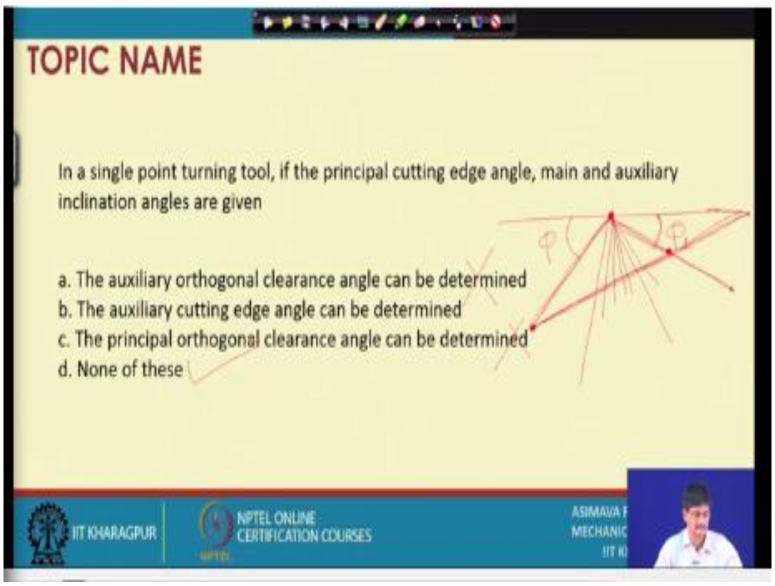
Metal Cutting and Machine Tools
Prof. Asimava Roy Choudhury
Department of Mechanical Engineering
Indian Institute of Technology-Kharagpur

Lecture-06
Different Types of Tools and MCQ

Welcome viewers to the 6th lecture of the course metal cutting and machine tools. So, today we are going to discuss different cutting tools and some leftover numerical problems which you might find uploaded on the website. And hopefully you have been able to make use of the very first week.

(Refer Slide Time: 00:43)



So, in a single point turning tool, if the principal cutting edge main and auxiliary inclination angles are given. The auxiliary orthogonal clearance can be determined, the auxiliary cutting edge angle can be determined, the principal orthogonal clearance can be determined, none of these. So, let us find out what is given? Principal cutting edge angle is given, so this is say the principal cutting edge, the main and auxiliary inclination angles are given.

So, I know the main inclination angle λ I know, so the way this is inclined from the starting point I am knowing this. And the way the inclination angle of the auxiliary cutting is oriented, that also I know. Mind you we are knowing nothing else, in that case whether so let me write down this is known. So, we can say that on the rake surface I am knowing the inclination of a straight line on it, that is the main cutting edge. Do I know the inclination of the rake surface as a whole?

I do not at this moment, because it is only the main cutting edge together with its inclination in a vertical plane. So, but auxiliary inclination angle is given but where is it? Like whether it is here or whether it is here or whether it is here? I do not know. So, in that case the auxiliary orthogonal clearance angle can be determined. Now auxiliary orthogonal clearance angle will require some knowledge about the clearance surface that is not given, so this is not correct.

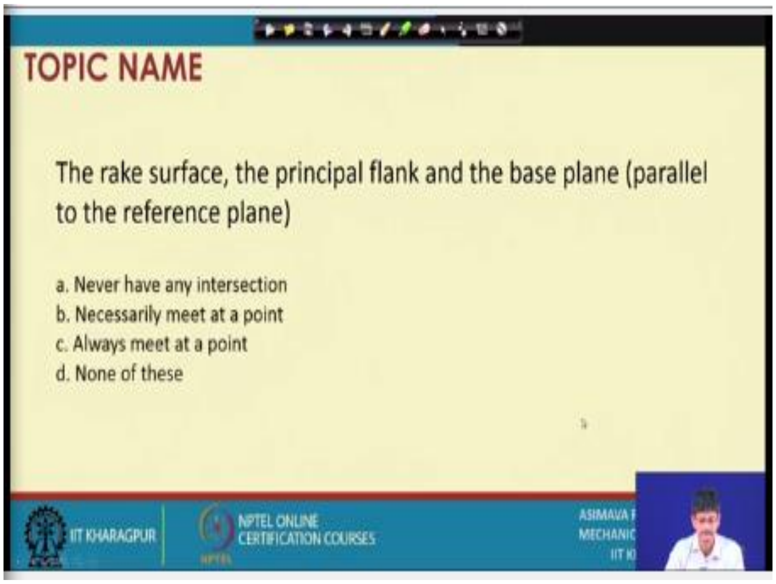
The auxiliary cutting edge angle can be determined, auxiliary cutting edge means that we can essentially find out the orientation of the auxiliary cutting edge, up till now we do not know it. The principal orthogonal clearance angle can be determined, now let us see this one. Principal orthogonal clearance angle, once again this deals with information about the clearance surface, so we cannot define this out.

