Introduction to Mechanical Micro Machining
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Lecture - 07
Scaling Laws

Good morning everybody and welcome to our course on introduction to micro mechanical machining processes. In the last class we have seen that what things we have to taken care, when you are doing machining at a micro scale. So, now, let us see that

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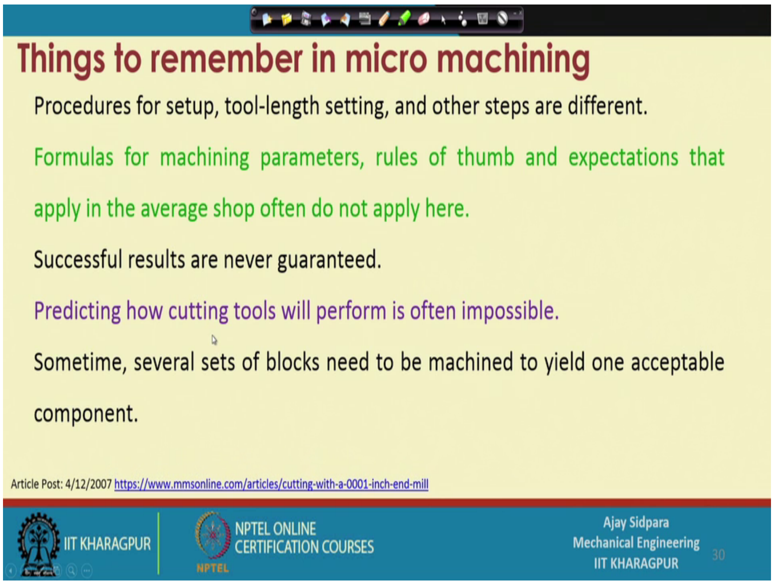

What are the different type of processes available, or what are the things available. This thing we have covered in the last class, and we have seen that how the micro machining is behaving different way, compared to the micro machining or conventional machining.

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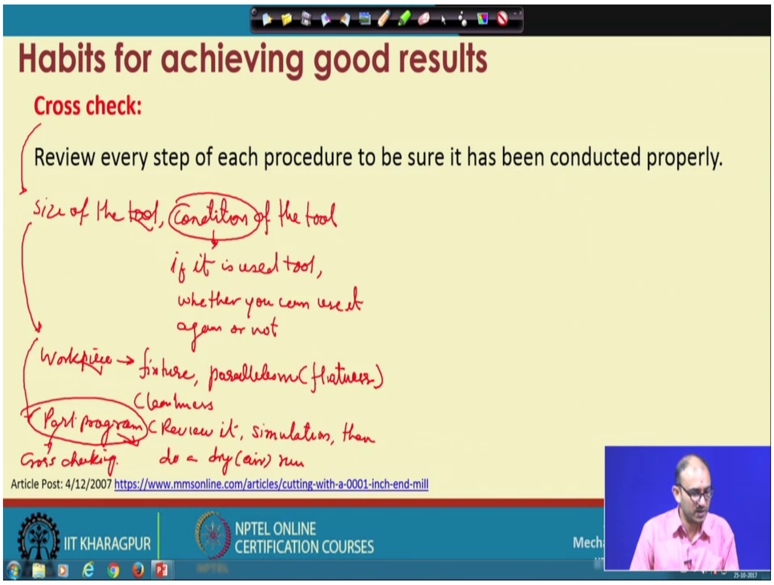

So, now, what habits we have to develop so that we can get the good results. So, let us go by step by step.

First thing is a cross check. Now what is cross check, because we know here this thing, that we do not have any chance of doing correction during the process or after the machining is over. So, first thing is that we are writing, how do we do cross checking that. First we see the what is the size of the tool, condition of the tool; that means, if it is used tool, then we have to find out that. If it is used tool then find out, whether you can use that again or not correct.

Then this is about the tool, and then you have to find out the workpiece fixture. It should be firmly fixed into the fixture; that is one thing than the parallelism, that all the surface should be flat. So, that is a flatness right. Then you have to see that whether the any, it is completely clean or not. So, those things about the tool and the workpiece, then you have to see the part program, because that is more important. Review it, then do a simulation, and then do a dry run, dry or the air run; that means, you are not touching the workpiece. You increase the (Refer Time: 03:30) a little bit, and a give a one simulation of the tool. So, that at least you can understand that where the tool is moving. So, this is about the cross checking of part program

And once everything is sure, then you understand that the. Now the setup related to the tool workpiece and the part program is ready to do for the next stage.

