Introduction to Abrasive Machining and Finishing processes

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Lecture – 11
Conventional Abrasive Processes

Now we are studying the Conventional Abrasives Processes.

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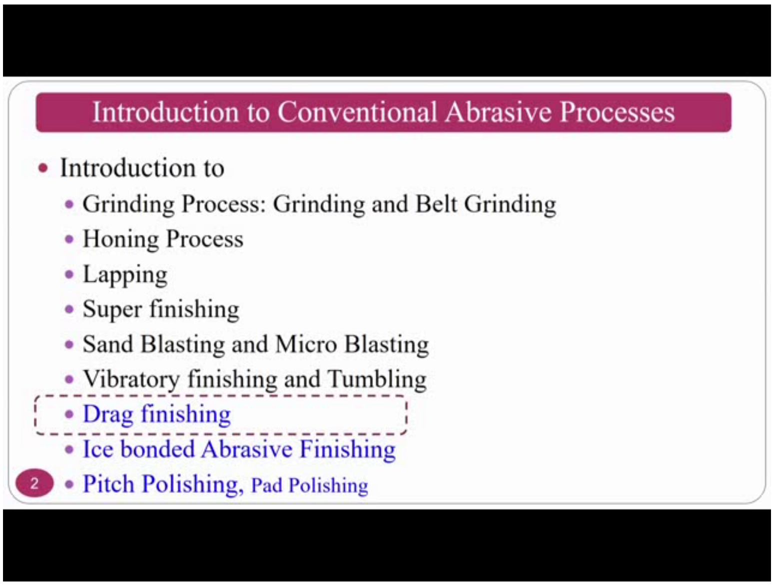

Where in we have seen the grinding process Honing Process, Lapping, Super finishing, Sand Blasting, Micro Blasting, Vibratory finishing and Tumbling Processes, we have seen.

Now we move on to the Drag finishing followed by Ice Bonded Abrasive Finishing, pitch polishing and pad polishing. These are the some of the varieties of the Conventional Abrasive Processes. You will see this processes slightly some of the things I may explain you in these some of the things I may explain you only introduction about this processes.

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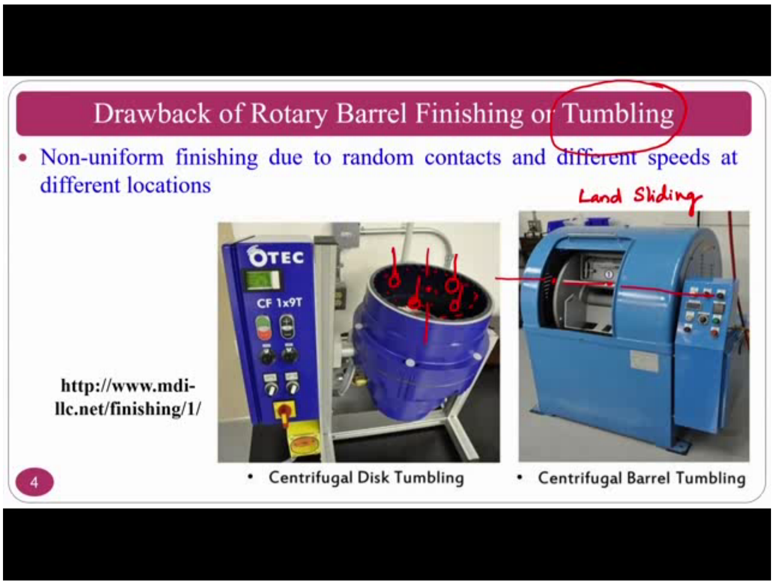

So, Drag finishing, in the drag finishing before going to that you should know what is the drawback of the process that you have seen in the previous class. So, in the previous slides, if you see the tumbling process, ok? In the tumbling process, the basic drawback is there are 2 varieties of tumbling process I said these 2 have certain problems. So, before going to it, we will see, what is the problem. If you see the axis of this one, this is the axis.

So, vertical axis, it will rotate about horizontal axis. You have seen in the, in the horizontal axis, there is a Land Sliding mechanism. Whenever you just put the parts as well as abrasive particles inside, whenever you rotate about its original horizontal axis what will happened, the finishing action will take place by, by the land sliding action?

So, in the vertical also the similarly what will happen? If you rotate in a vertical axis so, the abrasive particles and implants or the components which are there will rotate and the shearing of the peaks will takes place and there is a chance of burnishing. Also the abrasive particles will continuously heat or shear there has 2 mechanisms, one can shear another can the burnish; that means that it will deform the surface peaks.

But if you see the basic drawback of this particular process. If you see in the vertical 1, I will explain you in the vertical process. So, the abrasive particles assume that my implant 1 implant is here about this is what is the axis. Another implant is assume that it is here. So, in this circumstances the abrasive particles assume that it is uniformly a distributed.

So, the distance object 1 and object 2 covers will be, this is radius whatever it cover, this will be the radius whatever it cover; that means, that number of abrasive particles cover by the component 1 that is assume that this is C 1 and the C 2. So, component 1 will be very high compared two component 2; that means, that the finishing action taken on the component 1 will be better compared to the component 2. In that circumstances how to overcome this tumbling process.

In this process if at all I want to modify it then what one can do is you can go for the mechanism where in you can have local rotations are local component holders so, that you can do the finishing process uniformly on this components.

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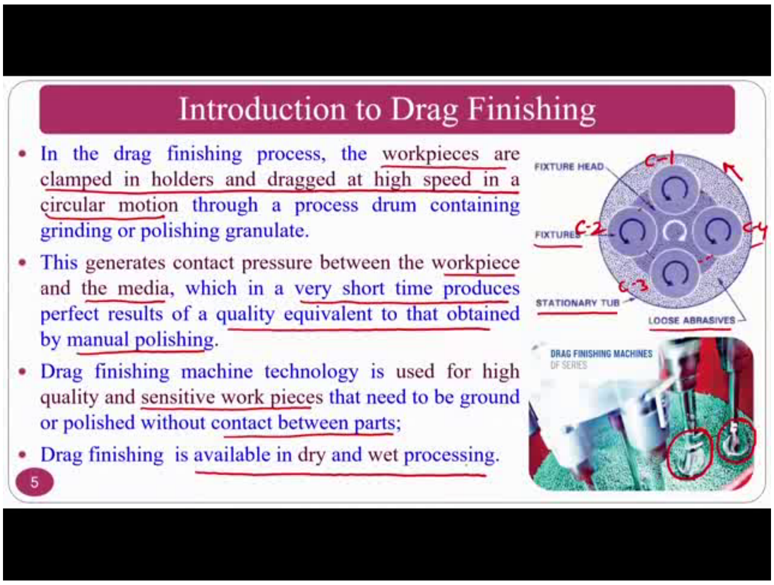

So, that process is nothing, but drag finishing process. If you see the drag finishing process, you are holding the implant or you are holding the component. Assume that my component is here and at the same time my component is here and this components also assume that my component is held like this, assume that knee implant for the this one, this will be also rotated at the same time the bowl is also rotated.

So, abrasive particles will have a relative motion between these 2 and approximately you will get a good surface finish compare to tumbling process that because you are controlling locally in a tumbling process what is, is happening is it is a global process. So, you are placing at once the a components and you are putting the abrasive particles then you are rotating it.

So, the particles are the components which are there at the center will have slightly less dynamic compared to the component which are there on the periphery of the tumbler, ok? In that circumstances to overcome this one instead of global we have converted into the local one so, that you can do a better surface finishing operation on this one. Assume that if you see here stationary tub is there, loose abrasive particles are there and pictures which you are holding the component and picture heads is there under top.

If you are rotating all if you see all are at the same pitch circle all the components are located at the pitch circle. So, all are rotated by keeping the abrasive particles, stationary or you can also give the abrasive particles also motion by giving even stationary tub. You can also give the rotary motion to the stationary tub also, but in this particular slide whatever you are seeing is your tub is stationary and your components are rotating.

So, this will give you better surface finish compared to your tumbling process that is the advantage of this particular process compared to your tumbling process the drag finishing process the work pieces are clamped to the holders and dragged at the high speed in a circular motion through which process drum containing a grinding are a polishing granules; that means, that abrasive particles are there in a tub wherein you have placed a holder or a fixture of abrasive, fixture of the component and you are rotating it rotating it uniformly all the things so, that you will get a uniform surface finish.

If you are going to rotate the tub also in this case if the stationary tub is also rotated then also there will be a chance of non uniformness until unless if you do not maintain this pitch circle, ok.

So, you should, if you can if you want uniform surface you can go for a stationary and rotate the components. This generate contact pressure between workpiece and the media; that means, that abrasive media in which in a very short time procedures perfectly results in the quality equivalent that are obtained in manual polishing process. These are all automatically polished things.

So, if at all you want to polish this whatever you are seeing here these are the knee implants that are fabricated by SS 3 1 6 cell are titanium are some other materials. Normally if what all you want to do you can go for manual polishing also, hand polishing or something for that.

In order to avoid this, what will happen you can go for automatic machines in a polishing, hand polishing what will happen if you are happy today you do the proper. If the operator is not happy tomorrow what will happen. So, the emotions also play a major role on the polishing action.

I am not saying the always or something then there will be a change in the nano level. In micro level it may not have much, much difference, but if the operator is not happy or if the pad is not proper or if the fluid is not proper or something many conditions will come, there may be a human errors will come into picture, ok.

So, to avoid human errors automatic systems will give the better surfaces. The drag finishing machine technology used for high quality and sensitive work pieces like sensitive work pieces like a knee implant hippie implant and other things and which need to be ground or polished without any contact between the parts.

This advantage here is your parts are fixed ok? So, your components are if you see here component 1, component 2 component 3 component 4 these are all fixed. So, there will not be any contact between the components, ok.

Among the components there will not be any hitting or any damaging and all those things in, in the tumbling process what will happen all are place. So, there will be heavy chance that the components will collide each other, this is also one of the drawback of the tumbling process that you can overcome in the drag finishing process.

The drag finishing process is available in dry and wet processing; that means that you can do this particular process using a dry type of abrasives or wet type of abrasives also.

