Manufacturing Processes II
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Lecture No. 7
Use of Chip Breaker in Machining

Good Morning. You are welcome again to the subject Manufacturing Processes II. We are continuing Module II Mechanics of Machining and the area we are covering presently is a mechanism of chip formation which is the part of mechanics of machining. Today is the lecture 7, Use of Chip Breaker in Machining. Chip breaker is a new feature. Now what are the specific instructional objectives of lecture today?

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To enable the students at the end of this lecture, identify the need and purpose of chip breaker; illustrate the various principles of chip breaking, design principle, design simple type of chip breakers, demonstrate configuration and working principle of some common chip breakers, state the overall effects of chip breaking. Before going to this one, let us have a look in to the chip breaking, the necessity of chip breaking.

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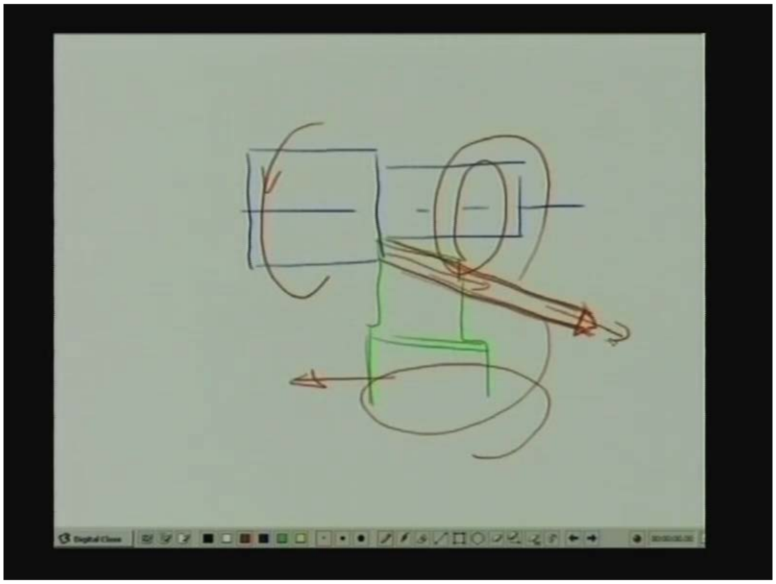

Suppose this is the job going to turn a rod being turned by a cutting tool, this is the cutting motion of a rotation and this is the feed motion of the tool. Now the chip that will be produced will come through this direction were the chip flows. If the work material is brittle, then the chips will be discontinuous type of irregular size and shape, small pieces will automatically fall into the container at the bottom. But if the work material is ductile and the cutting tool is having positive break of favorable rake then the chip will flow continuously if it is ductile material and this will straight trend to go flat just like a sod if we increase the cutting velocity this chip will come out of very high speed just like a and the edges will be very sharp just like sod.

It is more than a sod because it comes out at very high speed and secondly it is very hot of immediately after machining. Now this chip which is coming out at high speed continuously as a hot beam is a very dangerous to the operator as well as the people who will be working in other machine tools around. Secondly, this chip if not broken into pieces or this may entangle with the cutting tool it can be entangle with the job and spoil the quality of the job. So these are the problems which may come up if the chip is allowed to come at very high speed continuously just like a hot sod.

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Now let us come to the summarization. Major problems with continuous chip that generally develops in continuous type of machining ductile materials, danger to the operators that I explained already, damage of the finish surface if it is allowed to entangle with the difficulties in chip disposal, the collection of the chip and disposal of the chip becomes somewhat difficulty if the chips come out in the continuous form. Now the need and purpose of chip breaking: Now to control this problem, to overcome such problems some action has to be taken and this is called chip breaking.

Now what is the need to safety of the working people, protection of the finish surface, easy collection and disposal of chips? These are essential which is called need and purpose improvement in machinability. So if we apply proper chip breaker which will not only break the chips in a suitable form and provide safety, protection, etcetera. This will also help us give good machining or improved machinability.

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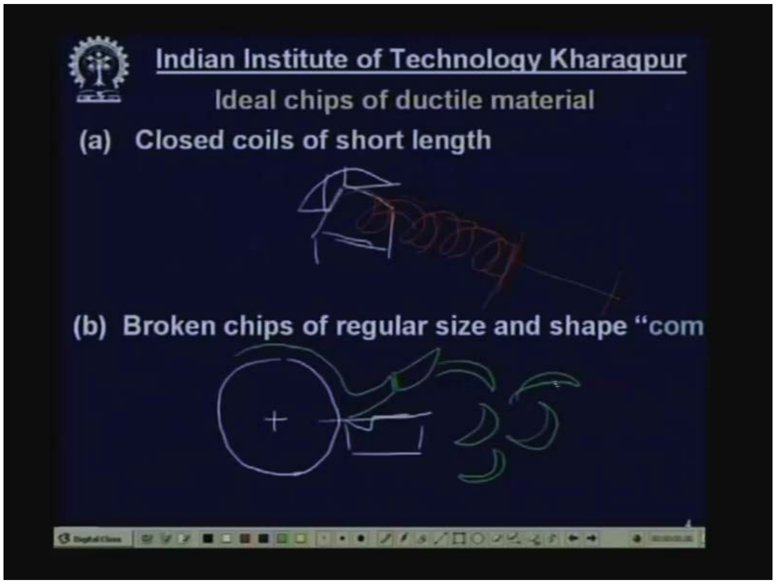

Now ideal chips of ductile material; the problem of chips comes from machining of ductile material, which produces continuous chip. In case of brittle material, this problem does not arise because the chips are discontinuous and they fall automatically into the collector. Now the closed coils are ideal, there are two types of ideal chips. One say, this is the tool and this is machining a job turning, now the chip will come in the form of a coil. Now this will continue, if it continues there is no problem like danger but the collection and disposal problem. So if it is made to break at regular distance in the form of small coils then it is very ideal. It is neither dangerous nor difficult to collect and dispose.

The other type - the convenient or ideal type of chip is the broken chips of regular size and shape, this is the ideals. Suppose your machine is a rod with the tool, now the chips will come out, and at regular interval it will break in the form of comma shaped or half turn. These are the various chips. If the chips that are allowed to cover may come into this half broken sorry broken into half turn or quarter turn chip in the comma shaped then this is very ideal which is neither dangerous. It automatically falls under gravity at the collector and it will not damage the tool not the job. So these are the two forms of ideal chips that have to be attained.

