Polymer Assisted Abrasive Finishing Processes
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Lecture – 10
Abrasive Flow Machining and Finishing: Part-II

As we have seen the flow properties, now we have to go for the viscoelastic properties. How much viscous component is there, how much elastic component is there? As, we know that the medium has 3 properties one is a self-deformability, better upgrading ability, and better flow ability ok. The flow ability and other things can be understood from this particular graph that is called flow test, where you can understand the viscosity, upper end viscosity, and the shear viscosity as well as a shear stresses and other things. Now, as we know that the medium is a viscoelastic medium.

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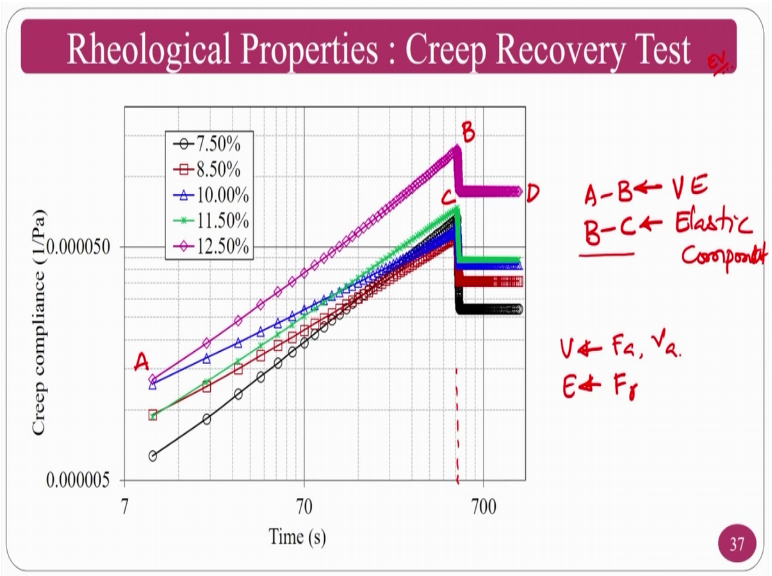

Now, we have to understand what is the viscous percentage, what is the elastic percentage in a medium. For that purpose we have to do the creep recovery test the creep recovery test. Means, you have to load or you have to strain the sample for a time and then you have to release. Now, it will undergo the viscoelastic change as well as elastic change the remaining will be viscous.

So, as you can see in this particular graph suddenly there will be a train is given and then what is happening is you are holding? So, there is something which you have to know we know point A B C and D ok. We will take any curve, because all the curves are following the same trend in that aspect.

So, you have to give certain stress or strain ok. So, assume that you are given a stress and you are observing the strain ok. Suddenly you have to give a stress and you have to hold it for a sometime. Now, the mysterious question here is that, how much stress I have to give that is the biggest question. So, whether I have to give 1 k g, whether I have to give 100 k g, whether I have to give 1000 k g or whatever the force in terms of force for that purpose what we have to do is we have to do the shear stress sweep test ok.

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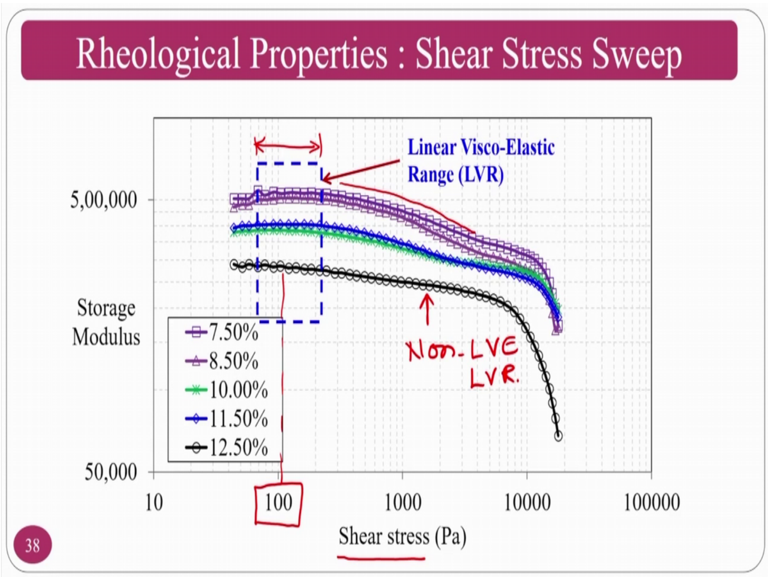

So, then we will get the answer for the creep recovery. So, what we are going to do in this experiment is we are changing the shear stress and observing the storage modulus ok. What we are doing we have kept the sample and continuously moving with respect to the shear stress change. If you are changing the shear stress all the graphs follow approximately same trend. So, you follow any 1 graph. As, you see at the initial stages there is some interruption is there, because from the static state to the dynamic state it is moving, because of which there is some stability problems are there. So, it is overcome in due course of time ok.

Later what it is going to do is it is not at all changing. I mean to say polymer rheological medium, that is kept between the plates, that is a the static plate, and rotating plate, and you are observing the storage modulus. Now, what is your seeing is there is no change in the in these region. Later on gradually there is a change ok; that means, that this is a L V E region, that is called linear viscoelastic region. What do you mean by linear viscoelastic region is even though you are changing the stress, but the polymer chains are at the original state.

That means, this is the non-linear L V E region or L V R region whatever you can say ok. So; that means, that the polymer chains are intact at original strength in the linear viscoelastic region, beyond which it is start breaking and it is going into non-linear viscoelastic region.

Now, the question is that, what is it is importance? Now, at means that you take any particular value of these in this region; for example, 100 Pascal ok, if you can take 100 Pascal and you put in the recovery that is a creep recovery test. That means, that whatever the viscoelastic properties that you are going to get will be at original condition ok. So, now, what we are going to see here is we know that, we have to find what is a viscous properties, what is a elastic properties, for that purpose now we understood that what is a load that we have to give?.

Now, what is the load that we have to give we have to give a load of 100 Pascal. So, that the polymers would not break, but they will give original values of viscous nature as well as elastic nature. Now, we can see that hundred Pascal we have kept from the storage modulus test, that is called stress sweep test and we are observing the strain ok. So, A to B is your viscoelasticity and B to C is your elastic component ok.

So, now, you can say the remaining is viscous component. What do you mean say, what do you mean by that, you are putting a sample in between the plates suddenly you are putting some stress and you are holding it for approximately 500 seconds. You are holding it for a 500 seconds, then you are releasing the load. That means, that you are giving a sudden load then holding and releasing during the holding of the L V E region load, what is happening is it is transforming or the transition is taking place in terms of strain. That strain is viscoelastic changes that is called A B, that is viscoelastic region, then you are releasing; that means, that whatever the elastic component that the medium will have will release; that means, that your B C is your elastic component.

Now, you know viscoelastic component and you know elastic component, if you can subtract then what you get your viscous component you will get. Now, I can understand what is the viscous component in the medium? What is the elastic component in the medium?.

Now, if I can experimentally find this viscous component as well as elastic component in that circumstances, I can understand whether this medium is elastic dominant or viscous dominant. If it is elastic dominant then what will happen? If the medium is elastic dominant what is happening your viscous assume that your medium is elastic dominant. So, your radial force will be high. If is viscous dominant then your axial force and axial velocity will be high. So, what do you mean by these if your medium is elastic dominant then indentation depth will be more, that you can infer from the upcoming slide.