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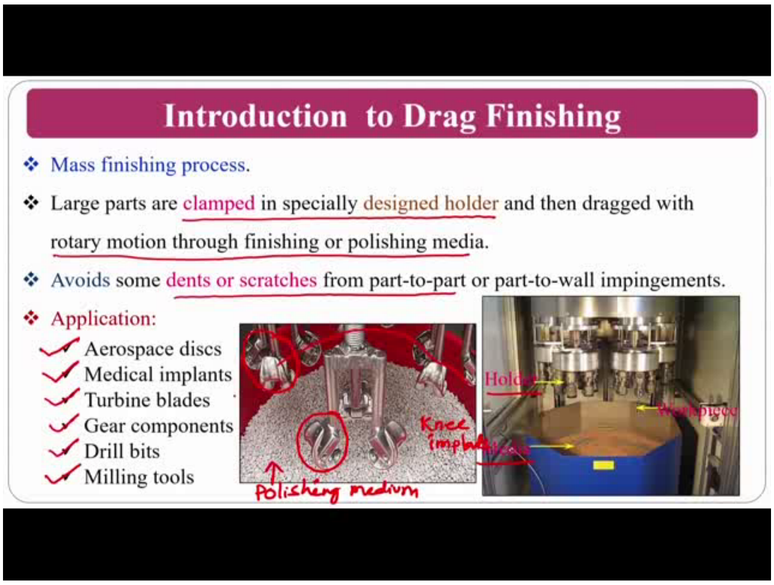

So, this is the if you see this is the mass finishing process such as tumbling process. And if you see the large point components are clamped specifically design holder and then dragged in a rotary motion through the finishing of polishing media.

So, this is the polishing media, this is the polishing media and these are the knee implant, implants.

So, you can see here also media is there holders are there and in these circumstances you should always keep your polishing media stationary. If you keep stationary because some of the components are in this periphery, some of the components are in this periphery thus the pitch circle is very less.

So, if you can give the same rotational speed in that circumstances what will happen? If you keep the medium or the polishing medium constant are without rotation what will happen all the components will get uniform surface roughness.

So, it avoid dents and scratches from part to part are the part wall to This also have another advantage that in the previous tumbling process the abrasives and the components will also hit the surface. Assume that in this case my component is here.

Assume that my component is here, there is no chance that it will hit the, this particular surface, this is a surface, ok. There is no chance, at the same time this components also there, but these are all looks like they are near to the surface wall of the drag finishing process, but it is not so, ok; that means, at the same time, we can even see the wall is also here also it is made up of polyurethane polymers. So, that if it is hit also nothing will happen.

So, but better condition is that it should not hit for that purpose they will maintain certain distance from the wall, ok. What are the applications of this particular process? If you see the applications of this process, it can use aerospace industries, medical implants, basically whatever you are seeing is a medical implant. You can use for the turbine blades in the aviation industry and the gear components in automobile or aviation or many, many places wherever the gear components are used.

You can also use the drill bits because drill bits have flutes which contours are completely different from tool to tool and other things at the same time, you can also use for the milling tools milling tools also will have some helical nature and other things.

So, in order to finish look and corner of these complex surfaces you can go for the Drag finishing operation.

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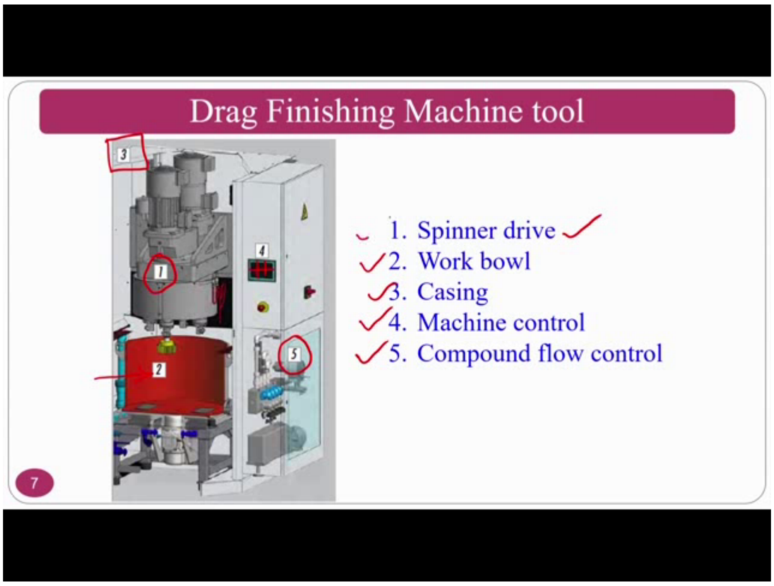

If you see the drag finishing operation, normally if you can hold it is a spinner drive, one is a spinner drive normally you can see the spinner drive and working bowl, this is the working bowl 2, the third one is complete casing and the fourth one is a machine control normally whatever you want to do the control like switch on what is the speed that I want to give. And what at what RPM I want to rotate the component at what RPM I want to rotate the medium and other things.

Compound flow control is another one. So, wherever compound is nothing, but abrasives and wet compound are a dry compound wherever the component what you want to use, you can use in this particular drag finishing process.

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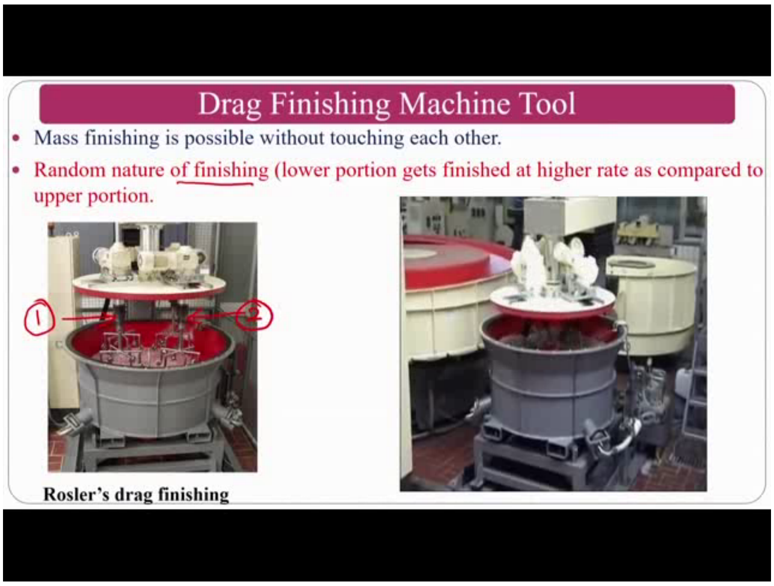

If you see in this one which is a mass finishing and random nature of the finishing, lower portion gets higher rates and all those things this can be overcome by this drag finishing. As you can see here implants are, a set of implants are held here, you know I am just giving you 1 and 2 3 4 also there. So, you can rotate about its own axis. So, that the your components are finished.

If you see the video, the continuously the abrasive particles are interacting and you can see the zoomed version also how the abrasive particles are interacting with respect to the implant.

This implants are continuously rotated by the motors which are there on top, you can see the motors are there on the top and these are rotated so, that the abrasives which are there will are the this may be a bonded abrasives these may be a unbounded abrasives and other things.

So, like this the components critical components like milling cutter, knee implants drilling cutters are many other aerospace turbines and other things can be finished using the drag finishing operation.

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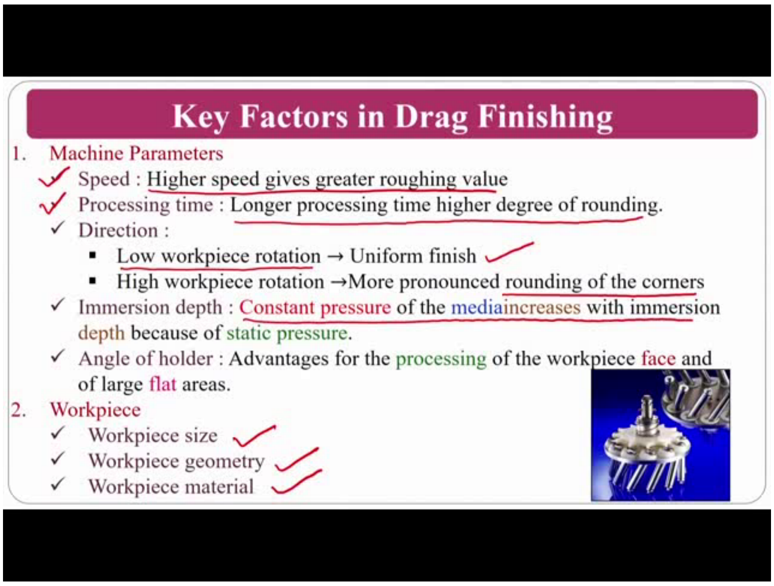

The mission parameters if you see which is nothing, but the speed, high speed gives the greater surface roughness value; that means, that if you are using a very high speed normally surface roughness may be very high, but because interaction force will be very high. At the same time processing time if the processing time is large then high degree of roundness will be there; that means that if at all I want to generate a roundness. Assume that there is a very sharp edge is there which I do not want as if this is the thing where the sharp edge is there assume.

So, if I want to hold it for a certain operation then it will heart to the hand. So, I need to give some roundness to this type of cutting edges ok. So, these sharp edges to be round for that purpose if I at all I want to go you can it should always use the higher processing time; that means, that higher finishing time and the directions. Lower piece rotation normally you will get a uniform surface finishing and the high work piece rotation more pronounced rounding of the corners if at all I want to use for low work piece rotation then you will get a uniform surface roughness. If at all I want to go for high workpiece rotation then the interaction at the edges because edge is sharped.

If this is the edge so, the surface area is very high here compared to the lower portion. The surface area, if I just do the sectioning I am just explaining what one picture this here it is prone to give radiacy rather than here the material is very high. So, that is a problem with this one.

So, if we what all your requirement is roundness then you have to go for the high workpiece rotation immersion depth, constant pressure of the media increases with the immersion depth because of the static pressure. So, you can go for immersion depth different immersion depths if at all I have a set of components where I want uniform surface roughness.

Then your immersion depth should be constant angular folder you have seen the vertical type of motion or vertical type of holding you can also give certain angles depend on your shapes of your components, the workpiece workpiece size plays a major role workpiece geometry and workpiece material. Normally if the size of the workpiece is high what will happen finishing time will takes place a finishing time will be high.

At the same time geometry is complicated then reaching to nuke and corner of the complexity or the complex shape will be will take more time. In that circumstances it also take more time, at the same time workpiece material if the workpiece material is harder workpiece material then the finishing time will takes place more. If the finishing time if you want to less same, you can go for softer type of workpiece material.