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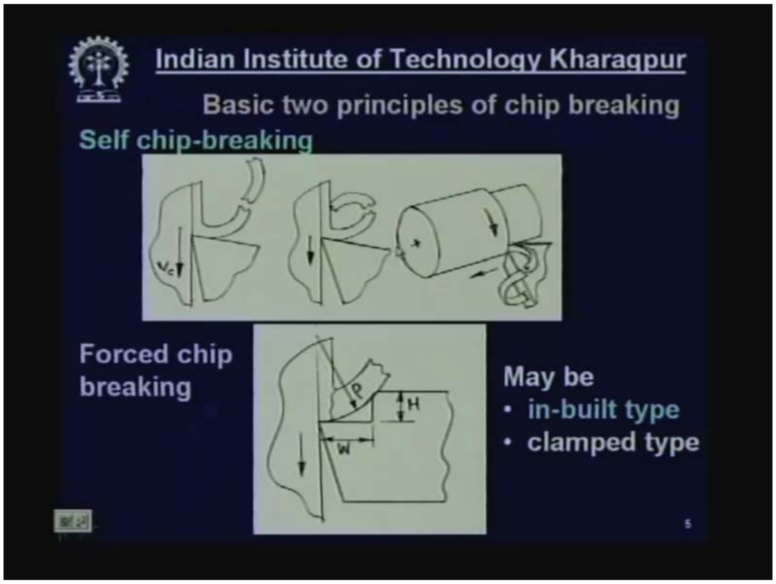

There are two basic principles of chip breaking. The continuous chip of machining ductile materials can break in two methods either Self chip - breaking or Forced chip breaking. Sometimes the chip breaks self automatically, then no need of any extra effort but some time if it does not automatically breaks, some forced chip breaking has to be adopted. Now Self chip - breaking can be natural or it can be slightly artificial like, the natural chip breaking takes place due to the curling of the chip.

You will always find that final machining ductile material is the continuous chip even it forms continuous, it becomes curve or tends to be come curve because the velocity at the outer end and inner end are different. At the rubbing surface the velocity is high and in the exposed surface the velocity is low beside that these two surfaces of the chip are subjected to different cooling rate or the cooling will be effective at the outer surface and the rate will be different. So this will become further curl and work hardened, then after sometime when it will be cooled, solid and elastic type and there will be spring back action in this direction. Spring back action will tend the break in the opposite side bent and this will break. So this is called natural breaking and this depends upon the work material, tool geometry, the thickness of the chip and rake surface and cutting velocity feed and all these things.

So this will not happen every time when these conditions will be favorable, then only this will break automatically is called self - breaking. Now again what happens? the chip curves due to curving hits the work surface. So the un-machined work surface then there will be further bending and the chip will break into pieces and again this will come and hit. It will break into pieces again this will come and hit and it will break. So this will continue, though the material is ductile the chip will be continuously broken into chips of same size and shape. There is another way that the chip which will come out here in the third one, this will come out and hit the flank surface of the tool because it is natural curling tendency and after curling this will hit at the flank of the tool and then this will break here because by this time, it will become work harden and brittle. So this will break and broken chips of same size and shape will continue, this is called self - breaking.

But, sometimes, this radius of curvature becomes so large that it does not break either self breaking or it tends to move very fast. In that case some obstruction has to be created to the flow of the chip. So this is the chip that is bent or curved. By the obstruction, just like a wheel by this subtraction, this chip will be forced to bend further or curled further and this has become already elastic after coming up from the hard zone. So this cantilever beam which has already been elastic will break here were distress is many stresses maximum and this will continue.

So this chip is forced to bend further curled more tightly under work harden condition. So this will break as a cantilever beam. This is called forced chip breaking. So a wheel is provided here to obstruct now this wheel of forced chip breaking can be attained in two ways: One may be in built type or clamped type. In build type means, this cutting tool is a single piece and a grove is cut into that so this is the part of the whole and this form of this group allows breaking and in a clamped type, this upper part is made as a separate piece, the cutting tool is flat and the upper part which will function as a obstruction or heel will be a separate piece of the clamped with the base tool. This is called clamped type.

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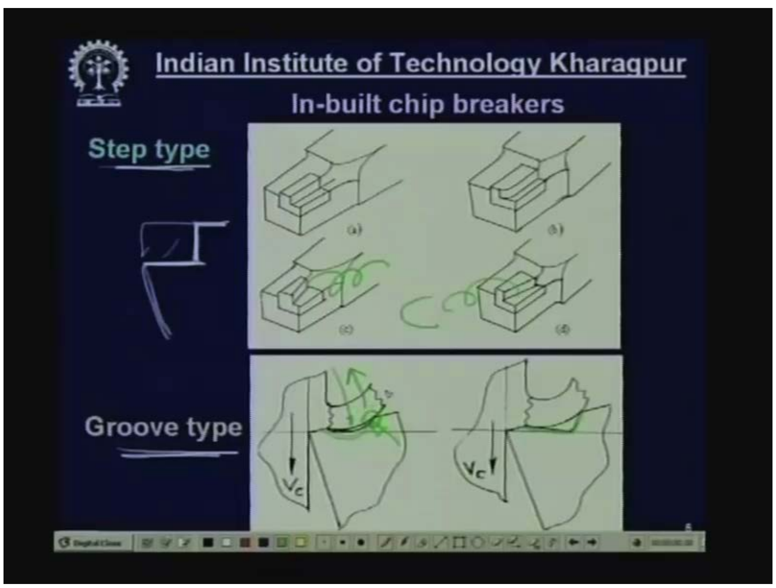

In - built chip breakers may be step type or it can be groove type. Now this is the cutting tool holder. For example, the cutting tool holder and this is the tool bit. A groove is cut, this piece of the carbide T powers steel may be brazed or fixed by brazing on this tool shank and then a groove is cut like these different types. So this is called step type. So, one step is made, so there will be a flat surface horizontal and vertical surface. So this will be like this. So this is the horizontal step and this is the wheel height. So this is called step. This material is removed by process.

Now step type may be of four categories. This is called parallel shape which is most simple and easy to manufacture and used to very commonly and this is straight but it is slightly curved radius at the end. This is very suitable for heavy duty cut at high speed feed depth etcetera and these two are the angular steps where the step is angular make either angular or widen in this direction. This is called positive angle and this is called negative angle. Here the chip will be curled or broken if it is curled, then it will be shifted from the work piece to the operator because work piece has to be protected from damage and sometimes the protection is required for the operator and the chip will be shifted towards the jobber away from the operator. The curling will take place like this this. In case the chip will flow like this and in this case the chip will flow like this.

Now groove type chip breaker. Here on the rake surface of the tool, a groove is cut and this is sufficiently deep and now this groove here is another groove. The two types of grooves are there. One is circular groove and one is tilted v type. Here you see that the radius of curvature of the groove should be smaller than the radius of curvature of the chip at which it is supposed to break. Now when the chip will come, this will hit here as an obstruction a force will act on this. So this will bend in this direction and because of the cantilever action lot of stress will develop here and this will break into piece and this will continue. In this case also, there is a gap so this is there and when the chip will come in absence of the wheel this goes straight like this but because of the presence of the wheel this will force the chip in this direction and bent and the cantilever beam and it will break here and this will continue. Now, let us come to the characteristics of in - built chip breakers.