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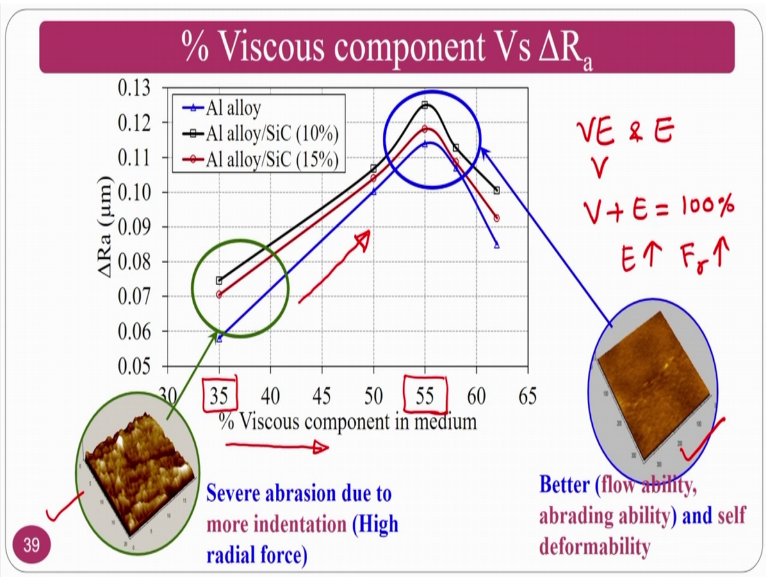

So you are calculating the surface roughness or the change in surface roughness with respect to viscous component. What is on the x axis you can see that is called viscous component? Viscous component how you are calculating you are calculating from the creep recovery test. You have viscoelastic element and you have elastic element, the from there you can calculate viscous component. How you are calculating viscous element plus elastic element equal to normally 100 percent ok.

So, if you know elastic component then you can calculate viscous component. Based on that what we are doing here is we change the different mediums, with a different viscoelastic component. And for example, if both are 100 percent now we are plotting with respect to viscous component.

If your viscous component is 35, what it means? It means that your elastic component is 65. So; that means, that your elastic component is dominating. If, your elastic component is dominating your radial force is very high. If your elastic component dominates, then your radial force will be high. If your red radial force will be high what will happen the abrasive particle try to indent on to the work piece. Not only the finishing it also creates it own dominating scratches that you can; obviously, see in the atomic force microscopy, where the surface is not only the shearing, but also a the abrasive particles are creating some indents as well as dominating scratches on it ok.

As, you increase the viscous component and it reaches to a good value that is called 55 at 55 the it is maybe a optimum better upgrading ability, because of optimum values of axial force, optimum values of radial force, you have sufficient radial force. So, that it will indent sufficiently and you have sufficient axial force, because neither radial force is big nor axial force is big.

So, you have a optimum value or the compromising between 2 values will be there and you are going to get better upgrading ability, better flowing ability, and better deformation ability. Because of which, you can see the atomic force microscopy picture here the surface is perfectly smooth surface ok. This is perfectly smooth surface and this is attributed to the optimum values of your forces and velocities because of the medium rheology.

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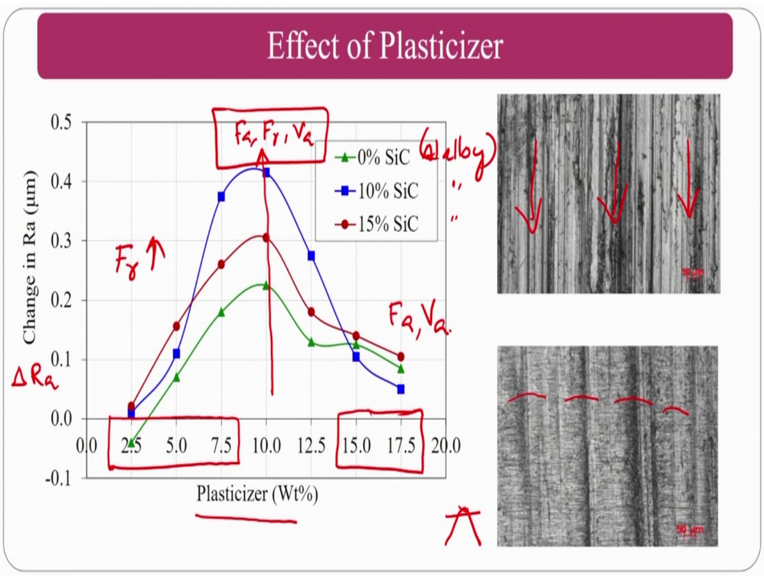

Now, we can see the effect of plasticizer effect of extrusion pressure and other things ok.

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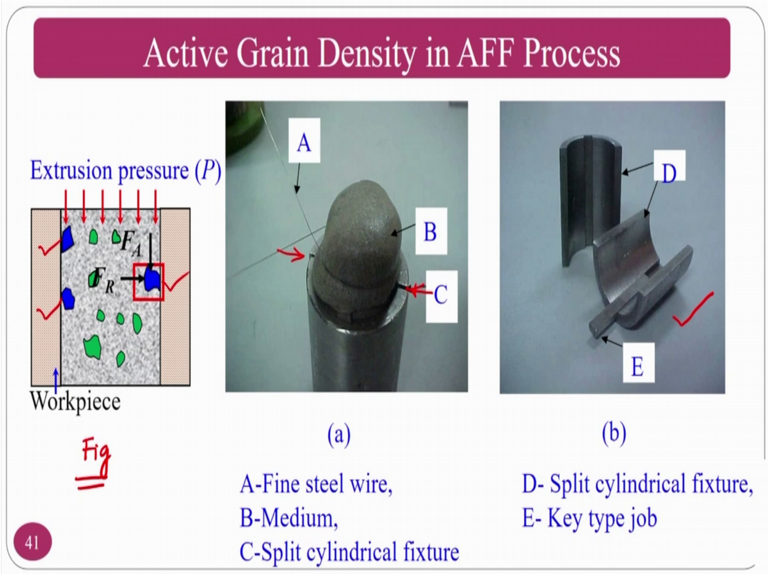

Before that what we can see here is that we should know what is active grain density and other things. Active grain density means, how much abrasive particles are presenting in the active region. This picture you might have seen this figure you might have seen in the previous slides. The active abrasive particles are those particles, which are directly involving in finishing operation. That is nothing, but in this particular figure the blue ones are the active abrasive particles ok. Now, I have to find the active abrasive particles. How to find? So, for that purpose Professor Gorana and Professor V K Jain they have experimentally carried.

And, a similar procedures are followed by many researchers also. So, just they place the medium in the medium cylinder and they try to extrude to the work piece. And, the work piece is made up of a split type of work piece that you can see here. This is a split type of cylindrical work piece fixture and they are extruding the medium half way done and you stop the process and you take out. And, this starting portion you will always get a curvature types. So, you can cut off. So, you can see here the cutting of this one is taken place and then you just split the 2 cylinders and you can get the medium slug ok.

So, what you are going to get here is that medium slug you are going to get, because you have a split here, you have a split here. Because of this you just divide 2 work pieces then you get a cylindrical surface of medium that is called medium slug.