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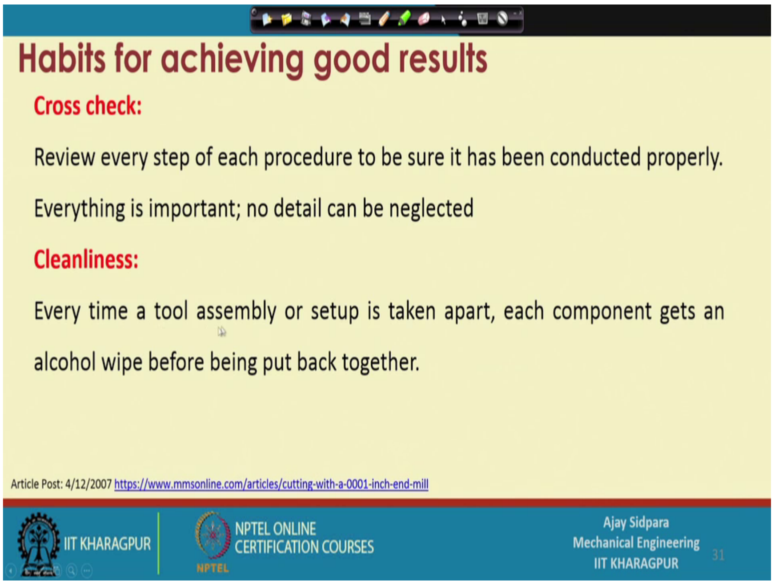

So, because here everything is important, no detail can be neglected, because when you do machining at a micro scale. What is the problem that generally we do not see everything at the micro scale. So, only thing is possible, that you use some type of sensor. So, here sensor understanding is more important, because each and every step you need some help from the sensor, or some camera or some type of microscopes, because when you are operating a machine at that location. Here problem is that you cannot get everything by naked eye.

So, every time some camera is located at the tool zone, because our objective is to maintain the tool for a longer time, because its life, should be little more and we do not want to damage the workpiece. So, in both the cases, we have to understand that we need at least two camera; one is focussing to the workpiece, and one is focussing to the tool.

If we understand this two things that you can use those camera when it is in operation, because once the operation started, you cannot see anything, because many times it is flooded with the coolant also, or some chips are there. So, it is very difficult to visualize the machining process, but when you find or when you focal the high magnification camera or microscope, at that time you can actually get the real life information about the machining zone.

So, that is important here. You cannot neglect anything when you are working with a micro scale, then the cleanliness is important, because we know that our dimension will be in hundreds of micron, or even less than that. So, if you are doing a machining with a one particular component and that are lots of chips available. So, chips are also in micron size, because when you are cutting it micron size; obviously, your chip will be in micron size, and there are coolant available. Coolant are completely spill away from the workpiece zone and everything

So, once operation is over, you have to clean the table, you have to clean the tool, and you have to clean the workpiece, these three things are more important. Another thing that once cleaning is over, then you have to find that, you have to wipe away all the things. It should be completely dry. Even as micron size of dust particle also play important role here, because when you are talking about dimension of less than 100 micron or less than 200 micron.

Even dust particle sometimes also in terms of tens of microns, and when dust particles are there, even if you clean the chips and everything. Many things you have to control around the part. So, when you do machining with a chip or this type of dust particle, it will create some problem, because it will consider as a foreign object, when you are doing machining. So, that will be not good for this type of thing. So, cleanliness is important. So, what type of cleanliness. So, every time a tool assembly or setup is taken apart. Each component gets an alcohol wipe before being put together

So, that is related to the machining once operation is over. So, you remove the tool you clean. The tool clean the workpiece, clean the table and everything completely around from the parts. And then you put into the required storage for a another operation. So, that is about the cleanliness.

