Fundamentals of Manufacturing Processes
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Lecture – 35
Material Removal Processes Machining

Hello, I welcome you all in this presentation related with the subject fundamentals of the manufacturing processes and today we will be starting the new process which is called machining.

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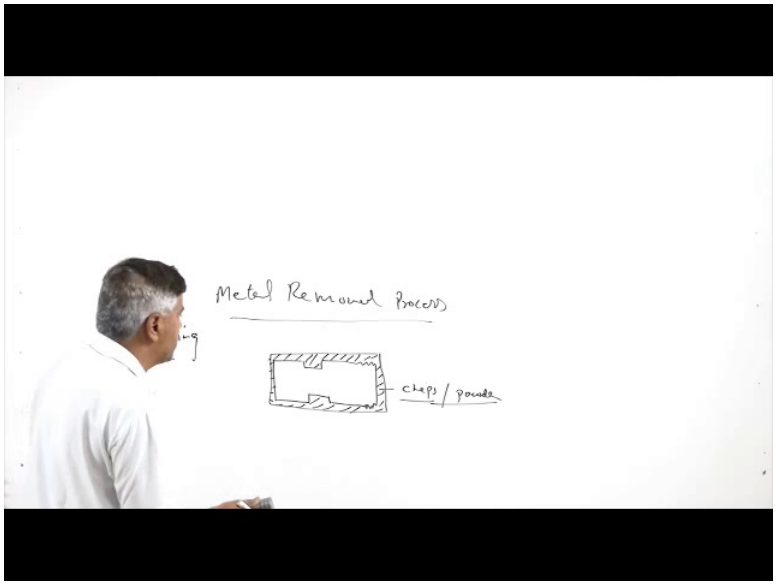

This is one of the processes in the broad family of the metal removal processes. So, this is an approach where, unwanted extra material is removed from the raw material or from the stock. So, that the desired size and shape is realized.

For example, the raw material is of the large row material of the stock is of this shape and we want the final product having number of the features like this. So, such kind of the features can be produced by removing the unwanted extra material. So, here if we see the shape of the stock was like this and where in we have to remove all this hatched material from this stock. So, that a final product of the desired size and shape can be achieved which will of course, be in this form.

So, in order to have this is the like say the product that we want to have and since this kind of product which is bit complex, requirements are more in terms of the tolerance and the surface finishes are more. For example, the surface finish of the 0.5 R a is needed and a very good control over the dimensions is required, say like 0.2mm, then or even finer like 0.2 mm.

Then such kind of the dimensional controls and the complexities in the shape can be easily achieved by the material removal processes, but here if we see the approach is basically what the unwanted extra material from the stock is removed. So, that the desired shape and the size is realized in form of the product which we want. So, the approach is basically focused on the removal of the unwanted extra material and this extra material is removed in form of the fine chips or it may be very fine powder form, depending upon the approach of the material removal which is being applied.

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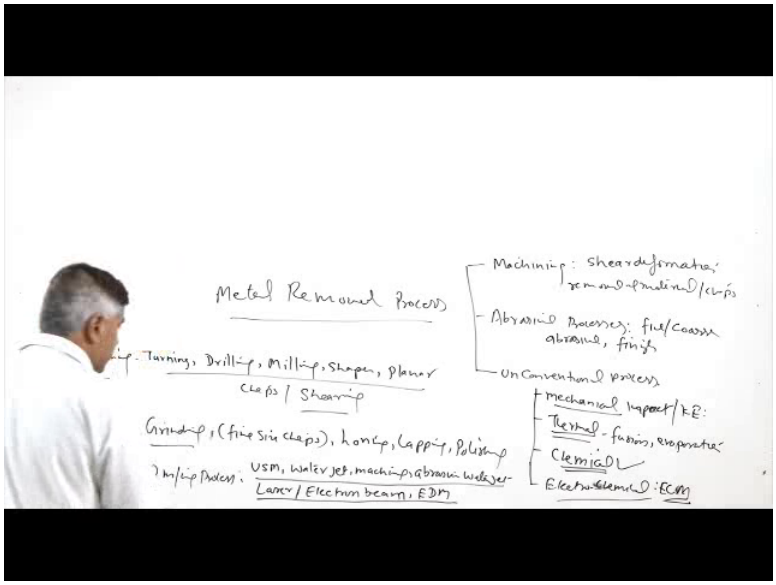

So, under the family of the material removal processes, there are three broad processes category of the processes these are like, machining, abrasive based processes where abrasive material is used abrasive processes and unconventional processes these are also termed as nontraditional processes.

