Polymer Assisted Abrasive Finishing Processes

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Lecture - 01
Introduction to Polymer Assisted Abrasive Finishing Processes

Dear all, as you know I am Dr. Mamilla Ravi Sankar who is going to teach you about one of the basic cum advanced finishing courses. That is a polymer assisted abrasive finishing processes first the overview of this class as well as this course. So, it is nothing, but the overview of the complete course that I am going to cover in 10 hours in 1 month of time.

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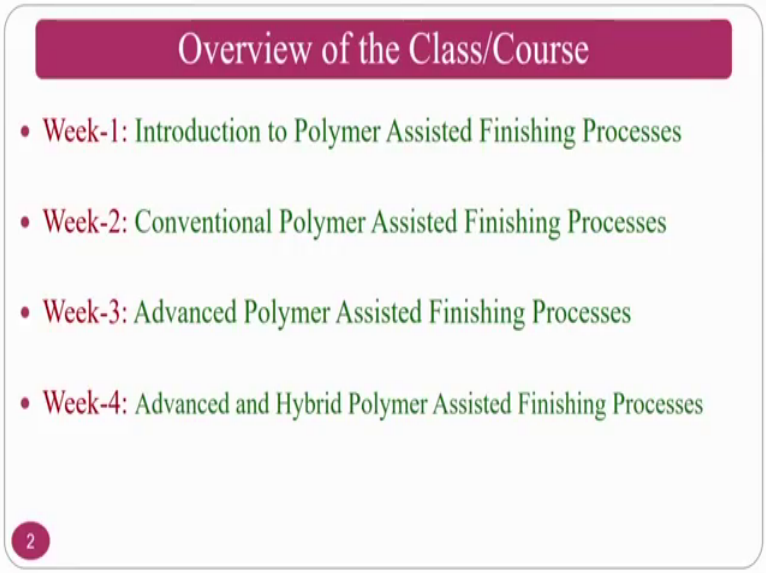

So, the first week I am going to cover is Introduction to Polymer Assisted Finishing Processes. Wherein you will see the what are the processes and their introduction, at the same time you also come to know what is the surface roughness, surface integrity, what is surface metallurgy and other things also ok. And you will come across the conventional polymer assisted finishing processes in the second week and some of the conventional finishing processes you also see in first week also ok. So, that covers first and second week though coming to the third week we will see: what are the advanced finishing processes like abrasive finishing process and so on.

In the final week we will see the some of the advancements of abrasive flow finishing

process, some of the hybridisations of abrasive finishing process and other things ok. So, on an average what you are going to study in this particular course is where the polymer as well as abrasive particles will come and unite to do the finishing process that is why this particular course is named as polymer assisted abrasive finishing process, the abrasive is getting assistance from the polymers.

And then it is going to do the finishing process and some of the names if you see like abrasive flow machining process in olden days or in 1960's 70's and 80's it is called as the machining process, but later on this process is considered to be the finishing process also. So, in this particular class you will also see: what is the difference between a machining process and the finishing process for the basic understanding of using students ok. So, importance of machining for the auspiciousness and other things the temple pillars are developed by machining and finishing process, if you do the only the machining process you may end up in bars and other thing.

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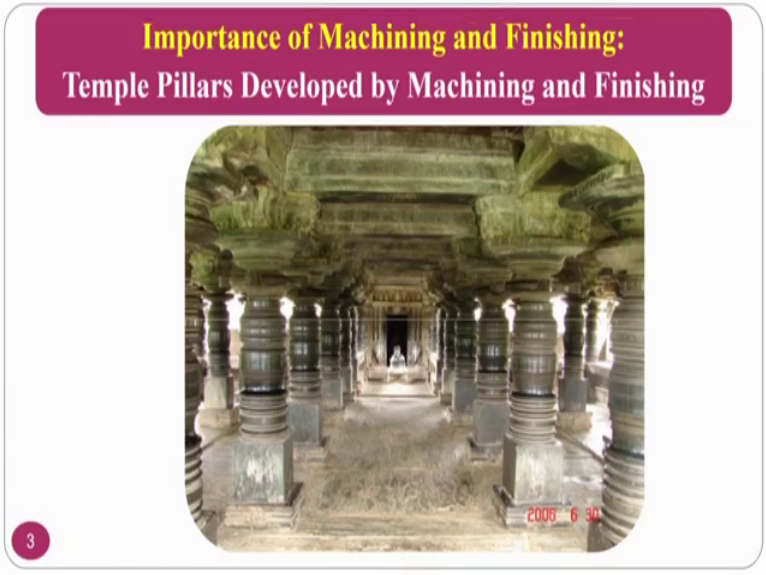

So, you need to go for the finishing operation also these are the pillars that is developed in a temple.

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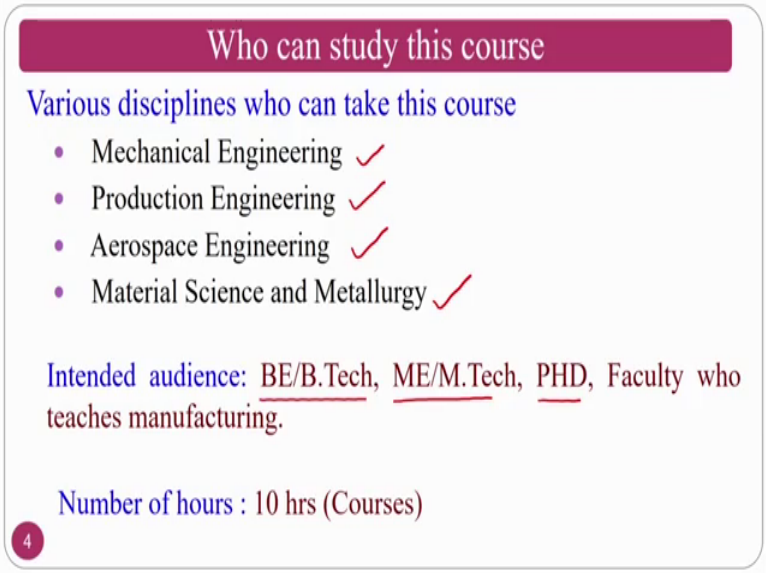

So, this particular course can be studied by various engineering disciplines such as; mechanical engineering, production engineering, and aerospace engineering. At the same time material science and metallurgy; so, all these people can be taken this particular course intended audience.

So, my course basically deals with primitives that will help the UG students who are going to do B.Tech in the streams that are mentioned above and the M.Tech and PHD. At the same time this is also useful for the faculty who can teach. So, whenever a teacher is teaching a course so it will always the research will always helps particular faculty to teach what is the latest things that are going on in that particular course ok. So, this will also help for the faculty and other things.

And coming to the PHD's and M.Tech that is research scholars as well PG student such as M.Tech student as well as research scholars this is most important you can also see some of the basics, you can also see some of the advancements, and you also come across some of the latest topics that can help you to take as a research. As I said this will cover in 10 hours that in is that in a span of 1 month so, coming to the syllabus and introduction of this particular course we will going to see in details about polymer assisted abrasive finishing process.

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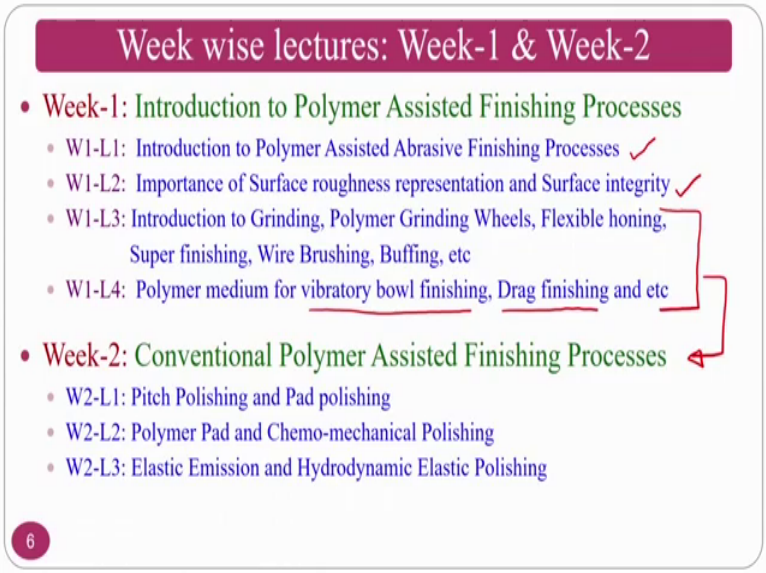

So, week 1 we will see introduction to polymer assisted finishing processes especially conventional processes. So, we will see: what is the introduction that we are going to see in this particular class. And importance of surface finish representation and surface integrity we will see what is mean by surface integrity what is mean by surface roughness and other things.

Once we come across what is the surface roughness how do we represent the surface roughness because surface roughness is one of the things that is most important for a finishing process. Why and all these things you come across in the upcoming slides. Introduction to grinding where polymer based grinding wheels are there flexible honing. Honing is one of the conventional finishing process and flexible honing you can see in detail in the upcoming classes, but introduction you can see in this particular class.

