Manufacturing Processes II
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Lecture No.26
Broaching Principle Systems and Applications

Good morning young friends. Our subject is Manufacturing Processes - II and our module is ongoing General Purpose Machine Tools and today is the last lesson or under the general purpose machine tools topic today is Broaching – Principles, Systems and Applications.

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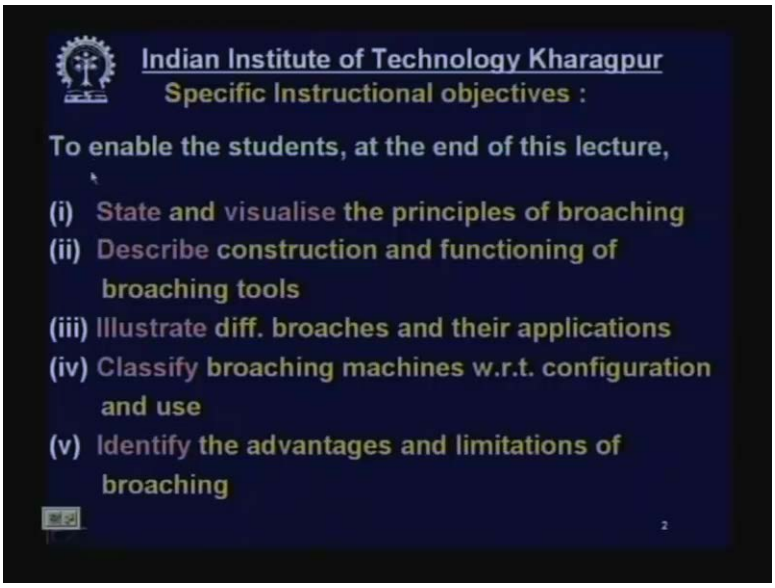

Now what are the content within this course, this today's lecture, this lesson will enable the students to state and visualize the principle of broaching like describe construction and functioning of broaching tools. Now I tell you that broaching is the machining process and broaching tool is a kind of cutting tool simply called broach, then this lessons will also enable the students illustrate different broaches and their applications. Classify broaching machines with respect to configuration and uses identify the advantages and limitations of broaching process.

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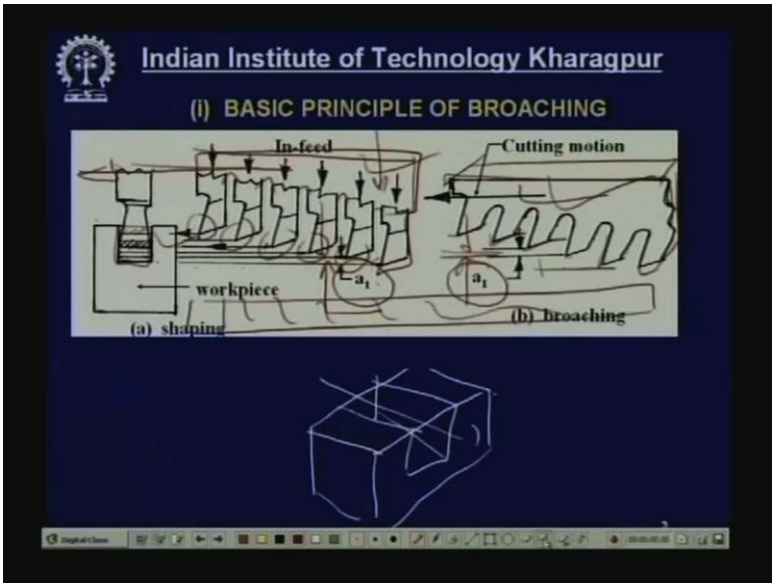

Now let us discuss the basic principle; why it is so navel? Why it is so modern and very much attractive. Here suppose this is the job okay, this is the job means here is a block, a rectangular block and suppose we have to cut a slot like this. Here a slot has to be cut onto this. This is the block from this side, it looks like this. This is the job and now this has to be the slot has to be cut okay. Now this slot has to be cut by suppose the shaping tool, the shaping process. So that it has to be cut since that depth of the slot is quite large, it has to be removed layer by layer in thin layers okay. So you give a small amount of depth then you give further depth to the shaping tool. After it comes back you give the feed again. So this is gradually infeed is given down to complete the total depth. Why it is done? Layer by layer or with the small load on the tooth. Because if you try to cut the entire material by this single pass, then enormous force will come on to the tool and tool will break.

So to enable this cutting tool to withstand that amount of force that will be coming, it is allowed to cut layer by layer thin layer so the chip load or cutting force on the cutting tool will be less. So the total depth will be completed in number of passes. So that the tool is not subjected to a very large force so that it breaks. Now here you can see that the productivity of such system is very low because the tool cutting tool moves forward to remove the material starts from zero velocity reaches with zero velocity then returns, there is ideal stroke. Now so much time gets wasted during repetition of this number of passes and this number of passes has to be given manually or say semi automatically. So this takes lot of time and effort.

Now if this cutting, so these are the positions of the tool instead we use different tools and join them like this. You join them and like this. So it becomes a single piece okay having number of teeth. Now you move straight way then what will happen? The entire material will be removed in one stroke. So lot of force will be coming on to the tool but force per tooth will be less depending upon the thickness of the layer that is getting removed by each tooth. So the force per tooth will be less but the total force and power requirement will be quite large. So machine tools should be strong, powerful, but the force per tooth will be reasonably less, so that it does not break and destroyed. So it looks like this apparently. So this is the broach okay which has got a thickness, it is a solid piece which has got number of teeth in series and in case of shaping, it was moved gradually downward and this amount of movement is called in-feed.

Now in case of this cutting tool, this gap will be there inherent. So all the teeth will be gradually protruding or rising. Amount of rise is called the rise tooth rise that is equivalent to the in-feed here in-feed; in case of this broach, this is called broaching tool and this process will be called broaching process. Now what is the main advantage? Very high production rate in one stroke, you produce the job. Now this is the very simple job. This job can be very complicated may be a keyway or is spline or a gear teeth and various things okay and finish will be better, quality will be product will be also a good and this strip, this broach can be very large one by like a rod having number of teeth may be up to 40 even more than 40 it can be so this is broach. So this is the basic principle of broaching.

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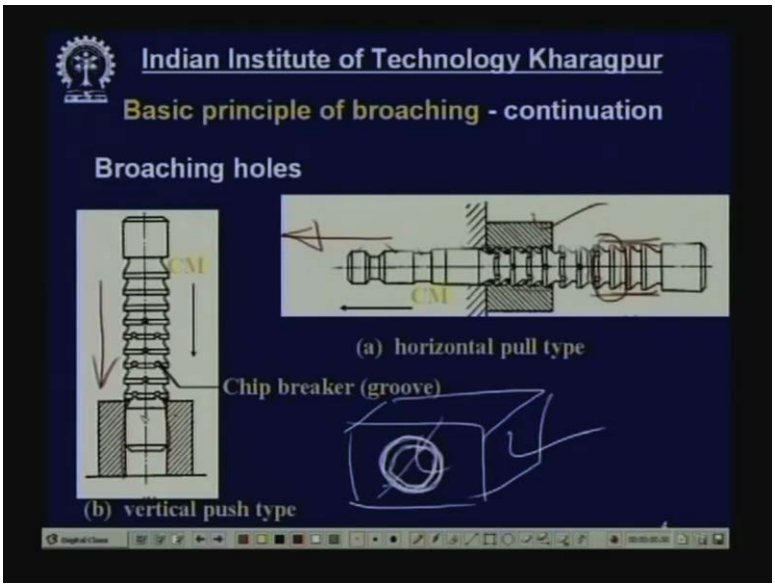

Now the continuation of basic principle; now suppose there is there is an object okay. Here is an object where there is a hole already made by casting or say forging or some other method. Now this has to be finished. It has to be enlarged and this has to be made perfectly circular and this surface finish and will be good and a dimension, the diameter will be also appropriate. Now this is that task. Suppose,this is the block where this hole has to be made. There is the pre hole, this can be made as I told you by pre forming, casting, forging or it can be drilling also. Now this has to be finish to appropriate dimensional accuracy, form accuracy and finish.

Now here, this job is this one. Suppose this is that job, here one and this is the hole which has to be finished and this is the broach. Now this is the broach of the cutter which has got number of rings okay number of rings and these rings at the edge, there is a cutting edge. So when this will pass through that, this will remove a layer of material. Now this has got so many cutting edges and the diameter of this cutting edge is gradually increasing. So that the finishing dimension will be decided by the last series of cutting teeth and this will be pulled in this direction. So the hole will be complete and to appropriate finish and accuracy. Now this is pulled. It can be push type also. We can push it like this, this broach and this will finish this hole. So broach can be you know pushed pull type or it can be push type.

