Manufacturing Processes – II
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Lecture No. 5
Mechanism of Chip Formation

Welcome! You know our subject is Manufacturing Processes – II

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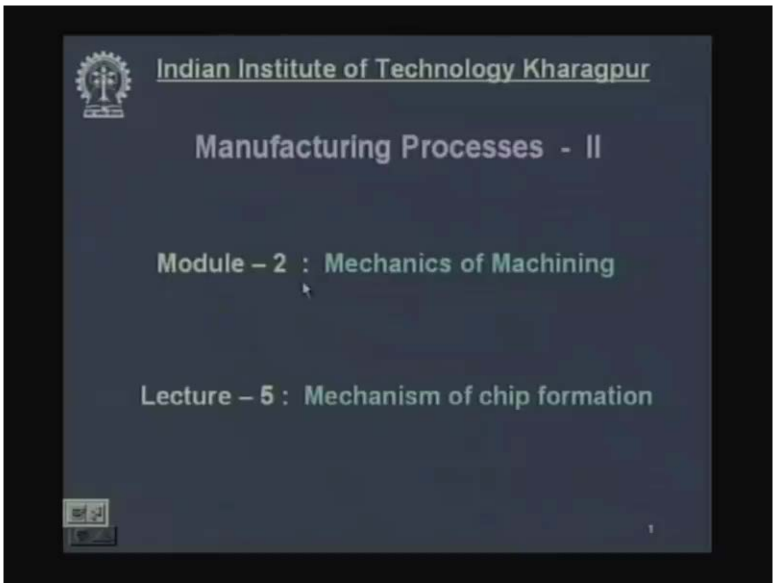

and this is now Module - 2 is continuing is Mechanics of Machining and under this Module, now we are continuing lecture number five. The topic of lecture number five will be Mechanism of chip formation.

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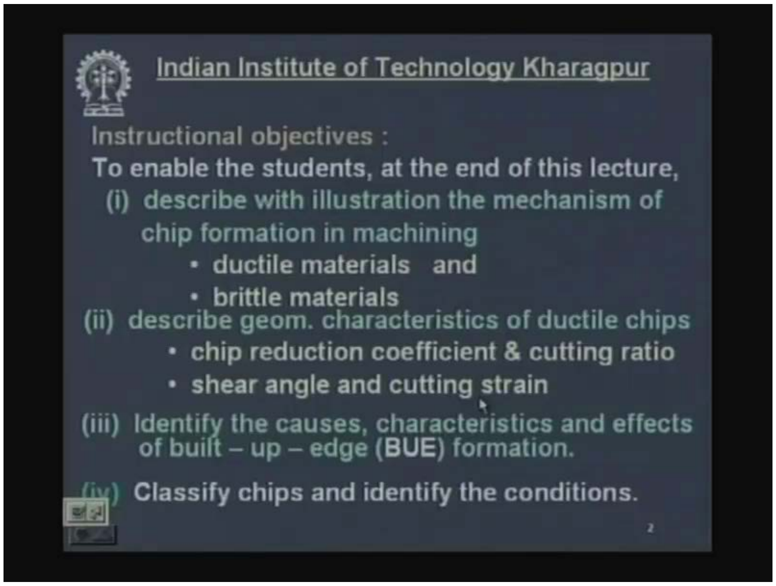

Now what are the contents of lecture today? Instructional objectives: After learning the subject the students will be able to (i) describe with illustration the mechanism of chip formation in machining, ductile materials and brittle materials, (ii) describe geometrical characteristics of ductile chips that is chip reduction coefficient and cutting ratio, shear angle and cutting strain. (iii) Identify the causes, characteristics and effects of built - up - edge (BUE) formation during machining and last (iv) Classify chips and identify the conditions under which such kind of chips form and last there will be some quiz and other exercise question numerical problems and solutions.

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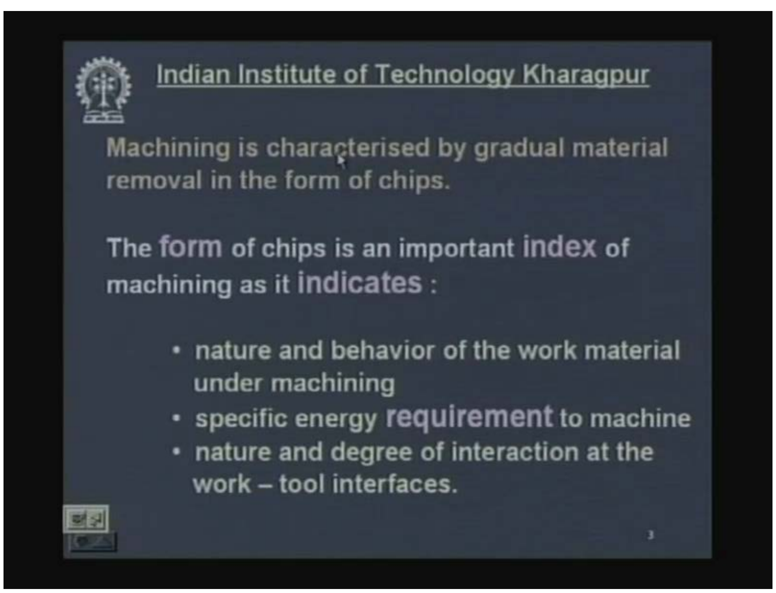

Now machining is characterized by gradual material removal in the form of chips. This has been described in detail and the purpose of machining is to provide dimensional accuracy and surface quality to the preformed blanks, to enable the object fulfill the function requirement of the object, work better, perform better and render longer service life.

Now the form of the chips that are produced during machining is an important index of machining. Index of machining means from the chips configuration and color, one can understand qualitatively whether the machining ongoing is favorable or not favorable. As it indicates, more directly because the chip form indicate directly and indirectly, the nature and behavior of the work material under machining. So what kind of material we are machining that will be understood form the chips if we get so discontinues chips it means that the work material is behaving brittle if the chips are continuous the work material behaving ductile. Now the specific energy requirement to machine if the chips are not uniform, continuous, rather constraint and broken and thickened that means the more energy is required to conduct the machining work which is undesirable. It also indicates nature and degree of interaction at the work tool interface. If at the work interface the temperature is very high or friction is very high, the chips color and configuration will change. So these things will be indicated from the chips.

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The form and colour of the chips depend upon the work material. For example, if the work material is brittle, the chips will be discontinuous broken chips or dusty chips. If the work material is ductile we get continuous chip. It depends upon the cutting tool both material and geometry. If the material is inert chemically inert, the chips will be better. If the material is sticky or you know have affinity chemical affinity towards the work material, the chips will be poorer and geometry like rake angles of cutting tools play important role on the chip form. Levels of the process parameters: Now process parameters indicate here the cutting velocity and feed not depth of cut with increase in cutting velocity feed temperature rises and then the form and colour the chips change, application of cutting fluid, what does cutting fluid do? Cutting fluid does cooling and lubrication both affect the form and colour of the chips.