Super finishing wire brushing buffing and all those things then we go across polymer medium for vibratory ball finishing drag finishing and other things ok. Vibrating ball finishing drag finishing this particular processes are mass finishing processes where you can just dump the components and you can do the finishing you can use a ceramic abrasive beats or you can use ceramic polymer combined. And you can also use hard plastic based beats also; so, how this surface roughness will change with respect to the beats change and other things.

Then we come across conventional polymer assisted finishing process in the second set

because these particular set also come under this particular name. So, the pitch polishing, pad polishing, these are some of the finishing processes where you can use for mirror finishing. Polymer pad and chemo mechanical polishing also a in a pad polishing you can go for a special variety of chemicals along with the abrasive slurry. So, that is called chemo mechanical polishing process then elastic emission and hydrodynamic elastic polishing techniques are the some of the advanced versions that you will come across in this particular course.

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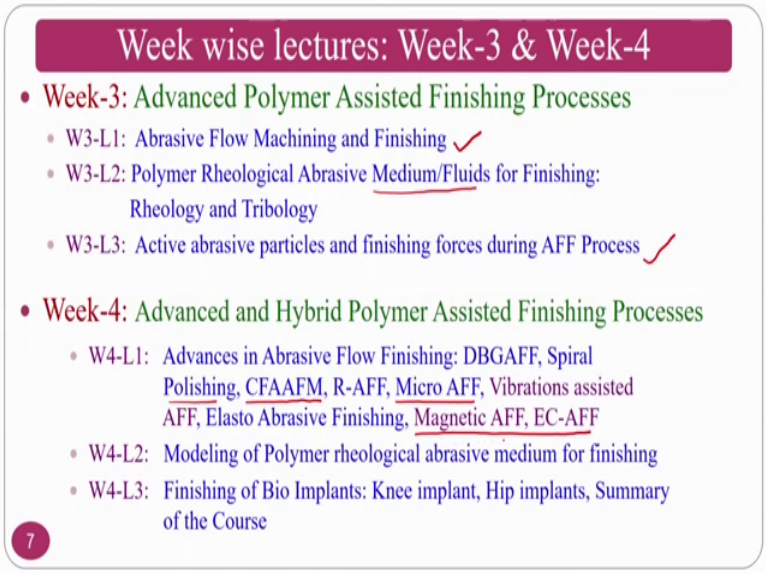

The third week we will see advanced polymer assisted finishing processes; that is abrasive flow finishing as well as abrasive flow machining why it is called as abrasive flow machining, why it is renamed as a abrasive flow finishing process that you will see. Then importantly you can see the most important component of abrasive flow finishing process that is called polymer rheological abrasive medium or fluid. This medium or fluid will depend on what is the viscosity of the medium ok. If it is low viscous then you can call it as a fluid, if it is high viscous or medium viscous you can call it as a medium or semisolid medium.

So, what is abrasive particle what is active abrasive particle. When you call a abrasive particle as active abrasive particle when you can call it as inactive abrasive particle and other things we will see. Then we can go to another version where advancements and hybridisation of polymer assisted finishing process like rotational abrasive flow finishing

process, drill bit guided abrasive finishing process, spiral polishing process, centrifugal force assisted abrasive flow finishing process, micro abrasive flow finishing process. And, some of the hybridisation you also you can see that is called magnetic or magneto abrasive flow finishing process, at the same time electrochemical abrasive flow finishing process.

Then we will see some of the modelling if time is there otherwise what we will see is we will see in detail about vibration assisted abrasive finishing process, magnetic abrasive finishing process, and other things. So, the finishing of bio implants like knee implant and other things all are the same time what are the other applications like nuclear applications, aerospace applications, semiconductor applications, and all these things how this particular finishing process can help them like that we will see in this particular course.

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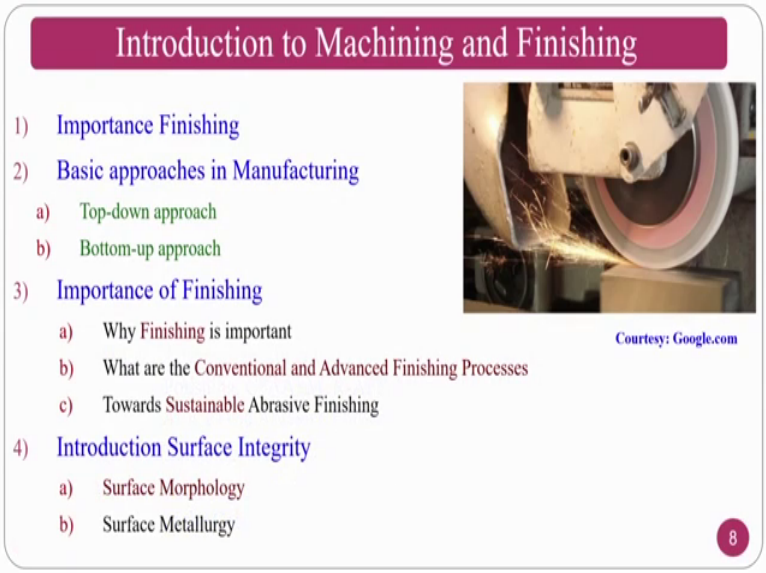

As I said this particular course is a finishing process that is why some of the UG students may have some doubt that what is the difference between a machining process and a finishing process. So, both are subtractive manufacturing processes where you can use the machining process as well as finishing process is like a top down approach ok. In a manufacturing process there are two approaches one is top down approach as well as bottom up approach.

Nowadays after coming the three d metal printing and other things. So, bottom up

approach is gaining its advantage; however, conventionally the machining and finishing processes are like top down approach. Top down approach means assume that I have a cylinder of 100 mm diameter and I want to make a shaft of cylindrical shaft of 85mm. So, I am going to do the turning operation and then post processing finishing operations to bring it to 85 that is nothing, but top down approach ok. Same thing I can also do by 3D printing also because how I can do I will take the particles of the same material and I can build it ok.

So, the material waste will be slightly less in terms of bottom up approach, but the cost of the product may escalate in our machine. That is why most of the conventional and Indian manufacturers will go for top down approach. So, importance of finishing why finishing is important: what are the conventional abrasive finishing processes towards the sustainable abrasive finishing process and all those things we will see if it time permits. Then introduction to surface integrity and other things we will see what is the surface integrity means surface morphology plus surface metrology and other things.

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And you can see what is the importance of finishing as this is the before finishing you can clearly see here how the weld joints are looking like ok. So, after finishing you can clearly see how these are disappeared. If you are going to use the same thing in a practical application without finishing then your performance will enormously go bad ok. That is why you require finishing in a great way the same thing if you can see for a

knee implant applications and other things.

If you are putting this is a before finishing this is after finishing. If you are going to put the before finishing here it is going to create lot of problems like the relative motion may be a problem at the same time body fluid flows on it if there is a surface roughness like this, then the body fluid will come and stay there this is the biggest problem for that purpose if you go for a finished product your surface roughness is very normal or something. So, there may be no accumulation of any body fluids at the same time relative motion will be better. That is why and indirectly the life of knee implant will enormously increases that is most important and it won't affect in any other adverse ways.

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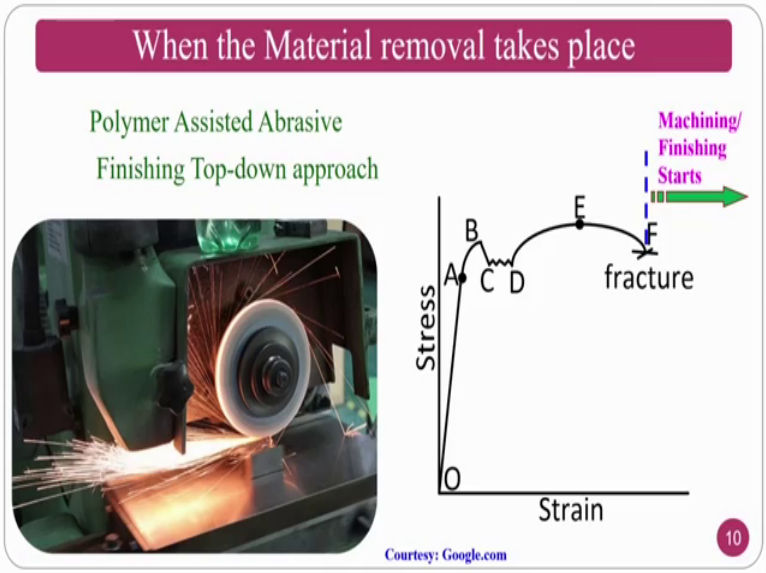

That is why as you know the material removal processes are subtractive manufacturing processes one of the common examples is turning grinding and other things. When the material removal takes place normally if you see any metal cutting process like turning process or a grinding process all these will called as saviour plastic deformation process because this machining starts after the fracture point.

That mean that that is why these are called as saviour plastic deformation processes and this will remove the material in a metal forming process we do not want after the fracture; that means, that it is damaged part. But in a machining process you always wish that the material is going off from the work piece material. That means, that the fracture

point is most important from where the machining will start ok.