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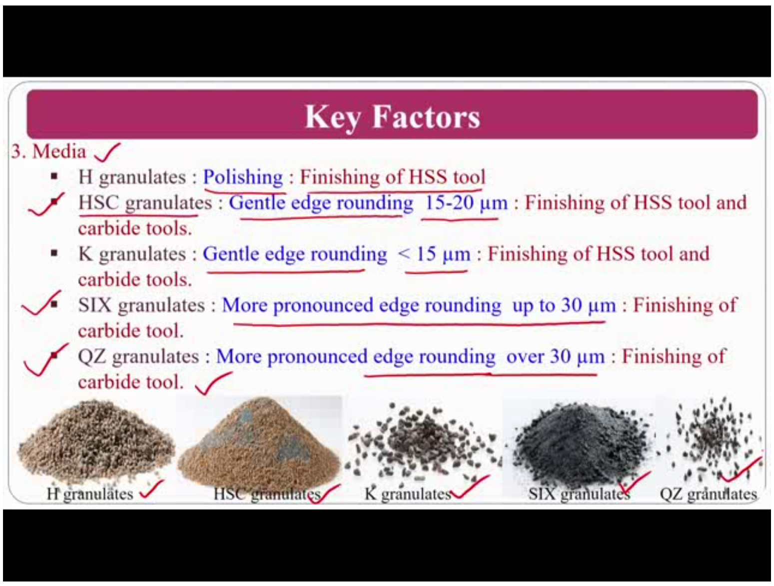

The key factors the other one is media H granules normally polishing and finishing of HSS tool you can use, HSC granulates the gentle edge rounding normally 15 to 20 microns finishing of HSS tool carbide tools will be used here and K type of granules gentle edge rounding process will be used and at the same time you can achieve less than 15 microns finishing of HSS tool 6 granules and QG granules these are the other type of granules where if you what all you want to have the more pronounced edge rounding up to 30 microns that is roundness, radius of the curvature that you want finishing of the carbide tools and other things you can go for 6 granules QZ granules are more pronounced for edge rounding over 30 microns finishing of carbide tools you can useok.

We can see the H type of granules HC granules K granules 6 granules and QZ granules are these type of granules that we can use for this type of drag finishing applications.

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The first application that normally people look at it is deburring operation. As you can see residual burring are swarf from the manufacturing process on the edge surface impair the workpiece quality. Basically existing of the burrs if you see the figure 1 and I am just dividing it this is figure 2. In figure one if you clearly see there are burrs on the surface, there are burrs on the surface.

So, if you what all you want to see here just I will show you this type of protrusions are there here, if you see just I will delete it these things. Again if you see here, you can clearly see that there are some burrs. Especially in the region of this region you can clearly see in this region the burrs. These burrs impair the quality of the component or if at all you want to put this particular component in the practical application these burrs ampere the performance of this particular component.

So, by choosing the right media you can do the drag finishing operation and you can clearly see in the figure number two how these burrs are removed? So, if you see the surface it is properly finished and this is the beauty about the drag finishing process if, if you want to use drag finishing. So, all these burrs are finished using the drag finishing process the removing of burrs a from a existing component; that means, that pre machine, assume that in this condition people might have use the milling cutter because what I am because there is a scratch marks like this.

So, are the feed marks are like this, this looks like it is a milling process are any material removal process, which comes are hampered. Some of the edges remain the un removed material will be stayed there that is called burr and these burrs are removed by using the drag finishing process.

Now, if at all you want to use the component figure 1component if you use the for performance and figure 2 also if you use what will happen figure 2 component which is there in figure 2 will give you good performance compare to figure 1 because you have properly done the deburring operation.

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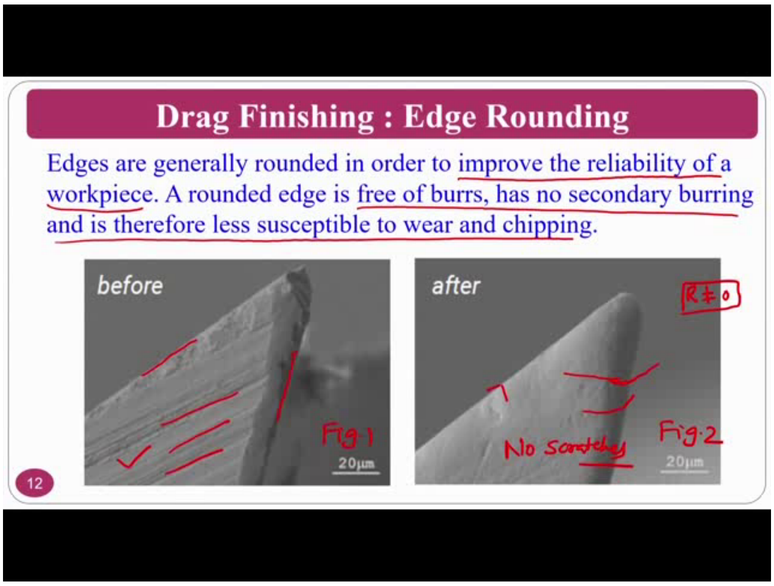

Drag finishing operation also uses for the edge rounding. Edge just are gently rounded in order to improve the reliability of the workpiece ok. In order to improve the reliability of the workpiece, if at all I want to use this figure 1 and figure 2.

If you see here figure 1 has lot of scratches at the same time lot of burrs and the surface roughness of this particle surface is also very poor. So, rounded of edge free burrs has secondary burring and therefore, less susceptible to wear and chipping; that means, that if you are going to use figure this particular component what will happen. ?

This will have higher wear rates in a practical at the same time this edge is very sharp and this is the edge which is very sharp and at the same time this is also edge is very sharp, whenever you use in particular condition or particular practical application this edge will just cut off as early as possible; that means, that catastrophic failure may takes place for that purpose in order to avoid that two things that is edge rounding can be done assume that you can see here edge rounding is done. At the same time you have removed all the scratches which are there on the surface these are the scratches are there no scratches are there. So, that is a beauty.

At the same time if you see the, what is a people sometimes this is also called as a edge radiasing also. Some of the applications like cutting tool and other places, you require sharp edges obviously, but normally nothing in this called is hundred percent sharp, it is cannot be hundred percent sharp. So, for that purpose you will always will have a sharpness radius that is nothing, but wherever 2 surfaces are going to meet, those will have certain radius that is nothing, but the sharpness radius, always this sharpness radius never be a 0 or something ok.

So, it will always will have certain value if the sharp less radius is increases, increases in cutting edge what will happen then there will be a problem you should have always choose certain sharpness radius.

This whatever I am talking about the cutting tool sharpness radiation and other things are nothing to do with this particular site, but this particular thing the drag finishing here that is edge rounding and other things is most important from the handling of the component. If you want to handle figure number 1 then you make hurt your hand if you want to handle figure 2 you will have a very smooth surface. So, there will not be any hurting of your hand or any, any damage to the operator.

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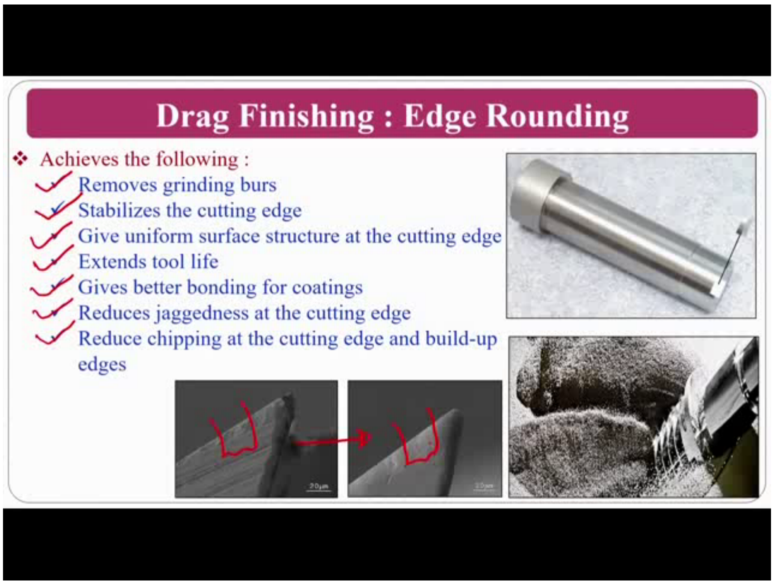

So, drag finishing again if you see the edge rounding. So, it removes the grinding burs, stabilizes the cutting edges normally the cutting edges will be sharp. So, it can do some roundness. So, that it will have a stability because if it is too sharp, that tool life will be very low; that means, that immediately the catastrophic failure takes place and along with its edge, if it may have chance that it may take out some of the material from the flank surface or from the crater surface of the things gives uniform surface structure at the cutting edge and extends tool life, because if you are nose radius are the cutting edge radius is slightly higher, what will happen?

The area contact with respect to workpiece will be very high. So, you will have good life, but there may be a chance of vibrations that is a drawback of it gives better bonding for the coatings assume that you have a better surface compared to this surface.

If you have this surface what will happen you will have a whenever you are hitting these surfaces what will happen it can generate super hydrophilic surface so, that you can quote it properly.

Reduces the jaggedness and the cutting edge. So, there is a any disturbances are something are there on the edge, edges it will reduce at the chipping at the cutting edge and build up information and other things.

If at all the chip moves on this particular surface what will happen, it will have lot of resistance. Assume that on this surface if the chip want to move the surface is very smooth and there is no high friction forces. At the same time you can also finish these type of complicated surfaces.

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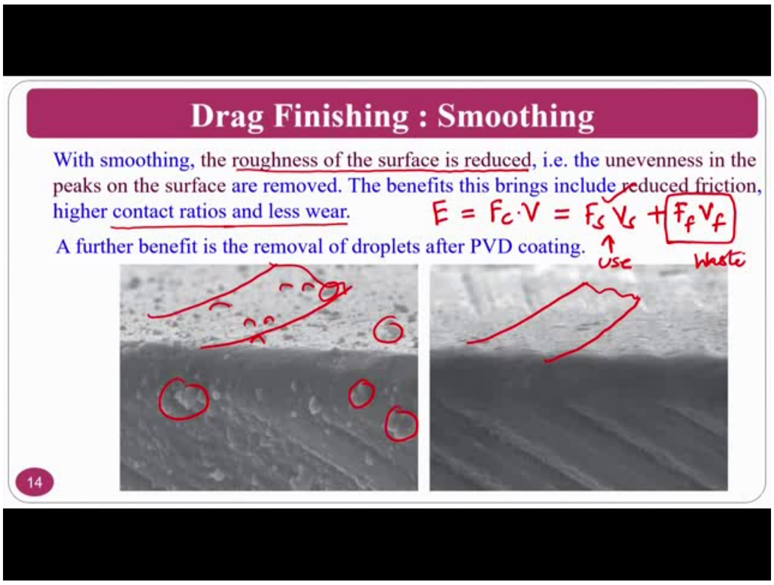

And this type of surface is also the smoothing operation is another advantage of this particular process. If you see with the smoothing roughness of the surface is reduced; that means, unevenness in the peaks of the surface are removed, the benefits of this one brings a reduced friction at higher can contact ratios and less wear. Further benefit is you can remove the droplets after the PVD coating. So, assume that if we want to remove the droplets.

Assume that this is the PVD coating that is done on a particular surface as previously what is in edge founding is there; that means, that sharp edges are at the same time the advantage of that particular process is you can make it super hydrophilic surface. So, that you can coat use in the PVD process that is physical vapor deposition process are chemical vapor deposition process.