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Just now you have seen in - built chip breakers. Now provided this in - built chip breakers are groove type or step or groove type provided as an additional geometrical feature like step or groove after or during manufacturing of the tool. If the cutting tools are made of high speed steel, then normally these grooves or steps are cut after manufacture of the cutting tool but if these are made of exotic materials like carbides or ceramic which are very difficult process, then these grooves or steps are manufactured during the manufacturing process like compaction and sintering process has to be done.

Next is the wheel of the step or groove causes the chip breaking by further bending and straining. So this an obstruction which further bends and strains the chip which breaks into pieces. This in - built chip breakers are very simple in configuration with slight modification, easy to manufacture and inexpensive, cost is low, but the geometry of the chip breaker once weight becomes fixed. That is the length of the groove, depth of the groove that remains same. So that will be suitable for a particular radius of curvature of the chip. If the radius of curvature of the chip changes, then this groove which has been formed already may not be effective and this radius of the critical radius of curvature at which the chip breaks depends upon the work material, the tool material, the cutting velocity, feed. So this fixed type chip breaker will be suitable for a particular material and a particular condition hence it is said that this groove type for a in built chip breakers are effective only for limited range of velocity and feed for a given work material. Now let us come to the force chip breaking by clamped type chip breakers.

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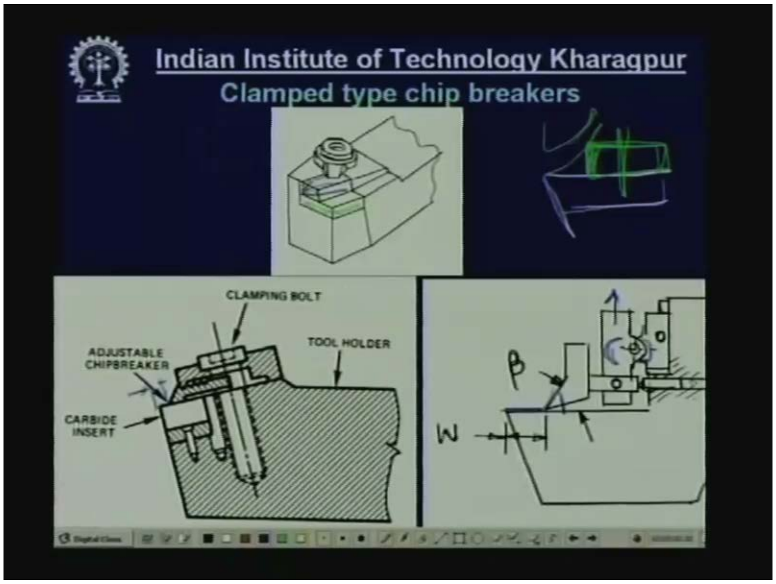

There are three types of clamped type chip breakers. As I told you that in clamped type chip breakers, this is the cutting tool flat like, and then a separate piece is fixed and clamped here. So when the chip will flow, the chip will be obstructed the flow chip will obstructed by the heel of the clamped chip. Now here you see that, this is the cutting tool. This is the cutting tool and the upper one is the chip for chip breaker.

So they form a groove like. So when the chip will come, it will hit here and break but this is fixed once make this is fixed there is no flexibility. So this is suitable for a limited range of cutting process now. This is likely versatile where the width of the length the width of the length. This portion can be varied depending upon the cutting velocity. So this clamped achieve that can be shifted along the rake surface by loosening the screw and the clamp and this gap this flat surface on which a chip will flow can be varied and depending upon the radius of curvature but here the slightly flexible only the width can be varied but here is another more versatile where not only the width can be varied by shifting the position of this one but it could be angle, this angle can also be varied by raising this upward and tilting around this axis. So this is more versatile which covers the wide range of material where a cutting velocity feed depth of cut and so on.

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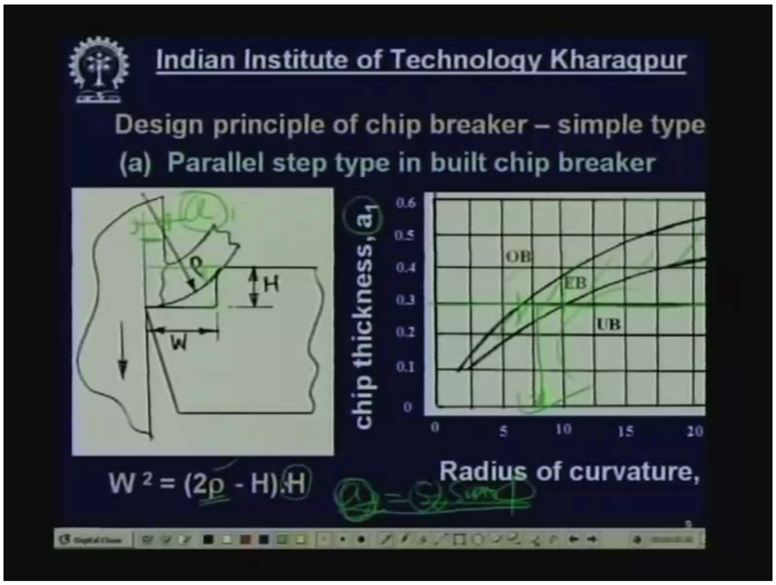

Now the design principle of simple chip breaker: W and otherwise the height of heel. So these two parameters has to be chosen so that, this chip undergoes the requisite amount of bending. So the radius of curvature decreases and lot of stress develops here and it breaks in to pieces. Now lot of research has already been done in this area what has been done that the critical radius of curvature at which a particular chip breaks depends mainly upon the chip design principle of chip breaker but simple or clamped type what might be but it should simple type may be step type.

Suppose is a step type chip breaker this can be in - built type or it can be a clamped type. Whatever might be, these are the two important geometrical features. One is width of the length, thickness of the uncut layer this thickness. This is the critical radius of curvature at which the chip will break will depend upon this uncut chip thickness called a1. The research data had been put here. This indicates, this is the one and the chip thickness a1 and this is the critical radius of curvature. So this is the region where the chip will break effectively and this is the area where there will be over broken, over strain, more energy will be wasted and this will be under broken area where the chips will not break properly. So this has to be done.

Now how the design has to be accomplished? We are conducting a machining work; we know the value of a1. What is a1? a1 is equal to the feed multiplied by sin of the cutting edge angle phi so sin phi. So these parameters are known. So from this a1, particular value of a1 like this. This is the region were the radius is brought to this level then, this chip will break. Now suppose we choose a particular radius of curvature for that particular a1 given. Now putting the value of rho here into this equation, because from this geometry you can see this is the radius of curvature of a circle this is the called W and this is the height and this is the expression W square will be two rho the diameter of this one minus H the wheel and H.

Now from the given value of a1 and so and phi, a1 has to be determined, from a1 the rho will be determined. If putting rho and assume any particular value of H say 2 millimeter or 1 millimeter, we get the corresponding value of W and this is how this type of simple step - type chip breakers are designed. Now if it is clamped type and with an angular clamped were the chip is now flowing like this is a clamped type chip design of simple clamp type chip breaker with an angle.