These processes differ significantly from each other especially in respect of the approach which is being used for removal of the material. For example, in machining processes mainly the shear deformation is applied for removal of the material in form of the chips.

So, the material is removed in form of the chips, in order to get the desired size and the shape.

Abrasive based processes basically use the fine or coarse abrasives as for the process, to achieve the high degree of the surface finish and the control over the dimensions, then in nontraditional processes there are a number of ways by which material can be removed. Which uses the energy in various form like the mechanical energy in form of the impact or the kinetic energy, high velocity particles are directed onto the surface or impact is done applied through the fine particles.

Then it may use the thermal energy for certain processes. So, that either fusion or evaporation of the material can take place in order to remove the material from the stock material, not necessarily in these cases the chips will be found, but like in the material chip will be removed in form of the vapors, in the processes like laser beam or electron beam machining or in the fusion material is melted.

Then we have chemical those processes, which use chemical reactions for removal of the material and then there is electro chemical processes like ECM, is one of the most commonly used machining processes. Which uses the electro chemical reactions in order to in electrochemical principle in order to remove the material from the surfaces and here mainly chemical reactions are involved for removing the material from the stock material and here the impact or the high kinetic energy in form of like say water jet is used for removal of the material. So, under the each of the categories we have very large range of the processes, these we can say as a big group of the big family of the number of processes.

So for example, if we will write about the machining processes under the machining, we have large range of the machining processes for example, turning is one of the commonly used processes for producing the cylindrical shape, then we have drilling which is used for making the holes, then we have milling which is used for making primarily flat surfaces, but it can also be used for making the gears another control or curved surfaces.

Then we have the shaper for flat surfaces planer also for flat surfaces, but it can be use for cutting the groups slots etcetera also. So, in all these processes material is removed in

form of the chips and the shearing is basic mechanism, by which material is removed in form of the chips in machining processes.

Then we have the abrasive processes one of the main abrasive process is grinding, where in the fine sized abrasives are fitted with the bonding material which removed the material in very small size. So, basically very fine size chips are produced in this case. Another process is an abrasive category of the process is honing lapping polishing all these are the abrasive processes and then under the nontraditional machining processes or unconventional machining processes, where in either the chemical reactions are used or the thermal energy is used or the mechanical impact mechanical energy in form of the impact and high kinetic energy is used or electrochemical reactions are used. We will; so number of there number of nontraditional the machining processes, which are based on the variety of the approaches like in the mechanical energy, thermal energy, chemical and electrochemical approach.

So, under this the commonly known processes are ultrasonic process, then a water jet machining, then abrasive water jet machining. So, all these the processes are the mechanical energy based processes, then laser beam laser and electron beam processes where high energy beam is focused over a small area so that the metal ablation or the evaporation takes place and controlled removal of the material from the stock helps to achieve the desired size and the shape.

Electric discharge machine is another process edm, commonly known as edm which also uses a thermal energy for removal of the material. So, laser electron beam and electric discharge machining, these are the some of the processes for the mechanical, which use the mechanical energy and the thermal energy.

Other processes like electrochemical ECM, is another process which uses the electrochemical machining and there is electrochemical machining process. which uses electrochemical reactions for removal of the material these processes have the wide very wide range of the capabilities in terms of the tolerance as well as surface finish, like the machining processes allow the high metal removal rate and very close control over the dimensions and the surface finish that is why the machining processes are of the great commercial importance.

While the abrasive based processes also remove the material, but the metal removal rate is very low, but they help to achieve the very high degree of the surface finish, very low surface roughness and very close control over the dimensions. On the other hand nontraditional machining processes are primarily used for machining of those processes, which are found difficult to process through the conventional machining route or conventional machining processes, like abrasive based processes or the machining processes.

So, the difficult to machine materials are basically processed through the nontraditional machining processes; however, they do not necessarily produce very good control over the dimensions and the surface finish, but since they are the material removal by the conventional processes for such kind of materials become difficult and that is why the nontraditional machining processes are preferred, for such kind of difficult to machine materials.

