Introduction to Mechanical Micro Machining
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Lecture - 19
Difference between macro and micro machining (Contd.)

Good morning everybody. And let us continue discussion about the burr formation in the micro machining. In the last class you have seen that there are different ways we can deal with the burr formation, or how we can reduce the burr formation. And we have also seen that if the material is brittle, burr formation is different at different, different locations. And if it is a brita ductal material, then again, the burr formation is different. So, let us further continue in that. So, in the last class we have seen this thing that what are ways we can reduce the burr formation, but these things are not true for all the cases.

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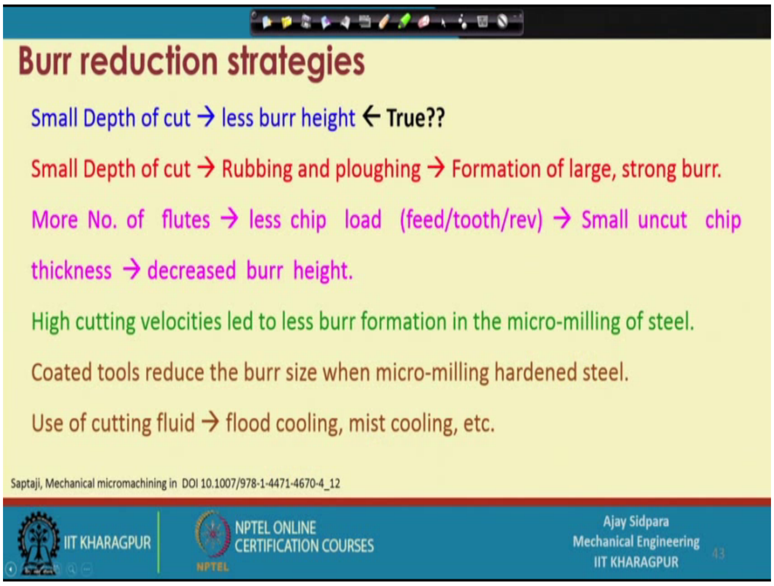

These are specific for specific strategies. And other than that, there are different ways we can reduce the thing.

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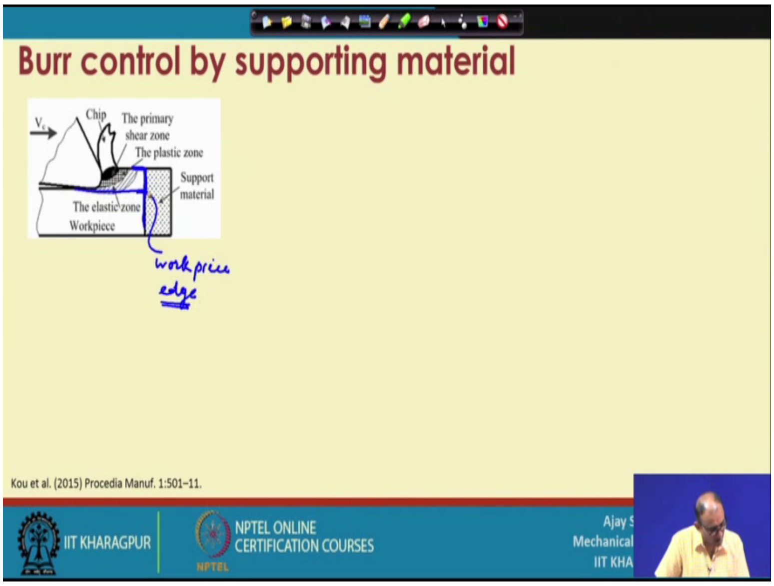

So, that is called the burr control by the supporting material. Because now we know that burr formation mostly occurs at the; this particular location. Hence at the edge of the parts this is the work piece edge, correct. So, when your tool is completely coming out of the workpiece you are this particular material will be actually located here in terms of the burr.

So now what we are doing here that; if we add one supporting material here which does not have any other role, then the just preventing the burr formation.