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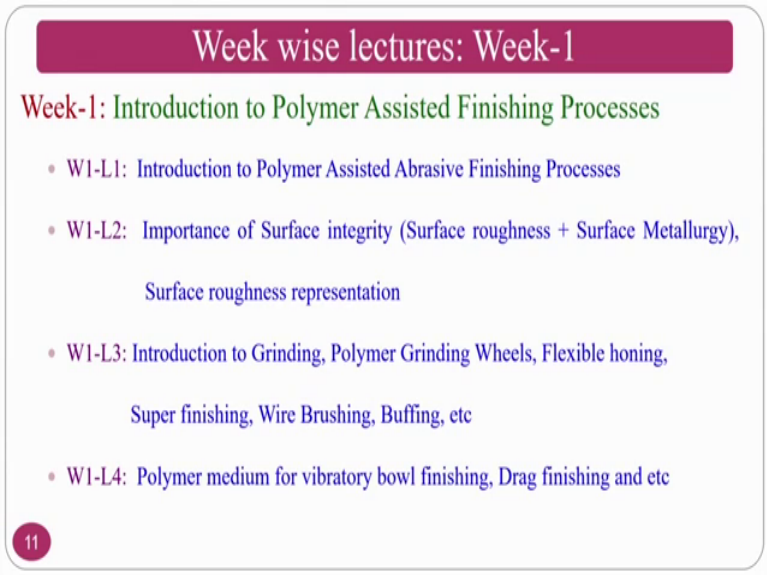

Coming to the first week we will see introduction to polymer assisted finishing processes importance of surface integrity then we will see the grinding polymer grinding wheels and other things ok. We will also see vibratory ball finishing drag finishing and other things these are all tentatively what I am going to talk, but if I am unable to cover in week 1. Sometimes one of the chapter or one of the lecture may going to week two also ok.

Slightly have the flexibility if I am proposing four lectures in week one doesn't mean that I may take four lectures. Sometimes when I am teaching it goes on. So, number of hours might be increases for that purpose I may shift one of the lectures to the next class also or if the time is less consumed. So, I may take one of the lectures from next week to in this class. So, there is a slightly flexibility what I mean to say is this particular lectures whatever I am proposing are completely tentative this is surface integrity in a finishing process.

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First conventional finishing process whenever you see what you are going to get into your mind is the grinding process. So, grinding process if you see lot of spark is coming here because of the friction that is generated between the grinding wheel as well as the work piece because of this the temperature goes enormously high ok.

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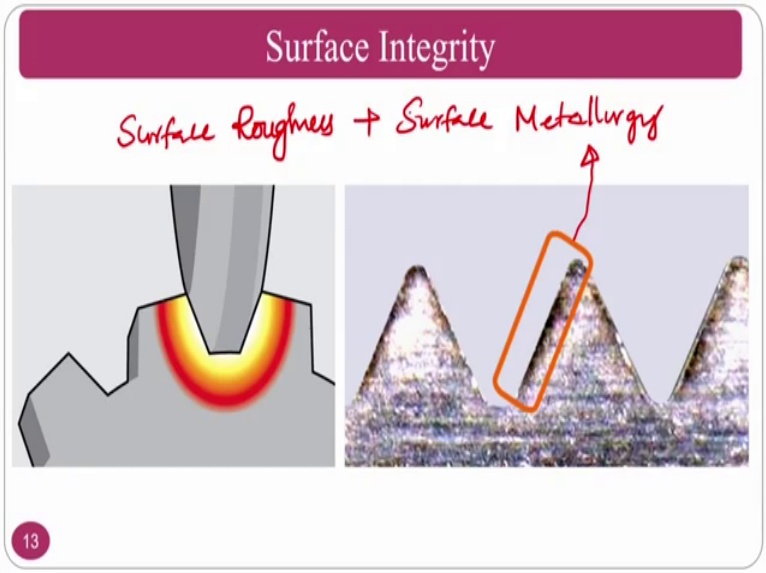

So, the basic problem comes is whenever you are grinding wheel is rotating or a form grinding wheel is rotating at a high speed temperature generates. Because of the temperature what will happen is there will be burning and there will be surface

roughness. That is why surface integrity means the surface roughness one is surface roughness plus surface metallurgy ok.

So, if you see this particular aspect this is completely burnt; that means, that microstructure are the metallurgical part of that particular component is enormously disturbed. That is why if your surface roughness is very good assume that this is less than micron which is your requirement and if the surface metallurgy is not good. Whenever you put your component in to a practical application because of the poor surface metallurgical aspect may fail.

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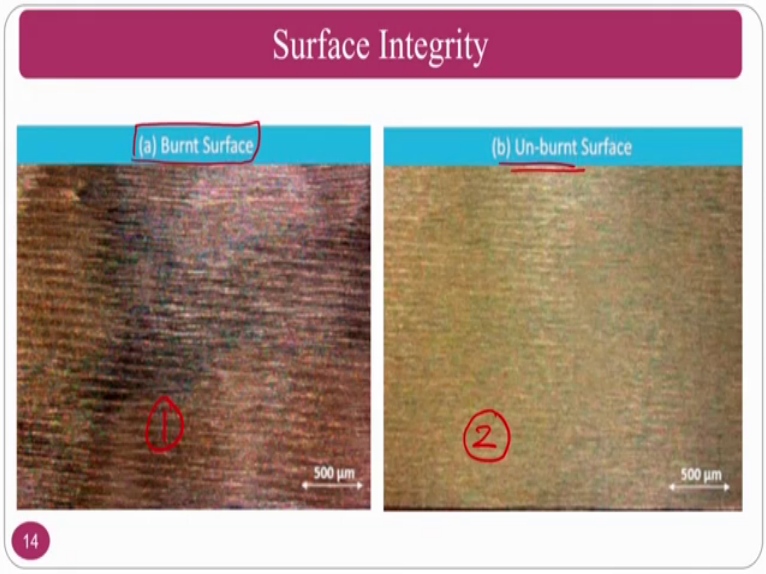

That is why you have to see the surface this is a burnt surface in a grinding process 1 is burnt surface and 2 is unburnt surface if you are going to put one then your life of the component may come down compared to 2. That is why you should always choose better surface roughness as well as surface morphology and surface morphology and surface roughness both are approximately similar and surface metallurgy is different.

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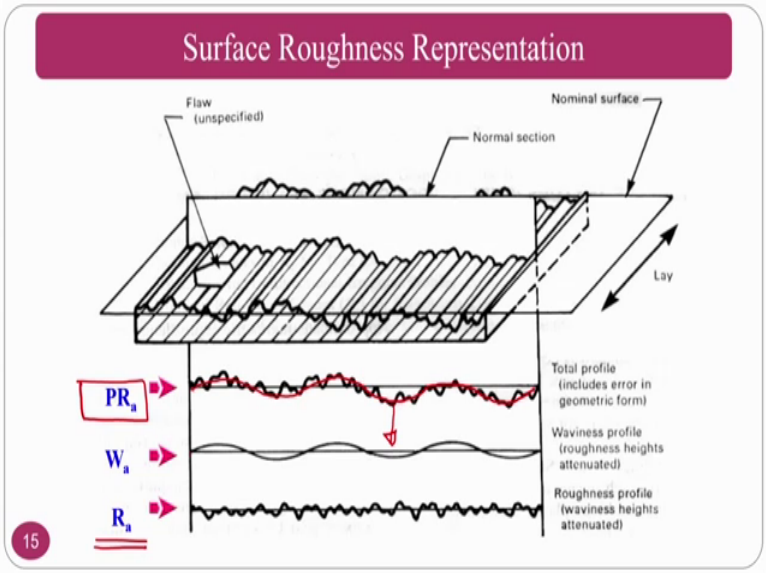

So, once you know the surface metallurgy is fine and you have to go for surface roughness representation. The surface roughness you can represent in terms of three profiles basically what we always check is surface roughness, but some of the people will always represent in a profile roughness as well as waviness. And other things the profile roughness PR a which you are seeing here you can divide into waviness as well as roughness.

So, the waviness is the low frequency high amplitude one is waviness that you can see here. So, that is what clearly representing here is nothing, but the waviness if you once you remove this one that remaining one is nothing, but the roughness value. But most of the people prefer the surface roughness apart from it many other things are there like flaws and other things.

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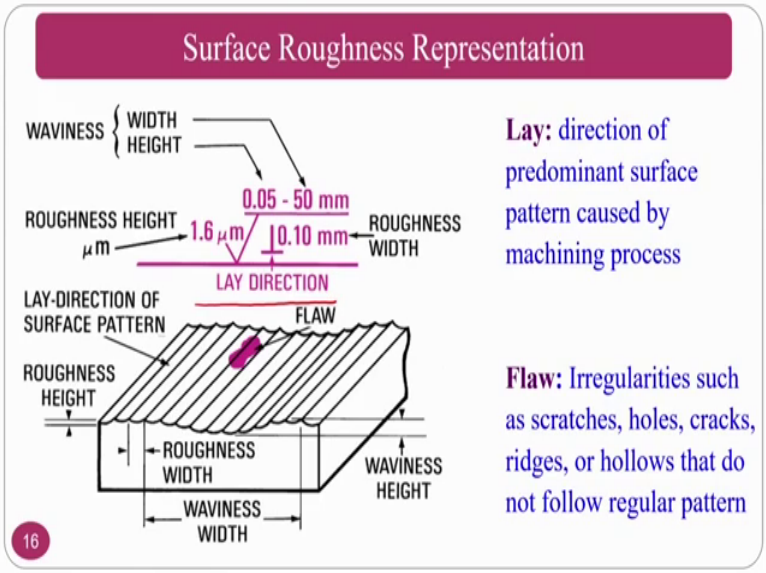

You can see how the representation will be taken here the surface representation of any particular surface can be represented like this. But in detail you will come across in the upcoming classes. So, this is how you will represent the lay direction roughness width what is the waviness width and height that is required normally the customers will represent about their desires like I want my surface to be like this is the surface roughness this is the lay direction and other things that thing normally people will represent like this and you have to prepare as a manufacturing engineer according to the requirement or their specifications of the customers ok.

