Introduction to Machining and Machining Fluids
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Lecture - 10
Tool Wear and Tool Life Part-2

So, we are discussing about the tool wear and tool life and we are also into the variables that are affecting the tool life ok. Till now, we have seen these are the, variables that are affecting the cutting conditions, tool geometry and tool materials or materials, as well as the type of cutting fluid and the cutting fluid application technique

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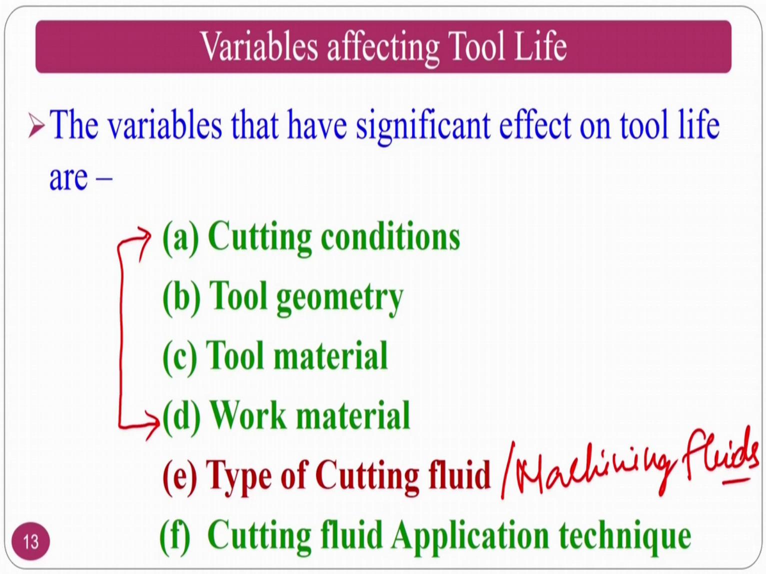

Now, we are discussing about the variables affecting the tool life, as you can see these are the a to f are the variables, that affects the cutting tool life, the cutting conditions, tool geometry, tool materials, work piece materials, cutting fluid type, and it is application techniques there are various techniques. So, till now we have seen 3 things that here is cutting conditions, we have seen tool geometry, we have scene and the tool materials different materials, that are from HSS to diamond we have seen.

Now, we are going to see how various work piece materials that will affect the tool life?. So, the m number of materials as the world progresses, we are coming across the variety of materials. So, those are nothing but the work piece material as the world grows the advancement grows; you are coming up with various work piece materials. If the work piece material is harder, you will need to take the tool materials also harder. So, that is about the work piece material.

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Now, we will go into the work piece materials. So, there are variety of work piece materials ranging from, soft tool hard tool brutal ductile. It is a overview slide where you can find the many of the world peace material brass these 2 are not the brass, but these are the brass work piece material, copper work piece material and the gold. Normally I cannot say that do the machining operation, but some of the special cases one do the machining operation, such as to fabricate the car and all those things and the silver and all.

These are the overview of materials and the world progresses we come across with to some of the biomaterials, ceramic materials and all those things come across with to some of the biomaterials, ceramic materials and all those things come across with to some of the biomaterials, ceramic materials and all those things.

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Anyhow this is just a overview t, we just go into the different materials that we come across. Silicon carbide is one of the ceramic material, it is very difficult to machine the ceramics, because these are the brittle materials and hard materials.

These are 2 properties. These are the brittle and another one is a hard materials. So, because of this it is very difficult to machine this material, another advanced material is the Titanium and bits allows. So, the basic problem in machining of Titanium is that, it is a poor thermal conductor, suppose if I want to machine this one what will happen? If it is a portable conductor during the machining operation if at all I want to cut the Titanium, the chip is moving and the it is a poor conductor.

So, the temperature stays in the machining region, itself are at the same time the temperature stays at the bottom of the chip. So, the bottom of the chip gives the temperature to the work piece, are the same thing the temperature that is staying on the one piece also, will important to the tool.

So, the tool thermal softening will takes place at early stages that is one of the disadvantage, but the same is take considered as the advantage in machining of aero specialized, for turbine blades and all those things.

If the temperature is stays on the surface, whenever the flight is travelling at a higher altitude, the air comes and give the surface temperature is very high that cold air will takes off the heat that is generated. That is one of the advantage, that is why mostly Titanium and it is allies are used in 2 applications, one is biomedical application, another one is aerospace application the.

So, these are the 2 applications normally, see in the aerospace I already said the turbine turbine components and all those things, if you come to the biomedical applications normally, Titanium and the Titanium alloys are considered to be the bio inert materials. So, they will cause anything to the body that is why, some of the implants like knee implants hip implants, these are all developed by the Titanium.

So, you know we will come across how these are machined and all those things in a big way, I mean to say in a elaborate way in upcoming classes; however, I will show you some of the glimpse just to do the introducing of these materials in this class. So, that is about advancement of the materials ok, I can say these are the advance materials.

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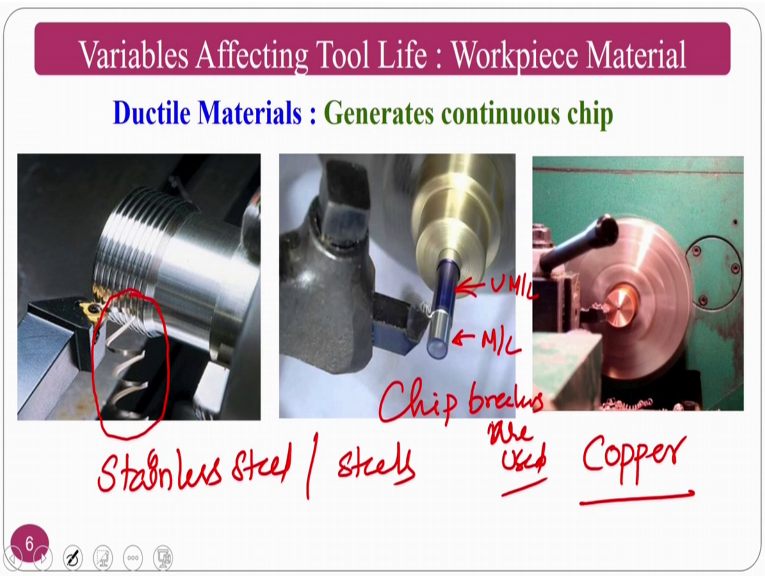

Now, coming to the ductile materials, the first variety of the work piece materials are ductile materials. Normally the leopard material ranging from stainless steel, this is a stainless steel and this is the copper. So, the stainless steel are with iron based steals. So, machining this normally generates the continuous chip, as you can see here it generates the continuous chips.