Just a moment what was the previous one? Auxiliary cutting edge angle, we are keeping it in abeyance. So, principal orthogonal clearance angle, now what is that? Principal orthogonal clearance angle, clearance surface, so this is gone, we do not know this one. So, now comes this one, auxiliary cutting edge angle. Auxiliary cutting edge angle is this one let me draw it φ_1. Suppose we know the auxiliary cutting edge angle, in that case we can orient and we can draw this particular line and we can pinpoint a particular point in space.

And we can say that yes, since I know the auxiliary inclination angle and I know the orientation of this φ_1, I can pinpoint the position of this point in space saying that yes, this belongs to the rake surface. And therefore I can draw this line, and I can say that this is the master line and therefore I know the rake surface completely. But the problem is, that this information has not been provided, auxiliary cutting edge angle.

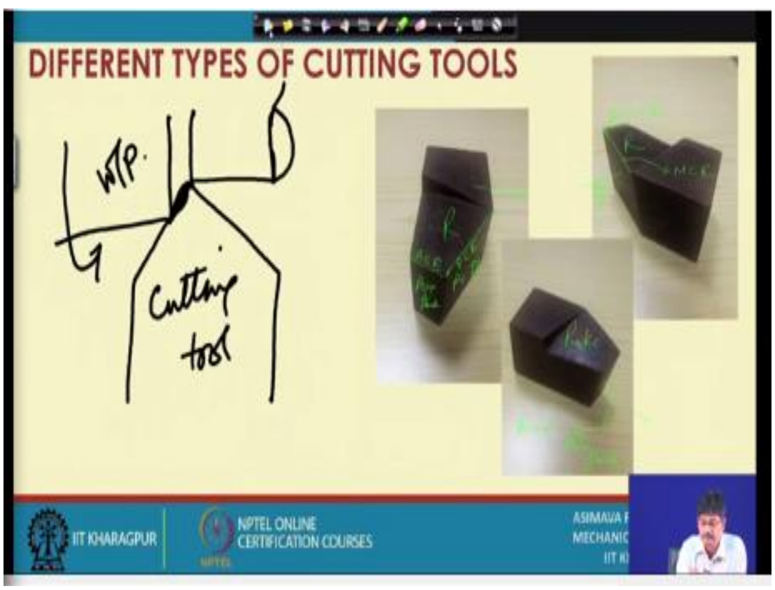
If the auxiliary cutting edge angle is given, I can find out a third point in the rake surface and I can join these 3 and say that yes, this represents the rake surface. But there is not complete information, suppose I say that in that case had I known the master line, in that case I could have shifted along the master line and got different angles. But the master line in the first place is not known, so the answer will be none of these**.** Now let us move on to our final discussion, just a moment**.**

(Refer Slide Time: 06:48)



So, today we have this lecture different cutting tools and numerical problems.

(Refer Slide Time: 07:04)



So, first of all let us start with the lathe tool, the lathe tool we have had so much discussion but we did not have any view of the tool. This is not the actual metallic tool; the metallic tools are very small. So, I could not get good photographs of those, so this is the model wooden model of the cutting tool. But it gives us a good idea what kind of inclinations, what kind of orientations are present here?

