Introduction to Machining and Machining Fluids
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Lecture - 09
Tool Wear and Tool life Part-1

Welcome to the course. So, this is about the tool wear and tool life.

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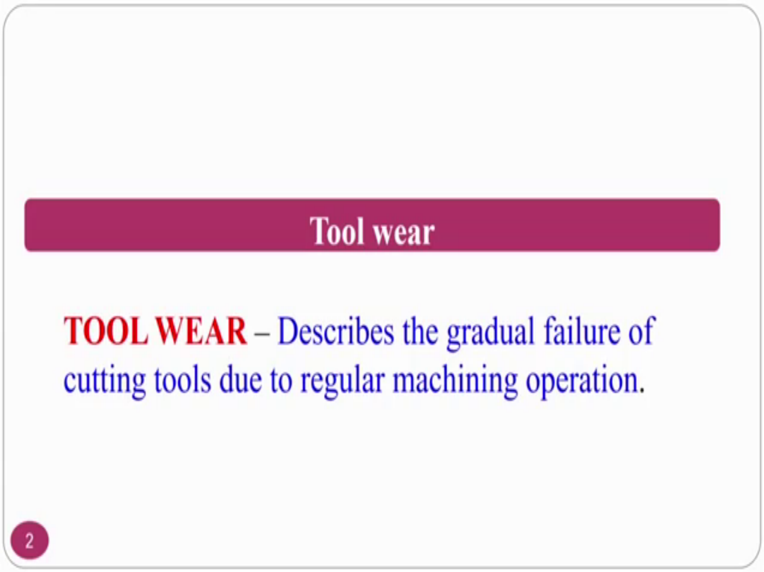

So, the tool wear, normally if you see the tool wear it describes the gradual failure of the cutting tool due to regular machining because it is a progressive wear basically. So, it describes gradually how atom by atom or molecule by molecule are the amount gradually it will goes off that is what the progressive tool wear is.

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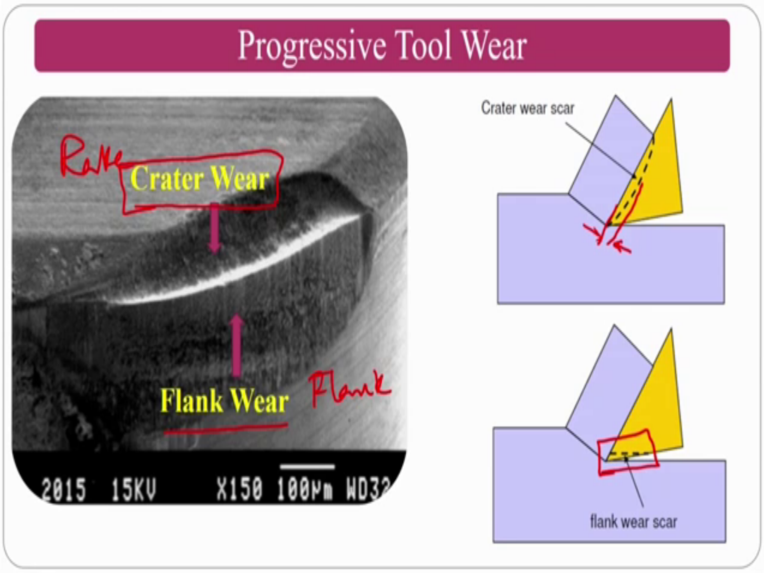

Just it if you see to the introduction to the progressive tool wear. There is a another tool wear that is called catastrophic tool wear which I am not a discussing it catastrophic tool wear is normally sudden breakage.

So, that will happen basically in the brittle and ceramic materials, but the gradual tool wear or the progressive tool wear takes place in the other materials like a HSS, carbide tools and all those things ok. So, we are here we are seeing about the crater wear and the flank wear these are the two varieties of the progressive tool wear that one can see here. At the same time how to represent schematically if you see the schematical representation, this is the rake surface, and this is the flank surface. So, the wear that is taking place on the flank is a flank wear and the rake surface the various taking place is crater wear ok.

So, now the crater wear represents normally in terms of crater wear depth this is crater wear depth, you can see the in terms of crater wear depth and in terms of flank wear it is normally represent in the flank wear land this is a flank wear land, so on the flank face ok. So, these are the two wears commonly observed in the tool wear in the machining processes ok. There are other wears like notch wear edge wear many other wears are there, but since this is the introductory course to the machining process. So, we are concentrating mostly on the two wears that is a crater wear and then the flank wear ok.

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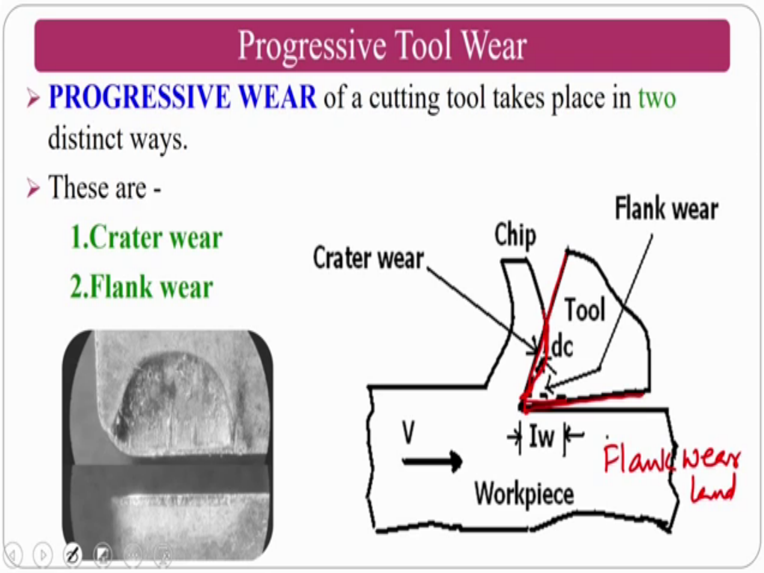

This is a progressive wear, now you can see how it takes place on the machining process we have seen previously. So, now, you see this is the cutting tool basically, in this cutting tool because of the chip motion you can see this is the crater depth that takes place because of the workpiece interaction normally abrasion there comes the flank wear. This is called the flank wear.

Normally it represents in terms of flank wear land this is represent in terms of flank wear land; that means, indirectly what it mean is it is a width of the flank wear and in terms of crater wear it represent in terms of crater wear depth ok. So, this about and if you want pictorially you can see in the next slide.

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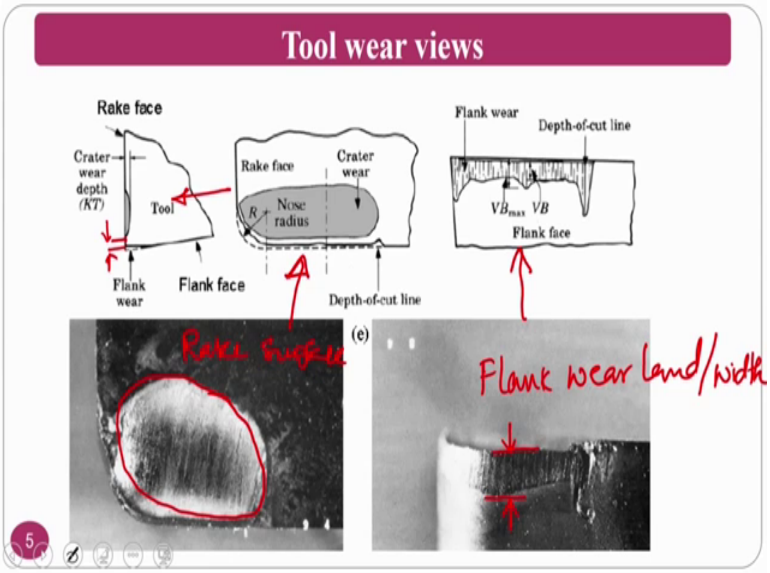

So, this is the crater wear depth normally this is the crater wear which takes place on the rake surface this is a flank wear.

So, I just talked about your flank wear ok. So, that is nothing, but this is the flank wear land or flank wear width the other term is width. This is the practically what we observe in the machining process if you want to represent schematically the flank wear represent like this and crater wear represents like this ok, the other view that you can see is the crater wear this is the other view ok.

So, one noting point that you have to always see here is just I will come to some question here which I will explain you from the point of questions. Just you have to see what is it starts slightly away from the cutting edge that is what you have to observe ok. So, I will ask you one question and I will also tell you the answer also.

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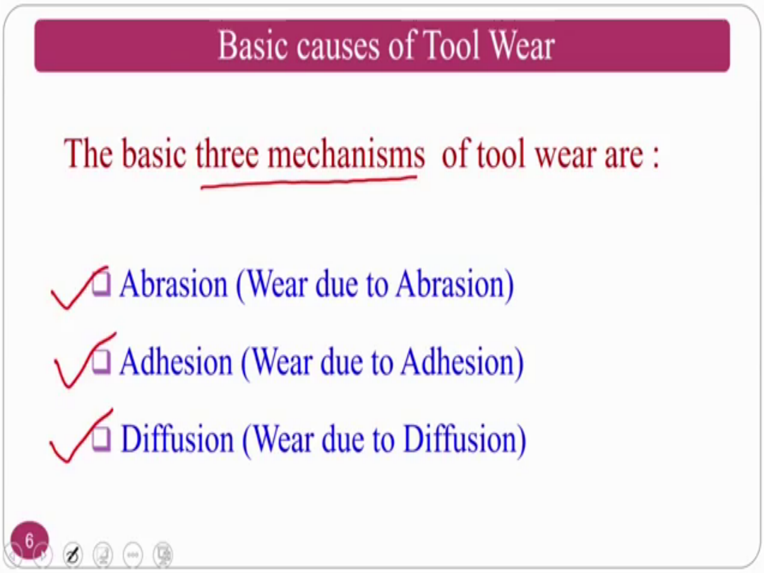

The basic mechanisms there are three mechanisms are the causes by which the tool wear takes place in the machining. So, whenever we talk about the output that is if there is a research paper on the machining process. So, people talk about different different wears whenever you have a different wear you should talk about the physics of it what is the physics behind it and how this process is taking place what are the basic mechanisms that are the people explained in the textbooks, that are the mechanisms that explained in the research papers and all those things ok.

This is the first one is abrasion, the second one is adhesion and diffusion ok.

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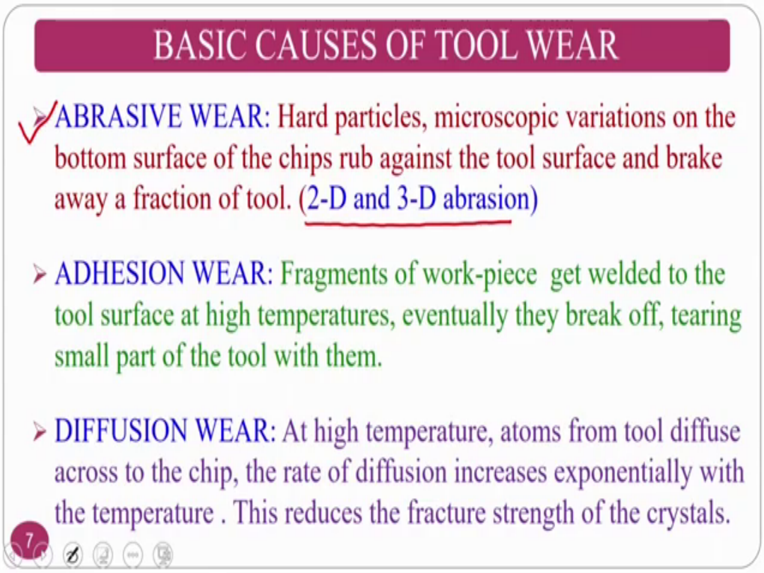

So, just we see this abrasive wear. So, these are the three hard particles microscopic variations on the bottom surface ok. So, this is about the explanation. So, microscopic variation on the bottom surface of the chip against. This is normally there is two types of abrasions will takes place one is a 3D, another one is a 2D practically speaking it is a 3D, so, for better understanding whenever we do the modeling or whenever we want to understand the things some people understand it is a 2D.

The adhesion normally adhesion is nothing, but the joining. Abrasion is nothing, but it is like abrading the surface whenever a kabaddi player falls on the sand in a villages you see the players. So, the sand if it is here so that will abrade the skin that is nothing, but the abrasion and adhesion normally is just joining that is two materials of different materials. And diffusion is a starting point of adhesion; that means, higher concentration to lower concentration if the material transfer is gradually taking place that is called the diffusion.