[Vocalized-noise] Most of the ductile materials generate continuous chip, because of each tool life because, why we are saying because we are studying the effect of this work piece material on the tool life. So, if a continuous chip is flowing on the red surface of the tool, there will be a continuous heat going into the tool, at the same time the there is no vibrations, because the system is continuous and the tool life will be good and all those things.

So, if the only problem with these materials is entanglement of these chips and on the finishing region or the machining region is another problems ok, apart from it there is no much problem. That is why, normally we have studied in the previous classes, the continuous chip is good from the point of power consumption, because low power is consumed at the same time surface means point of view.

But whenever this chip, if you see the figure number 2 figure number 2, if you see where the chip is entangled there itself. If the chip is entangled there, if it is slightly entangled under finish surface, if you see this machined surface this is unmachined surface.

So, if the chip rub circle as this one, what will happen? This will damage the surface finish of the work piece. So, I do not want this to be entangling, for that purpose normally some chip breakers are used. So, this is about the tool life ok. Tool life in the improve, if we can use chip breaker from the continuous chip, whenever admission in the contiguous.

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So, whenever we are going to the brittle materials, ductile materials will give the continuous chip, but the brittle materials normally the basic examples of the brittle materials is the cast iron. The first one whenever we think about the brittle material is a cast iron, normally in the short from we call it as a CI.

So, it will generate the discontinuous chips. The second is brass and you can see the discontinuous chips, discontinuous chips are lying on the lay bled.

So, the one noting point that you can see here is, on the tool life. The first I will speak about the tool life and I will speak about some other thing about the cutting fluid also, I will come to the point cutting fluid later whenever we are machining these materials, tool life will be good. If at all you are machining a basic brittle materials, like cast iron and brass, because if these are the very hard materials normally, if you go to the brittle materials like Silicon carbide, Alumina, Titanium nitride, boron carbide these are the very hard materials.

So, if you what are you are going for there, because of the interaction between these 2, the hardness ratio if you are maintaining the tool which is much much harder than the work piece that are using, then there is no problem. Whenever you are going for the harder materials, then assume that I want to be thin Al 2 O 3 or SiC and still my cutting tool is coated Carbide, then hardness ratio between 2 will be very less. The work piece hardness to the tool hardness is very less. In that circumstances the basic problem comes is, tool where will be high.

So, from the chip point of view this is better. Discontinuous chips are coming so, it is; obviously, better. So, there is no formation of continuous chip and damaging of the final machine surface is not problem.

So, now the, my question to you is, regarding the machining of the cast iron. There are some questions, whenever you go to the interviews because I face this question when I was masters. So, the question is that a which type of cutting fluid that you will use when you are machining the cast iron?

So, let me answer this question, normally cast iron will have high amount of carbon, and the carbon in the form of graphite. So, the answer is just it is a confusing answer, whenever somebody asked about the machining of the cast iron.

So, normally nobody are minimally you do not use the cutting fluids, the reason I mean to say cutting fluid is not used, just they may have asked to know the technicality of this process and all those things ok.

So, no cutting fluid will be used practically, but whenever the high depth of Kerten high fluid, if you are going may be used, but normal conditions whenever you are going for a low depth of Kertan in the low feed rate in that circumstances cast iron will have, high percentage of carbon will be there.

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So, carbon in the form of graphite graphite if you see nowadays people talks about graphing and all those things. So, the graphite act as a self-lubricant basically. So, whenever you drill a hole in a cast iron, whenever you do machining like if you see for example, here cast iron is machined here.

So, no cutting fluid is used, because the carbon content which is in the form of a graphite, in a cast iron will act as a self-lubricate. If I have already lubricant within the material, then I do not need to use additionally lubricant, why you have to increase the product cost?

So, normally cutting fluids are not used, whenever you are machining the cast iron ok, particularly because of the it will act as a self-lubricant.

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So, another materials are hard materials, hard materials some of the brittle materials are also called as a hard materials, but what I mean to say is a if you seen hard materials, whenever you try to machine it, there is a lot of spark will come. So, the spark in terms of you may say this it looks like a fire, that we can see in the video. See the video shows the turning operation of hard steels. This is the experiment that done at our laboratory, when I was studying.

Hard steals are machined by the coated carbides, since there is a hardness ratio is very less at the same time, the interaction forces are very high. Because of which you can see the chips, which are in terms of the chips are like reddish chips are coming out, at the same time if you see the process stops like this. If a process stops like this are, if it is continuous where you can see the chip is entangled there ok.

So, I am machining a hard material, but hardened steel is a ductile material ok. So, ductile material is giving us the continuous chip, since I am using moderate depth of kerten fluid at the moderate speeds.

So, the red coloured chips are coming out, which is very dangerous from the point of operator as well as from the point of tool wear also, at the same time chip entangled there in the machining region. If you see the chip is entangled there in the machining region,, which imparts the more and more temperature all to the rage surface of the tool. So, this causes or this reduces drastically the tool life.