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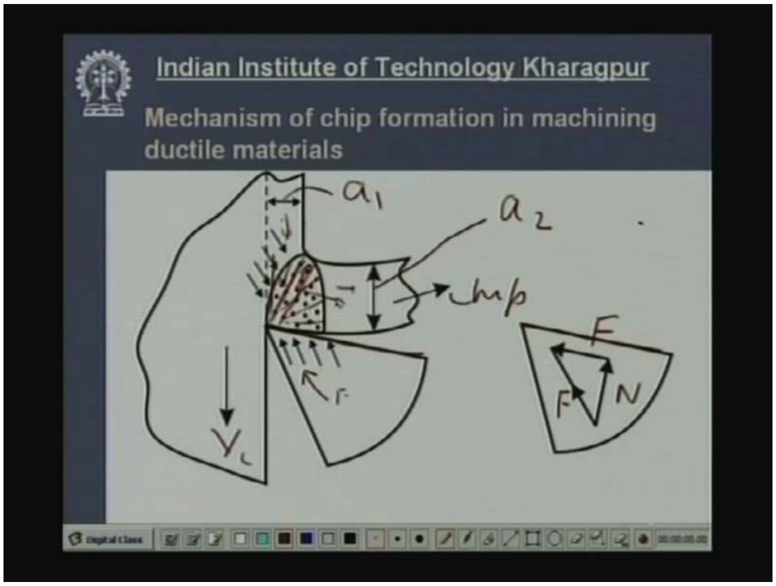

Now here let us see the mechanism of chip formation in machining ductile materials because of mechanism of machining ductile and brittle materials are entirely different widely different, but most of the materials engineering materials that a machine are ductile even if ductile they are semi brittle or semi ductile under the cutting condition they behave ductile. So most stress will be given on the mechanism of chip formation in machining ductile materials.

Here you see that this is the work material, this part, part of the work material. Suppose here is machining going on by a cutting tool. This is the cutting velocity and chips flow in this direction. Now if you take only this portion it is this. Here you can see that this is the cutting velocity V_c with which the work material is coming down and this is the uncut layer. This is the thickness of uncut layers say a1, the layer is going to be removed. Now it is coming ahead the cutting tool and then goes out in the form of chips. So this is the chip and this is the thickness of the chip denoted by a2.

Now the work material, this work material ahead the cutting tool is subjected to almost all sided compression. Here the forces are coming because it is trying to come down. So there will be force and these are resisting force from the tool site. So this material here will be interrupt and will be subjected to almost all sided compression. Now this force easily this one which has got two components: One normal force, one friction force at the working at the rake surface of the tool. Anyway now because of this compression shear stress simultaneously develops in different directions. You know shear stress develops in different directions and keep on going and this shear stress will be developing in different direction in different magnitudes when wherever and whenever the shear stress that is going to be develop reaches or exceed the shear strength of the work material then the failure will start. Failure means the separation will take place between this chips material from the Para material.

Suppose this is the plain along with the shear stress is maximum and that reaches the shear strength of the work material. So there will be slip between the Para material and the chip material and then there will be a slip, the chip will move in this direction and then a layer of material will be proceeding in this direction then again the work material is coming down, again shear stress will develop, again there will be slip and another layer will come up. So, this way this chip material will come out layer by layer because of the shearing action or yielding process. This will be more evident in the next figure. Say in this, the lamella chip formation by shear.

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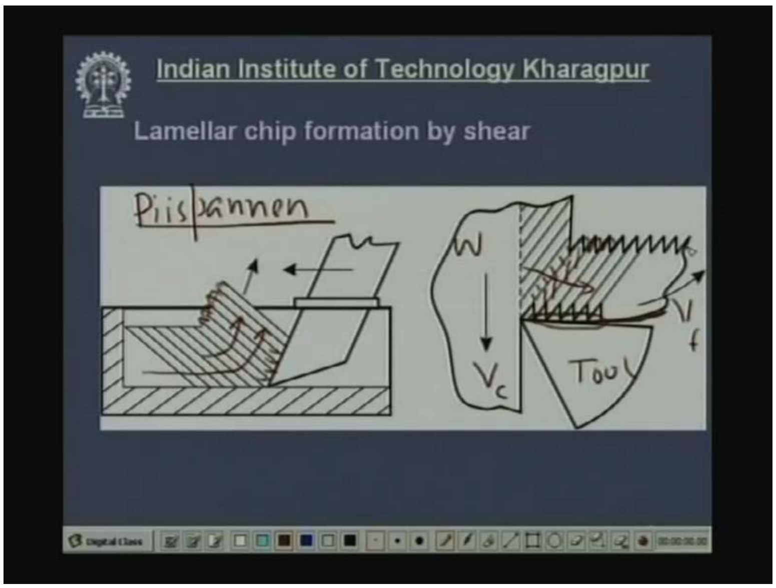

For example, suppose this is an analogy cardboard analogy. Suppose this is the stack of cardboard the post card here and now there is tool like a wooden tool. Now it has moved in this direction. It is moving in this direction, as a result these stacks will now because of this movement, these stacks will gradually this post cards will move in this direction. This will right on the rake surface of the tool and this will be like this. This will be serration.

Similarly here, so the stacks will be coming on to the surface and this is how the work material, this is the thickness of uncut layer is going to be removed is gradually going into this direction in the form of chip. So this is called cardboard analogy, this has proposed by Piis Pannen a scientist called Piis Pannen, a young scientist Piis Pannen and he proposed a model to describe the chip formation in ductile materials. So look into this diagram. This is the cutting velocity V_C and this is the chip flow velocity V_f . This is the tool and this is the W work and this is the uncut layer the chip. Now here is layer of the chip you see this layer. This could go straight in this direction in absence of the tool but because of the presence of the tool this layer will go into this direction and occupy this position. So this layer is shifted, in this way the layers are shifted one by one and coming out in this form and because of this the serration will take develop and when actually we machine that material and get the chip and examine such kind of serrations are visible. Such is very true but the bottom surface theoretical should also be serrated but it becomes smooth when you examine the chips because at this region the lot of softening takes place because of high temperature and because of this plastic deformation and rubbing this bottom surface of the chip become smooth for the upper surface remains just like serrated. This is called Piis Pannen model or explaining the chip formation of ductile material by shearing to office layer by layer. Now let us see the next

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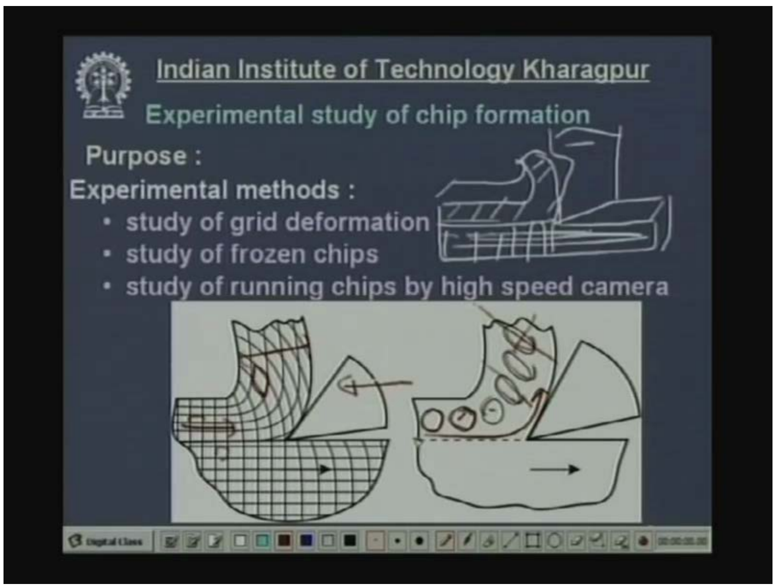

Experimental study of chip formation: The purpose why some experimental studies necessary because the chip that is form. There is kind mechanical failure because it is a permanent deformation of the tool material work material. So it is kind of failure now what is cause of failure? It is a mechanical failure that means it is cause by stress either compression stress or shears stress or tensile stress or combination. Now what is real cause or which one is more predominantly acting on formation of the chip? It is very complex phenomena. So it is very difficult to understand. So some experiments can be conducted to understand all this things that what is real mechanism or what kind a stress really responsible for chip formation and ductile materials.