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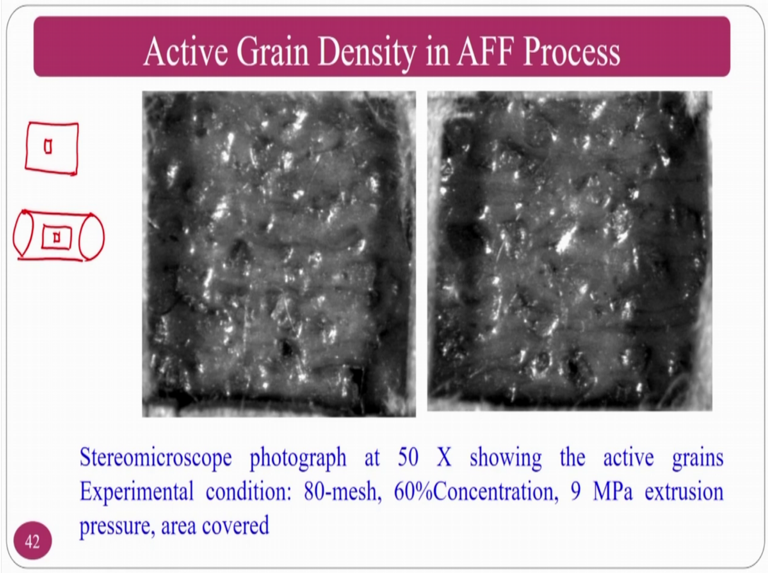

From the medium slug, what the authors have doing is just take some size. Assume that I have a medium slug where this is a medium slug on top of it what I am going to do or the authors have done is 1 by M, you take a paper just take 1 paper, and cut a small a square of 2 m m by 2 m m or 1 m m by 1 m m on it, then you place on the this one ok.

So, now you can take the optical, now you can take optical profiler meter images are stereomicroscope images and other things you can take. You know whether it is one by 1 m m or 2 by you have already kept a 1 by 1 m m or 2 by 2 m m square surface, and rest of the surface the paper will cover; that means, that only that surface is visible to us. Because, the paper assume that I am putting a normal paper on which we were going to write.

So, the stereomicroscope give me the number of active abrasive particles that are present on the medium slug per unit area if I am taking 1 by 1 m m. Now, from there you can easily calculate the number of active abrasive grains ok. If, 1 by 1 m m is this much, then you know the cylindrical length cylinder diameter and other things we know for the work piece material. Now, you can calculate with respect to surface area of the cylinder; that means, internal surface of the cylinder.

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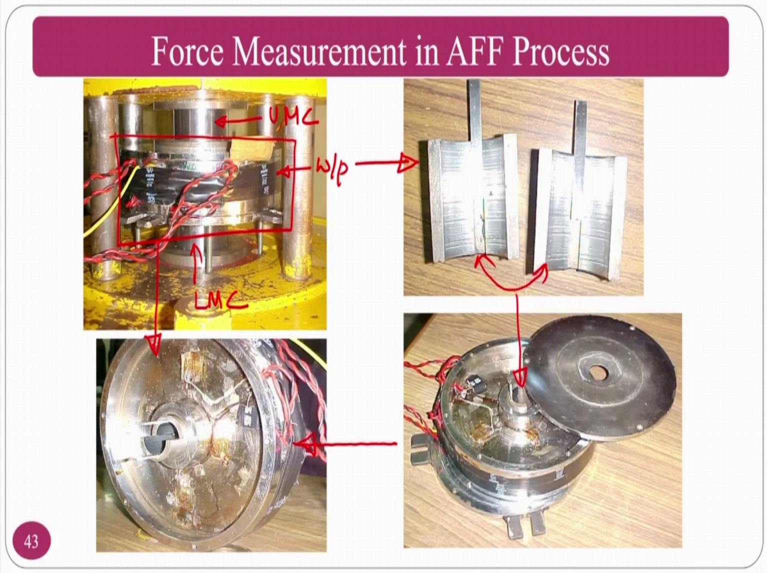

That way we can calculate the active abrasive particles. Now, we should also understand. So, no papers will give you how to measure the forces in abrasive flow machining process. Again, I am thankful to Professor Vijay Kumar Gorana and Professor V K Jain, they have done experimentation of force measurement in abrasive flow finishing process ok.

So, this is the first and I guess there is no other papers on force measurement. Those people who are interested in abrasive flow finishing process, they can do the force measurement. Because, some of the groups now recently doing on the force measurements, using similar type of dynamometers. Here what Professor Gorana and Professor V K Jain, they have did is they have developed a indigenous ring type dynamometer using the strain gages and other things ok. So, this is my medium cylinder I mean to say lower medium cylinder, this is my upper medium cylinder, in between I have work piece region ok.

The work piece region again will be a split type of cylindrical work piece. So, you can see what is the you can see, how this dynamometer looks like in this picture. So, it is a ring (Refer Time: 16:02) ring type dynamometer, where you can place your work piece and it will be if you want to see elaborative way you can see here also ok. So, these are the strain gages are mounted and you can fix your by clubbing these 2 work pieces, you can fix on to the ring type dynamometer ok.

So, various forces they have measured, the axial force they have measured, the radial force they have measured, and they have concluded experimentally and they have already done the modelling also. So, if at all in somebody want to know about a this force measurement and active grain abrasive particles measurement and other things, you can go through the papers of Professor Vijay Kumar Gorana and Professor V K Jain from IIT Kanpur ok.

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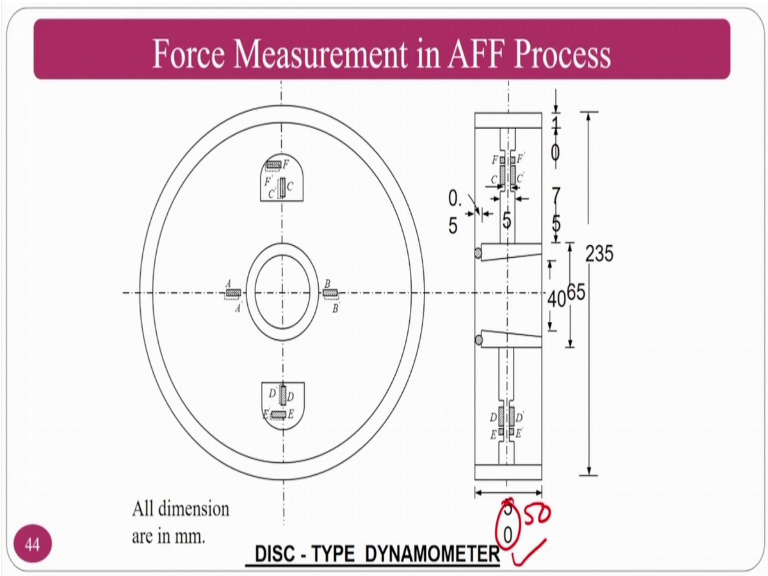

Once you have done this thing, then it is normally a disc type or ring type dynamometer that they have done. So, then now you have to balance the width stone beads and other things it is very common things that everybody will do. These are the dimensions of the disc type dynamometer, which is done at the IIT Kanpur. The schematic diagram, that they have done how they are mounting various sensors for measuring the axial force and radial forces.

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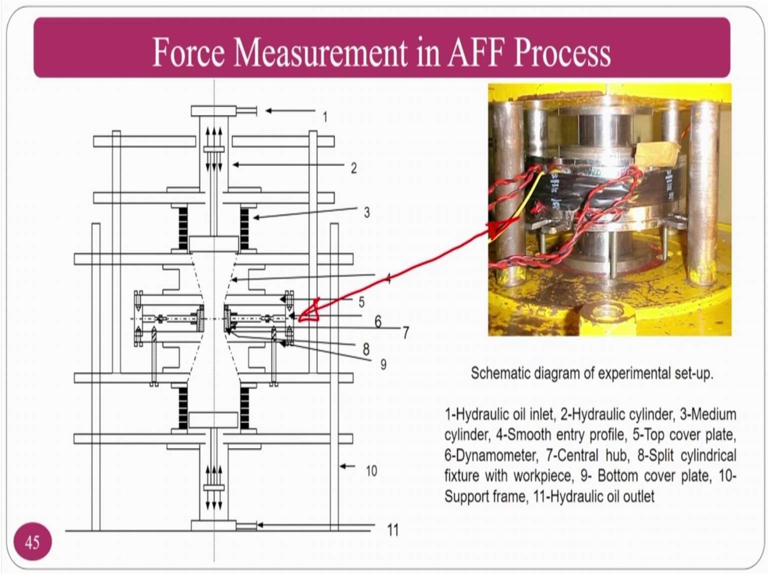

Ok. So, now, how they are mounting also we have seen there we have seen the schematic diagram if at all I want to see this is a original image and this is a schematic image. How they are going to mount the disc type dynamometer, wherein we have the medium cylinders on top side, medium cylinders at the bottom side, which are force by the hydraulic piston. So, that the medium moves in the work piece region whenever the medium moves in the work piece region, what is happening is the medium is exerting (Refer Time: 18:02) radial force exact in certain axial force those are can be measured by the disc type dynamometer ok.

