Metal Cutting and Machine Tools
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Lecture-04
Geometry of Single Point Turning Tools-III

Welcome viewers to the fourth lecture of the open online course on metal cutting and machine tools. So, in the last lecture we made some discussions on the relationships between existing between different angles of the single point turning tool in different systems. Like the orthogonal rake system, the machine reference system the normal rake system and that too we did not only restrict our discussion to the rake surface but we also are discussed I think one example from the clearance surface.

The clearance surface means that the tool is bounded on three sides by three planes, one is the rake surface, one is the principal flank or side and the other is the auxiliary flank. So, we established some relationships between the angles in the principal flank and the inclination angle. The inclination angle is shared between the rake surface and the principal flank. So, in these calculations we are generally assuming that some angles that we have shown they are positive. Now coming back to our discussion let us now take up the problem of the last discussion that we left behind.

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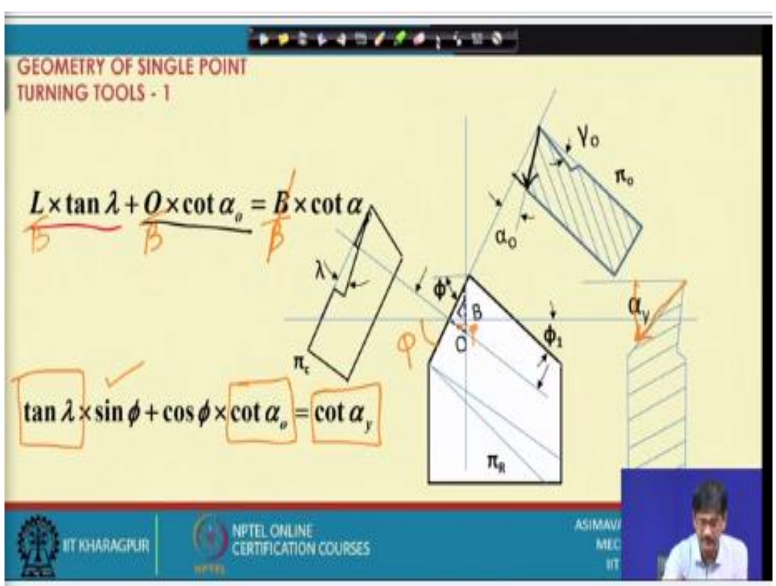

So, for that this was the particular problem that we left behind that you could solve it yourselves, let us look at it once again. This the main trick that we discussed in these problems is that to identify the particular triangular relationship between the vertical distances that we go down in different planes and that we establish the relationship between angles. Here we are saying that as we go down from this point very near to the cutting point down the main cutting edge.

It is shown here this way; we are coming down the main cutting edge in this view. For that we are incurring a vertical distance downwards we are having to move downwards by this vertical distance. What is this vertical distance equal to? As we discussed before it must be equal to $L \tan \lambda$ and that is why we write $L \tan \lambda$ here. So, we get $L \tan \lambda$ as the vertical distance down as you know shown here.

After that we are getting down further along the orthogonal plane by this distance O, what is the vertical distance corresponding to the movement along O? It must be equal to $O \tan \gamma_o$ we are not discussing about the rake surface anymore; we are going down by this distance as it is shown by a dotted line along this line.

We are going down this way, if we go down this way, so once again from the cotangent relationship that we had established last time the vertical distance that we go corresponding to O must be $O \cot \alpha_o$ and that is why let us again underscore it $O \cot \alpha_o$. That means O into cotangent of the orthogonal clearance must be the distance we are going down this way that is fine.

So, this must be equal to the distance that we are going down and transverse direction along the clearance. This is the distance that we are going down going this way and this is the corresponding downward distance. And therefore since α_y is here that will once again be equal to $B \cot \alpha_y$, I am sorry this is slightly covered please just imagine that there is a Y here, not shown very clearly I am sorry.

If that be so once again we identify the B being the hypotenuse, we can divide this by B canceled and therefore we have $\tan \lambda$ multiplied by L by B, now what is L by B? φ being equal to this we understand this must be φ, this is 90º - φ and therefore this is equal to φ, this is φ, if this is φ then L by B must be equal to *sin φ* and that is what we have here, *sin φ*.

So, we are replacing here *sin φ*, O by B must be *cos φ*, *cot α* comes here, so term by term we are simply this repeater and this is the relationship we get. α_y, α_o and *tan λ* can be related this way. So, we have established a relationship among the clearance angles for the main or principal flank in the orthogonal plane, the machine transverse plane and the cutting edge main cutting edge. Now let us move on to the next problem that we have take the cursor a new view and let us move on to the new problem. What does this one state?