The lay normally lay is nothing, but the predominant surface roughness directions suppose he want the straight line surface roughness; t hat means, that we have to go for grinding operation or shaping operation and other things ok. So, the flaws normally may be inclusions because of the metallurgical preparations of the particular sample and other things. T hat is nothing, but the irregularity such as scratches holes cracks ridges and other things in the material these are all called the flaws in a particular work piece.

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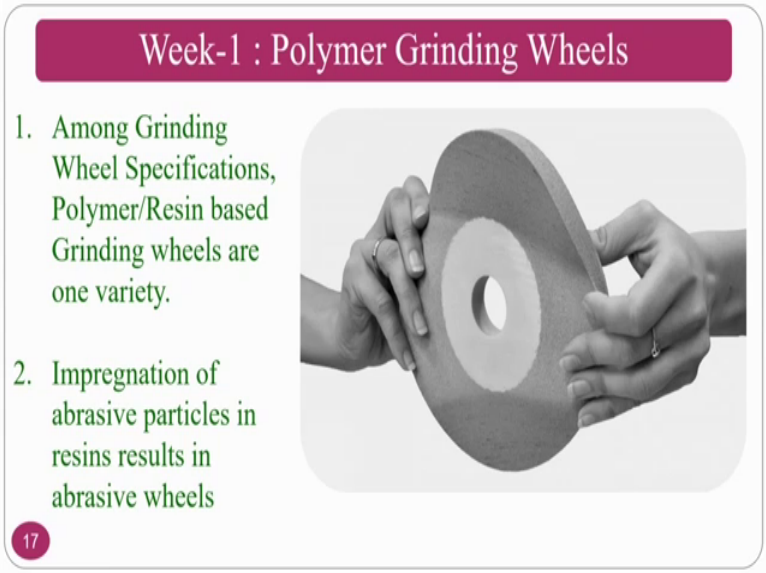

So, now coming to the grinding wheel whenever we see about a grinding process which is one of the conventional finishing processes we start with what is the grinding wheel and what is the specification of grinding wheel. Because the specification of grinding wheel, have multiple things among which bonding material is one ok. So, that bonding material whenever you are making with a polymer based bonding material in that circumstances that particular grinding wheel is known as polymer grinding wheel ok. One of the examples is resinoid bonding.

Among the grinding wheel specification polymer or resin based grinding wheels are one variety ok. So, there are specifications that you can specify by abrasive type whether you want silicon carbide or aluminium oxide or any other diamond or something the abrasive mesh size whether you want a core size whether you want a fine size super fine size the grade. Grade nothing but the ability of your bonding material in this particular course ability of polymer that the bonding material how it is holding the abrasive particle if it is holding smoothly or loosely. That means, that soft grade if it is holding firmly then it is called as a hard grade then structure of the grinding wheel how the abrasive particles are located at the grinding wheel in that circumstances if the abrasive particles are far apart it is called open structure if it is nearer then it is called closed structure.

Then comes the bonding material vitrified bond, resinoid bond, shellac bond, rubber bond, these are many many varieties are there among which wherever the polymer

bonding material is used that comes in the polymer based grinding wheels. So, impregnation of abrasive particles results in polymer abrasive wheels and you can see here how the polymer abrasive wheel can be deformed other thing this is for your better understanding. If you are going for a vitrified bond if you are going for a metallic bond you cannot deform like this you can see the grinding wheel is deformed with hands; that means, that this grinding wheels are flexible enough.

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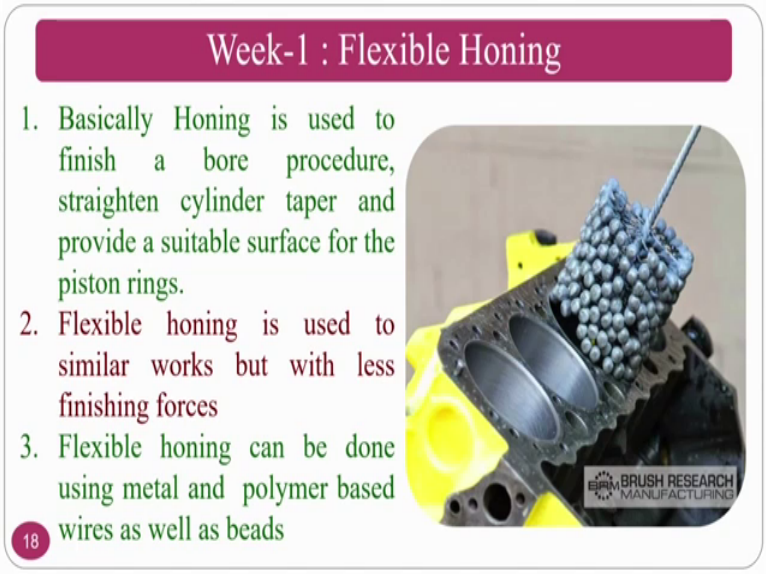

Now, we will move on to another thing flexible honing process. Basically honing is used to finish a bore and other things and in a flexible honing process instead of your honing sticks you will come across with a beads ok. So, these beads may be prepared with the metallic or it can also be prepared with a polymer. At the same time some of the agencies can also fabricate these with both ok.

You can have the metallic wires and which is having edge with the polymers also ok. Whenever you want to go for finishing of soft materials like aluminium and low hardness steels and other things it is very difficult if you are going with the ceramic based and metal based for that purpose people will use the soft grid or the polymer based beads.

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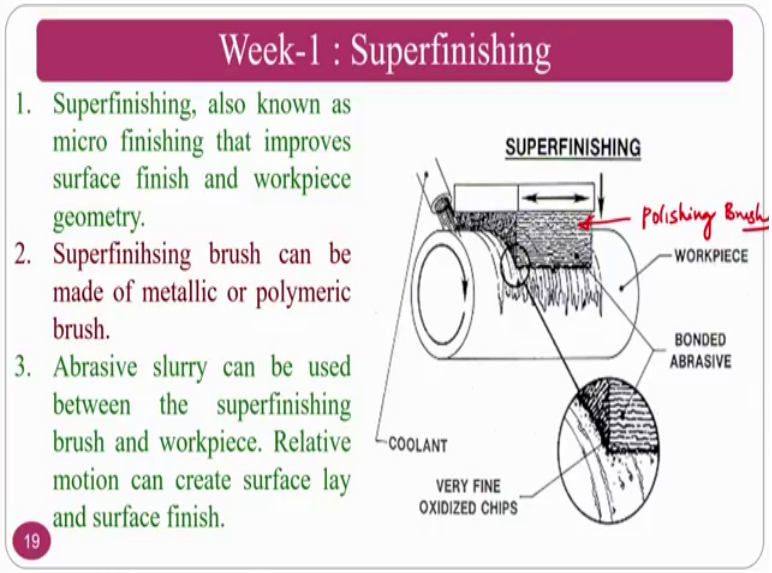

Now, super finishing super finishing also known as micro finishing in olden days this used one of the brush this is called the polishing brush ok. So, this polishing brush can be made up of metallic mesh or it can also be developed by the polymer brushes ok. And you can use the abrasive slurry and this abrasive slurry can be fed using nozzles or other things at the same time if you can generate the relative motion between the polymer brush along with the abrasive slurry on a any particular product you can get the surface finish that is called super finishing.

Super finishing as I said the super finishing can be used for the brush that is fabricated in super finishing can be metallic, can be polymer also that is why we will see in this particular process also.

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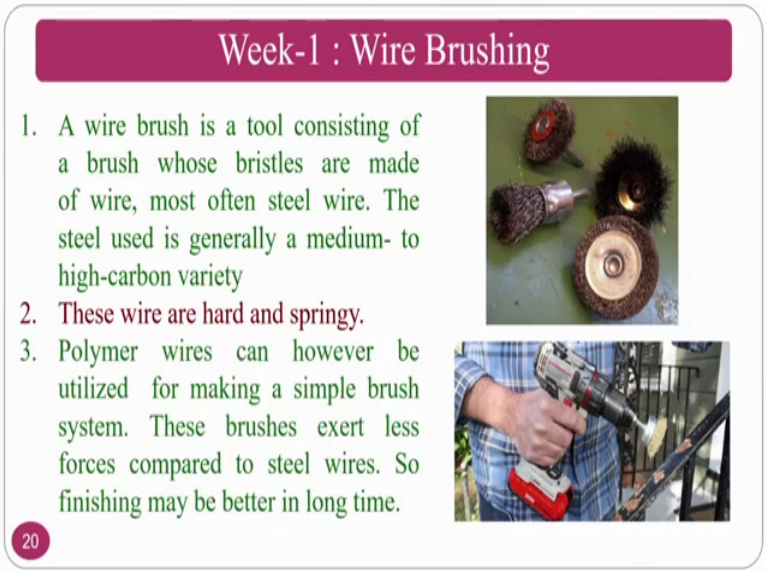

So, wire brushing basically uses metallic which is hard and springy. Some of the applications for fine finishing applications and other things people can go for polymer based also.