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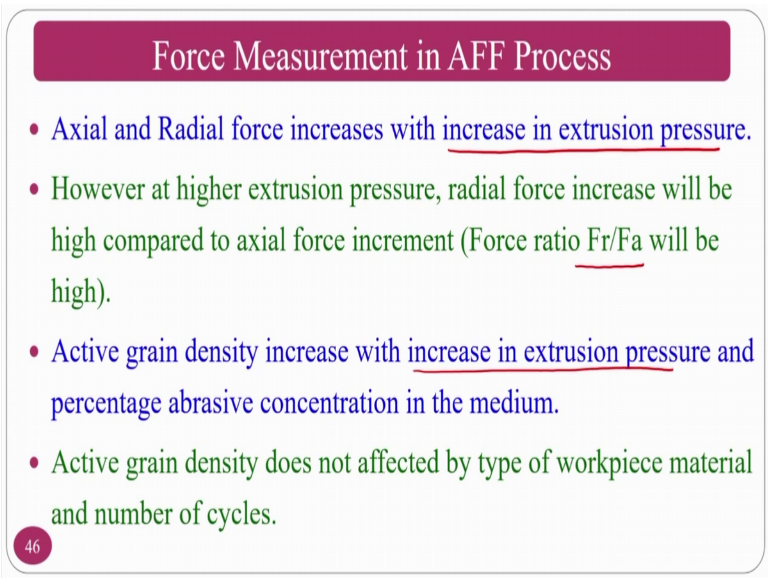

Force measurement so, axial and radial forces increases with the in increase in extrusion pressure. These are the some of the observations done by Professor Gorana and Professor V K Jain.

So, as you increase the extrusion pressure what will happen? Obviously, the pressure exerting on the medium by the hydraulic power pack or the piston will increase. If it is increasing, it is showed that, it is transferring to some place that is called the work piece; why work piece it is the most seizure zone or more restricted zone, because the diameter the work piece is much less compared to your medium cylinder. That is why; obviously, it is a high pressurized region that is; that means that axial and radial forces are high in that region ok.

However, at higher extrusion pressures ok. So, if at all I am using that T bar, or 3 mega Pascal, 4 mega Pascal, 5 6 7 8 10 mega Pascal. In that circumstances if I am using a 100 bar r 10 mega Pascal, pressure what is happening is the increment of the radial force will be high compared to your axial force. What I mean to say is if I have 5 mega Pascal. The radial force is assume the 5 Newton's and axial force is 10 Newton's ok. For the same thing if I am going to exert 10 mega Pascal ok.

So, 10 newton force that is exerting in the axial force will be increased to 20. In other case radial force instead of increasing 5 to 10 it is increasing to 5 to 15; that means, that increment at higher pressures or extrusion pressures is very high; that means, what they have told is radial force to axial force, that is called force ratio in abrasive flow finishing will be high. If that is the case the problem in the abrasive flow finishing process is your indentation is high compared to your axial force. You have axial force may be slightly higher, but the thing is that it cannot move the abrasive particle in axial direction, because the indentation depth is tremendously high compare to lower forces.

The active grain density increases with the increase in extrusion pressure and percentage abrasive concentration in the medium also will increase. So, if you are going to increase what will happen, you have the plasticizers, you have the polymers, and you have abrasive particles.

If, I am going to increase extrusion pressure the velocity at which the medium moves; that means, that the plasticizer moves will be very high followed by the polymer followed by the abrasive particle. That means, that number of abrasive particles in the restricted work piece region; that means, that work piece region is very very small compared to your medium cylinders that is why, that abrasive grains motion will be slightly less. I am not saying tremendously less or enormously less I am telling slightly less in that circumstances what is happening is that the number of particles staying in that region will be very high.

So, active grain density does not affect by the work piece material; obviously, it is nothing to do with your work piece material, maybe it depends on your medium viscosity and other things and number of cycles also ok. After, this force measurement as well as active grain measurements, we move on or we move back to the affect of plasticizer. If you see the affect of Plasticizer, what is happening change in R a; that means, that you are going to talk about delta R a.

So, as much as increasing; that means, that it will be better. So, you can see the work pieces the work piece is aluminium alloy with 0 percentage silicon carbide, and with 10 percentage, and 20 percent this is metal matrix composites ok. So, just we do not bother about the material of the work piece. So, it is nothing to do with the the current class, because it comes in slightly in a higher course. If, I am explaining only about abrasive flow finishing process and metal matrix composites and other things ok. So, we do not bother about the curves in the length wise in the Y axis wise we follow only with respect to plasticizer horizontally we will see.

What is happening here is as your plasticizer content is less assume up to 2.5 to 7.5; that means, that plasticizer is a low molecular weight material, whenever you blend with a polymer material; polymer is high molecular weight material. So, if you are going to blend what will happen it the cohesiveness of the polymer will reduce. Assume, that you are adding a very little like 2.5 or 5 in that circumstances, the polymer which is dominating elastic characteristics will be high ok.

The polymer is a viscoelastic material with elastic dominating characteristics. Now, if I am going to add plasticizer or I want impart the viscous properties ok. Hope you understood that I am having a silicone polymer. Silicone polymer will have viscous properties, but dominating elastic properties. Now, I want to manipulate or I want to adjust the viscous properties with respect to the medium by adding the some of the plasticizer. Plasticizer is a low molecular weight material and polymer is high molecular weight material, then you add it low polymer molecular weight material will embed, between the polymer molecular chains and tries to move apart. That means that the cohesive strength it is going to reduce ok.

If I am adding very little what is happening? The elastic dominating characteristics of the base polymer will be very high in that circumstances what you are going to observe is that it is not only finishing, but also creates indentations and other things ok. Because, your elastic dominating characteristics are there.

So, your radial force will be a dominating one. As you go on at higher assume that you are going to inc increase to 17.5 or 15, then what will happen your plasticizer content is so, high that it has lot of viscous properties very less, radial properties, or radial force is very less in that circumstances, it just slips over the surface rather than indenting the surface ok. Your axial force is a dominating one and axial velocity will be a another dominating one, that is why it just simply roles over the surface.

For example, this is the grinding surface and you have a grinding marks ok, just it is simply slides over; that means, that it is only shearing the top most peak or the top most part of the peak not the other (Refer Time: 26:04), but if you see at the middle region like 10 to 12.5 and other this region, what is happening your F a, your F r and your V a are approximately optimum, because of which you are going to get a better surface roughness change ok.