Now the experimental methods are study of grid deformation. Now this shows the study of grid deformation. Here suppose this is a tool shaping process and this is doing shaping work. This is the layer of material which is coming out in the form of chip. Now the shaping process. Now what do you do, before experiment this height surface this is the plate. Now on the size of the plate some grid marks are inscribed and some vertical marks. It looks like this, now when the chips are formed due to movement of the tool in this direction or this move in this direction it gets diverted and thickness increases. You see this small grits rectangular grits are deformed into some peculiar form. From this nature and extend of deformation, one can understand or analyze that what is the real cause of this deformation? shear or compression or tension again this is called square grits now here circular grit on the side surface you can inscribed some circular marks circles okay scribed. Now when this will move in this direction and going to form of chip you will find that this will be distorted and this will be converted to ellipse.

Now from the direction of the major and miner axis and from the values of the major axis and major radius and miner radius with respect to the radius of the circle there are Liouville's theorem and other theorems using which one can easily understand or analyze what is basic mechanism or cause of such kind of deformation? Is it shear or tension compression? It has been found that mostly it is caused by shear. If it is ductile material so if the main causes shear.

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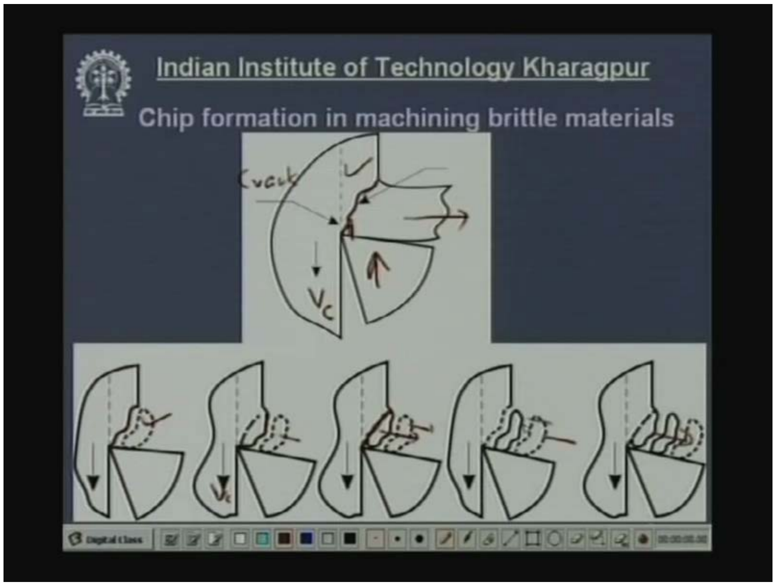

Now come to chip formation in machining brittle materials it is a different process now chip formation is a permanent deformation process whether is ductile or brittle because it is the failure permanent deformation of the work material in form of chips. Ductile material are formed by what is called yielding or shear, but brittle materials are formed by brittle fracture.

So that two basic mechanisms yielding and brittle fracture now the brittle material fail by brittle fracture. Now what is mechanism while machining suppose this is the cutting velocity this is the cutting velocity V_c is small you know crack is developed at the cutting tool, a very small crack this is the crack. Now brick at this end of the crack they will lot of stress concentration at the end of the crack and this developed due to wedging action of the tool is moving in this direction relative to the job. Now if it is ductile material then because of the stress concentration and stress will exceed the yield strength they will be yielding and tip of the crack will be rounded and because of rounding this stress will fall.

So this will not propagate but if it is brittle material then there will lot of stress concentration at the tip of the crack and that will exceed the strength of the material and that crack will propagate in a random path through minimum resistance path where the mean resistance is minimum and this propagates of the crack will quickly separate the chip from the parent body this is mechanism.

Now let us see this one. Here a chip particular has been formed of irregular size and shape and each has been separated out from a pick irregular surface with the minimum resistance path because these brittle materials have got lot of voids and defects. So it has got uniform property, not uniform property now after it goes out again this work material because of this movement V_c it is coming down there will be swearing. Now there will be again crack propagation so this will also come out so this is come out this will also come out. Now two chips are formed again will be swelling so this way continuously chips will be forming and these are all discontinuous chips and the size and shape of this chips will be different and sometime this will break into further pieces. Now come to next.

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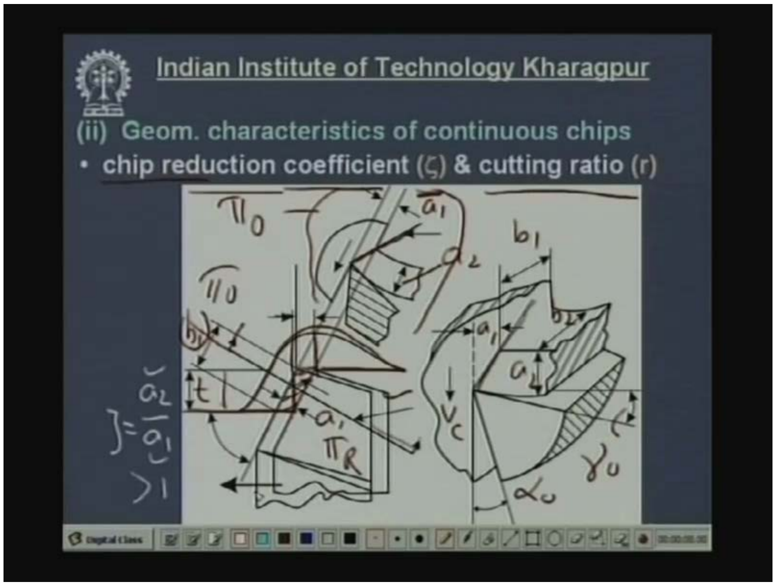

Now the geometrical characteristics of continuous chips as I told you that in machining activities most of the work material behaved ductile, engineering materials. So we concentrate on continuous chips produce by ductile materials now what are the major geometrical features of the cutting process. Chip reduction coefficient, that is chip reduction coefficient and denoted by zeta chip reduction coefficient or cutting ratio denoted by r.

Now here you see this is turning process going on. This is the work piece. This is the finish surface. This is the cutting tool to the first position after one pass one of the revolution the tool occupies this position. From this position tool goes into this position as a result, the chips cross section is chip cross section if you take a section this process to the tool and the chip by in orthogonal plain pi o and this pi R you know. Then we get a view like this. This is orthogonal view orthogonal plain.

Now this is a1 the thickness of the uncut layer. This is thickness a2 of the a2 of the chip. This is the plain of shear or slip and this a1 thickness of the chip this is the depth of cut amount of penetration of the tool from unfinished to finished surface and this is called width of cut b1 width of cut and this is the orthogonal plain. Now if you take this section you can draw this one the same figure drawn here its like it two D effect where you can see the width of the chip also say this is b it is b one this is the width of the chip after cut and this is the shear plain along which the slip takes place and this is the uncut layer thickness a one and this is a two and this is the cutting velocity V_c what is this one? rake angle what is this one? alpha clearance angle.

Now what is zeta? Zeta chip reduction coefficient. Zeta is equal to a2 by a1. What is zeta chip reduction coefficient? Ratio of the thickness of the chip after cut and before cut. It means always greaten than one why because the work material ahead is subjective to the compression because of compression the chip becomes thicker. So this will be thicker than this. So the value of zeta will be greater than one always.