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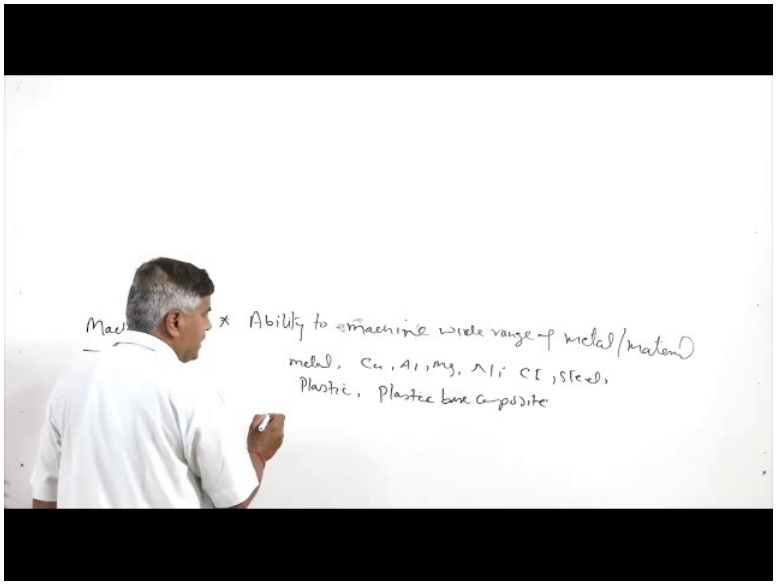

The common difficult to machine materials are like nickel based alloys, super alloys or the titanium and the in stainless steel category, especially the austenitic stainless steel these are the materials which offer lot of resistance for removal of the material by the conventional processes and therefore, nontraditional machining processes are preferred for such kind of the material.

Now, I will write the why the machining processes are of so, machining processes are of the great commercial importance. So, the reasons for the great popularity and of being great commercial importance include that, the ability to machine wide range of the metals or the materials.

So, not necessarily just metals will be processed, like the machining can be done of the metals ranging from like say the copper, aluminum, magnesium, nickel, then cast iron steels and not only these, but these also can be used for machining of the plastics and the plastic based composites in order to get the desired size and shape.

Machining is also used for can also be used for machining of the ceramic materials using the very good quality the tools inserts, but the surface finish and the dimensional control surface roughness and the dimensional control in case of the ceramics may not be that good. So, the dimensional control and the surface finish is not may not be that good in case of the ceramics, but it can be used for most of the metals and the plastics based composite materials.

So, the machining processes become capable to handle a very wide range of the material systems and by removing the unwanted extra material the desired size and shape can be achieved.

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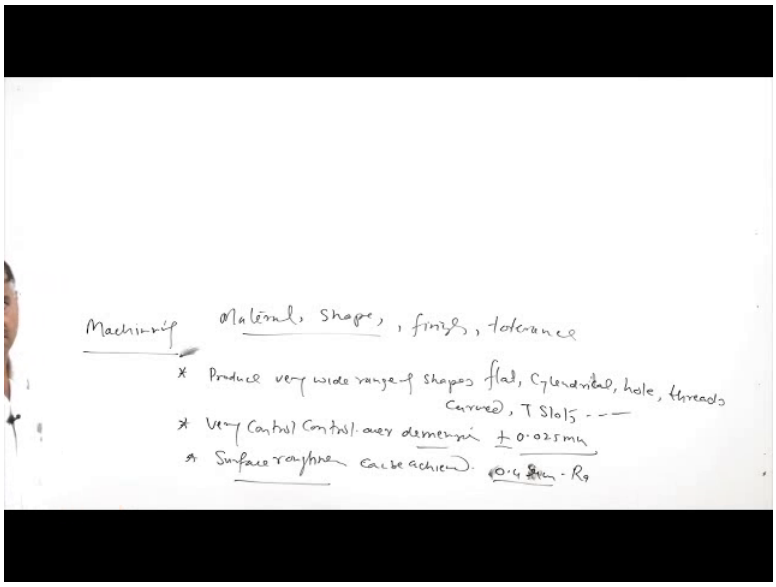

Another good reason is that capability to produce capability to produce a very wide range of the shapes, which includes like the flat surfaces cylindrical features like hole, threads and curved or control surfaces like convex or the concave surfaces then the t slots and many other the complex shapes and geometries which are commonly used in the engineering component. Another feature is that a very close control over the dimensions can be realized, control over the dimensions can be realized with the merge. So, proper using proper control over the process parameters, like speed feed depth of cut and proper machines can help us to have the dimensional tolerance as low as 0.25 mm and the surface finish.