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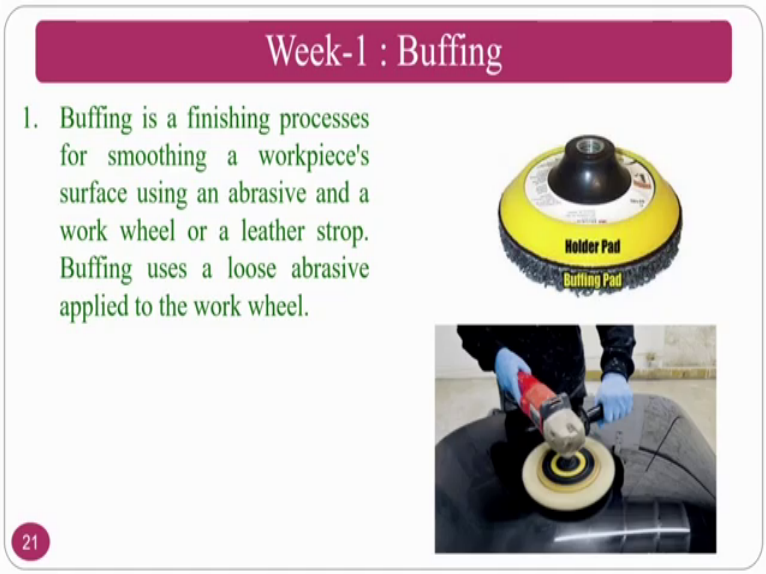

Buffing basically whenever you take your vehicles if you are a owner of a car it is certain automobile aesthetic appeal is one of the things then you can go for buffing if there is a burrs or there is scratches or something then the people will do the buffing process. Normally buffing wheels uses fabric oriented that is cotton oriented some of the difficult

to remove things can be done by polycotton; that means, that you will have a cotton also you will have a polymer also that thing can be employed and can get the super polishing.

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And we will see some of the mass finishing applications like rotary barrel finishing where you can see this rotary barrel can be rotated and in the inside you will have the beads which can be ceramic can be polymer and ceramic or can be only polymer. So, that depend on the type of component type of the complexity of the component that mean the geometry if it is delicate geometry and other thing then people going to use polymer oriented and it can be vertical or it can be horizontal also. So, you can use vertically you can use horizontally depend on availability of this particular process and the application.

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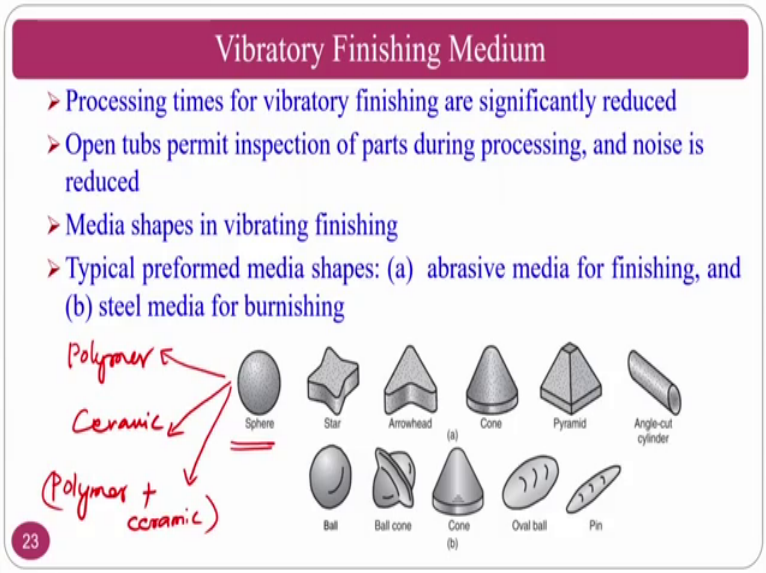

So, the most important part for this particular course is the medium your barrel will be metallic only, but inside medium whatever you are going to use is one of the important one in this particular course. That you can see the processing time and finishing are important open tubs permit the inspection of parts. At the same time media shapes in vibrating finishing or most important at the same time these are the varieties of shapes that one can use and we are going to talk about the composition of these shapes ok.

These shapes can be polymer, ceramic, and polymer plus ceramic both three things this medium can be prepared ok. That is why we will see where these type of polymer plus ceramic and only polymer based media are used in applications. This locally can be rotated at the same time this barrel also can be rotated that is option is there.

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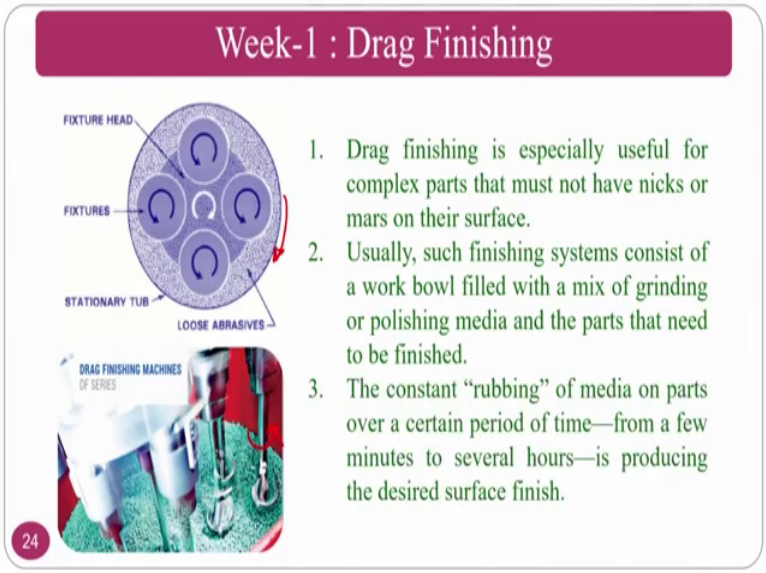

And here the component can be finished locally there all the components are placed in a bowl and rotated. So, it is a global and this is global plus local.

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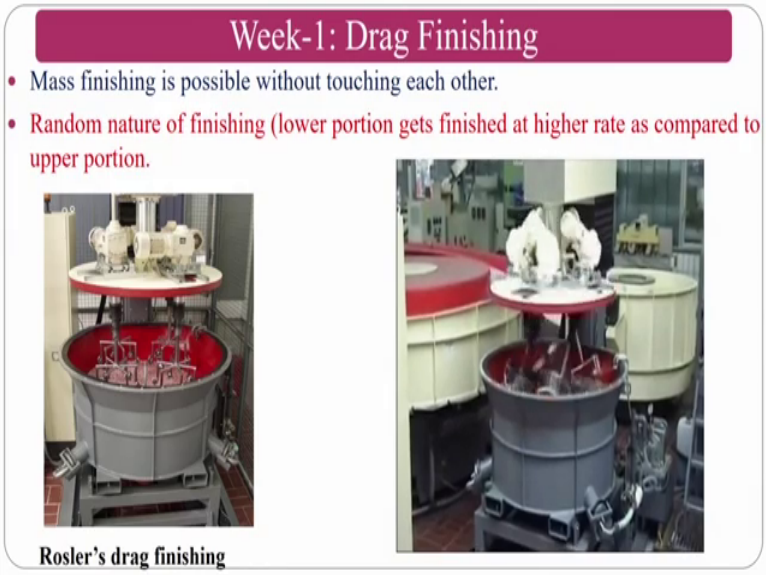

And you can see here how the drag finishing is operating. So, if you can visualise this particular portion that is going to show you how the finishing action takes place in this particular video you can see here the bowl is stationary. But, your component which is fixed to certain entity are rotating about multiple accesses in this way the component can be finished.

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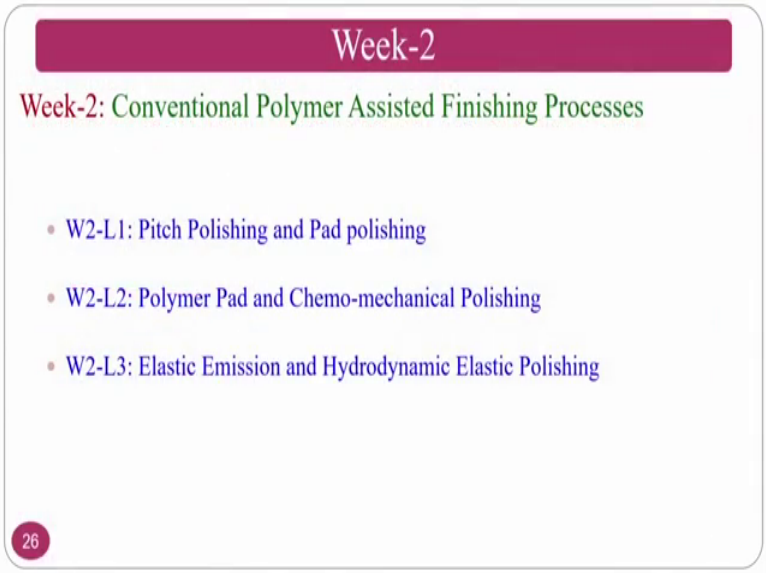

So, coming to the week 2 we will see about pitch polishing pad polishing chemo mechanical polishing elastic emission and hydrodynamic elastic polishing and other things. So, pitch polishing normally you can see here there is a lens and you are going to have a pitch this particular person having a pitch on his hand and he is doing the pitch polishing by the hand.

