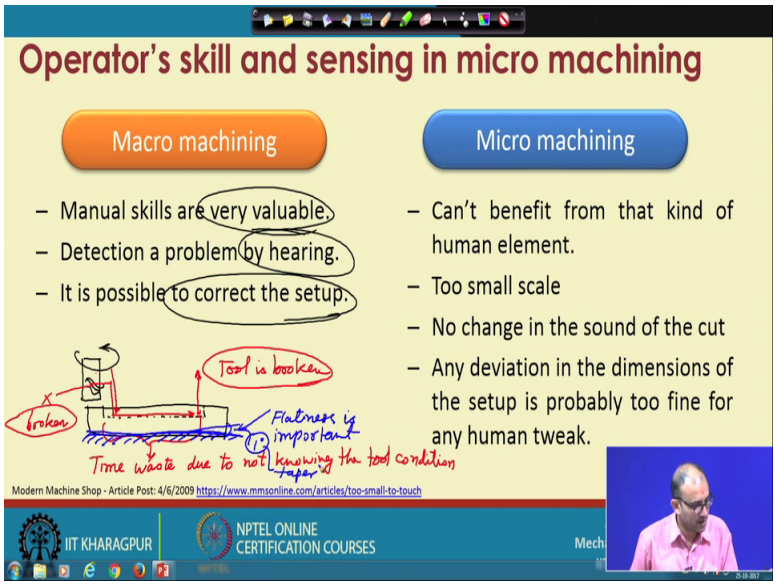


In macro machine; that means, conventional machining manual skills are very important or valuable; because when you operate any machine at this particular region, in this case then it is very important. So, here these valuable things how it is important? Because once a person use one machine for a longer time, he can understand that machine very well even a small noise coming out of the machine will tell you that how what is happening and what is wrong going on in the machining process.

Detection a problem by hearing because when you operate a machine you will find different type of noise; may be the because of the chatter also or the tool and workpiece contact are not very perfect or not uniform; then you can get different type of noise. And then if the spindle is not properly working or not fix tool with the tool holder then also it will create some noise. So, those things can be detected very easily in micro machining. Then it is possible to correct the setup because when you operate any machine and if you find some noise or something here; at that time it is possible. Because any; everything is visible and you can actually do correction during process. So, you can save a workpiece for if it is not completely degraded so, that is possible in the macro machine.

But if you consider the micro machining operation then there are problems because this cannot be benefit from the kind of human element. Because the way we are understanding this particular thing that by hearing or by hearing or understanding the

different type of fume also. Sometimes what happen that if the temperatures very very high, you can get different type of fumes also.

So, by just smelling the things also you can understand that the temperature is very very high what there is a aggressive interaction between the tool and the workpiece. But those thing is not possible here there are reasons because the tool size is very very small, even it is difficult to detect by naked eye; there is another thing the cutting is completely in the need the tool.

So, even you cannot see the whether tool is in contact with the workpiece or not. So, that are the problems then tool is very very small scale. So, that is very difficult; even tool is not possible to see and workpiece is also difficult to locate at that time. No change in the sound of the cut because even if it is machining or it is not machining, you cannot differentiate that what is happening there because everything is very very small scale and that is the problem what is difficult to understand in the micro machining.

Any deviation in the dimensions of the setup is probably too fine for a any human tweak. So, even small dimension is suppose you want to do a straight cut by a end milling cutter, but you are end up with a some type of a non straight cut suppose. Now this is your milling cutter and this is your work piece and you want to do a cutting of this particular slot. Now, this is our objective now consider the tool is moving from here to here then it will plunge inside the workpiece and then it will move in this direction and once reaching here again it will be retracted.

Now, this is the way it will do machining now considering the size of the cutting tool; now when it is plunging a inside it and by chance it is broken. And unluckily if you are not using any type of sensors here, then you will not get any information whether tool is present or not. So, what we generally do we continue the process and we thought that that machining is continuous and it is uniformly done and then we detect the tool. And then we reach here at that time we can understand that tool is broken at this location.