So, the surface roughness were also very low surface roughness can be achieved by the machining processes, which can be as low as 0.4 micrometer for in terms of the Ra as the surface roughness parameter. So, because of these capabilities to produce wide range to process, the wide range of the material ability to produce the variety of shapes, very good finish and very close control over that tolerance.

So, these features make the machining process is very versatile and are of the end of the great commercial importance, but apart from these positive features of the machining processes.

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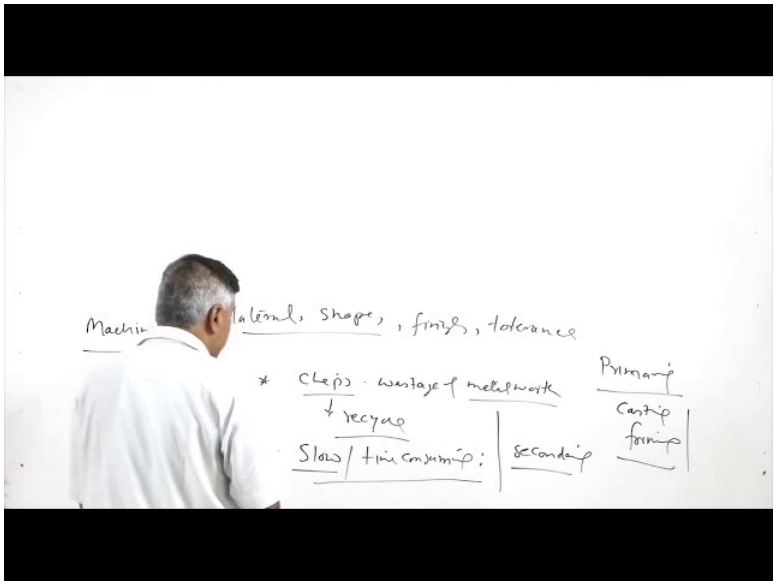

It also has some negative aspects and the 2 negative aspects which are prominent with respect to the machining processes, which can be termed as limitations.

So, one is since the machining processes approach is based on the removal of the extra unwanted material in form of the fine chips. So, such kind of the material is removed in form of the fine chips. So, removal of the material in form of fine chips from the stock, is just like wastage of the metal worth because this cannot be used for any other purpose only thing is that we need to recycle such kind of the material.

So, the loss of the metal worth takes place when the material is removed in form of chips in machining processes and this material needs to be recycled only because it cannot be used for any other purpose and another negative advantage related with this is that, the process is quite slow because it has in this process the material is removed layer by layer sequentially.

For example, if we have very large size of the stock and very small size component need to be made from this, then metal will be removed sequentially layer by layer one by one. So, number of passes of the machining will be needed for this purpose and this process needs to be repeated number of times, unless until we get the desired size and shape. So, sequential removal of the material is involved this makes the process slow and time consuming and to avoid such kind of a negative aspect only, what we do we try to the stock material is first of all brought close to the desired size using the primary processes, like for forming or deformation based processes or casting. So, that it requires as less machining as possible in order to have the desired final size and shape.

So, before going for the machining is basically the secondary processes, primary processes. In primary processes means it will help primary shaping process like casting and forming or deformation based processes, these 2 will be helping us to reach as close to as possible to the final size and shape of the product which is desired. But if we are not able to achieve the desired surface finish and the tolerance then same is realized through the machining.

So, if this is the approach which is used in where in first the primary desired size and shape is achieved through the primary processing, thereafter secondary processing in form of the machining is applied that will help us to really achieve the product in very cost effective and the time effective manner .

So, the first we need to use the primary processing and that the machining processing in order to achieve the desired size and shape. So, as I have said that the machining of the

machining involves the removal of the unwanted extra material in order to get the desired size and shape. So, how the material is to be removed so, that the shape is achieved for this purpose. Basically the relative motion between the tool and the work piece is important and this relative motion basically governs which shape will be achieved.