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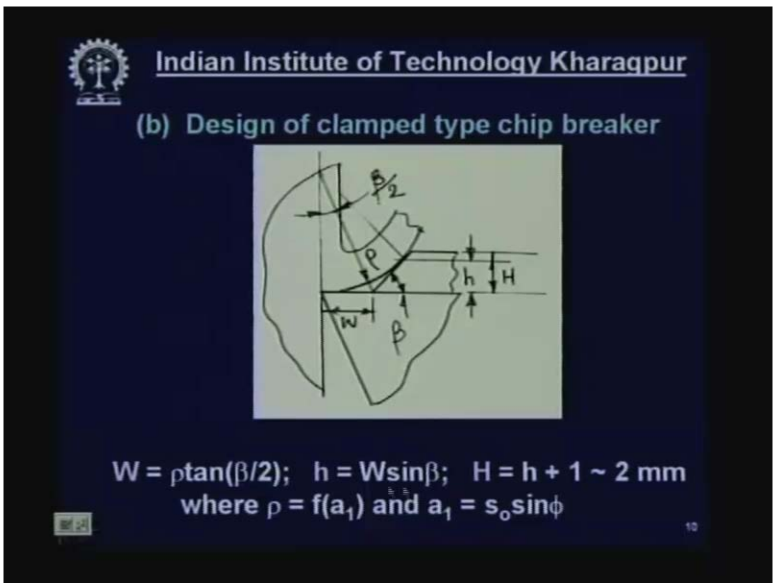

This is width W and this is the angle of the breaker and this is the radius of critical radius of curvature at which the chip is suppose to break and this angle is beta, then what we do from this geometry? From this geometry we get W. This W is equal to rho tangent of beta by two.

This is beta by two and what is h? Here this is equal to W. This is W sin beta. If this is W, this is also W and this height is equal to W sin beta and capital H, the total height will be small h plus 1 to 2 millimeter the total height of the clip or the clamp. Now where rho has to be this rho critical value has to be obtained from that is the function of the uncut chip thickness which s_o sin phi. These two values are known from a1 is evaluated, from this a1 from the previous chart this critical radius of curvature will be determined and that will be put into this equation and beta will be assumed may be 45 degrees, 60 degrees like that or up to 945 to 90 degree. Then we get the value of W. This is how chip breakers of this kind are designed, this relation of a1 and this rho a1 the uncut chip thickness and the critical radius of curvature of the chip at which it is expected to break should be taken from the chart.

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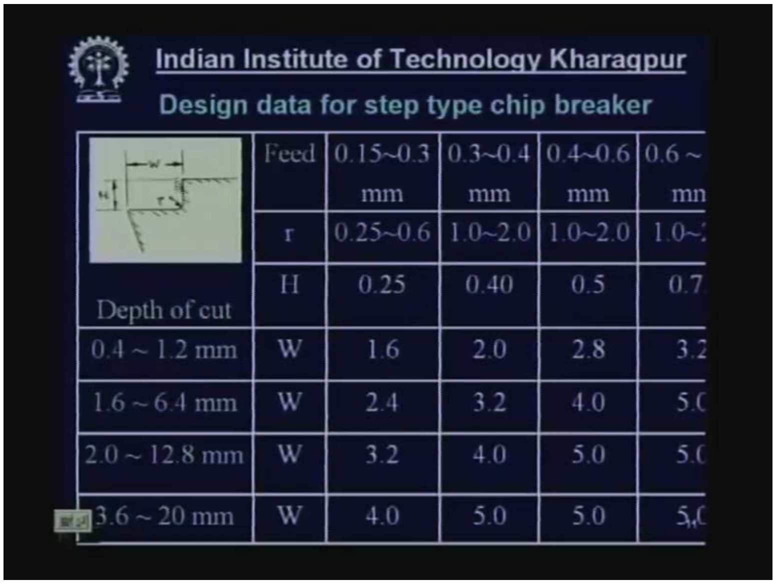

Depth of cut	Feed	0.15~0.3 mm	0.3~0.4 mm	0.4~0.6 mm	0.6 ~ mn
	r	0.25~0.6	1.0~2.0	1.0~2.0	1.0~
	H	0.25	0.40	0.5	0.7
0.4 ~ 1.2 mm	W	1.6	2.0	2.8	3.2
1.6 ~ 6.4 mm	W	2.4	3.2	4.0	5.
2.0 ~ 12.8 mm	W	3.2	4.0	5.0	5.
3.6 ~ 20 mm	W	4.0	5.0	5.0	5,

Here is the result of lot of research that has been already done for design of the chip breaker. This chart shows design data for step type chip breaker. These are step type chip breaker and this is the step width W and this is the height H. So these are the main parameters. Again at this corner, you see there is a radius, a curvature of radius small r. Now see the table feed as I told you that the critical radius of curvature for any work material depends upon the cutting velocity, feed, depth of cut, etcetera. So the value of H and W will depend upon what feed you are carrying out the work at what depth of cut?

Suppose these are the different feed range. 0.15 to 0.3 millimeter per revolution, 0.3 to 0.4, 0.4 to 0.6 and so on and depending upon the feed, the radius r should also vary. It should increase proportionally with the increase in feed. So 0.25 to 0.6 and so on. Height may be varying. You can assume it. 0.25 millimeter, 0.4 millimeter, 0.5 millimeter and 0.75. These are depth of cuts. Suppose for a given value of feed, say at this feed range we are working and this is the corresponding radius of curvature and this is the height already assumed for light speed and then what will be the value of W? If the depth of cut is 0.4 to 1.2 millimeter that is low duty cut, then W should be 1.6. If the depth of cut is increased, then this should be slightly increased gradually and as the feed is increasing you see the value of H the height is also increasing and W is also increasing because with increasing in feed of the feed a1 the radius of curvature at which it will break will increase for which values of H and W should increase. As you increase in feed you see H is increasing, W is also increasing. So this is a table which can be utilized very simply by the people to prepare either the step type or in built type or say clamped type chip breaker.