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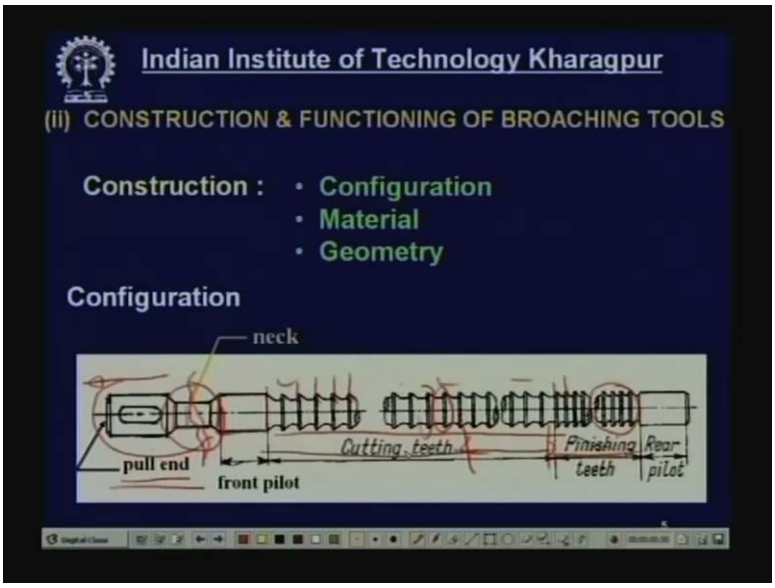

Now next is Construction and Function of broaching tool. Construction: what do you mean by construction? Configuration that is appearance, size, shape etcetera then material. What material it is made of and the cutting tool geometry. Now first come to the configuration. Now you will see later on we shall discuss that this broach can be push type, it can be push to the hole. It can be pulled it can be internal it can be external it can be of different types okay. Now most common is pull type. This is one, this broach shown over here. It is a single piece like a rod all right and it is pulled type and these are the cutting edges. This is to be used for making or enlarging holes by number of ring type cutting edges.

So this is the solid piece and rod like which has got several. You know features number in the front. This is called pull end. This will be connected with the adopter, adopter with the slide and slide will be pulling the broach through the work piece all right and this is neck, neck portion here you see the diameter of the neck is much small. It is deliberately made smaller, if by chance the cutting force increases very much and there is the chance of breakage or tearing or damage of the tool it will break here only all right and the entire broach will be safe. So this is for safety purpose okay and this is called front pilot. This will first enter into the hole to be finished.

Now there are series of cutting teeth. This is comprised of 2 parts; roughing teeth up to certain distance where the teeth are rising sharply with the tooth rise and then a number of semi finishing teeth with lesser tooth rise or in-feed. Then, a series of finishing teeth where tooth rise is less or feed will be less thickness of the layer will be gradually less and at the end there may be few burnishing teeth where there will be no metal removal. But, some plastic deformation to give good finish and surface integrity and the last is the rear pilot okay. So these are the general configuration.

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Now the material of broaches; now remember broach is a cutting tool as such. So what property a cutting tool material should possess, the same property should be possess by a broaching tool also. What are those properties essential for cutting tools as well as broaching strength and a tension as well as it compression and shape hardness to prevent wear, toughness then chemical stability against the work piece and environmentally cutting fluid, heat and wear resistance. During machining, heat will be generated and the tool material should not become soft or plastically deformed under heat and it should be wear resistance. So that life becomes longer. Formability, yes formability the material should be such especially in case of broach because broach is a very complex integral shape of a cutting tool which is very difficult to manufacture.

So that it has to be made of such a material which can be easily machine ground cart harden and so on. So that kind of material has to be taken, so that formability is bit there availability it should be available in plenty and cost should be reasonably low. What are those materials suitable for broaches? High speed steel, that is the best material for broaching and then cemented carbides are also applicable because high speed steel though it has got all properties but hardness is very low. Hardness and wear resistance heat resistances are low. As a result, the cutting velocity is low. If you want to increase the productivity and cutting velocity higher, then cemented carbides have to be used cemented carbides have to be used.

Now this is called tungsten carbide and cobalt and some other materials also there. It is used in two form blades. You know small blades which will be fitted in to the slots of the broach in series and these will be braced and inserts are also available in the market which can also fitted by clamping, mechanical clamping and time to time this can be indexed. Just like indexing turning tools or milling cutters. Now this cemented carbide even high speed steel cutters can be coated. Carbide tools can be coated with titanium

carbide, titanium carbonitride, titanium nitride and so on. But if it is a high speed steel best is titanium nitride coated tool which will give longer life and better performance.

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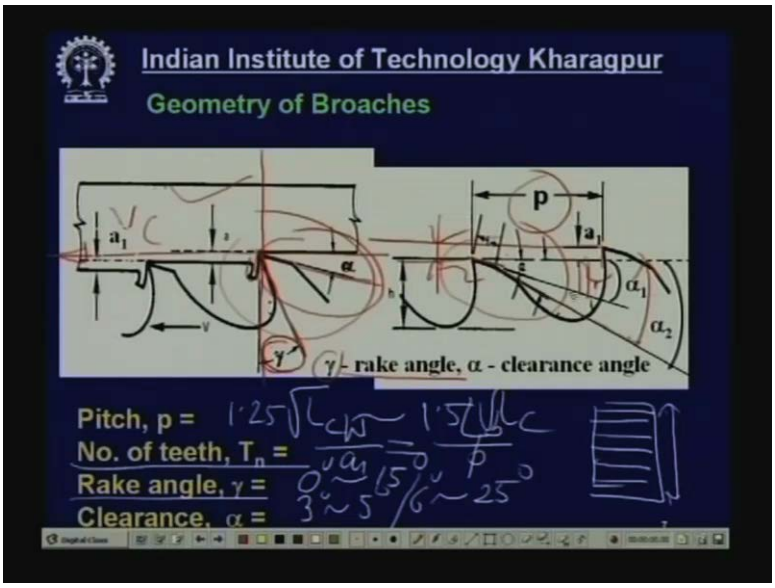

Now geometry of broach; Just like you know single point cutting tools, this broaching is also a tool and like all cutting tools, it should have certain definite geometry like rake and clearance. Here you can see, this is the work piece and this is the tool all right. This is the tool which is removing material and is moving in this direction, that is called cutting velocity. Perpendicular to that is a reference plane, this is the rake surface of the tool along which the chip flows. So this is the rake surface. Angle between them is the rake angle 'gamma' is the rake angle which is the very vital angle for cutting tools. On the other end on the flank surface, there should be clearance angle. So that it does not rub with the finish surface.

Now in case of broach, there are 2 clearance angles up to certain length called len primary clearance and then there after some secondary clearance with the larger magnitude and this gap between the teeth is called pitch and here you can see that the succeeding teeth is at the higher level. So this is called rise or tooth rise. So that, this will remove a layer. This removes another layer. So layer by layer, material will be removed by the consecutive teeth. Now what is the pitch this is pitch what should the value approximately it is stated that this p should be 1.25 root over L. L is the length of cutter, length of the job to be cut. Suppose 25 millimeter root over that 5 millimeter into 1.25 that is about say 6 milli 6 millimeter and this is for and it can be up to 1.5 1.5 it can be higher also.

What about the number of teeth? How will you decide? Suppose this amount of layer or material has to be removed layer by layer and number of layer means number of teeth. So how it is to be done? So total depth that divided by the true feed of this true feed, this called rise will give the number of teeth and this will be equal to the length of cut divided

by the in-feed okay like say total depth total depth divided by a 1 is a number of teeth. Now rake angle; it can also be decided by length of the cutter, length of the broach divided by pitch of the cutter. Rake angle; now rake angle should be positive. If it is say high speed steel, it should be positive. If it is carbide may be 0 also but not less than that. So 0 degree to up to 15 degree, it may vary depending upon the work material, tool material and cutting condition, etcetera. Clearance angle, primary clearance should be 3 degree to 5 degree and secondary clearance from 6 degree to up to 25 degree. It can be quite large, the secondary clearance here okay.

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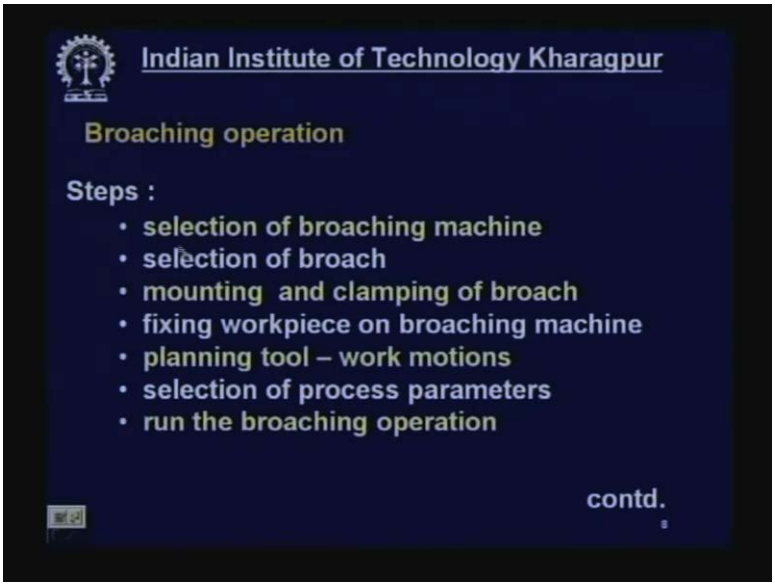

Next is broaching operation; now the broaching operation. What are the steps involved in broaching operation? These are selection of the broaching machine, selection of the broach or the cutter, mounting and clamping of the broach on the machine, fixing workpiece in fixtures in the broaching machine, planning tool work motions, selection of the process parameters, cutting velocity, feed, depth of cut and cutting environment then run the broaching operation. So these are the steps.