For example, suppose someone asks me by giving this particular tool to me, what are the different angles and edges and planes? So, here first of all this surface is the rake surface. So, this is not visible, so let me see whether I can choose some different colors, yellow, good, rake surface or the face of the tool. Here also this one is the rake surface. Which is the principal cutting edge?

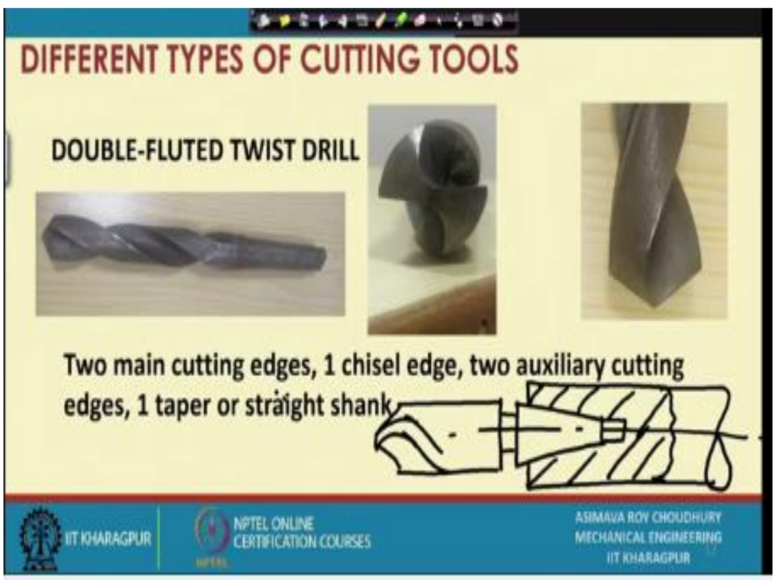
If you are moving the cutter this way, if the cutter is moved this way then this is the principal cutting edge, this is the auxiliary cutting edge, this is the principal flank. This is for example the principal flank I am sorry let me rub it out, this is auxiliary flank, this is principal flank. For example this one is auxiliary flank, it is hardly visible, auxiliary flank, what is this surface then? This one is principal flank, this one is the main cutting edge, this is the auxiliary cutting edge, this one is the main cutting edge.

So, this way you will also become quite conversant in identifying the different parts of the tool. So, once we have had a look about the single point turning tool, why do we refer to it as a single point turning tool? Because the tool has a single point at which it is connected to the workpiece, the workpiece is rotating. And this is the point at which, it is not really a point but any way it is a single point at which the cutter is connected to the workpiece. So, this is our cutting tool, this is our workpiece. Next.

(Refer Slide Time: 11:19)

So, we have already seen this.

(Refer Slide Time: 11:24)

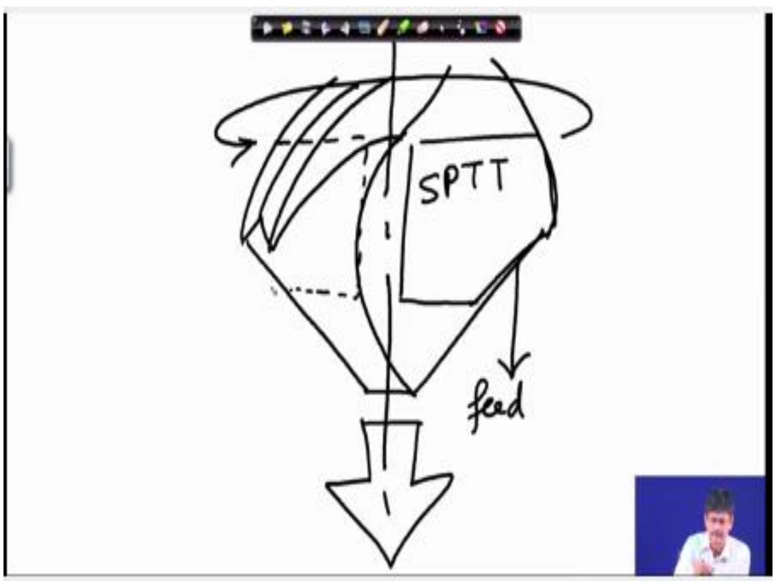


This is a drill tool, what are the characteristic features? A drill what you call it? The drill which is shown is a specific type of drill, what is it called? It is a double fluted twist drill, there are 2 cutting lips here, main 2 cutting lip, there is an auxiliary; there is a chisel edge also. This is one such in this one this is the main body, and this is the shank, the shank portion goes inside tapered hole in the spindle which is generally rotating.