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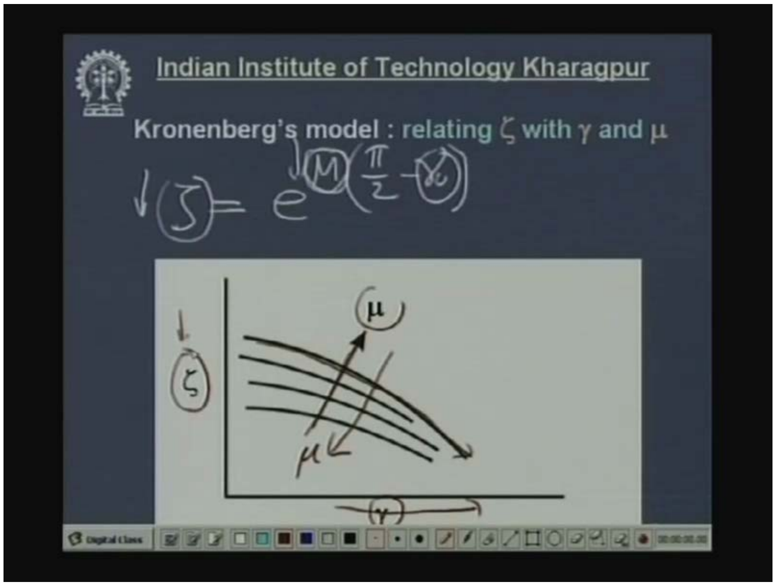

Now here the Kronenberg’s model. He is a scientist. He did lot of work in this area. He related zeta the chip less than coefficient with gamma and mu before we do write the equation we should understand that what is the significance of zeta? Zeta is called chip reduction coefficient, this is a2 by a1. So this is the degree of thickening of the chip. More thickening means more energy investment. Less thickening means less energy investment. What do you want? What should be done with lesser energy investment? That means this thickening should be as less as possible or the value of zeta should be as small as possible but not at the cost of productivity keeping productivity same. Our attempt should be to reduce zeta as per as possible that means lesser energy will be required to get the work done. That is the significance of zeta. Now here Kronenberg's equation states that zeta is equal to e to the power mu pi by two minus gamma say o orthogonal. Orthogonal rake and this is orthogonal cutting.

Now what is desirable? Desirable is that zeta should be as low as possible but this is a function of rake angle of the cutting tool. Now if the rake angle increases the zeta will decrease. If rake angle decreases this will increase which is unfavorable and if rake angle is negative then this will be plus and this will be very large which is also very undesirable then the cutting force and other problem will arrives. So this is one aspect then mu, the coefficient of friction at the chip tool interface in between the chip and the tool if that is high then zeta will be large and zeta is large then is undesirable. If mu is less then zeta will decrease that is desirable. Now how the friction come it reduced by lubrication process or by taking that kind of tool where the friction is less. Now graphically the relation of zeta chip reduction coefficient with respect to rake angle and mu are shown here.

So with the increase in rake angle, this value of zeta decreases. This is desirable very good and with the increase in friction this will rise. So we should always try to reduce mu a friction by lubrication and so on, so that zeta comes down that is desirable.

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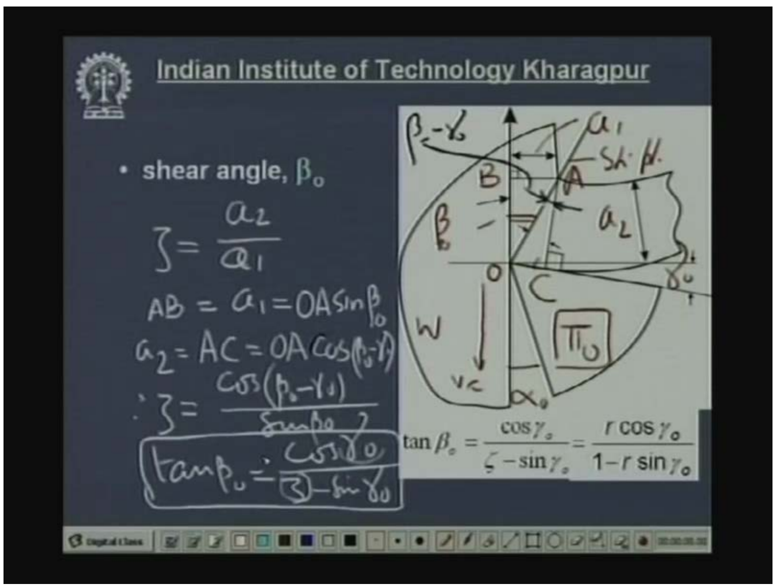

Now let us come to shear angle. This is the angle of bending of the chip. Now this is how the chip is formed. This is the cross sectional view of the cutting drawn in orthogonal plane. This is drawn in orthogonal plane the entire diagram, this is the cutting tool, this is the w work piece, this is the cutting velocity, and this is the thickness of uncut layer a1. This is shear plane. This is the chip thickness after cut a2 and what is this angle? This is rake angle you know and this is clearance angle but this angle is the angle of interrelation of the shear plane on the velocity vector. So this is the shear angle, angle of interrelation of the shear plane from the velocity vector taken in orthogonal plane.

Now what is value of this and how it is related to zeta, gamma and other things. Suppose this point is o, this point is A, this is B and this is C a draw perpendicular then what is zeta? Zeta is chip reduction coefficient equal to a2 by a1. Now what is a1? Where is AB? AB is equal to a1 and this is equal to OA sin beta. I write beta O because this shear angle is taken in the orthogonal plane and what is a2? a2 is AC and what is AC? AC can be written as OA. What is this angle? This angle will be if you check, this will be beta O minus gamma O then AC will be OA, this is the right angle, OA cosine beta minus gamma therefore what we get zeta is equal to a2 OA cancels. So this will be cosine beta minus gamma dived by sin beta. Now if you just use this equation and can find out tan beta will be equal to cosine gamma dived by zeta minus sin gamma. So this is very important expression. The shear angle beta is function of rake angle and the chip reduction coefficient.

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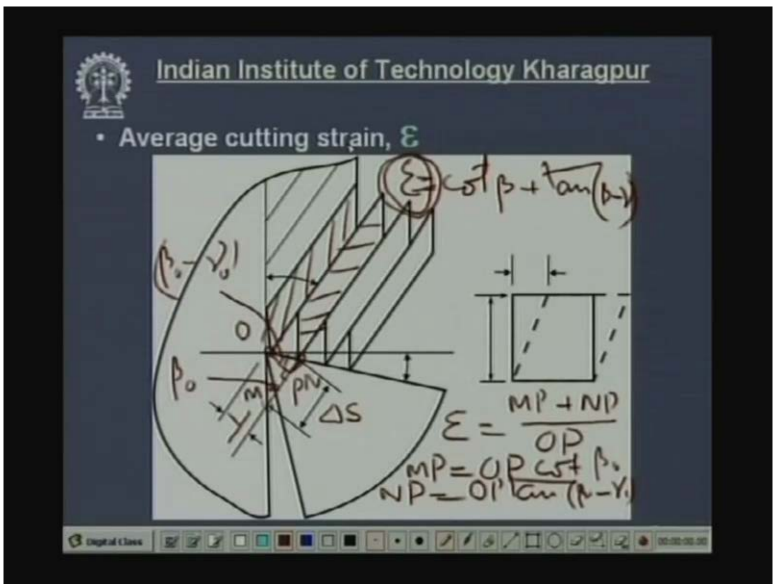

Now come to average cutting strain. Now it is cutting strain, cutting mean shearing as you know this is shearing process. So this is the shearing strain. Now shear in this diagram suppose the bottom line fixed, it is the block and subject it to a shear stress. So this will be the amount of shear say delta S over a height say Y then what is strain? Shear strain that will be equal to delta S this delta S divided by Y that is tangent of this angle shear angle gamma. Now in case of shearing that is according to Piis Pannen model if you see here, that this layer which was suppose to come downward if the tool is absent has occupy this position because of obstruction created by the tool that means this point which was suppose to be here has gone to that point.