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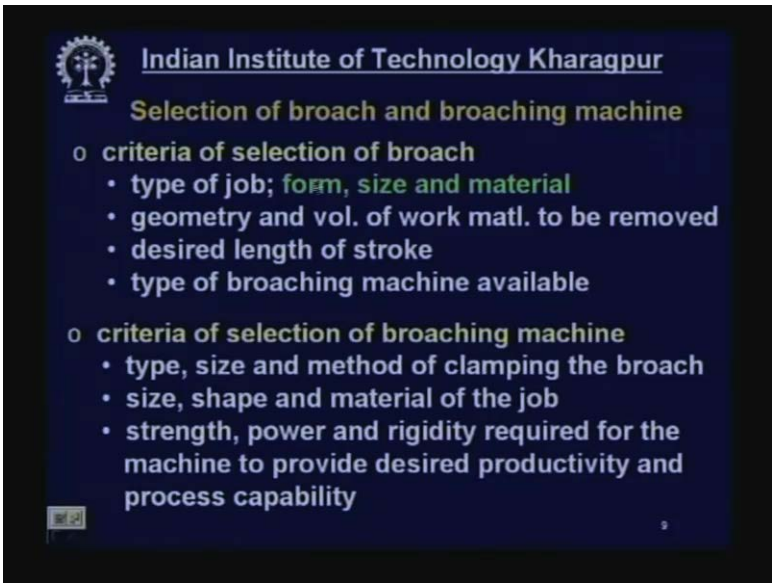

Now let us see selection of broach and broaching machine. Criteria of selection of broach: now broach is the cutting tool. There are many types of cutting tools, broaches available in the market or you can develop as you like and now from those broach available which one you will choose? What will be the criteria of selection of the broach? Those are type of the job. What kind of job you are handling? Form of the job - is a circular hole or it is a surface or it is a gear teeth or it is an internal external keyway different size, is a small size medium size or larger size and what is the material of the job? These things will decide the selection of the broach. If the work material is very hard and stronger, then carbide has to be chosen like that geometry and volume of work material to be removed. Now geometry, it is a circular hole or it is the external surfacing or it is a keyway or it is a splaying geometry and volume of work material.

If the volume of the work material to be removed is quite large, then length of the broach has to be proportionally longer. Desired length of stroke; if the length of stroke required being large, then this broaches have also to be longer. Type of broaching machine available: now different types of broaching machines are available and they handle different type or different ranges of cutting tools. If you know what kind of machine tools available to you, you can select the cutting tool in addition to considering the work piece. Now what are the criteria of selection of broaching machine? Type, size and method of clamping the broach.

How do you clamp the broach? There are different methods of clamping the broach. That system has to be available in the machine, in which machine that is available. You have to choose that one, then size, shape and material of the job. If the job is very large, shape is very odd then a different type of machine has to be taken. Strength, power and rigidity required for the machine to provide desired productivity. If you want high productivity then cutting velocity has to be high, depth has to be high, infest has to be high or machine

tool should be strong and powerful. If you want high process capability, that is accuracy and finish, then machine tool has to be rigid. So you have to select rigid machine tools.

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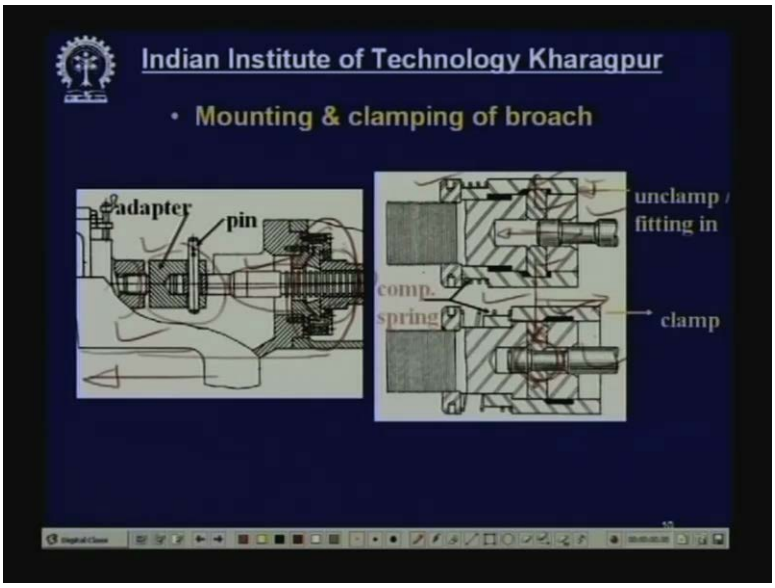

Now coming to, mounting and clamping of broach: Friends there are different methods of clamping, mounting and clamping broach in a broaching machine that depends upon what is a pull type broach or push type broach, internal broach or external broach. Various types are there types of there but remember, broaches are mostly internal working type okay and they are pull type. Now here you can see the examples of two pull type broach clamping method. This one this is the broach, this is the broach you can see and there is the adopter. Here is an adopter which is which is fitted in to the machine slide. This is the machine slide this one, which slides over the guide of the machine tool and by a pin, this broach is fitted into the adopter.

So when the slide moves hydraulically is preferably, then the broach will also move through the workpiece and this will produce the necessary surface. There is another method okay. Now this is the broach and this is called pull head this one. Now here when you feed a broach in or you remove it, then this outer socket has to be pressed in okay. When you press in then this strips these two strips radial strips, two or four will be able to go outward. So it can enter easily or go out easily after you put it inside fully then you simply release this one and this compression spring will push it outward and then this region of this socket will push this strips four strips inward and that will hold this one by this broach by the neck. So these are very simple, semiautomatic kind of clamping holding and clamping of broach. Now this is normally used for pull type pull type broach.

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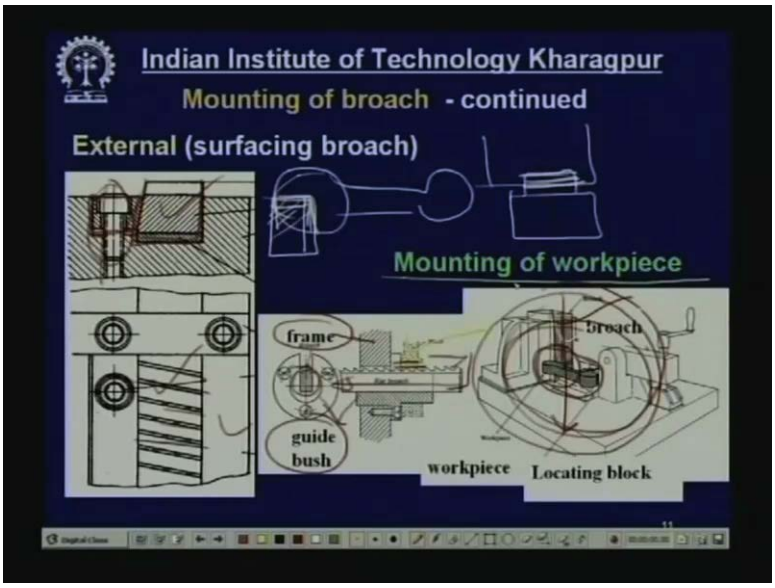

Now coming to mounting of broach - external broach; what is external broach that does external surface machining like making a flat surface, or say external keyway, external splines, external gear and so on. Suppose here this is the broach. This is the frame and this is the broach. This is the broach you know. This is a cross sectional view and this is the broach which has got number of teeth and this is suppose this is the work piece. This is the workpiece which has got a protrusion and these has to be machined layer by layer by a broach okay and this is that broach. So this will be mount clamp. There is a slot there. Within the frame shown over here there is a slot. In to the slot, a broach is fitted and then there is a clamping piece which is pushed in by an alien screw. It is one method.

There is another method, so this is the external. Now, mounting of work piece. Now how do you mount work piece? Now this is the work piece. Suppose this is a work piece where a keyway has to be cut, a keyway has to be cut inside this. So this broach will move in this direction and this will cut this one. So this is this one and this one is called guide bush and this is the frame and this will be pushed in and the job will be there and the broach is a strip type. This is the broach. If you pull the broach, then the keyway will be cut. Now this is another method okay. So, this is the work piece. This work piece is actually like this. Here is like this. Suppose it is like this, now you have to cut a slot. You have to cut a slot like this here.

This portion has to be removed and this can be done by a broach okay. So this is the broach which will this is the broach which will move downward and this will produce the required cart and the blank is mounted in this machine by this fixture. Now remember the job mounting in this broaching machine is a mass production machine. Very fast mass production machine. Therefore these jobs have to be mounted on special type of fixtures where the job blank can be easily, quickly and uniformly mounted for locating, supporting and clamping. So this is how the jobs are mounted.

