Introduction to Machining and Machining Fluids
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Lecture – 06
Tribology, Surface Roughness in Machining

Welcome to the chapter on a tribology surface roughness and in machining processes. So, let me brief you about what I am going to discuss in this chapter.

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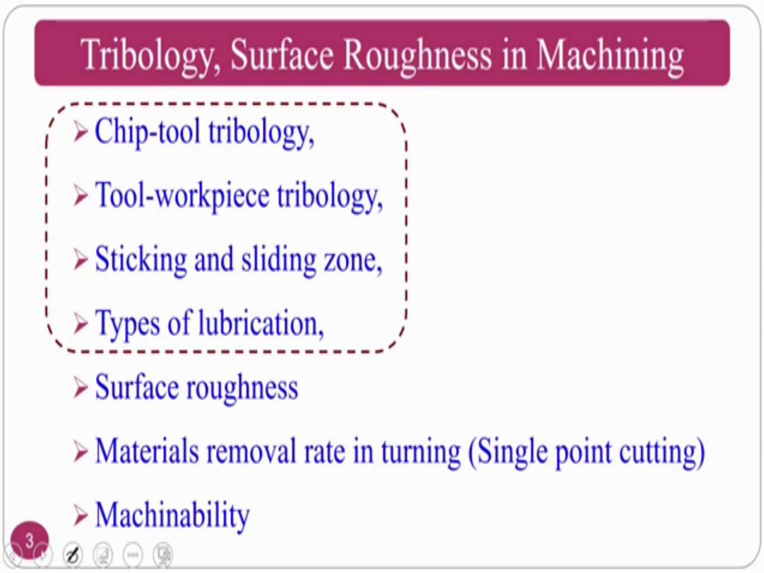

So, chip tool tribology tool workpiece tribology; that means, the cutting tool workpiece interaction, which is not that much important, but; however, I discussed slightly and sticking and sliding zones in the chip tool surface, and types of lubrication. Then I will go to the another area of this chapter that is called surface roughness.

So, material removal rate in turning process, how do you calculate material removal rate and all those things, then followed by the machinability, machinability is nothing but the ease of machining how and all those things. So, currently what I am going to deal in this class is a chip tool tribology. So, majorly the class all revolve around a chip tool tribology, how do you measure the experimentally by using the tribometers, and all those things tool workpiece tribology is not discussed much, but; however, I will just brief you sticking and sliding zones which are nothing but the part of a chip tool tribology types of lubrication.

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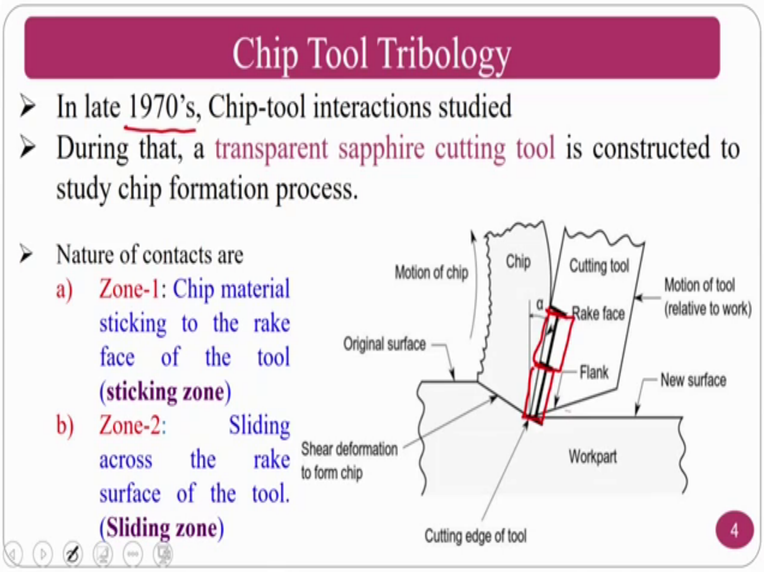

So, coming to this one chip tool tribology basically came into existence are the first, they started in a 1970's where a interactions are studied ok. So, you can see this one and during that what they have done is they have taken the transparent sapphire tool. Normally, the sapphire is one of the hardest materials. So, they have taken it as a tool ok. Since the hardness is most important in cutting tools. So, they have taken it. Normally nowadays, if you see the sapphire is commonly used as a nozzles for abrasive jet machining are some of the advanced machining processes abrasive processes ok.

So, they studied using this one because if it is the transparent. So, they can understand how the chip flow, on how the stick slip phenomena takes place and all those things ok. So, if you look at this picture, and we have 2 zones one is a sticking zone another one is a sliding zone ok. So, this comes under the zone one that is called a sticking zone and comes the sliding zone ok, there are the 2 zones ok.

So, these zones in the sticking zone chip, material stick to the rake surface of the tool. So, normally it will have a perfect contact, I am not saying that perfect behind the person, but it is a having a good contact and a sliding zone. It slides across the rake surface this is 2 surfaces one is the sticking zone another one is a sliding zone ok.

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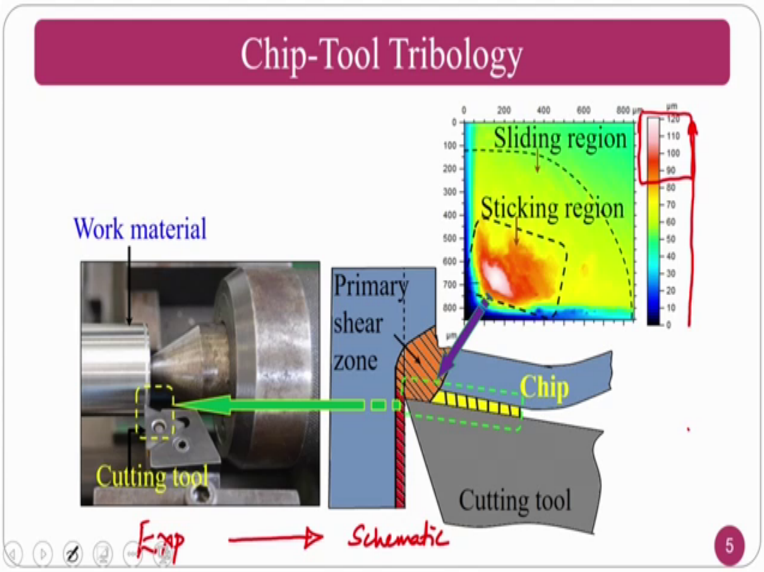

So, if you can see, how the sticking zone and sliding zones are differentiated from this point of view. So, this is a experimental which we have recently done some of the work in this area, for understanding the basics of the chip tool tribology. So, if you can see the cutting tool machining the workpiece in this case carbide tool is machine in the stainless steel. So, for understanding if you see the primary shearing zone, if you this is the experimental one, the experimental picture; so, this is a schematic one, how we are analyzing a schematic one.

If you see this one, what will happen this is primary shearing zone, and followed by the secondary shearing zone, which is most important in this case? Primary shearing zone is because of the plastic deformation, in the secondary normally we deal with. If you see this area, zooming we have a sticking region and followed by the, it represents a height of deposition that is taking place. So, the red color and white color that you are seeing at this position, this stands for the peaks or the height that is forming assume that this is my surface, how the things are piling up on top of it.

So, built up it formation, and the all these things are studied there ok. So, that is why this is a green region height is slightly less. So, that is what the beneath the chip material is adhered with the tool particular.