So, this shank looks like this, slightly tapered with the bottom is called a tang this one gets inside, another body with a fitting hole and so this is the axis line, this is how a drill can rotate in an exactly coaxial manner with the axis of rotation. That means the body of the drill can be made etcetera, the drill has this conical portion which fits with another conical hole, so that the axis of this conical portion of the body called spindle.

The axis of the spindle and the axis of the drill they coincide due to one cone going inside the other that is locating the drill is done this way. What about the front of the drill? The front of the drill typically has this sort of a shape as you can see here, there is one cutting lip here, there is another cutting lip on the other side, here it is very clearly shown. This is one cutting lip, there is one cutting lip here and there is another cutting lip on the other side. When the drill is rotating these cutting lips rotate and they remove material from the body.

(Refer Slide Time: 14:35)

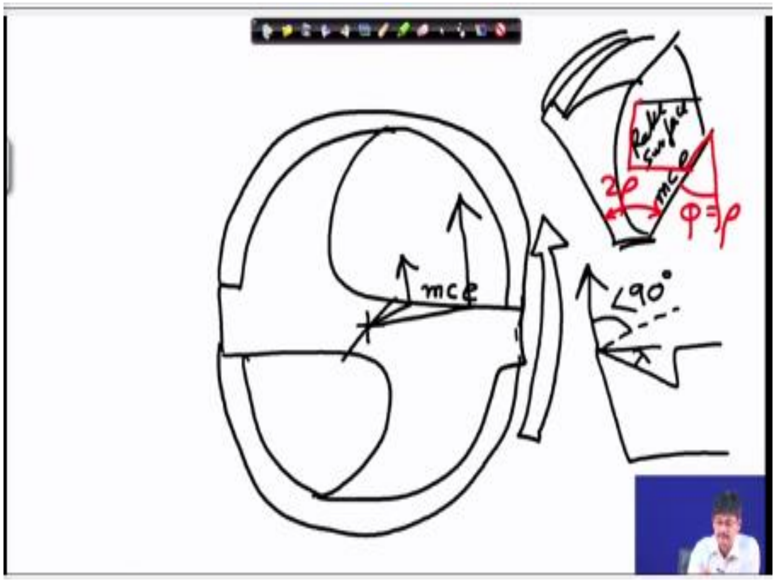


Now if we compare this with a a drill, a single point turning tool how would it look like? So, first of all that if we draw the drill this is one cutting lip, this is another cutting lip and this edge at the top is called the chisel edge. So, when this is rotating, it rotates about this axis. And you know this is the axis of the drill, and the drill procedes this way.

So, if the drill is proceeding this way, how does it compare with the single point turning tool? The single point turning tool can be placed this way, this is it, single point turning tool moving this way, this is the feed direction. Now you might say that there are 2 such cutting lips, how can a single point turning tool simulate it? Yes, there is a similar tool which can be supposed to be on the other side doing the very same thing.

So, a drill may be considered to be case of conjoint single point turning tools, 2 single point turning tools attached together. Now let us see the other view of the drill.

(Refer Slide Time: 16:31)



In the other view it looks like this, that is it, this is the main cutting edge; we can just have a quick look at the other view also. This is the main cutting edge or principal cutting edge, this one is the main cutting edge, therefore this is the rake surface. Rake surface cannot be seen here completely; this is the centre of the tool as it is rotating it rotates this way. If you rotate it in the opposite direction it will not cut.

