Indian Institute of Technology Kanpur

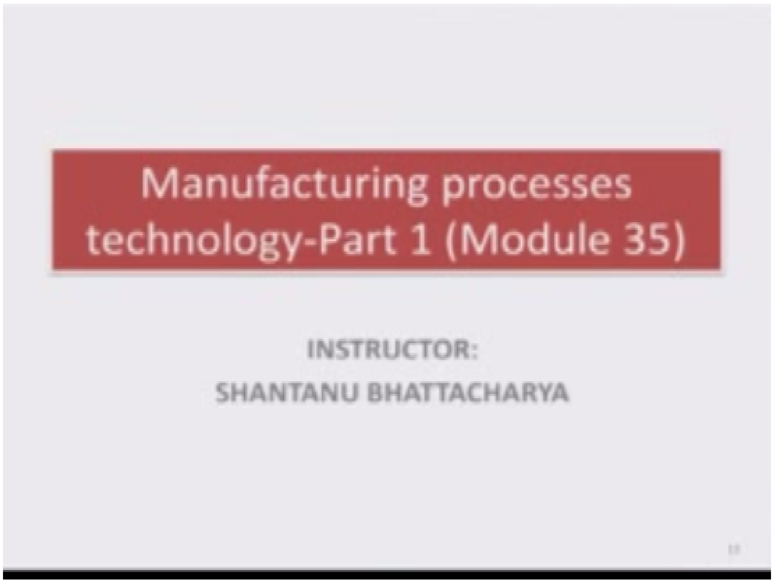
National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Manufacturing Process Technology – Part – 1

Module – 35

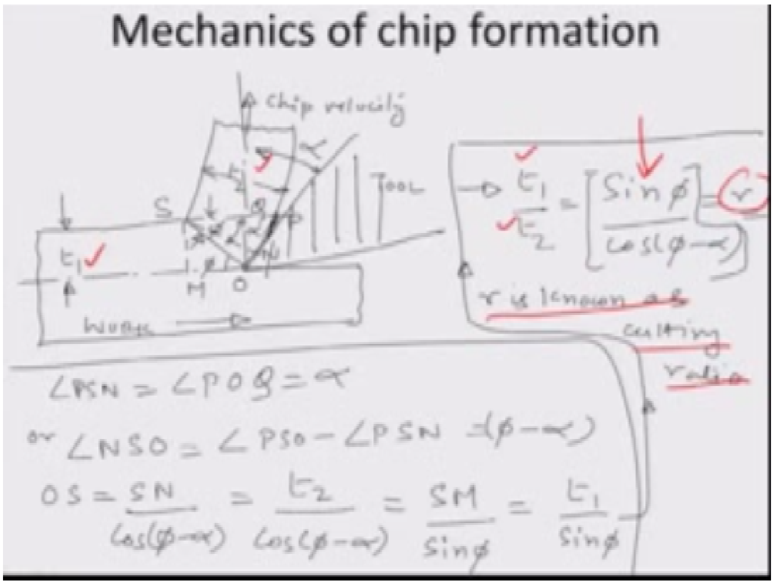
by
Prof. Shantanu Bhattacharya

(Refer Slide Time: 00:17)



Hello and welcome to this manufacturing process technology part 1, module 35. We were talking about the chip thickness ratio.

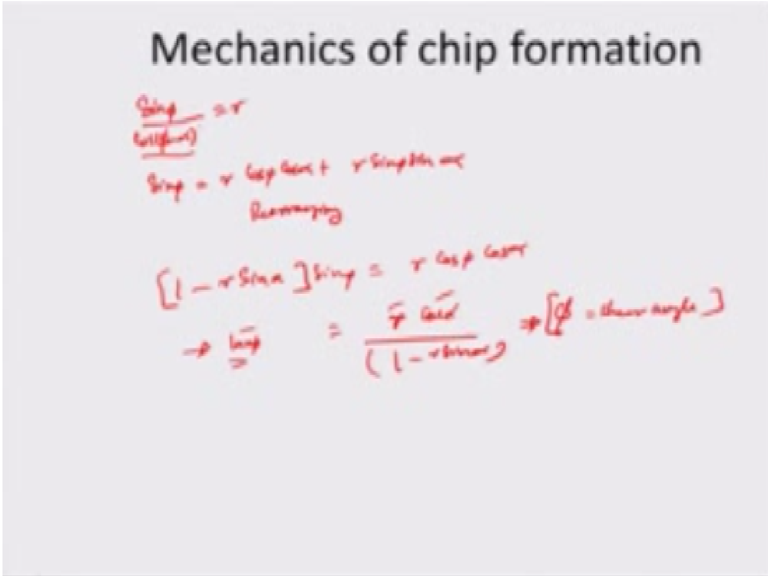
(Refer Slide Time: 00:24)