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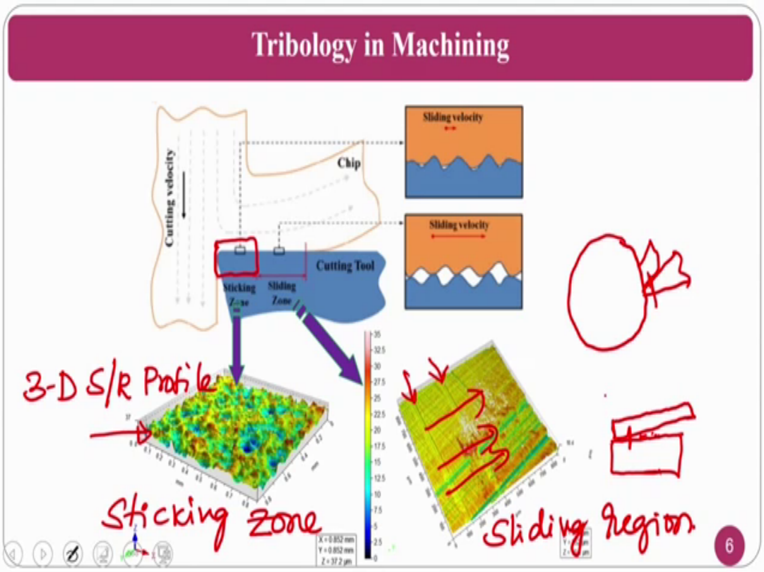

If you see the sticking zone surface roughness and sliding zone surface roughness how it will changes and all those things. If you see in the previous slide, you have seen the sticking and sliding regions; if you take the surface roughness of the sticking zone normally you will have a very rough surface ok. So, you can see the 3D profile, a 3D roughness profile normally this we will taken from the non-contact surface profilometers. So, this is a 3D surface roughness profile.

So, you can see the completely it looks like a some craters are formed, and some deposition is taken place. This is a completely random. This is corresponding to my sticking region. In the sliding region basically, they would not be proper contact ok. In the proper, if there is no proper contact what will happen it will slide, the chip will slide on my workpiece. What was happening here is, if I have a workpiece, and my tool is there, chip will move like this ok. So, the first portion is this is sticking zone. The next one is a sliding zone. So, there is a gap it is forms like a wedge type of thing what will happen this is the sticking region, and in between you will have a sliding region. There we will have asperities will rub against and it will form it is one lines ok. That is why this is called a sliding region.

So, slide these are forms the sliding marks can see the sliding marks. So, what you are seeing these lines are some of the textures that we have done, but it is nothing to do with the current physics what we are talking about. These are the marks ok, that that is about the thing.

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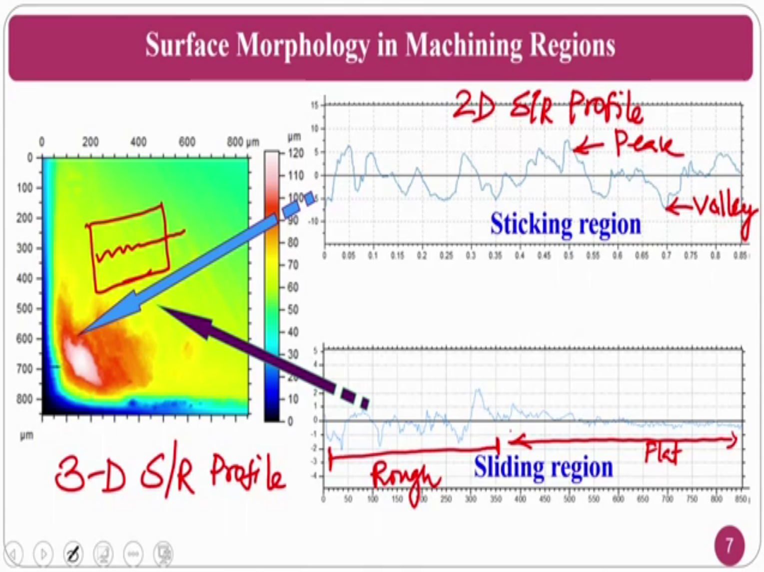

See, now we will see the surface morphology, how the surface morphology, because the surface morphology plays a major routine ok. The surface morphology means how the surface look like on the surface, that is called as a surface morphology, surface morphology includes surface roughness ok.

So, coming to the sticking region, if you see the surface, it is completely rough. If I am taking a this one is a 3D surface profile, surface roughness profile. And this is 2D surface profile. So, this is 2D surface profile if you see the sticking region, if I am measuring in this region. Normally some of the average region if I take, any randomly some of the region that I will take normally, these will have a peaks and valleys peaks and valleys. This is a peak, and these are valleys ok. So, this is a sticking region. So, this is too rough at the same time if you see the sliding region, sliding region the beauty about the sliding region is we will have a gradual flattening .

If you see here any surface in the sliding region, normally these are the sliding region. So, you have a rough surface here, rough surface rough surface and it is smoothly that is what you can interpret here. You can see the surface it is a rough zone here, but it is this roughness is much lesser than the sticking region. Then normally it will become partially flat region ok, is called a flat region ok. So, that means, that there are marks on the surface, and wave marks then it will become flat ok. So, that is the beauty about the sticking region and sliding region. The surface roughness and sticking region is much

much higher compared to the sliding region. And also, you can see that if the sliding region to the start of a sliding region to the end of the sliding region you will have a very rough to the flattened surface.

And then onwards you can see the completely flat surface, because there is no interaction between tool and chip ok. That is that is about the surface roughness in the tool chip interface ok.

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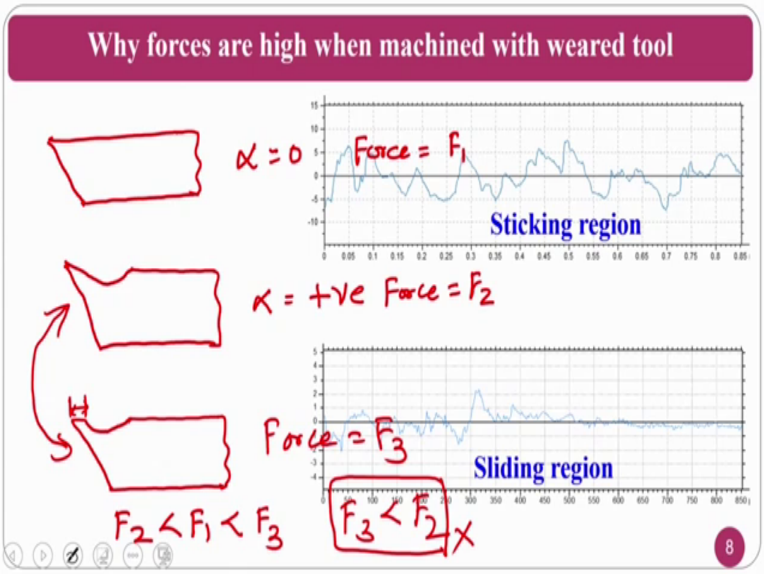

So, normally if you see a commonly question so, why the forces are high in when mission with a weird tool ok. So, if I ask you a simple question. Like, I have a 0-rake angle tool. This is a 0-rake angle tool. So, I am a having a positive rake angle tool, rake angle is alpha equal to 0, alpha is positive ok. Normally here force equal to F 1 here force equal to F 2. If I am giving you a 0-rake angle tool with crater wear basically. So, crater wear looks like with in terms of the crater depth we measure.