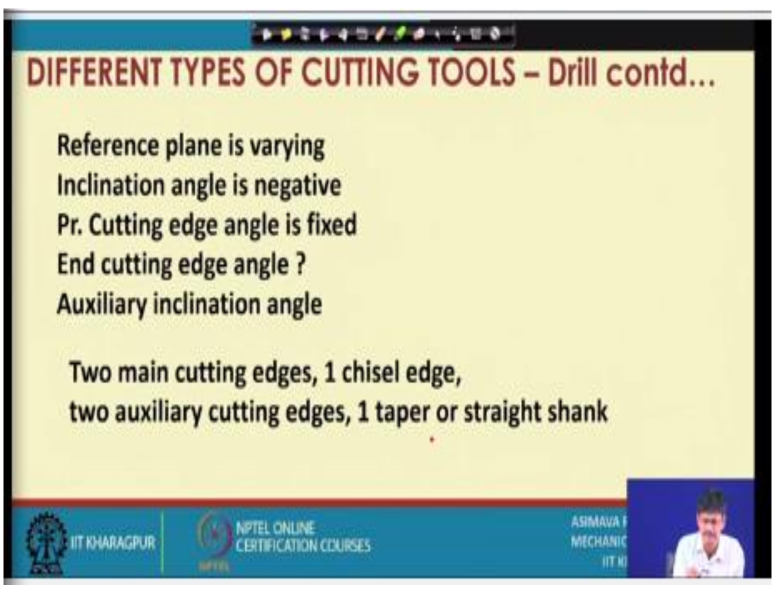
Therefore, if you say that where is the cutting velocity? Direction of cutting velocity, I will say this is the direction of the cutting velocity. Hence it is not perpendicular to this cutting lip but it is making an angle. But the main cutting edge is here, therefore the main cutting edge and this particular cutting velocity they are nowhere are they perpendicular to each other? This is another one, much less of course.

So, we understand that the cutting velocity is changing, why it is changing? Because at smaller radius values, at smaller radii you will develop smaller values of cutting speed, at larger radii you will have larger values of cutting speed. Now what about the inclination angle? The inclination angle interestingly in the drill will always be negative, why? Because this is the cutting edge, this is the velocity vector.

And the cutting edge instead of being a positive rake angle or positive inclination angle say this is the inclination angle. We call this positive; it is moving away from the reference velocity, it is moving towards the reference velocity, it is here for the drill, here, this angle is less than 90º. Therefore, inclination angle always will be negative; you might say as we put the tool here shall we use a different colour for this, yes.

As we have putting the tool here does not it mean that this angle is φ, yes, this is φ. So, if this angle is twice ρ point angle, so φ = ρ in the static system. So, now we understand in case of the drill λ is negative, the plan approach angle is equal to ρ, plan approach angle or principal cutting edge angle is equal to ρ. And there are some other interesting aspects like say let us take that one by one the points. Two main cutting edges, chisel edge, chisel edge I will show you just now, 2 auxiliary cutting edges**.**

(Refer Slide Time: 20:47)



So, here we have reference plane is varying, this we have already seen. Since the velocity direction is going to vary, therefore reference plane will vary in it is orientation. Inclination angle is negative, this also we have noticed. Principal cutting edge angle is fixed, in the fixed system the principal cutting edge angle is fixed as we saw that it is half the point angle. Now I would like to set a question to you, you can think about it and answer later on.

What is the value of the end cutting edge angle? And what is the value of the auxiliary inclination angle? If you ask me what is the value of the principal mean inclination angle? I will say it is negative and it is changing from point to point, exact values we will deal with later on. So, these are the main things that we note about the drill geometry. And I am setting a question before you what is the value of the end cutting edge angle in the drill in the twist drill with 2 flutes?

And what is the value of the auxiliary inclination angle? By the way the chisel edge that we were mentioning, the chisel edge is the front most point of the drill, where an additional edge is there. Shall we have a quick look at a figure to find out what is the chisel edge?

(Refer Slide Time: 22:34)

Yes, just a moment, this is the chisel edge let me underscore it in order to emphasize its importance. This is the chisel edge, what does it do? So, here there is the chisel edge, it cannot be seen from this side, it is a chisel edge. What does it do? What is its role? As we have to provide a body to the drill, ideally we would have liked this particular configuration let me show you. Yes, we would have liked this configuration, this is visible.