So how much is shift? So this is the amount of shift similar to this and what is height of this Y. So if we puts a O and this point M and this point N then what is cutting strain? Cutting strain will be equal to that amount of shift delta S that is MN divided by the height. So you can drop the perpendicular here say point P then this will be OP. Now here what is MN? This MN so, epsilon is equal to MN. MN can be divided to MP plus

NP divided by OP. What is MP? MP is equal to OP or we can write, forget about this MP clears MP is equal to OP. This angle is beta, this angle beta O. So cotangent beta and what is NP? Now NP is this much. What is this angle? This angle is beta minus gamma you can check it later on beta minus gamma.

So this is OP tangent of beta minus gamma. Now if you put it here, what we get? We get epsilon is equal to cotangent of beta plus tan beta minus gamma. Now mind that what is significance of this cutting strain? This should also be as low as possible. More cutting strain means more energy invested that is more power loss and heat will be generated all this problem should arrives. So this is another index of merchantability which should be as low as possible for good machining purpose.

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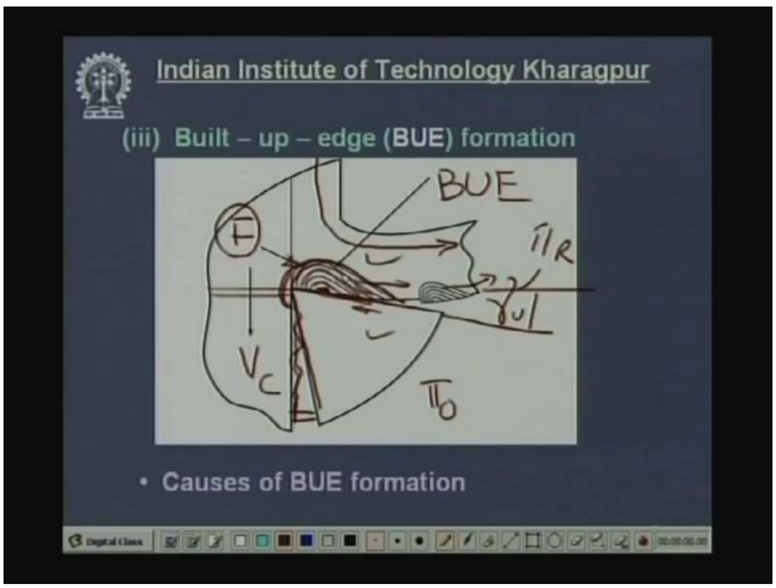

Then let us come to built - up - edge formation. This is the problem in machining particular ductile materials not all materials but some of the materials which are sticky or chemically you know sensitive. What is built - up - edge? Now here you see that, in this diagram what is this? This is cutting velocity. In which plane the diagram has been drawn? pi R sorry pi O. This is pi O orthogonal plane and this is reference plane. This is the velocity vector. This is pi R and this rake angle and this is clearance angle anyway. So the chip is coming and flowing in this direction. Now what about the chip tool interface? There lot of forces act and that cause stress and because of the rubbing of high states there will be lot of temperature.

So here lot of temperature and stress will develop beside that this surface of contact or rubbing or nascent very clean. So on one hand this two metallic surfaces are cleaned, nascent lot of stress exists and high temperature prevails. So all this three phenomena or factors favor what is called for adhesion, strong adhesion between the chip material and tool material or just like welding and this will start where the stress and temperature are maximum at this point. This is called embryo of the chip of the built - up – edge.

Now this embryo will gradually go on building are going and this is called built- up- edge but with the growth up built up edge a force will develop which will be acting in this direction and this built up which is held by adhesion, strong adhesion or friction and then this when this force exceeds the bond strength then this built up edge is separated out from the tool and it goes along with chip like this. So this built up edge that is repeated phenomena its starts then it grows then after sometime it get separated from the tool and it goes along with chip as so this repeated phenomena and sometime this can overflow on the if flange side of the tool and then there will be some mass left on the finish surface and that will spoil the finish surface for the causes of built up edge formation that is adhesion strong adhesion like welding because of two nascent surface are intimately existing and rubbing on the high stress and high temperature.

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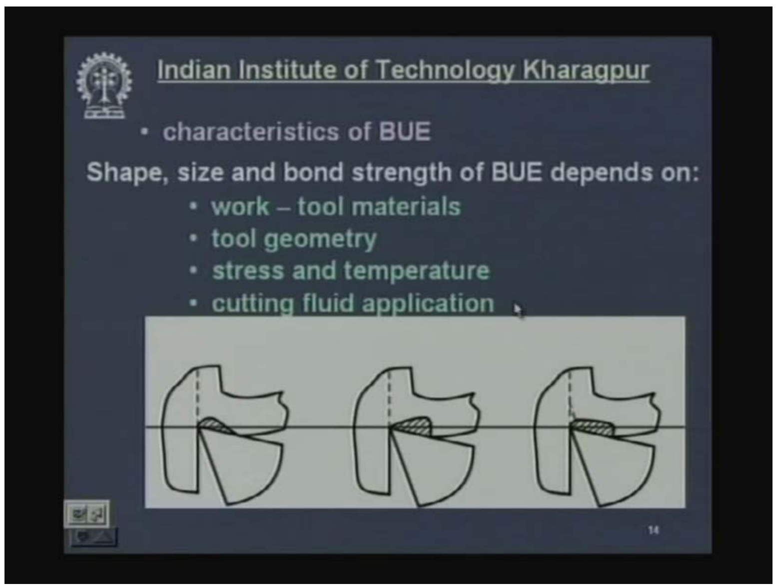

Now the characteristics of built up edge: So built up edge is desirable or undesirable, we have to study. Shape, size and bond strength of the built up edge depends upon the work tool materials. If the work material is brittle then such kind of phenomena will not take place, because this contact is not regular, very shorts contact. It is just should be continuous contact over long period and high temperature and pressure. That is work material should be ductile or continuous contact. Tool material, if the material very chemically inert then such kind of and no affinity for the chip material. So there will be no chemical bond, metallurgical bond. So there be no built up edge formation.

Tool geometry, if the tool geometry is unfavorable say minus or negative then there will be more built up edge formation. Stress and temperature: If the stress is very high because of high force, feed like that and hard materials are hardening when temperature is high because of high velocity and high feed then there will be more chances of built up edge formation. Cutting fluid application: Now cutting fluid does cooling and lubrication. Both cooling and lubrication retards or hampers or prevents formation of or you know obstructs formation of built up edge,that is about desired things.

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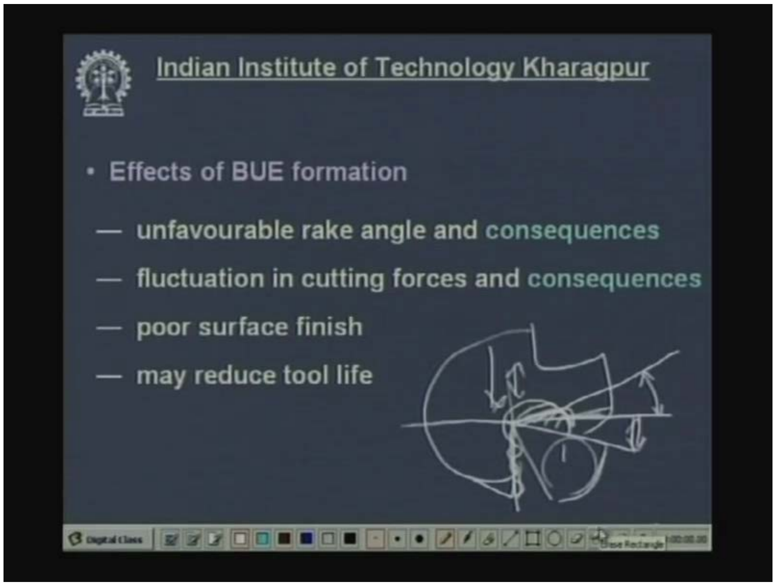

Now effects of built up edge formation: What the effects favorable or unfavorable? Mostly unfavorable. You see that effects of formation unfavorable rake angle and consequences of unfavorable rake angle. Now this is the cutting tool, the removing chip. What is the rake angle? Rake angle is positive which is always good. Favorable condition rake angle. Now when the built up edge forms then this becomes a part of the tool and the rake angle becomes negative. When it becomes negative, then the chip reduction coefficient increases the cutting force increases and then we have to face the consequences. That is in rake angle becomes negative the cutting force increases because of increase in cutting force more power is consume there will lot of vibration and the dimensional accuracy will be lost.

