CMR INSTITUTE OF TECHNOLOGY

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Improvement Test

Sub:	Machine Tools & Operations			Code:	15ME45B
Date:	31 / 05 / 2017	Duration: 90 mins	Max Marks: 50	Sem: IV	Branch: MECH

Answer Any FIVE full Questions

			Marks	OBE CO	OBE RBT
1	A)	Derive force and power relations in turning operation	[6]	CO4	L3
	B)	Explain the difference between orthogonal cutting and oblique cutting.	[4]	CO4	L1
2		Derive an expression for the shear angle in terms of rake angle and chip thickness ratio.	[10]	CO4	L3
3		With the neat sketch derive the conditions $2\phi + \beta - \gamma = \pi/2$.	[10]	CO4	L3
4		Explain the following types of tool wear with necessary sketches: (a) Crater wear (b) Flank wear (c) Corner wear	[10]	CO5	L2
5		Derive the tool wear equations for the following abrasive, adhesive and diffusion wear types.	[10]	CO5	L3
6		Calculate the percentage change in cutting speed required to give 65% reduction in tool life. Take n=0.2	[10]	CO5	L3
7		In an orthogonal cutting process the following data were obtained. Chip length = 96 mm. uncut chip length =240 mm, rake angle used =20^0, depth of cut=0.6 mm. horizontal component of cutting force = 2400 N & vertical thrust force = 240N. Calculate **Shear plane angle, chip thickness, friction angle** and **resultant cutting force** for the given date.	[10]	CO4	L3

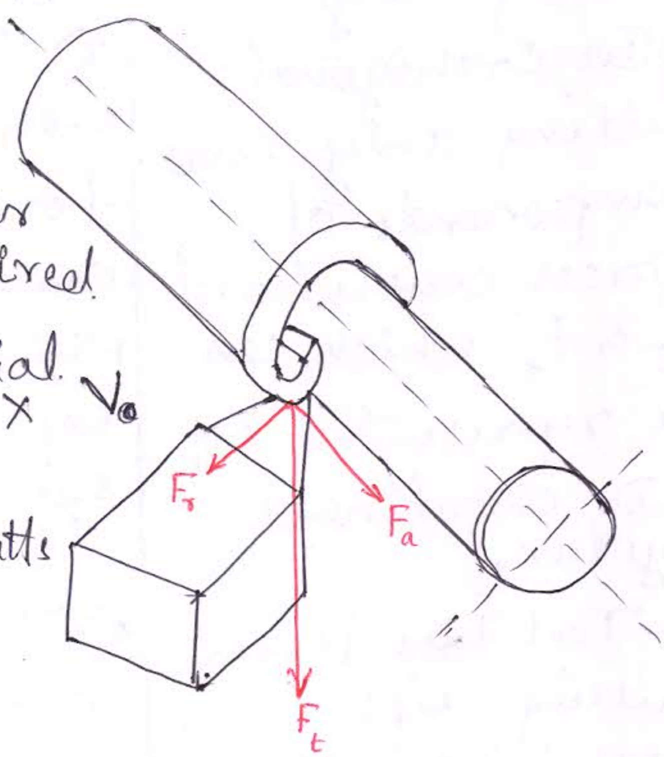
Improvement Test -
Machine Tools & Operations

SEM :- 4th

1)

A) Forces acting in turning process are resolved into three components as. 1

1) Tangential force (F_t).
2) Radial force (F_r)
3) Axial force (F_a)



work done in turning = Power required 2

= tangential force × V_c

$$P = \frac{F_t V}{60} \text{ watts}$$

F_t in Netwons
V is in m/min.

Force components in turning may be represented in exponential form. involving feed, and depth of cut 3

$F_t = R_1 f^{x_1} t^{y_1}$

$F_r = R_2 f^{x_2} t^{y_2}$

$F_a = R_3 f^{x_3} t^{y_3}$

B) Difference between Orthogonal and Oblique cutting operations:

Orthogonal	Oblique.
1) The cutting angle of tool make right angle to the direction of motion	1) The cutting angle of tool face not make right angle to the direction of motion
2) The chip flow in the direction of normal to the cutting edge	2) The chip makes an angle with the normal to the cutting edge.
3) In Orthogonal cutting only two components of forces considered F_c & F_t which can be represented by 2D coordinate system.	3) In oblique cutting three component of forces are considered ~~cutting~~ F_c, F_t and F_r which can be represented by 3D coordinate system.
4) Tool has lesser cutting life	4) Tool has longer cutting life.
5) The chip flow over the tool	5) The chip flow along the sideways