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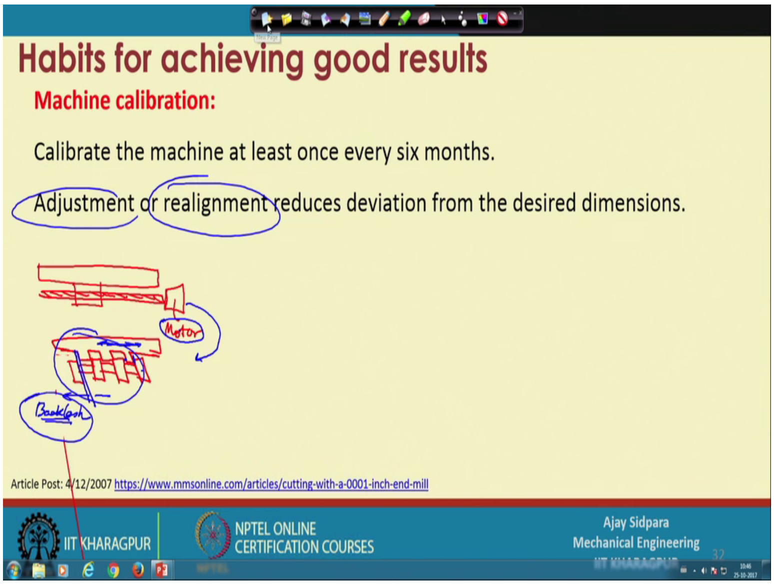

Then the machine calibration is important, because we know that each and every component, whether it is a living human being or the machine, everything we has some age or effective age, where they work at a very high efficiency. When you install a new machine at the time, all components will behave very accurately, but as the time passes, whether you use that machine or you do not use that machine, there is always aging of the components.

So, every 6 months or every 1 year, what you have to do. You have do to calibration, and again you have to find out whether your all components, whether it is axis, travel axis or the total deflection, because sometime it deflect, because of its own weight. Also it will be micron size, but after few years you will realize those things also, and we cannot ignore this thing when you are working at a hundreds of micron or tens of micron. So, you have to calibrate that machine at least for after 6 months, and understand, or do some type of adjustment, because there are lot of lead screw available, and some bolts (Refer Time:08:00) area circulated bolts are also there.

The backlash created, because of the too much movements from here and the to and fro motion, that would create a problem. So, calibration will make sure that your workpiece or the tool, machine tool is working very fine in this particular case. So, calibrate the machine at least once every 6 months to get the required correction done. Adjustment or realignment reduces deviation from the desired dimensions, because we have seen earlier case that if you operate a machine with this type of known calibrated thing, we are working with tens of hundreds of micron, and you are end up with some type of results, which you do not want.

Because when you know that suppose this is a table and this is the lead screw, by which your table is moving and this the motor. So, when your table is moving in this particular case, If you see this. Now if you see, this is suppose consider your teeth's of the lead screw, and this table is on this side, and this is your table part. Now what is important here. Important is this dimension

Because this is called backlash, now see when your table is moving in this, when your table is moving in this direction, there is a full contact between the teeth of this particular table and the teeth of the lead screw, but when it is moving in this direction, at that time your lead screw will rotate, but your table will not move, because unless it is touching or it is completely covering this particular distance.

It will not move in that direction. So, what happens in this case, their motor will give a signal, because motor is rotating. So, if it is a encoder or rotary encoder. Rotary encoder will give you a signal that your table has moved, maybe 10 micron or 100 micron, but your workpiece is not, but your actual table is not moving in this case. So, to take care of this backlash or everything, you have to calibrate your machine for a longer time.

So, after every 6 month, make sure that you calibrate the micro machining centre, so that you can do some adjustment and realignment, and to avert. This is one of the problems which i am mentioning here, but there are many other than this problem, parallelism between the two surfaces than perpendicular, little bit x y and z axis. So, those things will create a problem at the later stage.