So, what we have done? That we have wasted this much amount of time; time waste due to not knowing the tool condition. So, it may happen many times in this case; so, what we need? We need cameras, we need four sensors, we need some accelerometer which will tell you when the tool is in contact with the surface.

Because when there is a contact at that time there are force is generated let it be at a smaller scale, but you will definitely get some signature from the force measurement instrument. And if you do not get any information; that means, we can tool is broken or there is no contact between the tool and the workpiece.

So, this is the case of the tool broken; now consider the tool is completely intake, but another problem is there that you your workpiece is not completely flat. Because when you want to do machining at a micro scale, you have to also make sure that the both the surface if; that means, at least this surface it is flat with the fixture wherever you are mounting it. So, flatness is important now if it is not flared and it is at considered may be at a 1 degree or 2 degree; 1 degree taper.

Now, what it will do? That whenever there is a taper; so, this is little bit incline in the top part.

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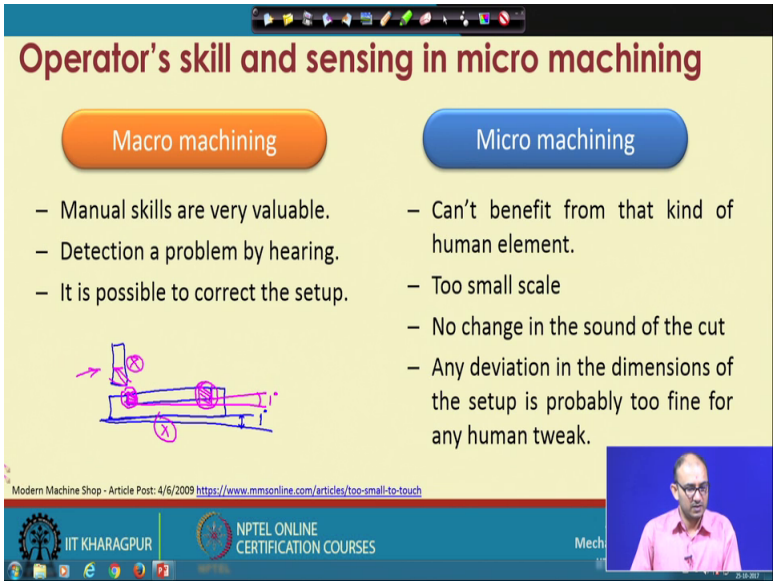


So, now, consider that your work piece is located like this and this is the angle 1 degree and your cutting tool is here again your objective is to cut something like this, but instead of what we are getting here? We will get something this cut will be the same, but instead of that whatever is this angle; that angle will be reflected here, so, these are the problems.

So, now not only the condition of the workpiece and the tool we have to also make sure the fixturing arrangement of the tool. So, what are the fixturing that how you are

mounting the workpiece in the tool that is also important in this particular case. So, now, you can understand that whenever there are some problems like this, you have to think at a microscopic level.

Because otherwise there are problems associated with the and at the end you are wasting the time also, many times tool is also broken because of this additional load it has to taken of. Now you can consider the here the total material removal of the contact zone is very small, but here that particular angle, it will increase the total load on the tool. And that is not counted when we have designed the speed feed and depth of cut when we had decided to use those particular parameter setting.

So, at that time because of the load increase it may break also and at the end the all tool as well as workpiece will be in the damage zone. So, these are the problems associated with this part.