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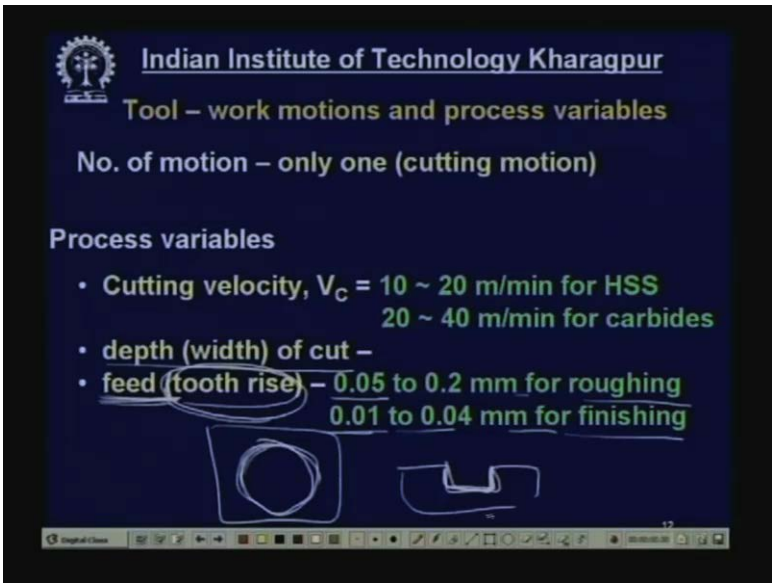

Coming to Tool-work motions: now friend I remind you that in cutting operation by end machine tool, there should be number of tool-work motions, relative movement, cutting motion, feed motion called formatting motions, then auxiliary motions like indexing motion, relieving motion and so on. Now here this broaching machine is characterized by very unique that number of motion is only one and that is cutting motion. The tool is normally the cutting motion is imparted to the cutting tool. Job remains stationary and the tool moves and the job is finished. So this is the only one motion so the machine is very simple. What are the process variables? Cutting velocity: Now the cutting velocity, this is the cutting motion imparted to the cutting tool either push or pull. Either you pull it or push it at a certain rate that is called cutting velocity expressed in meter per minute and if it is a high speed steel then velocity should be 10 to 20 per minute.

If it is carbide, then 20 to 40 meter per minute, if it is coated carbide you can go beyond that but mind that the machine tool should have should have that capacity of giving or withstanding that amount of velocity and power. Now what is depth of cut? Depth of cut will be decided by the length of the cutting edge involved in cutting okay. If it is a circular hole, if it is a circular hole which has to be made by a broach in a block, then the total perimeter is the width of cut that is the length of the cutting edge involved in machining. If it is, if you want to make a slot like this then this length okay total length is the width of cut but what is feed? In case of machining like turning, we called feed but in case of broach it is called tooth rise. This inbuilt in to the teeth which will be 0.05 to 0.2 millimeter only for roughing and 0.01 to that is 10 micron to 40 micron only for finishing work. It can be even lesser.

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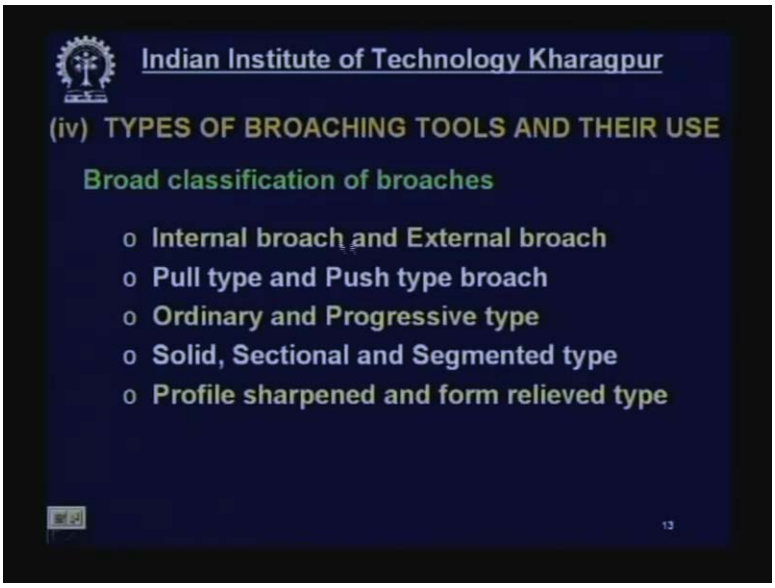

Next is, types of broaching tools and their use. I told you that various types of operations are done by broaching and this range is gradually increasing day by day because broaching process is very fast, very productive and it is a process capability like ability to provide accuracy and finish are also quite high. Broad classification of broaches: Internal broach and external broach. So first classification will be whether it is internal broach or external broach. Next is pull type or push type, ordinary type or progressive type. The broach is solid type single piece or it is sectional made of number of pieces or the segmented few pieces whether it is profile sharpen type or form relieved type. This is how these broaches are classified.

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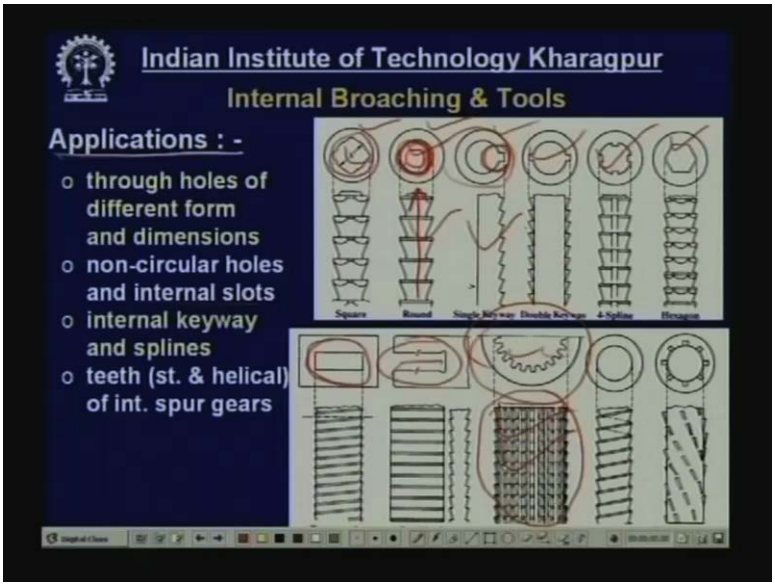

See some examples; internal broaching and the corresponding tools. Now, first the applications: Applications of internal broaching: What do you called, what do you mean by internal broaching? Internal broaching means, suppose this is a ring this is a ring okay inside which a circular hole, there was a hole initially very rough and inadequate. This has to be enlarged by removing a layer of material and it has to be finished to a perfect circle or a given diameter and good surface finish and this is the corresponding broach which will be moved through either by push or pull through this hole. So this is making an internal feature. So this is called internal broaching. This is another form okay, this is the various forms can be produced.

Now applications are through holes. Now these holes should be through they should not be obstruction. Step holes cannot be made or taper holes cannot be done. It has to be through straight cylindrical holes with the different profiles through holes of different form and dimensions fine, non-circular holes non circular holes this one. So there is a non rectangular hole okay, then holes and internal slot. This is an internal slot which has to be made in to the work piece. Now teeth - internal keyway and splines; Now see this is one keyway. This is a say gear blank or a ring in or a say pulley in which one internal keyway has to be produced all right is a long keyway that has to be produced by this kind of broach. This is two keyways. This is splines, this is the hexagonal prism. So, different forms can be produced.

It can also produce teeth of gears. In one stroke it can produce all the teeth in a gear. It is so fast. For example, here you see this is an internal gear having internal teeth and this is a corresponding broach. Now from the appearance, you can understand the broaches may be so of so complex shape and they will be very very difficult to design, manufacture, maintain, repair, re sharpen. So cost is very high.

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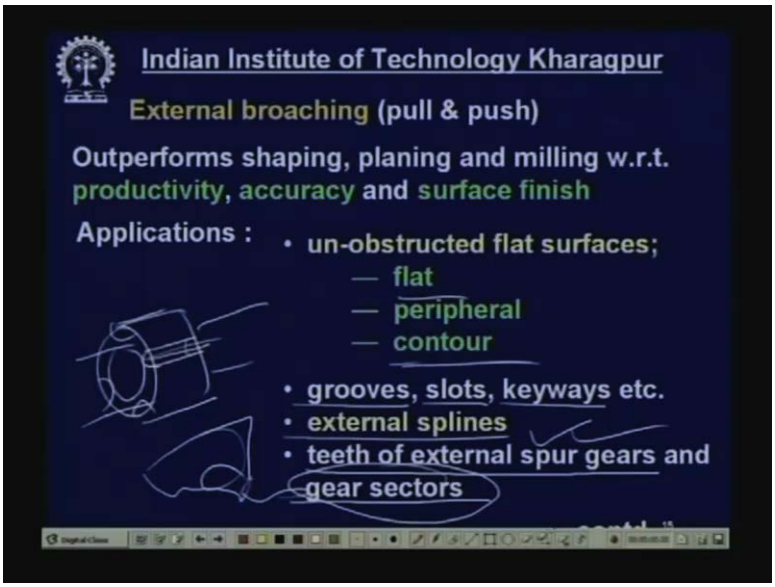

Now External broaches: Previously we saw these internal broaches. Now external broaches: these external broaches, they do really surfacing. It is very similar to shaping, planning, milling work, but this broaching outperforms shaping, planing and milling with respect to productivity, it was very fast. In one stroke it does the whole work, accuracy and surface finish. So in all respect, it is better than this planning, milling and shaping applications of outs, external broaching, and un-obstructed flat surfaces. It will produce flat surface. Suppose this is a block. This is a block; this flat surface has to be produced flat peripheral. So it can be a curve, curvature, you know. It can be contour. It can be contour surface. You know but it is through grooves. It can move these grooves, slots, keyways etcetera.

