Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

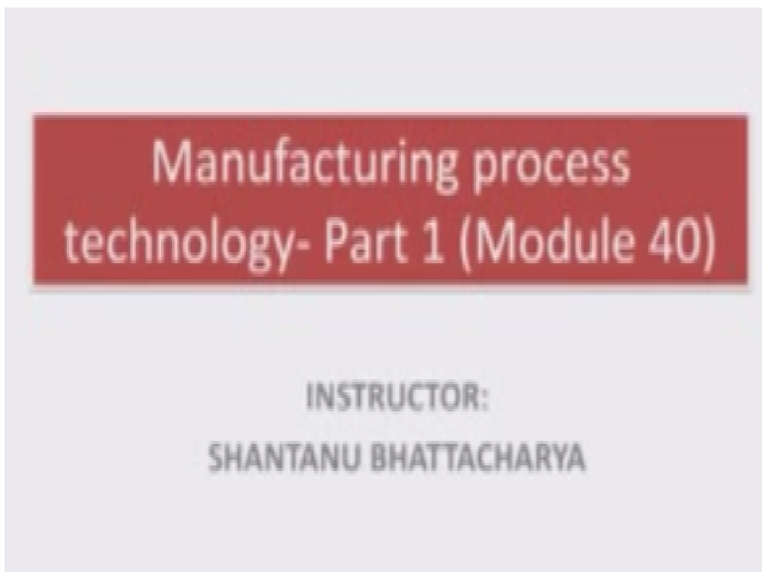
Course Title
Manufacturing Process Technology – Part- 1

Module- 40

by
Prof. Shantanu Bhattacharya

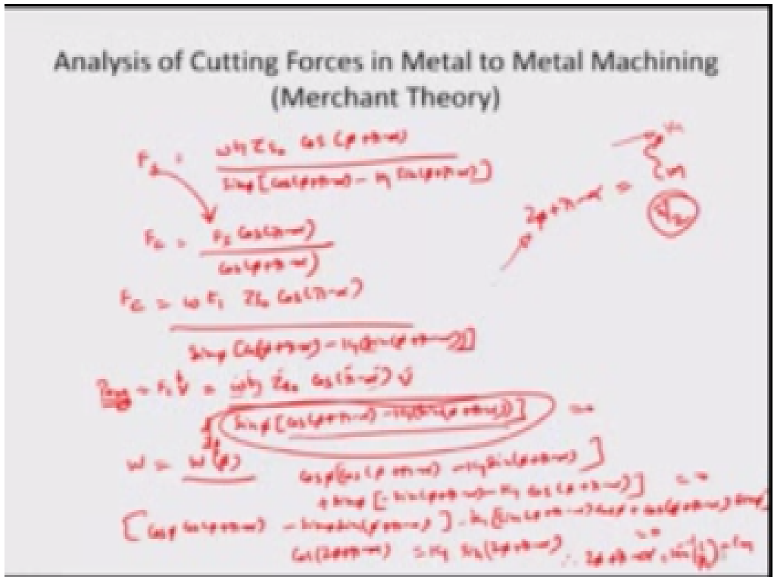
Hello and welcome to this manufacturing process technology part –I module 40.

(Refer Slide Time: 00:16)



We quickly recap of what we did in the last module we were talking about a relationship between the ultimate shear strength of the work material in terms of a component or contribution of the normal stress in the shear plane as well as the actual shear stress component. So in doing that we arrived at a formulation where we try to find out the shear-force the total shear force.