So, this is the basic problem whenever you machine the hard materials. This is about the turning process normally this is what the turning process, turning of hard materials. This is the milling, this process I will go in future and I am going to talk about this one, same phenomena you can see there also. If are tall a normal milling is done where the cascade or something this would not come, but wherever you are going to use very hard work piece materials, normally hard this is another one statement is there that is called hard turning.

Normally, people say hard turning, hard turning is where the work piece hardness is above 50 HRC, normally 50 HRC that is rock well hardness scale, see it can be some of the textbooks they refer it is 54 some people they refer there is a correlation between the speeds and hardness, some of the textbook they say that is above 60 ok.

Normally for the basic introduction purpose, you can assume that if you are going to machine a work piece material, whose hardness is above 50 HRC, normally you can call it as a hard machine, but 50 plus or minus fine ok. So, it can be I cannot say minus I can say only plus. So, this is about the machining of the hard materials.

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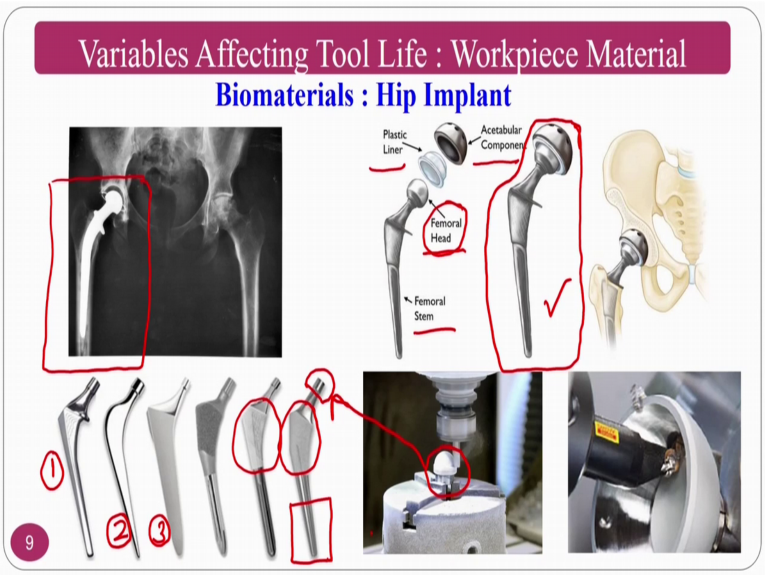

Now, we come to the machining of biomaterials. So, the basic purpose here is, a material you have seen the hard materials you have seen the soft materials and you have seen the ductile and hard materials and all those things. Whenever you are going for the implant materials like, the hip implant and knee implant and all those things the first you see is, whether the material is biocompatible or not or, whether it is a bio inert or not, you cannot use straight away mild steel or cast iron as a bio implant material.

So, normally these materials are hard materials ok, basically these are biocompatible materials, with slightly hardness and either it can be biouneta also ok. So, if you see the implant material, where is a hip implant is placed here.

So, how to fabricate this one? This hip implant we will have many components like, femoral stem is there, femoral head is there, some plastic are the synthetic liner is there, at the same time establer socket is there. So, these are the different components that are assembled and form a hip implied blend.

So now, how to machine this one? It is a big challenge because machining of the femoral stem is different process, femoral head is a different process, establer socket will be a different process. Normally, this femoral head and femoral stem can be dissembled also. Because this can be manufactured by different process, normally machining finishing and all those things will takes place ok.

So, why I am emphasizing about the machining of these things is, this if at all like you have seened hard machining. If there is a high temperature generation during the machining operation, the basic problem comes is it is metallurgical properties goes back, it is surface integrity goes back ok, what do you mean by surface integrity? Ok.

So, surface roughness plus surface metallurgy combinedly called as a surface integrity, because whenever I do the machining operation, I want to retain the basic properties of the parent material that is my objective, but if you see like the previous video, where the firing is there and all those things.

When there will be a temperature effect or the work piece, if that is the case normally the femoral stem that normally, if you see the femoral stem. This is machined and code different stems are there, to the basic stem if you see the first one this is basically machined by the milling process. If you the milling process is like previous one where the, that 5 chips red colour chips are going, then the metallurgical aspects of the this will go back.

So, I do not want that. For that purpose, I have to machine with a good at the time I have to choose my machining conditions properly. So, that my surface roughness what I will get is better, as you can see in the tool the surface roughness should be better, it is shining and all those things. And it should give you a property where whether I want it super hydrophilic property or super hydrophobic property and all those things, let us depend on normally I require hydrophilic proper. So, that I can code the biomaterials on it, as well as whenever you implant in it the cells will grow on it.

So, for that purpose, normally you do a safe machining process that about the stem. So, you can see under 3 normally coating is there. So, different people will coat at different locations, dissolve the bio ceramic coatings are there ok, different companies will coat or not different ok. We are not talking about the coating anyhow, why I am talking about the coating I have to such a way that I have to get the proper surface roughness.

If I have the proper surface roughness then my fluid my the surface wettability, I will get properly and the surface wettability is besides my contact angle that is surface wettable itself is a contacting. So, it will decides the coating effective coating and all those things.

Another one is surface metallurgy, as I said surface integrity is nothing but the surface roughness and the surface metallurgy ok. If I do not heat or the hard chips of are not coming; that means, that my surface of my product will have total surface roughness and surface metallurgy, both the things will be very good. So, these are both are required then I can call it as surface integrity ok. This is about the machining of the femoral stem.

So now, we can see how the femoral head is machine, this also use by the milling process only normally CNC milling, people we use for the femoral head. The femoral head is differently machined then, it will be assembled normally the femoral head whatever the machine here will be assembled all the, this one. So, it will come and occupied at this, as you can see in the, this picture.

So, this is about the femoral head and the most complicated is, internal machining of the establer soket or establer component, some people they say establer component, now people are saying the extabler socket some people they say at establer cup also they will say. This is also difficult to machine because you have to machine internally nowadays advanced techniques are there.