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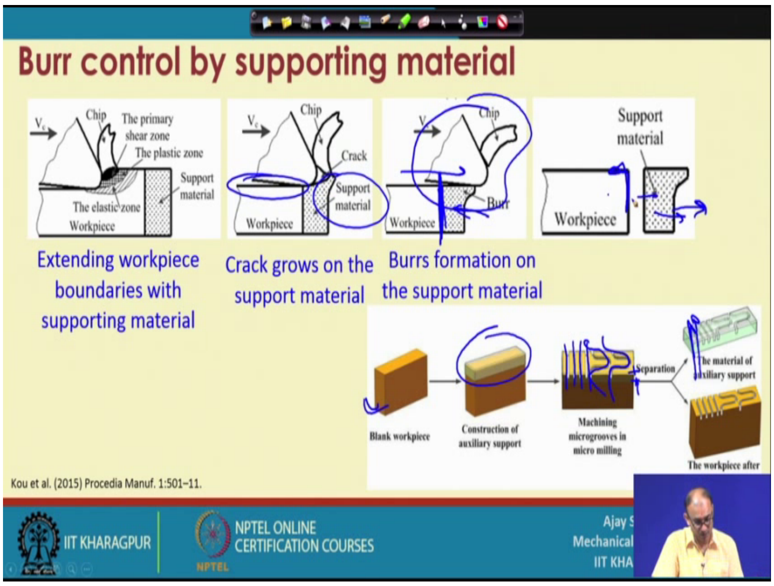

So, when you are putting the supporting material what is going to happen? Your tool will move here and burr formation will happens on the supporting material not to the workpiece material. So, let us see that thing here. So, this is the extending the workpiece boundary with the supporting material. So, we are extending that boundary. So, if you continue this thing you your cut chip will be like this. So, this is the chip of the workpiece. And again, this particular supporting material will be extended in terms of the burr formation.

And when it leaves from here at that time there is a burr on the supporting material, but we know that we do not have any functional requirement from the supporting material. So, at the end what we are doing that we are separating this supporting material. So, what we are getting here that we are getting a burr free surface from the exit side. Not from the entry side entry side. Also, you can do same thing that you put the supporting material. So, it will reduce the burr for or it will complete eliminate also in many cases that burr format at the entry side and the exit side, but now still there is one thing which is left that is the top burr. Because still we are machining at this location and it may happen that it will create a top burr formation. So, let us see that how we can reduce the top burr formation right.

So, same thing we can do here; that this is your workpiece material blank material where you want to do? Then what we are doing that when you are adding the supporting material from the side we add the supporting material on the top correct. So now, again you do the same machining operation. So, we are cutting a slot here 1 2 3 4 and then we are cutting one other than the straight slot. So, these are the 2 slots and once this machining is over what we are doing? That we are removing this supporting material from this part. So, your top burr formation is also reduced.

But now that depends on what is the thickness of this particular supporting material, which way you are grooving this material because ultimately this both this particular supporting material workpiece will come into contact with the highly high rotation of the workpiece. So, whenever there is a relative motion between the workpiece tool and the supporting material that is a chance of delaminating this supporting material. So, you have to find out that which particular mechanism you are using for grooving or supo fixing this supporting material to the workpiece, and once the material is machining is over then it should remove without pro creating problem to the workpiece ,ecause many times what happened that you do not want to remove this particular supporting meterial during machining. So, you are putting very, very hard contact between these 2; that means, you are sticking this workpiece and the supporting material with whatever the possible way it is high.

But at the end what is going to happen that you have to remove this particular part out. So, if the sticking you are very, very sure about the high thing; that means, you can comfortably remove the material, but the end your objective is to remove the supporting material also. So, if so, you to maintain a particular stickiness of this holding force in such a way that during machining it should not create any problem, but once the machining is over at that time it should be very easy to remove this part. So, if it is firmly stick to the workpiece material then removal is again problem. And if you apply more force in removing this part then it may damage the workpiece surface also.

So, in this is the one of the ways of controlling the burr by adding a supporting material from both the side entry side exit side, and if your machining from the top and you want to avoid the top burr formation, then you can add this particular auxiliary material or support material from the top also, correct? So now, coming to deburring.

