Manufacturing Processes II
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Lecture No. 14
Tool Life

Good morning. Now let us come into the subject Manufacturing Processed II

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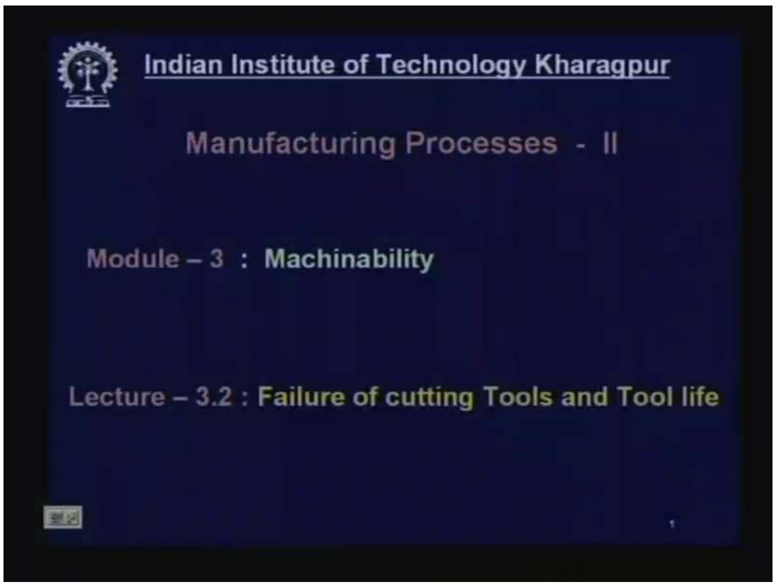

You know we are running the Module - 3 which is Machinability and today is the second lecture under machinability. The failure of cutting Tools and Tool life; As you know the cutting tools play very vital role, very very important role in machining and its geometry now we shall discuss start on failure of cutting tools and tool life and in the next lectures on tool material. What are there in our today's lecture?

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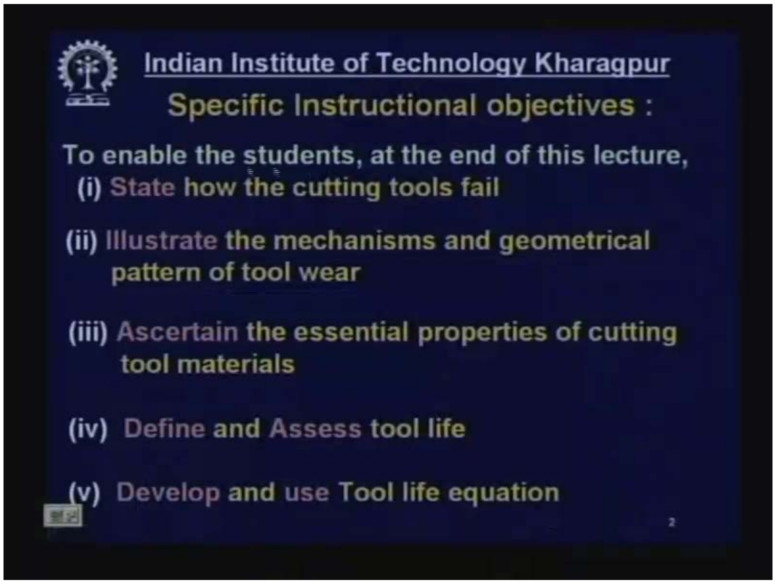

After attending this lecture hearing this lecture, the students will be able to state how the cutting tools fail, and then illustrate the mechanisms and geometrical pattern of wear of the cutting tool, then ascertain what should be the properties of the cutting tool material then define an assess tool life, and last develop and use tool life equation. So today only this much. Now failure of cutting tools:

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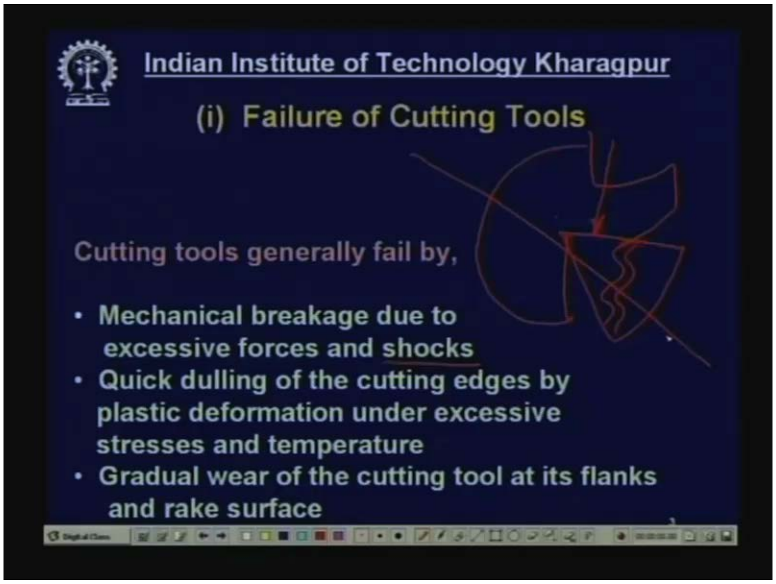

You know for smooth efficient and economic machining process to be continued the cutting tool should not be allow to fail abruptly or frequently. First of all, the abrupt or catastrophic failure of the cutting tools have to be prevented totally and the normal failure by wear has to be delayed or life has to be prolonged, but before we do so we must understand that how does a cutting tool fail because the fail has to be either prevented failure or it has to be delayed. So how does a cutting tool fail that has to be understood first, so cutting tools generally failed by mechanical breakage due due to excessive forces and shocks, how does it happen? Suppose this is the cutting tool and this is the chip flowing, lot of forces act on the tool tip. If the tool is not strong enough or if the lot of lot of vibration or shocks then the tool will break by little factures, it is the total failures and this failure is very detrimental and these has to be prevented. Next is another method is quick dulling of the cutting edges by plastic deformation under excessive stresses and temperature. Now again you see this is the cutting tool this is the cutting tool and the chip is flowing on that and this is the chip contact length, where lot of heat is generated.

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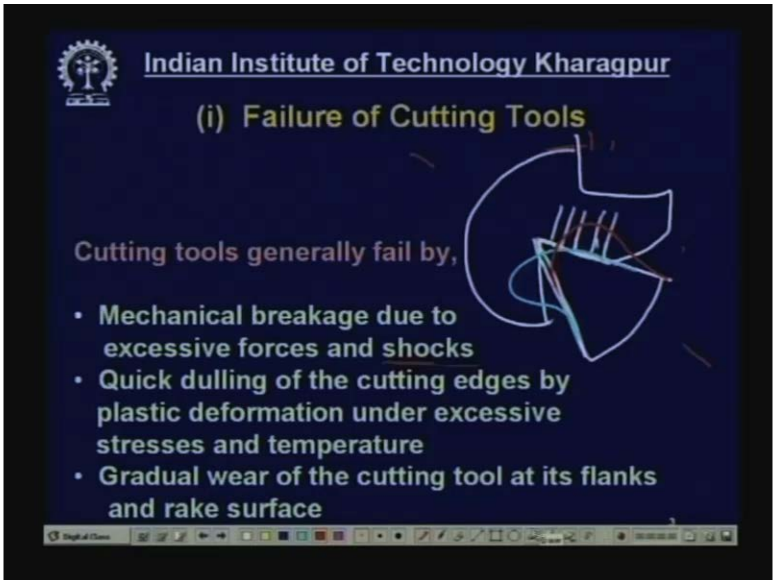

Temperature is generated, the tool becomes very hot along with the chip and lot of stresses also act because of the high stress and temperature this material will become soft the tool material and may undergo plastic deformation. Now the plastic deformation may be either like this, so the tool will be totally deformed or the deformation may be like this. What be the kind of deformation, the geometry of the tool is lost or the sharpness of the tool is lost. Hence this called the tool becomes very dull and totally unable to machine and this is very very detrimental and it occurs very quickly within few seconds or fraction of second, this plastic deformation will start if the cutting tool is not strong enough and hard enough. Then gradual wear, so this kind of plastic deformation kind of failure has to be prevented it is very very detrimental and cannot be accepted anyway. Now let us see the other one gradual wear gradual wear of the cutting tool. This process is gradual.