Now here is a say. Now you want to cut a slot here on this one. So this external slot or this groove or keyway can be cut external splines. So external splines can be cut the grooves on the external splines and finally the teeth of external spar gears both straight rooted and helical fluted, spur gear teeth or spur gears can be cut and even gear sectors say part of gear, say gear sector like this. This will be shown later on can also be cut. Let us see the example.

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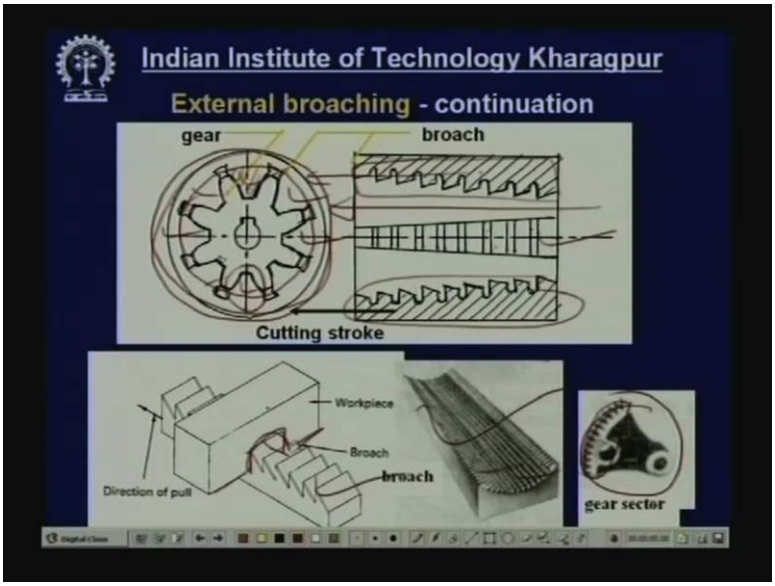

Now here you can see that suppose this is a gear okay. This is the gear. This was the gear blank. This was the gear blank you have to produce the teeth. So first you have to remove this layer or material okay, this layer or material in between the tooth. How you can do by shaping? It is possible by number of passes. But if you take a strip type broach this one, when this will be pulled through this piece then this groove will be made. If one groove can be made, why not this groove also? Two teeth productive; so this strip will make this one if two then, why not four, this one this one. So these two and different strips are broaches will be fitted in two way cylinder and when this cylinder will be pulled over this gear blank, all the teeth will be produced external teeth will be produced

with high accuracy, high finish and very fast production. This is another example you say, if you want to make a cut a slot like this.

So this kind of broaching is possible. You can make it different form also and now this is the gear sector. This is the gear okay gear teeth and for cutting this one, this kind of cutter has to be used which is conjugate with the form tools and it is an interesting to note an important note that broaches are really form tools. Most of the time these are form tools because the form of the tool will produce the profile of the job. So the profile of the job will be totally dependent on the form of the tool and any defect or damage in the tool will be reflected on the quality or accuracy of the profile of the job that is the disadvantage or limitation you can say.

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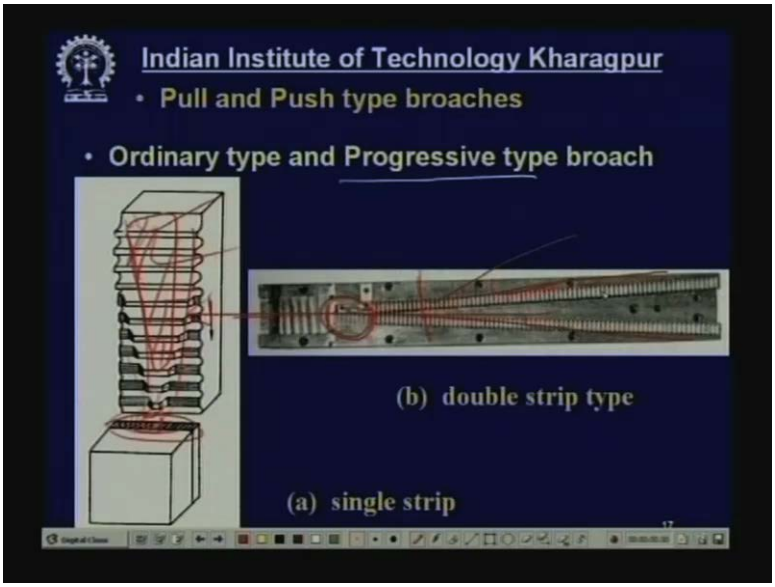

Now pull type and push type broaches: Pull type you have seen okay. Now pull type these are more common widely used and these are long in size with the large number of teeth okay. But what is push type? When you push it, it is subjected to compression. If it a pull type, it is you know subject to tension now if it is subject to tension then alignment is become very easy and this operation is simple and there is no chance of any buckling but if it is a push type, then there is a chance of buckling. So push type broaches will be smaller in size, will be more rigid and subject to lighter cut and they will be used for outer work. Now here can see there is the ordinary type or their broaches are ordinary type okay this, and it can be progressive type.

What is ordinary type? Ordinary type means in the previous case we have seen that where the there is it continuous tooth rise. The succedive teeth have got some rise or incremental protrusion by which it makes but here in the progressive type here you can see the progressive type this one where not the height of the tooth is increasing the height is not increasing, but the width is increasing. You see the width, the width is increasing. So gradually, if you want to remove a layer of material, you can first make a slot by this

one, then widen the slot and finally remove this material. So this is called progressive type. Now if is very long one, we can remove this material because this part of the broach does not work only this end, this portion and this portion. So this can be modified in to this form which is made of two strips. First of all, this end will enter and gradually the width of the job will increase with the progress of push of the goes through the hole. This is called progressive type.

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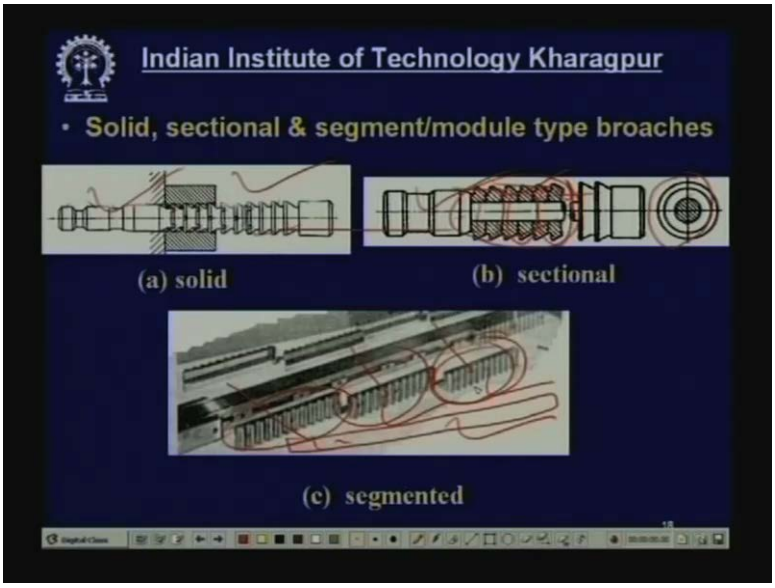

Now solid now solid sectional and segment or module type broaches. Most of the broaches, I told you are pull type and internal working type as this one okay this one. This is the most common pull type internal broach with the large number of teeth in a length. This is called solid. It is a solid single piece from which it is made mostly high speed steel. Now this is sectional where these are the cutting tool okay separate disk like which are fitted one by one and then assembled and then tighten from this end and when this is pulled or pushed this all this teeth will work simultaneously and here you can see the tooth rise. This corresponds this succeeding teeth are of larger diameter or larger protrusion what is the advantage? Advantage is, if one of the tooth is damaged, you can replace it.

You can replace it if suppose that diameter of the hole to be slightly increased or slightly changed in the form, then you can replace this single pieces or sections by another set. This is the advantage. Another called segmented type. If it is say ordinate type, this kind of outs broach for making flat surfaces and requiring quite a large amount of material removal, so instead of making a long broach which is very difficult to make you make in small length and then you fit in to the broach holder. So this enables design, manufacture, mounting, repair, maintenance of broaches easier and cost of the broach also comes down.