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So, the most important in this one is pitch composition. How and what type of polymers are used in this pitch and other things we will see.

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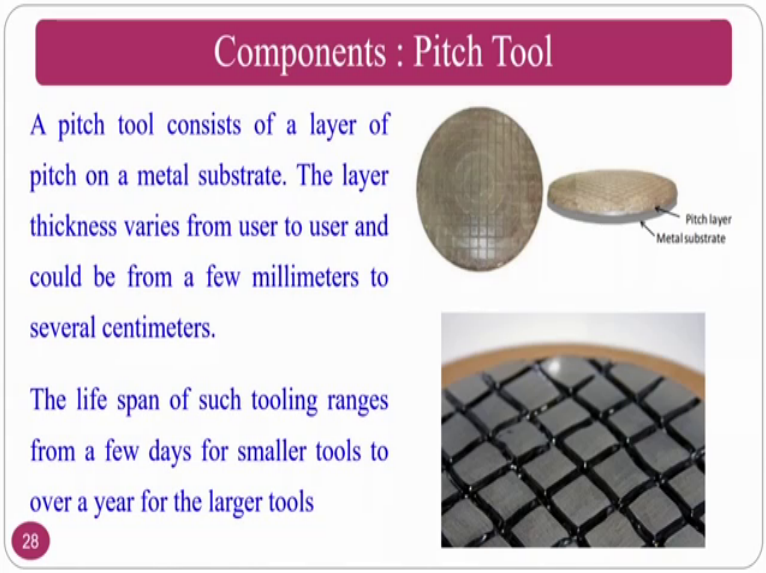

You can see the pitch tool basically pitch tool consist of multiple layers of few millimetres to several centimetres. And normally this pitch is developed on a metal substrate. So, it can be a gas iron substrate it can be a any other stainless steel substrate and many other substrates there will be glues also provided because, this will help the chips that are in micro to nano sizes which are coming out can be accommodated here.

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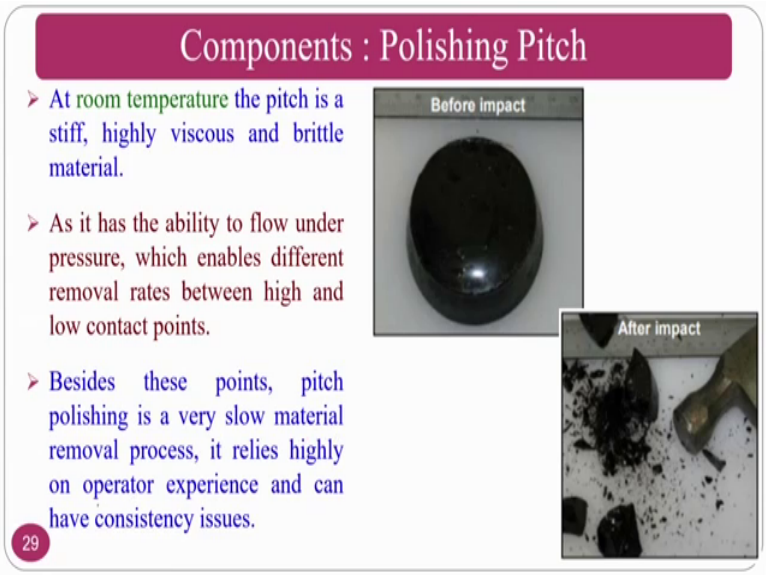

So, the polishing pitch normally it is very brittle at room temperature. So, you have to use certain temperature at the same time you have to use some of the pillars and other

things. So, as the ability of flow under pressure which enables different remove the material. See this pitch normally can be made up of. So, many polymers under the same time this can be mostly can be developed by natural type of polymers a natural type of glues as well as this can be developed by synthetic based also and petroleum based also can be developed. But this particular process is very slow material removal process and it requires very experienced operators ok.

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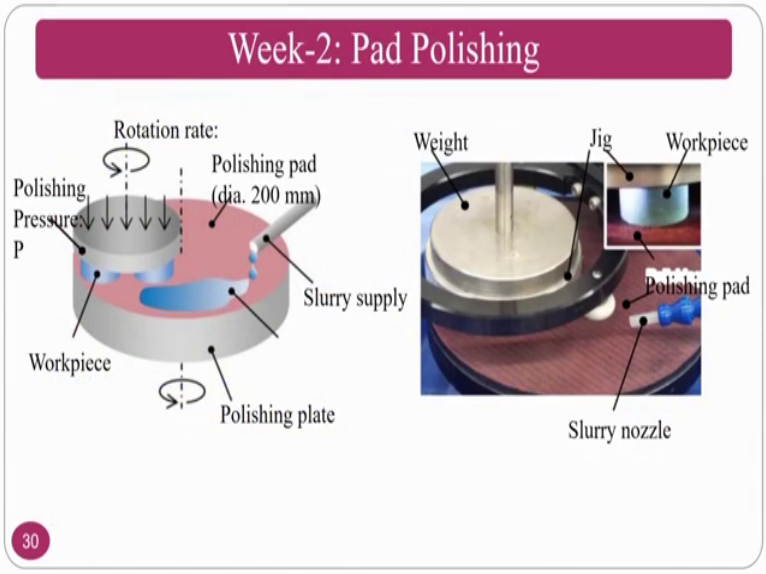

So, the pad polishing basically, the pad polishing nowadays are moving towards chemo mechanical planarization or chemo mechanical polishing process. Where you have a polishing pad you can see this is a polishing pad and you have the polishing pressure you are expecting and the slurry is kept and you have the work pieces here. This work pieces you can accommodate one or multiple in number then you just hold it by certain pressure and you rotate it. So, you can rotate you are workpiece holding part or you can rotate the bottom part also normally you can rotate the workpiece holding part; so, that you will get mirror surface on the workpiece.

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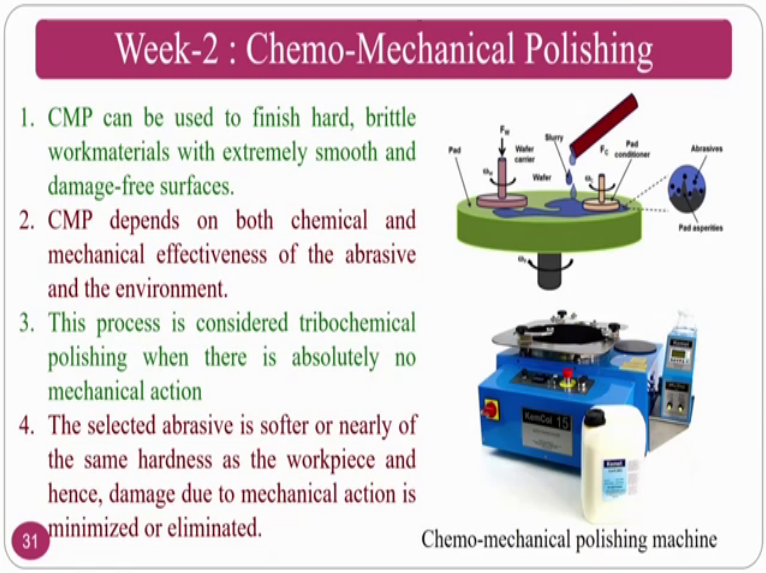

So, in chemo mechanical planarization the difference that you can see here is that you are going to add some of the chemical ok. That is why this chemical what it is makes the workpiece surface bit smoother so that the finishing can be easily taken place. And the workpiece parent material may be hard compared to your tool material, but because of the chemical that you are going to use these particular layers of one micron or something on a workpiece will become softer and that particular layer only can be removed. So, that you do not find any feed marks and other things you come across this particular process in detail in upcoming classes.

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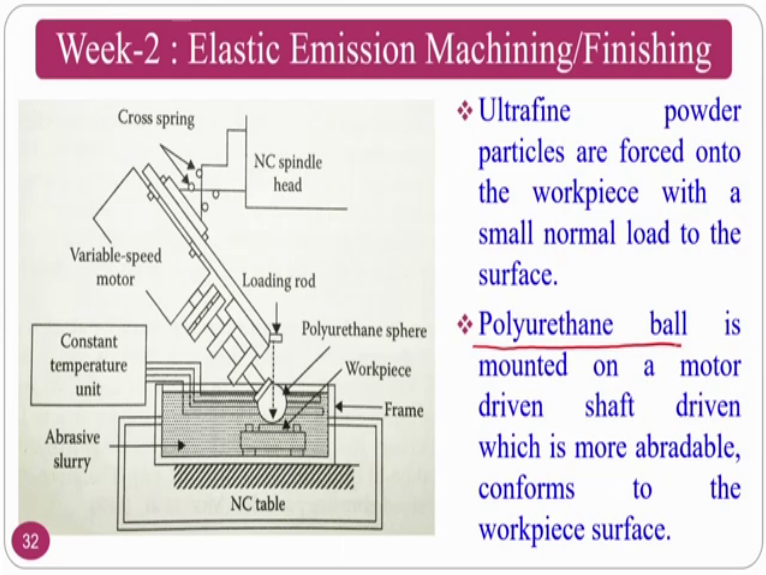

So, elastic emission machining process where you can see a ultrafine powder particles are forced into workpiece where there is a polyurethane ball is there mounted on a motor and you are going to drive it and what you can see here is.