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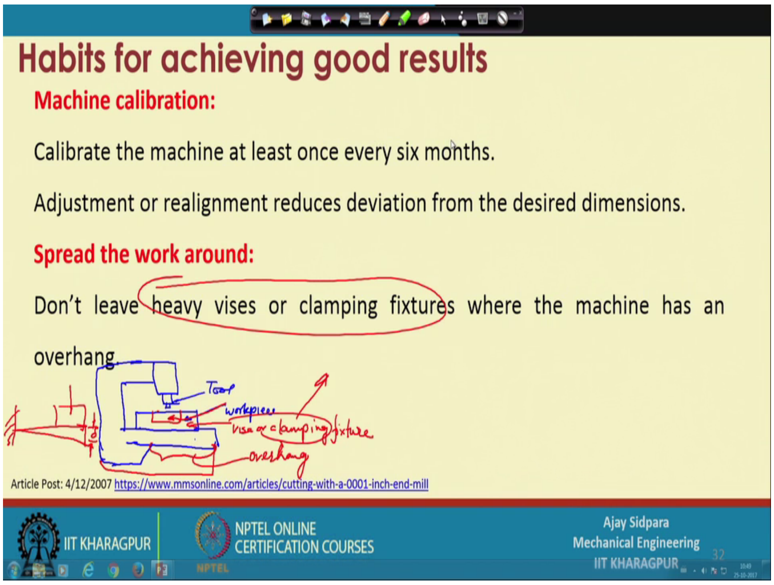

They spread the work around. Now what is important that they do not leave heavy vises or clamp fixture where the machine has an overhang. So, what is this? Suppose your machine structure. Suppose this is your table and this is the machine head, and this, your tool, and now consider this is your table, this is the workpiece, this is tool.

This is something like that. now consider this is called overhang part, that suppose everything is completely covered, then it is not a problem. Most of the time that you are getting some support from the bottom side, but if this is the structure, then this part is called overhang. Now what is problem with that, because now you use a heavy vise or clamping fixtures. So, those things are this.

Now consider that this is the workpiece and you are using some clamping mechanism here. Now consider this is the workpiece, and this is. Let us consider it as a vise or a clamping fixture. Now its weight is also very high in this particular case if you keep this thing here as it is, because of this. Now consider, this will considered as a cantilever beam. So, we are putting some weight here, and because of the weight there is some deflection, let it be at micron level, but that is enough to create a problem at the micron dimension of machine component.

So, once operation is over, remove this part and then you keep the machine clean, when you want to use that machine for a next operation then only you mount it. So, that is the way you can do some type of usefulness in the machining operation.

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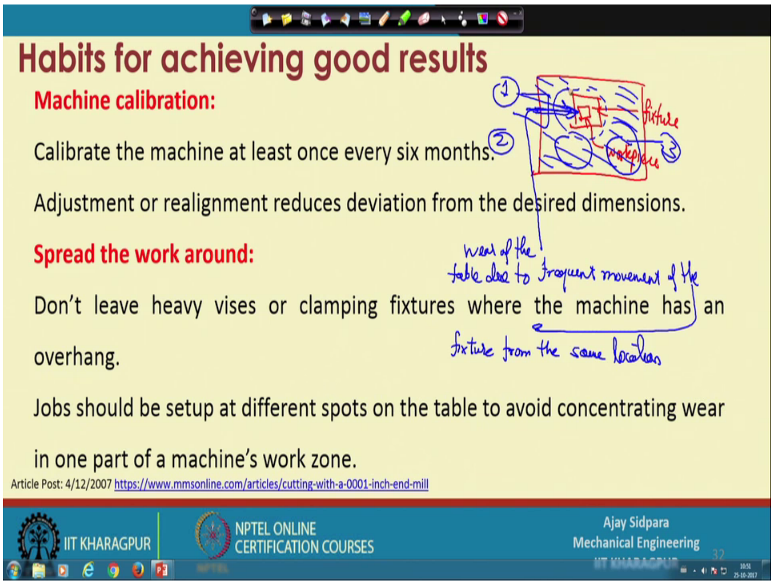

So, job should be setup at a different spot on the table to avoid concentrating, wear in one part of the machines work zone. Now what is that mean. Now consider we are looking from the top, and this is our table, and every time what we are doing that, we are mounting the workpiece and fixture here, everything here at this location. So, this is the fixture, and this the workpiece at this location. So, now, what is problem of that. How you are mounting that.