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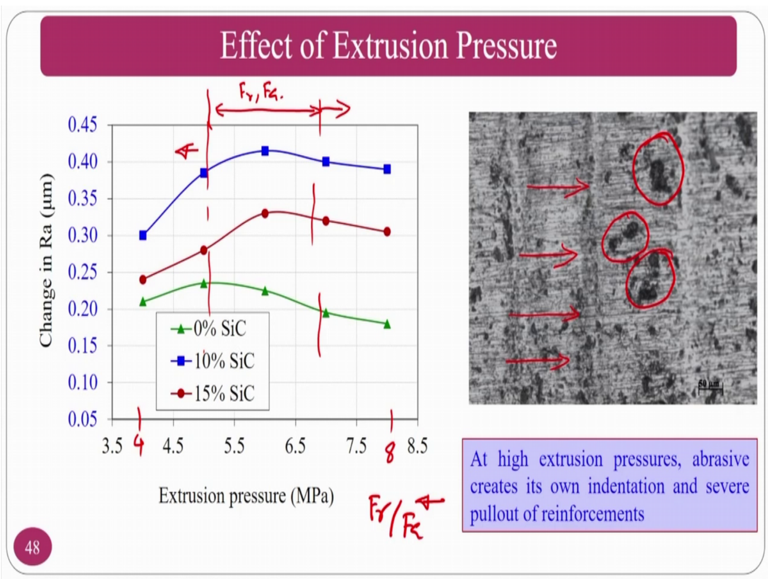

Now, we can see the extrusion pressure. Extrusion pressure also you can vary from 4 to approximately you can vary up to 8 or so, on you can vary 100 also ok, you can vary up to 10 also ok. So, whenever you see the surface, if the extrusion pressure is low; that means, that the medium cannot extrude ok. You have to do the preliminary experimentation at what extrusion pressure, this particular medium can pass through the work piece ok, that is the minimum extrusion pressure. Later on you can do some of the experiments ok.

If, I am going to use less than 4 mega Pascal for my setup whatever the setup that developed, it cannot extrude; that means that the finishing is not going to takes place. If, I am putting 4 now the medium starts flowing ok. So, if you see here if this is the region medium starts flowing and your forces are slightly less to do the surface roughness.

If you see at higher what is happening here is if your force is very high. If your force is very high your force ratio is very high if the force ratio is very high, you can see the indentation. That mean that your F r by F a is very high at high extrusion pressures; that means, that your radial force increments are high, that we have seen in the force measurement, that is done by Professor Gorana as well as Professor V K Jain.

This is indenting on the abrasive particles or indenting along with the surface finish, you can see the surface shearing marks very very small shearing marks along with what is happening here is it is also indenting the surface. Because of which what will happen you cannot go beyond 7 or something. At medium region what is happening here is you can get good F r good F a so, that your finishing will be better.

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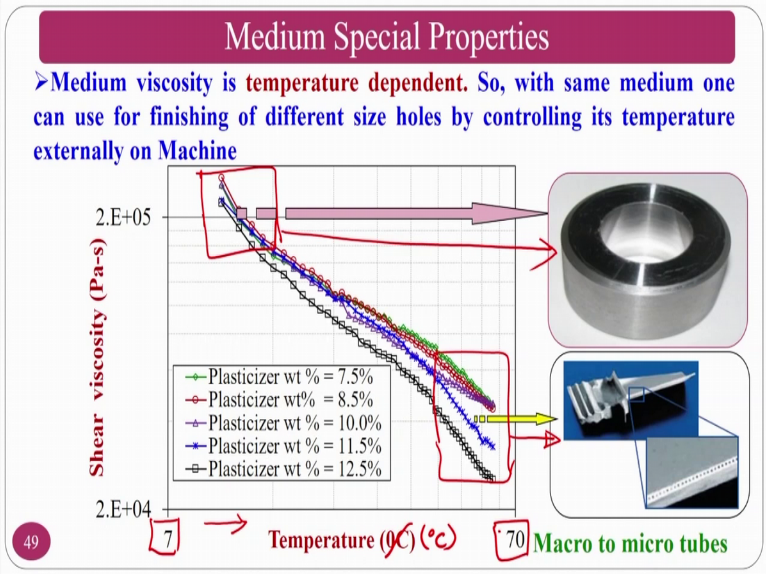

Now, the some of the applications assume that you have procured the medium now today your application is you want to finish a cylinder whose diameter is 100 m m. Tomorrow, if you want to finish a work piece material of 1 m m or 2 m m how to do? At the same time magnetorheological finishing processes or controlled or manipulating the rheological properties by external magnetic field ok.

So, using electromagnets and external magnetic field; here also abrasive flow finishing medium also, some of the reports says that you can control the viscosity; you can control the rheological property using the temperature. These polymers normally what we are going to use in the abrasive flow finishing medium or temperature sensitive, because of which what you can see here is if you are changing the temperature, please note that this is the logarithmic scale on the x axis as well as y axis, that is why you are getting 7 here and 70 here ok.

So, if you are changing the temperature degree centigrade. So, if you are changing the temperature from the lower temperature to higher temperature, what is happening is your shear viscosity gradually decreases; that means, if at all I want to finish a small hole, with the same medium what I have to do is I have to have a temperature controlling unit on the finishing region surface. And, you can manipulate the viscosities or you can have a temperature controller on the medium cylinders.

So, that if today I have a very big work piece I do not want any temperature change. Tomorrow assume that my work piece is small work pieces, then what I can do is I can increase the temperature. So, that the medium which is temperature sensitive can decrease the viscosity and this can pass through a 1 m m or 2 m m holes also ok. That is a beauty whenever you have seen that the plasticizer addition increases the distance between polymer molecular chains. Here also whenever the medium is exposed to the temperature, what is happening here is as the thermal energy increases or the gaining of the thermal energy into the polymer chains the polymer chains try to move apart ok.

Because of which with the viscosity will reduce ok. You can see any some of the polymers whenever you throw on to the fire or something in first it will become liquid then it will vaporize also some other things ok.

So, the requirement if your high viscosity is there you can do the big cylinders, if you have a low viscosity you can do the small holes applications that is a beauty about this one. And, those people who works in a abrasive flow finishing also can control the medium rheological properties. It is not only that magnetorheological people can do we can also or the people who do the abrasive flow finishing also can control by using the temperature.

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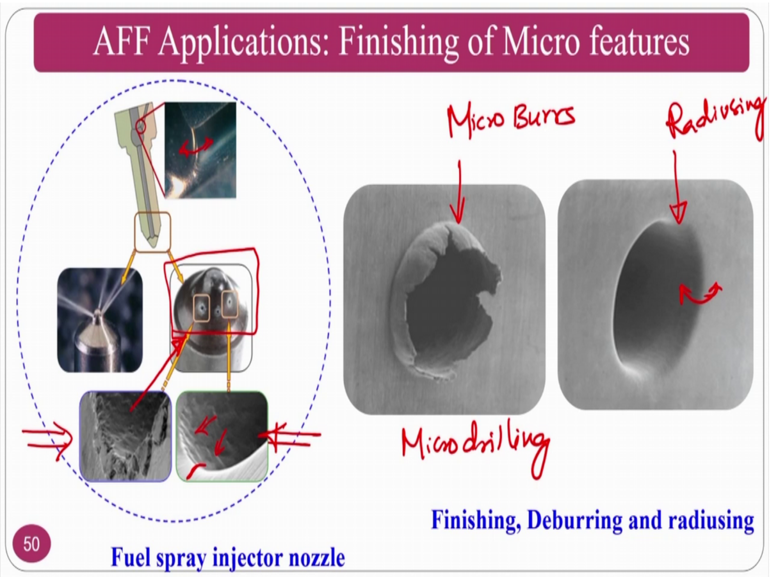

So, applications into micro features because your requirement is small holes in that circumstances, you can some of the applications is you can see here this is the fuel injector nozzles are the fuel spray nozzle injectors. Normally, these are the holes that are developed by micro EDM or laser or a hard steels ok. So, in that circumstances normally the surface roughness is very high like this surface. In order to finish these surfaces you have multiple options; one of the options is the abrasive flow finishing process.