(Refer Slide Time: 00:50)



$$F_S = \frac{w t_1 \tau_{s0}}{\sin \varnothing \left[1 - k_1 \tan(\varnothing + \lambda - \alpha)\right]}$$

$$R = \frac{F_S}{\cos(\varnothing + \lambda - \alpha)}$$

$$F_C = R \cos(\lambda - \alpha)$$

As a function of material properties and the geometric parameters. so in fact we wrote Female Speaker: = Wt_1 τ_{s0} Cos (ϕ + λ - α)/ Sin ϕ (Cos ϕ + λ – α – k1 Sin ϕ + λ – α) okay. so from an earlier relationship which we had obtained between cutting force and shear force and the much in first theory we assumed FC = Fs Cos λ – α / Cos ϕ + λ – α if I just substitute the value of FS into this equation we find out the relationship between FC and all the material in geometric parameters which was a way we did in case of merchant first theory so with the bring them assumptions true we have FC = Wt_1 τ_{s0} Cos λ - α / Sin ϕ Cos [ϕ + λ - α] – k_1 sin ϕ +λ - α, so we now do the force velocity products.

$$F_C = \frac{w t_1 \tau_{s0} \cos(\lambda - \alpha)}{\sin \varnothing \left[\cos(\varnothing + \lambda - \alpha) - k_1 \sin(\varnothing + \lambda - \alpha)\right]}$$

So the average powers the minimum energy consumption for you know the case w2here the average power is represented as the force velocity products so FC times of V where assumed to be constant we need to minimize this so we definitely need to write the power equation in terms of all these different terms Wt_1 τ_{s0} Cos λ - α times of Sin ϕ Cos ϕ +λ - α –k_1 sin ϕ + λ - α times of V and as we assumed earlier we would assume all constant C.

But time invariance in the case of the friction at angle and a certain machining operation the invariance of the velocity of cutting, the rake angle α and constant material properties and geometrical dimensions including the width of the zone of machining as well as the uncut chip thickness so basically the power again W becomes only a function of ϕ and minimization can be obtained by minimizing or maximizing this particular denominator here.

So I would just do the differentiation of this with respect to ϕ and equate that to 0. so this becomes equal to Cos ϕ Cos ϕ + λ - α – k_1 times of sin of [ϕ + λ - α] + sin ϕ times the derivative of this whole term here so this becomes equal to –sin ϕ + λ - α – k_1 cosine of ϕ + λ - α and so this whole term is equated to 0 and from that we are able to if you separate these terms out we are able to write this separately as Cos ϕ + λ - α – sin ϕ sin (ϕ +λ – α) – k_1 times of sin ϕ + λ - α times of Cos ϕ + Cos [ϕ + λ - α] times of sin ϕ.

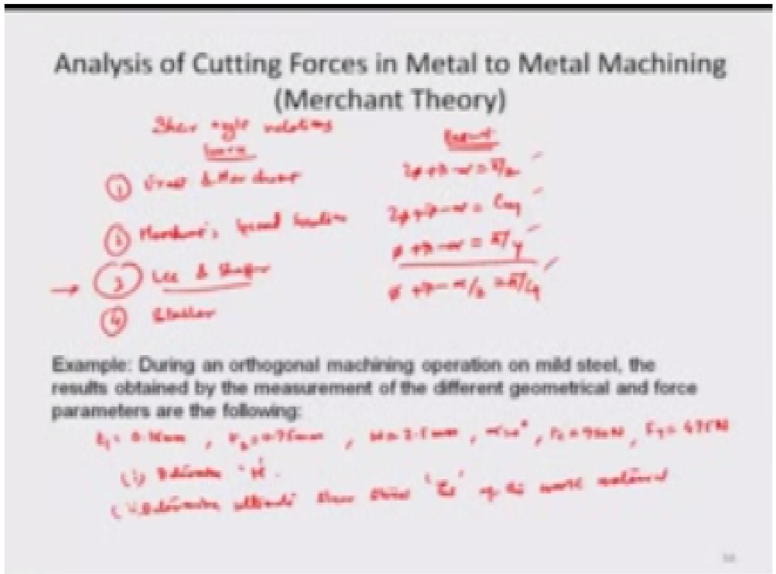
$$\frac{d}{d\varnothing}\{\sin\varnothing[\cos(\varnothing+\lambda-\alpha)-k_1\sin(\varnothing+\lambda-\alpha)]\}=0$$

And this is equated hence this equated to 0, so the way that this can be again rewritten is cos2ϕ+λ-α=k_1.sin2ϕ+λ-α meaning thereby that the 2ϕ+λ-α becomes equal to tan inverse of the value 1/k_1, because you know the sin/Cos is basically the tem component and this is actually a constant k1 so obviously 10 inverse of 1/k1 can be treated as a constant. In other words, our condition.