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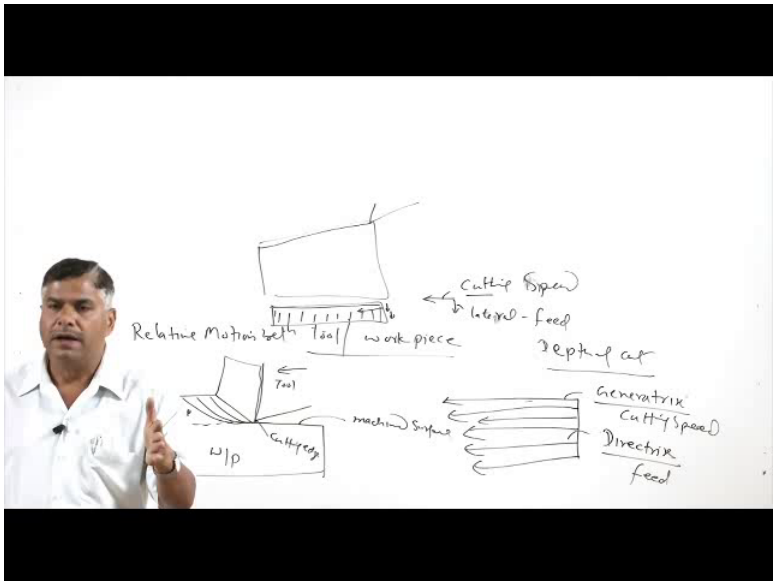

So, basically the two types of the motions are given, for example like this is the tool this is the machined surface, this is the work piece and this is how the chips will be formed and material will be removed. So, this is uncut material which is to be removed and this is the work piece and this is the machined surface.

So, basically the tool is moved so, that the material ahead of the cutting edge which is here this is cutting edge, material head of the cutting edge is compressed. It is deformed the metal very next to the cutting edge is very severely deformed, well that is away from the cutting edge is deformed elastically. So, the relative motion between the tool and the work piece here is 1, like in this case if the work piece is fixed then tool is moving with respect to the work piece and generating this flat surface.

So, in this case it is like this the tool is moved and the material is removed all along this line. So, but if we see the same thing in the top view this will be material will be removed along this line, but since the area is to be covered is this also in order to remove the entire material from the top surface. So, the tool is to be moved literally as well. So,

in this case we needed two movements 1 is along the length of the cut and another is the lateral movement.

So, this lateral the material which is will be removing the material, the case in which the material will be removed along a straight line. In this case this the motion between the tool and work piece results in the cutting speed, while the lateral movement which is used to cover the entire surface area like this one; every time cut is made in one line, the tool is to be moved literally in this particular case so that the entire surface area can be covered. So, this lateral movement is called feed and the depth by which the tool is penetrating to the work piece, say for a in this example this is the depth by which the tool has penetrated into the work piece and this thickness of the material will be moved. So, that is called this is the lateral movement. Lateral movement is feed and the movement of the tool with respect to the work piece, in the line of the cut is the cutting speed and the depth by which the tool penetrates into the work piece is called the depth of cut.

So, especially in this case when the tool movement is linear and the lateral movement is also linear. So, in this case a linear movement will generate 1 straight line along the line of the tool movement and the lateral movement will also help to cover the entire surface area and 1 by 1 the material moved from all these lines and of a simple flat surface is generated.

So, if we see here the movement between the tool and work piece, which is generating a shape is called generatrix and this happens due to the cutting speed. While the lateral movement because of which entire surface area is being covered that is called directories. So, directories or this is termed as feed helps us to achieve the removal of the material from the other surface areas, means from the lateral directions or to the feed basically helps to remove the material from the other locations as well.

So, the later movement of the tool with to cover the machining from to cover, the means for the removal of the material from other areas the feed is given and that helps to produce 1 flat surface especially in this case. So, we will see now how the relative movement between the tool and work piece helps to generate variety of the sizes, variety of the shapes so that this can be used effectively for generating the flat surfaces.