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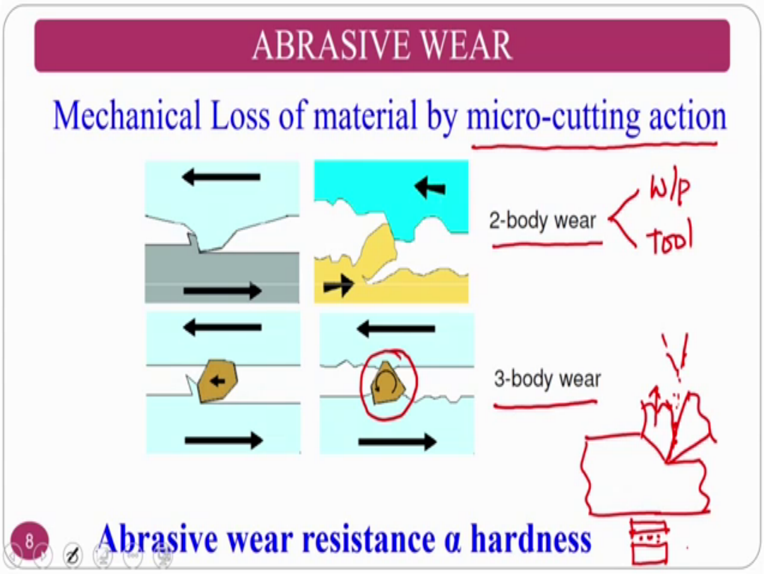

Anyhow I will come in detail about all these things that the mechanical loss of material by micro cutting action normally if you see this is to explain you what is abrasion wear. We have just taken the example of the micro cutting action.

So, whenever you have a two body abrasion; that means, that there are involvement of only two bodies in our present scenario these two bodies are one is the workpiece material another one is a tool material ok. So, if there is a interaction or wear between two bodies the abrasive wear between two bodies then it is nothing, but the two body abrasion or two body wear.

In term if you have a third body normally for example, this is commonly two body abrasion is commonly in terms of machining process, where in a tool single point cutting tool is there and you are removing a material assume that you are machining a copper with respect to the one of the hard tools like a this is are carbide tools normally you will have two body abrasion. The three body abrasion will takes place when there is a third body comes into picture like you can see that this picture; So, where third body come into picture which can rotate about its own axis ok.

What I mean to say is in for example, just to take a process where a loose abrasive particles are used. So, like lapping process, even lapping process you have a lower plate or a workpiece or something and upper plate where you have a or the lower one is their upper one is there one will be your workpiece and you put a slurry and you just polish it.

What will happen? You have the component, you have the lap on, and you have abrasive particles whenever you try to polish it what will happen the abrasive particles will also take part along with the lap ok. So, this is what three body abrasion.

Now, the same thing whenever we want to explain from the point of metal cutting. See whenever you have a single point cutting tool wear chip is taking case if you are putting a cooling fluid. What will happen? Because the chip is high temperature it will be in the form of semisolid or something and the tool is also chip is continuously flowing because of which the tool gets hot and hard ok.

So, in that circumstances it may create some particles this is in the semisolid state whenever the liquid with a high convict to heat transfer coefficient falls, it will may generate particles there is a chance I am not saying it is a compulsory. So, there is a chance whenever you are machining low melting point materials like aluminum and all those things. So, there may be the chance of particle formation because of the cutting fluid maybe ok.

So, not only the chip and the tool interaction here because of the foreign body particles that with particles generated, because of the interaction of the cutting fluid with the chip bottom side on the top side of the cutting where the particles comes because of these you have a chip you have a tool material in bit you have particles. So, because of which the three body abrasion also comes into the picture ok.

So, normally if at all I want to check this three body abrasion or something in terms of tribological aspects people uses for the two body abrasion normally people uses workpiece material and tool material and they, they will do the tribology pin on disc and all those things. If they want to go for the three body abrasion basically on the disc pin on disc that is pod they will instead of disc they will take the abrasive sheet and they will just perform the experiments and they try to correlate various tribological issues. So, in that way this can be studied ok.

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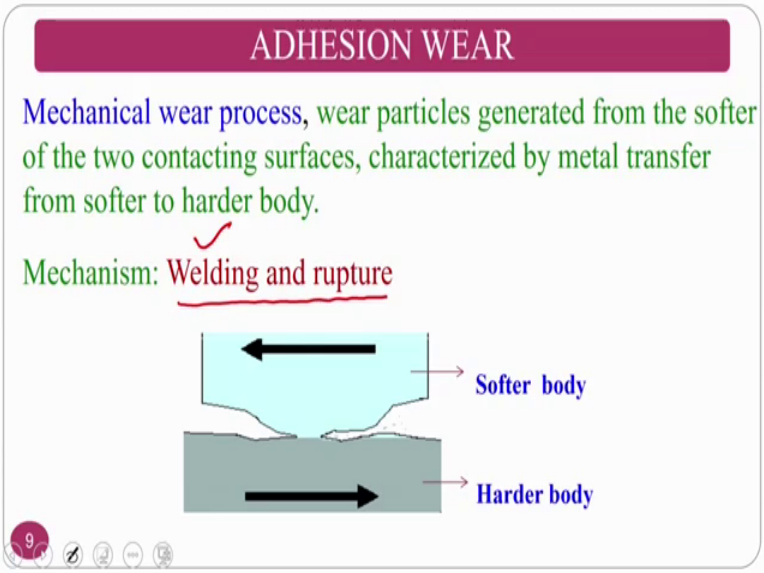

So, the next one is adhesion wear the, mechanical wear process wear particle generate from the softer and to contacting surface characterized metal surface and mechanism is welding and rupture ok. So, basically whatever here welding and rupture is the tool wear mechanism ok.

So, pertaining to the adhesion only welding takes place. So, whenever you are machining certain material when the temperature goes high what will happen? There is a welding that is nothing, but the adhesion takes place between chip and tool for a instant for a microsecond or a nanosecond. So, what will happen? If I have a soft workpiece material whose chip is continuously flowing on the surface in that circumstances chip is carrying already told that 80 to 85 percent of the generated heat ok.

So, it tries to build its internal layers nanometer by nano meter by nano meter on the tool surface and after some time because of this because of the friction and high temperature of the chip this temperature goes inside inside inside of the tool and thermal softening of the tool takes place and at the certain point of time. The tool top layers will goes off; that means, that crater wear whatever I am just shown the crater wear takes place; that means, that layer by layer by layer of the binning surface of the chip will accumulate that is welding takes place and because of this the temperature of the tool goes high.

Even temp tool also gets 10 to 15 percent of the temperature 80 percent of the chip is giving which is flowing also giving the temperature. Chip is a continuous body and the tool is a static body in that circumstances the thermal softening of the tool takes place after some time and these top layers of the tool whenever after some time it goes off. So, that is nothing, but the rupture.

So, this is about the adhesion and the rupture ok. Softer body normally work piece will be there softer body, and the harder body will be tool I mean cutting tool. This is about the adhesion wear.

Now, the diffusion wear. Normally the diffusions basic definition if you speak it is called higher concentration to the lower concentration ok.

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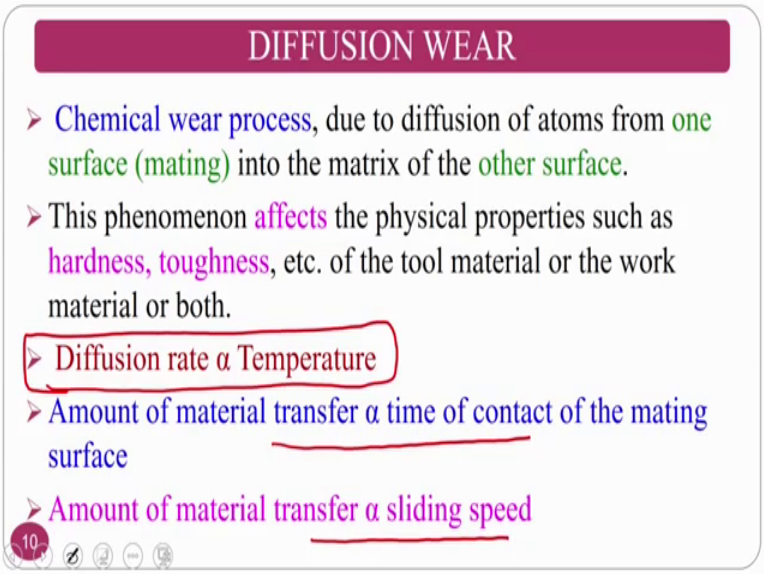

So, you can see whenever the chip is flowing on this and at high temperature normally the machining temperature gradual diffusion of atoms which are lying on a beneath of the chip gradually goes and sits on the tool surface; that means, that we will go into the tool surface that is nothing, but the diffusion.

What I personally feel is adhesion is a higher version of the diffusion may be just it is in my view. So, if the partial atoms of the workpiece chip is going to the lower concentration; that means, that here in the chip it is a higher concentration of the workpiece material the lower concentration is a tool material. So, if we if it goes that is nothing, but the diffusion the chemical wear process due to diffusion atoms from one surface to the matrix of the other surface goes the phenomena affect the physical properties such as hardness toughness of the tool material and others.

Normally diffusion is proportional to the temperature. At high temperature that diffusion will be very high ok. So, the initial step of the adhesion may also can call as the diffusion process ok. The amount of material transfer is proportional to the time of the contact ok. So, amount of material transfer is proportional to the sliding speed if the sliding speed is very high the temperature also will high, if the temperature is very high so the diffusion will also takes place if the contact area is very high or the contact surface between this area high.

What will happen? This is the lower concentration and this is the higher concentration if the contact area is this it is different, if it is this it is different. So, if the contact area is very high normally it is proportional to the diffusion where is proportional; that means, that it we increase ok. These are the 3 mechanisms, one is abrasion where rubbing action will takes place it is a mechanical action, the second one is adhesion which is the thermal one and the diffusion is also a thermal one ok. So, these are the three mechanisms on which the tool wear depends ok.

Now, we will go into the tool wears. So, the possible tool wears in orthogonal metal cutting process are one is crater wear we have already seen and the another one is the flank wear.

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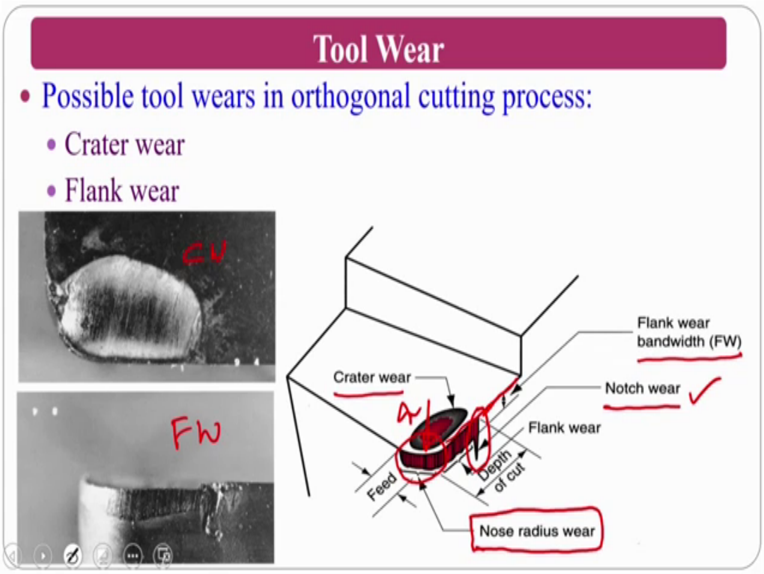

So, this is also I have shown in the previous slides which is a crater wear and the flank wear. To show you the isometric view just we have given you a glimpse here on a single point cutting tool this is the crater wear and this is the flank wear ok. So, this is about the flank wear ok.

So, normally flank wear I already told you flank wear width is the one flank wear land is the one another wear is nothing but the notch wear, you can see the notch wear which I am not going to talk much about this one. Just I am talking about the introduction to the tool wear. So, I talked about only tool wears, but however, you can see at the end of the flank wear there is a wear called the notch wear. So, that is another type of wear.

So, there is another one wear is nothing, but the nose radius wear, you can see here on the nose radius ok, this is the nose radius and this is the sharpness radius which is ok. So, these are the glimpse that schematically I can show you ok.

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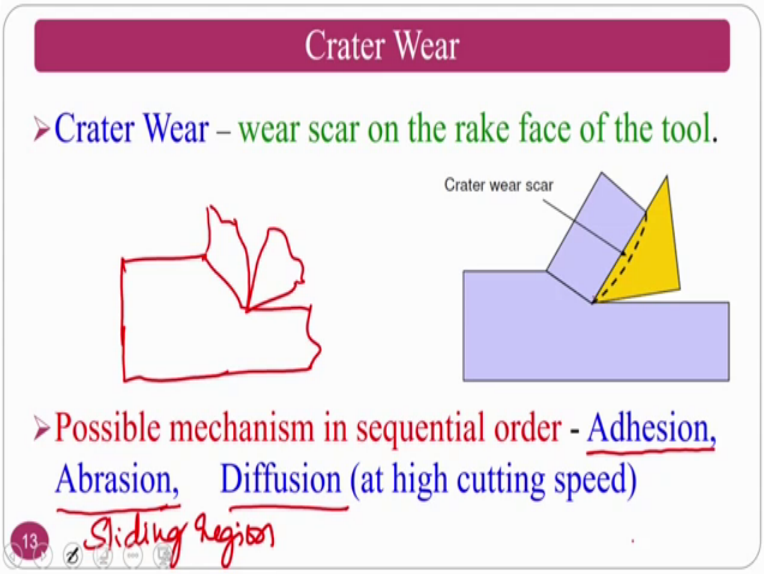

So, then a crater ware, the crater ware if you see crater wear this is the crater ware that I have already shown you the crater ware wear scars on the rake surface of the tool possible mechanisms.