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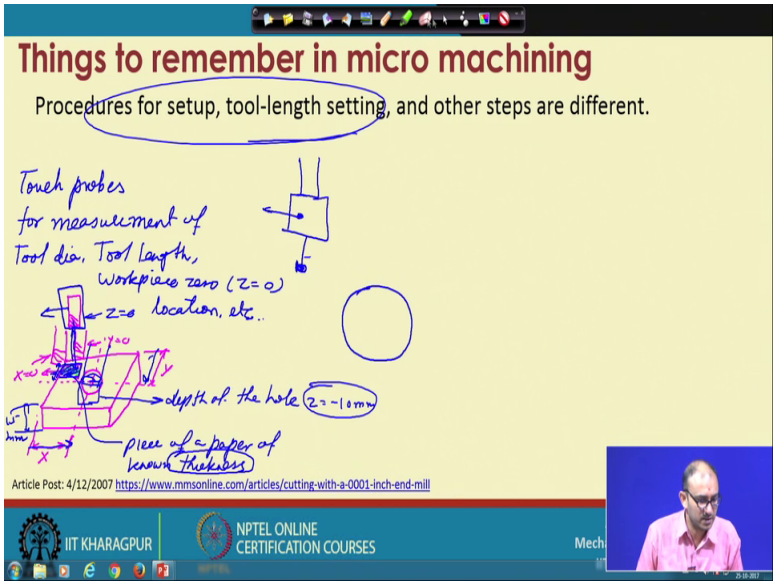


Now, before we go into the actual machining operation what we have to understand here; that what things we have to remember when you switch over to the micro machining zone. Whenever you use a conventional machining zone or conventional machining processes, we know that which may be how to operate the machine, what things you have to clean around the surface, once the operation is over what we have to do, how to clean the component as well as tool everything is very very clear in this case.

But here now what is problem that once the operation is over removal of the component itself is very difficult. Because you have to also understand that where machining is being taken place. Another thing that once the operation is over, workpiece removal is the one part, tool removal is the another part. Again you have to cross check both the thing that where the tool has any life or not, can you use the same tool for the next operation or not.

So, there are many things you have to understand or you how to actually inculcate so, that you can use a micro machine effectively and you can actually extend the total lifespan of the machine. Because it is not only the work piece tool material as well as the machine tool, but operative also play important role on how to manage or how to maintain the machining condition around the workpiece around the tool and around the machine itself.

So, let us see that what are those different conditions or different habits which we have to improve so, that we can use the machine effectively. So, first thing is the procedure for tools tool length setting in other steps are different here. Because when you see about procedure up setup; setup means that how to setup of the workpiece; that means, once you mount the workpiece, you have to find what is the Z 0, what is X 0, Y 0 from where you start the machining operation. Another is a tool length setting, when you operate a machine now consider let us take one example here.

Now, this is your work piece blank and this is your tool. Now here at the center of this, you want to do a drilling operation drill be dont want to go a through a drill. So, now first thing that we have to find out the what is this distance. So, this is X distance and this is Y distance and wherever it is here at that time when it is touching the surface Z becomes a Z 0 direction.

Now, when before starting that we have to understand what is the location of our cutting tool and where actual we want to move that cutting tool to the workpiece? So, for finding that particular thing first thing that we have to find out the what is the center of this particular job? Then only you can plunge the end mill cutter over the creating a slot or creating a one type of circular pocket.

So, here finding X Y what we have to do that? First thing that you have to find out what is this edge, you have to move this cutting tool to this location. And when it is touching

the surface you consider this one as a X 0, same way you have to move this cutting tool to the this direction on this side. And then you when it is touch it will consider as a this one is X 0 and this one is Y 0. And then you will know that where is this location; so, this is about the X and Y setting.

Now, second question is how to set Z 0? Mostly people work to do that, they gradually move this particular tool down to the surface and they put a piece of a paper with a known thickness. There we put one piece of paper of non thickness and then we gradually move this tool down over this particular piece. And then we move this piece move up a here and there and when it is touches the surface, you are not able to move this paper very easily. So, this is the very very general way to do this thing, but it may not be very very accurate, but here it will give you some idea that how much. When it is touching the surface at that time you have to also add this much amount of thickness of that; and then you consider there thing as a Z 0.