In this configuration the drill has nothing at the centre and the reference velocities would have been developed this way, inclination angle would have been 0. And the drill would have had as sharp point but there is a problem here, the drill does not have any body in the middle to sustain all the stresses and torque I mean not torque, the stresses that it will be having to endure, so that is a problem.

And these 2 bodies would have been physically different, they only have a point contact, line contact, so that is very difficult to imagine. And therefore in order to produce give it somebody we are having the material put here. And therefore it is having a sufficient thickness and edge forms. What is this surface? Let me draw fresh figure, what is this surface for example?

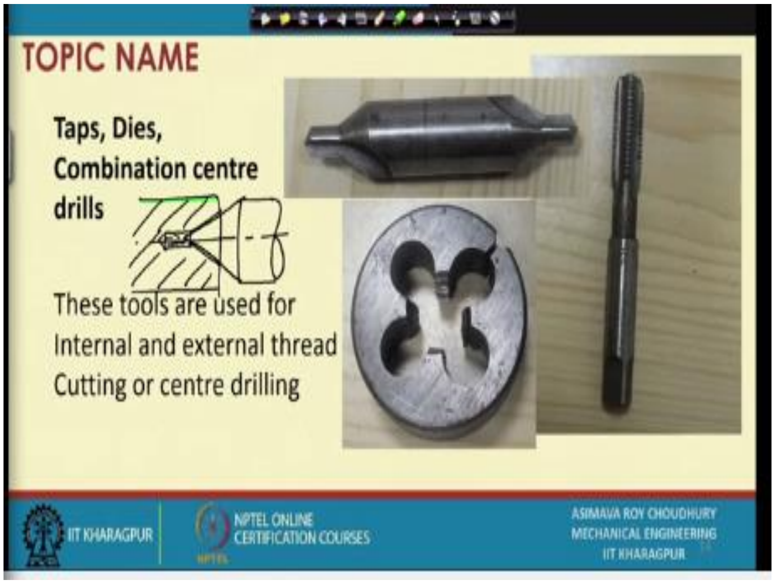
This is this surface, this surface by simulation this is the principal flank, so this is one principal flank, just a moment, this is the principal flank, this is also principal flank. If these are the principal flanks, they are meeting together to form an edge. This chisel edge hardly does any cutting, why? Because the velocity at this point is very low because the radius is very small, no matter how much rotations per minute you are applying you will not get much high velocity.

So, at this point velocity is low and the rake angle is highly negative. If the rake angle is highly negative, in that case instead of cutting with low velocity and a high negative rake instead of having cutting action, you will be having an extruding or indenting or pressing action on the workpiece. The workpiece is sort of pushed out of the way of the drill head that is why when you are using very large drills, huge amount of thrust force will be developed if you have this particular chisel edge acting.

There has been a lot of work in the investigation of the possibility of reducing thrust forces by modifying the chisel edge. Suppose we reduce the chisel edge by grinding this way, we reduce the chisel edge by grinding off this material. That is this is gone, so that you have a sort of point here. So, if you modify the chisel edge the thrust forces will come down, but there will be additional money spent in order to grind the tip and thus modify it.

So, after having learnt about something about the drill, let us quickly go on to the other commonly used tools in better cutting.

(Refer Slide Time: 27:04)