Now, we have to see what is the possible mechanisms. We have seen three mechanisms that is abrasion, adhesion and diffusion. Among which, which causes more in terms of crater ware which is high in terms of flank wear; that means, which is a most responsible mechanism in the crater ware which is the most responsible mechanism in the flank wear that we have to see, ok.

See the possible mechanisms sequential order I am just saying about the crater ware. The crater wear means if my workpiece is there and the tool is there if my chip is moving on top of it ok. So, the chip is carrying lot of temperature and it is imparting into the tool that what I have said and the basic mechanism here is welding and rupture. Why I am saying is welding and rupture.

If you see this picture where my chip is moving, so the bottom line surface of the chip gradually welds on the surface the surface of the workpiece and when the thermal softening takes place this will takes away. This particular portion is goes off; that means, that the basic mechanism dominating mechanism here is adhesion and followed by abrasion because it has a sticking zone as well as a sliding zone ok.

So, the crater wear takes place in the in terms of sticking as well as sliding, but the sticking it is dominating and sliding slightly less. So, sliding region sliding region is mainly because of the abrasion and the diffusion also plays at very high speeds ok. The basic mechanism that one can tell is adhesion is the dominant mechanism of tool wear in terms of crater wear, ok.

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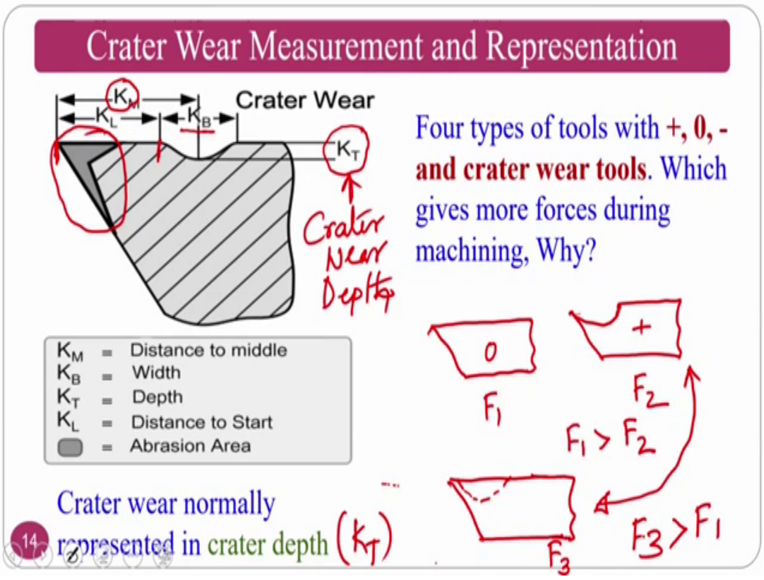

So, if you see the crater wear, normally crater wear represents in terms of this these are the representations one is the distance to the middle that is K M, this is the K M. Another one is K B that is a width this is the width of the crater wear, depth of the crater wear that is a K T which normally you can say is as creator wear depth and K L is distance from the start. So, this is nothing, but a K L, from the starting point to the cutting edge a starting point ok. These are the notations and the abrasion area is this one.

So, crater wear normally represent in terms of crater wear depth that is what I mean to say is K T crater wear depth which is represent ok. Now the question assume that I am taking only three types of tools, one is 0 rake angle tool positive rake angle tool ok. First let me take to wear normally forces will be very high basically speaking assume that here is if it is F 1, this is F 2. So, F 1 will be slightly higher than F 2 because positive rake angle is there assume that there is a crater wear an a 0 rake angel tool. What will happen? This is my 0 rake angle tool. So, I have a crater wear. So, how it look like? It look like similar to my positive rake angle where my forces is F 3, from the visibility from the what we are seeing it should give F 3 F 1 should be greater than F 2, ok.

So, normally it should be from the geometry what has a visibility from this point normally F 1 should be greater than F 3 also from the visibility point of view, but it is not. So, the, but the case is F 3 will be greater than F 1, greater than F 2 this will be the condition. Now, question is why, ok. So, the question is simple I have a 0 rake angle tool wear the force for the same conditions for the same depth of cut, speed cutting speed and all those things I have a 0 rake angle this is 0 rake angle this is positive rake angle this is a wear tool wear that is crater wear take place, ok.

So, in that circumstances F 3 should be wear tool normally will experience more forces compared to 0 rake angle, but geometry wise it looks like a positive rake angle. Now, the statements are contradictory basically the person who is doing experiment with experience F 3 greater than F 1 ok. From the visibility point of view from this slide it should resemble like a positive rake angle ok. The answer as per the partial answers I can say is normally the tool ware will not starts from the cutting edge like the positive rake angle ok. So, it has a slightly distance will be there.

Second thing here it is a smooth cut in a positive if you see it is a smooth cut here the tool wear is random and it is not proper. So, the chip that moves will have lot of disturbances and all those things ok. These are the partial reasons why normally F 3 whatever we are seeing here F 3 is greater than F 1, greater than F 2 ok.

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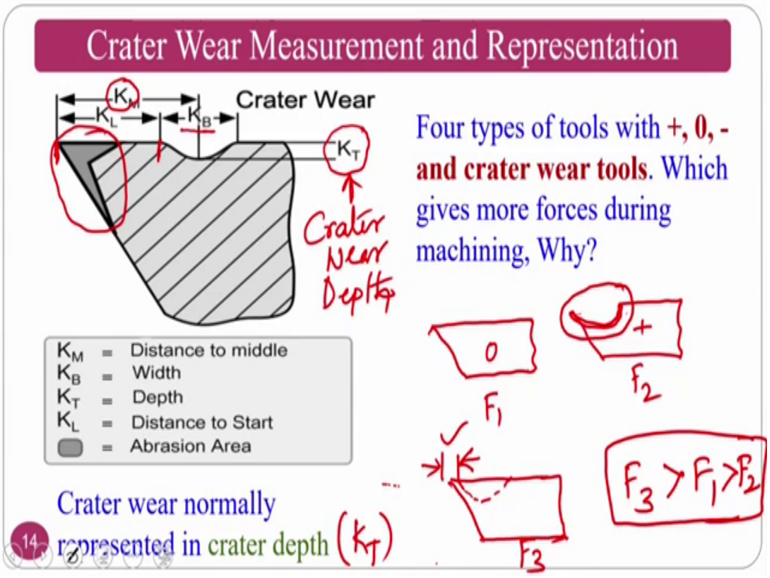

So, that is the some of the reasons there are many other reasons also for the same cutting tool normally this starts slightly ahead this is a distance and it is a rough, ok.

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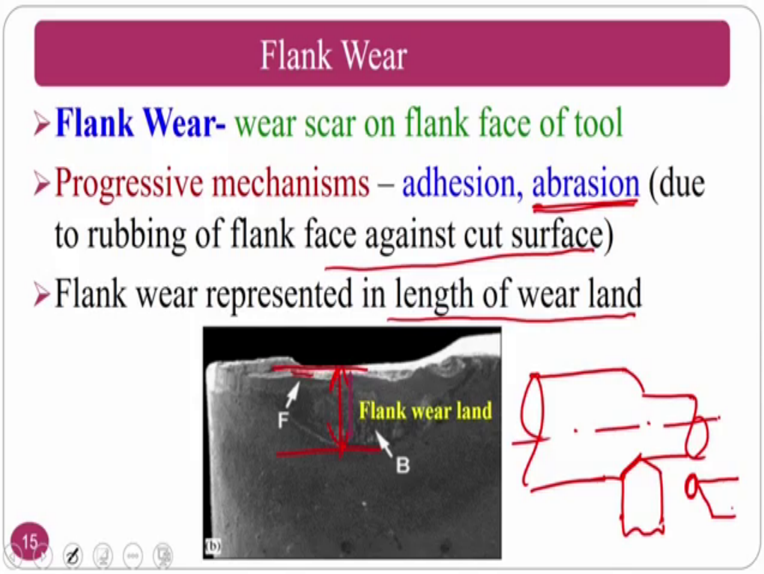

So, other one is a flank wear the wear scar on the flank face of the cutting tool this is also progressive wear, but here the basic mechanism is abrasion ok, because the workpiece or the missioned workpiece is in contact with the flank face ok. So, if you see the workpiece normally the rubbing action takes place on the flank face of the tool rubbing action takes place here because of which there is a flank wear land the dominant mechanism is abrasion. So, that it is a mechanical rubbing action against the cut surface that is a machined surface. Flank wear represents the length of the flank wear land ok. So, this is nothing, but the flank wear land

So, the summary is in a crater wear adhesion is the dominating mechanism here abrasion is a dominating mechanism that is the bottom line of the wear mechanisms versus the wears ok. So, now, we will see the flank wear versus time how the flank wear progressively increases with respect to time and all those things ok.

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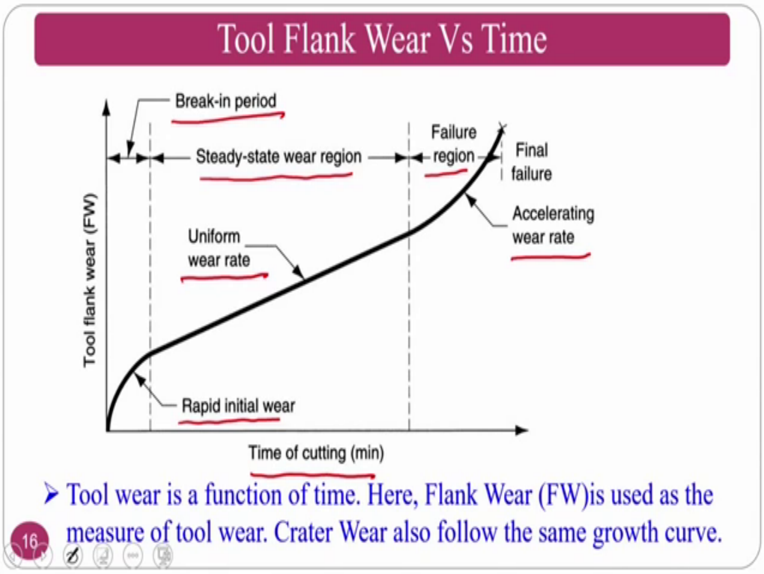

So, if you see this one the time of cutting versus the tool flank wear normally to similar trend the crater wear also follow. So, I am just touching about the only the flank wear. I will also explain you why I am touching only the flank wear because the flank wear is the criteria that people can easily measure, but the main reason is the tool life criteria basically takes from the flank wear only.

So, that is a main reason whenever the point comes I will explain you ok. So, there are three regions if you see in the tool wear region one is the break in period, initial break in period, then the second one is steady state wear region that is a uniform wear rate wear and the third one is a final failure region that is a accelerated wear region ok.

So, the first phase follows rapid wear uniform wear followed by exaggerated wear. So, these are the three wears in the three regions of breaking period and steady state wear region and the failure region. So, we will go by one by one.

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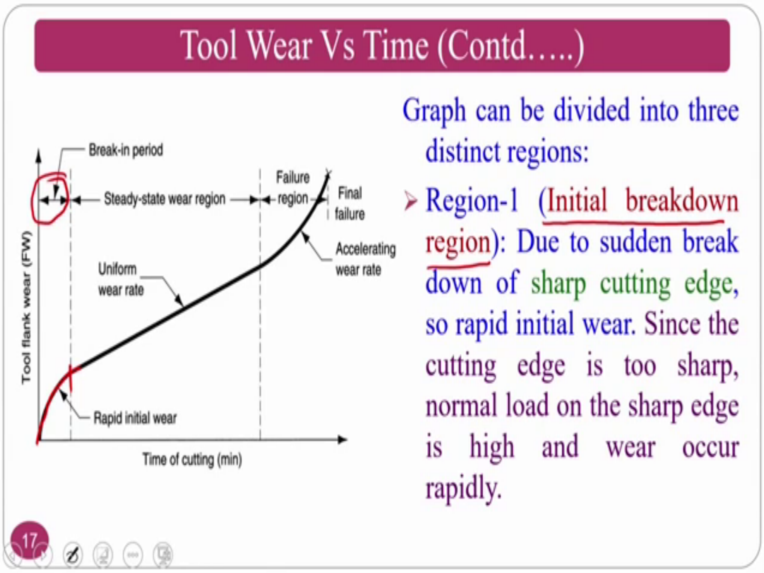

The region one ok, the graph is divided into three distinct regions as I said it is a break in period, steady state and as well as the failure region.