So, we measure in terms of this one ok. In that circumstances, what will happen it looks like a positive rake angle ok. Here force is F 3. In generally, what we study about the forces, normally, F 2 less than F 1 and F 3, but if you see the geometry wise. If I just remove this portion, weared portion what will happen?

So, you should get F 3 also like F 2, normally the if the rake angle is 0 my forces are F 1 if my positive rake angle forces are F 2. Normally positive rake angle experiences less forces, because chipping flow will be uniform, and there is no it is aerodynamic and all those things. In terms of 0 rake angle, the fraction of forces is very high because the chip will move parallel to the rake surface ok. That is why normally F 1 is higher than F 2. If the tool wear takes place that is crater will takes place, in that circumstance the force basically experimentally it will increase.

But geometrically if you see, it is resembling like your positive rake angle. These 2 are looking alike in that circumstances F 3 should be less than F 2, but this statement is wrong why. So, for to answer this one, we will see the things how do handle it. If you see the surface roughness is sticking zone. Normally whatever the surface roughness that you are putting in a tool, what will happen this is completely rough? At the same time if you see the tool wear, tool wear is starting slightly ahead of cutting edge. It is not from the cutting edge. Normally, whatever the angle that will give is starting of this one.

So, that it will be having a smooth flow, but here the roughness is very high, at the same time it is start away. From this cutting edge these are the 2 reasons there are many other reasons ok. So, these are the 2 reasons that why normally F 3 is much much higher than your F 2 and F 1 ok because tool wear may be geometrically same, but it is not. So, practically the forces are very high. Because of this reason as a sliding region also it will have the negative effect, because of the sticking and sliding zones surface roughness. So, obstruction will be there if the obstruction is there the frictional forces will goes up.

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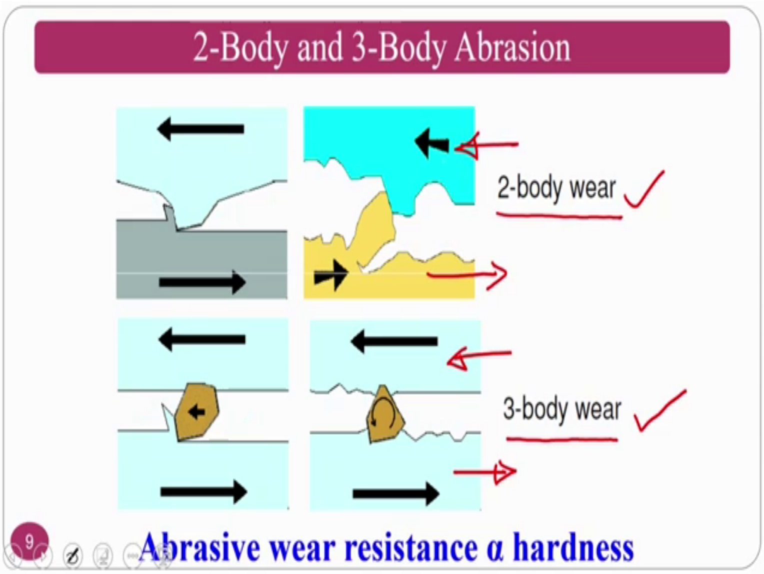

Normally, there are 2 mechanisms whenever; I already told you, when I am talking about the tool wear mechanisms. So, there are tool a tool types of abrasion takes place in the chip tool interface, one is a 2-body abrasion. So, 2 body abrasion means when the 2 mating surfaces are abraded each other ok, because of the relative motion ok. One is moving in this direction another one is moving in this direction. Because of relative motion between 2 bodies, if there is a wear and tear takes place, that is called 2 body abrasion. So, if the if the mechanism is abrasion. So, the 3-body abrasion means, whenever 2 bodies are abrading each other are moving related to each other, and if there is a third body which can rotate about it is own axis is in between them.

Normally what I mean to say is that if the chip tool interface is only interacting; that is, called 2 body abrasion. If I some people nowadays are using the nano fluids as the cutting fluids. So, nano fluids will have particles. At the same time, there is a possibility of the tool which is made up a powder metallurgical. If the binder is loosens and goes off what will happen it may releases the particles into the chip tool interface region. This also has one probability, that the particles come into the chip tool interface. Because of this you will have this particles are no more adhere to the tool material ok.

So, they can rotate abouts their own axis because they are independent enough. In that circumstances it is called a 3-body wear. Why I am talking about a 2-body wear and 3 body wear is, nothing is how we have to measure 2 body abrasion and 3 body abrasion approximately using experimentally, because tribology is itself is a big subject ok. We have to correlate with respect to machining. So, there are some standards ASTM standards that one can follow ok. So, however, the abrasive wear resistance normally is a function of hardness, if the tool is much much harder what will happen.

So, what will happen normally the wear resistance will be more ok? Hardness is nothing but resistance to penetration. If the penetration is less what will happen abrasion is less. Now you understood what is the difference between 2 body abrasion and 3 body abrasion ok. So, 3 body abrasion takes place when there is a chance whenever you use the nano fluids as a cutting fluids, solid lubrication if we are using. Or whenever you are using whenever your tool got whenever temperature of the tool goes high and binder goes loosened then the particles of the powder metallurgy tool, some of the particles may come and in between chipper tool may have their independency in that circumstance of 3 body abrasion ok.

So, this is about the 2 body abrasion as well as 3 body abrasion ok. So, because of a these 2 body abrasion as well as 3 body abrasion, there will be a lot of a frictional heating takes place ok.

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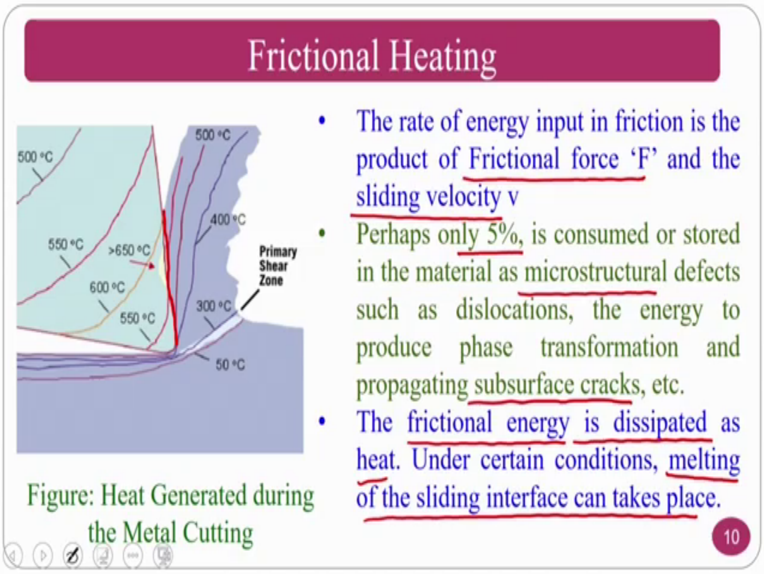

So, the frictional heating normally the frictional heating will takes place in terms of a in the region where a chip tool interface region ok. This is the region. So, the rate of energy input in the friction is the product of frictional force and the sliding velocity ok. So, this is the multiplication or if you multiply frictional force, and sliding velocity normally you will get the frictional energy ok.