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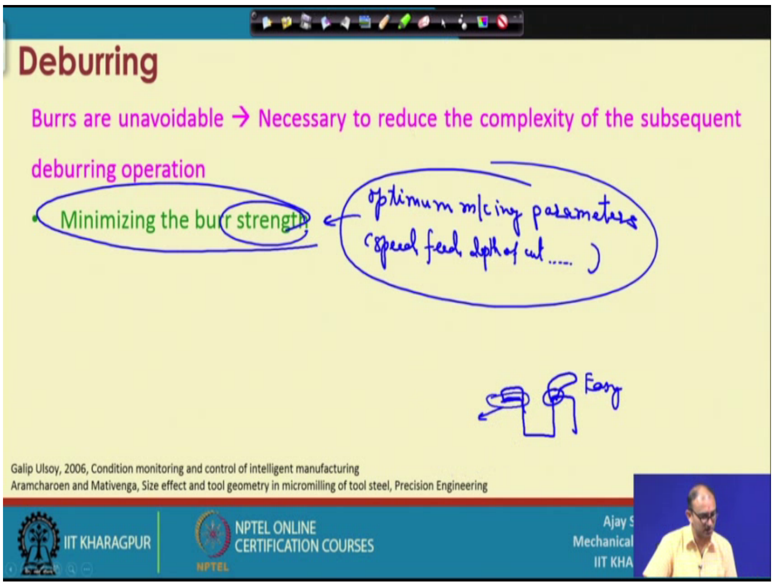

So, earlier case was the how you can reduce the burr formation and you control. But in some cases what will happened? The poo applying of this particular supporting material may not be a right strategy or it is very difficult also. So, what we have to do? That ultimately, we have to apply one deburring operation. So, what is the deburring operation in this case that you know that burrs are unavoidable. So, it is necessary to reduce the complexity of the subsequent burr for deburring operation w which we can do that that first is a minimizing of the burr strength.

So, how you can reduce that burr strength that; that means, you have to set the optimum process parameter, optimum machining parameter; that is, speed depth of cut and these are the main there are many auxiliary you whether you are using coolant or not, then how many cut, how many flouts of cutter you are using see it is a 2 flout cutter, 4 flouts cutter like that and other than that what is the machine specifications. So, those things are also play important role. So, by mostly if you maintain this particular 3 parameter you can actually minimize the burr formation. Strength of this burr formation; that means, suppose this is your workpiece, correct? And your burr form is here.

So, this is your burr formation. So, actually what is going to happen that this is the only location where burr is at edge with the workpiece surface, correct? And there is another way that this burr is form something like this. So, this is the location of the attachment. So, if you reduce this particular thing, that at which location it is touching the surface; that means, from where how much if the area which is welded with the workpiece surface. If you reduce it; that means, you are reducing the strength of the burr.

So, here it is very easy to rem remove material or remove burr, but here it is difficult because the contact area is large. So, in that case you can reduce the burr strength. Or ensure the burrs ensuring the burr form at the workpiece location that are easy to access.

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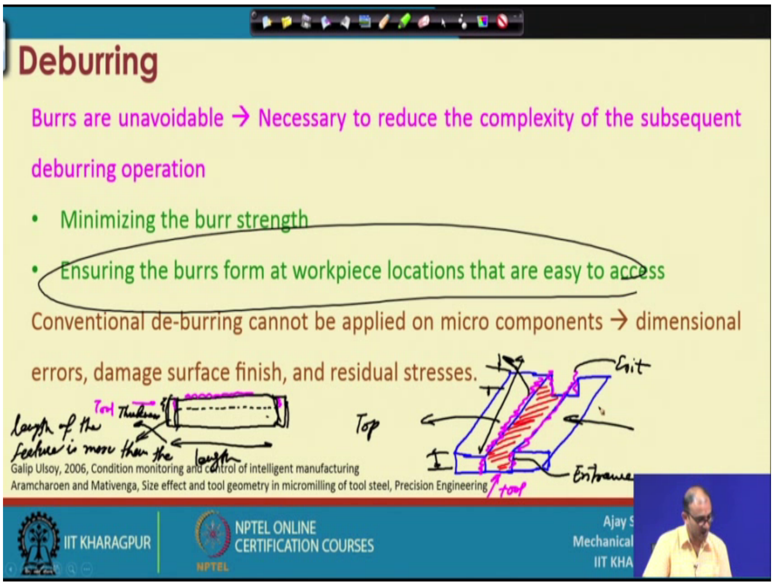

So, what does it mean that, if when you are looking for these let us see again this thing first. Now let us do that we want to cut a channel. Let me draw it again.

This is the channel which you want to cut. So, this is the channel. Now we know there are different ways of formation of the burr. So, burr formation are something as these are the burr formation. So, these are the top burrs these are the entrance burr if your tool is moving from here. And this are the exit burrs correct. So, these are the top burrs, these are the entrance burr, and these are the exit burrs, correct?