Normally whenever you do it then again will the problem will come, what is the problem. The droplets are some of the features nano features or micro features will be on the surface assume that if the chip is moving on this PVD coated cutting tool, what will happen these particular portions will hamper the cutting chip velocity, if it will upstream the chip velocity for that purpose you should always go for the drag finishing process.

So, that the surface finish get smooth and your chip will move as per the requirement and your frictional forces will be very less; that means, that your rake surface chip moment will have very less friction if you do the drag finishing operation and removes the what are the droplet type of structures, nano structures micro structures that are formed on the after the PVD coating. If you can remove by the drag finishing process; that means, that your frictional forces can be reduced.

If you see here in the metal cutting normally input energy is nothing, but F c into V cutting velocity into cutting force, which is equal into 2 shearing velocity and shearing force plus frictional force and frictional velocity. So, if you can reduce the frictional velocity and frictional force what will happen; that means, that you are shearing component will be very high; that means, that this particular thing is known as useful and this is waste.

So, if you can reduce the friction on particular surface on a cutting tool your fictional force as well as frictional velocity, if it goes down what will happen; that means, that you are shearing ability of the your cutting tool and useful energy will be maximum for that.

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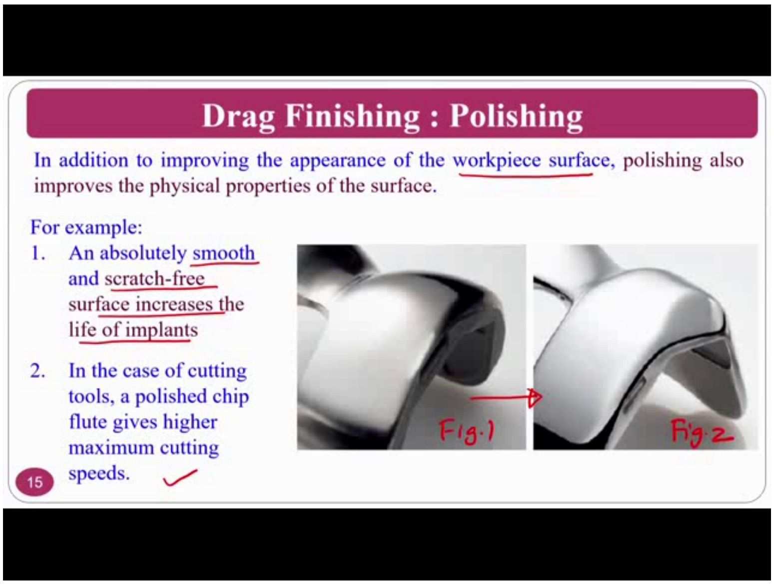

For that purpose you have one option of finishing is drag finishing process. Again the drag finishing process also can be used for the polishing applications, in addition to improving the appearance of the workpiece surface polishing also improve the physical properties of the surface; that means, that it will improves the aesthetic appeal at the same time it will reduce the surface fix?

So, for a next absolute example absolutely smooth scratch free surfaces of can improve the implant life. This is figure 1 again figure 2, you can improve the surface roughness at the same time you can improves the good aesthetic appeal good look also will come the brightness will also come on the surfaces.

If you see figure 1 to figure 2, the surface roughness is decrease that means that the finishing is improved; that means, a polishing action has worked there shining also is improved; that means, that aesthetic appeal. Suppose if at all somebody want to purchase then what will happen ok. If they if they want you as soon as they see these both figure 1 figure 2; obviously, the person likes to go to figure 2 because aesthetic appeal is very good. At the same time the life is also very good and many more advantages will be there.

The frictional losses assume that the knee implant is there that there will be a relative motion always will be there whenever walk and other. If the frictional forces are very high then always the patient will have a lot of problem and if at all if you go for a nano finishing application of this knee implant what will happen the body fluids flow easily at the same time interacting muscles ask your block cells, that are the bone cells and other things will have proper interaction.

In case of cutting tools polished chip flute higher maximum cuttings, normally you can also use for cutting tools polishing applications also.

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So, if you see the polishing of these things, this is before polishing application after internal grinding and after polishing. If you see the transformation from 1 to 2 this is a tremendous transformation of the quality of the particular component. So, you can get a very good quality component.

So, at the same time tool holders you can do this type of complex surfaces by drag finishing operation and thread cutting taps also you can do the this particular mass finishing operation you can go for many workpieces at a same time.

Now achieve the following this can achieve the improves the surface quality at the same time reduces the roughness and improves the chip flow also; that means, that as I said, if the chip flow is increased; that means, that material removal per unit time will increase; that means, that your production rates are increased so, that you can be competitive in the market.

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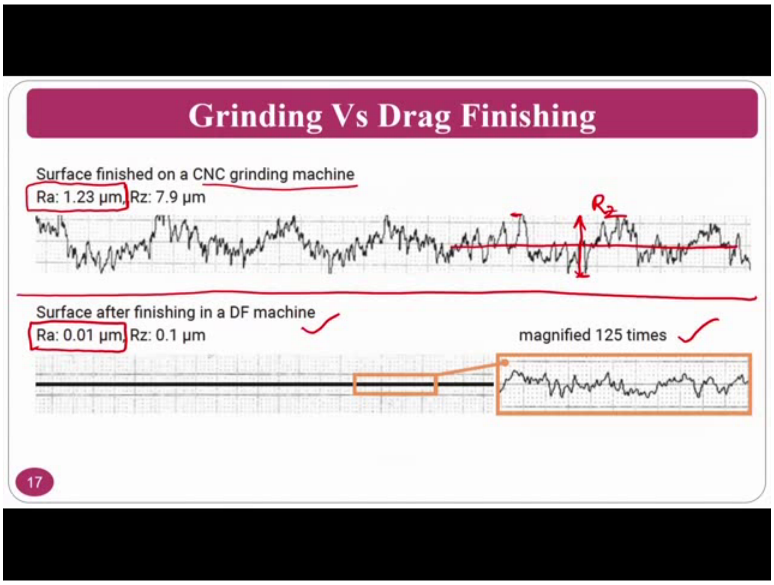

If you see the surface roughness, surface roughness in the grinding process this is the CNC grinding process the average roughness value is approximately 1.23 microns and Rz is 7.9 microns; that means, that Ra is 1 by L 0 to L ok. So, you can it express at the same time.

Let me explain you in physical terms average surface roughness about the centerline. Assume that this is my centerline average roughness, it will tell and R j tells about maximum peak to minimum value this is nothing, but R z and average value of about the center line will tell you the Ra value.

So, if you see after the drag finishing process, it looks like a very straight line. If assume about 125 or something then your surface is looking like a grinding process; that means, that you are absolutely getting a very good surface finish about 0.01 micro meters. See the improvement 1.23 micro meters to 0.01 micro meter the surface improvement is taken place in the drag finishing process compared to the grinding process; that means, that there is a enormous improvement of surface finish.

If you are using the drag finishing process at the same time this is a batch finishing process or a mass finishing process depend on how much components you are using what is the size of your tub and other things,ok. So, this is a beauty about the drag finishing process.

Next we move onto the ice bonded abrasive polishing process this is one of the new processes that is why I am not touching very deeply. So, I will just give you some of the gleams, if at all people want to know about these things professor Ramesh Babu who is currently HOD of Department of Mechanical Engineering at IIT Madras extensively work in this area.

So, those people who want to know about this particular process can see his papers and you can get a knowledge about those ice bonded abrasive finishing process,, but I can give you the some of the introduction about this process.

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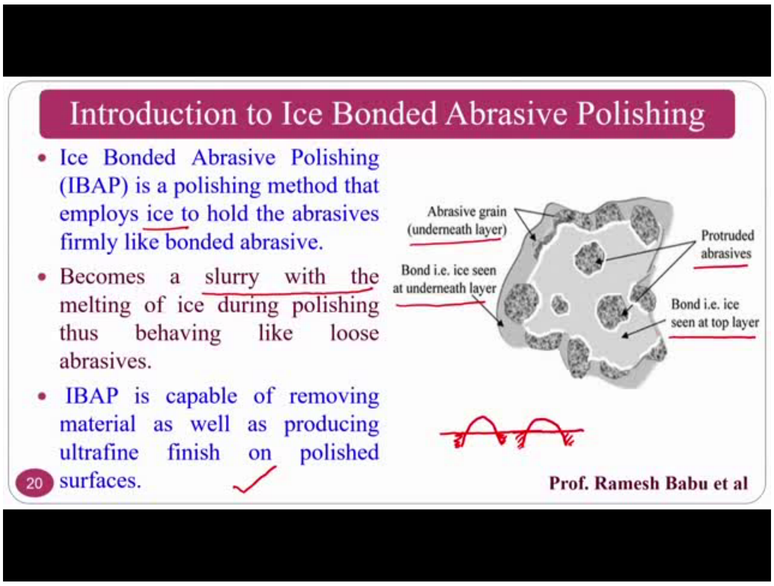

So, introduction to ice bonded abrasive finishing process this ice polishing method is employs a ice to hold the abrasive firmly like a bonded abrasives. Normally here if you see the grinding wheel you have a clay, you have a rubber bonding, you have a vitrified bonding that is using where the material is a clay like that rubber, rubber bonding, shellac, shellac bonding and may that various metallic bonding, this type of bondings are there.

There is a another variety of bonding here that is nothing, but ice bonding. So, where you just use water to make it ice and you impregnate or mix the abrasive particles and make a ice bonded abrasive tool, then you use for the finishing applications become slurry this ice bonded abrasive tool becomes slurry when it melting of ice during the polishing behaves like a loose abrasives. It can be a hard and it can be a soft also.

Say in the case of grinding process, you have to grades one is the soft grade another one is a hard grade. In a hard grade means abrasive particle is held by the bonding material very firmly. In a soft grade these are held very lightly whenever if at all hard workpiece is there it will remove and the new cutting edge will come into action, but this particular process has a beauty about both.

At the initial stage it will act as a hard bonding; that means, that hard grid. Whenever the temperature increases give with respect to time of the polishing it will become soft because your ice is start melting, in that circumstances you can have the soft bonding also.

Whenever it becomes a soft bonding the d bonding of abrasive particles will takes place and new cutting edges will come. So, the requirement of the dressing is not required, ok? May be doing, may be required if at all you make a wheel type of things, but if you see the polishing pad or something in upcoming slide you may not require that also.

So, say ice bonded abrasive polishing is capable of removing material as well as producing ultrafine surface polished it can be used for material removal and you can also use for the ultra fine finishing applications also. If at all I want to remove material then I need a hard grid with respect to a soft workpiece material, if at all I want to go for ultra finishing there you can go for the soft type of plate; that means, that you can also use the software by controlling the temperature; that means, that you can have less cooling. So, that it will act as a finishing tool.