And in context of that we have derived out this formulation related to the ratio of t_1 and t_2, t_1 is being the uncut chip thickness and t_2 being the cut chip thickness. And it basically resulted in the angler ratio sin φ / cos(φ – α). And this is very important term the cutting ratio, because that determines the lot of properties to the chipping process and it also determines how smooth would be the surface finish based on the different velocities and the depth of cut and cutting ratio all these terms together.

$$\angle PSN = \angle POQ = \alpha$$
$$\angle NSO = \angle PSO - \angle PSN = \varnothing - \propto$$

(Refer Slide Time: 00:55)



So let us now do a little bit of mathematical conversion here, we already had sin φ divided by cos of φ – α = r and from that formulation we can always have sin φ is r cos φ cos α + r sin φ sin α. I am just expanding the cos (φ – α) term here. And then we do some rearranging and try to get all the sin φ is together, so I have (1 – r sin α) sin φ on one side and that becomes equal to r cos φ cos α.

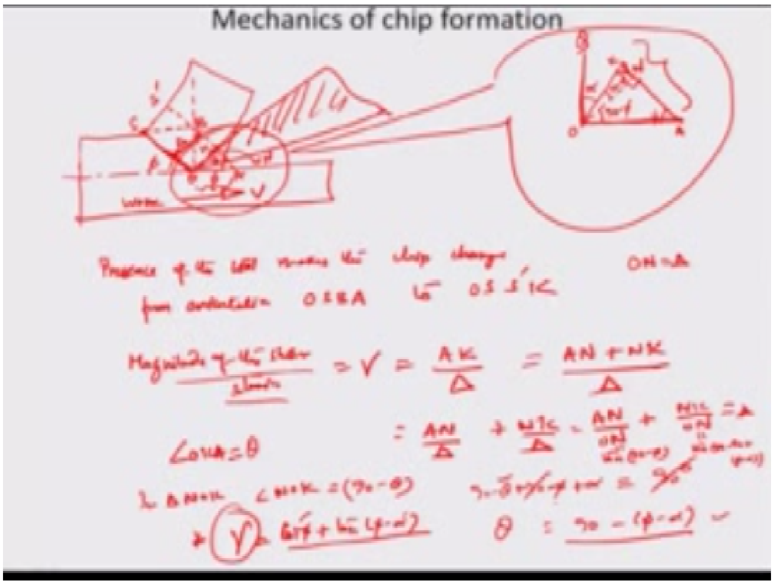
$$OS=\frac{SN}{\cos(\varnothing-\propto)}=\frac{t_2}{\cos(\varnothing-\propto)}=\frac{SM}{\sin\varnothing}=\frac{t_1}{\sin\varnothing}$$

$$\frac{t_1}{t_2}=\frac{\sin\varnothing}{\cos(\varnothing-\propto)}=r$$

$$\tan\varnothing=\frac{r\cos\propto}{1-r\sin\propto}$$

And so from that I can easily have tan φ which is sin φ / cos φ is r cos α / 1- r sin α. So we have a deterministic formulation for determining the here angle φ and basically the φ would really depend on what is the r and what is the α that is how the tool makes an angle with respective to the vertical of the break face of the tool makes an angle with respective to the vertical in any cutting process.

(Refer Slide Time: 02:46)



$$\gamma = \frac{AK}{\Delta}$$

$$\angle KAO = \varnothing$$

$$\frac{\pi}{2} + \alpha = \angle OKA + \varnothing$$

$$\angle OKA = \frac{\pi}{2} + \alpha - \varnothing$$

$$\gamma = \frac{AK}{\Delta} = \frac{AN + NK}{ON} = \cot\varnothing + \tan\angle KON$$

$$\gamma = \cot\varnothing + \tan\left(\varnothing - \alpha\right)$$

So having said that now we want to just further take one geometrical estimate of what is going to be the shear strain which is involved in the chipping process for that let us actually just draw this chipping formulation process again. Let us say this is the chipping action which is happening and point to that there is a shear angle which has been formulated, let this angle φ be there with respect to the work pieces surface.