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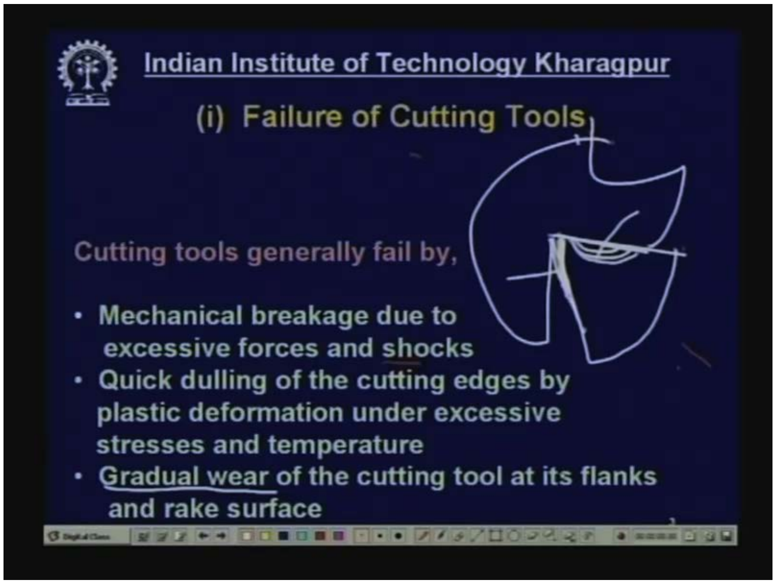

What happens? This is the cutting tool and this is the chip flowing and this is the work surface. Lot of rubbing takes place here and here. So gradually the wear will take place. The material will be lost from the tool and from here also. This is called flank wear and this is called crater wear. This is the slow process and this is inevitable. This cannot be prevented, wear cannot be prevented. Whatever be the hardness of the rubbing surfaces too large chip the wear will be there but what can be done there the rate of growth of wear can be controlled. So ultimately what is the the decision that this catastrophic failure or immediate failure by plastic deformation and breakage should be prevented by the manufacture of the cutting tools and by the users of the cutting tool, but the wear cannot be prevented but it cannot be it can be retarded or slowed down.

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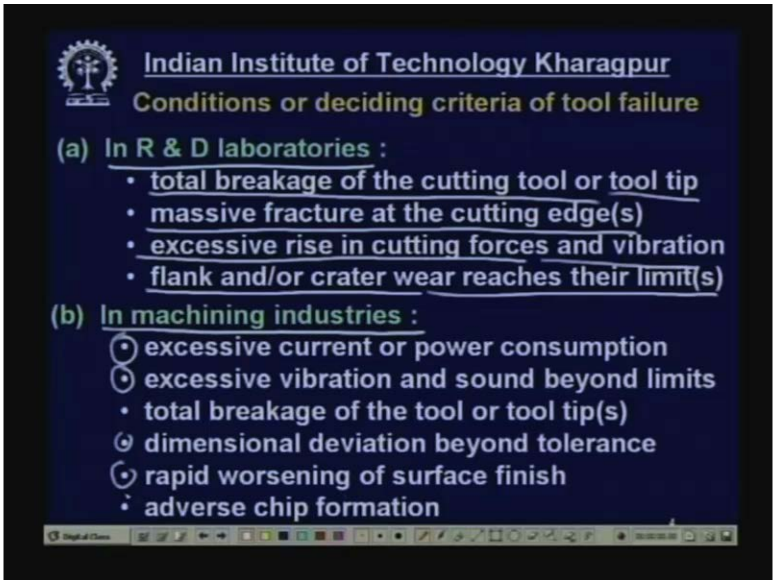

Now next is Conditions or deciding criteria of tool failure that means a tool is continue the continuously cutting, but how one will understand that the tool has failed because when the tool fails lot of problem arises in the machining. Machinability gets lost the last time you heard the last lecture what is machinability. So with the growth of as of the tool failure, these machinability gets lost and the tool becomes totally unable to machine and the machine may also be damaged. So the tool has to be withdrawn before it fails or or immediately after it fails. But how one will understand that tool has failed? Now there are two methods. In R and D laboratories there is one method. Now sorry Now the conditions of deciding criteria of tool failure what I was telling how to understand that the tool has failed, now different practices are followed in different situations and different areas say in the R and D laboratories in R and D laboratories in R and D laboratories how it is understood? When the tool breaks totally, that is total breakage of the cutting tool or tool tip, so the tool is understood that tool has failed.

It is very easy to understand the massive fracture at the cutting edge(s). So chunks of materials will come out from the cutting edges. So this also leads to failure. Excessive rise in cutting forces during machining some force will be there but if the force rises very fast and excessively and lot of vibration takes place then it is understood the tool has failed. So machining has to be discontinued. Tool has to be replaced but another thing which is most important flank and crater wear reaches their limits. So the cutting tool gradually acquires wear if not failed by plastic deformation or breakage the gradual wear but wear takes place very gradually and slowly but when these amount of wear reaches their limit preset limits then the tool it will be understood that tool has failed and the tool has to be withdrawn but in the machining industries, what is the done what what is done how do they understand?

So first is excessive current or power consumption. Now during machining cutting force will develop and power will be consumed and accordingly there is an ammeter or say power meter where it will be visualize how much current or power is being drawn when the tool is about to fail or the condition is worsen then, the power or current will increase excessively and the operator will understand the tool has been damaged and need to be withdrawn. Then excessive vibration and sound beyond limits. Total breakage of the tool or tool tips if happens they limited to withdrawn that means the tool has failed. They also understand from the dimensional deviation, suppose they do turning operation and while turning they suddenly found with the find that the diameter is gradually increasing unexpectedly that indicate the tool has out excessively and it has failed. Rapid worsening of surface finish with the damage of the tool the surface finish will be very very bad. So from the surface finish the operators understand the tool has failed, and also sometime they understand from the adverse chip formation. If the chip formation becomes suddenly abnormal or unfavorable they stop machining because the tool has failed.

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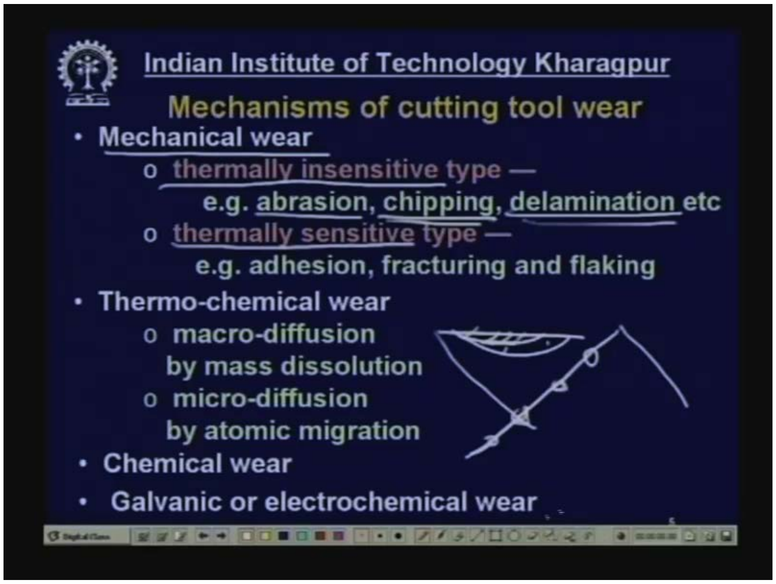

Now the Mechanisms of cutting tool wear: So what we have seen that there are three modes of failure. One is mechanical breakage which is very random, catastrophic and detrimental and has to be prevented. Second one is plastic deformation which also takes place rapidly and that makes the tool totally unable to cut anymore so that has also been prevented but wear cannot be prevented but it has to be reduced the rate of growth of wear has to be reduced. Before we do so, we must understand what is the mechanism of wear? How does cutting tool undergo wear? What are the different mechanisms of wear under the different conditions? So that action can be taken or planning can be made so that this rate of growth of wear can be reduced to enhance tool life.

Now the different types of wear that generally occur in cutting tools first is mechanical wear. What is mechanical wear? Mechanical wear now there mechanical wear can be of two types; thermally sensitive insensitive type that means this kind of wear does not depend much on the temperature and another thermally sensitive, were the rate of wear mechanical wear depends upon the temperature. First about say thermally insensitive what are those mechanisms abrasion, chipping and delamination. What is abrasion? Abrasion is really comprised of say attrition shearing or scratching and the fatigue of the high pons asperities. Chipping means the cutting edge you get certain amounts where at certain points, the damage of the cutting edge a small amount of material gets removed and the continuity of the cutting edge gets lost this is called chipping, delamination this is the rake surface because of this stress, sometimes stress develops inside and it grows like this and this material goes out. Gradually this material goes out this is called delamination.

Now what is thermally sensitive type? Thermally sensitive type are adhesion, fracturing thermal fracturing and flaking. Now adhesion the cutting the sliding surfaces when they meet, they meet at certain high points of asperities high points of asperities all right and now they they undergo joint by welding what is called welding and there is a sliding motion. So the breakage will take place suppose this is the one asperity of the chip and this is another asperity of the tool and this is the weldment because of high temperature and stress that is called adhesion or the welding life.