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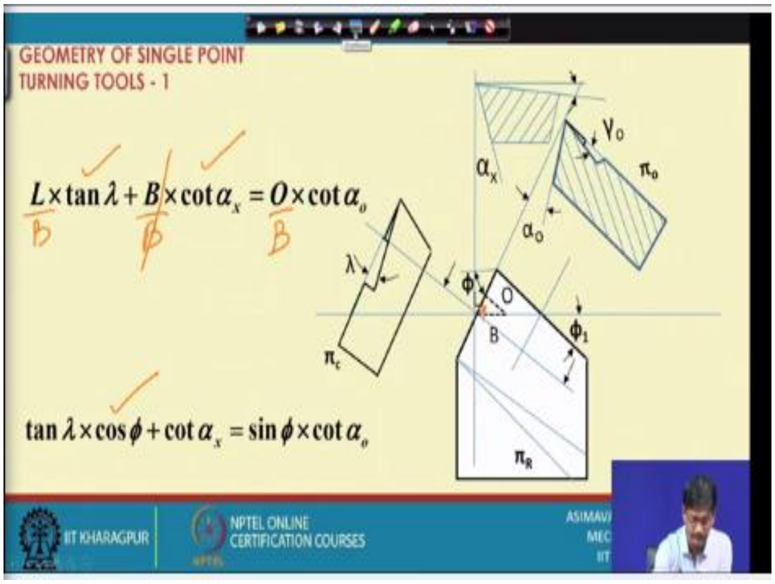

Just like the established relationship between machine transverse plane we can also do it for the machine longitudinal plane. Machine longitudinal plane here in this expression is represented in this direction. So, what are we doing here? We are saying that if we start from a particular point, if we go down along this and along that, it is the same as going down this way by this amount.

Therefore, if λ is shown to be positive we go down here, if this α_o is shown here as positive and clearance angles have to be positive anyway. So, we go down along this and therefore it must be *B cot α*. Now that you have got the hang of it you can move very fast also it must be *L tan λ* we have to be alert about this. This is tan while this is cot.

So as we are moving in the clearance surface $L \tan \lambda + B \cot \alpha_x$ must be equal to $O \cot \alpha_o$ in this plane, here, $\cot \alpha_o$. You will find that this triangle that I am drawing and in the figure they might not exactly correspond drawing wise. So, please understand that I am not strictly following the drawing rules and principles and traces etcetera. So, let us move right away in the same method that we have taken up before L by B, B by B, O by B that is it.

We get $\cot \alpha_x$ equal to I mean $\tan \lambda$ into what is L by B let us see. This must be our φ and therefore L by B is nothing but $\cos \varphi$, so that is why we get $\cos \varphi$, $\tan \lambda \cos \varphi + \cot \alpha_x = \sin \varphi * \cot \alpha_o$ alright. So, this one helps us in relating that what you call it inclination angle, the clearance the side clearance of the main cutting edge may other principal flank and orthogonal clearance in the principal flank.

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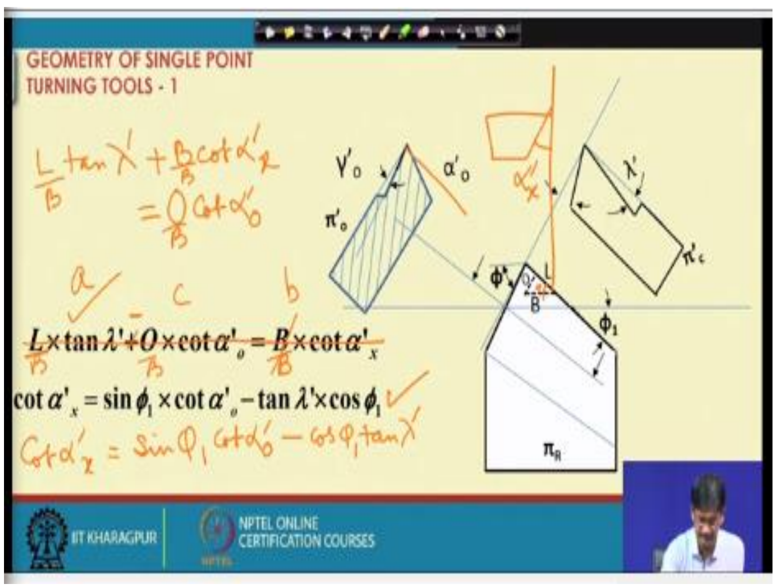

So, in this one what do we have? Now we move on to the auxiliary flank, up till now we have been discussing problems on the principal flank and of course the rake surface now we go to the auxiliary flank. In the auxiliary flank what are we trying to establish? First of all, we have shown the sections that we are going to obtain here, that this section is perpendicular to the auxiliary cutting plane, this is the trace of the auxiliary cutting plane.