So now once part is over; that means, you have machine this complete part and your end up with the burr formation. Now what is going to happen, that if you are one if you want to remove this entrance burr and exit burr these are very easy to remove. Now why it is easy to remove? Because now consider you are looking from this particular side. So, this is your workpiece, and this is your cut depth of that particular hole, and you have some burr formation on the top. So, let us add those burr formation here. So, these are the top burr formation, these are this is the entry of the tool. So, this is the entrance burr and this is the exit burr.

Now, what is happening that you can easily remove this burrs compared to the top burr formation. Because when you are looking at this particular thing, because you know that you have some functional requirement with the depth of this channel. Length of the channel you can maintain that you can increase the little bit length of this particular part, and then what is you are going to do the let us increase little bit this particular thing. So, burr formation will be here at this location, and at this location. And then you apply some of the deburring operation from this side. So, that is basically you can do by the EDM also. You can do by some type of polishing operation, lathing operation that is easy to remove or you can easily adjust the length. But when you are doing operation on the top surface what is going to happen? You can it is very difficult to maintain this particular thickness throughout the surface. Because mostly we end up with the surface where the length of the workpiece is more, length of the feature let us write feature is more than the thickness, correct? So, here what is happening your thickness is very, very less of whatever features we want to create, but we have more length in this case.

So, whatever is the problem is that if thickness is less then it is difficult to maintain that thickness throughout the component if you are applying the same deburring operation or the lathing operation or any type of other deburring or polishing operation. So, it may actually damage the thickness here. Whatever even one percent of change in this particular thickness is sometimes create a problem and the function requirement, but if you work with the length compensation, then it is easy that you can easily remove the length because one percent is equivalent is very, very small compare to the depth of this particular part.

So, you have to ensure that you reduce the top burr formation. Entry and exit can be removed very easily comparing we have seen also that there are 2 different ways where we can stick the surface from the entrance side and the exty exit side by the auxiliary material. But we have seen that when you have using the same auxiliary material from the top, your contact area is very, very large. So, at that time removal of those auxiliary material is also very difficult, so better to avoid the top burr formation that will create a problem.

And we also know that conventional deburring cannot be applying the micro component, because our dimensions is also very, very small in this particular case. And the features which are created many features have some very, very delicate complex locations and that is difficult to come across this particular deburring operation. So, if you apply; what is problem going to happen. So, you have you do not have the dimensional control here.

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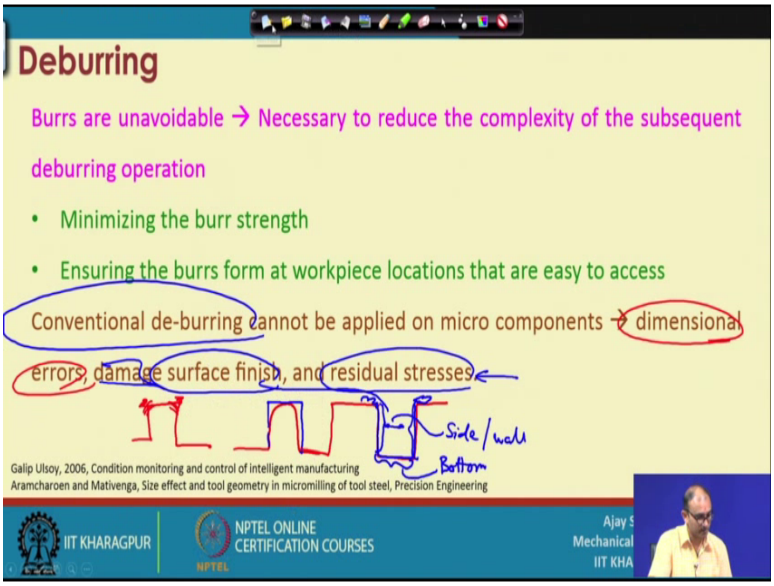

Because it may redu it may change the dimension, suppose you want a square pillar here at that time what is going to happen that if you have burr formation here, here, at that time if you apply burr formation what is going to happen that it may come in to this particular shape. Because wherever there is sharp edge your deburring operation remove those sharp edges, and instead of a exactly located surface. This is your requirement, and in this requirement, you are getting some type of additional removal. So, your dimensional features will be destroyed in this case, damage the surface finish now what is going to happen that our surface is here. Now this is the surface. Now when you are cutting a slot you have a 3, surfaces 2 surfaces. Let us write something like that. So, this are the side surfaces, it has 2 sides so, but we can tell that these are the same. So, this is the side of the wall. And this is the bottom, correct?