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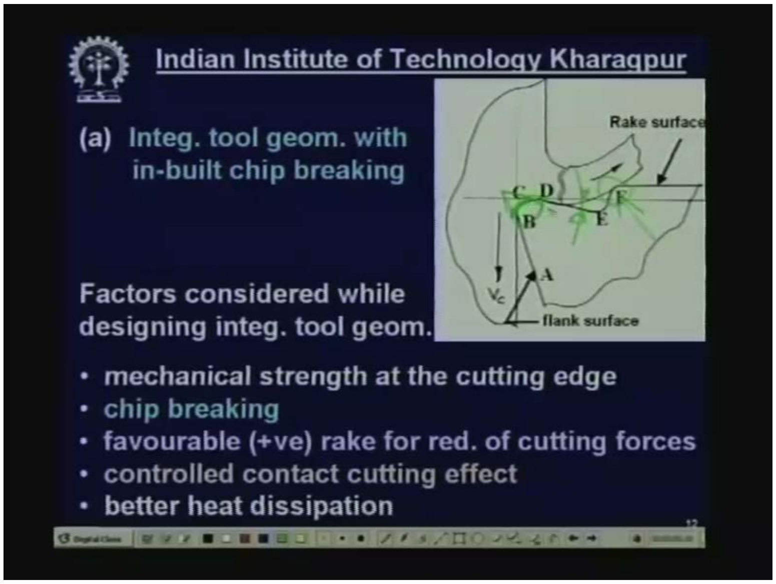

Now integrated tool geometry with in - built chip breaker: Now in - built chip breaker as I told you can be step type or group type and those are created on the rake surface of the tool during manufacturing or after manufacturing by grinding or by powder metallurgical process during compaction and so on. So this is basically in this case, suppose this is a rake surface of that tool we make it groove. A tilted v groove is created for breaking the chip. This is the heel portion F is the heel portion that exerts a force and the chip is forced to bend further and because of the stress it will break.

While making this chip break, other factors are also taken in to account to deduct the benefit of such that means factors considered while designing integrated tool geometry. why it is called integrated tool geometry. The chip breaking in in - built chip break up plus some other features which will provide further benefit. What are those factors? These factors are mechanical strength at the cutting edge the cutting edge if left very sharp, and then it will become mechanically weak. So it has to be rounded. Here you see, from B to C it is cut. It is called edge rounding and this is done for strengthening mechanically the cutting edge. Sometimes it is beveled also, then from C to D this portion is flat portion and that is the negative break and that is also from mechanical strength then the chip breaking. This is the chip breaking part DEF for chip breaking and favorable rake for reduction of cutting force.

Here in this slope, this is the rake angle, this rake angle should be possibly positive so that cutting for the chip flows easily can be and then the cutting force will be reduced and power saving were there. So this should be positive, negative for strength followed by positive for reduction of cutting forces. Controlled contact cutting effect means, this chip tool contact length means it causes rubbing. This should be reduced and if you can reduce it by modifying the tool geometry is called controlled contact cutting effect. That has to be automatically achieved, further better heat dissipation. If you make this instead of very sharp edge some flat and then curve, so this is the flat type of the cutter the heat will be very quickly dissipated and the temperature will not be concentrated. So there will be no stress concentration, no thermal concentration, heat concentration. So these are the advantages.

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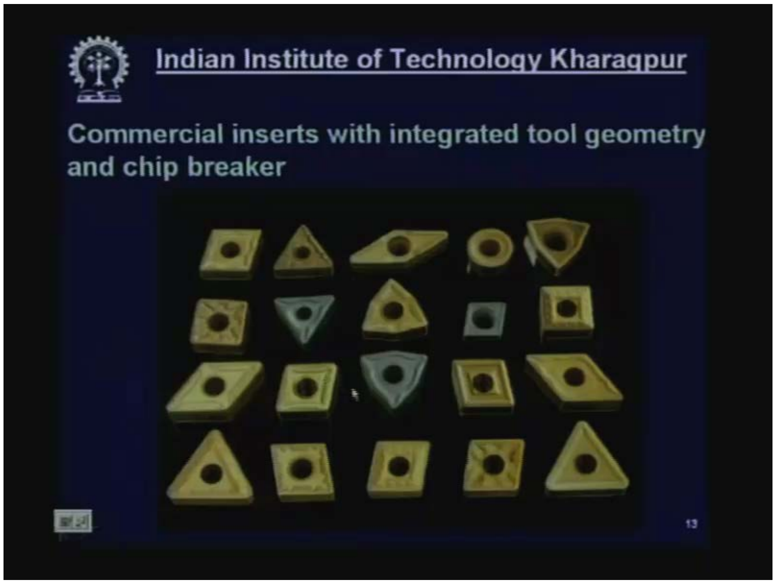

Here you can see some of the standard chips standard inserts. These are carbide inserts. The colors are coated insert titanium nitrate or titanium carbo nitrite coated insert is a turning insert. This copying lathe copy turning is a triangular, is a rhombus type and this is also rhombus type triangular. There will be from various shapes for various purposes. The big survey are basically tungsten carbide, cobalt carbides and now what we have to see commercial inserts with integrated tool geometry. As I told you the integrated tool geometry so the rake surface the tool geometry is provided not only for chip breaking, but also for mechanical strength, then control contact cutting effect, reduction of cutting force all these factors taken in to account. Now as a result, you see the profile of the rakes has become quite complex, very complex some of them is pattern like.

Now earlier days, it was very difficult because providing such typical geometry or configuration or a pattern like it was very difficult particularly when the work tool material was ceramic or carbide brittle material. But nowadays, it has become easy because of the advent of number one is the sintering process - improvement in the sintering process. In a compaction process, the tool by which the compacting is done before sintering those are given this typical shape by electro discharge machine, electro chemical machine which was not available earlier. But nowadays these are available and the design part can be very comfortably and quickly done nowadays with the help of computer that is computer aided design. So the advent of computer aided design and this process like EDM and ECM and easy compaction and sintering. Such kind of very difficult patterns with to give the integrated chip tool geometry has been possible and now these are very popular and are widely used.

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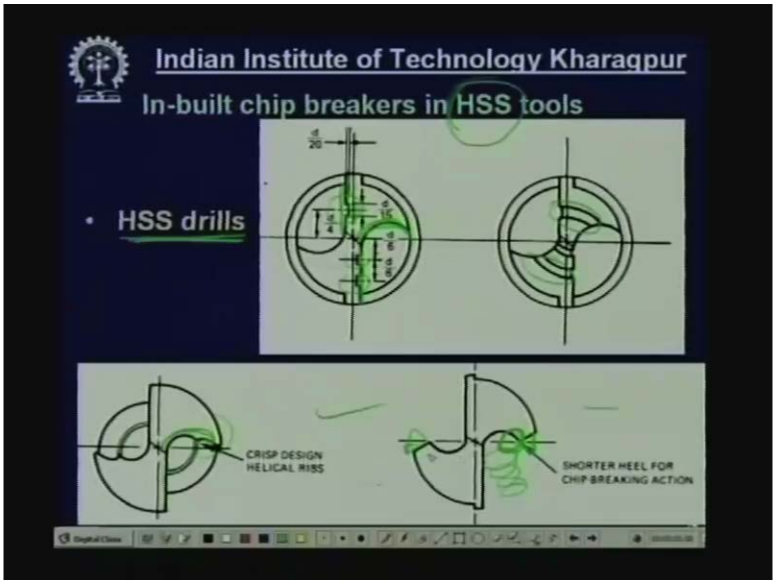

Now this chip breaking is not only used or confined to carbide tools or ceramic tools. Those are adapted in high speed steel. Here you can see high speed steel tools. Now high speed steel is very primitive tool material which was invented at the beginning of 20th century. But this primitive tool is still getting used for because high speed steel though are not comparable compared to carbide or ceramic in respect of hardness or wire resistance or chemical stability but they have got certain unique properties such as the transverse of the strength which is very important property for cutting tool, transverse strength, then the fracture toughness which is easy to form that is formability then grind ability and low cost because of this unique properties of high speed steel, this is a steel used in industry along with the other modern cutting tools but not everywhere these are used for some cutting tools which have got very difficult geometry or configuration like drills, milling cutters, hobs, gear shaping cutters form tools taps and dies and so on.