This is what we see in the auxiliary cutting plane, λ' the auxiliary inclination angle. You might say why are we giving the inclination angle at all, we could have kept it to be zero. Generally whatever rake angle we are using, if we give a positive rake it will help us in reducing the forces and facilitating chip formation. Higher the rake positive rake angle less will be the change in momentum of the chip coming out and therefore less will be the forces.

Then comes a question then why do not you use huge positive values of the rake angle? That is because in that case the tool will become very weak; even if it does not break it is likely to bend as a cantilever which will reduce our accuracy. And therefore rake angles are generally restricted to not more than 15º and more frequently it is 5º to 7º. So, we use small values of rake but if we can use positive rake angles it will help us in facilitating chip formation and reducing forces.

Do we ever use negative rake angle? Yes, whenever we want the stresses occurring on the rake surface to be purely compressive. In that case I mean if the stresses created by the chips impacting on the tool or applying pressure on the tool if we want this pressure to be not if we want this pressure not to create tensile forces then we will try to use negative rake. Negative rake ensures that there will be no tensile forces on the tool body.

That is because generally the materials which make up the tools they are strong in compression and they are weak in tension. In that case if we apply tension they will break very easily. If you use positive rake it can be shown that they are likely to develop tensile stresses inside them and by bending as a beam which we will be discussing later on. Coming back to our present discussion, so let us take up a problem on the auxiliary clearance angles.

What are auxiliary clearance angles? So, you might say that if you are talking about the auxiliary cutting edge and the auxiliary flank then how come we have not discussed about auxiliary rake angles, this is a very pertinent question, yes. Auxiliary rake angles should have been discussed and we should have established relationships between those angles etcetera. But there is a particular limit to what we should discuss in tool geometry there is no end of it. Since this is only a 10-hour lecture course, so I will be giving you the basic essence.

And I am sure that with the knowledge that you acquire here and the confidence that you will be having, you will easily be able to establish relationships between say auxiliary orthogonal rake auxiliary transverse rake or auxiliary side rake, relationships between these angles. We have yet another class in which we are supposed to discuss the fifth lecture that means the one directly after this we are supposed to discuss numerical problems.

So, there I will take the opportunity to discuss some problems in which we have not made any earlier discussion, it will both give you the experience of solving for the auxiliary rake angles and it will help us in solving numerical problems also. So, coming back to this, now we are discussing about the auxiliary cutting edge and the relationships between the inclination angle and the clearance angles in that plane.

So, when we are considering this particular triangle we are saying that suppose I am going down the auxiliary cutting edge. Then what is going to be the relationship existing between these vertical movements downwards. If you see the auxiliary orthogonal plane from this point we are moving down and I have not drawn the auxiliary side rake auxiliary clearance, we can draw it here itself. Let me take this opportunity to draw it if we move from here this is the point of cut if you move upwards we can draw this section of the tool and this will be our auxiliary side clearance.

So, if this be our auxiliary side clearance therefore we are moving down this way, sorry once again I made a mistake we are going to move this way down, let me draw that also. This is our shows our downward movement. So, we are moving down this way and we will say that the amount that we have moved down here and the amount that moved down here should be equal to this total movement.

So, let us start this one is again $L\ tan\ \lambda'$ from our previous experience $L\ tan\ \lambda'$, what extra movement are we executing here? This must be equal to $B\ cot\ \alpha'_x$ this one should be $B\ cot\ \alpha'_x$ do we have it correctly here? If we are going down from this point reaching this point we can also go down this way and that way. So, we are or we can do one thing if we are going down from this point but we are moving up here I think there might be an issue at this point.

Let me have a look once again, $L \tan \lambda'$ is this distance and then I move further down along this one, so this is equal to this expression. So, I will do one thing I will introduce one negative sign here. So, that it is $L \tan \lambda'$ this one and here also I introduce a minus sign here. So, basically a + b = c, if that be so let us see what the expression of $\cot \alpha'_x$ comes out to be, $\cot \alpha'_x$ if we take it to this side alone. In that case first of all B is divided I mean B divides this, this and this, this gets cancelled out and what we will have is that if this is coming to this side $\cot \alpha'_o$ will be positive and this one will be negative.

So, please bear with this particular change, I will write the proper equation here, this one I cancel out and I write $L \tan \lambda' + B \cot \alpha'_x$ must be equal to $O \cot \alpha'_o$, this is the relation that we are talking about. If this be so then $O \cot \alpha'_o$ this one is everyone is going to be divided by B, B and B. So, that we will have $B \cot \alpha'_x$ = O by B**.**

So, this is φ_1 and therefore this is φ_1, this is φ_1, so O by B happens to be $\sin \varphi_1$. So, we have O by B $\sin \varphi_1$ multiplied by $\cot \alpha'_o + \cos \varphi_1$ multiplied by since α'_x is kept here it is equal to $\sin \varphi \cot \alpha'_o$ it will be $-\cos \varphi_1$ which is L by B, $\cos \varphi_1$ into $\tan \lambda'$. So, I am sorry there is a change in this particular expression, so I will cut this out as well.