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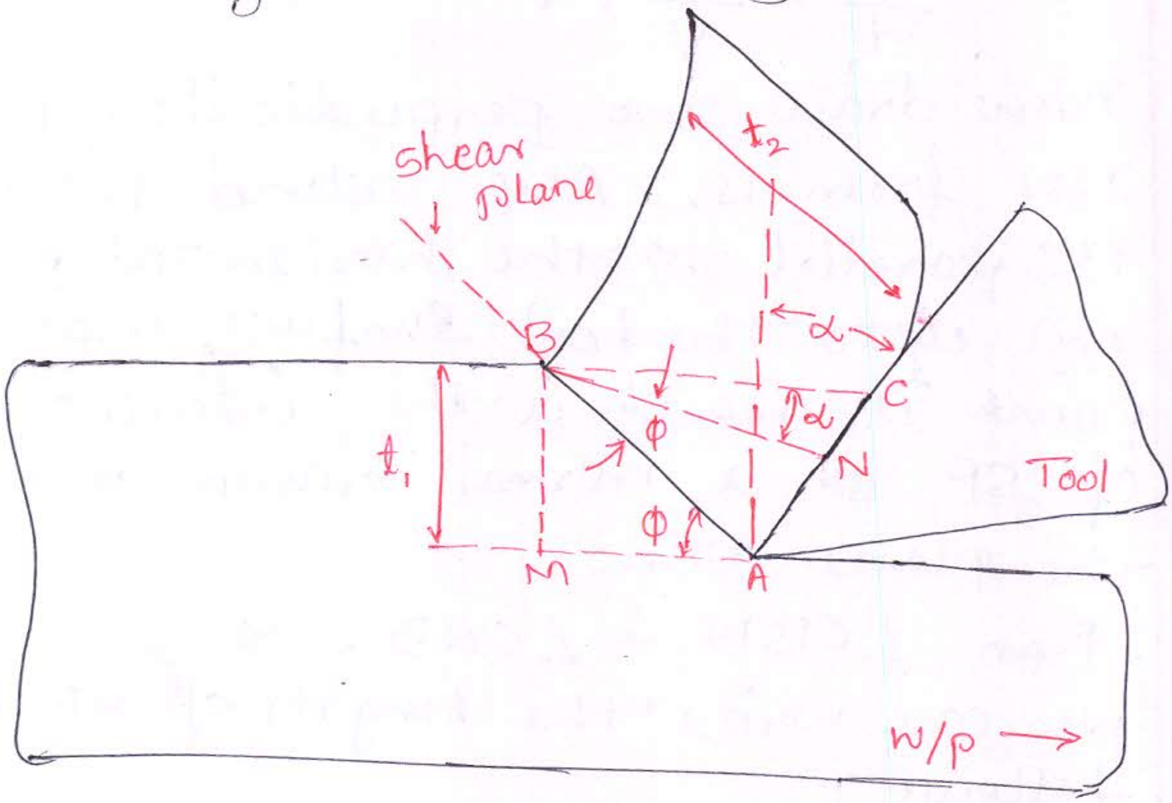
1
1
1

2) Shear angle relationship in terms of rake angle and cutting ratio.



2

In plastic deformation there is negligible change in volume of work material, hence we can write.

$$t_1 b_1 V = t_2 b_2 V_c \quad \text{——} \quad (1).$$

1

<u>Where</u>

t_1 = Chip thickness before cutting

t_2 = Chip thickness.

b_1 = width of uncut chip

b_2 = widths of chip

V = Cutting velocity

V_c = Chip velocity

1

In most cutting processes b_1 is nearly equal to b_2, hence

$$t_1 V = t_2 V_c \quad \text{——} \quad (2)$$

Therefore:

$$\frac{t_1}{t_2} = \frac{V_c}{V} = r \quad \text{---} \ (3).$$

Now draw two perpendiculars BM & BN from B. Also extend the line BC parallel to the horizontal plane AM upto the tool surface, mark point D., which is the intersection of SP on a normal drawn at A in the plane AM.