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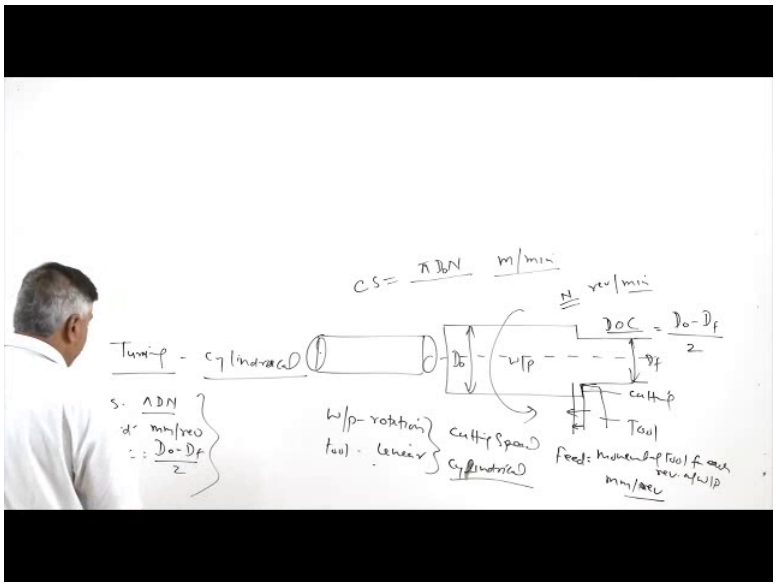

For example, in turning process is known for producing the cylindrical shape components. So, here like cylindrical shape components like this will be produced. So, for this purpose what we do basically like say this one, is the portion where machining has been done and this is our tool.

So, the work piece is rotated this is work piece and this is tool and so when work piece is rotated the tool remains fixed and material is removed all along this line, material is removed like this. So, this is the cutting edge which will be removing the material. So, in this case in the cutting edge is fixed and work piece is moving.

So, the relative movement between the cutting edge and the work piece is called cutting speed and say if the tool work piece is rotating at the n number of revolution per minute and the diameter of the work piece is D o and the final diameter means the cylinder which is being produced in after 1 cut is that D f. Then pi D N this will give us the speed in per minute cutting.

So, the diameter in meter and the rpm is in our revolutions per minute. So, then pi D N will simply give us, the cutting speed in meter per minute and so this is the kind of relative motion between the cutting edge and the work piece which will be producing the cylindrical shape. But in this case the rotational movement, the kind of movement which is being given is the rotational movement to the work piece and which kind of movement

is given to the tool, is moved linear given tool is moved linearly parallel to the axis of rotation of the work piece.

So, the tool is given basically linear movement, so when a combination of these 2 is utilized in the turning process. It results in the cylindrical shape product, similarly in case also similarly in the different machining processes the different kind of the movements are given. So, for covering the entire length of the work piece we need to move the tool linearly parallel to the axis of the work piece. So, amount of movement which is given to the tool linear movement given to the tool for each revolution of the work that is termed as feed.

So, the feed is basically movement of tool for each revolution of work piece. So, that is why it is given mm per revolution, this is how it is expressed and if we compare here initially the diameter was D naught and here D f after the machining. So, the difference change in the diameter which is taking place, D naught minus D f and the kind of the depth by which tool is penetrating into the work piece that if we can simply obtain from the D naught minus D f.

So, this will give us D naught by D naught minus D f divided by 2, this will give us the depth of cut means the depth by which the tool penetrates into the work piece. So, there are now we have the three parameters cutting speed which is being given pi D N and the feed which is basically the linear movement of the tool for each revolution of the work piece and then depth of cut which is basically the change in diameter divided by 2.

So, D naught divided by minus D f divided by 2, this is how the cutting speed feed and depth of cut for turning can be achieved. Similarly the variety of the combinations of the tool and work piece can be used for producing the variety of the shapes. So for example, here like another commonly known the process is the drilling process.

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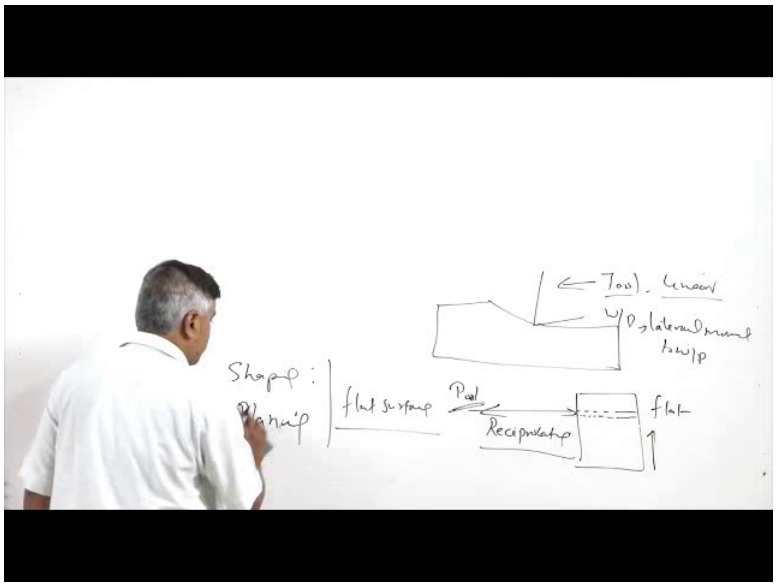