What are the other effects? Next effect is fluctuation in cutting forces, as I told you that built- up- edge that develops and goes out, again develops and goes out because of that the force that develops into the cutting tool and machine tool that keeps on fluctuating. So the fluctuation in force causes a vibration and quick damage of the cutting tool worsening of the surface finish of the job and damage of the health of the machine tool also. Poor surface finish because of the built up edge formation and over flowing it comes into the finished area and damage finish surface may reduce tool life. Yes how? If the cutting tool the built up edge forms then when it goes out this built - up - edge it removes a layer of cutting tool material along with this weldments or the built up edge weldments. So this and here because of the fluctuation there will be breaking of the edges.

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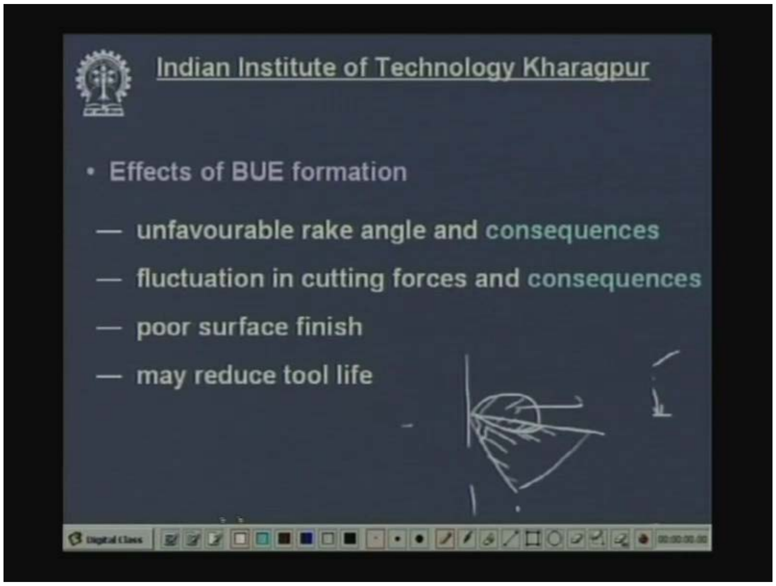

So the cutting tool will quickly lose material by damage and its life will decrease.

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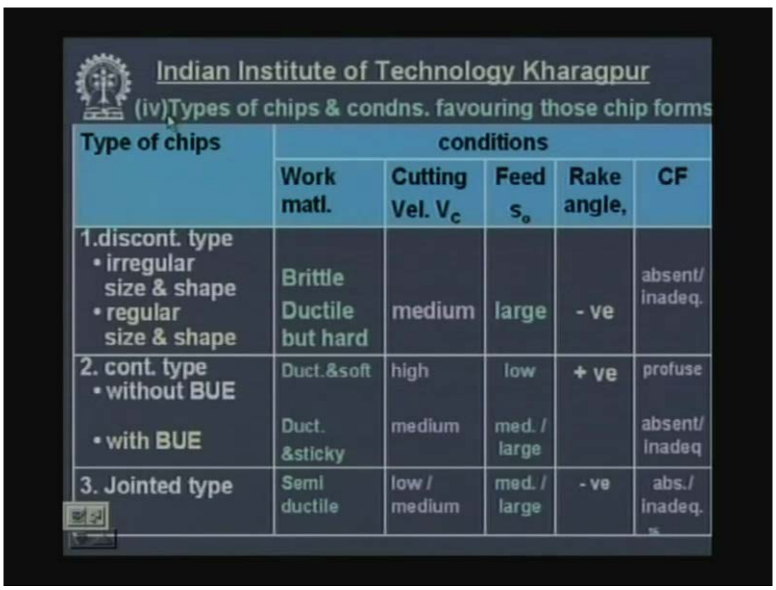

Type of chips	conditions				
	Work matl.	Cutting Vel. V_c	Feed s_o	Rake angle,	CF
1.discont. type • irregular size & shape • regular size & shape	Brittle Ductile but hard	medium	large	- ve	absent/ inadeq.
2. cont. type • without BUE	Duct.&soft	high	low	+ ve	profuse
• with BUE	Duct. &sticky	medium	med. / large		absent/ inadeq
3. Jointed type	Semi ductile	low / medium	med. / large	- ve	abs./ inadeq.

Now here you see the types of chips. There are different types of chips formed under different conditions. As I told the form and color of the chip, the good indication may be directly or indirectly indicate whether the machining there is going on is favorably going on or unfavorably going on? It is the acceptable condition or unacceptable condition.

So, one should have thorough knowledge about the machining chips. Now there are different types of chips. Expert people can predict or they can assess the condition of machining favorable or unfavorable good or bad just from the configuration, color and dimension of the chips. So a chip reduction coefficient and so on. Now let us see the major classification. There are many types but we shall consider only four basic types. Major types of chips and the conditions another which such kind of chips develop. What are those? Now this type of chip. Identify the correct one. Sorry here, the type of chip. types of chips and conditions favoring those chips form first one is discontinuous type.

Now here you see discontinuous type irregular size. There are two category of this continuous type. The chips are broken, but it can be the small, particular chips may be of same size or shape, irregular size of shape or regular size of shape when this will be discontinuous and irregular size of shape, little lumpy and may be little dusty of various size where the work material is brittle. When the work material is brittle say cast iron was bronze or ceramic then chips will be discontinuous and of irregular size and shape and here now this will be whenever the work material is brittle then the chip will be irregular discontinue the variable size and shape inspective of cutting velocity feed or rake angle or cutting fluid irrespective but we can also get discontinuous chip of regular size and shape.

They will continue uniform size and shape same repeatedly when the work material will be work material will be ductile but hard or hardenable. Cutting velocity medium neither very small low or nor very high feed large rake angle negative and cutting fluid either absent we are not applying or inadequate not sufficient. Now continuous type chip the now continuous type chip obviously develop so in the work material is ductile. Now there two categories without built up edge and with built up edge when is with built up edge the chips will very uniform continuous smooth sharp and that is very favorable condition when there is built up edge along with this continuous chip the chips will be continuous but it will not be very uniform.

There is some waviness or a surface will be rough and all these things will appear because of the existence of built up edge under the chip surface. Now when this continuous type chip, without built up edge develops for them ideal when the work material is ductile and soft like mild steel aluminum. Say brass cutting velocity normally high feed should be low or medium rake angle favorably positive and cutting fluid profuse cutting fluid applied with built up edge when built up edge will develop which is undesirable work material ductile and sticky all right lets a mild steel or low carbon steel or say copper and cutting velocity medium if the cutting velocity is very low then temperature becomes insufficient to cause built up edge

If the cutting velocity is very high then built up edge will worst out will be simply removed will not be ah able to develop and built up edge develop only when the cutting velocity is medium. The temperature correspondence to which is favorable for welding now feed medium or large rake angle irrespective and cutting fluid absent or inadequate. Now jointed chip is another chip it is neither continuous nor broken is in between jointed chip. So chips will be segmented and there will be kept joint but you little touch or pressure this will break in two pieces of irregular and size and shape I shall show you later on but this happens when the work material semi ductile or semi brittle and hard cutting velocity is low or medium feed is medium or large rake angle will be negative these are all on favorable condition and cutting fluid is absent or inadequate. Now I shall show you segmented chip cause a jointed chip and this is the regular chip why does it happen.