So, now all things are setup because when you are drilling or creating a pocket of a shallow hole; because here the depth also important. So, depth of the hole Z is equal to minus 10 mm considered we are thinking about that. So, and these thickness is 15 mm; so, it is a shallow hole, so, shallow pocket. So, once whole things are done then what you have to do? You have to retract this tool little bit of then move into X up to this dimension to the center and then move Y up to this; your tool will be located at this location and then you create a hole over the pocket with a minus 10 millimeter of a depth.

So, this is the routine way of doing this thing; other than that right now there are sensors available which will find out the what is the total length projected length of the cutting tool. And then it will also find out by means of touch probe. So, those are the highly sophisticated instruments which can be used for micro machining, but it mostly we do not use for the normal machining.

Because here few micron here and they will not make much difference in the machining part, but when you are going with this particular micro machining; then you need a sensor. So, those things are called the touch probe l touch probes for measurement of tool, diameter to length, workpiece 0; that means, it is Z equal to 0 location and etcetera there may be some other applications also, but these are the main applications.

So, now how this touch probe works? Those touch probes are instead of this cutting tool what we do that we use those touch probe here and there is a small ball located here. And when it will move up and down, then there are some light available here that light will blink and once blinking is our machine control will understand that it has touch at some location. Once touching is over at the time it will find out will remember that location. Now suppose this is the circle and you want to find out the what is the center of this particular circle?

So, now what we have to do? Now let us do a cross section here, let me remove all this things.

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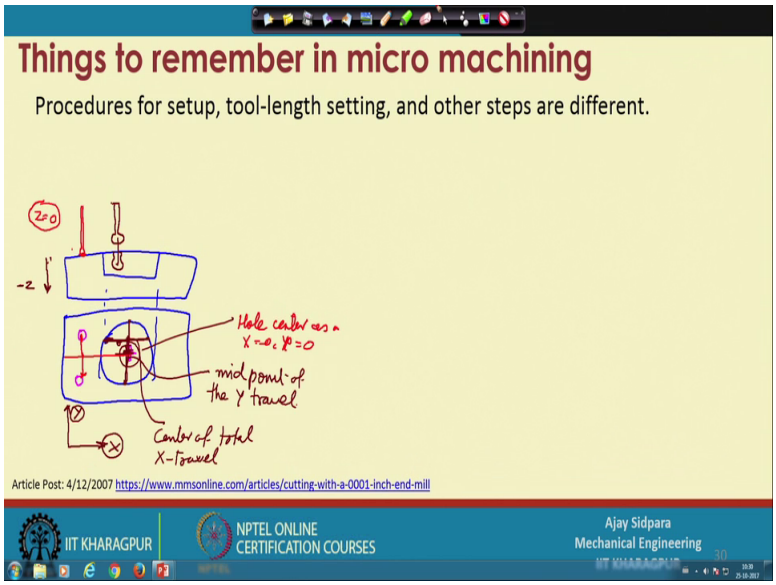


Now this is the side view of the cavity, this is the side view and when you see from the top now let us see this circle only. This is the circle and this is the remaining part; now what we have to do? Our objecting is with reference to this circle center we want to drill two holes here; we do not want to take reference of X direction or the Y direction, but we want to go with reference to the circle center.

Now for doing this thing first we have to find out what is the circled a center is this. So, what this particular touch probe does ? So, touch probe is something here; so, this is our side view and this is the top view of the work piece. So, touch probe is something like the and this will enter inside the hole, but it will not touch to the surface.

So, now, location of the touch probe considered this is the location of the touch probe here. So, it will gradually move in this direction and once it is touching the surface; it will identify what is that coordinate. So, now, let us see here; so, this is X direction, this is Y direction and this one is the Z direction this minus. So, it is touching at this direction; at the time it will remember what is the X dimension here then from that location it will go to this location. So, and then it will find out what is the center of this location, center of total X travel.