So, this has a feature. So, if you have maintained this features. So, maintain the surface finish whatever surface finish you want to achieve that is accepted, but you have some burr formation here. So, when you are removing this burr at that time sometimes what happened that your surface finish also degraded. Because ultimately you are using some type of physical process which will remove which will come into contact in terms of abrasive particle in terms of brush or in terms of different type of small balls.

So, at that time those particular things will interact with the finish component also finish location also and because of that it will reduce or it will damage the surface finish. And at the end it will generate the residual stress is also. Because why it is problematic because suppose you want to use this particular component for some type of sensing element. And if some residual stresses are there that that time it will not actually bend or it will not respond to the actuation compared to the stress-free surface.

So, these are the problem associated with the deburring of a micro component using a conventional deburring processes. So, we have to find out some other processes which are very gentle, gentle means the sense that it should not destroy or it should not damage the features which are already created. So, it will take some time, but it should not destroy those thing and then gently remove this burr formation.

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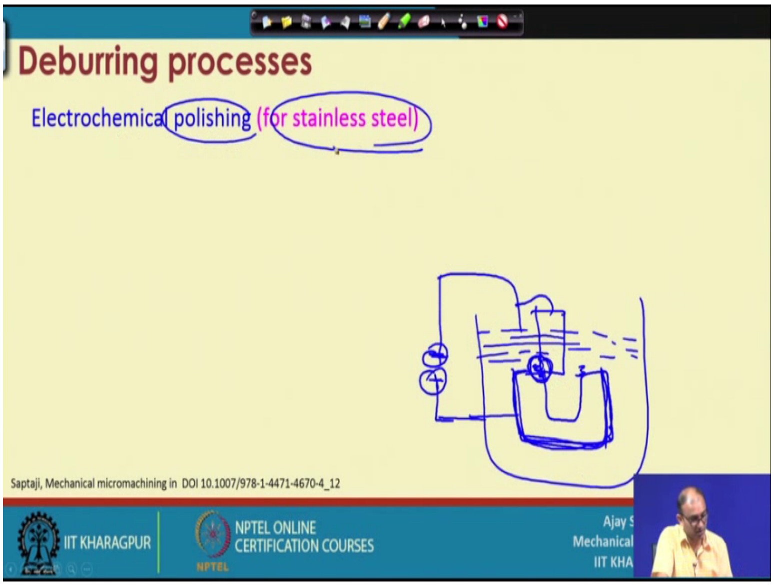

So, let us see that what are the thing the electrochemical polishing in one of those things, where what will happen you are not physically actually giving any type of what we can say that any type of forces. So, how is this thing will work? That you add one this is the workpiece and you have burr formation here, and this burr formation here, you put in electrolytic particular cell, and then you have to provide the voltage support. This is plus, this is minus. So now, what is going to happen, that when you put this type of electrolytic circuit, at that time this particular this particular electrolyte, it will actually attack the surface which has very, very high stress concentration. So, and the very, very small area available.

So, it will start attacking this particular surface, because this is the surface which is usually bond with the surface. And if you want to avoid electrolysis of this part then what you to do you have to play some coating here, because you want to you do not want to anything to anything happened to this particular surface, then it will attack this particular part. So, this is called electropolishing operation. Or what you can do that whatever you are adding this particular tool here, whatever tool you are aising adding here. So, these tool will actually target this location only. So, this is the way you can pursue you put this thing is a negative tool, and this small work this is a positive and then you do some type of machining. So, it leads to electrochemi it is similar to electrochemical machining operation where you are using a conductive environment for workpiece in the cutting tool.

So, that is mostly upon stainless steel. It is well proven in, but you can use for the other conducting material also.