So, you can machine it now the tool. So, establer socket and establer femoral head establer head or femoral head, we will have to assemble properly for that purpose machining is properly done and the surface finish should be, as minimum as possible then only, these are all called ball socket joined whenever the ball will go into the socket you if the surface roughness is good, then the flexibility or the rotation will be easy and all those things.

So, machining of these things is most important, because you have to maintain proper surface roughness in the range of nanometers for that purpose, people will do the machining operation, followed by the polishing operation and some people they are also using the liners. So, the still hardliners are used inside the as per your socket. So, this machining that I am not talking about here, the machining of those liners also will be difficult.

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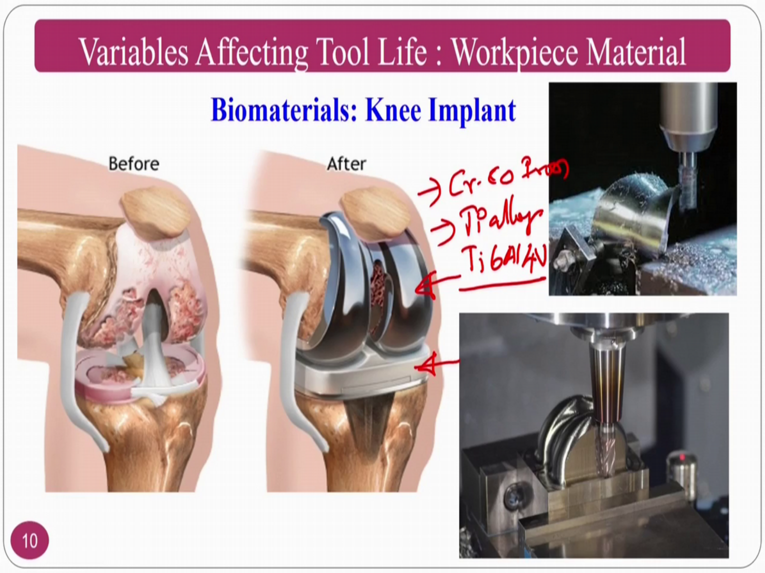

So, surface should be properly maintained. If you come to the another one material, normally nowadays people are moving towards the polymer-based implants and all those things, but ; however, as a mechanical engineer and the most important thing to might be used important things are, hip joint and the knee joints. That is why I am talking about the machining of knee joint and hip joint, and all those things.

If you see that knee joint, normally whenever the knees goes back, then the totally replacement is done. So,. So, artificial cartilage will be there at the middle normally this is cartilage or the meniscus people say this is the knee implant ok. So, if you see the knee implant, knee implant required very good machining properties, normally this is machine by the simple processes like milling only.

So, you can see how the milling operation is taking place although. So, there are different varieties of knee implants are there. This knee implants are machined and you can see in the zoom version, how these are machined ? This is another version of the knee implants there are different different knee implants, these are done by the milling operation you can see here in the zoom version.

So, what I want to emphasize here is, whenever you are machining the bio materials. So, there are 2 varieties of common materials that are used one is Chromium Cobalt iron based and Titanium alloy based.

So, these are the 2 varieties that are used that is Ti 6 A 4 V, is one of the Titanium alloy, but cobalt iron is the one of the common material. So, these are the 2 materials whenever you machine these 2 materials, you should take care about the temperature should not go beyond, what it has to go.

Otherwise the metallurgical layers will form metallurgical deviation will takes place on the surface of this one, which we do not want and the surface of this also should be maintained properly, for that purpose there are the post processings are there, not only the milling, but the basic process that one has to make sure that it should be in a good shape and good surface roughness should be that at the machining, if you have machining you have to use ones tools, at the same time you should take care that the tool wear should be as minimum as possible.

So, that you will get proper roughness, proper metallurgy on the work piece. So now, we move to the some of the other materials like elastomers, just I will give you the glibs. Since we are talking about the biomaterials, there are so much polymers coming into the market where the machinings taking place.

For example, the machining of internal fixation devices that you are doing, that the internal fixation coils like cortical screw, bone screws and cortical pins and staples and all those things, which are to be machined whenever you are machine these things. These are all the square elastic materials and it is very difficult to machine it, some people goes for 3 D printing also.

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So, whenever you do the machining, if it is elastomers and all those things it has it is own drawbacks, because if I give a certain depth of cut. Because of the elasticity of the work piece material it may deform, some material may come in the particular depth of cut, some material may not come if I am giving 5 microns, the cut maybe 4.5 or something, there will be a some deformation will takes place and all those things.

So, some of the components that are shown here, where the elastomers are plastics are used, things like is some of the small small components are given which are made up of plastics.

So, in combination with this what I want to say to you is, if at all we want to cut the small value materials polymer biomaterials because this is a just a basic. But the application of these pictures is, if I want to cut a polymer-based biomaterials like goal screws PLA polylactic acid is the one of the thing, PEG these are the some of the polymers, nowadays coming up, which are used in the human bodies.

If at all I want to cut a component or if I want to cut a simple screws are pins for biodegradable pins, it is this knowledge of machining of the plastics machining of the elastomers will help a lot. This shows simple whatever the application is enormous in terms of bio applications, as well as some of the components you will use in automobiles and all those things.

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Now, move forward to the different materials, that is called ceramic materials. Ceramic materials can be machined by normally, if it is a soft ceramic like hardness is not that much big or, if it is done by the powder metallurgy technique normally the ceramic components are done by the powder metallurgy technique.

Whenever I want to do the machining operation of this one, you can do it by giving the low depth of kerten low fluid rate and all those things, but commonly used methods are heaters is a dead methods. Normally if you see, these are all heated assisted techniques whenever I want to machine it what I will do is, I just apply a heat then I will do the machining operation this is called the hot machining of ceramics or another way of mentioning is this is called hot machining, or some people. So, call it as a ductile regime machine machining of brittle materials.