So, the region one, initial breakdown region ok; So, this is initial breakdown region in this region the due to sudden breakage down of the sharp cutting edge. So, the rapid initial wear takes place since the cutting edge is too sharp normal load on the sharp edge is high and the wear occurs rapidly; that means, we have seen in the merchant circle and also those things where the cutting tool is too sharp; that means, that sharpness radius is 0 ok. So, the sharpness radius is nothing, but my rake surface is there, my flank surface is there, wherever this rake surface and the principle flank surface meets the cutting edge that is called the principle cutting edge the radius of this one is nothing, but the sharpness radius ok.

So, normally that the manufacturers try to keep it as sharp as possible, so that sharpness is very good; that means, that sharpness radius is too low; that means, that this is too sharp. So, in that circumstances whenever the load takes place that mean that whenever the machining start process starts this cutting edge is too sharp and after some time suddenly it goes off that mean sharpness radius suddenly increases; that means, that that sharp edge will goes off that is nothing, but initial breakdown region ok.

So, that is why initially this portion will come ok. So, I said you know initially because you are area interacting with respect to the cutting region because of the sharp cutting edge is very less. So, that will goes off automatically after sometime that is called initial wear by breakdown or something. The second one is steady state wear region where uniformed wear rate takes place.

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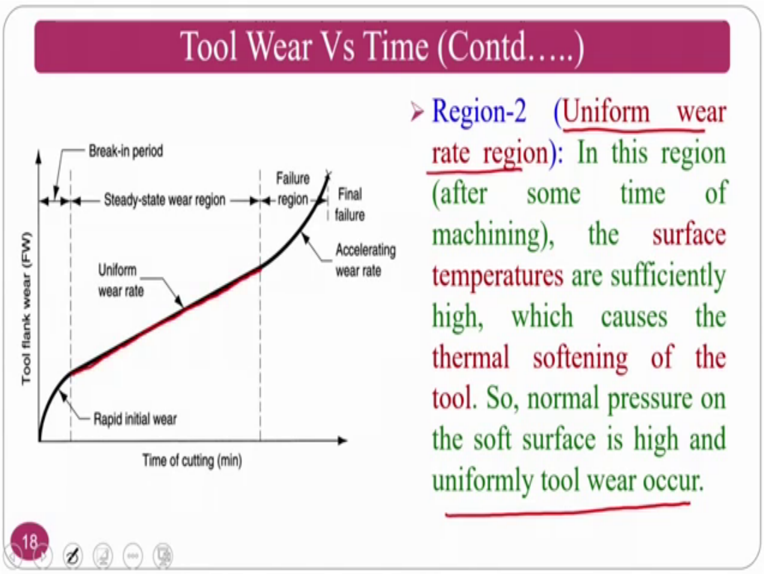

In this region after sometime the surface temperatures are sufficiently high which causes the thermal softening of the tool so the normal pressure of the surface soft surface is high and uniformly wear takes place. That means, whenever you have the sharp cutting edge is gone now your sharpness radius is increase.

So, the contact area between work piece and the tool is very high, in that circumstances the chip is going on going on by shearing action. So, temperature gradually increases in the tool because of the friction, because of that tool carrying temperature and all those things. So, thermal softening of the workpiece tool takes place. So, the normal pressures gradually increases and the wear gradually uniformly increases ok. This is the second region and if you see.

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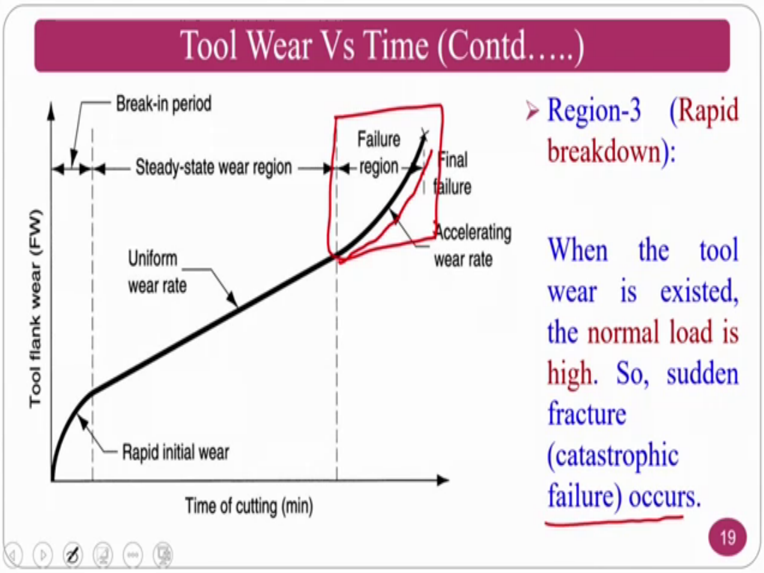

The third region that is called a rapid breakdown, when the tool wear exceeds its normal load high, so sudden fracture that is called catastrophic failure occurs this is nothing, but the failure region ok.

What is its going to be take place is, so the thermal softening of the tool takes place gradually and the tool become soft and it loses its properties basically which are the main important for machining operation. So, these are all goes and suddenly there will be a fracture in the tool because that is nothing, but the catastrophic failure catastrophic means sudden.

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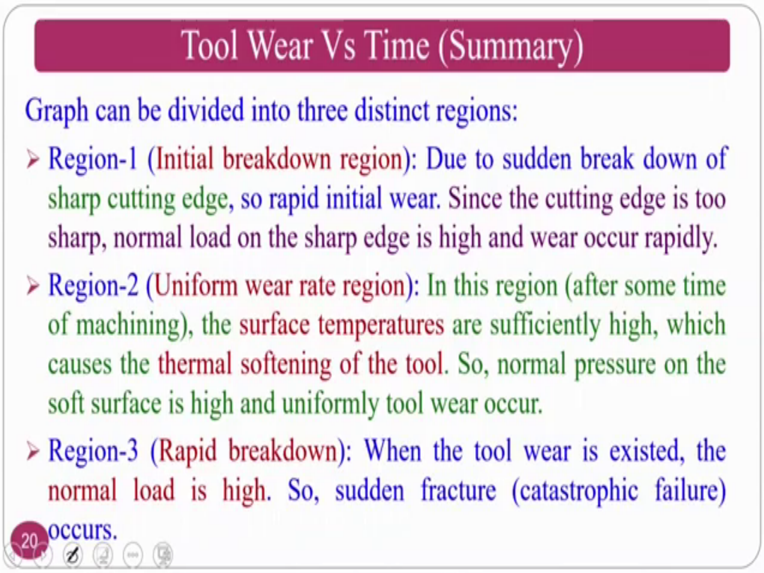

If you see these three regions normally so initial breakdown this is the summary where the initial region that is a region one initial breakdown uniform wear the sharp edge will goes off immediately, and the uniform temperature goes in goes in goes into the tool because of thermal softening takes place. So, uniform progressive tool wear takes place and the third one is breakdown takes place because it is completely thermals offend because the machining time is too high and the tool is a stationary body that is why the catastrophic failure takes place. This is about the time versus the tool wear.

So, now we will go to the tool life as I said when I am explaining you that I am explaining you to the flank wear. Why I am explaining the flank wear? Since the similar mechanism is there in crater wear also just. So, you can go through that some basic textbook. So, you can get it. And the tool life if I will say which wear is can be treated as a tool life criteria whether it is a flank wear or crater wear and why.

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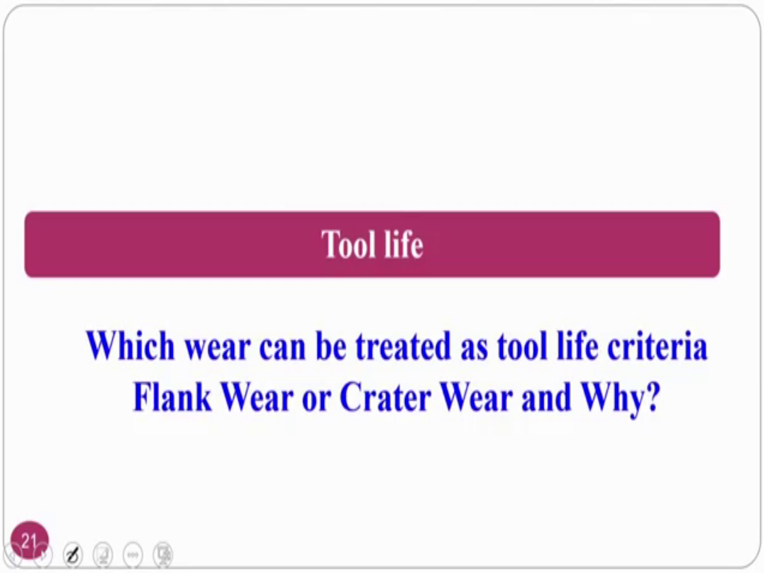

Thus I said you when I was discussing about flank wear mechanism and all those things ok. Which wear? So, can anybody guess, its normally the flank wear ok.

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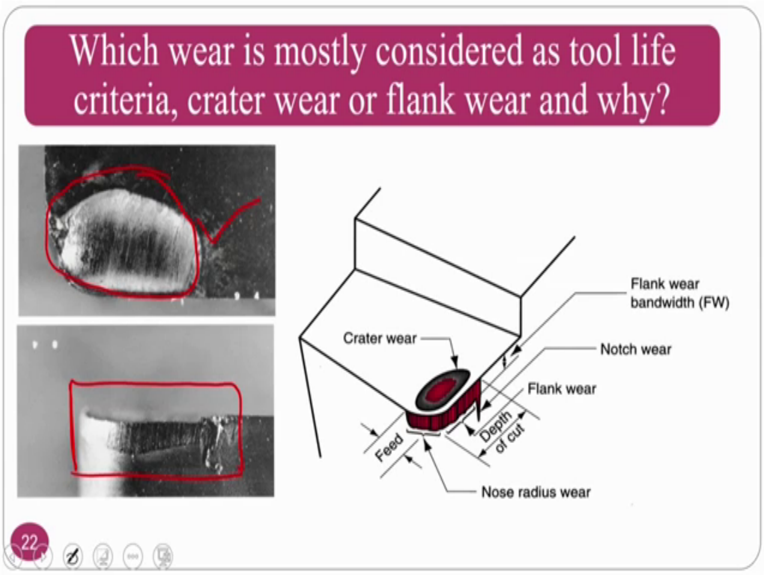

So, why the flank wear? Whenever the machining operation is taking place crater wear takes place on the rake surface and the flank wear takes place on the flank surface and the flank surface is the surface which will be in contact with my final product. So, whenever customer ask me I have to give you a product to him in a good size, good tolerance good surface finish and all those things. If my flank wear is disturbed or the flank wear is high in that circumstances I cannot give him the good product because the product comes out will be in a not good shape or in an acceptable form for a customer.

So obviously, my chip will be in contact with rake surface which causes the this wear crater wear the chip I do not bother because the chip is the one which is not useful for me. I cannot say useful, but you can recycle into workpiece material and all those things, but I am worried about the final product, if at all I want to give a good product my flank wear land should be within the limits. If my flank and flank wear is the criteria if my flank wear I can keep the criteria as my criteria I can give you good product that is why always or the most of the time flank wear will be the criteria. Some of the times crater wear will also a criteria that is whenever you are speaking about high speed machining and all those things where the temperatures are goes high.

In that processes crater wear is also a criteria, but however, for the normal conditions of the machining process the flank wear is the criteria that one can follow.

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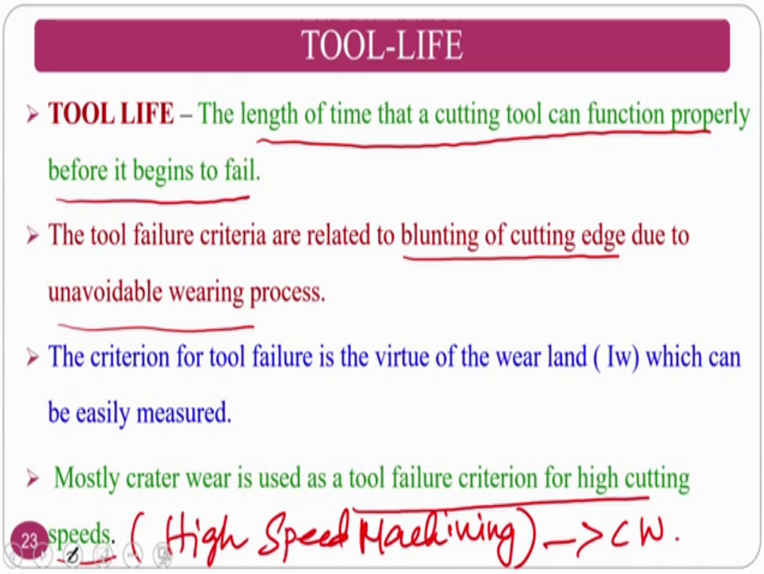

So, the tool life, tool life normally can be defined in many ways. You can see the length of the time that cutting tool can functional proper before it begins to fail ok. So, it is performing its own function, it is a machining operation. So, if it is fake; that means, that my I have to change my tool; that means, that this is my about my tool life one wear.