You can see here, these are the abrasives grains and bonded ice underneath it ok. So, I seen on the top at the same time protruded abrasives, normally I assume that this is my ice by abrasive particles are like this. So, protrude abrasive particles are like this.

So, whatever the bonding here it is forming will depend on the temperature that you are controlling. For that purpose you need to design your particular setup in a such a way that you can maintain the constant temperature or you decrease the temperature with respect to time So, that whatever the temperature that is generating inside the system during the polishing can be countered by the decreasing temperature.

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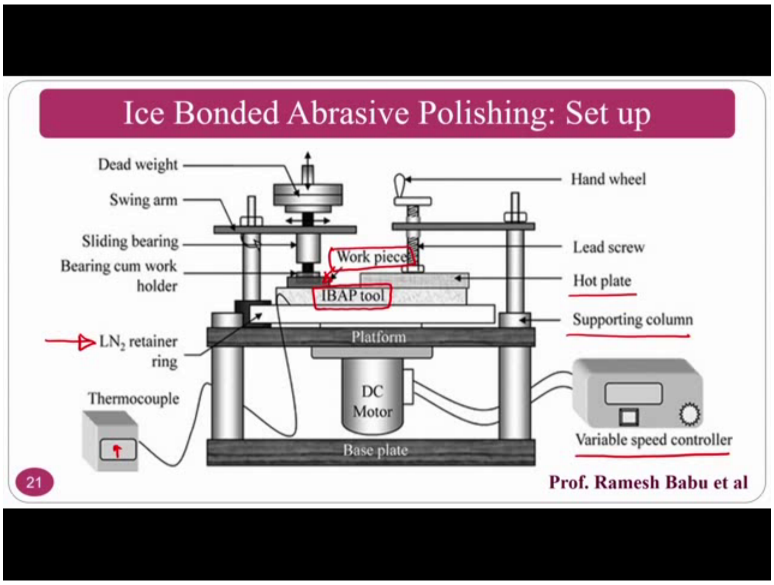

This is the polishing setup that is developed by the authors, ok. So, where we are very much concentrated about the workpiece material Normally this is the workpiece material which is polished and IB that is ice bonded abrasive polishing tool is this one so, that you can finish this one.

At the same time you, you have a platform where the DC Motor is there to rotate and you need to have the supporting columns you need to have hot plate. If at all I want to measure the temperature or if I want to reduce the bonding strength; that means, that the grade of that particular ice bonded abrasive polishing tool you can do. And mainly other, other applications are there, you can use the thermocouple to control the temperature and you have also liquid nitrogen retaining ring are some. This liquid nitrogen b is normally in the temperature below 100 minus 100 degrees temperature will be there.

So, it will always will have to keep the your tool very firm and abrasive intact. For that purpose normally liquid nitrogen ring and other things can be used in this one, ok.

You can also use variable speed controller. So, that if you what all I want to rotate at different speeds as in today I am rotating at 100 speed, tomorrow I want to rotate at 150 speed. So, that variable frequency drives are available. So, that you can use, you can connect to the motor DC Motor and you can use the gear systems also to control the various speeds if at all if you do not have this type of costly setups. If you, if at all you want to go for economical something you can go for the gears also.

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Like this if you see the practically the ice bonded abrasive pad will be like this on which you will hold your work pieces and you rotate this particular ice polishing pad so, that the finishing action will takes place.

So, you can also check the hardness of this particular thing. Normally since ice behaves like a brittle material, you can go for a cone type of indenter and you can check the hardness value, what is the hardness of this ice polishing pad and other things ok.

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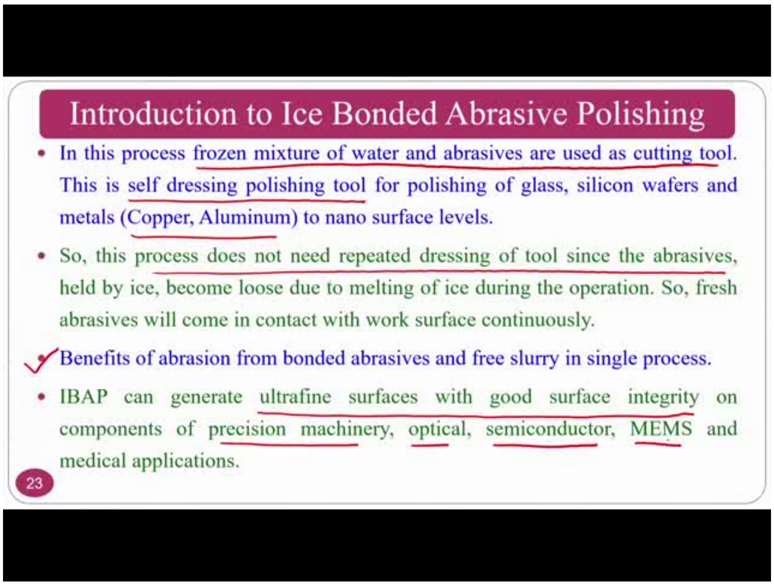

This process is a frozen mixture of water and abrasives are used as a cutting tool as you have seen in the previous slides. And it is a self dressing polishing tool for polishing of glasses silicon wafers and other metals like copper and aluminum.

You can also use for mild steel and other things, but there may be a chance of rusting after some time may be because this water whenever you react with (Refer Time: 42:59) based work pieces will may be chances of rusting. For that purpose safely you can go for aluminum and silicon glasses these type of things. You can go because these have tremendous applications in the mirror applications for silicon industry or MEMs industry and other industries.

So, this process does not need repeating dressing of the because the abrasives are held by the ice. Whenever the temperature of this ice will increase what will happen the bonding will become lose or it will become hard bonding or the hard grade of this polishing pad will become soft grade.

So, the abrasive particles will dislarge and new abrasive particles will come into existence. So, there is no requirement of dressing like a conventional grinding process. Benefit of abrasion from the bonded abrasives and free slurries in a single process you can go for bonded abrasives or free slurry; that means, that you can also use this particular process for bonded abrasive type that is a abrasives are held firmly by the ice or you can also increase the temperature and you can make it slurry that be the semi solid slurry to solids. So, in between also you can maintain so, that you can do the polishing operation also.

So, in ice bonded abrasive polishing can generate ultrafine surfaces with good surface integrity on the precision machinery optical semiconductors MEMs whatever the these are the industries that this particular equipment has applications.

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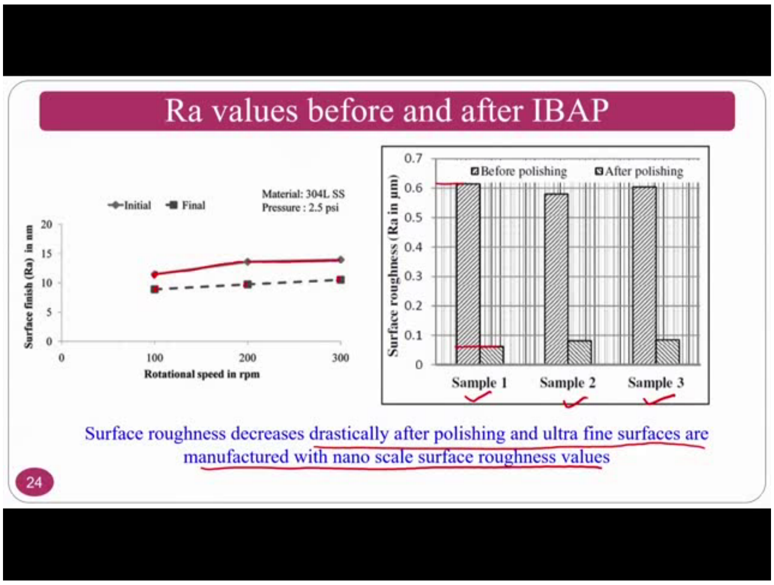

Ra values before and after, normally if you see the initial surface roughness this is the initial surface roughness of this one, approximately the surface roughness is around 14, 13 to 15 nanometers then after finishing then you can see here, it will reduces by a certain value.

So, you can use this particular process at the same time you can see the surface roughness in microns also whenever before polishing and after polishing some of the materials may be different. So, if at all for the more details you can go through the some of the papers on ice bonded abrasive polishing processes by Professor Ramesh Babu and other groups also some groups may be working. So, you can see those things.

In a sample 1 sample 2 and sample 3 this is the surface roughness approximately 0.62 or something and it is decreased to approximately 0.06 or something so; that means, that it is a great achievement from the point of surface roughness.

The surface roughness decreases drastically after polishing ultra fine surfaces are manufactured with nano scale surface roughness values; that means, that from micron surface that is nothing, but 0.6 microns you are reducing to 506. So, it is a great improvement from the point of surface roughness.

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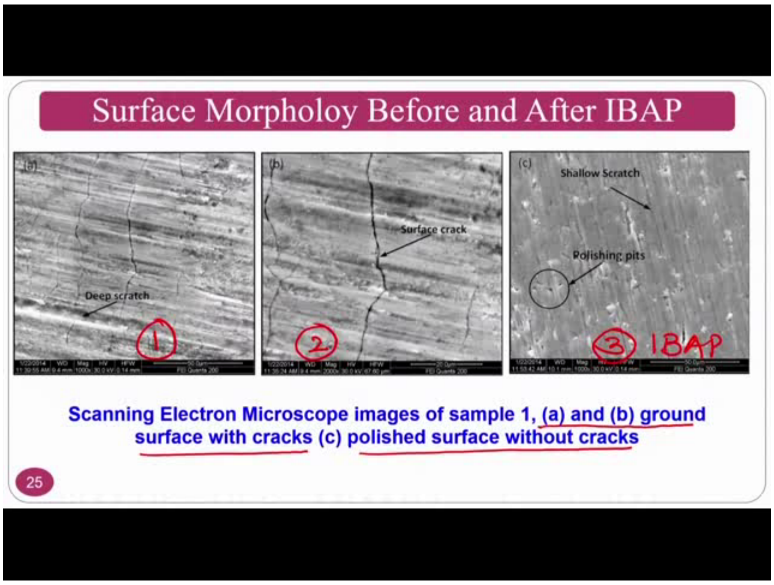

Surface morphology if you see these are the surface morphology before and after. So, a and b are nothing, but the ground surface cracks and c is the polished surface without cracks; that means, that if at all I want to generate certain surface roughness on using the grinding process these are big the figure 1 and figure 2 are the grounded surfaces and figure 3 is ice bonded abrasive process because in ice bonded abrasive process the forces involved will be very less compared to the grinding process.

Because of this there may be you can avoid the cracks and other things which are normal in case of grinding process ok.