So, what I mean to say is, ductile regime machine of brittle materials. If you see this one, I will just explain you what it is ductile regime machining of brittle material; that means, I have a brittle material here, this is a brittle material which is initial stage of the work piece.

Now, I have to convert into the ductile mode then I have to measure it that is what it says. I have a brittle material, I have to convert into the ductile material then, I have the measure it for that purpose I have a brittle material and I am using heat source, by induction heating are laser beam heating and all those things I am converting intothe ductile mode then, I am machining it.

So, I will show you a picture where you can clearly understand what I want to specify from the point of, ductile regime machining of brittle materials, you can see here laser assisted machining of ceramics.

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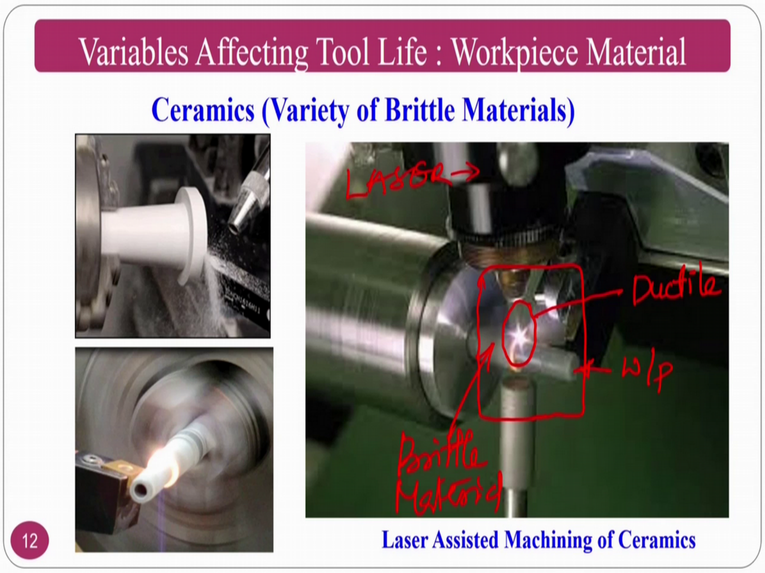

So, I have a work piece material, this is the work piece the tool is cutting from the other side, this is the laser source this is a laser. So, if the beam is falling here you can see in this machining region.

So, work piece is a ceramic laser is falling from the top, and the bottom there is a some support if the laser falls sideways or something, it should not fall on the bed or something for the laser will be support and the machining is taking place ok. What here is, basically the material is a brittle material brittle material and because of the heat, that region converts into ductile then machining is taking place ok.

So, material is a brittle material because of the laser beam which is a high temperature beam, but I am not saying that laser is very high or something the laser that one has to use the laser power accordingly. So, that it will convert into the ducktail regime according to the material basically and you have to do the machining operation. This is about the ductile regime machining off brittle materials, one of the examples is the laser assistance machining.

So now, the variables we have covered is a to d we have covered, and next one is the type of cutting fluid, as we see our process machining fluids. And we come elabaratively about the cutting fluids in upcoming classes. However just a slight glimpse I will give to you.

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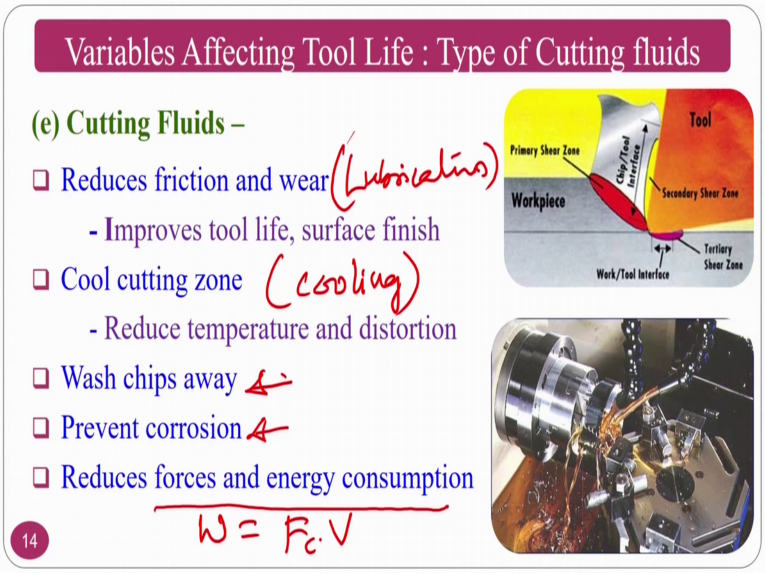

So, the cutting fluid basic function if you see that, it reduces the friction and wear and cools the cutting zone, that is nothing but cooling and lubrication this is called as lubrication, and this is nothing but cooling. So, 2 primary a functions of cutting fluid is cooling and lubrication, that is what I mean to say it from the first 2 points.

Last about chips, because there should not be any entanglement are sticking to the. So, washed away the chips, normally this wall comes in terms of dealing operation.

So, prevent corrosion. So, in order to prevent corrosion it will have lot of corrosion inhibitors and all those things that will help the cutting fluids, reduces the forces and energy consumption normally lubrication will help from the point of reducing the forces we have seened already power consumption equal to your C into V.

So, cutting force if the lubrication is there, proper lubrication is there the cutting force will be minimized or reduced. If the cutting force religious normally the power requirement goes down that is about the cutting fluids.