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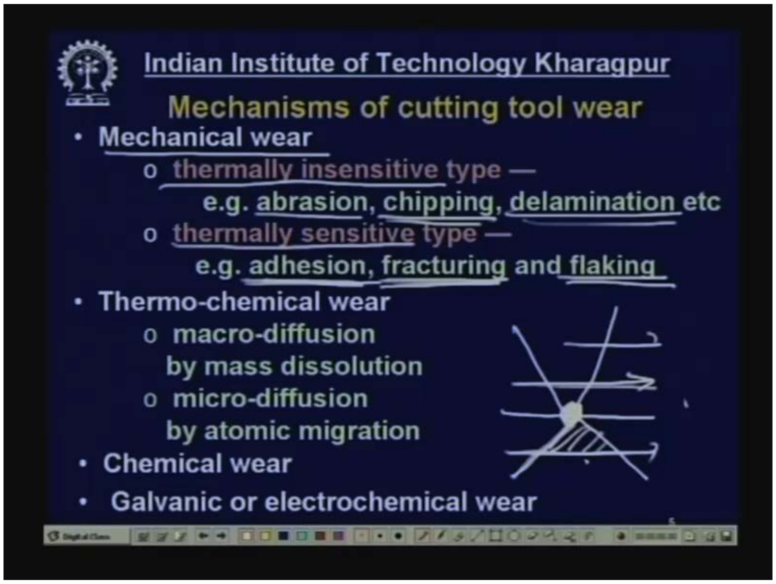

Now because of the sliding motion the fracture can take place either here. It cannot take place through the weldment because weldment is very strong this will take either through this or through this. If it fractal separation takes place through this asperity of the chip material the tool does not loose anything, but if the fracture occurs through the high asperities of the tool then this amount of material gets lost. So the cumulative loss of this kind of material from the tool which lead to what is called adhesion wear. Thermal fracturing, so gradual fracturing by high temperature of thermal gradient there will be some loss of material from the tool surface then flaking. So, chunks of materials will go out along with the built apache, then thermo chemical wear. In thermo chemical wear, you know that there are two surfaces.

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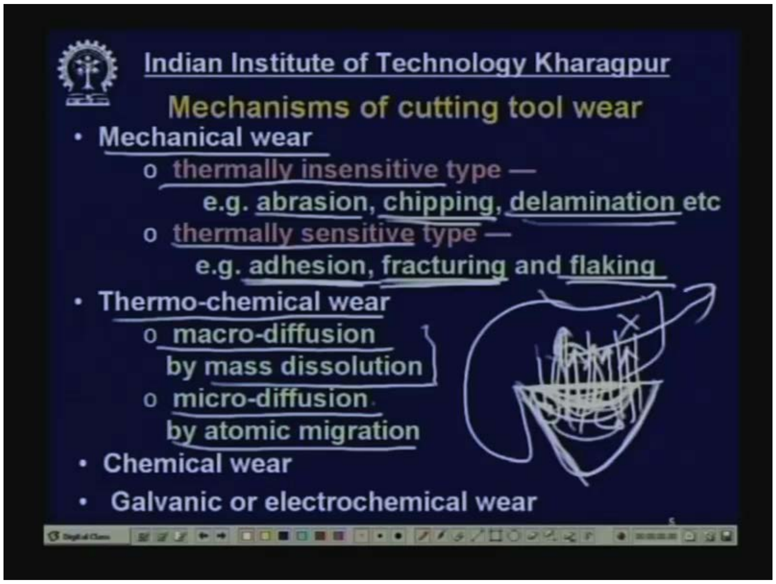

These are the two surfaces. This is one surface, this is the tool and this is the chip flowing. So this is the surface rubbing surface and this is an intimate contact on the high pressure and temperature. So what will happen? The material from the tool can go into this chip or sometimes the material can come from this chip to the tool. But this migration or transfer of material from the tool to the chip that really causes loss of material and this is called diffusion. This process is as a slow, so the material gradually goes into the chip even if some material comes from this chip to the tool that does not help the tool, because this material is coming from the chip to the tool is very weak that does not help the cutting tool but the material moving from tool to the chip and the chip carries it away that is a great loss for the tool and gradual wear will take place. This is called diffusion wear that is the material diffuses from the one surface to another.

Now this will happen only when these two materials or the rubbing surfaces of materials have got mutual affinity or mutual solubility number one and then secondly this will depends upon the temperature. With increase in temperature, the rate of diffusion accelerates and also the concentration gradient. Suppose, there is lot of cobalt and there is no cobalt, so the cobalt will diffuse into the chip from the tool say carbide tool. Now this transform transfer of material from tool to chip can take place in two ways. Either in a bulk so the whole material tungsten carbide cobalt or other things will go together or the material will go atom by atom say cobalt atom by atom, tungsten atom by atom like that, then this is called micro macro diffusion by mass dissolution which is much faster, but it can also take place like micro diffusion slowly but steadily by atomic migration atom by atom metal transferred from the tool to the chip and chip will take it away and the tool will loose materials and wear will take place. This is called diffusion wear.

Now next is chemical wear. This chemical wear that means chemical wear when the cutting tool material is not chemically inert or it has got some chemical affinity with respect to the tool or environment or this cutting fluid, then there will be chemical wear.

So chemical wear is detrimental, but it does not occur all the time. So the cutting fluid has to be chosen carefully.

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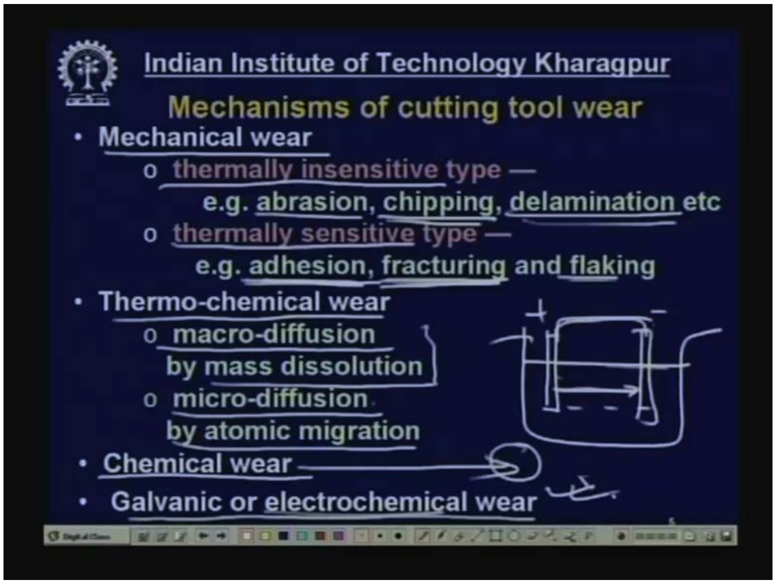

Now galvanic or electrochemical wear: Now galvanic or electrochemical is an electrochemical dissolution process. Now you see, suppose in a bath there is electrolyte and there is one anode, there is one cathode, and they are connected like this, the current will flow then the material will gradually flow from this to that. Now this is called electrochemical dissolution. So this anode will gradually loose material just like wear. In cutting process what happens at the chip tool interface lot of heat is generated and that heat causes generation of electricity by thermo effect. So the current is produced by that heat at the hot zone hot junction and the cutting fluid that is applied that behaves like it behaves like a cutting say electrolyte the cutting fluid there will be lot of electrochemical action and material will flow from the tool to the to to the chip and this will lead to loss of material, but galvanic wear is very slow and is not very common. Now next is general pattern of tool wear and its geometrical features.

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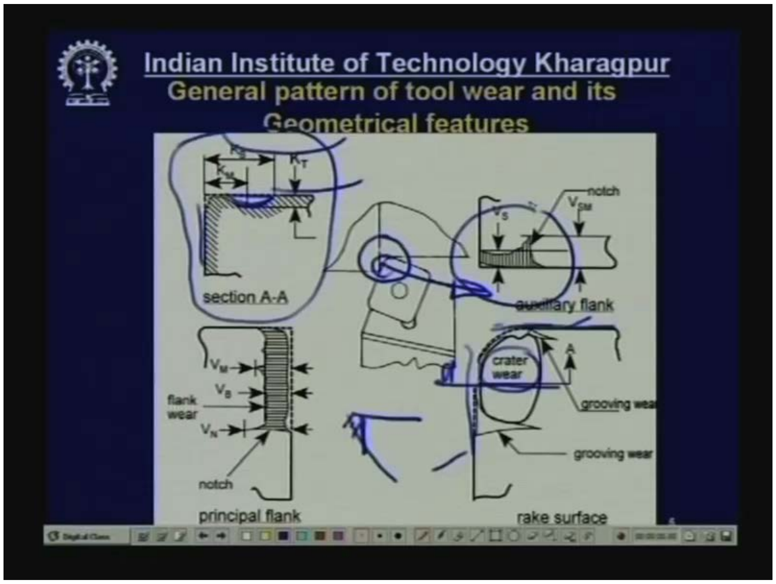

What are the usual patterns of tool wear, geometry of tool wear? Here you see that, this is the cutting process. This is the cutting process and this is the tool tip. This is the tool tip here this is the cutting tool tip. Now, if this cutting point is magnified, it looks like this. This is the magnified view of this cutting point of the tool. This is the main cutting edge. This is the main cutting edge, this is auxiliary cutting edge and the chip flows along the rake surface. So, now this is the section of the rake surface. This is the section of the rake surface all right and then the chip flows along with this. So there will be some crater wear this is called crater wear and because of the rubbing action at the flank, there will be flank wear this is the flank surface and this is the flank wear which is uniform along the principle flank, as similar wear occurs on the auxiliary flank, this is the auxiliary flank surface.