So, it will reach to that particular middle portion; then it will move into the Y direction touch to this location, find out that what is this particular coordinate of the Y; then it will move to the other extreme of the Y find out what is this position and then it will find out the what is the center or the midpoint of the of the Y travel. So, this is the center of this X and then this is sensor. So, you will find out what is the center of the particular work piece or particular work.

So, once it is done at the time you consider this one as a this particular centre as a. So, hole as a X 0, Y 0 and then you find out that from there how much is this distance located? How much is this distance located? So, this is the use of a particular touch probe in that direction; that is finding out the diameter of the hole when the and you can also find out what is the Z that when it is touching this particular surface; at that time it will sense that thing the touching is very gentle and this sensor is enough to understand that it is minutely touch the surface. And once it is touching the surface you considered this one as a Z 0.

So, earlier case was the manual case by which you put the paper and then understand there how much is the Z direction, but this is the fully automated and more reliable system. So, that you can get the required dimension in the micro machining zone.

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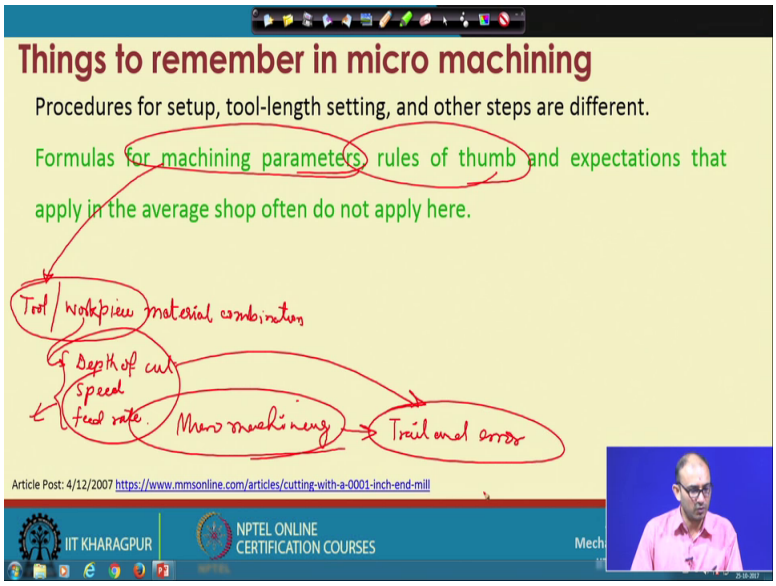


Then the formula for machining parameters mostly and rule of thumb and expectation that apply in average shop often do not apply here. Now what does it mean? Then what are the machine parameter that first what we do here that first we know that what is the tool work piece combination; work piece material combination. And based on that; what we decide? That we decide; depth of cut speed and feed rate and many times those things are standardize in which are well available into the literature.

And thumb of rule; that means, if these are the particular parameter you do not need to even look into the particular database or anything data book; you understand by means by your experience and you can find out what are the reasonably optimized parameter for particular workpiece and the tool material combination. And you expect that the all things will work fine because you can see the operation very easily which is not possible in the micro machine.

So, those things generally do not work here; what you have to do here that when you do micro machining micro machining, at that time you have to do that you have to find out that this particular parameter setting by trial and error. Because nothing is available right now; if you change the workpiece and tool material, this particular setting will change and then you have to play around the parameters to find out what is the optimum level of this.