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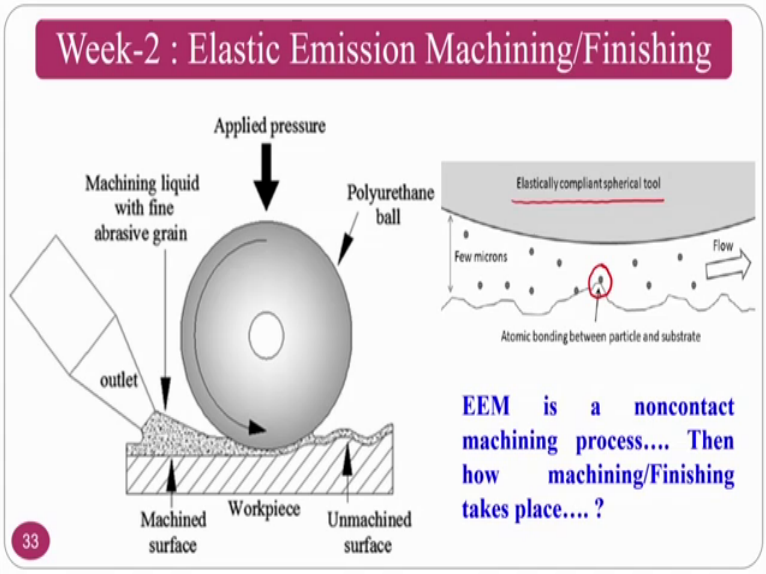

So, you are rotating a polyurethane ball and the abrasive particles and slurry is coming in contact and there is no contact between the elastically complaints spherical tool as well as the workpiece surface. Only thing is that the particles that are going to use in elastic emission machining are finishing is going to come in contact with the workpiece material. In that circumstances this particular process is called noncontact finishing process. So, then how the material removal takes place ok.

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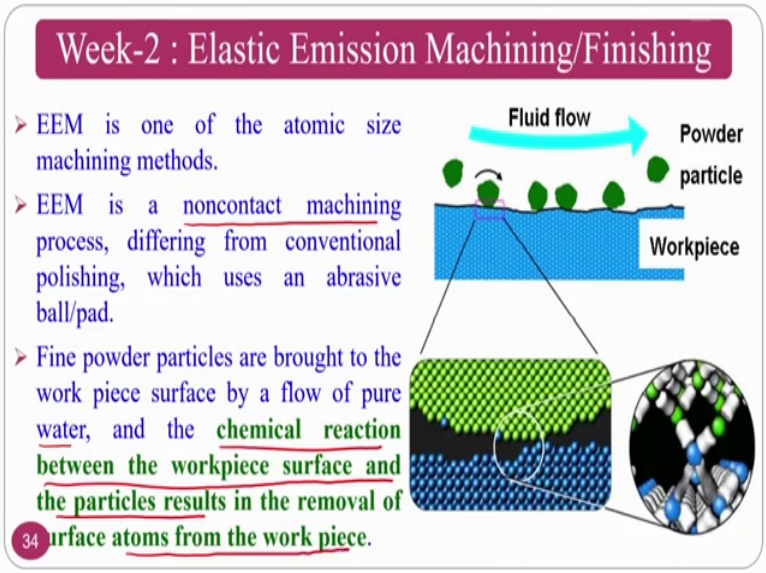

Elastic emission machining is one of the atomic size machining process, but this is the noncontact machining process. So, fine powder particles are brought into the workpiece surface by the flow of pure water and chemical reaction between the workpiece surface and the particles results in the removal of the surface atoms from the workpiece. That means, that the main function of polyurethane ball is to facilitate the particles to come near to the work surface and to pressurise the particles.

So, that there will be a chemical interaction between the particles as well as the workpiece surface peaks and there will be a chemical reaction takes place and the material removal in a atomic scale can be removed. Because, of these the surface roughness that you are going to get is in a atomic scale.

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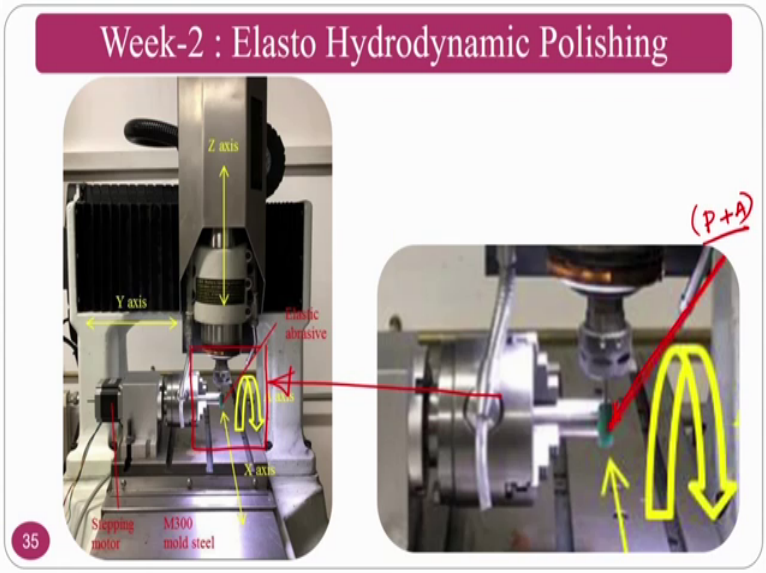

So, elasto hydrodynamic polishing where the people are generating the polymer based grinding wheels you can see the zoomed version of this particular thing here ok. This is a polymer grinding wheel where polymer plus abrasives are made and you can use this particular grinding wheel against any cylinder or any particular flat surface and other things. But, the advantage of this particular process is you are going to get less forces compared to vitrified bond where you can use the clay as a material that benefit enables us to do for a better surface finish.

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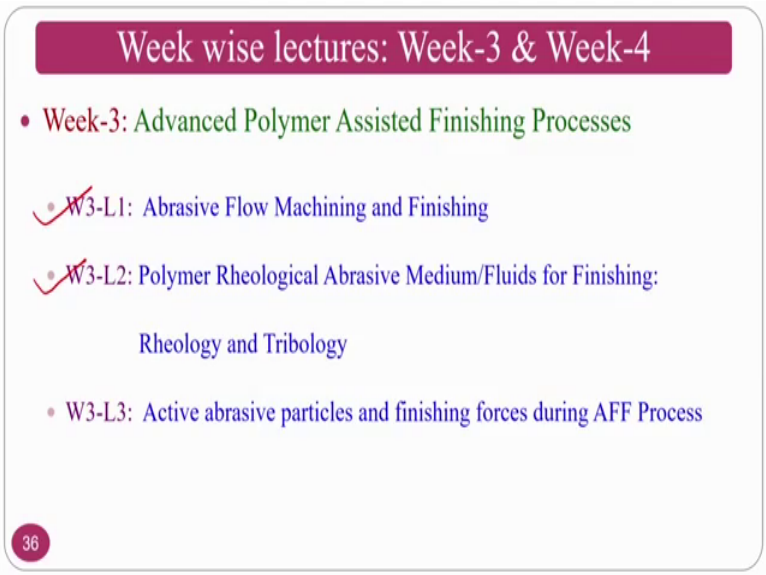

So, week 3 we are going to see the advanced polymer assisted finishing process where you can see the abrasive flow finishing process and abrasive flow machining process why it is called abrasive flow machining as well as why it is called as abrasive flow finishing process. Then polymer rheological abrasive medium and its rheology then we will see what is active abrasive particles and how this finishing process will help in removing the material.

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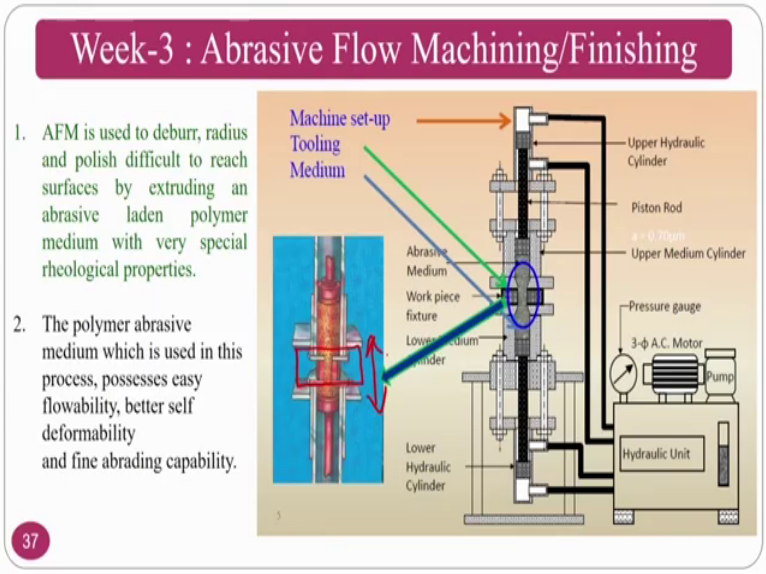

So, abrasive flow finishing process is one of the advanced polymer assisted finishing process where we will use polymer rheological abrasive fluids or polymer rheological abrasive medium. And, you will reciprocate through the workpiece this is the workpiece region and you reciprocate the polymer rheological abrasive medium and you can finish.