Now let us come to drill. This is a high speed steel drill. Now this is the axial view of the high speed steel drill. These are the cut. This is the one main cutting edge and this is another main cutting edge and this speed varies along the cutting edge. What is done along the cutting edges some grooves are cut. Here the grooves are cut on the main cutting edge. These grooves can be cut along the rake surface or along the frank surface. Both are possible.

Now one thing you see that this chip breaker and these two chip break should be offset because the material will not be removed by this cutting edge here. That will be removed by this portion. So the chip the grooves cut on the cutting edges should be offset so that the entire material gets removed and this is the chip breaking in high speed steel drills either cut on the rake surface or on the flank surface. Now these are little complicated. This can be simplified by another two designs. These two what is this. In this case, this is round it is easy to manufacture; it is done by milling cutter. Instead of cutting as a round so simple you make a ridge. What is the function of this ridge here when the chip will be formed by this cutting edge, this ridge will force the chip to curl tighter?

More close curling as a result the disposer of the chip will be easy that will not jump into space or it will not damage the internal drilled surface. So this basically not does not break the chip, will force the chip to curl closely and the chip will come out more easily without any disturbance and obstruction. This is further simplified by the earlier normally this is shaft like this. By removing this portion by milling one heel is created here. So this will force the chip to curl closely and that will make the length the chip disposal and collection convenient.

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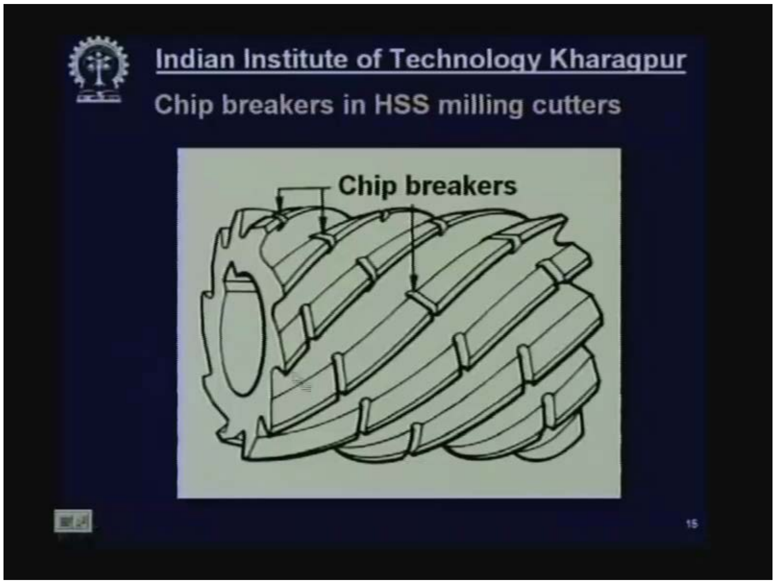

Now this is applied to milling cutter, in milling cutters, slab milling cutter and also in case of broaching cutters. Now here you see the milling cutters and this is a helical milling cutter these are the cutting edges, the fluids or the cutting edges. On the fluids the grooves are cut small grooves are cuts. Actually what happens in milling?

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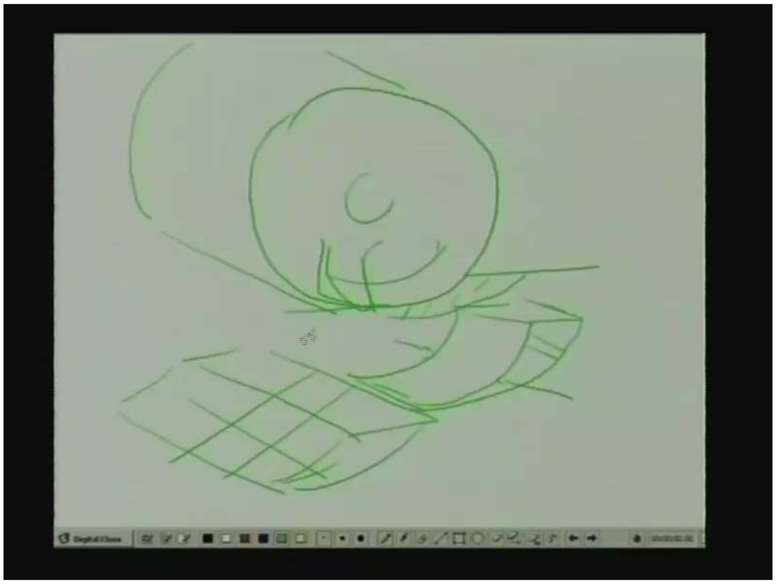

Suppose this is a milling cutter cutting tool and this is the work piece. So this will move in this direction, rotate in this direction. So this chip will be formed. What is the shape of the chip? This is just like a comma with thick, this is a width. This is the width and this is the thickness but in milling process the chip is automatically it is inherently broken into pieces. So as such there is no problem, but the problem arises when the width of the jobber width of the cutter is very large, then this width of the chip becomes short in length but becomes very wide like this.

So removal of this kind of chip again makes some problem. Disposal collection of such kind of chips becomes problem. This needs to a broken laterally like this. Here you see that the grooves are cut, this is called chip breaking grooves are cut and what offset this distance and this distance so this will be in the chip grooves will not be cut in the same distance from each of this will be offset. So that the material will be removed through out the work surface and this kind of chip breakers or the grooves can be cut in nowadays this kind of helical or solid helical or straight cutters are made of carbide. In case of carbide this can be grooved by special grinding or slight additional grinding. In broaching also this can be done.