The tool life criteria can be related to the blunting of the cutting edge due to unavoidable wearing process ok. Blunting of the cutting tool if the my cutting edge is gone what I mean to say is that I have to replace because otherwise lot of vibrations will takes place which hampers the accuracy of the product and all those things.

The third one is the criteria of the tool failure in the virtue of wear land which can easily measure under then most crater wear is using tool failure criteria I said that in the high cutting speed that is high speed machining basically ok. Normally here crater wear will be criteria ok. So, that is what I want to convey. Now, what are the variables that affects a tool life? If at all I want to see what are the variables that affect the tool life of my any tool that I have taken whether; it is a HSS or carbide diamond or something.

So, the variables affect is cutting conditions, tool geometry, tool Materials, workpiece material, type of cutting fluid and cutting fluid application techniques.

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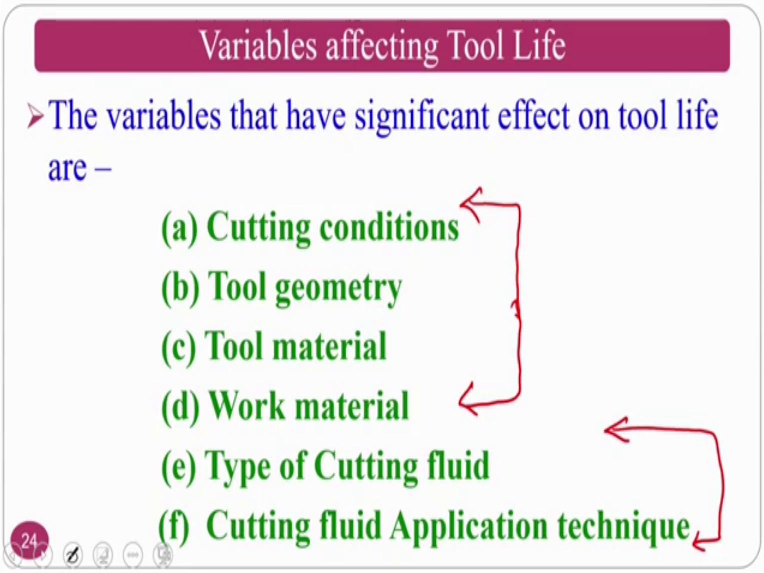

If you see some other things some are already given that is cutting conditions, tool geometry, workpiece material and all those things these are you can find in some of the textbooks. However, cutting fluid technique and cutting type of cutting fluid these are all you may find in some of the new textbook whenever we prepare our slides or our notes normally we follow multiple textbooks. So, for the basics we follow the old books and some of the pictures that we never we take we take from our own research since we are doing some of the research in these areas we also take with that is why a research and teaching goes hand in hand ok.

So, whenever we teach we also teach some of the advances that are found during the research ok. So, the first one which we can see is the cutting conditions.

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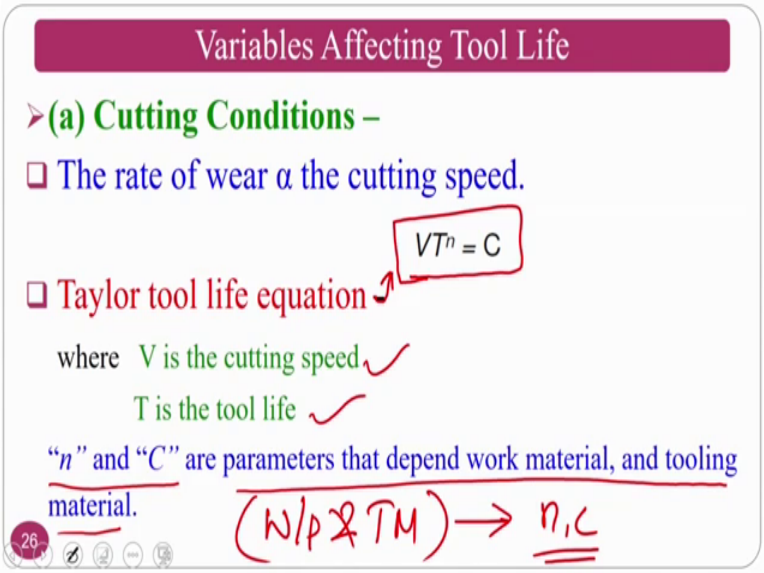

So, the cutting condition the rate wear and the cut is proportional to the cutting speed that is V T power n equal to constant this is called Taylor tool life equation. So, whenever you see this Taylor tool life equation V T power n equal to constant where the V is cutting speed, T is the tool life and n and C are the constants ok.

So, V is the cutting speed, as I said T is a tool life and the n and C are parameter that depend on workpiece and tool material that is nothing but workpiece material and tool material combination n and the C depends ok. It is not depend on as a workpiece material or the tool material it will always depend on the combination whether you are using HSS versus steel HSS versus cast iron or carbide versus cast iron or mild steel or something ok.

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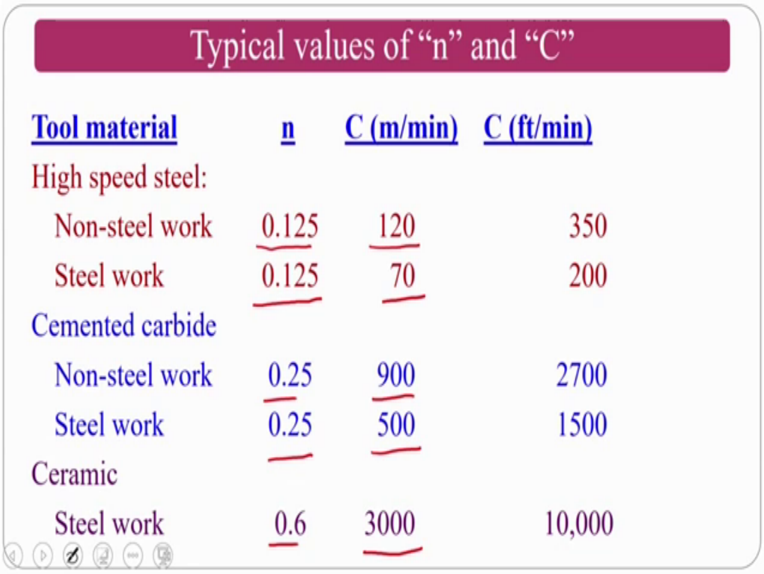

Typical values of “n” and “C”

Tool material	n	C (m/min)	C (ft/min)
High speed steel:			
Non-steel work	0.125	120	350
Steel work	0.125	70	200
Cemented carbide			
Non-steel work	0.25	900	2700
Steel work	0.25	500	1500
Ceramic			
Steel work	0.6	3000	10,000

Normally, the typical values for the tool materials whenever you are machining the one of the workpiece materials like high speed steel whenever you want to machine non steel work pieces it is n equal to 0.125 C equal to 120 in terms of meters per minute; in steel work pieces 125 and 70. Cemented carbide if you see 0.25, 900; steel work pieces 0.25 and 900. Ceramics it will be if you see the values the values of n and C are gradually increasing with respect to tool materials ok.

The basic problem if you see in the Taylor tool life equation is it is considering only cutting speed as the criteria, but if you see that is not the practically acceptable theorem.

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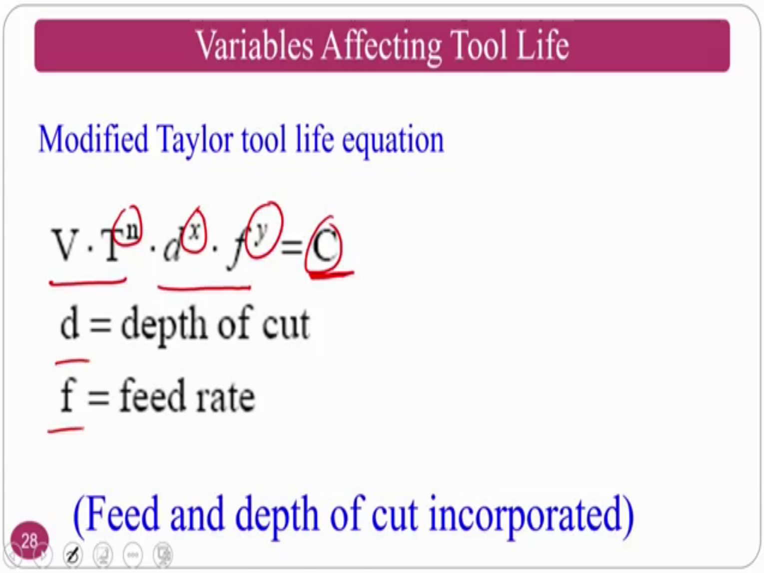

That is why there is a modified Taylor tool life equation there it is incorporated with respect to a depth of cut as well as speed ok. So, V T power n equal to constant was a Taylor tool life equation now feed and depth of cut is incorporated and constant is there. So, n and the C material constant x and y also have similar material combination constant where d is the depth of cut and f is a feed rate ok. So, now it is practically acceptable ok, that means, the tool life majorly depend on my cutting velocity and followed by feed followed by depth of cut.

Some of the research papers they show these that for the normal conditions of speed depth of cut and feed basically the contribution of the Taylor tool life equation or the tool life cutting speed will contribute more followed by the feed followed by depth of cut. In some circumstances it may be like a depth of cut also plays a major role compared to the feed. So, there is a striking balance between these two ok.

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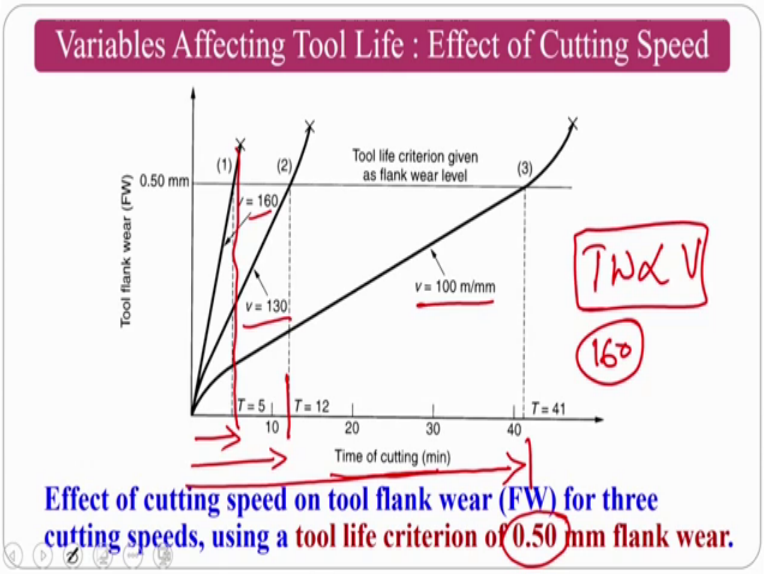

So, if you see the time of cutting versus tool flank here the effect of normally I see at know this V T power n equal to constant if you see 3 cutting velocities if ok. So, one velocity is 100 meters per mm, and 130 and 160. If you are going to increase the speed the cutting time and the for a less cutting time the tool flank wear will increase. So, this shows that tool wear is proportional to your cutting velocity ok.

If you are increasing to 160 if you see this is the time of cutting, for 130 this is the, for 100 this much is your time ok. So, I mean to say is if my speed is very high; that means, my tool life is or the time of cutting before it reaches to the 0.5 that is a criteria, 0.5, 0.5 mm is a flank wear ok.

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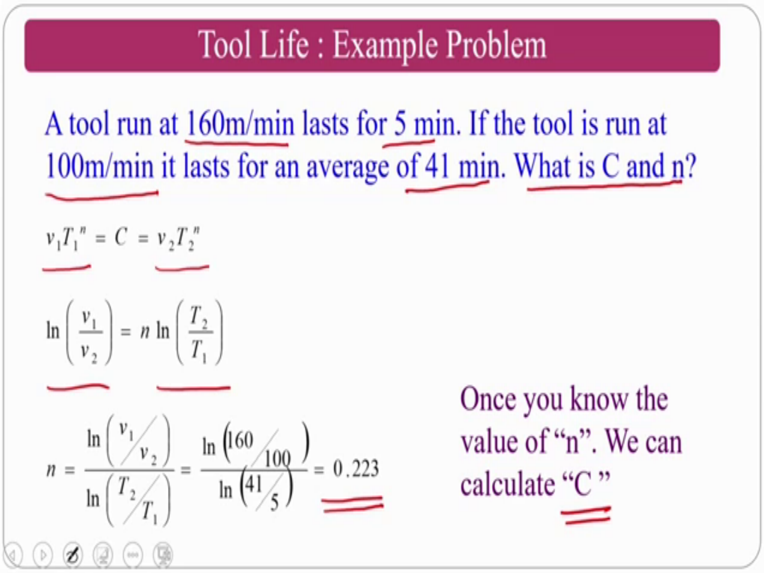

So, let me explain a problem for some of the people who are beginners to the manufacturing and all those thing just I will give you some a tool run at 160 meters per minute last for 5 minutes. If the tool runs at 100 meters per minute it lasts for 41 minutes what is a C and n values.