Now so what are the wear that occurs on the rake surface? Crater wear is a pond like and on the flank principle flank is a flat surface where if the cutting tool is like this then this material will be lost at the flat surface will be produced like this and auxiliary surface also this where will take place. Now what are the how this wear will be indicated or quantified how this will be quantified here you see the crater the flank wear the flank wear is more important. So for as tool life evaluation is concerned, these are total patch of wear, now the average wear VB this is the average wear.

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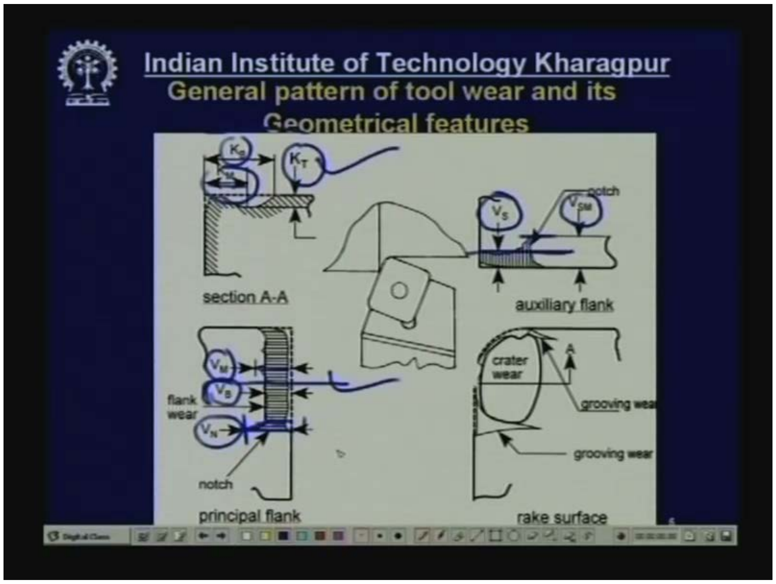

This is the most important index or says indication of wear feature of wear. This is called flank wear and flank wear has measured by VB average flank wear. Then the maximum flank wear where it is maximum, then a notch develops because of excessive rubbing and chemical action. So this is called this amount is called notching wear in the auxiliary surface average auxiliary flank wear is denoted by VS and maximum auxiliary flank wear is denoted by VSM. What about crater wear? Crater wear is depicted by the depth of the crater, this KT and the width of the crater KB and location of the crater group KM. Out of which VB is most important next is KT and by KT and K VB is generally expressed the amount of flank wear develop and crater wear develop. These are also utilized to decide whether the cutting tool has failed or not. Now here you can see exact pattern.

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A typical wear pattern of carbide tool inserts. Now this is a carbide tool inserts of negative square. Insert may be half in square and this is another another insert with a hole but this is a square insert. Now this is a tip of the tool which undergoes wear like this. So here you see this is a rake surface this is the rake surface and this is the principle flank and this is the auxiliary flank. Now at the prince the rake surface, we get lot of crater wear a grooving like crater wear and the principle flank, the flank wear which is very uniform and this is flank wear on the auxiliary flank. Now the wear here you can see it is a groove like this is called notching wear. Here also you can find a small notch wear on the rake surface at this end, you can find one grooving wear. This grooving wear is basically a chemical wear process in addition to abrasion abrasion and chemical action. Now coming to a milling inserts.

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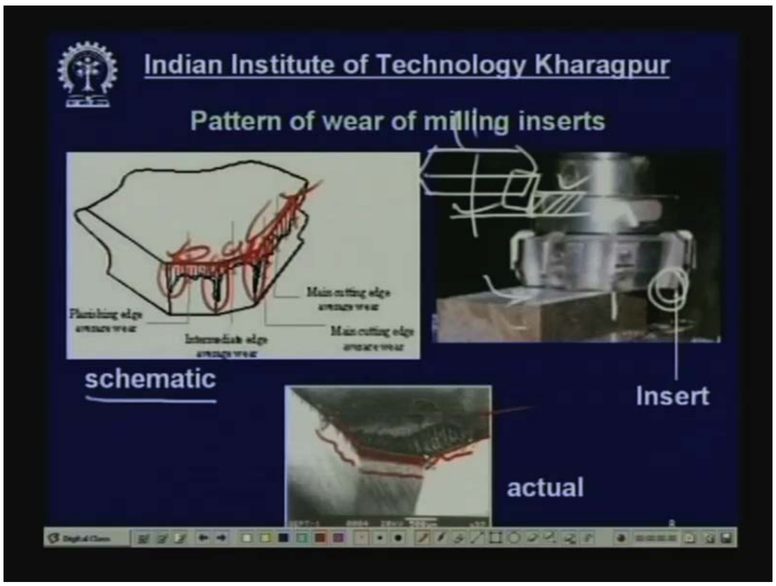

Now there are different types of milling cutters you know slab milling cutter, plane milling cutter, end milling cutter and there are different types of end milling cutters and they are generally small, shell milling cutter and for making large flat surfaces, normally this industrially face milling cutters are used. This face milling cutters the face milling cutters are very large, they produce flat surface like this. This is the flat surface of the job this is the job this is the flat surface getting produced by this cutter which diameter may vary from 80 millimeter to 800 millimeter, even beyond that and which has got large number of cutting edges around the periphery and this the one cutting edge which is fitted at the periphery and that removes suppose this is the milling cutter, this is the cutting edge and this removes material.

So this is the unfinished surface, this is the finished surface and they are this is the layer of material getting removed by this cutter which rotates at high speed. Now this cutter if exerted it looks like this. So this shows the schematically the how this tip of the tool undergoes wear. Now tip of milling inserts this kind of milling inserts have got three cutting edges. 1. This is the main cutting edge, cutting number 1 and this is this is the main cutting edge. This is intermediate cutting edge or second cutting edge and this is called planishing edge third cutting edge.

So, there are three cutting edges and this main cutting edge takes the major amount of load and responsible for removal of material. Now each one undergoes wear like this, at the corners because of high stress concentration and temperature confinement lot of wear takes place at the corners other way this is the flank wear and lot of crater wear also takes place on the rake surface. Now this shows one practical example. When cutting tool such kind of milling cutter has undergone wear, here is if the main cutting edge which has undergone wear and this is auxiliary cutting or say medium intermediate cutting edge where also wear has taken place and is a planishing edge, here also you can see lot of wear has taken place. Now when this wear becomes excessive beyond certain limit we declare the tool has failed and which has which is changed the effects of tool wear other than its failures.

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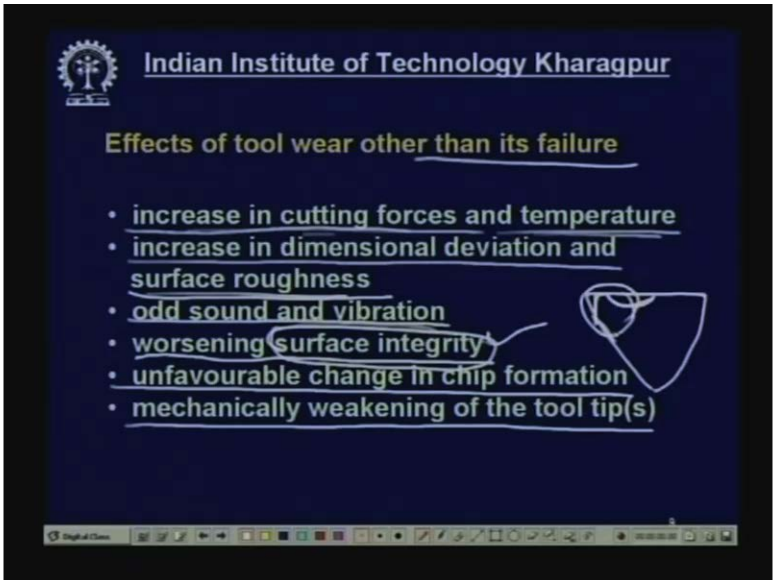

So one thing you understand that by wear also the cutting tool will ultimately fail after sometime, but this wear the growth of wear not only ultimately results in failure of the tool. This not only causes the failure of the tool but along with the growth of wear, lots of other problems develop which gradually reduce the machinability. What are those effects of growth of wear on machinability? Increase in cutting forces and temperature because this tool over and out the sharpness of the tool gets lost it becomes just the dull and more force will be developed and more energy, more heat will be developed because of that temperature will rise which is detrimental.

2. Growth of wear causes increase in dimensional deviation. Yes, if the cutting tool gradually wears out that the dimension also gets affected. So dimension accuracy gets lost, surface finish is also impaired or jeopardized. Now odd sound and vibration may take place even up to certain a very large sound when the cutting tool wears out. The

wearing of the cutting tool also induce causes loss of surface integrity that is, it induces lot of surface stress like tensile, residual stress, micro cracks, burning, oxidation, rapid corrosion that kind of thing. So the surface gets damaged again, in addition to surface roughness so, the surface gets spoil by other factors also. It is called surface integrity. So like tensile residual stress and the surface cracks micro cracks and so on. It also causes unfavorable change in chip formation. The chip normally flows in a particular condition preset the design but when the tool wears out and becomes excessive, the shape of the tool starts changing and becomes unfavorable hence cause some problem. Overall this mechanically, weakened the tool. So when the tool wears out suppose this is the tool sharp tool so it gets flank crater wear and flank wear so this tool becomes weak in this region. So this portion breaks, so this is another effect of tool wear.