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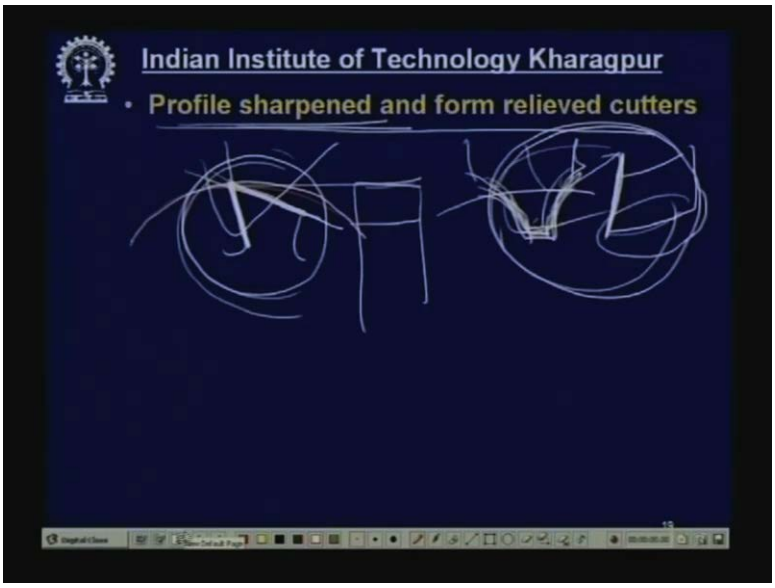

Now the profile sharpened and form relieved cutters. You remember that milling cutters the milling cutters. This has got this kind of tooth and another so, here the cutting tooth is like this. So this is the cutting tooth flat and another case, suppose you want to produce the gear tooth profile okay. So, in this case the tooth will be like this. This is called profile sharpen milling cutters. This is called form relieved milling cutters and here the tooth will be like this. This is Archimedean spiral and this is flat. This kind of milling cutters are used for making flat surfaces and this type of form relieved milling cutters used for producing forms particular form.

Similarly the broaches can also be divided in to two classes. Profile sharpen type where this will produce on the flat surface or surfaces bounded by flat surfaces very simple and this is flank surface is flat and resharpening is done by grinding the rake surface sorry grinding the flank surface on the in case of profile sharpen cutter which is simpler but in form relieved cutters. So the milling or broaching the grinding has to be done in the rake surface because at every point, this is rake angle, clearance angle are different which is much more complex. So most of the tools are in a broaching tools are form relieved type because they are form tools.

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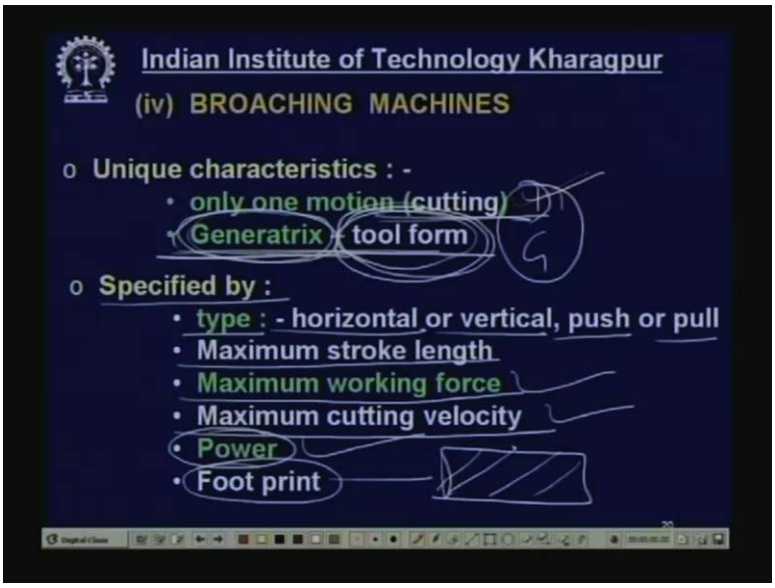

Now coming to broaching machines: Again as I told you that, there are different types of broaching tools available and which can be design and develop and similarly the number of machine tools are also quite. There may be may be say about dozen types of broaching machines are available. So what are the unique characteristics of broaching machines. These are costly. No doubt for different reason but unique characteristics are only one motion. You will not find any other machine tool where the motion is only one broaching machine is the only machine tool where the motion is only one and that is called cutting motion and imparted to the cutting tool, cutting tool but occasionally this motion can be given to the job keeping the cutting tool stationary but that is very rare.

Now you also know that the machining work is accomplished by producing the surfaces which is produced by generatrix and diretrix. Here in broaching machine, the generatrix always provide the tool form. The tool form acts as the generatrix and cutting motion as the diretrix combination of this diretrix and generatrix produce all geometrical surfaces. Now how the broaching machines are specified broaching machine tools. Type - Whether it is a horizontal or vertical? Is it push type or pull type means broaches handled. Maximum stroke length that can be accumulated in the machine tool maximum working force that will be acting on the broach. So machine tool should be able to stand that amount of force, maximum cutting velocity that machine tool can provide. Power - that can be provided by the machine tool and foot print foot print means the area of the floor space that will be occupied by the machine tool, because floor space is also very expensive may be as expensive as the machine tool.

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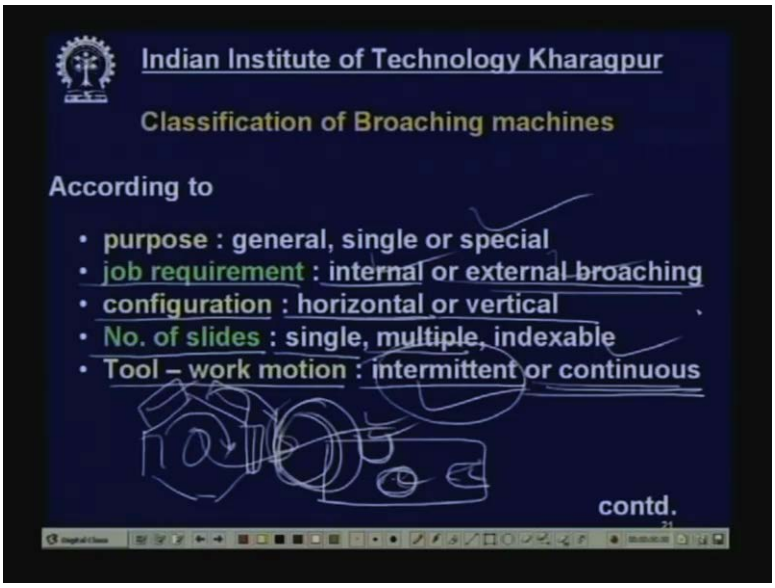

Now the classification of broaching machines: Broaching machines are classified according to purpose. General purpose, single purpose or special purpose: say general purpose - you can change the cutters frequently, single purpose. Suppose you have to produce gear sectors, for example in huge quantity over say yes, then this machine should be is single purpose producing only gear sectors not doing any other thing. Then the productivity and quality will be high. Special purpose where a complicated job say a complicated job requiring number of broaches to produce this slot, this slot, and this hole finishing and simultaneously working, then this will be special type. Job requirement - internal or external broaching. So, the machine can also be classified accordingly but there are broaching machines which enable allow got internal and external broaching that is called compound.

Configuration - This machine tool is horizontal. Most of the broaching machines are horizontally acting, but some of them are vertical number of slides. Here you see three operations have to be done simultaneously so three broaches will work simultaneously call three stations and for that three slides may be necessary. So the single slide or multiple slide or indexable. Now there can be a hexagonal turret suppose which has got six faces on six faces the broaches will be mounted six broaches okay. Now here is a work piece which will require surfacing, slotting, grooving different things. So this will just rotate and bring the desired broach in to cutting action and the entire if job will be completed so this saves time. Then tool-work motion, intermittent motion that is common. So this will move with either pulled or pushed, then pushed or pulled back. Another job is mounted then this is repeated. This is called intermittent type. Another one is continuous, a large number of workpieces will be moving continuously and done fast that will give more productivity.

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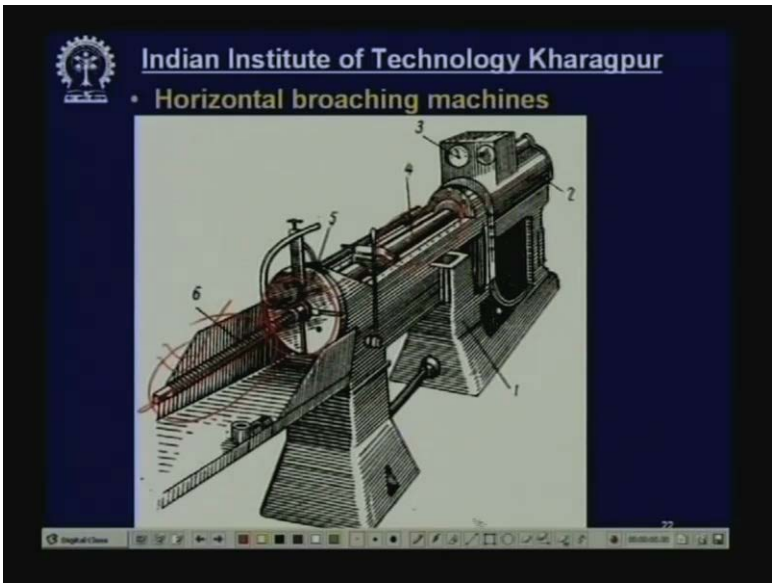

Now horizontal broaching machines - Most of the broaching machines are horizontal type and they are used for internal work by pull type broach. For example; here this is the broach which is for internal working and this is for pull type. The job will be mounted here on the fixture and this is the hydraulic drive ram which will push or pull this broach away or towards the work piece through the work piece.