The abrasive flow finishing process not only do the finishing of the surface you can see here the finishing of the surface, it is also do the radiusing ok. At the junctions also it do the radiusing. What do you mean by radiusing and other things this is a micro drilled surface ok, these are the burrs or the micro burrs.

Now, removing this is one task at the same time generating the radius on this edge is also another task this both the task can be simultaneously done by the abrasive flow finishing process, whenever you pass on the low viscous medium what will happen it is not only finishing the surface. It is also do the radiusing ok. You can see this is called radiusing. Deburring plus radiusing it can do. And, if you see the fuel injector nozzle what is the problem if you do not finish, that improper combustion will takes place because if I want a 10 m l per time for x type.

So, the surface of this particular surface is there and this will abstract sudden flow, instead of 10 it may send 9.5 for the engine from for the energy developing. In that circumstances what will happen improper combustion will lead to carbon monoxide. If you can do the polishing like this, what will happen, you may improve the efficiency. So, that the carbon monoxide emissions will be less, the efficiency of the engine will go up. This is a beauty about the abrasive flow finishing process.

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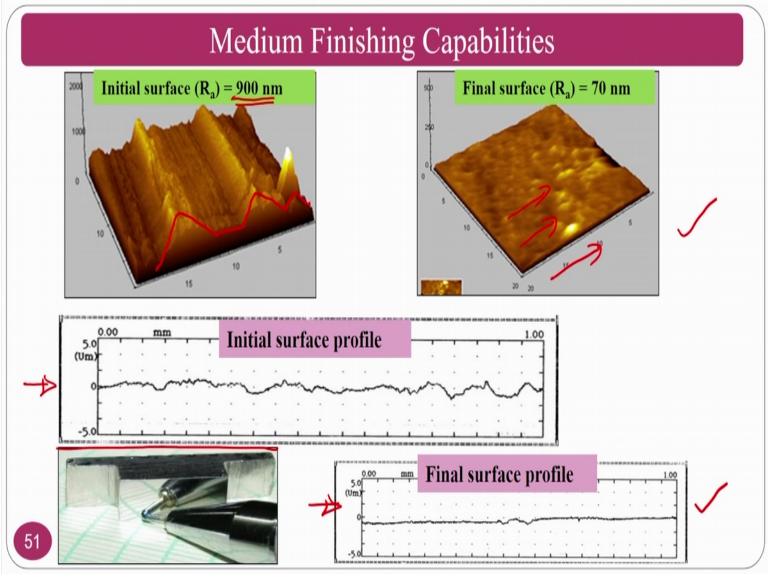

You can also see how the surface finishing is done using this particular abrasive flow finishing process, initial surface roughness is 900 nanometres. As, I said that initial surface roughness is the function of spiral surface roughness, because if you are going to give 10 microns and I want 10 nanometres it is not possible. So, whenever somebody want the Nano surface finish, if you can give a approximately some of 10 times or something, if you can give it will be ok. Assume that I am going to get 1 micron and if you ask me like 100 nanometres, that you can see here this is the initial surface that is done by the grinding operation.

And, after the abrasive flow finishing process you can see the how the smooth profile is generated in the abrasive flow finishing process and other things. This is the atomic force microscope 3 D images are provided. However, you can see for the long lengthy work pieces, you can also see the initial surface and final surface. And, you can even see how the mirror image of the pen tip, what out the pen tip is there. You can clearly see how the pin tip is showing on the finish surface. For the same this surface, we have measured using the contact and we have measured using atomic force microscope, to understand 2 dimensional surface profile, to understand 3 dimensional surface morphology and other things ok.

So, then this surfaces are mostly required for die industry, this surfaces are mostly required for many applications including biomedical and other things.

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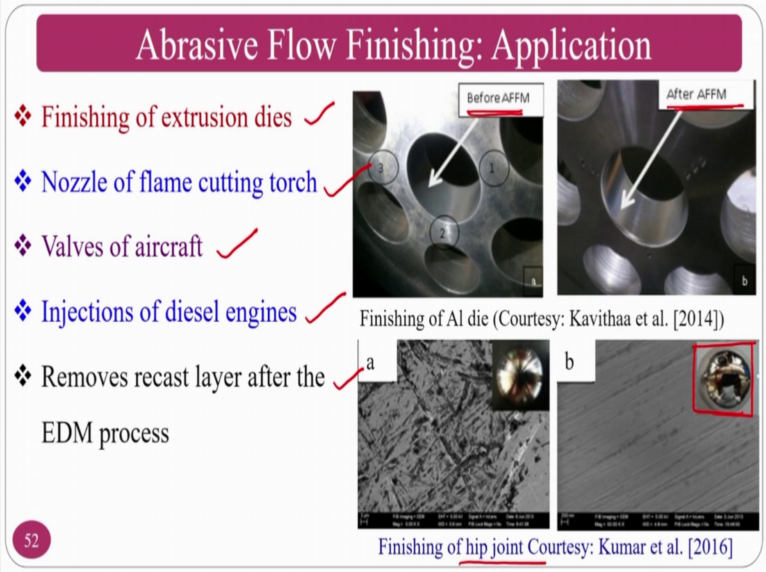

If you see the applications finishing of extrusion dies abrasive flow finishing process is required nozzle of the flame in the cutting torch, aircraft valves injections in the diesel engines, removes recast layer and other things these are the some of the applications where you are going to use ok. So, the dies industries you can clearly see the before abrasive flow finishing process and after abrasive flow finishing process.

This is the hip joint top surface, that is the acetabular socket has to be in contact with the this sphere. If the sphere is so, rough what will happen your acetabular head will be like this? Your acetabular socket will be like this. If it so, rough then it may eat away or it will have a terrible tribological characteristics, whenever if it is going in contact with the acetabular socket ok, that is why you require a better surface so, that the tribological conditions in the hip joint will be better.

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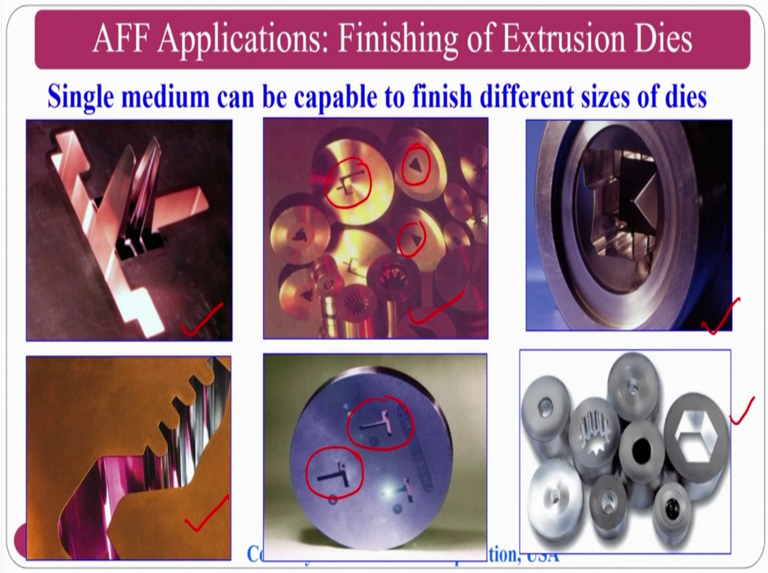

Some of the applications you can see that these are the dies that are generated simple to complex dies one can generate. These are the various dies for various applications one can use the abrasive flow finishing extensively, the die industries one of the biggest industry for the manufacturing of many things extrusion and other things. So, if your dies are not properly polished using abrasive flow finishing process or any other polishing technique what will happen? Your extrusion pressures requirement will be enormously high. The energy losses will be very high, because of the friction if the surface is very rough ok.