And we have the extension of the work piece surface. So this right here is the rack angle and φ and this is the remaining portion of the cut surface, this right here is the tool. So we making a clearance angle on the tool on one side and the rack angle of the other side. So having said that now we want to really find out what is going to be the total shear strength that is needed to do this the chipping action that is going to take place.

So let us call this point S as usual, and what we do here is this is the work, this is the direction and motion of the work V, this point we call O. And what we are now interested in is to sort of draw a line which is parallel to the shear plane okay, this is the shear plane. So we draw a line parallel to the shear plane, in a way so that the angle that this line makes with respect to the finished work pieces also in the same φ okay.

And then we consider a triangle by putting and we call this point A and the point which is obtained by just projecting the point S forward and the intersection with the line that we have just drawn here as the point B, and the point which is corresponding to the tool chip interface here with the intersection of the dotted line that we have just drawn as the point K okay, so this point is K.

So if we were to actually drop a perpendicular form the point O on the surface AK let us call that perpendicular here connected to the dotted line as the point N. We have a case here where the total amount of deformation that would otherwise happened to a surface, because of the cutting action can be easily record. So if we just look at a magnified view of this particular region right here, let us draw this region somewhere here and a call out.

So we have now a line which is perpendicular at the point O where with respect to that you define the rack angle, so this line with a line OA which is corresponding to this flank of the triangle that has been illustrated. And then a point K here somewhere here which is corresponding to the point where the line parallel to the shear plane has cut the tool chip interface.

And then a line jointing the points A and K obviously the angle here of this line along the A B direction a part of it, segment of it AK is add an angle φ with respect to the finished work piece, and you have a perpendicular dropped from O all the way to the point AK and this we call SN. So if I consider the initial thickness of the chip to be Δ, let us say the thickness is defined here.

For example, this particular thickness is Δ, and we want to find out what is really the deformation which is happened on to the chip for I would say that the presence of the tool makes the chip change from orientation OSBA to the orientation, if I call this let us say prime OSS'K. So basically, the chip present is like this, you know it is like this parallelepiped that you can look at it okay.

So this is the parallelepiped OSBA all the way here and the chip is being deformed because of the chipping action or the chipping process because of this next element which happened here is OKS'S. So the total amount of shear strain, of the magnitude of the shear strain would actually be hold to γ is the total displacement that has happened to this element moving from OABS to OKS'S okay, that is total displacement is AK divided by the initial thickness Δ.

So that is how define the shear strains and in this particular case the AK can again be split up into two parts AN + NK, and the total shear strains magnitude would be AN + NK/Δ. And now let us actually see what are the different values for example what is going to be AN/Δ, and what is going to be NK/Δ okay, and so far doing that we just geometrically tried to estimate the angle OKA.

So the angle OAK is actually this angle right about here and if we consider that to be some value let us say θ, then obviously in the triangle NOK the angle NOK should be equal to 90-θ. So you have a case here that you have an angle 90- θ here which your adding to 90-ϕ and to α and together the sum is actually one right angle which is demonstrated by this AO, and let us call this some value Q, so AOQ.

So then from that the θ can be expressed in terms of ϕ and α, so θ here for example, would be 90-(ϕ-α). And if I were to just explore what is the value AN/Δ, so AN/Δ and Δ is basically ON or where that is the ON was drawn here as a perpendicular, so it is basically the thickness of the un-deformed chip you can say. And so this ON value becomes equal to Δ and AN/ON, so basically this is nothing but AN/ON.

And AN/ON is actually tan(90-ϕ) which can be recorded as cotϕ okay. So this is tan (90-ϕ) +NK/ON and NK/ON is basically again tan(90-θ). So you have this has tan (90-90+ϕ-α) which is actually the value of θ, and so therefore I just continue here the value of the shear strain γ is actually equal to cot(ϕ+tan(ϕ-α). So just by knowing the angles now which is ϕ and α you should be able to predict what is going to be the value of the magnitude of the shear strain which is generated for the chipping process to happen again.