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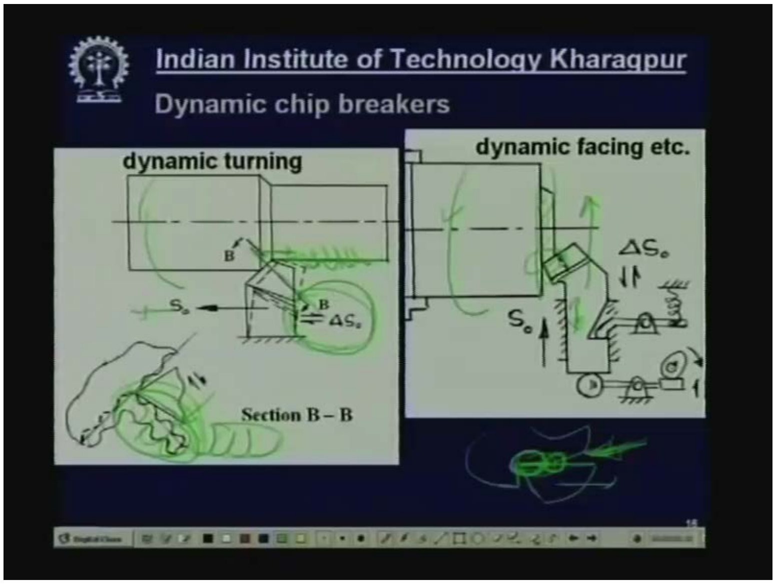

Now let us discuss something about dynamic chip breakers. What is dynamic chip breaker? It is very interesting. There is a process called dynamic turning. It is a special technique really. What is the special technique? Suppose this is the cutting tool is the tuning simple strict turning process and the chip this is the federation and this is the cutting direction. Now this is the cutting velocity and this is the feed direction.

So chip will flow straight and these are steady cutting condition. The contact between the chip and the rake surface will remain constant that means this is the rake surface and the chip flows and is a contact area. This contact area is bulk contact or solid contact as a result, the cutting fluid that you apply will not enter to this region this is a bulk contact. So this cutting fluid that we are applying is not very effective which can enter on a little extent where the elastic contour but in the plastic contact region it does not enter as a result the cutting fluid that you apply is not very effective.

Now in this process in the dynamic process, the cutting tool is oscillated or vibrates in the direction of feed in this direction with the small magnitude and medium frequency along with the continuous feed in this direction. So this feed and this oscillation feed will move continuously. What are the effects? The purpose of such dynamic machining is a multifold. 1. Because of this oscillation is cutting tool oscillate this contact will break and joint. So the cutting fluid will be pulled inside this contact line so this is effective. This cutting fluid lack will more effectively that means cooling and lubrication will be more effective. As a result the force will come down, the tool life will improve, and wear will come down and so on. Beside that because of this oscillatory motion of the cutting tool additional the feed mark that is produced on the job due to turning that will be removed. So the surface will be very smooth because of removal of the skid by this oscillatory motion of the cutting tool but what about chip breaking?

Here this is the cutting tool. If you take a section along the orthogonal plane, this is the chip flowing, so this is oscillating. So this is the path, the previous path was like this which was oscillating and now it is going to cut in this direction not a straight path because it is oscillating. Now these two waves the wave already cut and the groove going to be cut. These two waves may be aligned or may be offset by 90 degree or any degree.

Now if it is offset by that one, these chips come out in the form of bids and there neck is very weak. If that is slightest obstruction from this side then this will break in to pieces just like small bids it will come out. So this kind of dynamic turning will not only help improving the surface finish and make the cutting fluid action more effective, but also enable chip breaking automatically. Now this is another kind of dynamic machining called dynamic facing. So this is an example. Here a layer of material is going to be removed by the facing operation, the tool is moving in this direction were the cross feed job is rotating as usual and the material is going to be removed and the chip is coming out continuously.

If the chip comes out continuously there will be continuous contact and there will be no effective cutting fluid action and surface will also be rough. Now if the cutting tool is given an additional vibration in this direction, the direction of feed then the surface will be smooth the cutting fluid will be more effective in cooling and lubrication and at the same time the chip will take this particular shape and that will break in to pieces. Only thing is that this frequency and amplitude of this one has to be carefully chosen with respect to the feed or cutting velocity then only chip breaking will be more effectively obtained.

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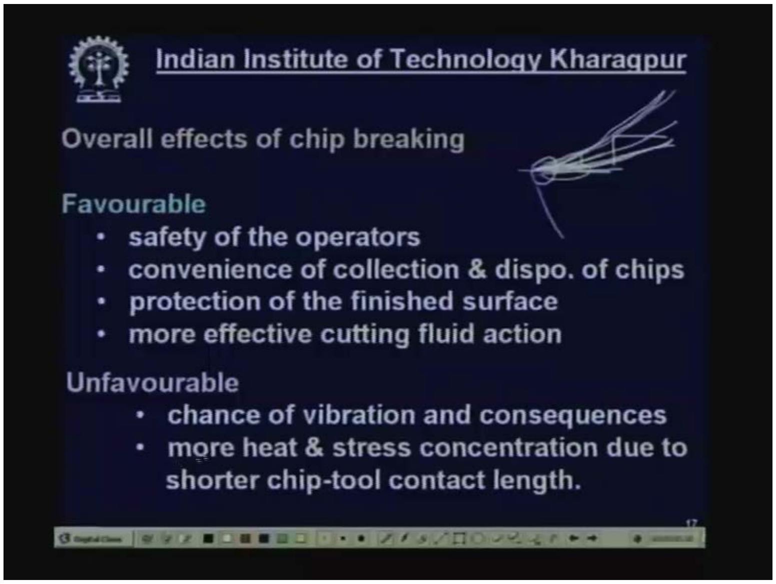

What are the overall effects of chip breaking? Let us summarize. Now there are two types of effects: Favorable effect and Unfavorable effects.

What are the favorable effects? safety of the operators; As you said, if it is not broken in to pieces, it is allowed to move very fast as a sod hot sod as I told is an analogy then it will be very dangerous to the operator and I remember while doing PhD in my earlier days, one of my colleagues was conducting one experiment on machinability of ductile material steel at high speed. Chip was coming out so for research purpose he used flat type negative break flat type cutting tool without any chip breaker and a cutting speed was increased this chip was coming out very fast and it was creating problem.

So he tried to catch hold of this chip and break it or hold it or pull it but it was so sharp, high speed and hot when he got it by a solid and strong leather gloves you know he had deep cut beyond the glove which also got cut and he found profuse bleeding. How is this happen? It can go to that extend. So this chip needs to be broken immediately after coming from the cutting zone. So safety of the operators that is achieved by chip breaking that is the most important favorable effect.

Convenience of collection and disposal of chips; The chip will be automatically broken and fall into the container or a screw conveyer and that can be easily disposed out. If it is allowed to come out continuously and tangle toward the workshop then it will create problem. Protection of the finished surface - if the chips are broken there will not strike on the finished surface nor on the tool suppose the tool and the finished surface are really protected more effective cutting fluid action. Now as I told you that because of this pulling, pushing the chip upward by the heel the contact length between the chip and the tool decreases and through this small contact line the cutting fluid comes closure to the cutting edge or the chip to interface and then cooling and lubricating effect becomes more effective.