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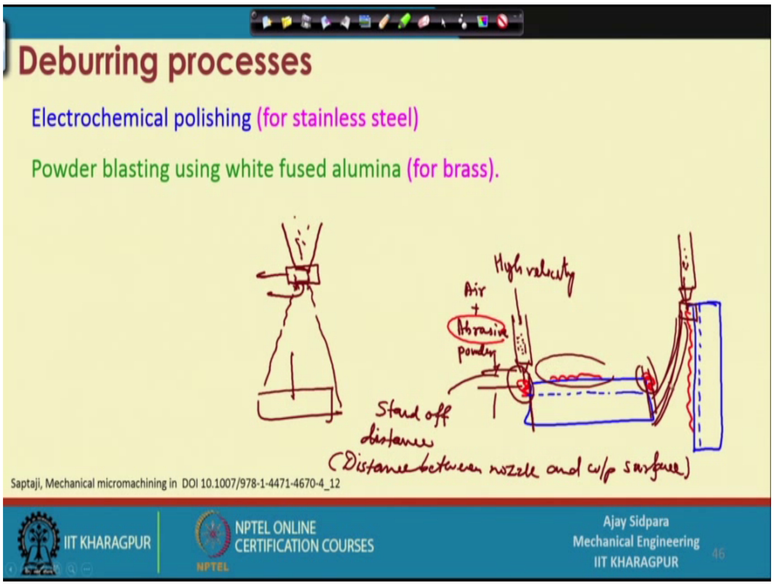

Then the powder blasting using white fused alumina for the brass material (Refer Time: 17:47) is similar to that suppose you have burr formation on that. Now you let us see that this is the workpiece, and you have some burr formation here at the end. Entry side and exit side then what we can do that we can actually apply one nozzle here. And some small, small particles are there, that are passing through a very, very high velocity. High velocity, air plus abrasive powder. What is going to happen? That when it is passing through it at that time it will strike with the surface and it may remove this whole part also. So, that is you can understand, that is very easy to remove this particular entry burr and the exit burr. So, same thing you can apply here, but if the same thing is happen here that suppose you have a burr formation at this location.

Now, if you apply in the same configuration, then what is going to happen that this particular whatever abrasive particles are there, those abrasive particle will stick to the surface. Because we know that we have this surface machine. And if you are putting something from the top, either it will damage this part completely or it may stick this particles at this location. So, what is the solution if you want to do this thing here? Then what you have to do you have to rotate this workpiece to the 90 degree.

So, keep this workpiece, this is correct? And this is your channel and these are your burrs, which are the top burr correct and then you apply the same thing here from the top. It is moving this by what is the problem? Here again so, this particular distance is creating a problem. So, this is called the standoff distance. So, that is the distance between the nozzle and workpiece surface. Because now what is going to happen let us just let us analyse this thing as a abrasive flow machining. So, this is your nozzle z, and this is the things and your workpiece is located here. So, what is going to happen that this particular abrasive particle is spread? So, whatever the zone is coming here that will spread in this location. And the velocity will reducing the worst as soon as even reach the surface.

So, what is going to happen the; you do not have dimension control? Only this particular region is there where the; you can expect that the diameter of this nozzle is same as the area which is going on which your; abrasive will strike this location. So, if this is the case what is going to happen at this location you may get a reasonable good amount of removal of this burrs, but as soon as it is passing through this location nothing is going to happen these all particle will be spread away in this. So, you can understand the removal of the top burr is difficult compared to the entrance burr and the exit burr, right.

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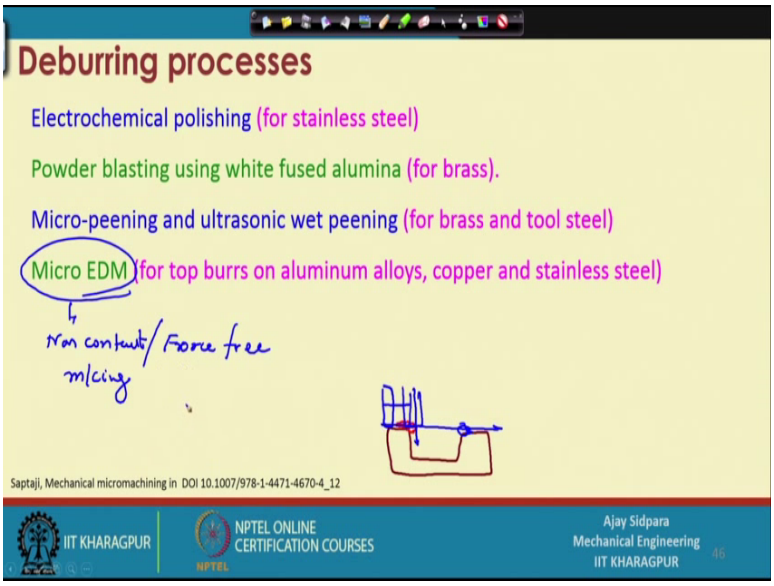

Micro peening and ultrasonic wet peening. So, this is also similar to blasting, but what you are doing here that particle size very, very small here. Instead of this high pressurise thing you are using a ultrasonic as a one of the assistance to give the energy to this particular micro particles. So, that it can actually vibrate and then it will strike to the surface. And these materials are efficiently mushy or deburred by this particular process. Micro EDM can be also use in this case similar to micro electrochemical machining or the polishing operation, because here also what we are doing? That we have a workpiece correct and we have burr formation here. So, this is the burr formation, then what we do that let us add one EDM tool here, then EDM tool will move in this direction.