So, in case of the drilling process basically used for creating the holes and in this process work piece is kept fixed and the tool of the various configurations tools are used and they So the tool is basically is known as drill must drill is rotated. So, rotational movement is given to the drill and a rotating drill is also moved along the parallel to the axis of its rotation. So, that drill is fed deep into the work piece until the required depth of the hole is realized.

So, in this case basically the work piece is fixed, but the tool is given the 2 motions; one is the rotational movement and another is linear movement. In case of the linear movement is parallel to the axis of the rotation of the drill and this is given and means that the linear movement is like a given in form of in feed.

Now, there are 2 processes like shaping and the planning these are the 2 processes, which both are used for producing the flat surfaces with the difference that, here in case of the shaping basically the tool is given the linear movement.

So, tool is given the linear movement of in terms of means for the cutting purpose as well as the lateral movement is given lateral movement to the work piece. So, work piece is subjected to the lateral movement and the tool is moved along a particular line. So, like say the tool is always moved along a particular line for producing the cutting, but in order to cover the entire surface area the work piece is moved literally. So, in 1 go cut

will you made here then work which will be moved literally and then cut will be made at another location.

So, these are the kind of combination which should be resulting the flat surfaces. So, in this case basically the tool is moved, means the reciprocating movement is given to the tool. While the work piece is given the lateral movement. So, basically two reciprocates along the line along a particular line and the work piece is moved literally in order to produce the flat surface.

Similarly a similar kind of the combination of the movement is also used in case of the planning, where in the reciprocating movement is given to the work piece and the tool is kept fixed.

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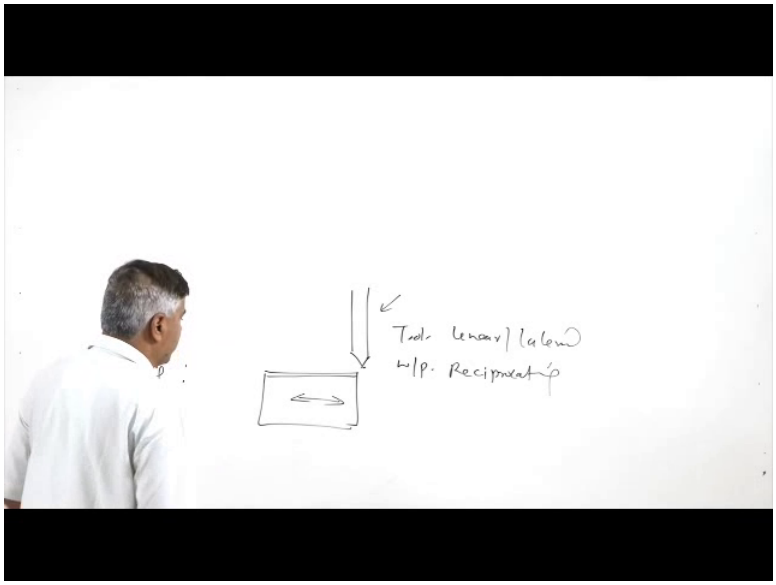

So, the tool location is fixed and the work piece is subjected to the reciprocating movement past the tools. So, the cut will be made and when the cut is made along the 1 line then tool is made given the lateral movement.

So, the tool is subjected to the linear and the lateral movement, linear movement literally with respect to the work piece and the work piece is given the reciprocating movement for producing the flat surfaces. So, this is the difference in case of the shaping work piece is fixed and the given the lateral movement in order to cover the entire surface area. So, means feed is given to the work piece. While in case of the planning, the reciprocating

movement is given to the work piece and the tool is fixed and lateral movement is given to the tool in order to cover the entire surface area of the work piece.

So, now, I will summarize this presentation in this presentation I have given the overview of the machining processes and the how any kind of the chip can be generated by the common processes and basically there are 2 movements which are required like genertrix and directrics and a combination of these two movements helps to achieve the different kind of the shape.

Thank you for your attention.