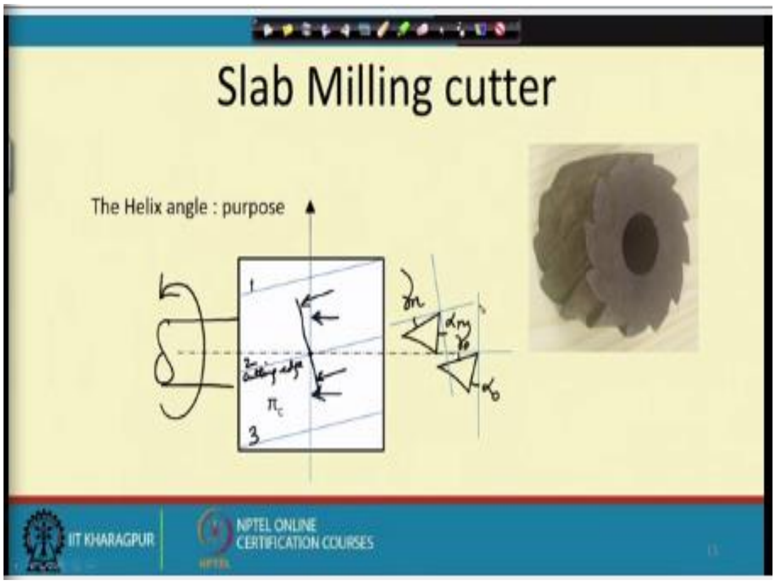


This is called a combination centre drill; it makes such a hole in material. If you have a material like this combination centre drill will typically produce a hole of this type, what is the use of such a hole? Such a hole allows us to put centre inside this, which holds it properly, locates the axis of this hole aligned with this particular centre. I mean the axis of this centre and the axis of the body which is being held, they will become aligned together.

Moreover since we are offering some latitude here, there can be some bending. So, that when you are doing taper turning and other things, this will not be going and indenting it at a particular corner. So, some latitude is there you can put fill this up with lubricant, some sort of lubricating material, so that friction is less and this hole can be done by this one. So, it is having a combination of cutting edges, 2 cutters on 2 sides.

Once this gets blunt you can use the other one. This is called a die and this die is used to cut external threads, this is a tap which is used for cutting internal threads. There can be different types of taps starting tap, finishing tap, bottoming tap etcetera, depending upon the extent to which they have to go inside a hole whether it is a blind hole etcetera. So, next since time is short for this one, let me finish whatever is to be covered.

(Refer Slide Time: 29:36)



We have a milling tool now, so yeah, this is a milling cutter, this is called a slab milling cutter. And as you can notice that cutting teeth they are helical, what is the advantage of helical teeth? Advantage of helical teeth is that at one point in time more than one teeth will be acting, so that the forces are distributed among more teeth, I mean higher number of teeth. And hence the force is not very high on a single tooth, wear and tear is less.

Moreover the cutting is not jerky, if the cutting is jerky, if there is no helix angle the one tooth suddenly engages with the workpiece and there is a jerk, jerks are always detrimental. Also we have to notice this problem is this brings in some end thrust which might create some detrimental effects like buckling. So, we have to be sure that this end thrust can be absorbed without causing much of a problem in the machining process.

Let us have a quick look and at this particular figure, what have we tried to show here? If this is mounted on a shaft, this is the shaft and if it is rotated this way, we have the velocity vector at this point, what is this one? This is the cutting edge, so we write cutting edge, how many cutting edges we have shown? We have shown 1, 2 and 3, if we take a section on the cutting edge since this is the cutting plane this straight plane passing through this point, this is the cutting plane.

And if we take a perpendicular I mean a section perpendicular to it, we will get the orthogonal section. So, therefore if we take this particular section we get this angle as the orthogonal rake and this one as the orthogonal clearance. But if we now observe that the cutting edge is inclined, if we take a section this way we are going to get the normal section. And therefore this one comes out to be normal rake, normal clearance.

Now after all this discussion you might ask me, why are we giving this inclination to the cutting edge? Why is inclination angle provided? What is it is purpose? Now inclination angle if it is 0°, then the chips will come out and they will move over the rake surface. And they will basically travel on the orthogonal plane; the chip velocity will be contained in the orthogonal plane if there is no effect of the side or auxiliary cutting edge.

But if inclination angle is provided the chip is deflected from the orthogonal plane and we can have a desirable direction of the chip by suitable selection of the inclination angle. So, with this we come to the end of the 6th lecture, in the 7th lecture I will be dealing with further discussion on tools, chip formation, cutting forces etcetera and then proceed on to other subjects like tool wear, thank you.