So, the normally perhaps 5 percent is consumed or stored in the material. This frictional energy what will happen if it is stored in the material what the temperature goes up. If the temperature goes up what will happen micro structural defects; that means, that if in your earlier courses, if you see, what will happen there is a core cold holding and a hot holding in the metal forming processes. If the temperature goes up, what will happen? My microstructure will change. For example, if you see black smithy if at all you want to make a sharpen the knives, will happen you just put into the fire then after 10 minutes or 15 minutes, just you will take out the orange red one.

So, then because the number of a atoms in the knife is same, but the thing is that whenever you take out after sometime what will happen it might have slightly bulged enough, why? Because the micro structural changes taking place because of the temperature. Then what you will do you will take on the edge and you will hit it. So, that it will become sharp then you will put into the water. So, that again it will go to it is original microstructure. May not be 100 percent original microstructure. It will go. So, the sharpness will increase ok. What the bottom line of change it is microstructure.

So, because why the microstructure is taking micro structural change is taking place, because of the temperature if the temperature is stored what will happen? The microstructural defects or microstructural changes will takes place ok. That is about if the temperature is still more what will happen that will be defects cracks and all those things will takes place ok. So, this is about the frictional heating drawbacks ok. So, frictional heating is dissipated as a heat. Normally whatever if the frictional energy whatever these stored energy. You can it can dissipate as a heat under certain conditions. And melting of the sliding interfaces also can take place ok.

So, if the temperature is up. These are the sliding interfaces. This is the sliding interface, let me show you. This is the sliding interface ok. What will happen ? This may melt ok. So, normally that mostly the workpiece is much lower hardness than the tool, at the same time if the temperature is high; normally the temperature that is carried away by a chip is always higher that is 80 to 80 4 percent. So, beneath the chip always is melting tendency ok. Not in all workpiece materials, those workpiece materials which are soft enough whose melting point is low, these type of things will have a melting tendency ok.

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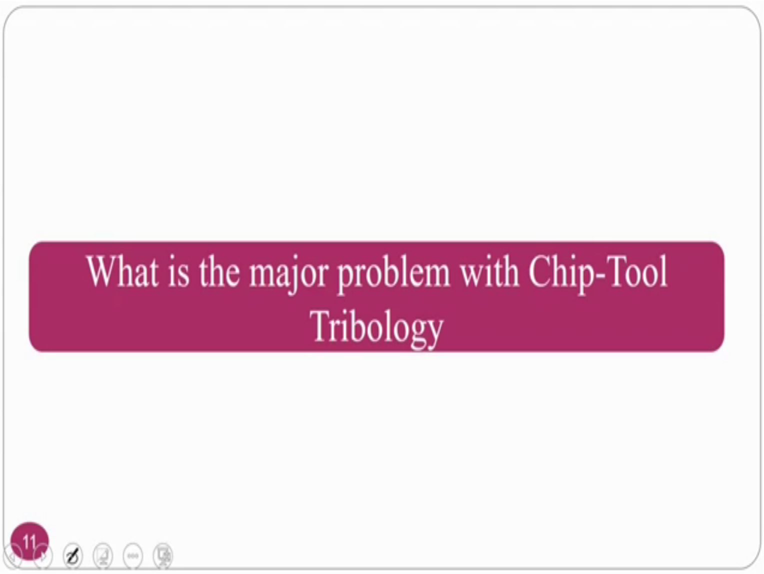

So, this is about the frictionality. So, what are the basic problems with the chip tool tribology? Ok, why we have to study? We have already studied this, what I am going to show you, but it is a interlinking ok. Everything you have to interlink whenever you study in the past in this course. So, some of the metal cutting course and metal fluids having it is a single subject. So, always some things analysis you have to take from there and you have to correlate and all those things ok. So, why you want to study is the if the tribological conditions are bad; that means, that if the tribology is very high, then your input energy will be very high; that is, already I have shown you, you in the previous class, where I am telling about the forces in the machining operation and all those things.

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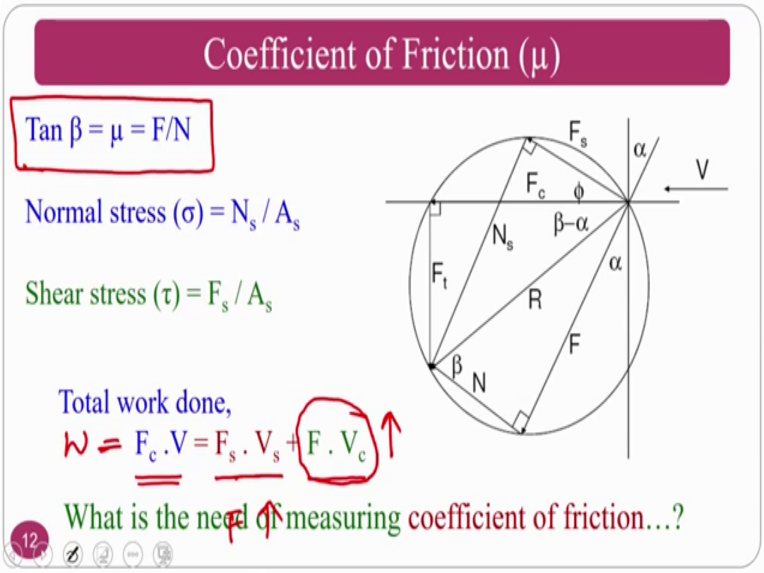

You have seen the tan beta that is called a coefficient of friction is nothing but F by N. So, it your N is high what will happen frictional force is why they high, then your waste energy will be very high if you see. The complete that normally work done or energy input if you see what will happen Fc into v or the energy input, shearing force which is multiplied by shearing velocity this is called useful energy frictional force multiplied by chip velocity. This is called that will go as a waste that we have already seen. So, if my frictional force or the tribological conditions are bad frictional force will increase if my frictional force increases. What will happen? This particular part of my energy will goes up. If it goes up, what will happen? My input also will goes up ok.

So, for that purpose you should be always careful and you should study the rheological things ok. So, that is why we have to coefficient of friction and all those things.

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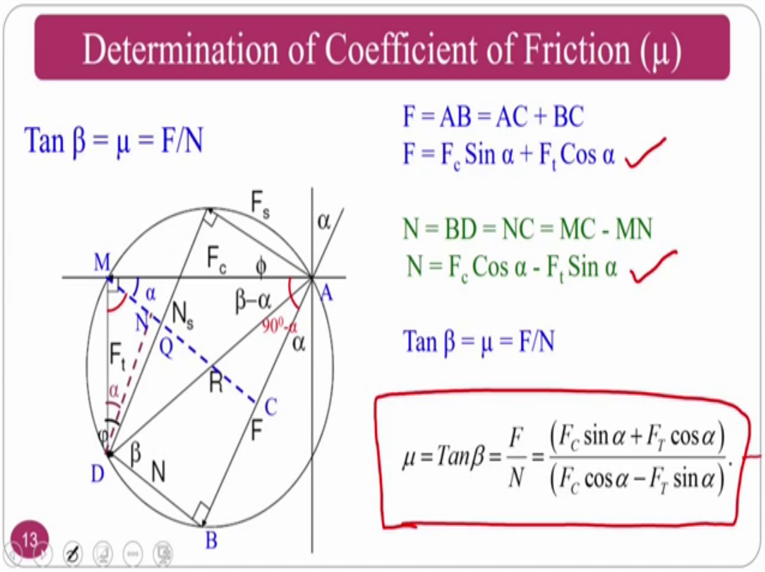

So now, coefficient of friction you have already seen just and I have just want to give you glimpse F by N and previous class if you see, how you calculate F, F is F sin alpha plus Ft cos alpha is 1. And N is Fc cos alpha minus Ft sin alpha. So, if you place both what will happen? You will get a final equation which is called mu equal to coefficient of friction. It is Fc sin alpha plus Ft cos alpha by Fc cos alpha minus Ft sin alpha. This is what you are going to get ok.