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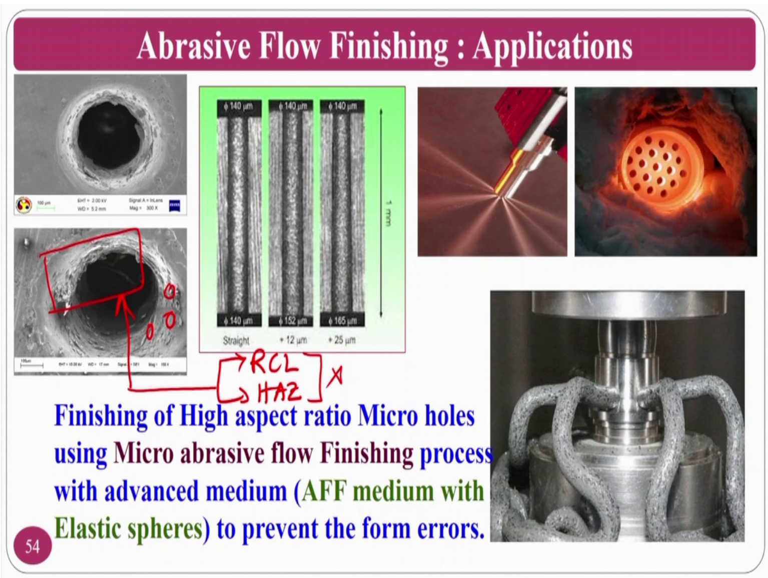

You can also do you finishing of this laser machine surfaces, because if you can see here this surfaces are thermally destroyed surfaces. This layers will have recast layers recast layer, heat effected zone, and many other zones. This recast layers has to be removed, otherwise whenever this come into practical applications these particles may go away and may causes lot of problem.

This application may be in biomedical application, this application may be in fuel injector applications, this application may be many other applications like filters and other places ok. So, you have to take care about this particular surfaces. So, that you can remove this recast layer and partially heat effected zone and other things so, that the good and parent surface will be exposed to the practical application.

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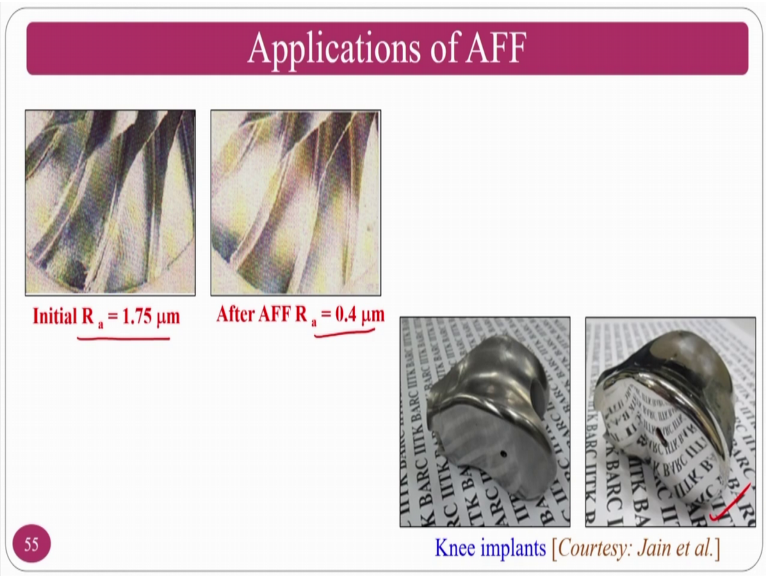

So, turbine blades (Refer Time: 40:15) turbine blades knee implants if you can see here initial surface is 1.75 microns and final roughness is 0.4 micrometres. The knee implant also this is another knee implant, you can do by abrasive flow finishing process, you can also do by the M R A F process and M R F process also ok. So, for a this process is done using M R F process. However, the same thing you can do by abrasive flow finishing process also.

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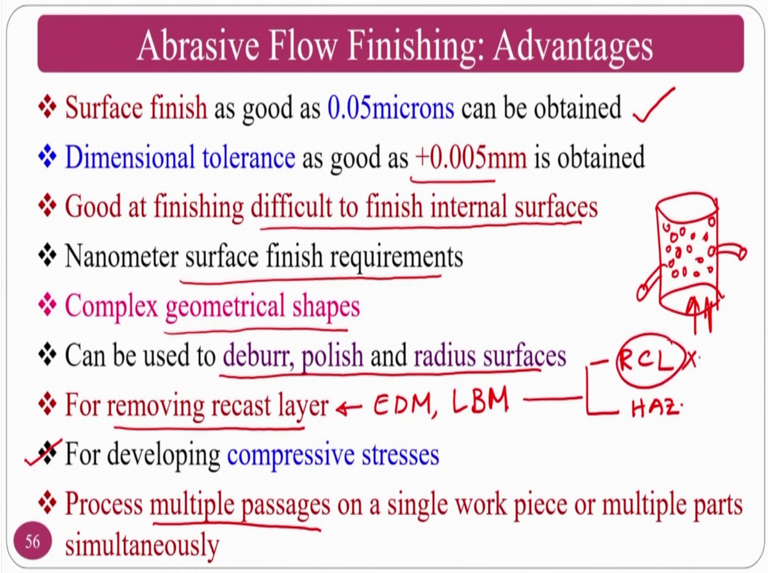

The advantages of abrasive flow finishing process the surface finish as good as 50 nanometres you can get, dimensional tolerances you can get up to 0.005 m m, and good finishing to difficult to internal surfaces, because internal surfaces some are some type of complex shapes will be there, sometimes there will be intersections will be there and other things.

So, solid tools cannot go. As you have seen this abrasive flow finishing process uses mostly polymer rheological abrasive medium, which is a acronym for this particular course polymer assisted abrasive finishing process. That means, that this is having a good potential, and you have to choose a right polymers, and you have to choose a right rheological additives, you have to choose right abrasive particles to do the finishing of complex surfaces that are made up of any other work piece materials.

The nanometre surface finish requirements can be achieved complex geometry some shapes can be finished. This can be used to deburr, polish and radius the surfaces, you can do simultaneously deburring polishing; that means, that surface finishing you can do and radiusing also you can do ok. For removing the recast layers as I said the E D M Surfaces; Electric Discharge Machining surfaces, Laser Beam Machining Surfaces. This surfaces as I have shown you in the previous slide there will be a recast layer heat effected zone and other zones.

These are to be finished at least recast layer should be removed. Otherwise it will be a problem. For developing the compressive stresses, because of the reciprocation of the medium in the contraction region of the work piece what will happen compressive residual stresses may be incorporated inside the work piece material.

So, for multiple passages on a single work piece or multiple parts can be done, because this is a medium, if you can design your fixturing, you can do the multiple components at a single time, if your medium cylinders are big. At the same time you can also do a single work piece with multiple holes (Refer Time: 43:20) ok. Some other slides you might have seen a work piece with this type of cylindrical surface where you have lot of holes ok. These are all holes can be done or finished using one way AFF process ok.

Whenever, you have studied about the one way abrasive flow finishing process, whenever you extrude the medium from this side all the medium is coming out from this one ok. So, a single component with multiple passages or the multiple holes can also be finished, and if you have big cylinder, medium cylinders, you can accommodate a small component in a many way and you can do the polishing or the finishing of this one.