So, it will remove this part, and then once it is reach here it will move little bit down. So, EDM will remove this. So, what is important here that you have to give a tool path in such a way that it should not destroy this particular feature, and then you can use the EDM for the top burr for the aluminium alloys and the copper and the stainless steel?

So, these are the different materials which are use successfully machine or deburred by EDM process. So now, whenever it is on the top burr, now what is going to happen that you just move this particular EDM tool in this direction; so whatever this burr formation everything will be removed because it is again called a force free machining. So, no non-contact or the force free machining, because this EDM tool and the workpiece is not coming in physical contact, but because of the melting and vaporization your material is being removed. So, that is also one of the advantages of using this particular tool.

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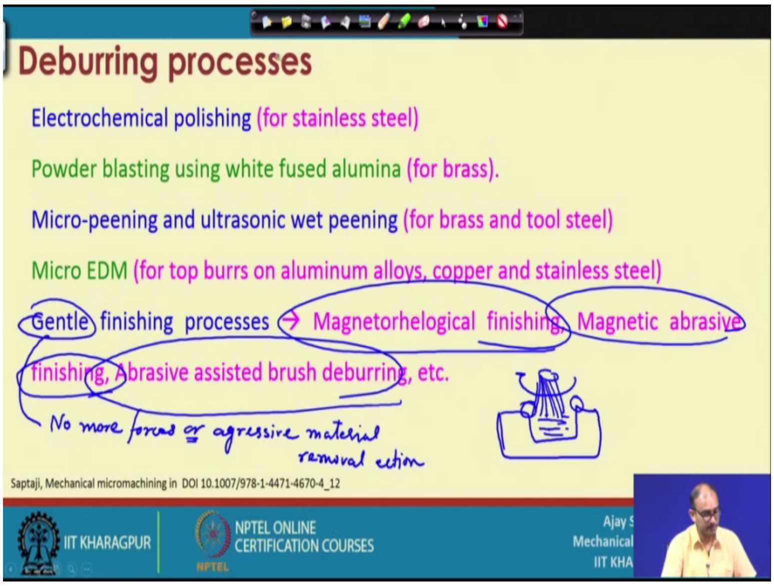

And then there are gentle finishing operation, because almost of this oh processes uses abrasive particle, but those are gentle, gentle in the sense that they are not applying much force is here, so no more forces or aggressive material removal action, correct? So, it is not applying so much force, but it will take little long time, but that is not a issue because here our objective is that workpiece should not be damage at all. So, these are the magnetorhelogical finishing is one of the process where an abrasive magnetic abrasive finishing of the deburring is also process. These are the processor which are successfully use for deburring of a micro component.

Then there is one thing is abrasive assisted brush deburring, then you put the abrasive and put some brush here. So, this is called; suppose you have one brush, right and this is your component. You put one abrasive slurry here at this location and then you rotate this brush at a high velocity. So, what is going to happen this particular bush will impart some velocity to this abrasive particles? And this velocity particle which strike to the all the surfaces, but you have to also make sure that this particular particle should not damage the features or the different surfaces of the machine component.

So, these are the different ways of doing deburring operations. So, this way we can actually work with the deburring the how we can reduce the things.