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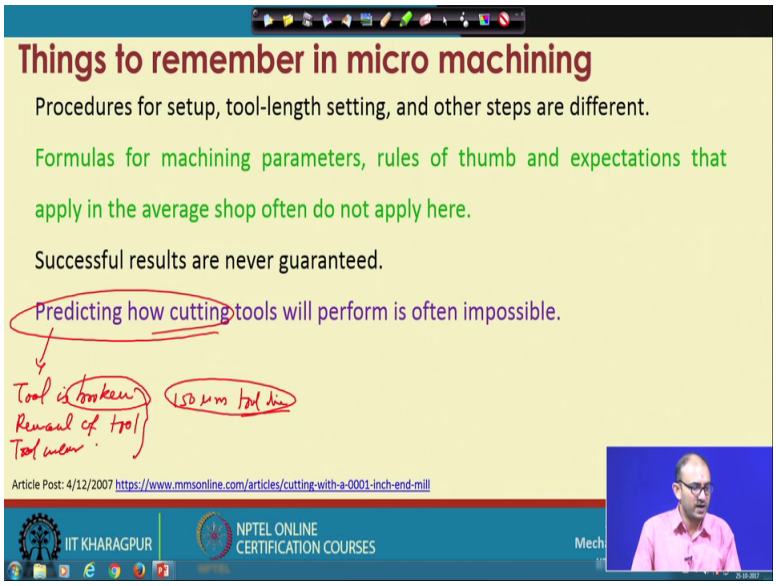


Successful results are never guaranteed that is happened because we have seen earlier case that; even if you continue operation and you do not know that whether your workpiece and the tool are in perfect position, whether tool is broken or whether tool is in reasonably good condition; you cannot understand this thing. So, you how to find out the way to how to monitor or how you can visualize those things by means of camera or by means of some other sensor so that you can get the required results very easily.

Predicting how cutting tool will perform is often impossible that we have seen in the class that suppose the tool is broken. So, that is performance of this particular tool is the tool is broken, then run out of the tool; these thing we will discuss in more detail when we discussed about the different component of the machine; these are the two things then the tool wear.

So, those things will create problem because everything is in a micron. Because when you are talking about the tool dimension, let us consider this is a 150 micron tool diameter, then it is difficult to identify all these things very easily.

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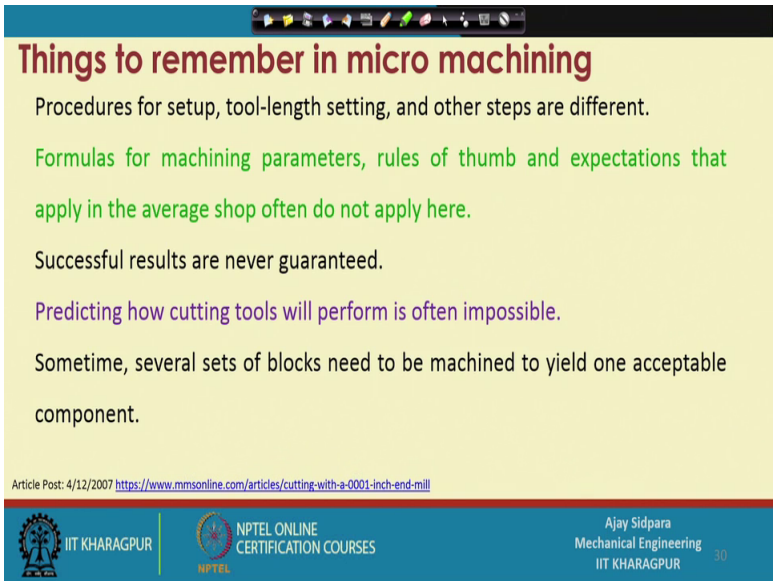


So, sometimes several set of blocks need to be machined to yield one acceptable component. So, this is everything is trial and error because if you continue with a one particular setup and you understand that it is not working tool is broken; then you note down those speed feed and depth of cut parameters. And then you convert into that that this particular setting is not working with a particular tool and workpiece combination then you will find out some other parameter setting.

And then you again do the machining; if you are lucky, then you can get the required result; if you are not then you again you to set out some different parameters setting. So, in that case you have to machine and many components to find out one acceptable component and that is creating problem in the parts. So, let me finish this lecture here; we will continue from the next slide in the next class.

Thank you very much.