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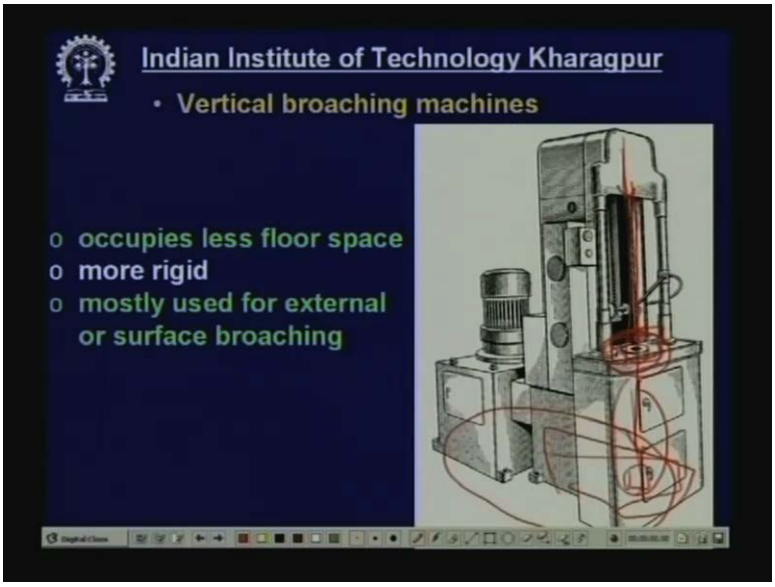

Now next is say vertical broach. The vertical broaching machine; now this is a this is a hole on which you can mount a job okay different type of job and the broach will be moving like this either pulled from bottom or this will be pushed from top. So both kind

of system may be possible. Now what are the unique features of this vertical? It occupies less floor space. It occupies less floor space. This is very important, more rigid because the broaches are acting by the slides which are resting on ram is moving or resting on the base to a support. Mostly used for external or surface broaching for external work but occasionally, this can you be used for internal work as well but mostly push type broaches are used.

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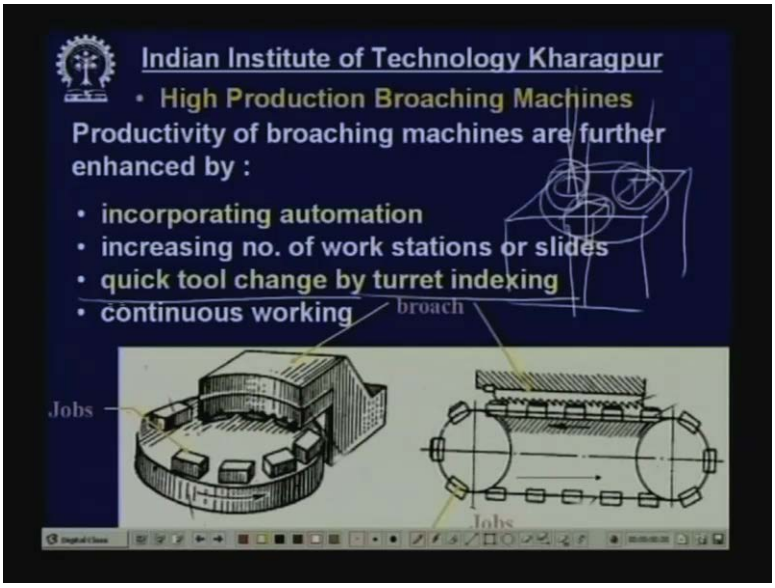

Now this is high production broaching machine productivity of broaching machines. Now let me remind you that broaching is a process which is very very highly productive because it works very fast, removes the entire material normally in one stroke, unlike milling or shaping or planing all right. So as such broaching is a very high productive and used for mass production. It also provides good surface finish and accuracy okay but the production rate or productivity is even such broaching process and machines can be increased further. How by incorporating automation: Now incorporating automation that is mechanisation make where in mounting of the jobs. So jobs will be quickly and automatically mounted clam located supported and clamped and then unclamping will be also very quick and by an ejector this job will be thrown out from the fixture.

Similarly there should be a mechanism by which this cutter can be quickly changed okay from one form to another depending upon the type of the job to be done. So some kind of automation, then say entry of the blanks and removal of the blanks. So conveyor all these can be automated or mechanized. Another way of increasing productivity further increasing number of work station or slides. Here, this means that suppose this is as I told you earlier also this is the workpiece a large block okay. Now here you do a hole her you do another square hole here you make a slot a slot like this. So there were number of broaches will be acting. For them, different slider slides will be used and different stations and then the productivity will be multiplied. Next is quick tool changing by turret indexing this has been already mentioned that,

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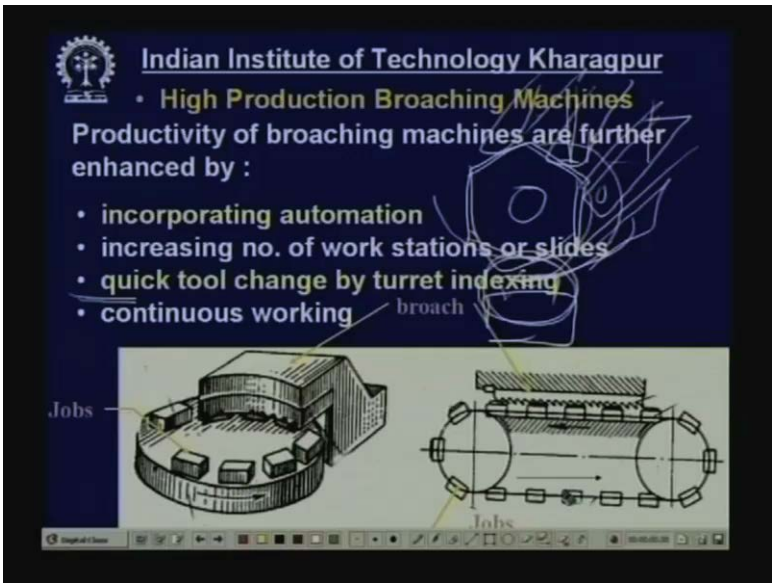

There will be a turret and on the turret, this turret a long turret and on the turret, the broaches will be fitted okay either clamped or it will be fixed temporarily or permanently and job will be say placed at the bottom and the one broach will do some work first. Then this will go out another broach will come into action another broach will come into action. So successively 6 broaches will come forward and do 6 different works on the job and in one spell, you can get the entire job complete. So, this way the productivity can be enhanced.

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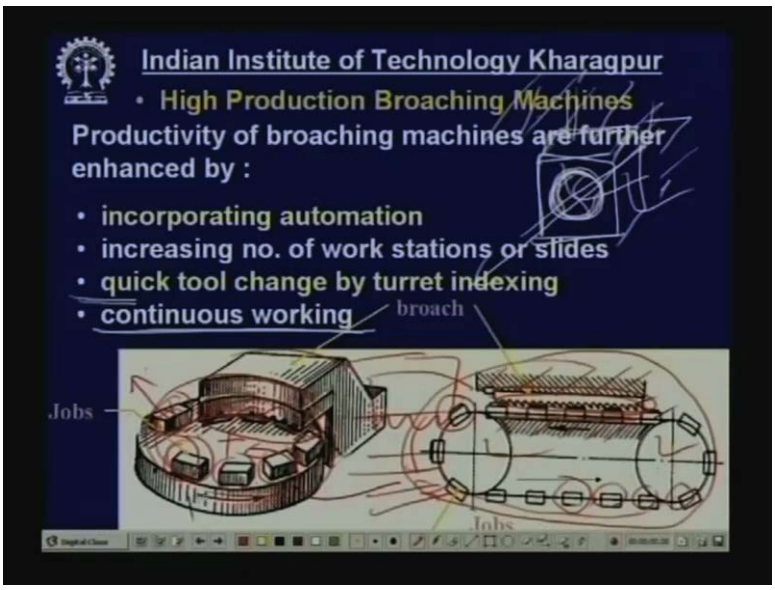

Next is continuous working; now the continuous working normally what we see in broaching machine that, one hole is one job is say here is a block, a block which has got originally a hole and this hole has to be complete, finished to appropriate dimension finish, circularity, etcetera. Then this has to be clamped in to fixture and then the tool has to be moved through this either by pull or push. All right now, this is called intermittent but what is continues working instead of one piece. Now here you will see there is a large disk okay. There is a large disk this one, on which this small workpieces are mounted either by magnetic chuck or magnetic force or by clamping and now this will rotate about this axis.