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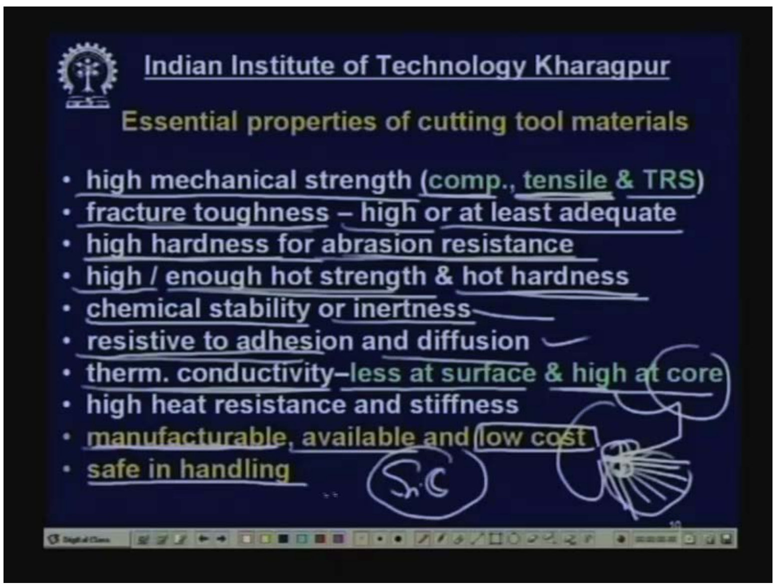

Now friend what should be the properties of the tool material? We have seen how this will be decided, what we have seen in the previous lecture and today's lecture till now that cutting tool fails. It will definitely fail, but it can fail in three modes: catastrophic fail or immediate failure, random failure, total failure by breakage which has to be prevented. Second one is plastic deformation because of loss of hardness that is also to be prevented at any cost but what remains is the wear. So those two have to be prevented and wear has to be retarded, reduced rate of growth. To accomplish this three, you know objectives what should be the property of the tool material?

Now one by one you see, high mechanical strength to prevent mechanical breakage and a compression or tension of bending, the material of the tool should is strong enough in compression basically because the most of the region of the cutting tool is subjected to compression, then at certain points it is subjected to tensile. Normally tensile strength of work tool material is less because it is very hard and brittle. So tensile strength should also be adequate then transverse rupture strength should also be reasonably high to prevent this mechanical breakage. Now fracture toughness, because of the shock or vibration the cutting tool may break by little fracture so the fracture strength the fracture toughness of the material should be high or at least reasonably adequate or high.

Now high hardness for abrasion resistance: To prevent or reduce not prevent to reduce the rate of growth of vibration where the material should be hard then now this strength and hardness that has to be high that have to be high but at low temperature tangent temperature it may be high but under cutting condition at high temperature and stress, these strength and hardness may fall but then it will be detrimental. So, the material of the tool should be such that its strength and hardness should be retained or continued even at high temperature cutting temperature, then only the tool will survive otherwise at high cutting temperature the tool will become weak and soft.

So this is stated that high or enough hot harden hot strength and hot hardness that is retention ability to retain hot strength and hardness at high temperature. Chemical stability or inertness with against the work material, by atmospheric gases and the cutting fluids resistive to adhesion and diffusion yes, it should be resistive to adhesion diffusion kind of wear. Thermal conductivity- very interesting what it should be? It should be high or low it should be less at surface and high at the core why? First of all, when the tool that is in contact with the chip, heat will be developed here. First attempt will be made so the heat does not enter into the tool that means at the surface the thermal conductivity will be low but once the heat comes in to the tool, it should immediately disperse.

For that what is required? The thermal conductivity should be high at the core. First of all, if we try to reduce the amount of heat to be entered into the tool and secondly whatever amount enters that has to be dispersed so that, the temperature rise becomes less because it is not the heat but the temperature that causes harm to the tool. Next is manufacturable; Now, we should imagine something which cannot be manufactured economically and easily it should be manufacturable, if the cutting tool measure should be available and it should be of reasonable cost not very costly. Diamond is a very good tool, but is very expensive. So we should think of the cost also and safe in handling. There are certain tool materials which you know environment not friendly not echo friendly. For example there is a tool ceramic tool where silicon carbide is added viscous and handling of silicon carbide during manufacture and use may lead to very serious problem even the carcinoma or cancer kind of thing. So this thing also to be born in mind while manufacturing the tools cutting tools.

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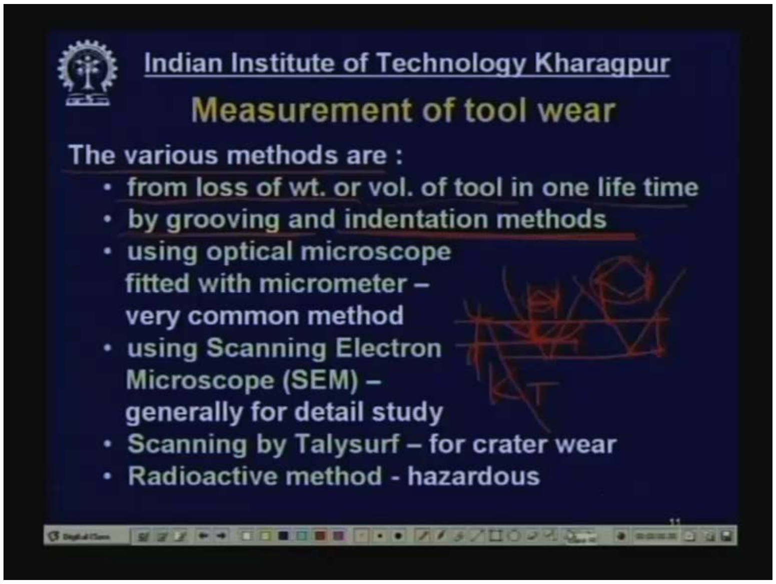

Now measurement of tool wear: How will you quantify that how much wear has taken place, so that you can decide that whether it is crossed the limit or not. The various methods say the various methods are from loss of weight or volume of tool material in one lifetime. You take the weight of the tool if it is a small one before machining and after completion of machining then you take the difference. So difference indicates the total loss of material either in volume or in weight. But this does not give the value of the features like the flank wear VB or crater wear KT that does not that is not given. It gives ah the more or less a qualitative idea or quantitative idea the tool has worn out reasonably by grooving or indentation method. This is the very old method and nowadays it is not that much practice.

Actually this is the tool surface suppose and this is the worn out surface and by indenter one indentation is made up to this depth and you get an impression here on the surface like this and then again on the worn out surface the same indenter is pressed against the tool in the worn surface. Now here, this material is lost. So the impression will be this much a small impression. So you see this impression is small compared to this one from which the difference and depth, so this is the depth here and this is the depth here. From the difference in depth we can get this measurement depth of the crater wear KT it is a one method. Similarly you know grooving also it is done but it is old method. It is not very popular.

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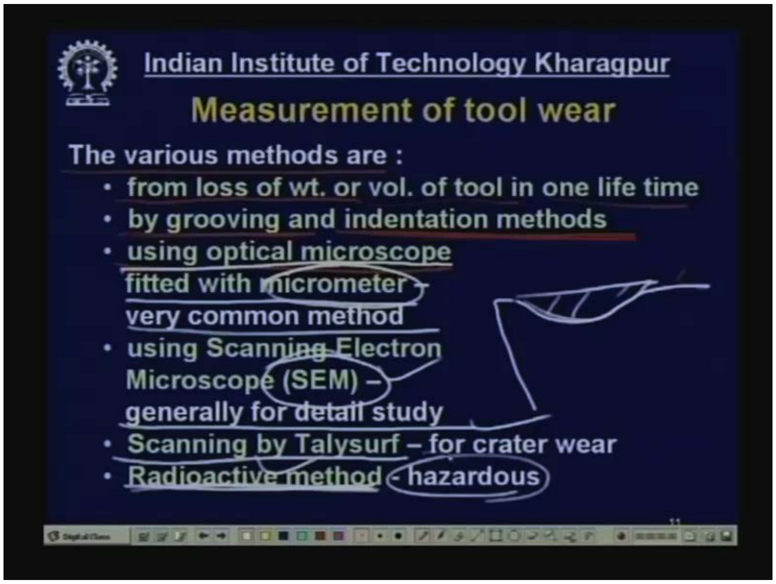

Now next is using scale using optical microscope all right. This optic using optical microscope is most common and fitted with the micrometer. So first you see through the microscope and measure the width of the wear or length of the wear say VB BM KT all cannot KT by KM etcetera by this micrometer. This is the easiest method, very reliable method and this this is very common very common method. Now if you want to study the wear geometry qualitatively and the amount of wear or the feature by feature the amount of wear in detail then, scanning electron microscope has to be used but this is expensive and this is for generally detail study. Now scanning by Talysurf - now measurement of this groove crater wear is very difficult. This type of crater wear is profiled is measured by Talysurf which is normally used for measuring the surface finish.