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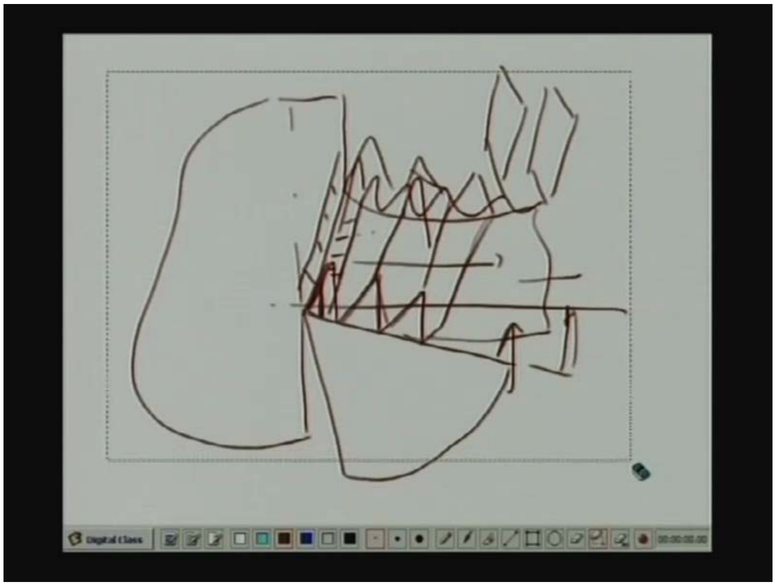

Just imagine this is the cutting tool and chips are flowing like this. Now the shear takes place, this is the one layer, this is another layer. So this layer has gone to that layer leaving a small crack inside or discontinuity and this becomes serrated as I told you earlier. Now then the work material is semi ductile and the rake angle is negative or there is unfavorable cutting fluid is not given and work material is hard then this crack goes to a bigger longer stand, it remains goes like this but these are not separated. The chips remain connected but it is white gear, so this is called jointed chips.

So this happens while machining titanium alloy by carbides such kind of gaps remain you know these are all segments connected in over a small area. Now if you apply little pressure or if the rake is negative further then this will break in to pieces this will come out as segments like this this will come out as segment but of uniforms size and shape. This is the reason who or the condition when we get this continuous chip of regular size and shape.

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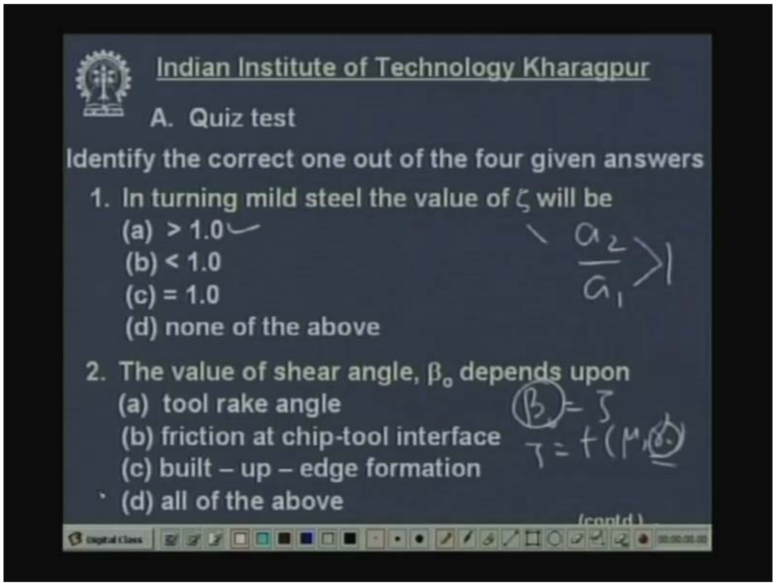

Now let us have some quiz test. Very simple some questions have been designed. Identify the correct one out of the four given answers. Suppose there is there is point that in turning mild steel the value of zeta the chip production coefficient will be this is four answers greater than one less than one equal to one a none of the above. Now which one is correct you should give tick mark to that zeta the you remember that zeta is a two by a one thickness of chip after cut thickness of chip before cut and this is greater than one because this chip for because of the compression the chips undergo compression which increase of the thickness.

So this will be greater then one so this is correct answers next one the value of shear angle beta O depends upon tool rake angle friction at chip tool interface built up edge formation all above the above. Now which one is correct let us examine tool rake angle does it effect beta now this beta is a function zeta you have see earlier and zeta is function of mu friction and rake angle. So beta will depend upon the tool rake angle so this is correct friction at chip tool interface this is also correct this is also correct and the when the built up edge forms the rake angle changes. So the effect of built up edge is also there and last is all of the above so this is the correct answer that all this previously are applicable.

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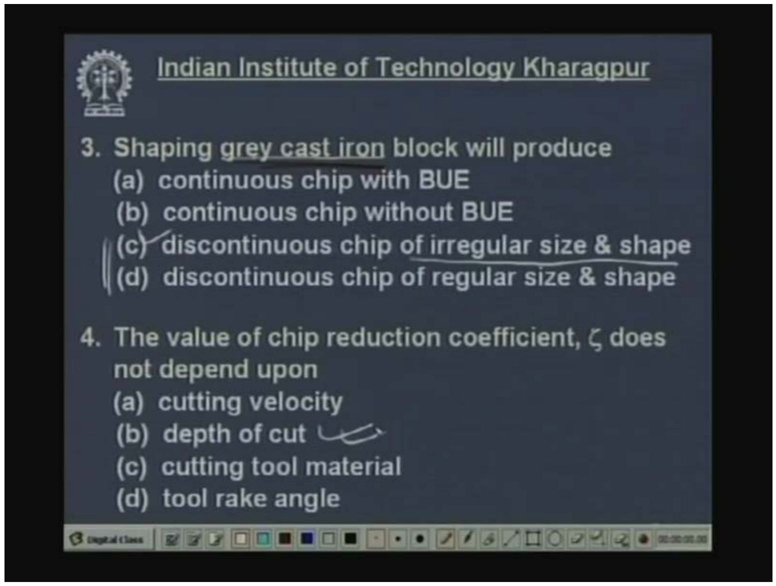

Value chip reduction coefficient zeta does not depend upon cutting velocity it depends depth of cut doubtful cutting tool material sure because if the cutting tool materials is very you know chemically ah weak next question shaping process in a shaping machine grey cast iron block will produce if you just a shape a cast iron machine a cast iron block in a shaping machine by any cutting tool say high speed steel or carbide will produce what kind of chip continuous chip with built up edge continuous chip without built up edge discontinuous chip of irregular size and shape discontinuous chip of regular size and shape first you decide that continuous or discontinuous chip this is grey cast iron this is grey cast iron grey cast iron so this is the brittle material all right so this will produce discontinuous chip discontinuous chip and since it she grey cast iron so irregulars chip will be of irregular size and shape so the c is correct answer number four the then there will be lot for metallurgical bonding with a chip ah there will be built up edge formation and zeta will increase and so on tool rake angle is the most important parameter that effect very much zeta so only one this depth of cut that does not effect. So this is the answer so all these answer are given in next page now let us solve question a