Now here is a broach all right. This broach is a circular arc type, circular arc type and at the bottom it has got cutting edges okay. This cutting this is called cutting edges. Now when this will move, suppose this moving in this direction. So this was all this one will undergo the broaching action then come out when this will come out then this will be withdrawn because this is finished okay. So, this will continue when all when this now when this is finished, this will come in to this portion, you mount another block. So this will be a continuous process. Now if the number of pieces is large, you can apply this method also. This is a chain in this is the sprocket.

There are two sprockets and on which a chain is moving on the chain workpieces are mounted identical small pieces are to be mounted produced in huge quantity. Now when this will pass through, this is the broach. This broach cutter is fixed on a rigid frame and when this one will pass through they will rest on a rigid surface. So when this will pass through the rigid surface and undergo this cutting action by the broach and this will be finished here and you take it out and new blanks will be fitted in. So this will give you very rapid that is mass production.

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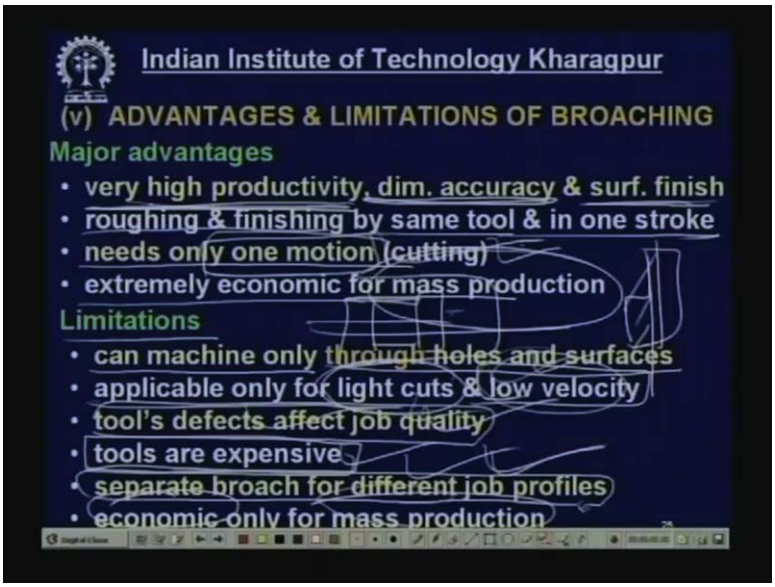

Now friend you have heard about this good qualities, favorable qualities that is productivity, accuracy, finish all these things an economy but what are the finally advantages and limitations in brief? Advantages – very high productivity. This has already been discussed. Why it is so? Because in one stroke it can finish the product the high productivity which can be engaged further by mechanization dimensional accuracy is also very high and surface finish is excellent. Roughing and finishing by same tool, because the tool has got the series of roughing tooth followed by finishing and super finishing. So you get all these activities in one stroke of the cutter all right. Now needs only one motion. There is no motion, more motions mean means more components, parts are involved more wear and tear less rigid backlash all problems.

Since the motion is less, so the machine is very rigid and very fast extremely economic for mass production because it is very fast working but friend what are the limitations then? Whenever you get into sacrifice something what are those? Can machine only through holes and surfaces; Now this tape surface is this one cannot be removed it has to be through then the hole it cannot make say stepped hole stepped hole it cannot make it has to be through hole applicable only for light cuts yes the cut cannot be very high then this tool will break or there is a chance of buckling and other problems will arise and velocity is normally low because usually it is a slender rod type cutter and the tool may be tension or in compression. Tools defects affect tool quality. Yes, because this broaching is a forming process.

So the profile of the job will depend upon the form of the tool if there any damage defect or anything in to the tool form that will damage the tool job also tools are expensive obviously is very complex size or shape difficult to manufacture and all these things friend and separate broach for different job profiles. Now suppose you want to produce gear external gear or internal gear if the number of teeth changes even by one if the module changes, if the helixagol changes the pressure will either changes a new broach has to be used. So several broach has to be procure. It is of great great advantage. This is advantage or limitations of broaching in case of such kind of applications. It will be economic, only for mass production if the production side is small then this machine tool will not be economic because the cost of the machine is quite high because of its process ability rigidity zero raggedness accuracy alignment and all this things. So this has to be used for large volume or production otherwise it will not be economic. So this has to be kept in mind that it will be it has to be used only for mass production, huge production otherwise it will not be economic. Friends, you have heard lot about broaching. Now I shall again go back to the beginning just to tell you again and remind you that what is the basic principle and unique characteristics of broaching. Let us take an example and elaborate.

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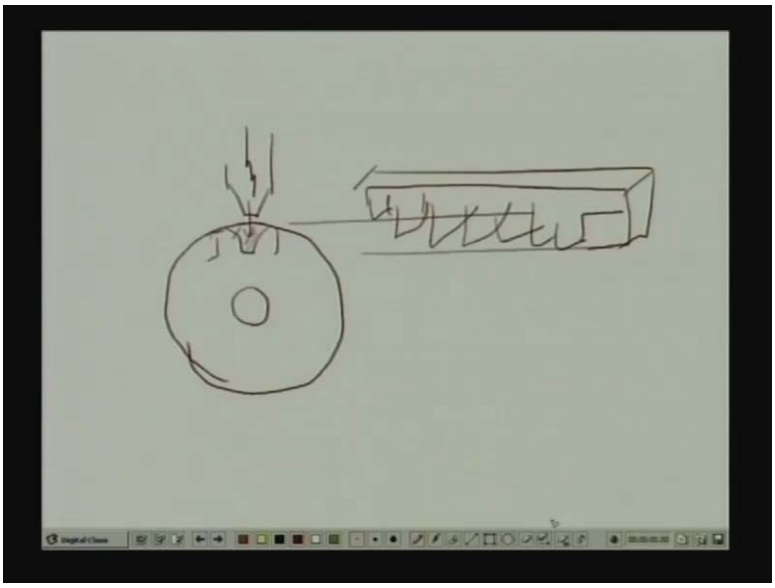

Suppose this is a gear blank okay, a disk on which gear teeth have to be produced. Now actually we do not cut the teeth. What we remove? The layer of material, this layer of material has to be removed in between two teeth, next another two teeth have to be produced. Now this material has to be removed. How do you do that we can do that by shaping tool. So shaping tool here say, this is first and next next gradually you increase the in-feed. So the shaping tool if it is the shaping from tool, then this has to be intermittently radially moved in so like this. Now instead of number of passes if we assume there are number of cutting tools then we can simply join it. Now it becomes a single piece as you see is not it. It becomes a single piece.

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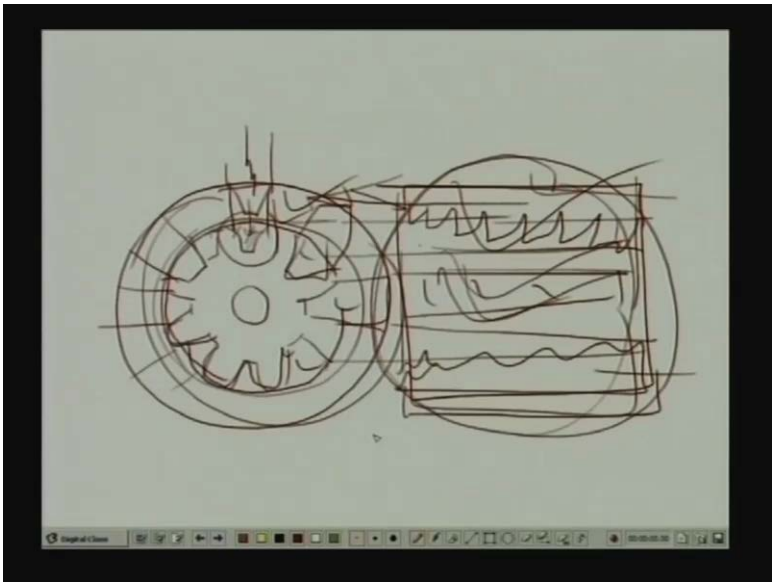

Nicely you can see here. So this is one tooth, then one like that so it one piece. Now instead of number of passes, if we just push it in this direction, the entire teeth will be complete. Now this is we want if you we want to increase the productivity why not we make another tooth gap tooth gap by another similar another similar cutter. So were this two will move simultaneously then, why not two more? then why not two more. So if you produce say eight like this as there shown and remove these materials then what remains, in between the teeth remains? So there will be two cutting edges here there two cutting edges here and all the strips will be fitted into a cylinder, into the cylinder this will be fitted this broaches this will be this broach will be fitted into this plane but this will be done very carefully and perfectly otherwise accuracy will be lost and now if you move it in this direction all the teeth will be produced in one stroke.

Now again, this is the good part that you get very high productivity. In one stroke, you get a gear it you can produce internal teeth also by a rod like cutter and a dimension accuracy will be good and serve is finished but remember if the number of teeth changes then they the entire broach has to be changed. If the module changes, then another broach has to be used. Now the broach as such is very complex, very costly, may be say 20000 thousand to may be up to 1 lakh. Now, if you change the number of teeth or number of module or helix angle or pressure angle, any pitch of the gear a separate broach has to be procured. Now you can understand that so this quick change in the product should not be allowed. So this kind of cutter has to be used for huge mass production. So that, the cost of the tool and machine will be met by the number of pieces and cost per piece will come down.

Thank you.