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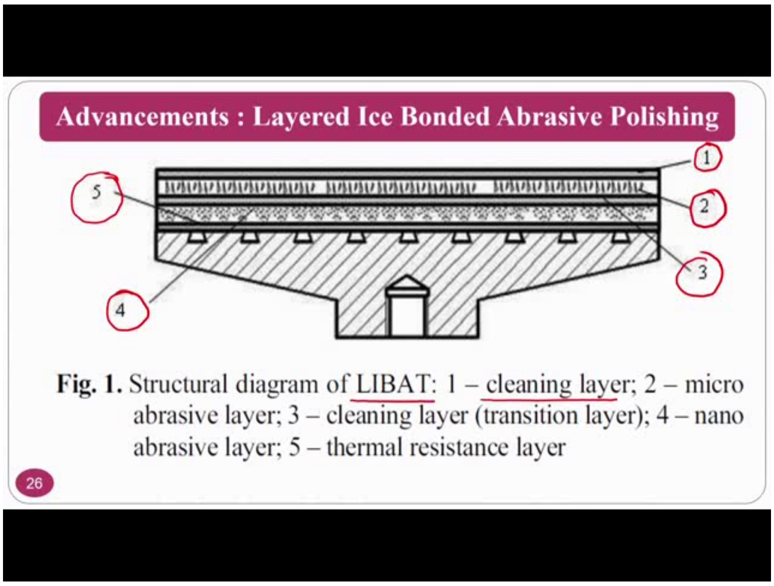

Advancements if you see one of the advancements the people have done is layered ice bonded abrasive polishing machine where different layers are there, one is the cleaning layer the one which is there cleaning layer is there then the micro abrasive layer is there then the cleaning layer again you have another cleaning layer and nano abrasives layers are there and then there will be a thermal resistance layer where ever the temperature development and other things can be avoided and all those things.

So, you can go by layer by layer also; that means, that this is the one of the advancements, if somebody want to take up as a research you can go through the papers I am very thankful for the authors who have given this type of good works. So, this is just a introduction about ice bonded abrasive polishing process, but if as I said if at all you want to go through in a deeply you can go through professors work.

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The next process is a pitch polishing. The pitch polishing is one of the good process for the lens polishing as well as for the mirrors polishing applications. As you can see here this is the lens basically which is polished by the trainer and error methods of the operator. Normally pitch is 1 type of polymer along with abrasives which you and this type of pads there will be some pads will be available where you can use this and this pitch and you can do it by trial and error method. Normally it started with trial and error method nowadays this also can be this is automated technologies are there which you can see in the upcoming slides.

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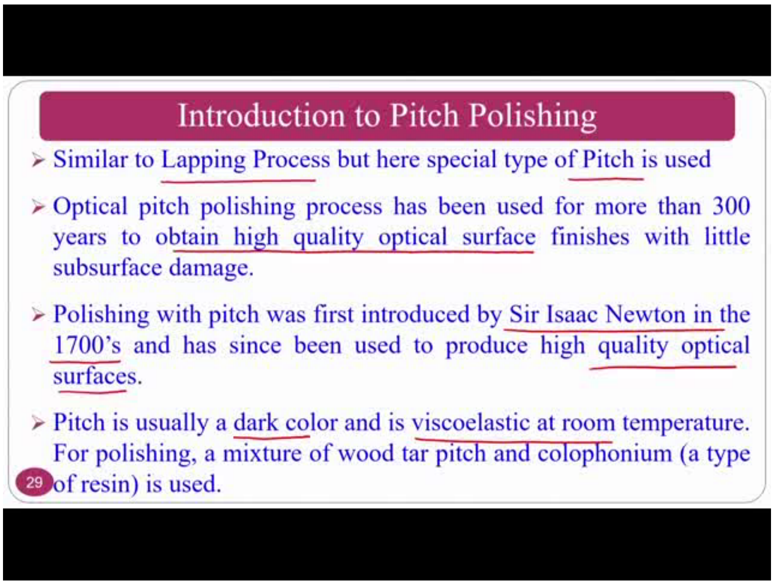

This is a similar to lapping process, but specially is nothing, but here the pitch is used which is slightly different from lapping fluids.

Optical pitch polishing process has been used more than 300 years to obtain high quality optical surface; that means, that this particular process is hugely used for optical industry. For the lens polishing assume that I want to polish these type of lenses are something lenses. So, you can use this type of pitch polishing techniques.

Pitch polishing pitch was first introduced by Sir Isaac Newton in the 1700 and has since been used produce in high quality optical surfaces finishing applications you can use. Pitch is usually in a dark color which is a viscoelastic at room temperature. It will have viscous component, it will have elastic component.

Viscous component can help you in moving along the direction of motion that is given by the external source. At the same time elastic component will try to move perpendicular to it. So, that you can get the finishing this viscoelastic effect and other things you will see whenever I am teaching abrasive finishing processes in advanced level; that means, that advanced abrasive finishing processes whenever I am going to deal there, one of the processes is abrasive flow finishing process.

There you will observe what is this viscous effect, what is this elastic effect and how this viscous and elastic effects are going to help the abrasive particle to finish in a nanoscale there. Those things you will clear these basics in that particular process time being you whatever I explained you that viscous component of this pitch will move along the direction of external energy; that means, that in the previous slide the operator is moving like this.

So, if at all I want to move like this that my pitch viscous component move try to move in this direction and the elastic component moves perpendicular treat. So, that it will indent and this will create the shearing. So, that you can remove the surface peaks and you will get a mirror surface finish and this can be used for optical applications.

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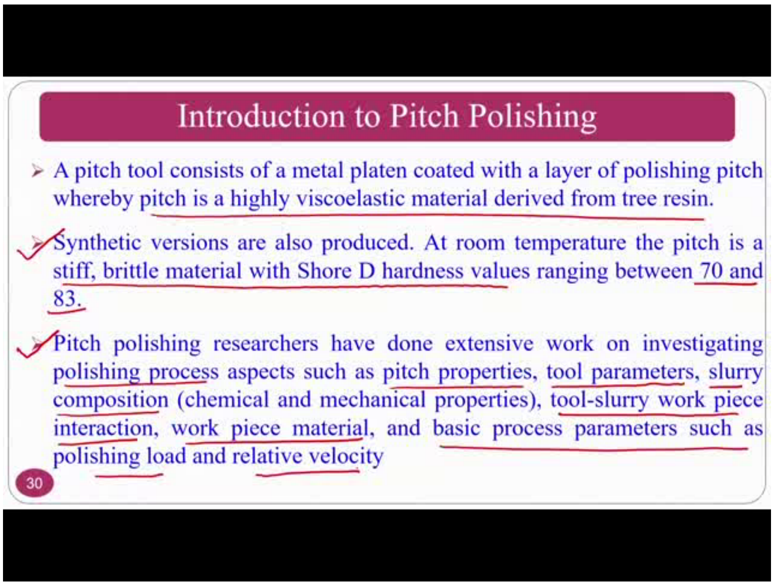

The pitch tool consists of metal pattern coated with a layer of polishing pitch whereby pitch is highly viscoelastic middle driven from the trees resin. Normally this is naturally taken material. There are 2 varieties one is natural pitches another one is a synthetic pitches are there.

So, natural pitches are like taken from the tree resin, synthetic versions nothing, but synthetic pitches also produce at room temperature this yard stiff brittle material with shore D hardness values ranging from 70 to 83; that means, a shore hardness normally used for measuring the hardness of very soft materials like rubber, elastomers and other things.

So, normally this pitch shore hard D hardness ranges from 70 to 83 the pitch polishing researchers have done extensive work on investigating the polishing process aspects such as pitch properties because pitch properties play a major role even in order to understand those it is itself is a very big study. So, tool parameters tool also pitch tool also is the another input parameter and slurry composition and slurry interactions and other things.

Chemical and mechanical properties of also play a major role, tool slurry and workpiece interactions will also play a major role. Workpiece material, which type of workpiece material? When I whether I am using fused silica for as I workpiece material, whether I am using a polymer lenses as my workpiece material that will also play a major role because the hardness of this will of these materials will drastically changes from fused silica which is a ceramic to a polymer.

And basic process parameters such as a polishing load and relative velocity will play also major role how much load that you are giving at the same time how fast you are rotating. If you are rotating by a manual method then you cannot rotate at constant speed for that purpose people nowadays are going for automatic machines, ok.

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Experimental setups, these are some of the experimental setups that are available and you can see the lenses many lenses are there and you can do it for mass finishing applications.

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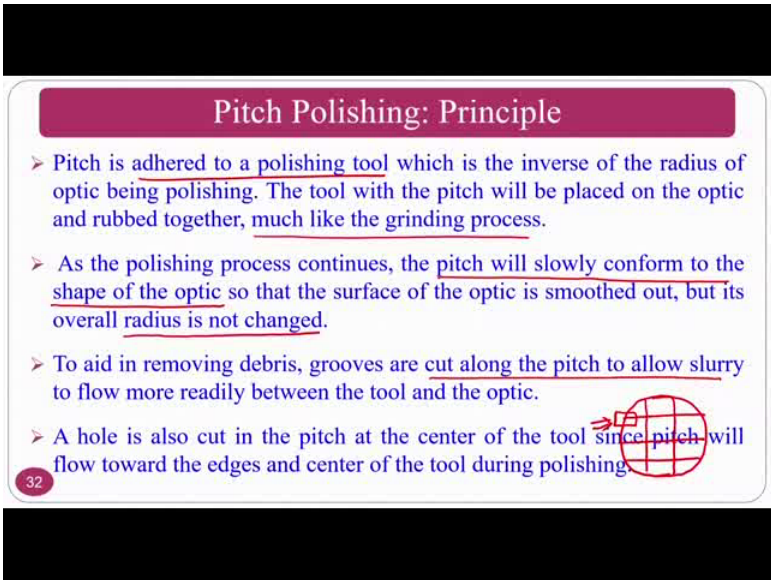

Pitch polishing principle, pitch is adhered to the polishing tool which is the inverse of the radius of optic being polish. The tool with pitch will be placed on the optic and rubbed against which much like a grinding process. You just take the lens that is if you take a pitch tool and you will put the slurry as well as pitch then you do the operation by applying certain load at you are required speed this will act as a grinding process also because basic thing that we have as a mechanical engineers, which we see the basic this is as a grinding process.

As the polishing process continues the pitch slowly confirmed to the shape of the optic. So, that the surface of the optic is smooth out and it overall radius is not change; that means, that this speech eases initially at the room temperature it may be bit high viscous.

As you increase the temperature sensitive nest will increase normally this on viscoelastic material, I cannot say on the most of the viscoelastic materials and which comes these pitches this whatever the pitch polishing techniques which uses the pitch also comes under viscoelastic materials. Most of these pitches are temperature sensitive with respect to time temperature goes up. If the temperature goes up this get low viscous and it confines to the complete area.