If you see these one two conditions are given that is in one case v 1 is given as well as T 1 is given, the second case v 2 is given and T 2 is also given. Normally for as this we are giving for a constant work piece material and tool material; that means, if I am using a same material combination my n value my C value are same ok.

So, considering that you can solve like this v T v 1 T 1 power n equal to constant which is equal to v 2 T 2 power n. So, if you take log on both sides you can easily get and you can get the value of the n. If you get the n value; obviously, if you can put into any one of the equations I can calculate the C value. This is how you can calculate the material combination constant n as well as C it is about the problem.

So, whenever I am giving you these are problems. So, in the examination also you may get some of the simple problems where the question paper goes like multiple choice questions, where you may have to solve the question and you choose the answer in the a b c d. So, you should be prepared for the problems as well as the theory ok. But in my case mostly it will be theory based. So, problems will be slightly less, since I am not touching much about the mechanics as I said some of the professor will take this course in this season or the next season where he explains mostly important mathematics ok.

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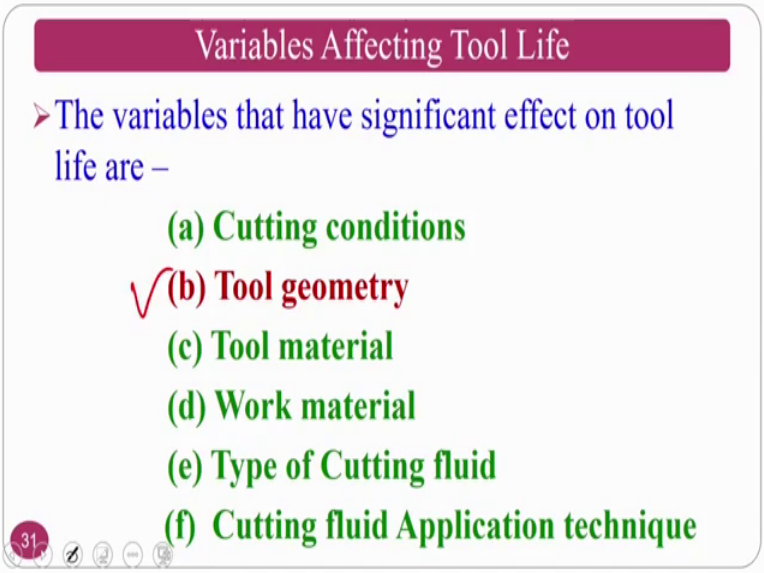

So, the second one is the tool geometry you can see the tool geometry.

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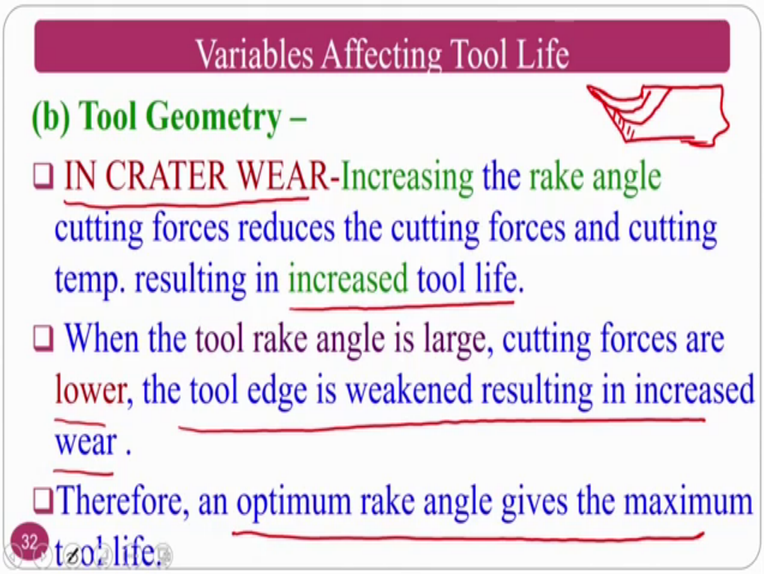

So, the tool geometry if you see normally the in crater wear. So, in the crater wear increasing the rake angle cutting force reduces and cutting forces and the cutting temperature resulting in increased tool life. Now, what I mean to say if I increase the rake angle my tool chip will be smoothly flows at the same time forces will reduce if the forces reduce; that means, that my crater wear will obviously, goes down when the tool rake angle is large the cutting forces are lower and the tool edge is weakened resulting increased the wear ok.

So, you cannot go for increasing beyond certain level of my a rake angle. If I go on increase assume that this is my ok, up to this is I can increased by a slightly I cannot go like this, if it is go in the material available to cut is very less. So, if weakens the tool. That is why optimum rake angle will gives the maximum tool life you should choose the back rake angle or the rake angle optimum such a way that the tool life will be maximum.

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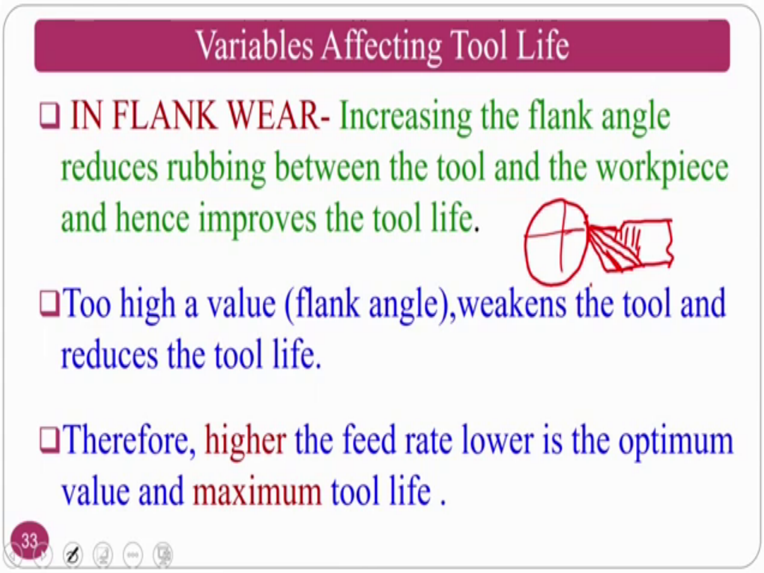

In the flank wear increasing the flank angle reduces the rubbing action between the tool and the workpiece hence it improves the tool life. This is the workpiece, this is the flanking angle ok, this is the flank angle which helps from the rubbing action. If I give the 0 flank angle what will happen? If I give 0 flank angle it will completely rub again is this one.

So, always you have to provide the flank angle so that rubbing will not takes place ok. High value of the flank angle also weakens the tool ok. So, what I mean to say is I can give a flank angle like this. If I start giving like this like this what will happen? Material amount of material will be very less. So, it weakens the tool material or the tool.

So, therefore, high feed rate lower optimum value is maximum for the tool life normally you have to choose optimum flank angle. Higher feed rate lower is the optimum value of the maximum tool life ok. So, you should go I mean to say you should go for optimum flank angle also this is about the flank angle as well as the rake angle how this will affect.

Third one is tool materials ok; So, the tool materials, if you see the tool materials selection of tool material, ok.

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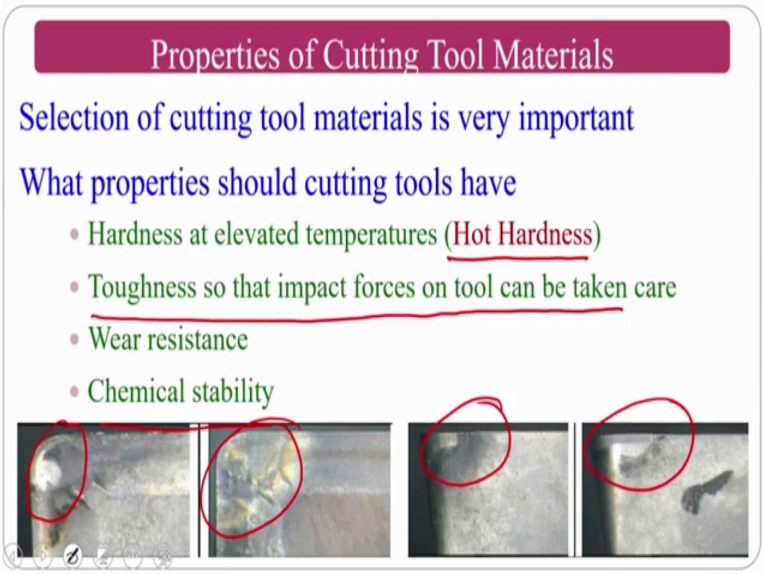

The selection of tool material what are the important one is hard hardness; that means, that hardness of that particular tool material at elevated temperatures ok. If a machining process is taking place and the temperature that is generated in a assume that 700 degrees, 800 degrees at that temperature it should process its original properties. I mean to say properties pertaining to hardness. Assume that if it is not losing its hardness at elevated temperatures; that means, that it hard hardness is good ok. The toughness is impact forces to the tool. Normally toughness also should be provided to the tool the toughest tool material normally is the HSS, ok.

So, if you do not provide toughness what will happen? The impact forces it cannot absorb, and on the wear resistance normally wear resistant it should be wear resistant otherwise the tool wear will takes place very fastly. So, chemical stability, it should be stable whenever the machining operation is going on otherwise it is a combination of tool material, workpiece material, some chemical I mean to say the cutting fluids is falling and atmospheric environment is there, where nitrogen is there, where the oxygen is there and some of the other gases also there depend on the location of the industry and all those things. So, it should be chemically stable also you can see glimpse of the tool wears some of the just practically what people have observed.

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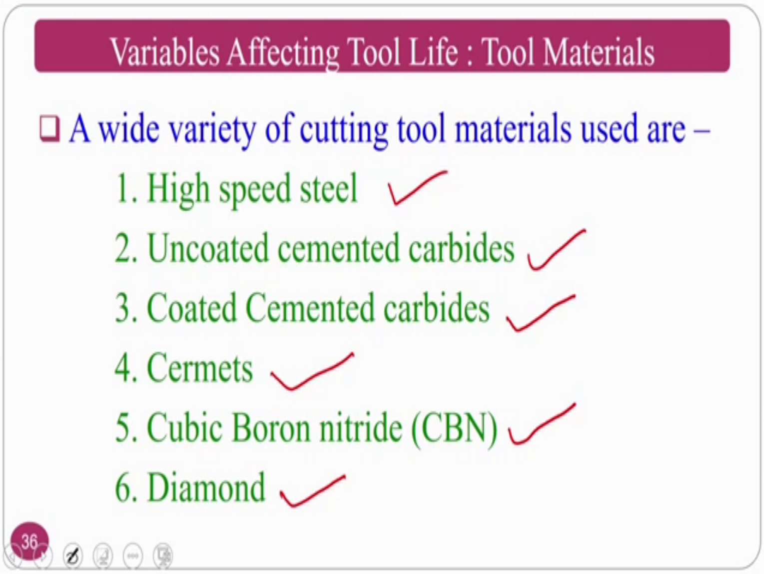

So, the wide variety of cutting tool materials used are one is a high speed steel, uncoated carbides, coated carbide, cemented carbides, cerements, cubic boron that is nitrate that is called CBN tools and the diamond tools these are the some of the materials. Apart from this many materials are coming up at the same time many materials are invented for coating on this material ok. So, these are all we will some of the things. We will see the history of the cutting tool materials.

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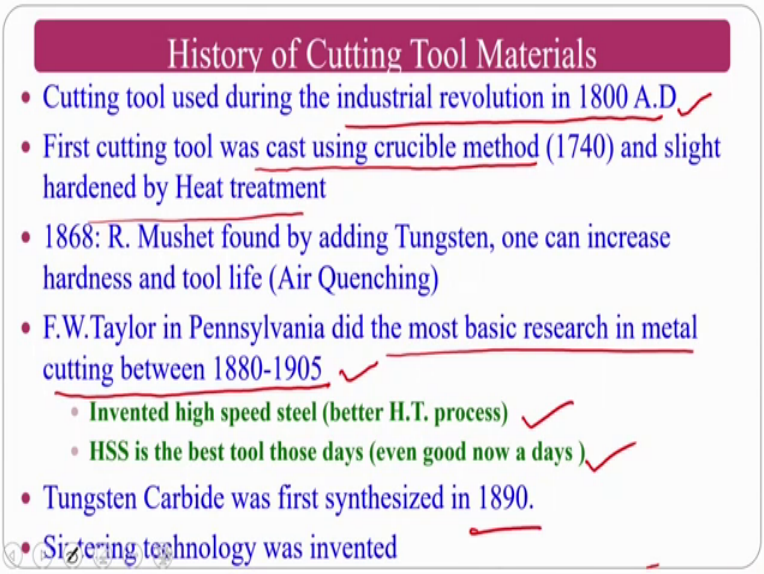

If it is the cutting tool was used during the industrial revolution that is 1800 AD. The first tool was cast using crucible method and the slight hardened by the heat treatment method normally. So, it is developed by the crucible method.