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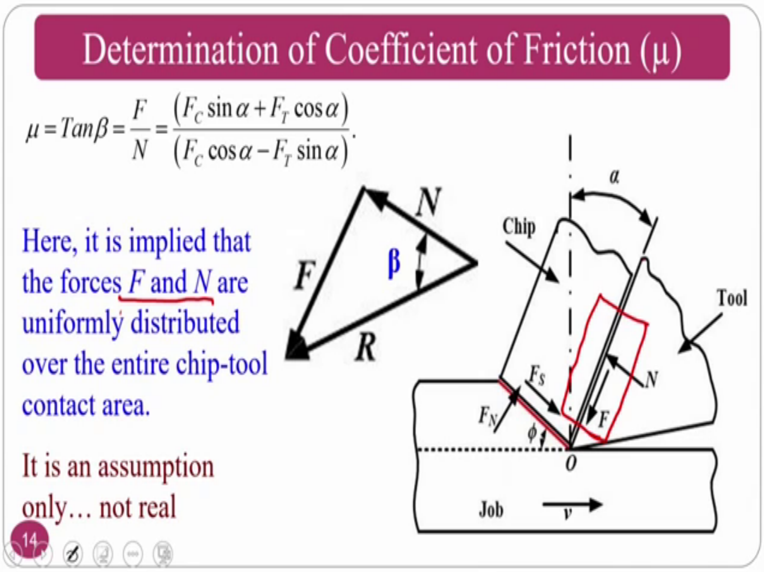

So, determination of friction coefficient you have seen, and the basic assumptions normally what we consider in the this one is, normally F and N which are they on the tool rake surface. This is the rake surface this is the region ok. So, these are all uniformly placed ok, but; however, this is a assumption is not so a realistic ok. So, that is why that what I want to say is that applied forces that is F and N are uniformly distributed over the chip tool interface. That is the assumptions normally whenever will be we want to derive some equations like a (Refer Time: 22:51) equation or leash of us some of the equations, whenever you want to measure. We want to calculate the shearing angle and all those things. For that purposes normally, we take F frictional force on normal to the frictional force coefficient of friction and all those things ok.

So, we assume that these are all uniformly distributed on the rake surface; however, this assumption is not so.

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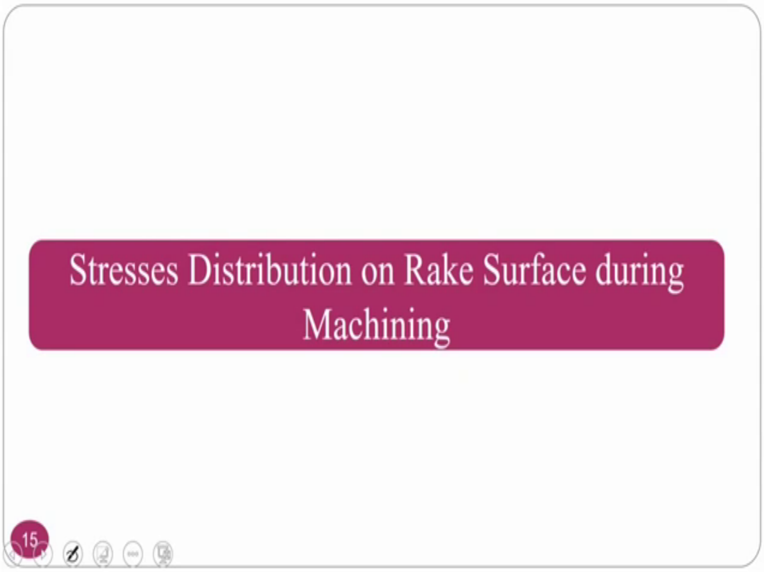

So, we will see why it is not so, though in terms of stresses distribution on the metal cutting you will see, because of sticking zone region stresses are different, I mean to say F and N and the sliding zone F and N are different ok. So, this is the chip tool interface this is the cutting tool.

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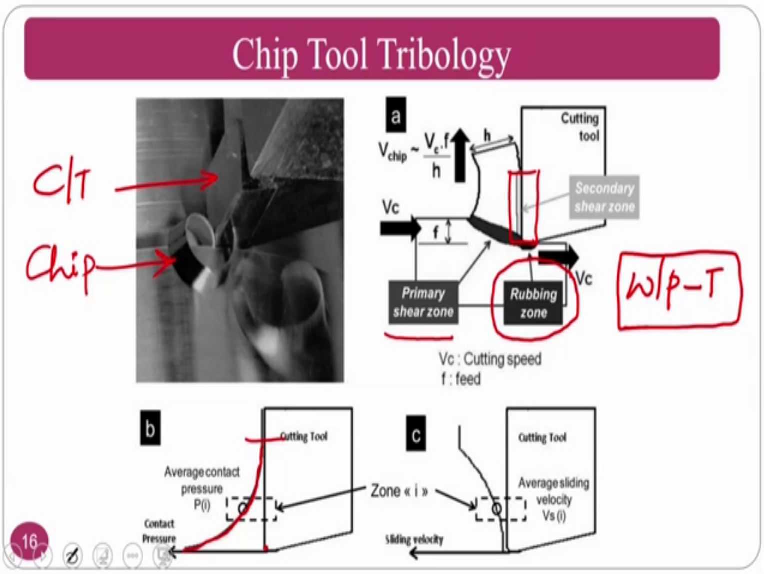

And the chip is coming here ok. So nowadays the contact pressure will be maximum at the tip point. And gradually it will decrease. This is a stresses ok; however, we have seen in a previous slide the assumption that it is uniform.

But it is not uniform, if you can see it is or the tip it is maximum, and it will become a minimum as a the in moves from the tip ok. That is what we are seeing here. We can see the primary shear zone, which you have already seen rubbing action that is between the workpiece, and the flank face of the thing that is called tertiary normal shearing. And second is the shearing which we are talking about and we are talking in this one also. So, rubbing zone basically this will takes place between workpiece as well as the flank surface. So, this is not that much important; however, I said in the starting of this class, that we just give you the glimpse that is nothing but if my frictional rubbing between the workpiece is very high, what will happen? The surface roughness that you are generating and the final product will destroy. I mean to say the surface roughness will increase.

If it is increases, what will happen? It may not qualify the quality check ok. So, for that purpose always you try to avoid by putting the cutting fluid or any tool coatings or something ok. So, since normally if you have given a relief angle at a flank angle properly so that can itself is a good thing from the rubbing action against the workpiece. That mean I mean to workpiece means I mean to say the final product that is coming out ok. If you can provide the lubricant jet across the workpiece and a tool interface, that will also find. So, in order with this will help the rub workpiece and tool flank surface interface ok.

But not much a study has been done in this area, but some of the researchers they have done in this area by putting a multi jets. One jet on the tool rake surface, where the cooling property of the cutting fluid is much better, another one they are putting on the workpiece that is a final product, and a tool flank surface they will put where a lubricating nature of cutting fluid is good. This type of a things they will do ok. So, people if somebody is interested to take the research in this area.