And to avoid removing debris grooves and cut along the pitch to allow the slurry to flow more radially between the tool. Normally this pitch you can give some of the scratch, normally if you see that polishing tool will be like this where in pitch will be there in the pitch they will make this type of grooves ok.

So, this type of grooves are there whenever these grooves are provided on a pitch what will happen the chips which are there or something, assume that this particular cross section if I want to take. So, it will look like a like this is the pitch is there and whatever the chips that are coming out may embody here.

So, that it will not disturb the finishing process. For that purpose the grooves are provided too I think you may see this type of pictures in the upcoming slides. The hole is also cut in the pitch at the center of the tool since the pitch will be flow towards the edges center of the tool during the polishing; that means that there will be a hole. So, what I mean to say is that the pitch try to move out towards the edges are pitch try to move towards the center or the edges for that purpose you will have a hole at the center.

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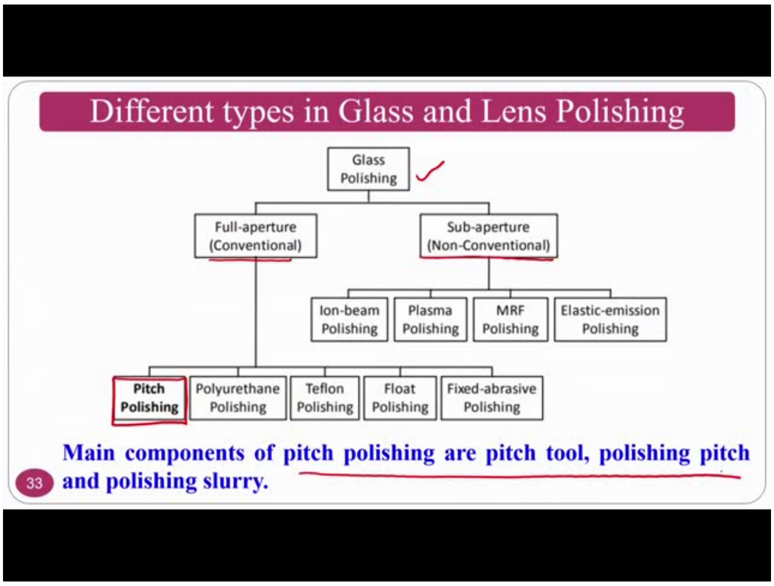

Different types of glasses and lens polishing if you see the glass polishing techniques there are full aperture that is conventional methods and sub aperture non conventional methods. In the conventional methods there is a pitch polishing is one of the techniques that is commonly used then there is a polyurethane Teflon polishing, float polishing fixed abrasive polishing is these are the techniques, which are used in a conventional way. At the same time in a non conventional way ion beam polishing, plasma polishing MRF polishing elastic emission polishing will be used ok.

So, these are the, there are 2 varieties one conventional and non conventional then we are seeing the conventional type. The main components are pitch polishing or pitch tool pitch polishing pitch and polishing slurry these are the 3 varieties.

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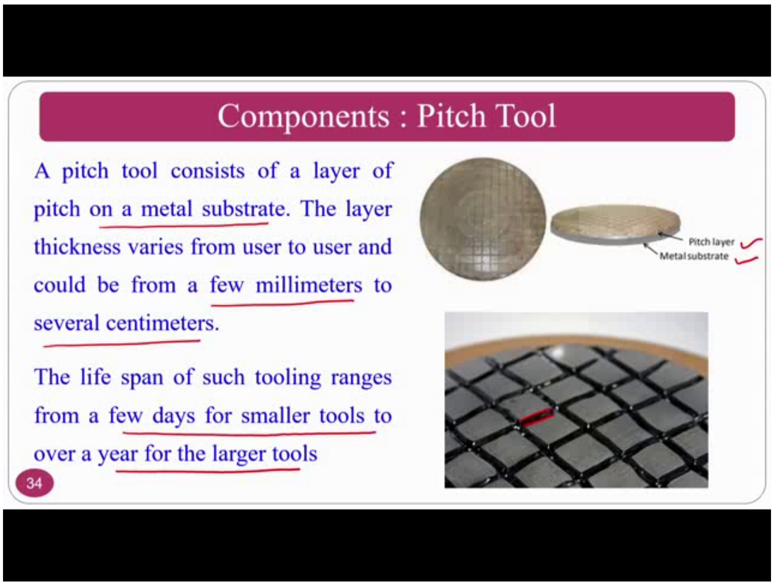

And the pitch tool as I said you will get the pitch layer. At the same time metal substrate will be there on which the load will a applied as I was telling you there will be a grooves are generated. So, that the chips that are generated microchips are nano chips will go and occupied this grooves. So, that it will not disrupt the finishing process.

Pitch tool consists of layers of pitch and on a metal substrate; this layer thickness varies user to user and could find few millimeters to several centimeters so. And the lifespan of such tooling ranges from few days to for smaller tools, for few years for larger tools; that means, that this thickness gradually decreases with respect to a number of component that you want to finish. And the same time what is the load that you are applying another things.

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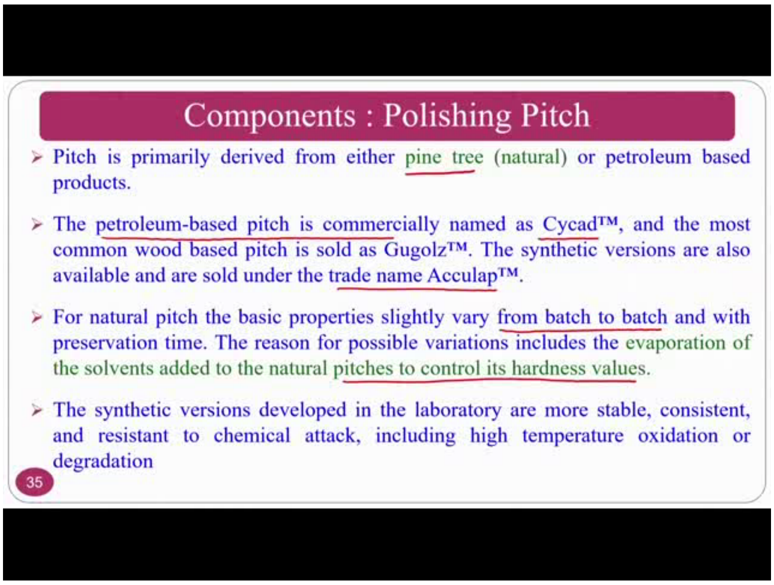

Polishing pitch primarily derived from the pine tree which is a natural source, the other things are that you can also generate from the petroleum based pitch which are commercially namely as Cycad and these are the commonly for the wood based pitches like that Gugloz and these synthetic versions also available and should be under the trademark of Acculap.

These are the companies that it will produces as the different types of pitches for natural pitch the basic properties slightly vary from batch to batch because if you are taking out in a winter if you are taking about in a summer then the properties slightly will vary ok.

At the same time the possible variations include evaporation of solvent added to the natural pitches control the hardness value; that means that you have to add some of the solvents to the natural pitches.

So, that you can vary the viscous and elastic components and other things and if elastic component is more normally the hardness will be more. The synthetic versions developed in the laboratory are more susceptible and consistent because the synthetic ones are developed as per your requirement I know this much elastic component require, I know this much viscous component is required so, that you can develop your own.

But naturally available you have to take the natural, what are the properties that have, but only thing that you can use is you can use some of the solvents to modify it that is all, but you cannot decide whatever the you require whatever you the properties that you require.

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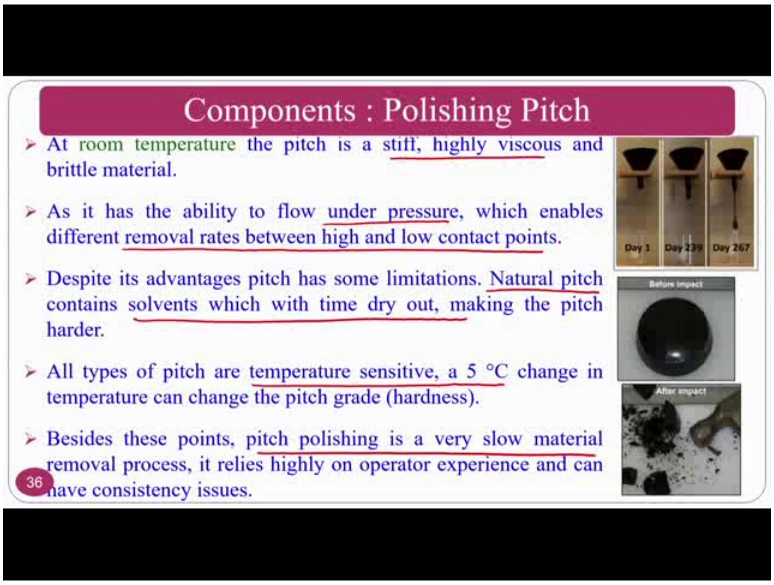

These are the polishing pitches if you see that the room temperature, pitches are stiff highly viscous and other things which are act as a brittle materials and it is ability to flow under the pressure and which enables different removal rates between high and low contact points because if you are applying certain load what will happen, if it is very brittle the stiff, if the pitch is very stiff, then it will causes material, higher material removal rate. And desperate advantages of some limitations also is there some of the natural pitches contain solvent which may dry out with respect to time because the temperature will increase, if the temperature increases what will happen that solvents will goes off.

Then the pitch will become more stiff. So, the material removal rate will be very high and the roughness will increase; that means, that nano polishing you may not get all types of pitches are temperature sensitive; that means, that 5 degrees change in temperature can change the pitch grade; that means, that hardness. As we have seen in the grinding process the pitch grade also will change.

Beside this pitch polishing is very slow material removal so; that means, that specific energy requirement for this pitch polishing will be very high the material removal is very slow, but the input energy is very high. This is also one of the drawbacks of polishing pitch.