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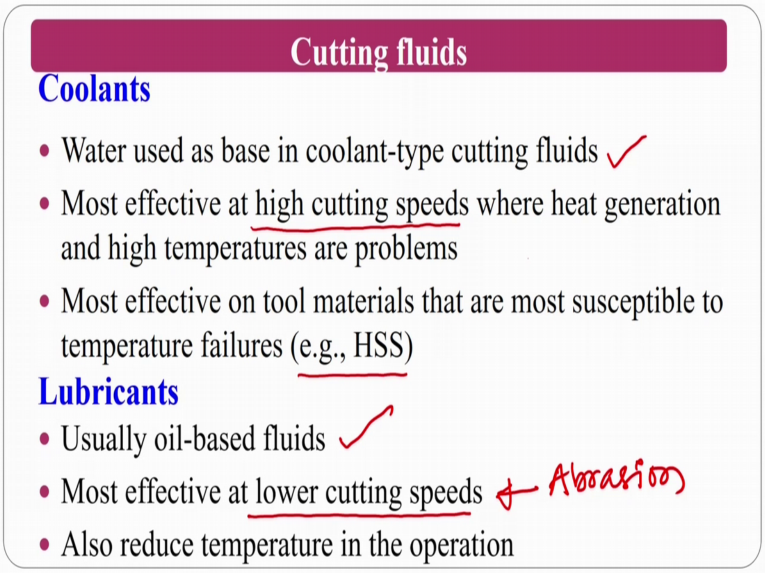

So, now cooling properties normally if at all I wanted a cooling properties, in a dominating cooling properties. Waters used to be as a coolant type, basic coolant type normally the cooling variety of cutting fluids are used in high speed applications because high speed applications temperature generation will be high.

So, you have to take out the that whatever the heat develop due to the temperature and all those things, for that purpose cooling dominating cutting fluids are used. The most effective cool material that can susceptible is HSS, tool materials susceptible for temperature failures is HSS; that means, that the HSS cannot sustain for higher temperature.

Normally in the previous classes, when we are talking about the HSS the basic drawback of high speed steel is it is hot hardness, the hardness at elevated temperatures is low that is a problem. So, it is a tough material. So, it can take the impacts, but hot hardness is low.

So, the lubricants normally lubrication dominate in cutting fluids usually, are oil-based fluids now what I mean to say is that, coolant based are dominating cooling properties and lubricate based are dominated by the lubricating; that means, that the friction reducing agents. Most effective or the lower cutting speeds, normally lower cutting speeds abrasion will be more.

So, at lower cutting feeds friction and abrasion will be very high, for there the lubrication is required of that purpose normally lubricant based cutting fluids are used, also reduces the temperature and operation if the friction is reduced partially you can reduced also the temperature. So, this is another function.

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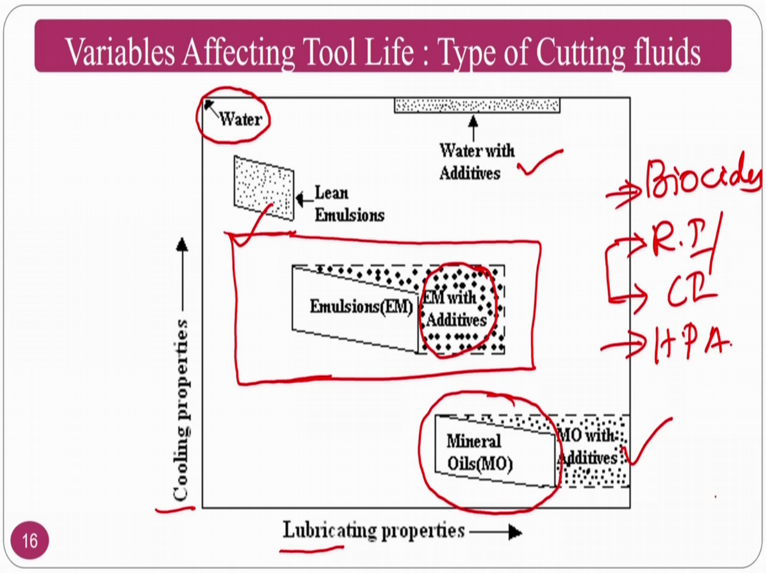

If you see already the lubricating properties and all those things, any how this graph we will see in the whenever we are talking about the cutting fluids and all those things still since we have seen already, the cooling properties and the lubricating properties.

So, if at all I want the better cooling property, water is the better cooling property. At the same time if at all I want at the better lubricating property oils mineral oils or petroleum oils are very good. So, I want partially lubricating properties, but dominating cooling properties then I will use some water with some of the additives.

Now, I can go even for lean emulsions emulsions are nothing but, wherever we mix 2 fluids normally this will become the emulsions. These are the other one commonly used, if at all I want to go for the better lubrication and the low cooling properties that is what I was talking about, the mineral oil with additives can be used.

So, the most of the time they commonly used are emulsions. So, that I can have optimal cooling properties and optimum lubricating properties, for that purpose the emulsions will be used, if at all I want to add some other additives like biocides, the rust inhibitors and r is also called as corrosion inhibitors both are same.

So, high pressure additives, many additives are there that you can add to the emulsions ok. This is about the differentiation, at the plot between lubricating properties of the cutting fluid to the pulling properties of the cutting fluid.

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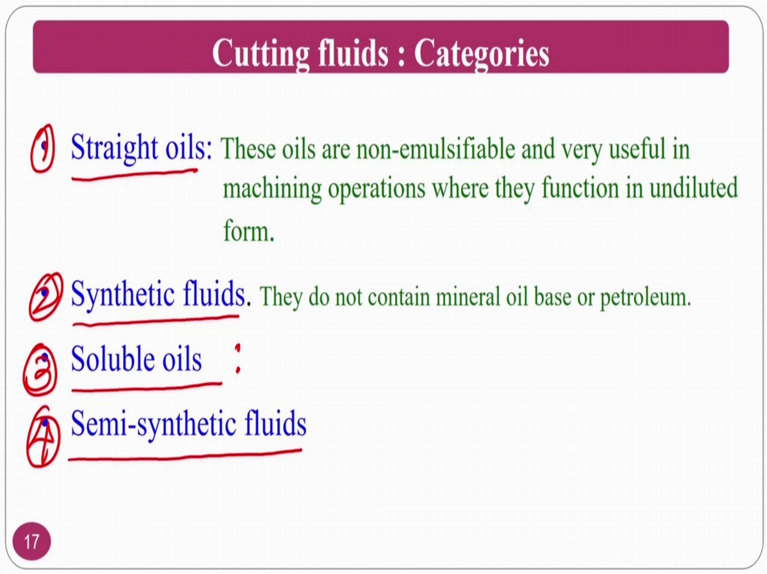

So, there are varieties of cutting of cutting fluids. 4 basic styles are there one is strait oils and the synthetic fluids, soluble oils and semi synthetic fluids these are the 4 varieties.