So, there are some of the papers who talks about the a multi jet based a turning processes, where they will use a as I said one jet which is having a cooling better cooling properties. Better cooling properties means water-based coolants on the chip tool interface, and the less water content are a mineral iron content cutting fluids on the flank surface. You can try and in the advance materials, some people who are PhD students who are seeing, or who are watching my slides can take up a multi jets, assume that if I want a machine the titanium with the see the N or coated carbides.

So, you can use similar technologies, even you can use some other technologies like, a cryogenic on one side and another side mineral ion based and all those. But you should be very careful because how to recycle it. because once it go back to the cutting fluid how tank, then how to recycle it and all those thing. One we should be take care and care about the lathe bed or mission tool bed and all those thing because cryogenics also involved here for the better cooling ability and all those things ok.

If you see a normal forces on the coefficient of friction is ok.

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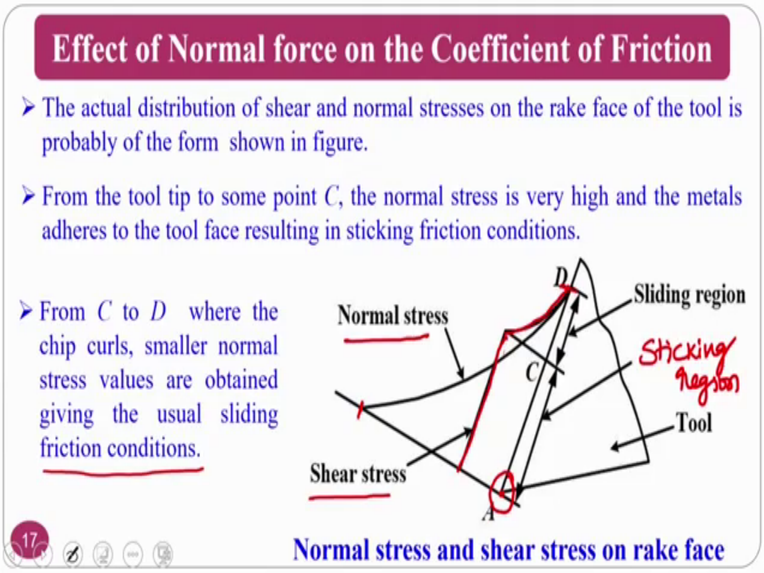

So, the actual distribution of shear in normal stresses and the rake surface of the tool is probably from the shown figure. So, if you can see the normal stress, this is a normal stress, and this is the shear stress ok. So, this is a sticking region, and this is a sliding region ok. So, the stresses you can see here, this is a normal stress as and this is the shear stress ok. The steer shear stress is constant in the sticking region, but; however, in the sliding region, it is gradually decreasing ok. As you can see here, this is a constant domestic in region and it is decreasing gradually to the minimum from the maximum of a sticking region to a minimum in the sliding region.

However, if you see the normal stress, that is N normal to this one. So, which is gradually it is maximum of the tool tip surface, this is called a tool tip. To maximum here and it will gradually decrease to the minimum degree at the end of this sliding region beyond which there is no tool chip interface is not there ok. If you see some point see the normal stress is very high and the metals adhere to the tool tips resulting in the sticking friction conditions. This is the normal stress normally if the normal stress is very high; that means that normal force is very high for the same area.

So, what will happen? This causes the sticking in the region, because of which there is a built-up edge formation will takes place and all those things. From C to D where the chip calls smaller normal stresses are update and given the results sliding friction conditions. C to D which we are studying in this is a sliding region. Because of the normal stresses are low here, what will happen? There is a sliding action takes place. And since there is no not much stresses on the tool by the chip. And if you have a cutting fluid application also in this one, if there is a cutting fluid and much difference.

But there is a difference, what will happen? There is a just a slight rubbing action will takes place wherever the stresses are very high there sticking at sticking will takes place with the normal stresses are low there is a sliding reaction will takes place. That is what this normal stress and a shear stress distribution want to tell ok.

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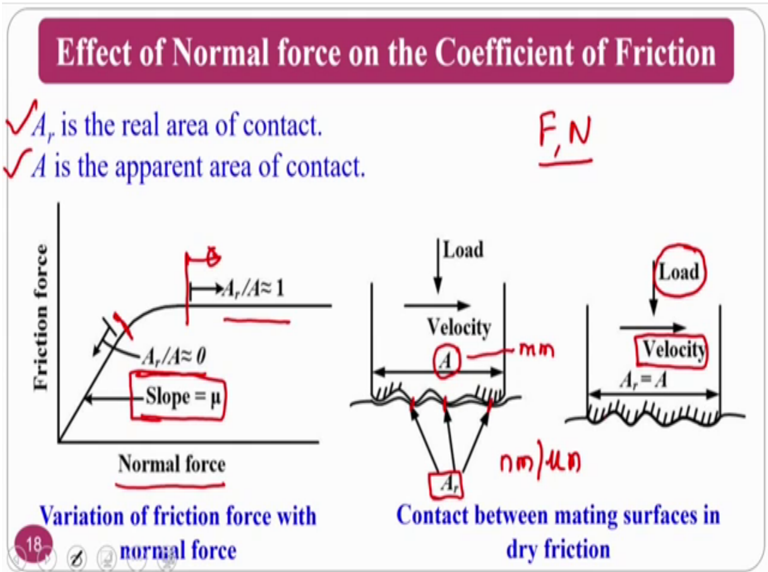

If you take the analysis in the contact surfaces, basically Ar is the real area of contact, and the A is the apparent area of contact. If you see the normal force versus frictional force that is called F verses N ok. So, if your normal force in this region, region 1, what will happen? Normally your Ar by A is approximately 0 ok.

Now, see what is mean by a real surface area of contact, and what is apparent area of contact. If you see here, this is a area is complete apparent area contact and real area of contact Ar ok. You real area of contact in chip tool interface. I am talking about petal cutting that is why correlating to the chip tool interface. So, Ar only it is at a certain points basically if this is the point, and this is the point, and this is the point.

If your area of contact is approximately apparent area of contact is in mm normally, because it is a complete area that we are talking about. But real contact is some points that mean that it may be some few nanometers or micrometers. If you take the ratio of a real area of contact to the apparent area of contact where a nanometer by millimeter, millimeter is a big area where it is some about assume that it is more than thousand, 10 thousand times, that is why it is apparently 0 in this way ok.

Slope is nothing but your quotient of friction. But if you see in the another region, where this is the region if you see, if my area of real area of contact is equivalent to area of apparent area, then it is a relation is one contact between ok. In this region normally, it is one ok because the contact area is same. For that purpose, normally, lower conditions will be high and velocity will be very low. In this condition velocity will be very high and load will be normally low ok. This is about the 2 forces and real area and this contact area and all those things ok.