As you see that this is the cutting tool and a chip tends to flow like this. Now if you have an obstruction the chip will flow like this. So there will be more space if it goes like this chip then this is a bulk contact but if the chip goes like this you get small contact and the cutting fluid will come into this region and the more effective. So more effective fluid action that is lubrication pulling and so on. As a result the tool life will be higher the cutting power consumption will be reduced or etcetera but what are the unfavorable effects? Since the chip is growing and breaking coming and then breaking so there will be fluctuation in the cutting force, as a result some vibration will take place chance of vibration and the consequences like damage of the tool, fatigue failure of the tool or damage of the machine tool and all these problems may creep in. More heat and stress concentration due to shorter chip tool contact. Again I tell you that, if the chip is obstructed by a heel, then this contact length will be very small because of this obstruction.

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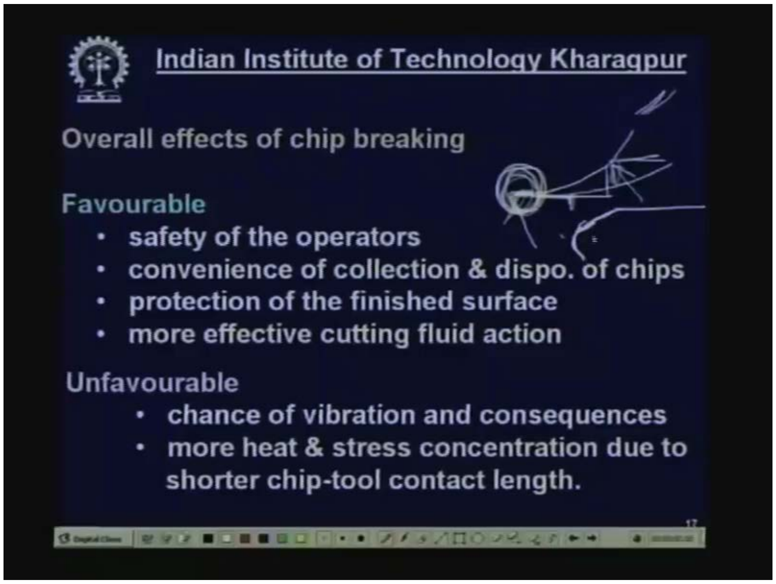

Otherwise it could go like this and contact length would have been wider. If it is wider then the stress the force will be distributed over wider range but if this heel is applied obstruction for chip breaking then the contact length will reduce. So the heat and stress will be confined in a small region near the cutting tip and the lot of stress concentration and heat concentration. As a result, there will be chance of breakage or chipping or plastic deformation. Hence it is said for more heat and stress concentration due to shorter chip tool contact length that is why this sharp corner should be with the negative blend and then rounding to provide the mechanical strength as well as heat is sufficient as needed. Now come to some exercises.

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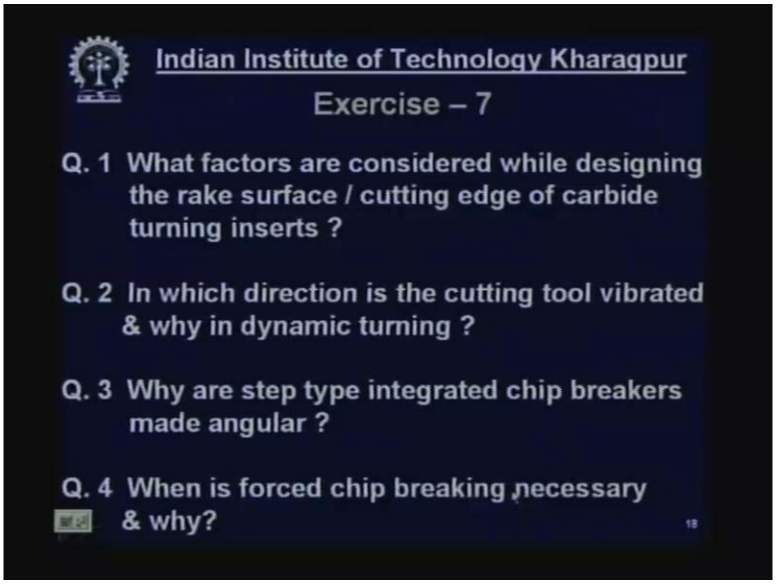

After learning the entire lesson, you will be able to solve the problems and I have given few lessons; Question number 1. What factors are considered while designing the rake surface or the cutting edge of carbide turning inserts? Now what is this that will be answered later on. Next question, in which direction is the cutting tool vibrated and why in dynamic turning? Is it in the axial direction or toss feed or in the transient direction? that has to be answered. Why are step - type integrated chip breakers made angular you see the step types chips are angular radius parallel why some type is made angular? What is the advantage of making angular? When is forced chip breaking necessary and why? this is explained number of times so answer will be very easy? Now the answer for question number 1.

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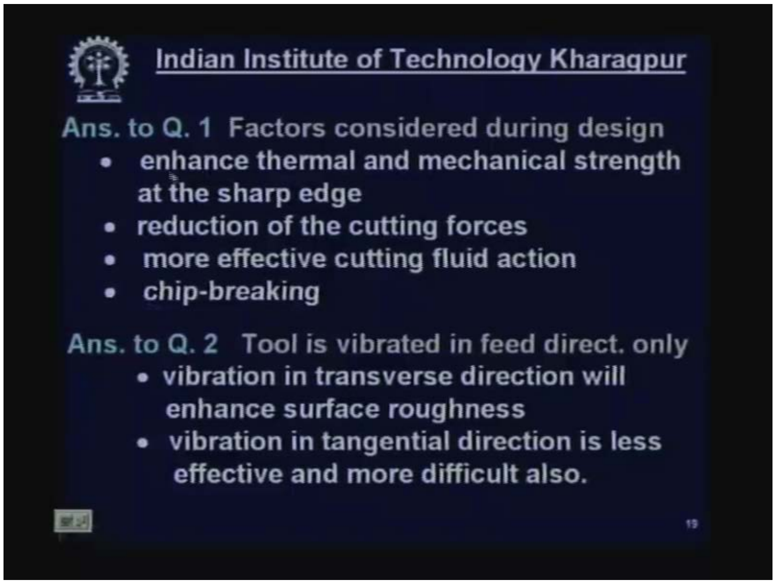

Factors considered during design of the inbuilt chip breaker along with the chip breaking. Along with chip breaking, what are the other factors? Enhance thermal and mechanical strength at the sharp edge, reduction of the cutting forces by more effective cutting fluid action, which will also help in reducing the wear. Answer to the question number 2, Tool is vibrated in feed direction only in case of dynamic turning, if it is vibrated in transverse direction, then the surface will be rough, if it is vibrated in tangential direction, then the effect will be lesser than the chip breaking effect and is more difficult to provide.

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Answer to third question. The chip breakers are made angular to shift the chips either away from the operator or away from the job according to the necessity and finally the

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forced chip breaking is necessary when continuous chips form and come out very hot sharp and at high speed that is very dangerous under the condition work material is soft and ductile. Flat rake surface with the positive or favorable right angle for why it is given forced chip break is necessary safety and convenience of the operator, easy collection and disposal of chips.

Thank you.