And Mushet found the adding of tungsten one can increase the hardness of the tool life that is air quenching and all those things. F. W Taylor in Pennsylvania did the most of the basic research on metal cutting between 1880 to 95 invented high speed steel. HSS even nowadays also people will be using and the carbide tool was first synthesized in 1890, this is about the history ok. So, 1800 AD it started and the research on cutting tools basic research was done up to 1905. 1880 also the tungsten carbide also synthesized ok.

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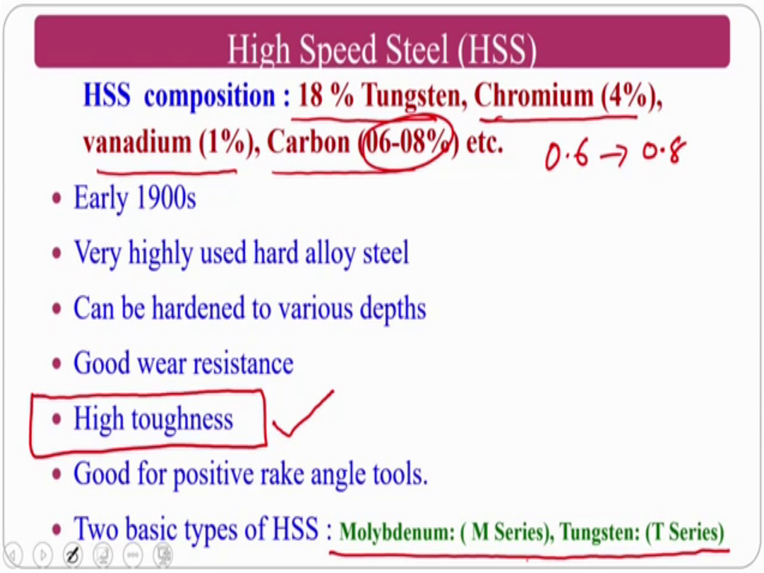

Coming to the HSS that is a high speed steel the competition goes 18 percent tungsten, 4 percent chromium on 1 percent vanadium and sorry it is 0.6 to 0.8 ok. This was found the early 90s, very high early used for a hard ally steels can be hardened to various depth good wear resistance high toughness good for positive rake angles and there are two basics. What I mean to say is the best thing about this material is it is having high toughness, compared to other materials this is the toughest material because it can absorb the impact and all those things.

So, from among what I am teaching is the highest toughness to cutting tool is HSS, hardest is diamond basic ok. So, there are two basic types one is molybdenum that is M series, another one is tungsten series that is T series, high speed steels are there.

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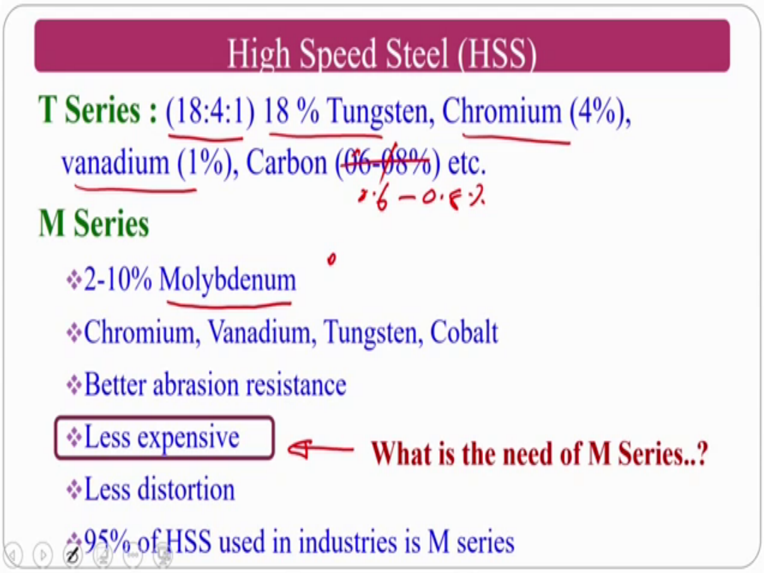

T series is same as what we have seeing that is 18 is to 4 is to 1, tungsten chromium and vanadium ok. M series normally 2 to 10 percent will be molybdenum, in 18 percent instead of 18 percent tungsten ok.

So, if I am going to use 2 to 10 percent in 18 percent. So, I am using another assume that 8 percent I am using 10 percent I am using tungsten ok. The chromium vanadium tungsten and cobalt, cobalt will be the normally binder better abrasion resistance less expensive and less distortion and 95 percent of HSS industry are M series one ok.

So, one of the question is if we have tungsten series that is T series why we have to go for M series. The reason for this one is it is less expensive ok. This is the reason why molybdenum is M series the molybdenum series the molybdenum cost is low, but the properties are approximately same. So, that is why we are going for the M series.

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So, another one is normally these are manufactured by casting and powder metallurgy technique. So, the applications it can be turning tool, taps, gear cutting, drills and all those things ok.

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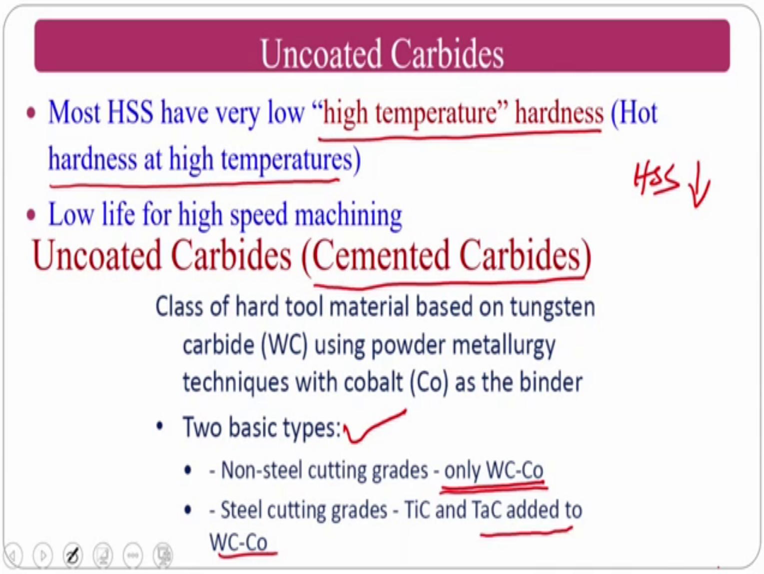

So, we are going for the uncoated carbides. The second variety is most of the HSS the basic problem is high temperature hardness is very less; that means, that hot hardness at elevated temperatures or the hot hardness is low. So, if at all I want a machine a hard material where machining temperature goes high in their circumstances the HSS will fail ok.

So, the low life for high speed machining, normally if at all I want to go for high speed machining in that circumstances it is very less. That is why we go for the next version slightly higher version that is called uncoated carbides. Uncoated carbides are uncoated cemented carbides class of hard tool material based on tungsten using powder metallurgy. There are two basic types in this one, one is tungsten carbide based that is called a non steel cutting rates and the titanium carbide and tantalum carbide based tungsten carbide tools. These are the two varieties of cutting tools are there.

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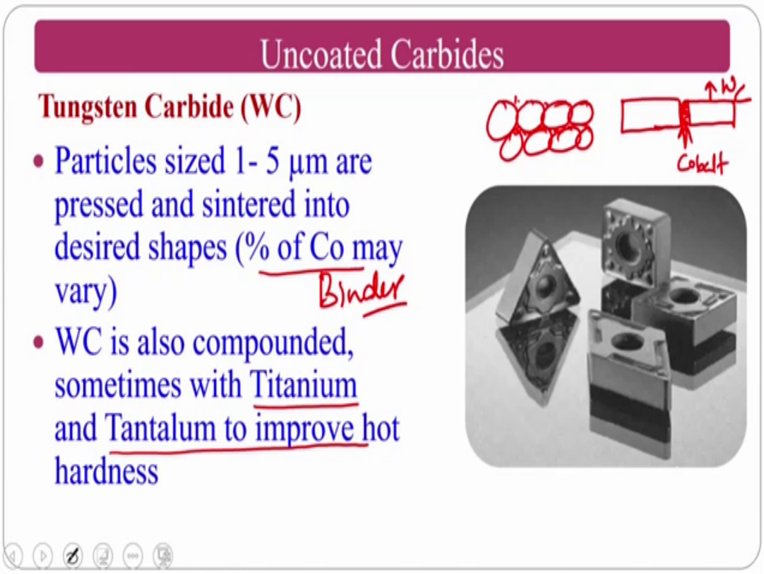

First we will see the tungsten carbide. The particle sized 1 to 5 microns are pressed sintered into the desired shape and percentage of cobalt may vary. Cobalt is a binder basically ok.

So, tungsten carbide is also component sometimes with the tantalum and improves the hard hardest. To improve the hard hardness normally tantalum and titanium are used. Basically these are developed by the powder metallurgy techniques where we will used the tungsten carbide particles tungsten carbide particles are used and the binder is added to it and they will do the ball mixing and all those things then they will do the compaction sintering and they will from. The normally the cobalt is a binder. So, it will like assume that if you what to build the hole normally brick by brick we will do, so in between we will put the cement. So, this is nothing, but the cobalt this is nothing, but cobalt and this is nothing, but your tungsten carbide ok. This is how this will work ok.

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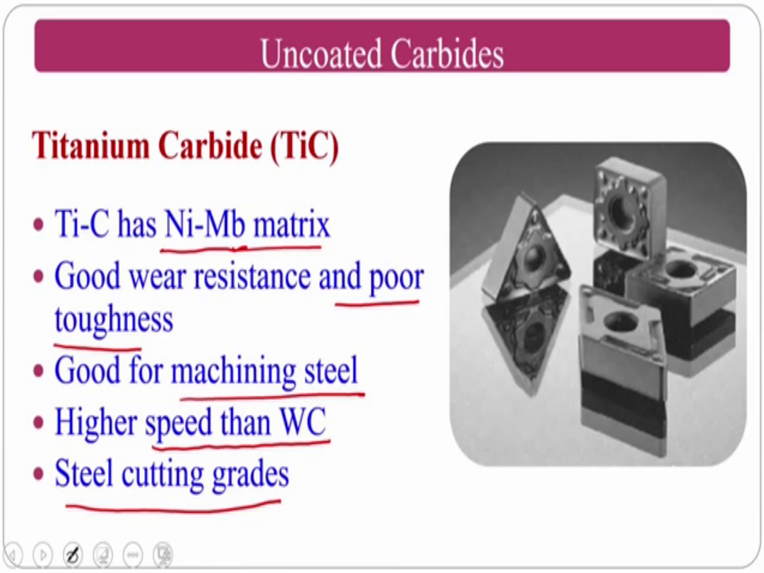

Next we will go for titanium carbide ok. So, in the titanium carbide tic nickel molybdenum matrix will be used. This is steel grades, normally previous one tungsten carbide which we are using is a non steel grades where if at all we want to use the nonferrous based those can be used.

So, titanium carbide as a base material and nickel molybdenum is the matrix is used good wear resistance and poor toughness as I said toughness is good in HSS, good for machining the steel and the high speed then tungsten carbide. So, you can use for higher speed than the tungsten carbide. So, when the temperature goes up it can stays at the same time it is very good for the steels ok.

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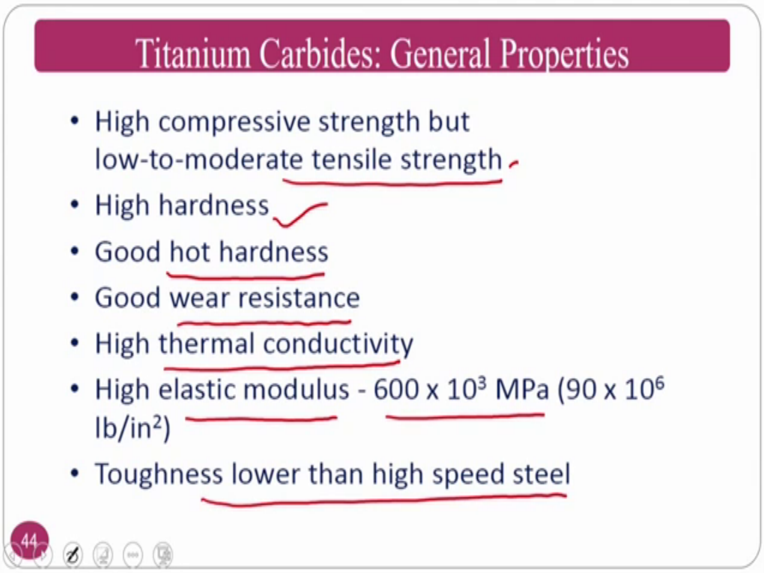

The high compressive strength normally general properties if you see high compressive strength, but low to moderate tensile strength this is problem, but you have a compressive strength is very high. So, normally it will be very good. So, high hardness and good hot hardness I said at a elevated temperatures.