You are putting something like that, something you are just moving. At least you are putting at this location, then you are sliding it right. You are not moving directly there. So, when you are sliding here and there continuously consider hundreds of time, you are doing same thing at the same location. So, there is a wear of this particular location. So, this is the wear of that. So, wear of the table due to frequent movement of the fixture from the same location. So, if you do everything at the same location. This remaining portion whatever is this. This is unaffected, and you are not utilising the whole thing here.

So, what you do that you operate the first operation here. This is the first operation. For the next operation you mount everything here. For the third operation you mount everything here. Seeing that way you can actually spread around your workpiece, and you can do this particular operation very easily and very efficiently in work zone.

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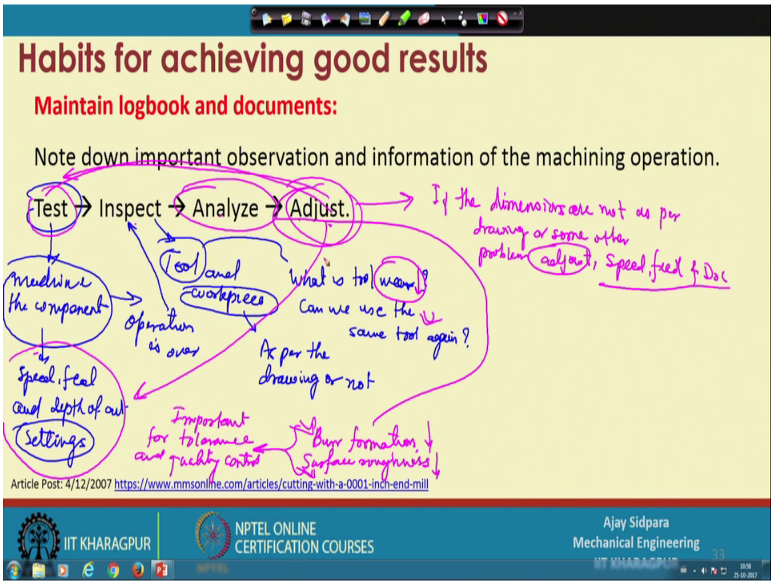

Now, maintain logbook and documents. Now we have seen here that we do not have any type of backup data. Backup data means, we do not have any type of standard rules regulation for speedy or finalizing the speed feed and depth of (Refer Time: 16:35) for a one particular tool, and workpiece combination. So, everything we are doing trial and error. So, once you do a operation. What is our thing that if the tool is not sustaining that particular reading. So, note down those thing. You note down those thing; that is the particular setting of the parameter which is not workable. Do the second reading, if it is not, again note down those things. So, in that way you can actually create your own rule based data.

So, next time after one month or after one year you have. So, many data and you can you do not need to spend more time in the trial and error. So, in that way you can get the required data set ready for your machine, as well as for your operation. And you can get the required done very easily. You do not need to spend more time on the rejected components, or you can actually expedite the products at that, because once you know that this is the particular tool and workpiece condition or the material, and you have spent lot of time and energy in finding out the optimum parameter.

So, without spending or without wasting any time, you can directly said those optimum parameter and you can do work done very easily without any type of problems. So, this is more important; that is important in the micro machining zone, because we do not have any backup datas. So, note down important observation information of the machining operation. So, this will create a very long lasting list, and that will be a resource book for the other people also, who are also working in the same field.

Now how it work that first you test the component; that means, you machine the component, component you do machining, find out what are those speed feed and depth of cut feed, and depth of cut setting. So, note down those settings, and once operation is over, then you inspect the component, inspect what you have to inspect. You have to inspect tool and workpiece, because workpiece is important. We want to see that whether it is a as per the drawing or not, as per the drawing or not. And for tool what you have to understand that, what is tool wear can we use the same tool again. So, this thing you have to inspect in this case. So, once this part is over, then what you have to do. You have to analyze the things. What you have to analyze that you have to analyse burr formation.

Then surface roughness, because this parameters are also important to find out the quality components for tolerance and quality control. So, you have to analyze everything. Now you have to find out what is the tool wear; that is the inspection is done with the tool and workpiece, then you have to find out everything about the workpiece that what is the condition, whether this workpiece can be directly used for the operation or you have to do some deburring operation, or surface finishing operation here.