Now the radio active method was another method which was introduced for sometime to measure the volume of wear that has taken place in some complicated type of cutting tool say hob or such other kind of cutting tool wear of which cannot be could not be measured by other conventional method, it was very difficult. So radio active method was introduced for some time. But it became absolute in no time because it is hazardous. It is so hazardous that it is dropped nowadays. Now come to tool life.

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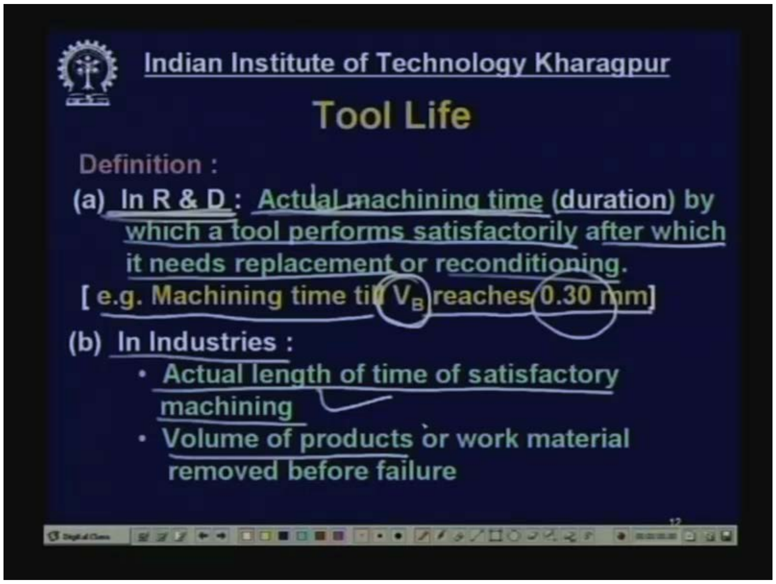

What is the definition of the tool life, life of the tool, what do you mean by tool life? Now again it is defined in different manners. So in R and D laboratories or institutions or research, it is defined by actual machining time or the length of the machining time actual machining time or duration say 5 minutes 10 minutes 12 minutes like that by which a tool perform satisfactory after which it needs replacement or reconditioning that is in between two replacement or reconditioning, what is the actual machining time by which the tool could work satisfactorily that length of speed of machining actual machining or duration is called tool life and it is expressed in minute.

For example, say here machining time till VB the average flank wear reaches a limit of 0.3 millimeter and this is the internal sub- standard. So this is one way then this is so the tool life is defined by actual machining time in between the failures and it is expressed by minute. Now in industries how is it done? Actual length of time of satisfactory machining okay this is a like R and D. Sometime the volume of products how many pieces have been produced that is the measure of tool life. Say 20 pieces, what is the life of the drill? 20volts.What is the life of that milling cutter? 30 pieces or volume of work material removed before failure. Next is assessment of tool wear.

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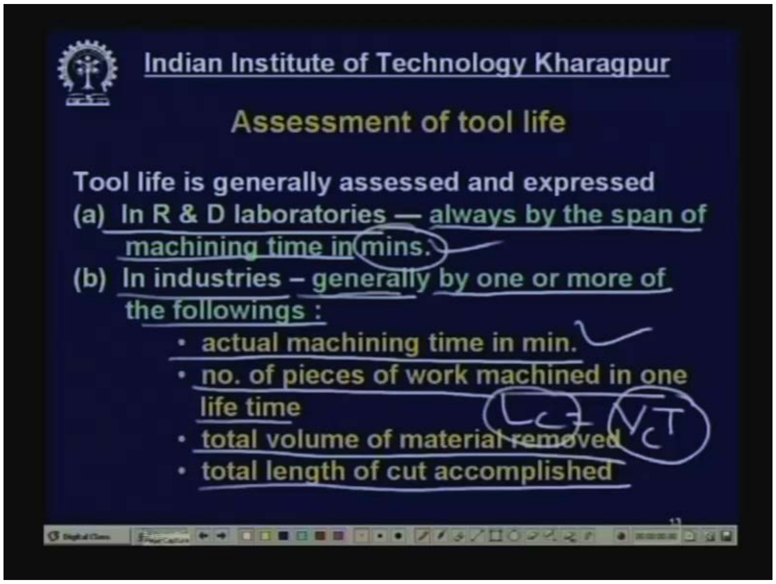

How the tool wear, amount of tool wear is quantified that has to be considered tool life is generally assessed and expressed in R and D. How it is done in R and D laboratories? The tool life generally assessed and expressed in laboratories and it is always done by the span of machining time in minutes. Say 10 minutes 5 minutes 20 minutes like that. In industries, how is it done? Generally by generally, not always by 7 methods by one or more of the followings: what are those by actual machining time in minute as it is done in R and D or number of pieces of work machine in one lifetime that is 20 pieces of peen machine. So what is the life of the turning tool say 40 pieces like that number of pieces. Again by total volume of the materials removed what is the life of the milling cutter? So it is expressed by the volume of work material removed by that cutting tool satisfactorily before failure or total length of cut say 1 kilometer or say this is actually V c cutting velocity into time. So this is called length of cut L c. So tool life is decided by what is the total length of cut the cutting tool could work before failure.

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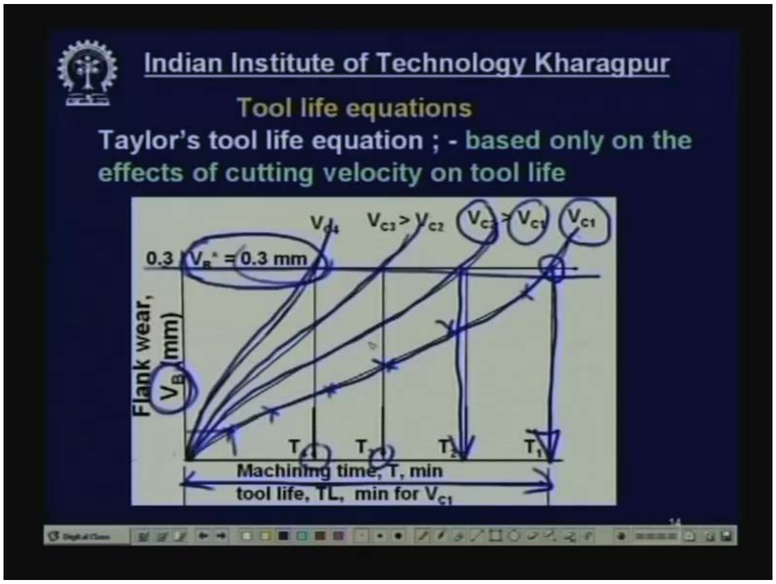

Now come to tool life equations; Tool life equation- what is equation? Equation means the pictorial representation of the relations between the variables and their responses. So here the response is tool life and variables are cutting velocity, feed, depth of cut and other parameters like tool geometry. So this connects connectivity is expressed by equations. With the you use it By using this equations, we can evaluate or estimate that what will be the life of the cutting tool which will enable planning of machining, process planning and so on. Now this was first done long back more than 100 years back, F W Taylor a scientist, first introduced a technique what is called Taylor's tool life equation. In this method, it is based on a fact in a simple way based only on the effects of cutting velocity and tool life as if only cutting velocity if berried will affect the tool life. Other parameters will not affect that much. Anyway how this is done? How the tool life is developed? We determined and this shows how the tool life is determined experimentally or says conceptually and then how the equation is developed by Taylor and so on.

Suppose this is the machining time, the growth of machining time and is a flank wear say V B. This is V B average flank wear. See at the cutting velocity, low cutting velocity V c1 you continue machining after at regular interval, you withdraw the tool and measure the V B and plot this. So this way number of points will be plotted from experimental results you measure the tool life at different velocity and sorry this wear, the V B you measure the VB, flank wear of the tool and plot against the machining time. Then you draw a line this is the wear pattern. Now if we decide that the limiting value of the average flank wear is 0.3 millimeter, this is the 0.3 millimeter line, so this is the end of machining and corresponding time, this time is the tool life span. Now, if we increase repeat this experiment at higher speed V c 2 greater than V c 1, the tool wear will grow faster and the life will be less by say T 2. For even higher velocity V 3 life will be T 3 and for V 4 and setter life will be T 4. Now for V 1 T 1, V 2 T 2, V 3 T 3 and V 4 T 4, V 5 T 5, etcetera we get set of data. Now this data will be utilized to correlate tool life and the cutting velocity. How it is done?