And we have this relation existing $\cot \alpha'_x = \sin \varphi_1 * \cot \alpha'_o - \tan \lambda' \cos \varphi_1$, just a minute is not that correct? The same let me do that, so $\cot \alpha'_x = \sin \varphi_1 * \cot \alpha'_o - \cos \varphi_1 * \tan \lambda'$, this one is correct. So, what did go wrong the last time? Last time we had as a change in sign I think only we had only a change in sign.

So, everything is alright now with the cancellation of this expression. So, please pardon me for the change but now we are sure that we have got the correct result.

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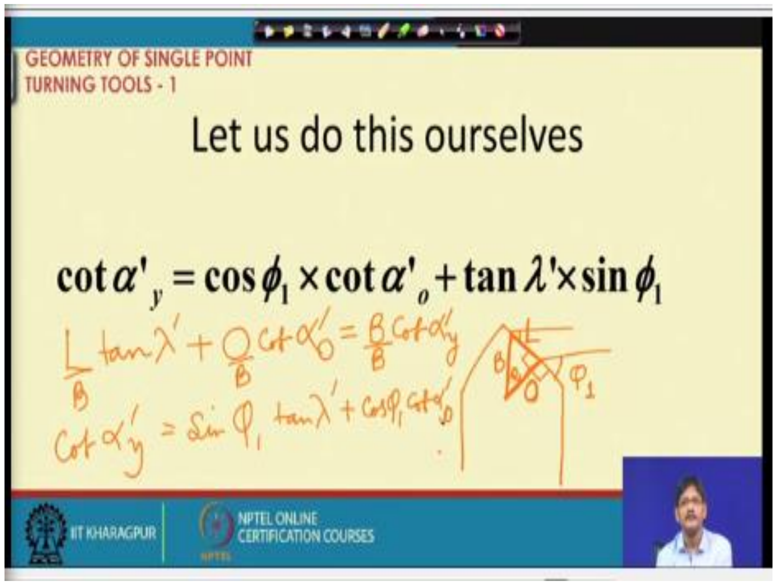

So, last of all in this particular section let us do these ourselves completely, that is finding out cot the value of $cot\ \alpha'_y$ in terms of $cot\ \alpha'_o$ and $tan\ \lambda'$. So, this would mean that we have this sort of relationship this is our tool. So, this will give us good practice let us see, I have α'_o, I α'_y and I have $tan\ \lambda$. So, the triangle that I have to draw will be essentially having machine transverse plane.

It will be having auxiliary orthogonal, so auxiliary machine transverse plane of auxiliary orthogonal and this one. So, if I move down this way and if I move down this way I will be coming to this particular distance down this way. So, let us name them as back and L and O, what will be this angle? This is φ_1, end cutting edge angle, so in that case let us quickly write the relationship that we can establish.

$L\ tan\ \lambda'$, we have gone down this way, now we will go down this way plus O tan what is this? This one must be the here is yes, if you kindly remember we have to use cotangent here so let us use that $cot\ \alpha'_o$ equal to, what is it equal to? This transverse direction we have B * $cot\ \alpha'_y$ and therefore if we divide it by B, so we have $cot\ \alpha'_y$ equal to what else do we have here right, L by B.

Since this is φ and this is a right angle, no that does not seem to be here right angle yeah this is a right angle, this is also a right angle and this is φ, right. If this is φ_1, this must be φ_1, so this is our angle of interest. So, if this is φ_1 L by B is nothing but $sin\ \varphi_1$ into $tan\ \lambda'$ this term + O by B therefore is $cos\ \varphi_1$ into $cot\ \alpha'_o$. Hence we come to the conclusion that this expression given here is correct and we have derived it.

So, after this we will also have some discussion on another system which is used for grinding of different tools which is called the maximum rake system. And after that you will be having full confidence to convert from one system to another. In the next lecture when we are going to discuss with different types of tools, we will look at these tools in the light of the different angles that they bear on their different phases.

For example, if we look at a drill we will try to see which one is its rake surface? Which one is its clearance angle I mean yeah clearance angle? Which is its inclination angle? What is its principal cutting edge angle? How many cutting edges it has in the first place etcetera? So, we are going to look at different tools like drilling tools, milling tools and so many other tools are there. So, with this we come to the end of the fourth lecture, thank you very much.