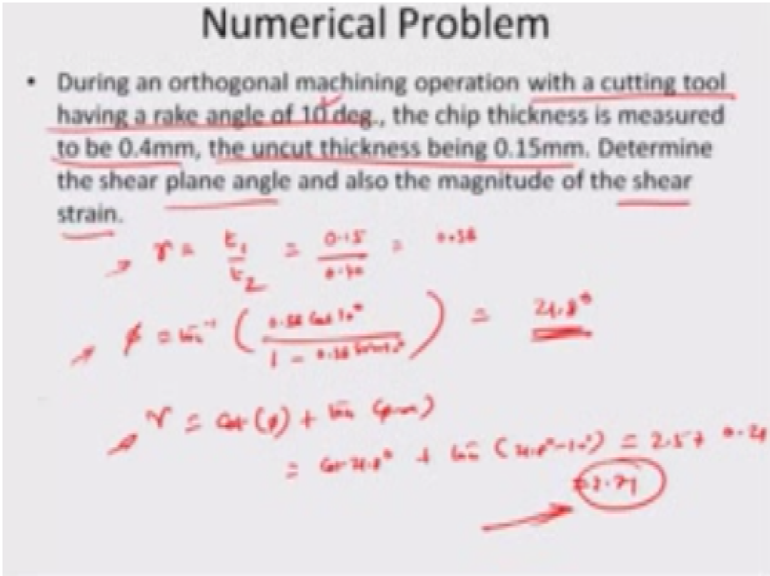
$$\gamma = \frac{AK}{\Delta} = \frac{AN + NK}{ON} = \cot\varnothing + \tan\angle KON$$

$$\gamma = \cot\varnothing + \tan\left(\varnothing - \alpha\right)$$

As a recall we are just assuming the initial thickness of the chip to be this Δ which is actually, although the chip is parallelepiped, but the thickness which actually is the initial thickness is the Δ value and you actually subjecting the chip to shear, so that it moves along the distance AK and from a horizontal orientation it goes like this. So there is some kind of shear deformation which happens and that is what we are trying to get by looking at the magnitude of the shear strain.

A shear strain obviously is the perpendicular deformation per unit the thickness of the material.

(Refer Slide Time: 12:49)



So let us do numerical problem now coming back to this problem here during and orthogonal machining operation with the cutting tool having a rack angle of 10° the chip thickness as measured to be 0.4 mm the uncut thickness is being 0.15 mm. We have to determine the shear plane angle and also the magnitude of the shear strain. So the first think that we have to do is to determine what is they are thickness ratio which is actually t_1/t_2 as we can see earlier.

So this is actually the uncut chip thickness by the cut chip thickness 0.15/0.40 is obviously the thickness changes because of the shear deformation process, so this comes out to be equal to 0.38. And from the r and given value of the rack angle α we could calculate the ϕ and so we have ϕ as the $\tan^{-1}$ of R cos(α)/1-R sin(α), α being 10°. So this comes out to be 21.8 degrees and from that you could further record what is the magnitude of the shear strain γ which is actually cot of just in the last step we have formulated ϕ+tan(ϕ-α).

So this comes out to be equal to cot(21.8°+ tan(21.8°-10°)=2.5 + 0.21 or 2.71. So that is how you calculate the γ value and the r value, and also the ϕ value and this problem example. So having said that this kind of brings as to the end of this particular module, but in the next module so we have now figured out what is the geometrical relationship between the various dimensions as well as angles that the tooling formulates with respect to the surface where the chipping action is taking place.

$$r=\frac{0.15}{0.4}=0.38$$

$$\varnothing=\tan^{-1}\left(\frac{0.38\cos 10^0}{1-0.38\sin 10^0}\right)=21.8^0$$

$$21.8^o+\tan\left(21.8^o-10^o\right)2.5+0.21=2.71$$

$$\gamma=\cot\varnothing+\tan\left(\varnothing-\alpha\right)=\cot$$

The other thing that I would like to point out now is what are the interplay of the forces are one of the relationship between the various forces that are involved and then finally try to do something on energy minimization. So that we can estimate how the shear plane gets formulated by different cutting criteria. So having said that I am going end this module here and look forward to see you in the next module, thank you so much bye.

Acknowledgement

Ministry of Human Resources & Development

Prof. Satyaki Roy
Co – ordinator, NPTEL IIT Kanpur

NPTEL Team
Sanjay Pal
Ashish Singh
Badal Pradhan
Tapobrata Das
Ram Chandra
Dilip Tripathi
Manoj Shrivastava
Padam Shukla
Sanjay Mishra
Shubham Rawat
Shikha Gupta
K.K Mishra
Aradhana Singh
Sweta
Ashutosh Gairola
Dilip Katiyar
Sharwan
Hari Ram
Bhadra Rao
Puneet Kumar Bajpai
Lalty Dutta
Ajay Kanaujia
Shivendra Kumar Tiwari

an IIT Kanpur Production