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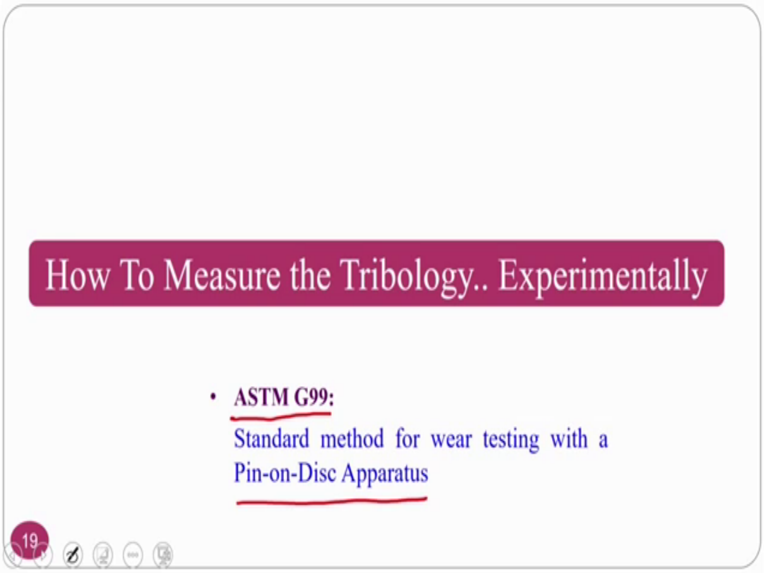

So now, how to study this tribological aspects? Tribology of metal cutting in experimentally, can be some machining tests or how to do ok. So, for that purpose there is one standard is a ASTM G99 one standard one of this there are many standards, first I am telling you about one standard. Standard method for where testing within a pin on disc apparatus, we sitting on disc apparatus is a another tribal method ok.

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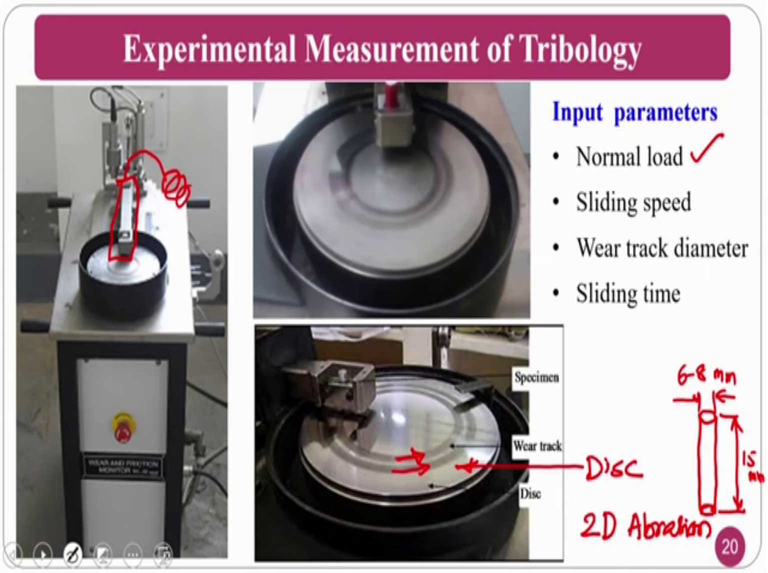

So, this is if at all I want to test it, what will happen? This is a simple pin on disc ok. I mean to say, there is a pin is there on disc is there, this is the disc ok. You can see this is the disc. And this is that pin ok. This is a holding position is there, but; however, you can see a pin here. This is the pin ok. This pin will be touching the surface like this, this will be ok.

If at all I want to wish in a mild steel with respect to hss. How I have to do? Ok, so now, what will happen? I will make a steel disc and I will make a pin hss. You can make hss pin by using edm process basically, you take a hss block, then you use the wire edm process. And you can cut normally the size of the pin that cylindrical pin that one can use in the as for the standard is 6 mm diameter by 15 above 15 mm, you can use. Normally, what people take in the range of above 15 mm 6 to 8 mm normally, we will a people will take ok.

So, this pin you will hold here. You are holding a pin here. And you are giving some input conditions. What are the input conditions? That you are going to give is normal load. If you see here there is a load cell is there, and you have to put this is the one that is a cantilever beam type it is holding. So, you can put a load connecting to it here load on other side which is not visible here. So, you can put a load. So, that is how much load. You have to put sliding sliding speed is nothing but how fast you are rotating your disc ok. So, whether you are rotating at a 60 meters per minute or 30 meters per minute wear track diameter. So, whether you are giving this track, or whether you are giving this track sliding time.

So, how much time normally whenever you want to do 1 hour, and 2 hour, 24 hours or your 6 months; some of the experiments we learned for a one week also continuous to understand the these things ok.

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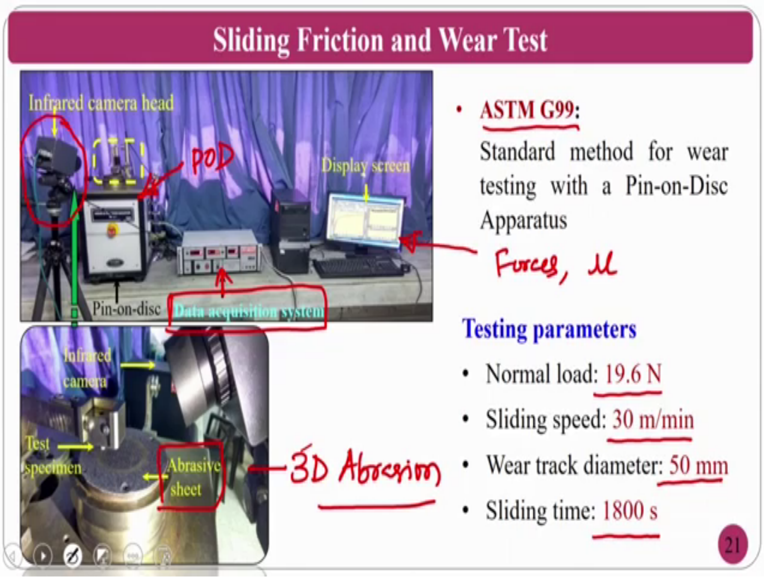

Some of the conditions also we will explained, as I said ASM is G99, we are a normally we will be used for the pin on this wear testing. So, the conditions for example, what we have used is 19.6 meter is is the normal load, and 30 meters per minute is the sliding speed wear track diameter is 50 mm, and the sliding time is1800 seconds that, and we can measure ok.

Here if you see the very just slight difference between the previous slide; where you would see here the disc and a pin are there ok. This is holds good for 2D abrasion ok. Why because, you are having a hss which is a solid material. At the same time, you have a workpiece material mild steel. So, you are test it ok. There is a very less chance that the particles formation between these 2 mating surfaces. That is why this is a 2D abrasion; however, you can also simulate or you can also do the 3D abrasion by placing a emery paper, that is called abrasive paper on an under disc.

So, you have to hold it from you can see the abrasive sheet here are or abrasive paper. So, and you just move on this is 3D abrasion ok. So, you can also check 2D abrasion as well as 3D abrasion. 3D abrasion some of the people will follow for grinding applications and all those things ok. So, if you see the setup how to measure this is a pin on disc. So, this is a pod pin on disc setup. So, this is called data acquisition. You can see this is a data acquisition system ok. So now, data acquisition will give to the CPU and in the computer; however, we can also measure the infrared camera or the temperature generation of those things. This is the infrared camera is also attached.

So, this will display will give me forces. I can calculate coefficient of friction and all those things ok. So, the my infrared camera gives me the temperature how the what is the temperature generation takes place for the normal condition, if I am using a lubricant how the temperature varies and all those thing ok.