The synthetic foods are not the naturally occurring, one mark to these are prepared in the laboratory these are called as a synthetic fluid. Soluble oil they soluble with the water and all those things. Semi synthetic is some of the things are naturally taken, some of the things are developed at the laboratory and all those things. These are the basic categories which you can find voltage text books and all those things.

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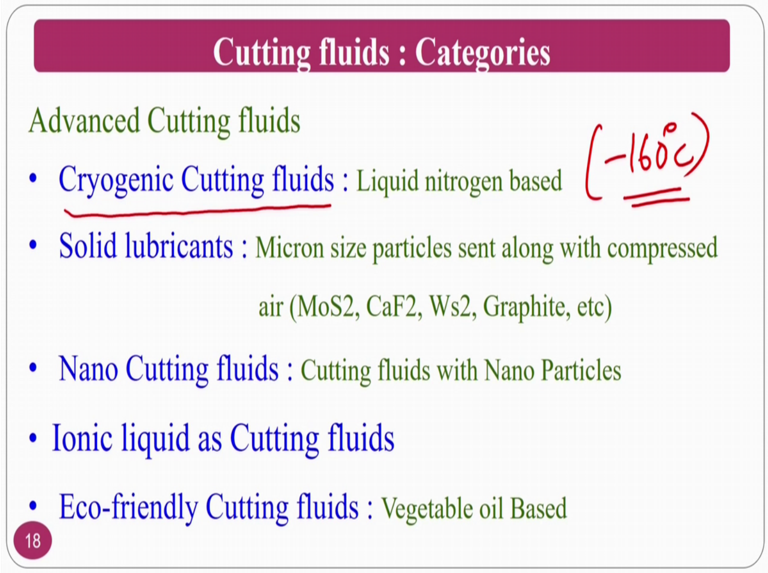

Whenever we want to go for the advanced versions, these are the advanced version of the cutting fluids. If you see the first and foremost is the cryogenic cutting fluid, normally cryogenic cutting fluid is nothing, but a liquid nitrogen based fluid. This is basically used for high temperature applications, wherever if at all the Titanium is machined are ceramic materials machined and all those things.

See here the temperature goes minus 160 degrees and all those things ok. This is about the cryogenic fluids cryogenic, whenever you in the next slide, I will show you how the cryogenic fluid is used and all those things, that is why I am not talking about much about this cryogenic fluid here.

So, the second verity is is solid lubricants, solid lubricants it cannot be a big solid or something. Normally, this solid lubricant are the solid nano particles or micro particles, you just mixed with the externally mixing or internally mixing the aid and you can send to the machining zone, that is nothing but you have a normally these are, MoS 2 or it is CaF2 sorry it is subscript you can see here.

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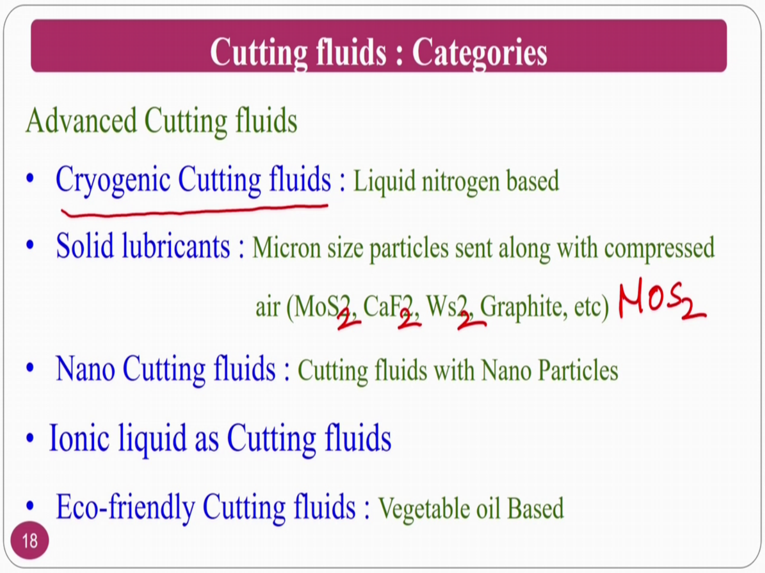

So, MoS 2 CaF 2 that is Calcium Fluoride and Tungsten Disulphide. So, these are the common lubricating properties, even graphite also. Just you make a power of this, which are the lubricating properties and you send along with a highly compressed day.

So, this jet of a along with solid lubricant, will go into the machining zone and it will help in the lubrication ok. The noting point here is, the cooling properties of this one will be very low. This will help in terms of lubrication. So, it will reduce the friction in the machining region ok that is about the solid lubricants.

Nano fluids is taking up in a anonymous way. The nano fluids are nothing but, you have the cutting fluid you and you have the particles, some of the people are using copper nano particles or copper micro particles some of the people are using Al 2 O 3 ceramic particles, some other people are using MoS 2 solid lubricants. What they are doing is? They are taking a cutting fluid they are taking the nano particles, they are mixing it and they are sending.