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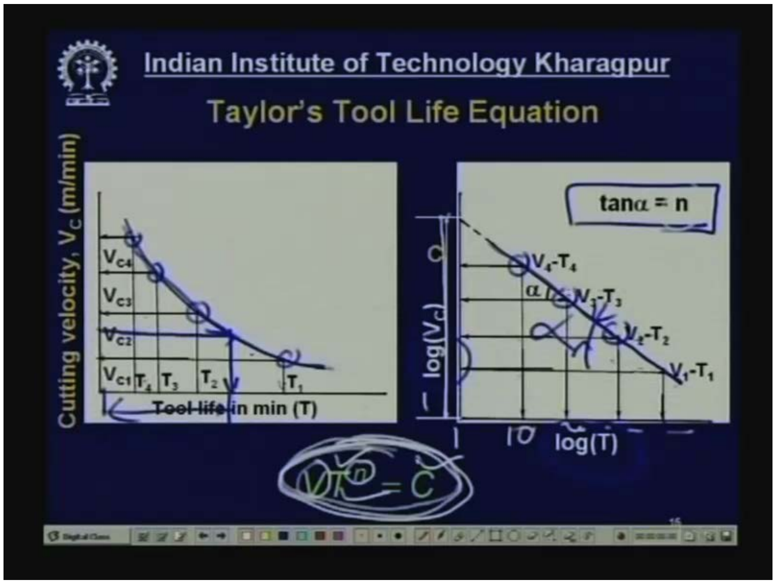

Now this is the curve. Now again you will have plot. This is tool life of 10 say T 1 T 2 T 3 T 4 you obtained by the previous experiment and the cutting velocity corresponding cutting velocity Vc 1 Vc 2 Vc 3 Vc 4etcetera. Now if you plot these are the points okay this is V 4 T 4, V 3 T 3, V 2 T 2 and V 1 T 1 and then you join this line, this is the plot. Now you can understand if you plot it just like calibration. Now if you machine at a certain arbitrary velocity, what will be the tool life? This will be the tool life, amount of tool life. But how to correlate? Make an equation; prepare an equation relative velocity and tool life. Now if you draw in a log scale, in a log log scale the same velocity and tool life, then we get a straight line, we get a straight line and these are the corresponding points and you get a straight line okay and this is the slope, this is the slope of the curve say alpha.

So tan alpha is equal to n and this suppose this is 1 is starts from 1 1 value 1 say 10 20 and so on. So the log scale so this C is the intercept that means when the tool life is only 1 velocity will be this much and now this is the straight line equation of which will be like this, V T to the power n the slope is equal to constant this intercept. Now if you this we if you know this constant and this constant n then for given value of V we can estimate what is the value of tool life. If we decide tool life, what will be the corresponding velocity, we can determine using this simply equation this simple equation V T to the power n is equal to constant is called Taylor’s tool life equation. It has got tremendous application. Now I show you one example.

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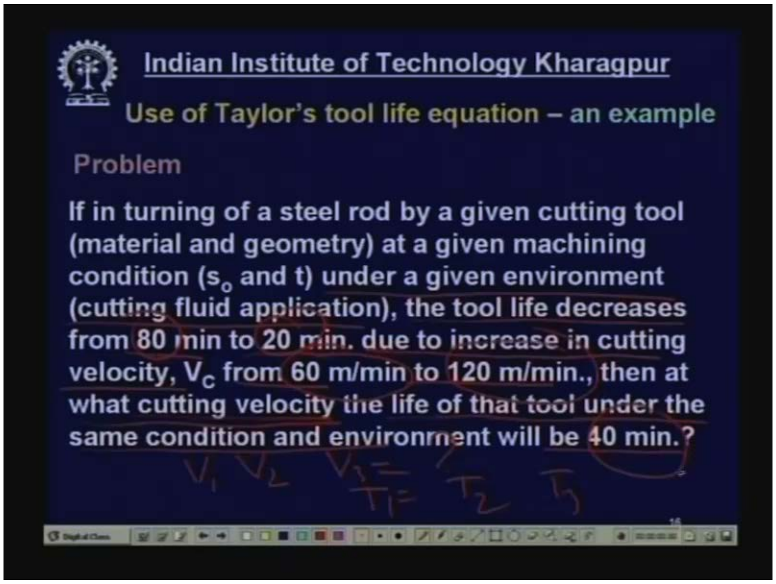

Use of Taylor's tool life equation- an example: suppose there is a problem. If in turning of a steel rod by a given cutting tool material and geometry at a given machining condition in a given machining condition that means everything is same. Only varying is the velocities under a given environment say cutting fluid application the tool life decreases from 80 meter minute to 20 minute tool decreases due to increase in cutting velocity from 60 meter per minute to 100 meter per minute. Then at what cutting velocity the life of that cutting tool under the same condition will be 40 minute? Now what we get here? Here V 1 is given what is V 1? V c 1 is 60 meter per minute what is V 2? V 2 is 120 meter per minute. What is V 3? Not known that has to be determined that is at what cutting velocity this was determined. What is T 1? Given T 1 is 80 minutes. What is T 2? 20 minutes. What is T 3? 40 minutes. So these are the data given. We have to determine velocity V 3. So this is the problem. Now let us see how it is solved.

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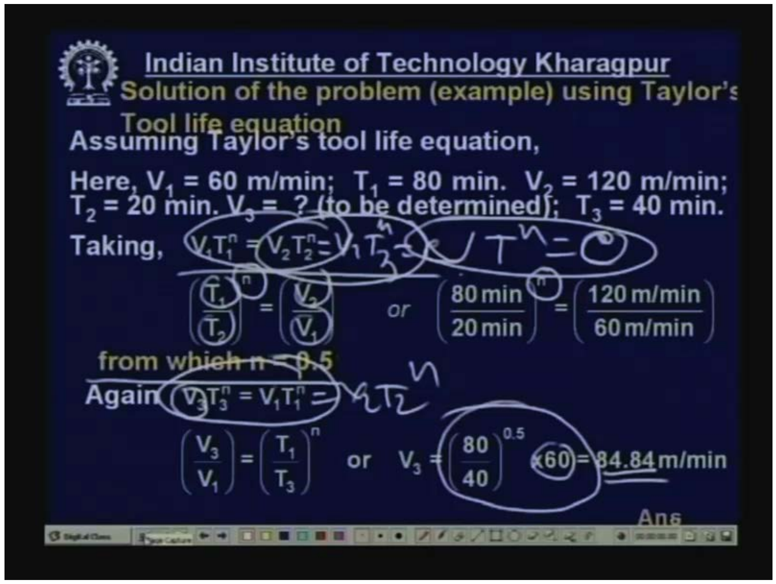

Now assuming Taylor's tool life equation, use the equation V T n is equal to constant that is V T n is equal to constant okay. Now this can use therefore, since it is constant V 1 T 1 to the power n V 2 T 2 to the power n is equal to V 3 T 3 to the power n is equal to constant all are same. Now from these two if you put like this then T 1 by T 2 is equal to V 2 by V 1 and here is the power n the values of T 1 is known T 2 known V 2 known V 1 known. So we get the value of n from these known values and suppose this is 0.5. So this is obtained 0.5 value. Now what we have to determine? We have to determine V 3. Now from this V 3 T3 n is equal to V 1 T 1 n is equal to V 2 tell V 2 T 2 n also. Anyway let us take this one. So from where we get V 3 V 1 is equal to T 1 by T 3 to the power n. n is known 0.5. T 1 is known 80. T 3 is known 40 minute and V 1 is also known that is 60 meter per minute then V 3 is equal to this expression which is equal to 84.84 meter per minute. This is how it is determined. Now you can see how powerful this Taylor's method. Now modified Taylor's Tool Life of equation:

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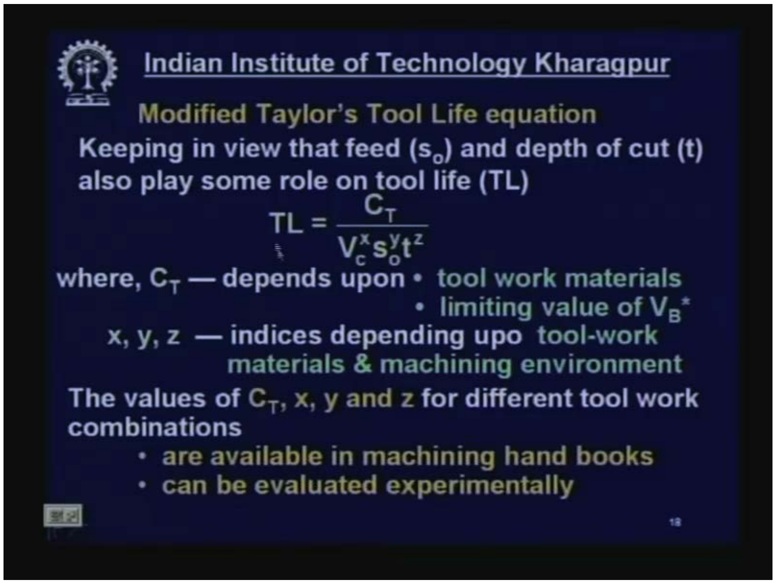

Now friend just now you heard the Taylor 100 years back developed the Taylor's Tool Life equation. But that time, he assumed that only the cutting velocity is a variable but really the feed and even depth of cut plays some role on tool life. Now keeping in view that feed and depth of cut also plays some role in tool life, a new equation can be thought of. This is called modified Taylor's Tool Life equation that has been done later on. What is that tool life is equal CT, a constant. V c to the power x V to the power y and depth of t to the power z. Now where CT is a constant but it depends upon the tool work material tool and work material and limiting value of V B where that the limiting value of V B is equal to 0.3 millimeter or sometime 0.4 millimeter or 0.6 but remember normally 0.3. So that will decide the work material, tool material and limiting value of V B the value of CT.