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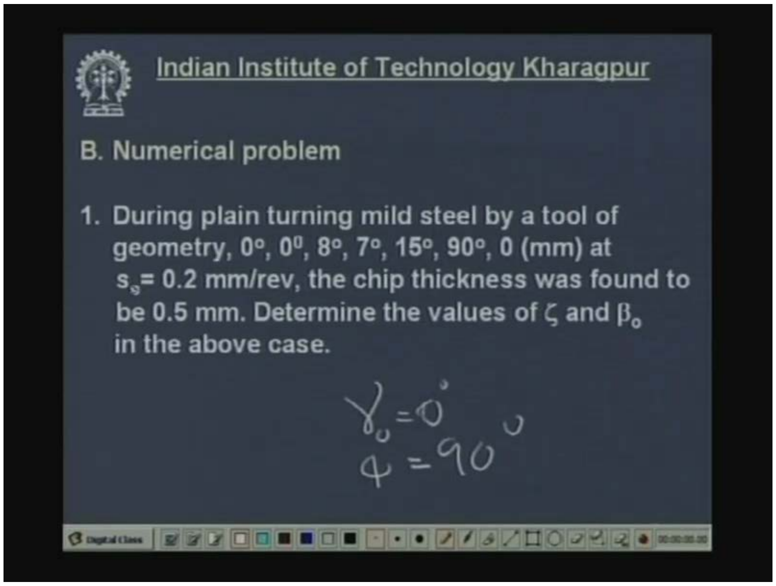

Numerical problem during plain turning mild steel rod suppose by a tool of geometry now look the at the geometry very carefully zero degree what is this the first one is if it is millimeter that means it is never by no means ace a system. This will be either ORS system orthogonal system or normal rake system because this nose radius given in millimeter. Now this first one stands for the first one stands for lambda if lambda is zero then there is no difference between normal system and orthogonal system.

So this can be orthogonal normal system said orthogonal the what is next one rake angle so orthogonal rake that is orthogonal rake that is zero degree then is a clearance angles this is cutting angle phi what is phi ninety degree so this to be get knows radius zero so machining is very simple at feed point to millimeter per revolution the chip thickness was found to be point five millimeter determine the value of zeta and beta in the above case okay let us try.

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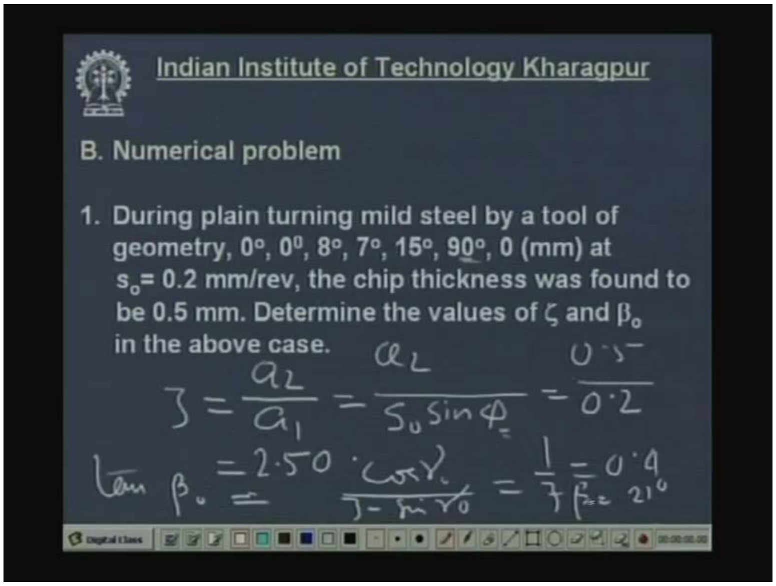

what is zeta zeta is equal to a two by a one a two is thickness of the chip what is a one a one equal to feed multiplied sin phi sin phi. Now what is phi? phi is ninety degree so this is one so a two by So what is a two given point five and So given point two. So this is two point five two point five zeta so greater than one then what is ah shear angle shear angle is equal to tan or tangent of shear angle is equal to cosine gamma zeta minus sin gamma. Now gamma is zero degree where is zero degree so this is one this is zero so this is equal to one by zeta so this is point four then what is beta tan inverse of point four. So beta is equal around twenty one degree so this is obtained now one thing I forget to mention you should remember that

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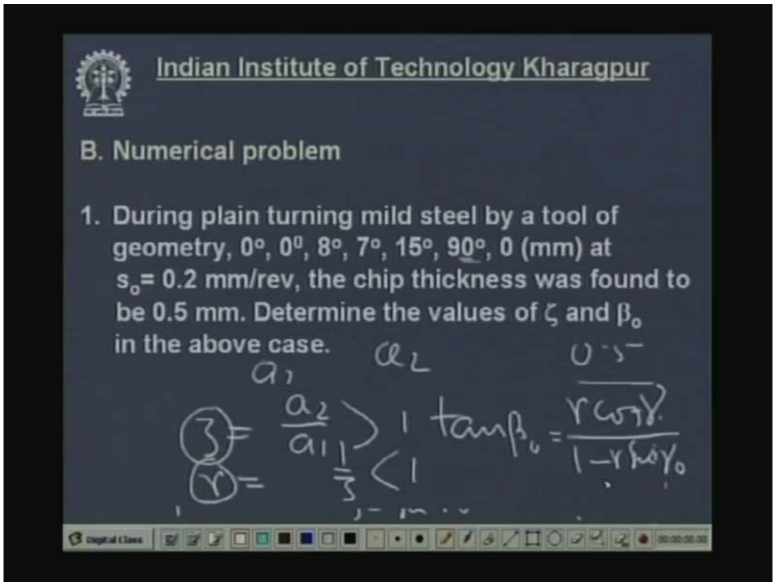

what is zeta zeta is chip reduction coefficient a two by a one which is always greater than one there is another term used say r r is called cutting ratio cutting this is nothing but one by zeta which is less than one. So both zeta and this cutting ration or utilized by the ah scientists for research and analyses and all these things. So and in that case that tan beta will be r cosine gamma divided by one minus r sin gamma. So this is about this mechanism of chip formation and the character of the chips built up edges and then classification of the chips and you can practice few more you know this ah will you will get lot of questions and get quiz questions in books and we can try solve it so
so this ends today.

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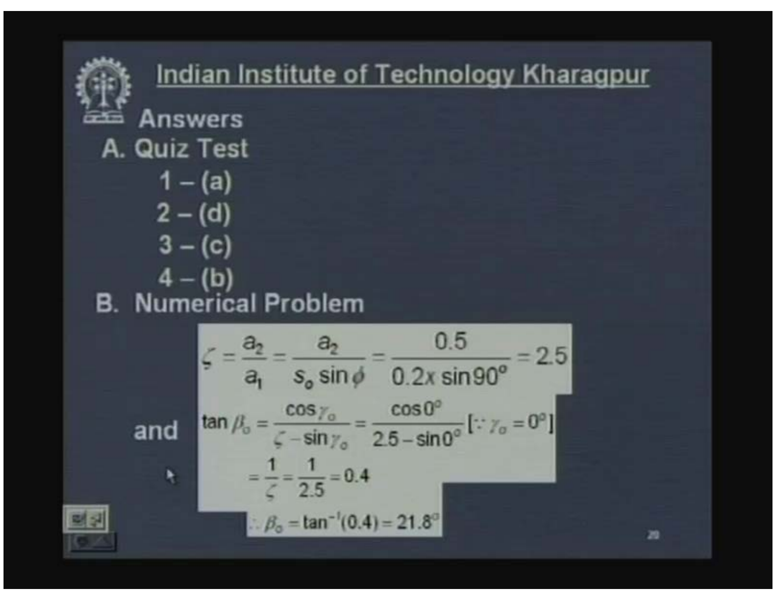

So this is the solution given here and thank you very much.