Now changes to 2ϕ+λ-α= a constant C_m earlier from first theory it was π/2 this c1 now is something which is dependent on the dependent on k_1 value which is actually the coefficient as defined by Bridgman as A, is a multiple of which the normal stress in the shear plane would formulate a part of the ultimate yield strength and shear of the material. So that is how the formulation here becomes little different then the first theory of Ernst- Merchant. in fact there are many other theories proposed by different people and I am going to just not get into the derivation of all those any more but just write down some of the different results that have been obtained by various sources.

$$2\varnothing+\lambda-\alpha=C_m$$
$$C_m=\cot^{-1}k_1$$

(Refer Slide Time: 07:01)



So I call this shear angle relations, the first theory of course is the one which is proposed by Ernst- Merchant. You derived this which indicates the following optimized condition 2ϕ+λ-α recorded as π/2 have a yet another merchant's second theory which comes into being because of the Bridgeman assumptions. so that makes 2ϕ+λ-α become equal to C_m . then there is one theory proposed by Lee and Shaffer where ϕ+λ-α can be recorded as π/4. I am not going to prove this in the interest of time and the yet another proposed by Stabler which talks about ϕ+λ-α/2=π/4.

$$Ernst \wedge Merchant : 2\varnothing+\lambda-\alpha=\frac{\pi}{2}$$

$$Merchan t' ssecond\ solution : 2\varnothing+\lambda-\alpha=C_m$$

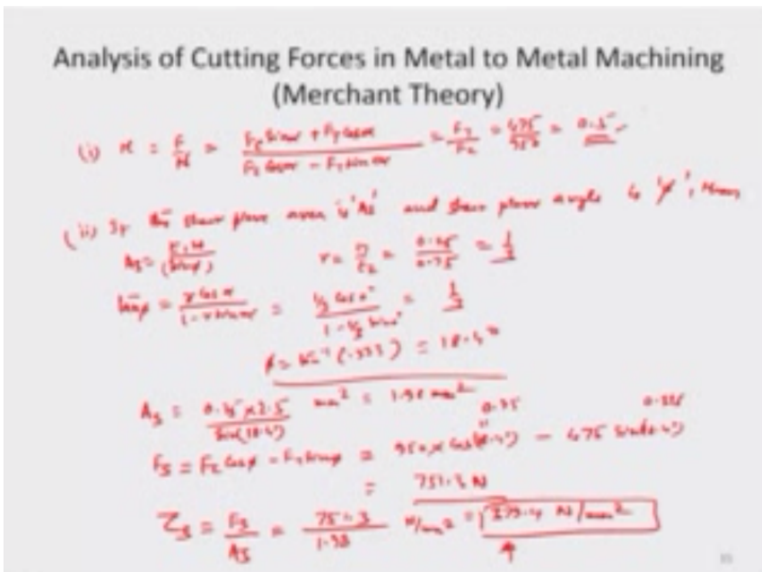
$$lee \wedge Shaffer :: \varnothing+\lambda-\alpha=\frac{\pi}{4}$$

$$Stabler :: \varnothing+\lambda-\frac{\alpha}{2}=\frac{\pi}{4}$$

So with all this on board I think we can now proceed towards doing some numerical examples to estimate what is going to be the value of the different geometric parameters given a certain cutting condition and certain material property and we can actually go for this optimum power consumption criteria to have a good relationship of the whole cutting process. So I would just like to discuss this example, problem here that during an orthogonal machining operation on mild steel the results obtain by measurement of different geometrical and force parameters are following we have the uncut thickness t_1 as 0.25mm the cut thickness so the cut shipped thickness as 0.75mm.