So, it possesses its own good hardness. So, wear resistance is very good. So, it is normally do not wear at less time, so high thermal conductivity. So, the temperature it can conduct easily that means, from the cutting edge it can conducted to the next other parts of the tool that is the benefit of high conductivity. Elastic modulus is in this range and toughness lower than high speed steel as I said the high speed steel will have higher toughness ok.

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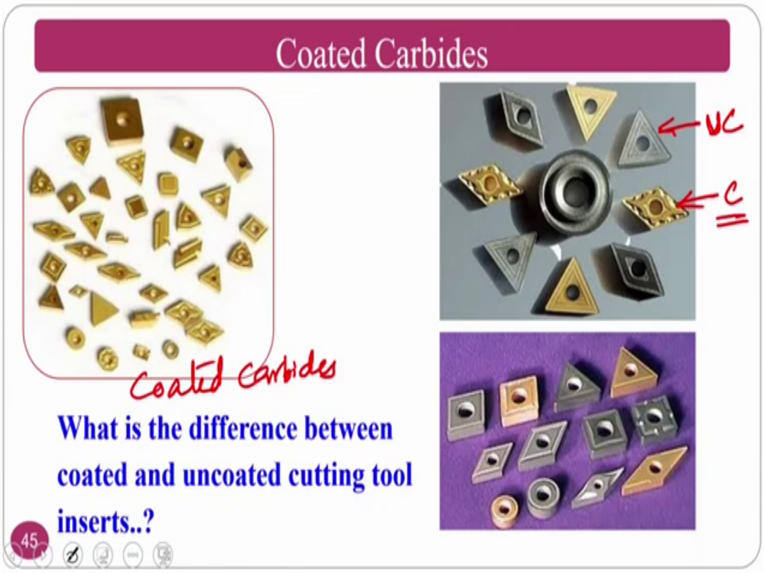

We see the coated carbides, normally coated carbide what is the difference between coated carbide and uncoated carbide. Normally these are the coated ones ok. How what is the difference normally if you see? This is the difference, this is the uncoated one this is the coated one ok. So, you can see normally it is the gold color normally the coating is done on this one ok.

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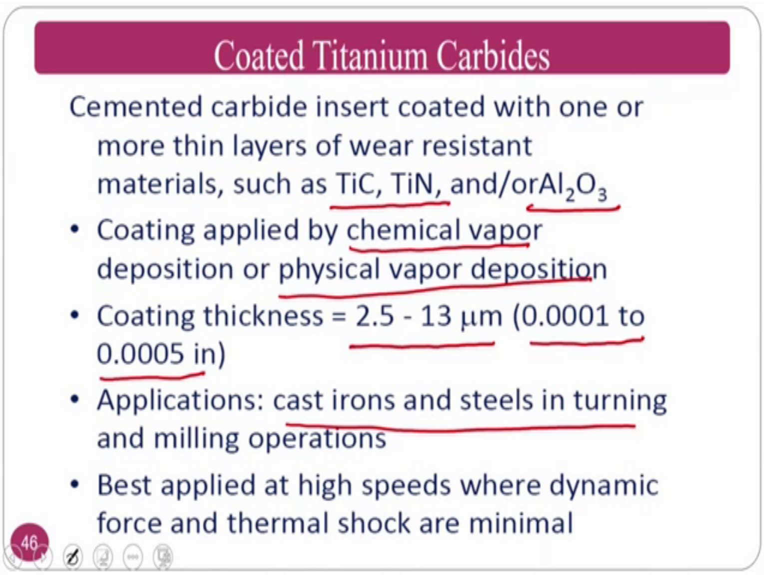

So, why the coating is required? Cemented carbide insert recorded with one or more layers normally tungsten carbide tools are not good for the steel based workpieces and all those? If at all I want to use it what people will do is TiC, TiN this is titanium carbide and titanium nitride or ceramic Al 2 O 3. Coatings will be done there are various techniques that is chemical vapor deposition. physical vapor deposition radiofrequency sputtering there is a laser coatings are there may many techniques are there. So, normally these thicknesses ranges from 2.5 to 13 microns.

Nowadays very good nano coatings also coming into the market; Applications normally you can use for the steels and other simplest applied for high speeds and dynamic shock and the thermal shock and whenever the minimum if you want you can go for this coated carbide tools ok. Cermets normally what is meant by the name itself says cermet means ceramic plus metal.

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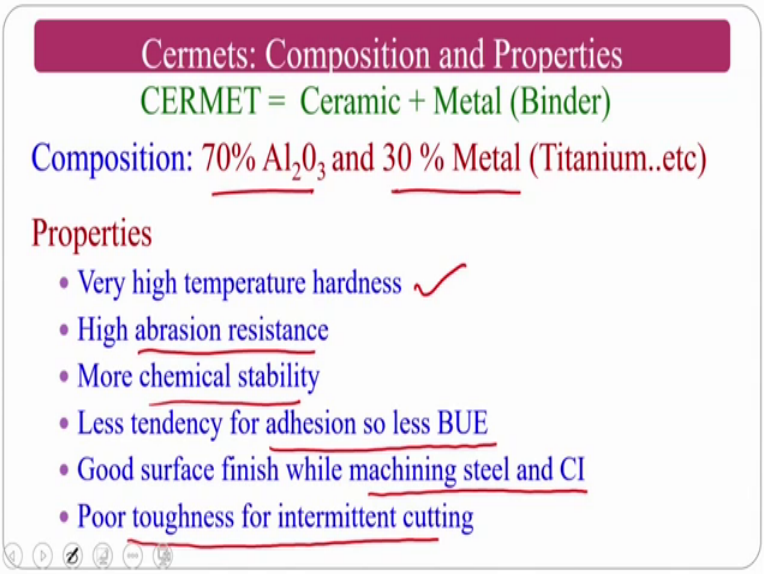

So ceramic will be the base material and metal will be the binder basically ok. The composition if you see 70 percent they will be in ceramic that is Al 2 O 3 and 30 percent will be like titanium or something has a binder they will use ok.

So, since there is a ceramic is there, there is a metal is there, that is why these are called cermets ok. The properties very high temperature hardness that is hot hardness is very high abrasion resistance is very good and more chemical stability because ceramic is are there, ceramics are highly stable materials. So, this if the ceramics are very high stable materials, so the chemical stability will be very high and there will not be any chemical reaction and all those things. Less tendency for adhesion, so there is a less chance of buildup edge. Good surface finish while machining the steel and cast iron.

So, put only the problem here with this one is it is having poor toughness. So, if at all I want to use for intermittent cutting it cannot be used. For intermittent cutting you need good toughness in the tool material ok. So, this is very good from the chemical point of view because this is having a dominating ceramic ok, so ceramic is highly stable material.

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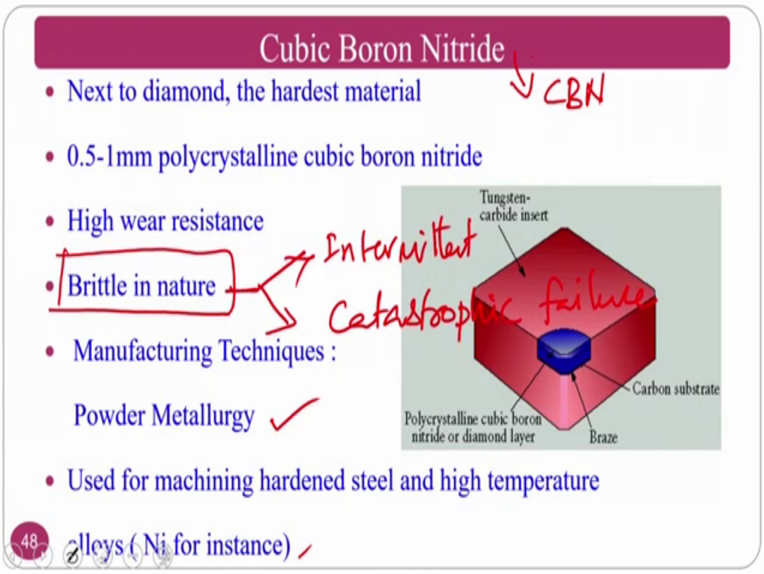

The next one is cubic boron nitride CBN, whatever you can say it is a CBN is commonly known as next to diamond and the hardest material that below the diamond and 0.5 to 1 mm polycrystalline cubic boron nitrides normally. High wear resistance brittle in nature this is a only problem it is brittle in nature and it is very hard material ok. So, if it is brittle normally intermittent is cutting is the problem and catastrophic value will takes place it cannot be used for intermittent catastrophic will failure will takes place.

So, manufacturing techniques normally powder metallurgy this produced for the machining hardened steel high temperature wear, wear for example, nickel based alloys and all those things. You can see how it look like. So, completely the tool insert cannot be made from the this one that is why they will make a small bit and they do the brazing operation ok. So, whenever we stake about the brazing see you may get down that if the it is braced the normally brazing is done at very low temperature welding process or the joining process, brazing comes out.

So, some of the local tools which we got unfortunately these are the brazing is going. But if you purchase from the standard companies like sand (Refer Time: 61:17) and other companies you will get the proper tools. So, what I mean to say is that the brazing normally it can sustain up to 300 degrees and all if it is go for 600-700 degrees the cutting tool temperature it may not sustain, but why brazing is done still is if you see the thermal aspects of machining the only 15 percent tool takes care ok, out of each the CBN have low thermal conductivity so that means, that the top edge of the cutting tool will only experience most of the heat and it cannot conduct towards the bottom side.

So, there is a very less chance of one if it is not maintained properly. So, it means goes off ok. So, diamond tool also look like this only instead of CBN they will put the diamond.

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So, diamond normally will be the polycrystalline diamond and single crystalline diamond will be there normally these diamond do not think that these are the diamond that people wear or something. This is the artificial diamonds. Low friction high wear resistance good cutting edge and the single crystal diamonds are used for machine copper to get high.

Normally this is called a diamond turning, turning operation. Nowadays it is one of the good process and I will teach whenever I am teaching about the advances in advancement in metal cutting process or machining process they have brittle rake angle should be low. So, polycrystalline diamond compacts synthesized crystals and fused high temperature and all those things ok. So, this is about diamond.

One thing please note that diamond is a hardest material HSS is the toughest tool material ok. So, do not confused between the toughest tool material is not the diamond ok. So, it is a brittle material and it will fail in the brittle fracture ok.

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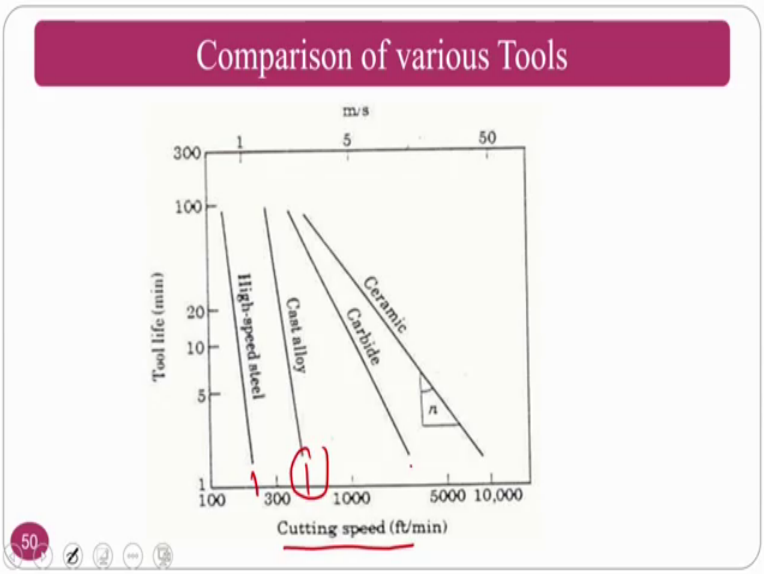

So, the comparison of various tools if you see the cutting speeds if the cutting speeds versus tool life high speed steel will have very low range of cutting speeds then the cast alloys which I have not taught then the carbides and the ceramic that is cermets and all those things. Diamond will follow next; CBN followed by diamond will come ok.