So, the beauty about it is if you take the cutting fluid, and assume that you are adding a MoS 2 to it. So, you have to check before that what is the chemical compatibility? and all those things, and you make a mamo fluid, assume that I have a 2 things cutting fluid is there, Plus MoS 2 is there.

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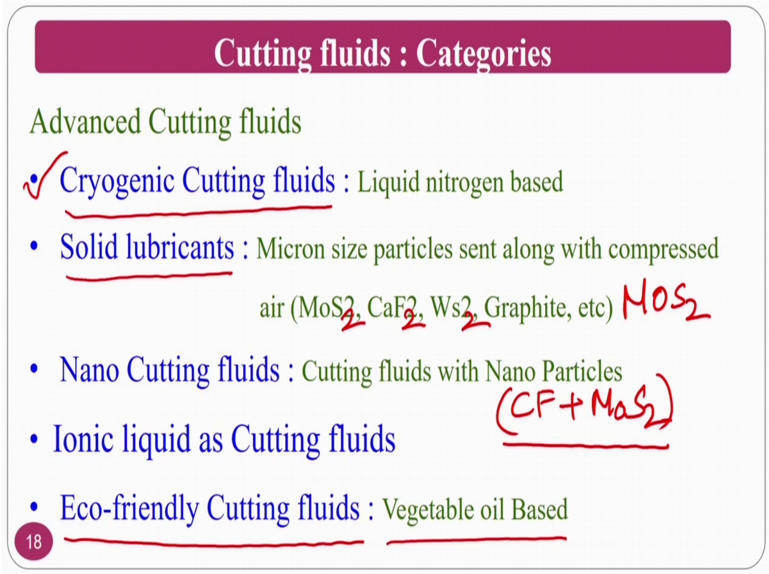

So, I am mixing and I am sending with high pressure what will happen? The density of particles is very high compared to my fluid. So, there is a tendency that in the chip tool interface, the particles will go and occupy this interior regions. So, that it may help in the lubrication also, at the same time it may try to lift by some of the nano meters or something.

That is what to the some of the hypotheses people says, and all those things. Some people they will use maybe use ceramic particles, some people they will use metal particles also. They have their own analogy in terms of these are the nano fluids, term came from the refrigeration in the air conditioning nowadays it is more 11 to the cutting fluids and all those things ok. This is about the nano fluids.

So, ionic liquids as a cutting fluids this is one of the recently seen papers, where the ionic liquids are also used as a cutting fluids, but mostly these ionic liquids are used for the lubrication purpose, these are very good lubricating. So, most of the papers of this cutting ionic fluids as lubricants, in tribological aspects as well as you can also see in the metal forming and wherever the lubrication is required ok.

So, biology and lubrication applications ionic fields are used. So, people are bringing this and they are mixing with the compatible liquids, cooling liquids such as water and all those things and they are using it.

The another one variety is eco-friendly cutting fluids normally some of the people are using vegetable oil based, and all those things. Eco friendly with cutting fluids are some of the vegetable oils or the mixture of vegetable oils. Since is cutting fluids, the petroleum based cutting fluids like a straight oils or synthetic oils causes lot of problems when have the emissions comes.

So, you will see in in deep in the upcoming slide. So, this causes lot of problems. So, in order to avoid all these things vegetable oil based a cutting fluids are used ok.

So, I was talking about to you on the cryogenic cutting fluids, but the cryogenic cutting fluid. The first one is to let me come back in the next slide about the cryogenic cutting fluid. This is about how we do the machining operation using the cryogenic.

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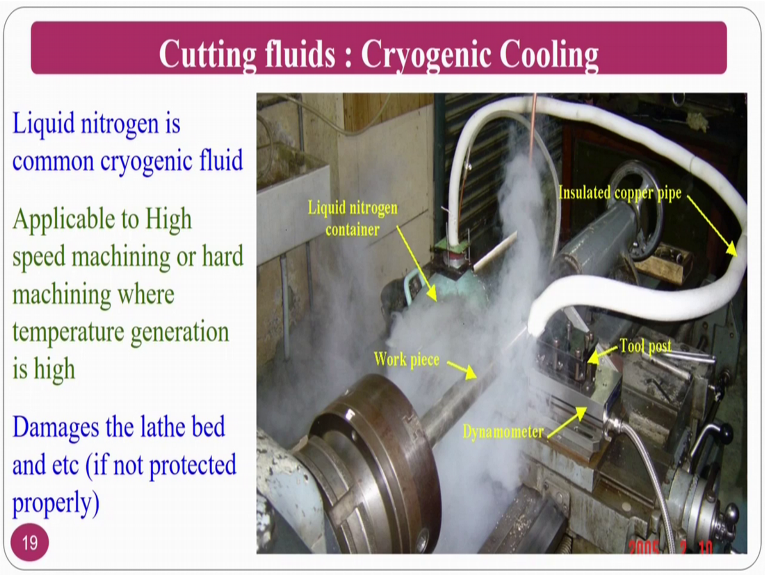

So, normally used is liquid nitrogen in the current photograph whatever you can see is the liquid nitrogen based cryogenic machining, where the cryogenic fluid is as a coolant basically. It is a better coolant, because the temperature is minus 164 degrees, normally minus 160 degrees is a temperature.

So, it is a better cooling agent. So, applicable for high speed machining normally applicable for high speed machining are machining of the Titanium and all those things. Because the temperature stays on the surface itself, that is that is why these are used there.

So, the basic problem about this cryogenic is. If we do not protect the base or the lathe bed and all those things, if it falls minus 64 degrees or minus 160 degrees fluid whenever continuously falls in the lathe bed. The lath wherever the component are the it falls it makes it completely brittle.

So, you should be very careful, that the operator should be completely careful because his hands, or it any body parts should not come in contact with it. Because, it is dangerous at the same time the lathe other parts also should be protected apart from work peace and tool ok. And especially from the machine region apart from these, everything should be protected, if you can protect then this is a good process.