Now what is x y? What is the x y z x y z the are called the indices the value of this indices depend upon the tool-work material and machining environment that is cutting fluid application. Now it is obvious that out of this x y z indices, x that is power of velocity is maximum and the effect of depth occurred is minimum. So, z is the smallest, x is largest, x may be say 0.5, y may be 0.2, and z may be even 0.05. However the values are exactly the CT x y z for different tool-work material combinations are available in machining handbooks. The lot of handbooks is available on machining and there the charts are given for different work material, tool material combination, cutting fluid combination and you get these values of x CT, x, y, z. But, if it is not available then it can be developed also. You can do experiment and by doing lot of experiments, the value of the x, y, z and CT can be determined and you can produce a database which will be used further by somebody else.

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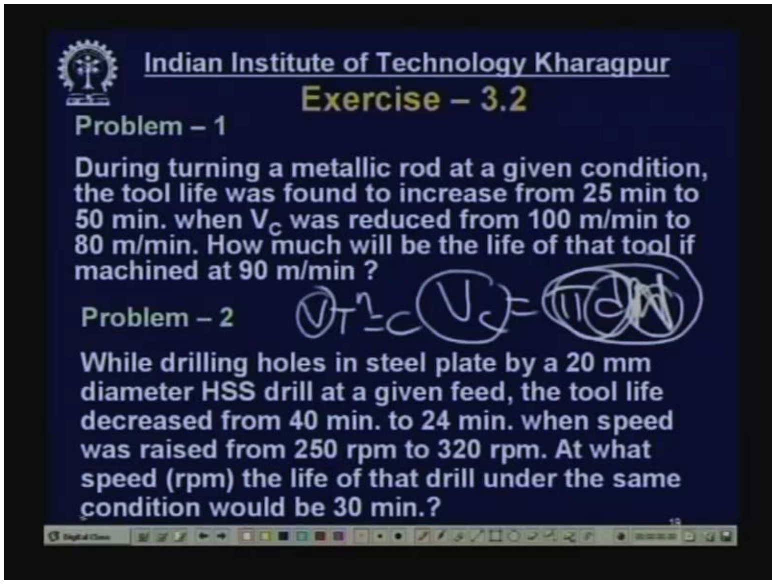

Now these are the end of the lecture today and now some problems are given for your practice. This is the problem-1 and problem-2. Very similar I just give a little hint, during turning a metallic rod at a given condition the tool life was found to increase from 25 minute to 50 minute when velocity was reduced from 100 meter per minute to 80 minute per minute. How much will be the life of that tool if machine at 90 meter per minute? That means, here again you see that what are given V 1 V 2 V 3 are given. T 1 T 2 are known only T 3 the time T 3 tool life has to be determined using Taylor's tool life equation. Now there is another problem-2. Here instead of cutting velocity the speed rpm of the drill is given but you know that velocity is equal to pi dn. n is the rpm of the drill and velocity. So diameter of the drill remains constant. Therefore the V T n is equal to constant. In this case this V can be replaced by pi dn where n is the rpm n is the rpm all right and then pi d will be cancelled from the equations and n will remain but the procedure will be exactly same. There is no difference.

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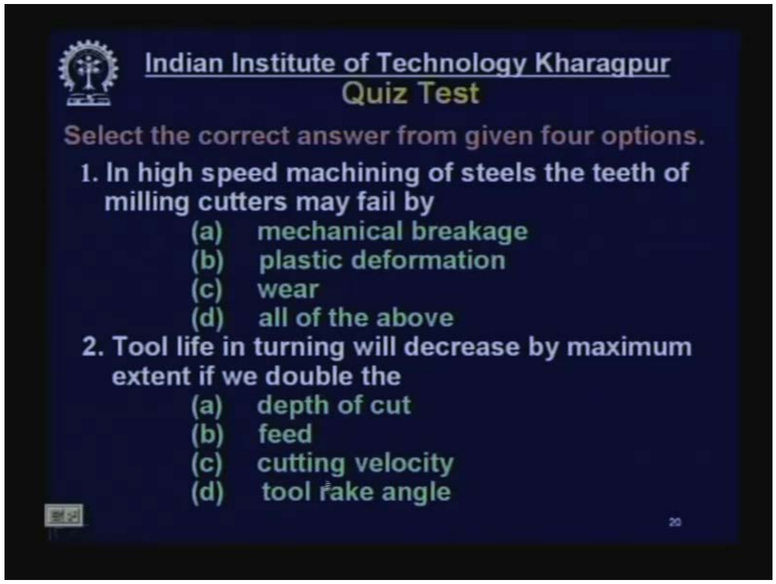

Now some quiz tests have also given for your practice, very interesting. Now 4 options are given for a particular step mention question and you have to identify the correct one select the correct answer from given four options. For example 1. In high speed machining of steels the teeth of milling cutters may failed by in high speed machining you look careful into the statements the high speed machining of steels strong material the teeth of milling cutters failed by mechanical breakage is intermediate cutting. Plastic deformation wear, all of the above. Here the answer is given on the next frame. You can see later on, so that you select judiciously here. 2.Tool life in turning will decrease by maximum extent if we double the depth of cut, feed, cutting velocity or tool rake angle which one is most sensitive for creating tool life?

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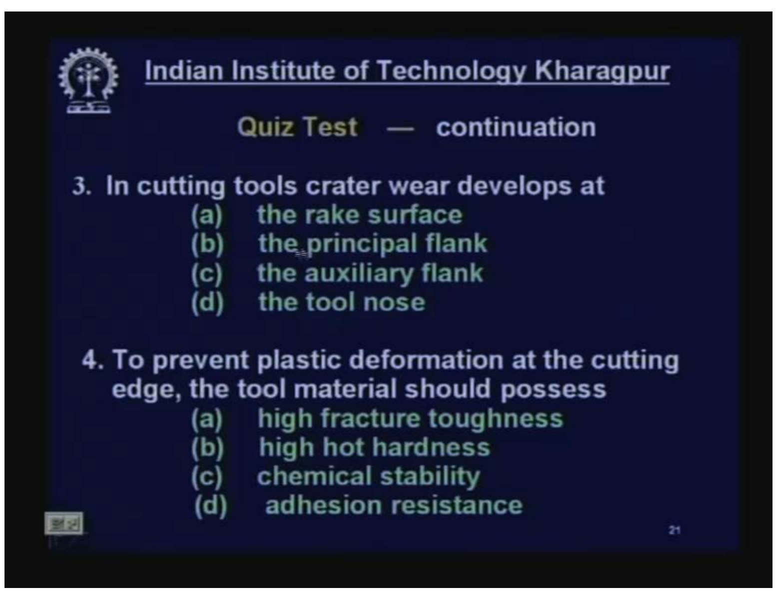

3. In cutting tools crater wear develops the rake surface, the principle flank, auxiliary flank, the tool nose. Crater wear obviously on the rake surface. 4. To prevent plastic deformation at the cutting edge, the tool material should possess that is plastic deformation occurs due to softening, lack of hardness. You have to find out the answer. High fracture toughness, high hot hardness, chemical stability, adhesion. Obviously, the high hot hardness is the answer. Now you can see the answer in the next page. All the answers are given okay.

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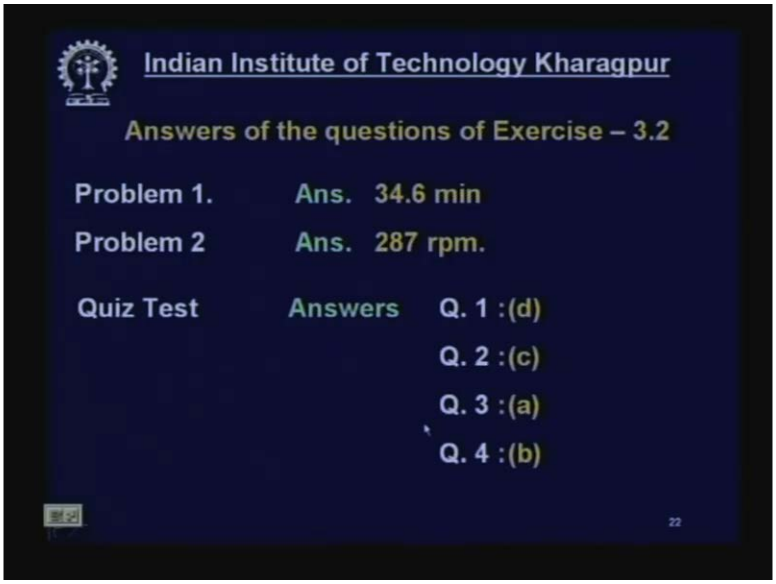

Use now, practice. You can find out lot of questions as exercise in many books also and you can practice.

Thank you.