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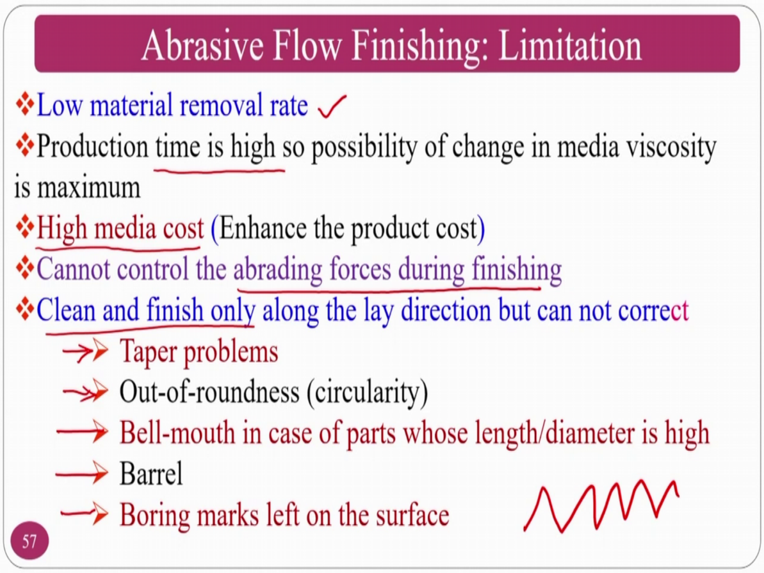

So, the limitations of this abrasive flow finishing process material removal rate is very low; that means, that the F efficiency if you are seeing from the point of material removal it is not good option, but if you see from the point of finishing it is a good option. Because, as I explained you in the first lecture that difference between a machining and finishing; the difference between a machining and finishing in machining process you see, what is the material removal? How much material I am removing per unit time?.

But, you do not see the same thing in finishing operations, whatever the less material is removed no bother, what is the final surface that I have achieved ok. That is the challenge and that can be achieved by abrasive flow finishing process. If you are looking for a machining or material removal then abrasive flow finishing process is not a right process. If you are looking for a finishing applications getting a Nano surface finish then this process is good ok; that means, that low material removal rate production time is high. So, the possibility of change in viscosity will be maximum.

As I said the work piece region is much much small assume that your medium cylinders are cylindrical in shape your work piece also a cylinder. So, the medium cylinders are assumed it is 150 m m, your medium cylinders are 150 m m; however, your work piece is like 5 m m or 10 m m or 20 m m. So, the relation ratio is very high, if it relation ratio is very high friction will be very high, if the friction will be very high; obviously, the temperature generation in the machining region or the finishing region of abrasive flow finishing is enormously high.

If the temperature generation is very high, if you are going to have high number of cycles, then medium viscosity will change. If the medium viscosity will change, because of the temperature the holding ability or the abrasive particle that is holding can loosen; that means, that the grade from hard grade it will change to soft grade ok. So, your work piece is not changing; that means that your efficiency of the medium will go down.

Medium cost is very high, because this medium is normally sold by some of the companies like Kennametal extrude hone, micro flow, there are some companies from Germany and Europe, there are some companies from US and there are some companies from China also. So, if at all you want to procure the medium cost is slightly expensive like; extrude hole medium as I said Kennametal extrude hone medium. If at all you purchase then it is expensive like a 2 cases is like 4 lakhs, 5 lakhs, and a rupees ok.

So, the if you are going to use this medium in your practical application then it will be a the product cost will escalates enormously up. For that purpose you if you can develop your own medium that will be better. Cannot control the abrading forces during the finishing like, compared to M R finishing process magnetorheological finishing process, which you see in the upcoming classes just a glimpse you will see you do not see what is magnetorheological finishing and other things, other things. Just you see how magnetorheological finishing works? Because, magnetorheological finishing works by controlling the magnetic field, you can change the viscosity, you can change the finishing forces, but here you cannot control deterministically.

However, as you have seen in a previous slides, you can control up to certain extend by temperature ok. Temperature if people can do the enormously the work on temperature controlling of medium, then it is also can be controlled in a good way. Clean and finish only along the lay direction, but it cannot correct the taper problems. If it there is a existing a taper problem in a work piece itself it cannot do ok. Out of roundness up to certain out of roundness it can correct, but if it is 2 then it is not bell mouth barrelling and boring marks and other things, boring marks are predominant type of marks which you get like this. So, this it is very difficult for abrasive flow finishing process to do up to the valley level.

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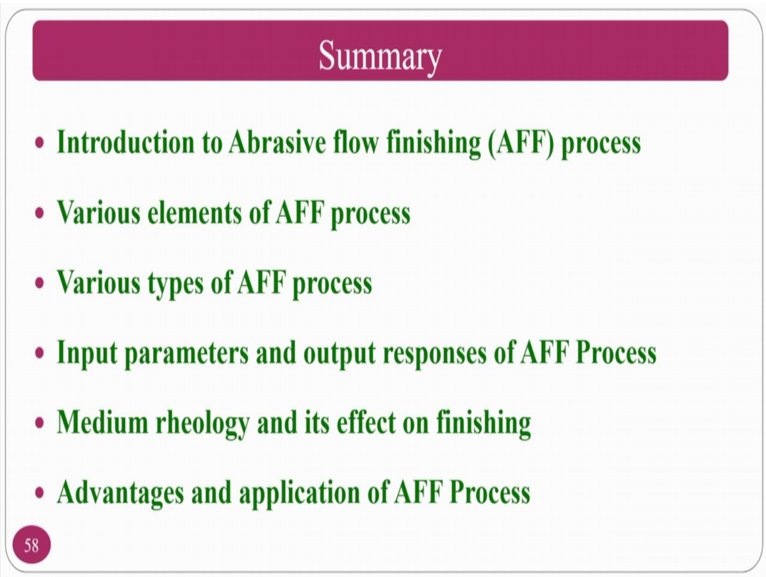

The summary of the class we have seen some of the things in the at the start of the abrasive flow finishing, introduction various elements of abrasive flow finishing process, various types of abrasive flow finishing process, input parameter output responses, medium rheology and it is finishing action advantages and applications ok. So, abrasive flow finishing process is a one of the commercially available and most required to the industries. So, that is why the many people who want to do research in this area can always welcome and many people are doing also in India. So, some of the research groups that are working from IIT Roorkee, IIT Kanpur, NIT Jaipur, IIT Madras so, on there are many many new institutions also working ok. So, you can also work and you can publish very good journals ok.

So, as I said that this particular process the finishing rate is less, because of which what will happen high time taking will be very high. If, the time taking is very high what is happening is medium viscosity goes down. For that purpose what we will see in upcoming classes is that we will see how to improve the finishing rate, by providing the rotational speed to the work piece, rotational speed to medium, and vibrations to the work piece how these are all can work and other things we will see in the advancements of abrasive flow finishing process. At the same times some of the people they have used hybridization; hybridization means clubbing one process with another process like EDDG; Electric Discharge Machining is Clubbed with Grinding. So, electric discharge grinding is there.

Similarly, people have used magnetic field clubbed with abrasive flow finishing process, they have done ultrasonic machining clubbed with abrasive flow finishing process and they say vibration assisted abrasive flow finishing process and so on. Electrochemical machining also clubbed with abrasive flow finishing process these are these are things we will see in the upcoming classes; the 2 varieties to incorporate the finishing great improvement, one is advances in abrasive flow finishing process we will see and we will see hybridization of abrasive flow finishing process and.

Thank you for your kind attention for this particular class.