The width of the cutting zone w given as 2.5mm, rake angle of 0 degrees so tool is actually almost perpendicular to the surface that is cutting or scribing and there are force measurements of the cutting as well as tangential force which are required mostly by the tool dynamometers kept near or just on the bottom face of the mounting are of the tool mount so the cutting force is recorded as 950N and the tangential force is recorded as 475N we have to determine the tan of friction angle the coefficient of friction μ. And we also want to determine the ultimate shear stress τ_s of the work material. So having set that let us actually now try to answer eh question point by point.

(Refer Slide Time: 10:10)



$$\mu = \frac{F}{N} = \frac{F_C sin\alpha + F_T cos\alpha}{F_C \cos\varnothing - F_T sin\alpha} = 0.5$$

$$A_s = \frac{w t_1}{\sin\varnothing}$$

$$tan\phi = \frac{rcos\alpha}{1 - rsin\alpha} = \frac{t_1}{t_2} = \frac{1}{3}$$

$$\phi = \tan^{-1}\left(\frac{1}{3}\right) = 18.4^o$$

$$A_s = \frac{w t_1}{\sin\varnothing} = \frac{0.25 * 2.5}{\sin 18.4^o} = 1.98\, mm^2$$

$$F_S = F_C cos\phi - F_T sin\phi = 751.3\, N$$

$$\tau_s = \frac{F_S}{A_s} = 379.4\, N/mm^2$$

So we find out μ by ratio of F / N that is the friction force by the normal reaction and in terms of cutting force and tangential force F can be expressed as FC sign of α + FT cos of α and normal force can be expressed as FC cos of α – F_T sine of α, so obviously this can now because α being 0 it can be recorded as FT/ FC and this becomes equal toi 475 N /950N which is equal to 0.5 so that is what the friction coefficient is μ and the second part addressing the ultimate shear stress τs of the work material if the shear plane area is A_s let us say and the shear plane angle is the angle φ then we have φ or we have the as = t_1w / sin φ of I that is basically the uncut chip thickness times of width of the cutting zone and the component you know t1 / sin φ along the shear plane and the tan φ in that case obviously as I defined earlier is also the cutting ratio r * cos α / 1 – r sin α. in this case r can be calculated to be a third so t_1/ t_2 basically which is 0.25/0.75 as defined the problem 1/3rd so tan Φ becomes equal to 1/3rd cos of 0 degree so divided by 1-1/3 sin of 0 degrees. so basically 1/3rd so ϕ becomes equal to the tan inverse of .333 1/3rd which is 18.4 degrees so that is how you calculate the ϕ also the A_S on the shear plane area and this particular case is basically equal to the thickness t_1 times of the width of the machining zone also recorded as 2.5 mm in the problem divided by sin of ϕ the sin of 18.4 degrees.

Basically comes out 1.98mm^2 and if I wanted to look at what is the value of Fs, so fs can again be recorded as the combination of the cutting forces FC and also the tangential force F ts recorded in the cutting zone has FC cos ϕ-FT sin ϕ look at the equations that have been illustrated earlier so in this case it is to be 950 times of cos of 18.4 degrees which comes out to be about 0.95- of 475 times of sin of 18.4 degrees which actually comes out to be 0.316.

So the totality comes out to be 751.3 N so obviously the τ_s are the shear stress in this cases shear force penetrate the shear plane area so 751.3/the shear plane area which is 1.98 N per mm^2 which comes out to be 379.4 N per mm^2 so that is how you actually tackle these problems about the different unknowns like what would be the shear strength ultimate shear strength in the zone of the cutter etc by looking at the geometrical parameters.

And also looking at the measured forces of in the cutting and the tangential direction at the zone of the cut so with this I would like to end this topic there are any more topics to cover including what is going to be temperature distribution of the cutting zone as well as what is going to be specific energy of cut which is needed but will do this in subsequent module thank you.

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