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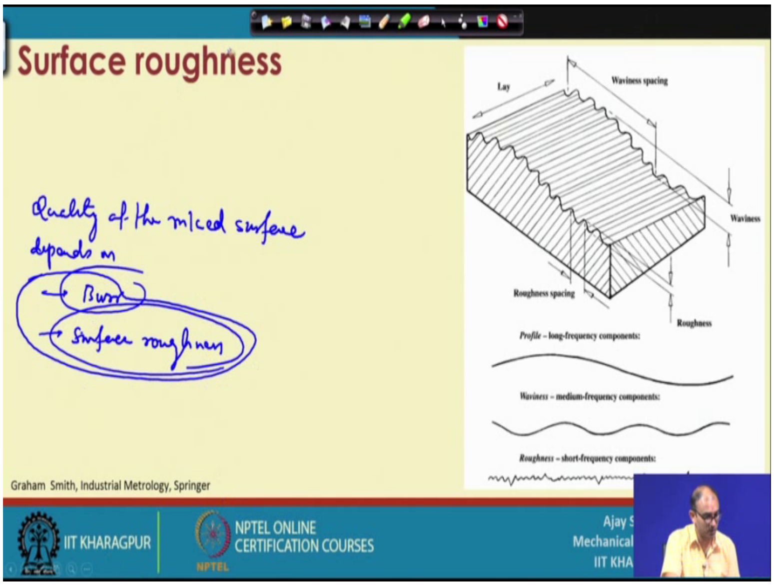

So, let us now talk to another aspect of the machine surface. That is called the surface roughness. Because earlier we have seen that one is the deburring burr formation another is the surface roughness this both the things are the output of the machine, right. So, quality of the machine surface depends on one is the burr formation and another is the surface roughness, correct? So, these are the 2 main because now once machining is over then you have to find out that what is the size of the component what you have design. So, burr formation creates problem and surface roughness also create a problem. Because these 2 things are very, very important to analyse.

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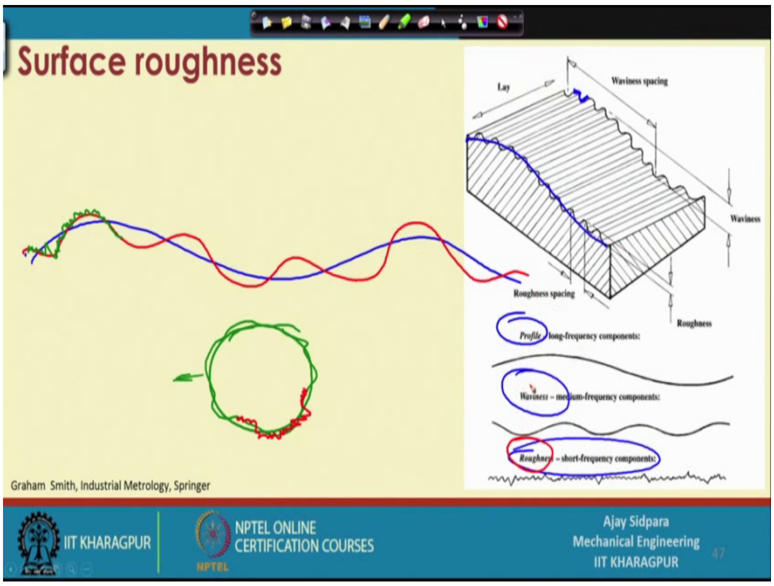

So, what is the surface here? So, this is one surface. And what this particular thing? So, this surface has many, many different artefacts. So, first thing is this particular profile. If you see this thing, this is the profile. So, this is called profile that is called long frequency component, because if you see it has a frequency something like this, correct? And now another thing is a medium frequency. Be instead of medium frequency let us see something about the last one that is called roughness frequency. So, if you see this waviness here on this waviness if you find a small, small aspirates. So, this is called roughness; so if out of these particular things now coming to the medium frequency.

So, when you are looking this particular part. So, this is the first thing and this one is the waviness is the another thing. So, this particular things what is going to happen? That you are an entering in this particular part. So, this is the waviness, correct? And third one is the roughness. So, what we are talking about. So, this is the roughness. So, these are this is called short frequency. So, your frequency this is the first frequency, you can say this frequency at is vary another is a medium frequency that is in between these 2 and this is the short frequency.

So, what is our important thing here? Suppose you are looking at the cylindrical components, and then this is called the profile, right? And if you are talking about the waviness suppose, if it has some dimensional problem then it has some type of waviness of something like this, correct? So, this is called waviness and if you are looking at the smaller scale at this particular location then there are small amount of vibration or that is the unevenness. So, that is called the roughness; so old component save these 3 comp all different type of machine component this 3 particular artefact of the surface roughness.

So, we will see about this detail that what things are there and how this thing will affect the surface in the next class. So, let us finish this lecture here, and this surface roughness component we will continue in the next class.

Thank you very much.