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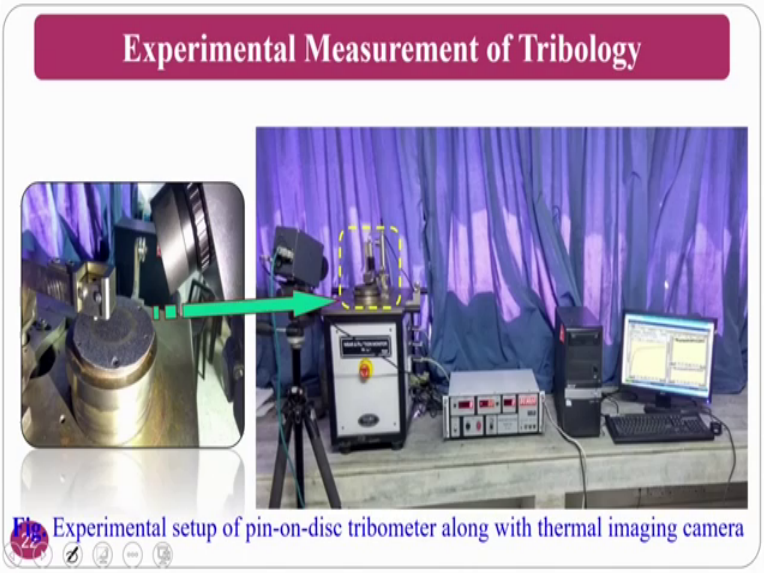

So, if you see the same picture in a good way without flow and all those things. So, this is what the abrasive paper is, and this will give you the; now I you will show you how the abrasive sheet and my workpiece are the tool material, if I want to understand the workpiece material nature I can use a pin as a workpiece material, if I want to use the tool material versus a abrasive sheet I can use it also. Normally, the pin will be basically made up of a tool material because we will understand with respect to tool materials only ok.

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In a zoomed version if you see body abrasion, this is a track you can even see it is running basically this is the track ok. So, track is there. So, this is about the 3D abrasion, and you are capturing and the temperature profiles also ok.

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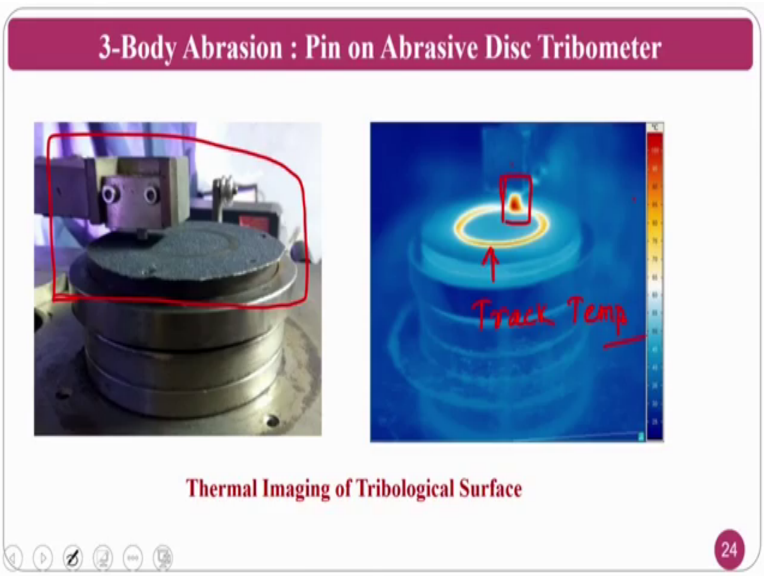

You can see how the temperature is shown here. So, the same track. Here, whatever the experiment that I am doing at this practically. I am also catching the image in the infrared camera; where I am also observing the temperature ok. So, normally the temperature is about 60 to 70 to 80 degrees temperature it is according ok.

So, since the experimental conditions are too low, for demonstration purpose, for what is the temperature effect and all those things to show you, we have done a simple sample experiments as a part of our research experiments also ok. So, you can see the temperature of the track, you can see the temperature of the pin and all those ok. So, this is a temperature of the pin, and this is the temperature of the track temperature ok. Your pin is situated here. So, this is about a the 3 body abrasion as well as the temperature measurement and all those things ok. Because we were talking about the frictional heating and all those thing. This is completely because of the frictional heating the temperature is raising around 70 to 80 degrees.

So, it is a huge amount of temperature ok. Now in a machining operation, the savior plastic deformation this giving you major temperature, Apart from it, frictional also is there. So, if savior plastic deformation is giving you the major amount and a frictional heating also gives you some part ok, because of this the temperature goes up ok.

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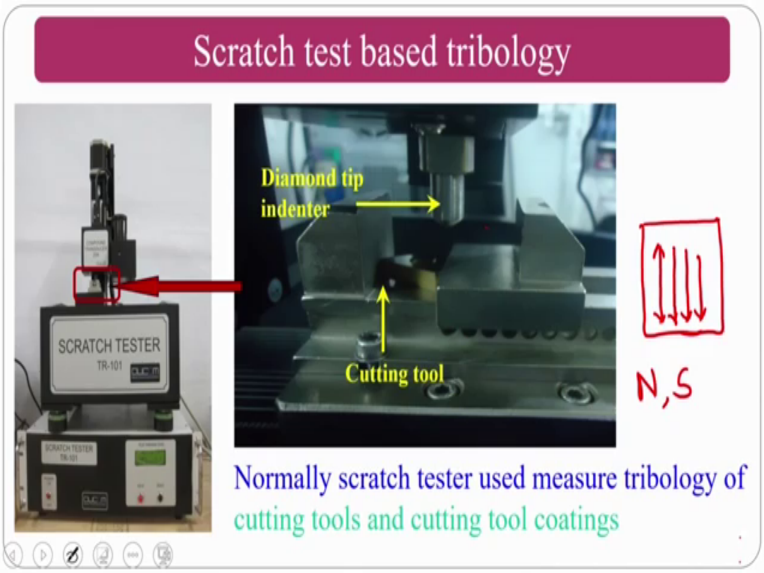

Another one normally to test the tribological aspects, the scratch tests are used because whenever that there is a tool coatings are there, in that circumstances what is the load what are the speed at which the this de lamination of the coating takes place. For that purpose, for the type of tribological aspects, normally, scratch test-based tribological conditions are used. This is a diamond indenter normally, and you will give a reciprocation assume that I have a tool in this form.

So, I am just using the reciprocation. So, how a reciprocation you can increase the lamp I can do this. So, I can get the different different loads, and scanning speed, if you do what will happen the scanning the shearing of the tool surfaces will goes off. It can be tested for the virgin tools, or it can be tested for the cuticles also. So, in that circumstances. You can see where the delaminating the in terms of tool coatings you can see at what load and what speed the delamination of the tool coating system taking place that you can study ok. So, in this way, one one can study is the pin on disc experimentally you can study the 2-body abrasion 3 body abrasion, if at all I want to study the de lamination of the coatings you can go do the scratch testing. This scratch testing is also one of the ways of a doing the tribological test ok.

Ah this is about the tribology as well as this one still, now we have studied the what is a chip tool tribology as well as how the frictional heating takes place, on how the tool where is can be simulated in terms of tribology, I am not saying a tool wear. So, normally tribological conditions can be done experimentally. And if at all normal tools you can do by the pin on disc, a workpiece can be a disc as well as a pin can be the tool material. And if we if I have a coated tools; nowadays, people are talking about advanced tools like a nano coatings, or micro coatings, are taking place. For this purpose, normally, you can go for the scratch tester also ok. This is about today’s class.