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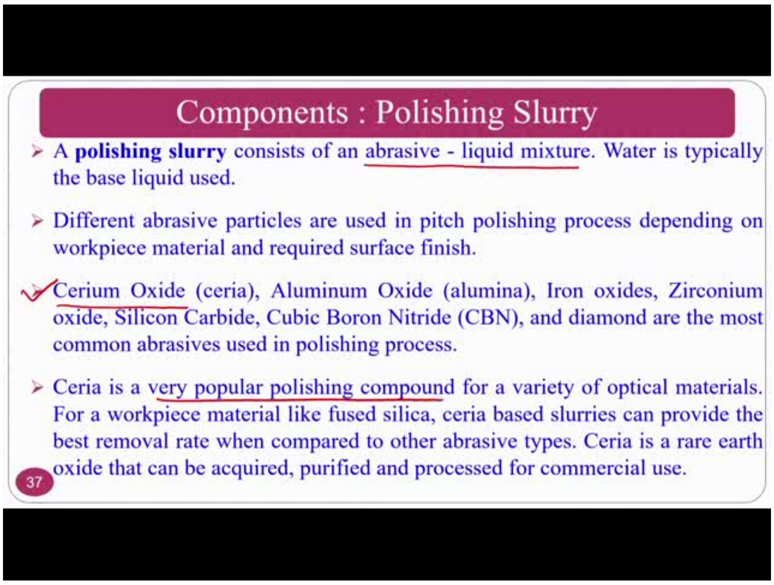

Now, we go to the second component that is a polishing slurry, polishing slurry consists of abrasive liquid mixtures, normally water, typically is a liquid different abrasive particles are used in a pitch polishing process depending on the workpiece material. Commonly used are cerium oxide compared to other abrasive particles like Al 2 O 3 that is alumina iron oxide, zirconium oxide silicon carbide cubic boron nitride diamond other things, but commonly for the lens polishing applications people will use cerium oxide which is nothing, but ceria will be used and ceria is very popular polishing compound for a variety of optical materials.

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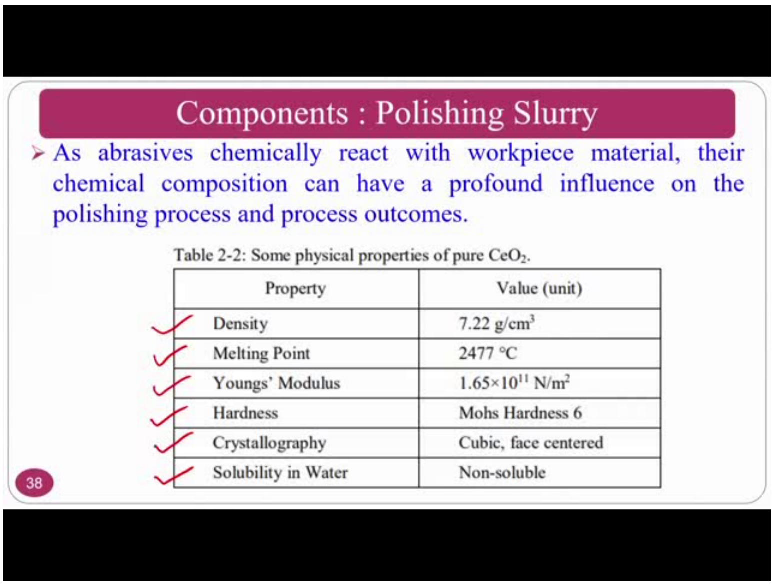

And you can see the properties of this ceria. Here the density and melting point Young's modulus hardness crystallography is solubility of water if this is a it is a insoluble one and you have a better properties of the cerium oxide for lens polishing or the glass polishing applications.

At the same time this also chemically react with the workpiece material that their chemical composition have profound influence on the polishing process and process outcomes; that means, that the if at all you are using these type of ceramic particles these are stable and this will not react, but the pitch which you are getting synthetically developed or which you are getting from the plants are would this all have their own chemical properties with influence the finishing process.

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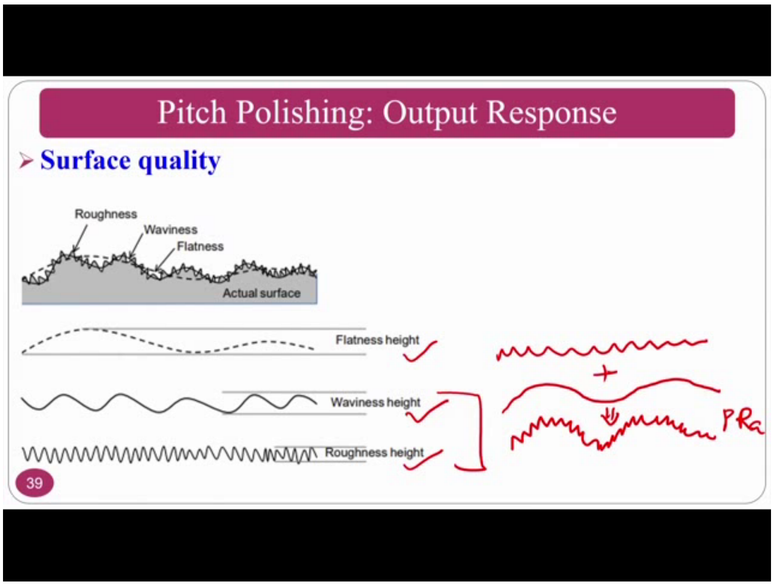

The output responses, if you see the surface quality this particulars thing I will explain you in deep in the upcoming slides. Normally the profile roughness will be there. If you see here this is the roughness and this is the waviness and this is the flatness height. Normally, if you see these 2 your surface will be like this. This is called profile roughness that is normally represent a PRA, which you can divide into waviness and you can divide into roughness, ok.

So, these 2 gives raise to profile toughness these are all things I will explain you in the upcoming classes where the surface properties, you should know all these things in the upcoming slides.

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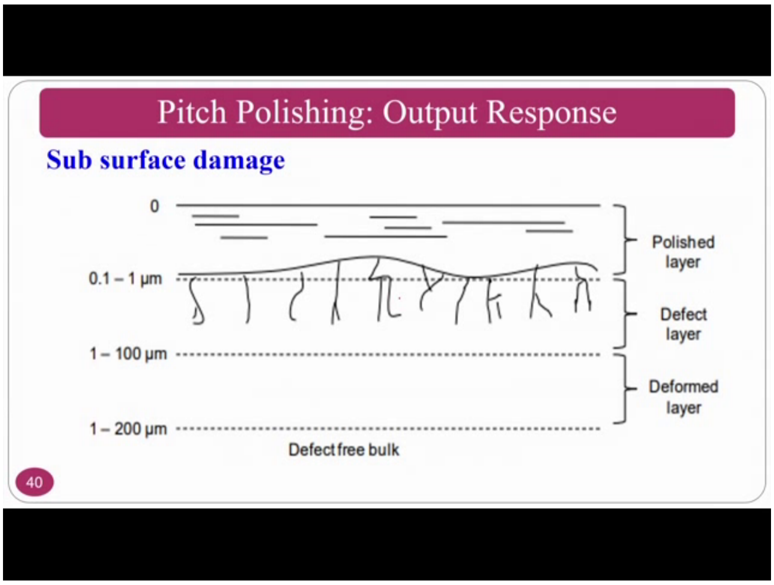

Subsurface damage, the subsurface damage if you want to see this is a surface and normally there will be if you are going for the grinding applications and other things what will happen the forces are very high, if the forces are very high, then there will be a subsurface damaged cracks and other things, but in the pitch polishing this things may not happen.

In the pitch polishing this may not happen because the interaction forces are very less.

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The other process that you can use is the pad polishing you can use the abrasive slurry here and you can use for slightly applications like polishing or buffing applications you can use the pad polishing and not much. Apart from introduction I am not touching this pad polishing.

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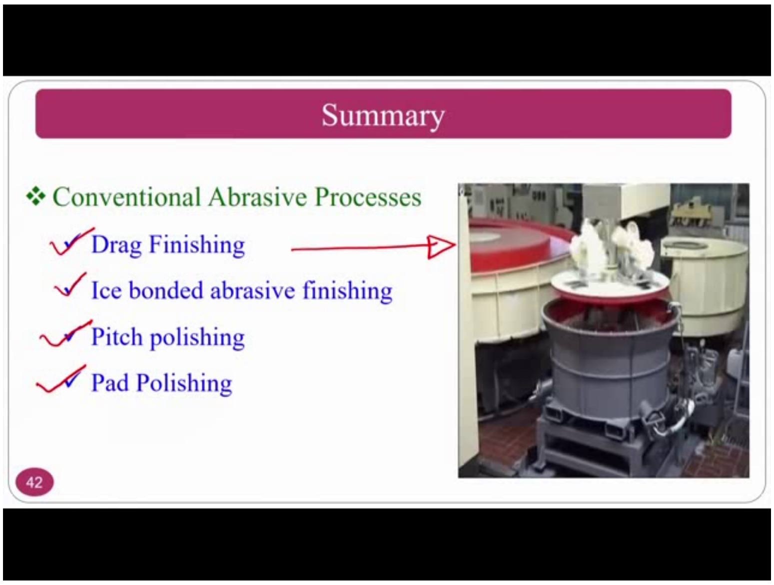

So, if you see the summary of this particular class I have taught you drag finishing which is a enormous tremendous application which you can see here in this particular video are the same type ice bonded abrasive finishing process we have seen. And if at all you want to go for more and more study you can see professor Ramesh Babu's papers who is eminent faculty in advanced finishing processes and advance (Refer Time: 65:33) processes.

Pitch polishing and pad polishing I have just given you Glimes and introduction.

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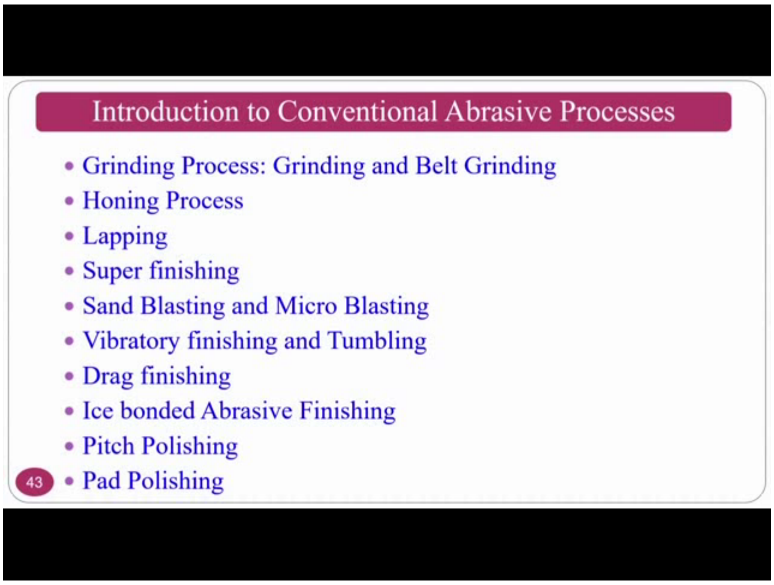

Summary of the conventional abrasive processes I have taught you are the grinding belt grinding honing process, lapping process, super finishing process, sandblasting and micro blasting processes, vibratory finishing and tumbling process, then drag finishing process, ice bonded abrasive finishing process, pitch polishing and pad polishing. These are the things that I have taught you in the conventional abrasive processes ok. So, I will move on to the another area in the next classes.

Thank you for your kind attention.