Now once everything is over and by chance you are finding something the tool wear is very high then, next operation is the adjustment. So, what you have to do. Adjustment, that everything is adjustment. You can do with this particular parameter, because this are the parameter which you are setting and our objective is to do not burr formation, should not be very less and surface finish should also be less. Tool wear should also be less, and the this if it is tool wear less this you can; obviously, use it and then you can get the required dimension.

So, if the dimension are not as per drawing or some other problem, adjust speed feed and depth of cut to some other value, then those. This is the one particular complete cycle in this case. So, if everything is working fine, then you can find out that this is one particular set of process, para process setting, which is working good for this location. If it is not working, find out what is the problem here in adjustment, and then do adjustment in terms of speed feed in depth of cut. Again do the same inspection, analyze and adjustment in that particular cycle. You can find out all the things which are very important in this particular field. So, this particular operation; that means, where, what you do you maintain the log book, whether it is workable, not workable, what are the problems. So, in that case, it is important to understand this particular thing, and this habits will give you a good result or longer time. It will be very useful in the operation also.

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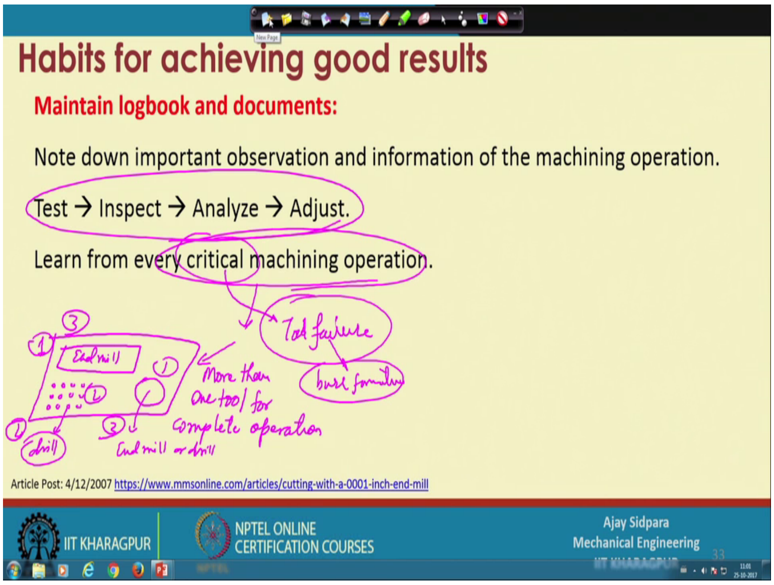

Learn from every critical machining operation. Now we know that we have many things to be done here, there suppose your workpiece is here, and you want to create some pocket here. You want to do drilling here also, and then what you have to do. You have to create some type of arrays also, here also right. So, here you are using more than one tool at a time. So, here we are using more than one tool for complete operation. So, here you are using an end mill. Here you have a option, if the size is very big then you can use an end mill or drill

Or here you are using drill right. So, once you do this thing first, you have to finalize that in which sequence you have to use that, whether it is a first thing is this, second is this, and third one is this, or you take the this one as a first, second and third. So, sequence is important, because that will tell you that how much processing time is required. Many times by just changing the part program, by changing the sequence of machining operation, you can save a lot time and resources also.

So, those things are important, and you have. Not only you have to find out the optimum parameter you have to look in to the part program; that means, how the tool is moving from one location to another location it will also take time, and a small time adjustment or time saving will also end up in the last saving at the end. So, that is important in this particular case. So, critical operation, critical operation; that means, mostly it is a tool failure.

So, tool failure is one of those things, which are very difficult to maintain. So, those are the tool failure is there, then the burr formation that we have discussed just now. And this are the things which are detrimental to the component or the tool. So, those things are critical. So, you have to find out the how to deal with this type of critical parameter and learn from everything, which is happening in the micro machining.

So, in this particular introduction, let us finish here. From the next class we will cover about the scaling law. So, what are the scaling law? So, scaling law will tell you about the system that once you complete a particular scaling down of the component. Suppose you have big milling machine, and you do not want to use that big milling machine, you want to scale down the machine itself, not required related to the component. So, what things you have to change there.

So, those things will tell you that, how things will change, when it will scale down at the lower side, or it scale down at the higher side. So, those things we will cover in to the scaling law lecture in the next class.

Thank you very much.