So, this is simple thing to see, but it is very complex to fabricate the medium and other things. Because whenever you have a glass of water if you put a diamond particle because of the density difference it may sediment that is why it is very difficult to fabricate the medium where the abrasive particles do not sediment and other things ok. So, in detail and other things you will see in 3 week of this particular course.

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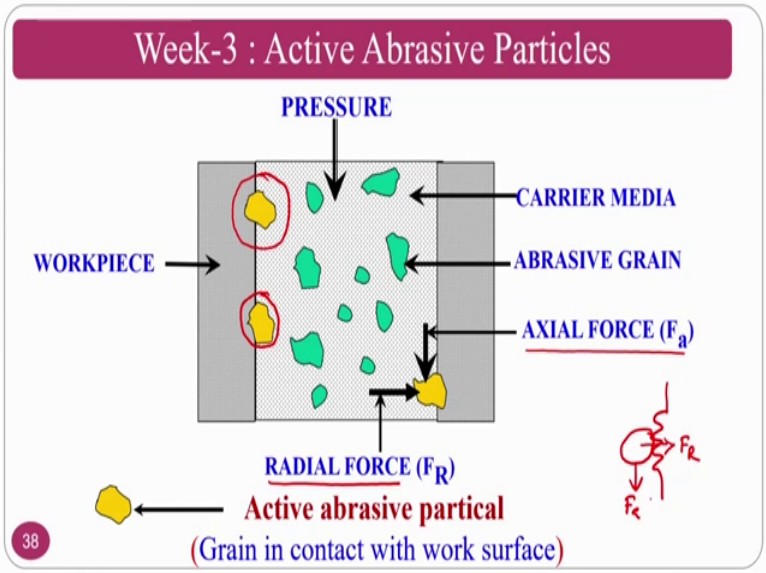

As I said what is the difference between active abrasive particle and inactive abrasive particle. Whenever you are reciprocating the medium by exerting some pressure what will happen those particles that come in contact with respect to workpiece are nothing, but active abrasive particles ok. And what are the pressures that are involved here is radial pressure as well as the forces that are involved in this particular process is axial force as well as radial force.

Axial force will move according to the direction of the applied pressure and radial force will move perpendicularly. Because of there is assume that you have a surface roughness like this abrasive particle because of radial force it will try to indent because of the axial force it will come in this direction. So, combination of F R and F a that is radial force and axial force you remove the material in the form of a microchip.

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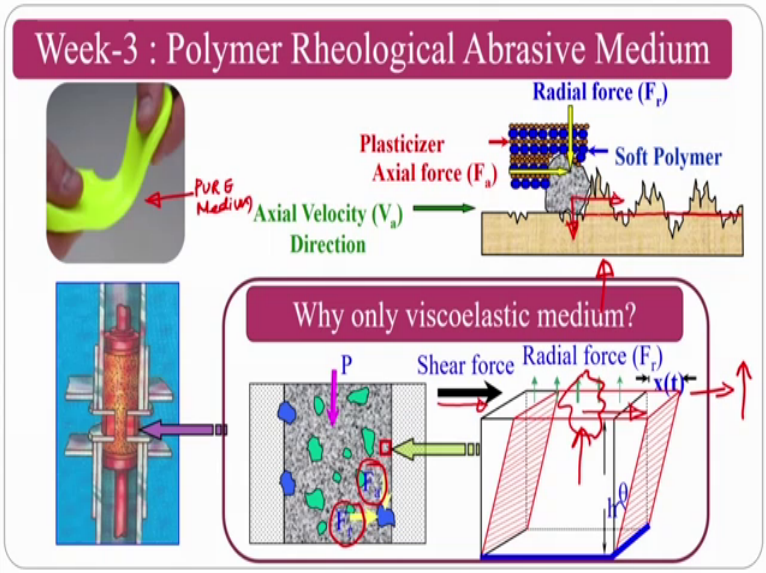

You can see here whenever you are applying a pressure P in this medium this is a pure medium this is pure polymer medium where your abrasive particles are embedded inside ok. So, whenever you have a medium you are going to exert pressure P because of this there is a axial force there is a radial force. This is nothing, but there is a (Refer Time: 35:35) effect will be there. There is a principle called (Refer Time: 35:39) effect whenever you are going to apply the shear force along this direction the axial motion will takes place on the same direction and there will be a another motion that is called radial motion ok.

So, if there is a abrasive particle here. So, abrasive particle will try to intent because of your radial force and it will try to come out with respect to axial force because of this the chip will come out that is why you can see in this picture. So, because of the radial force it will intent like this because of the axial force it comes like this. So that is why the surfaces will all go finish the surface peaks all will shear off and you will get a better surface.

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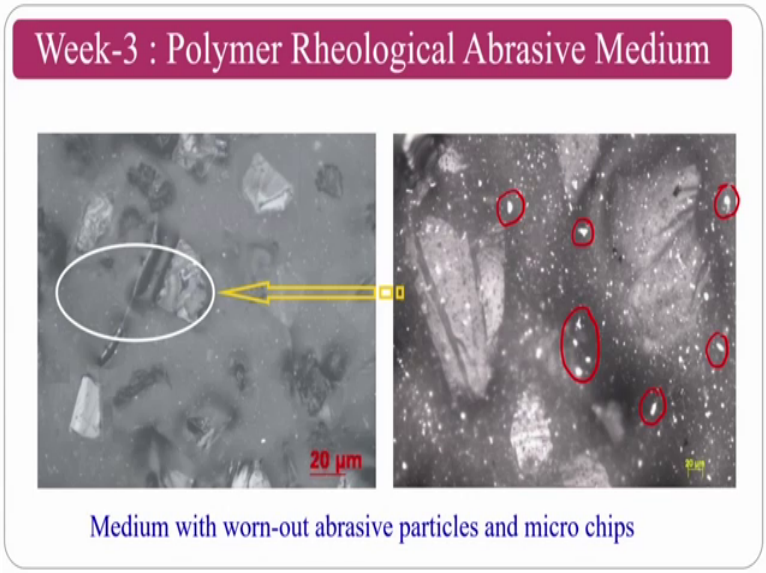

In this picture you can clearly see the polymer rheological medium after finishing action ok. So, what are the shiny parts that are seeing here is nothing, but the chips ok. So, the life of the medium also counts if you are going to accumulate more and more number of chips in this one then it will be a problem ok. So that means normally the literature says that whenever you have the original weight of the medium is 1 kg if it is exceeds by 1100 grams; that means, that 10 percent of its original weight then you have to discard the medium ok.

That is why you should always see the life of the abrasive medium. Many people might have studied about life of a grinding wheel life of a honing wheel and other things in this way the people also study about what is the life of a abrasive medium or in a advanced finishing processes also ok.

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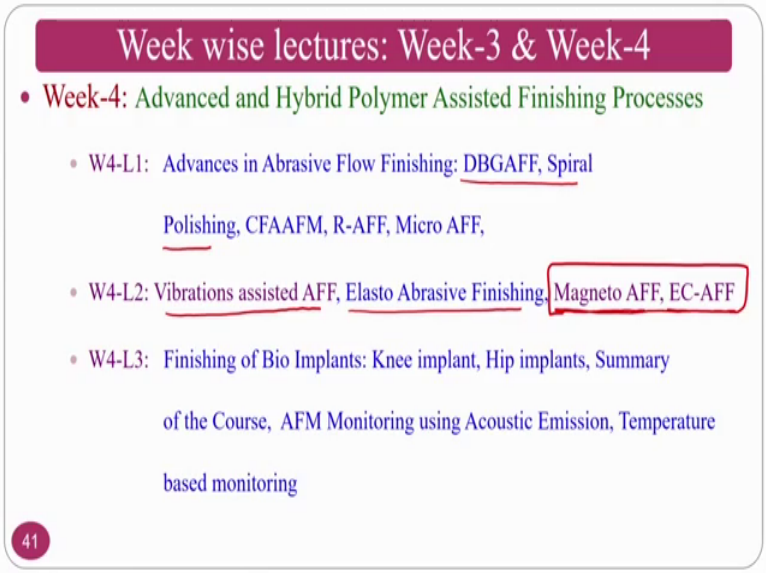

Week 4 that means, that last week that we are going to see is advances in abrasive flow finishing process that is drill bit guided and other things. And if time permits as I said this is completely a tentative plan some of the lectures may be taken in week 3 also. That is why I am mentioning week 3 and week 4 because some of the advancements can be taken up in week 3 itself ok. So, spiral polishing, centrifugal force, assisted rotational, abrasive flow finishing and other things. We will also see in the advancements such as vibration assisted, elasto abrasive finishing process, magneto abrasive finishing process, and electrochemical abrasive finishing process.

This magneto abrasive finishing process, electrochemical abrasive finishing process, comes under hybrid abrasive flow finishing process ok. Then we will see what is the practical applications some of the practical applications you might have come across in the previous slides also ok. Like by your implants like knee implant, hip implant and other things. And, if time permits we will also see about abrasive flow finishing monitoring using acoustic emission temperature based and the other things.