From $\angle CBN = \angle CAD = \alpha$.

we can write the length of AB as follows.

$$AB = \frac{MB}{\sin\phi} = \frac{NB}{\cos(\phi-\alpha)}$$

$$AB = \frac{t_1}{\sin\phi} = \frac{t_2}{\cos(\phi-\alpha)} \quad \text{---} \ (4).$$

Hence

$$r = \frac{t_1}{t_2} = \frac{\sin\phi}{\cos(\phi-\alpha)} \quad \text{---} \ (5).$$

The equation (5)

$$r = \frac{\sin\phi}{\cos\phi\cos\alpha + \sin\phi\sin\alpha}$$

$$\sin\phi = r\cos\phi\cos\alpha + r\sin\phi\sin\alpha.$$

Dividing by $\cos\phi$.

$$\tan\phi = r\cos\alpha + r\tan\phi\sin\alpha.$$

By rearranging, we get

$$\tan\phi\,(1 - r\sin\alpha) = r\cos\alpha.$$

3

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha}$$ 3

3) In orthogonal cutting the components of F_r in the direction of the width b' is zero. Therefore, F_r may be resolved into two orthogonal components. According to the chosen directions the components useful for analysis

From the geometry force components are

$$F_c = F_s \cos\phi + F_{ns} \sin\phi$$

$$F_t = F_{ns} \cos\phi - F_s \sin\phi$$

$$F_f = F_c \sin\alpha - F_t \cos\alpha$$

$$F_n = F_c \cos\alpha - F_t \sin\alpha$$ 2

$$F_s = F_c \cos\phi - F_t \sin\phi$$

$$F_{ns} = F_c \sin\phi - F_t \cos\phi$$

$$F_r = \frac{F_s}{\cos(\phi + \beta - \alpha)}$$

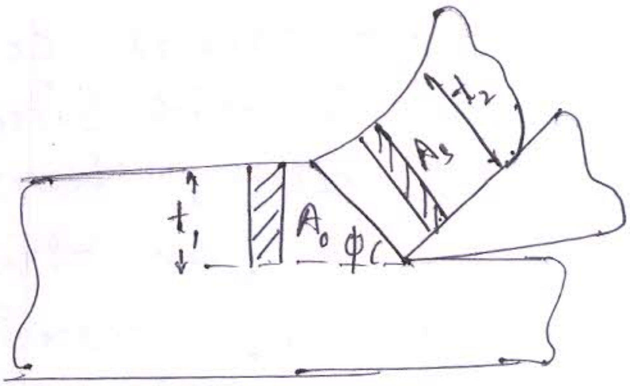
$$F_s = F_r \cos(\phi + \beta - \alpha)$$

$$F_c = F_r \cos(\beta - \alpha)$$

$$F_t = F_r \sin(\beta - \alpha)$$

$$F_s = F_r \cos(\phi + \beta - \alpha)$$

w.k.t max. shear stress $= \tau_s = \dfrac{F_s}{A_s}$



Where

F_s = Shear force.

A_s = Area of shear plane.

from fig. $A_s = \dfrac{A_0}{\sin\phi}$.

where

A_0 = c/s area of uncut chip.

$$A_0 = t_1 b_1$$

$$\tau_s = \frac{F_s}{A_0/\sin\phi} = \frac{F_s \sin\phi}{t_1 b_1}$$

$$F_s = \frac{\tau_s t_1 b_1}{\sin\phi}.$$

The coefficient of friction is given by

$$\mu = \frac{F_f}{F_n} = \frac{F_c \sin\alpha + F_t \cos\alpha}{F_c \cos\alpha - F_t \sin\alpha}.$$

$$F_r = \frac{\tau_s A_c}{\sin\phi \cdot \cos(\phi + \beta - \alpha)}$$

$$F_c = \frac{\tau_s A_c}{\sin\phi} \frac{\cos(\beta - \alpha)}{\cos(\phi + \beta - \alpha)}$$

2

2

$$\frac{dF_c}{d\phi} = 0.$$

$$\frac{\tau_s \cos(\beta-\alpha)\left[\cos\phi\cos(\phi+\beta-\alpha) - \sin\phi\sin(\phi+\beta-\alpha)\right]}{\sin^2\phi\,\cos^2(\phi+\beta-\alpha)} = 0.$$ 2

where

$\sin\phi \neq 0.$ $\cos(\phi+\beta-\alpha) \neq 0.$

Thus

$$\cos(2\phi+\beta-\alpha) = 0.$$

which gives

$$\boxed{\phi = \frac{\pi}{4} - \frac{\beta}{2} + \frac{\alpha}{2}}$$ 2

4) Crater wear

Wear occurs on the rake face of the tool and takes the form of a cavity called crater. It occurs along the cutting edge but some distance away from ~~the~~ it and within the chip contact area. As wear progresses with time, the crater gets wider, longer and deeper and approaches the edge of the tool.

This form of wear usually occurs with maching ductile materials which produces continious long curled chip and are slides up at high force.

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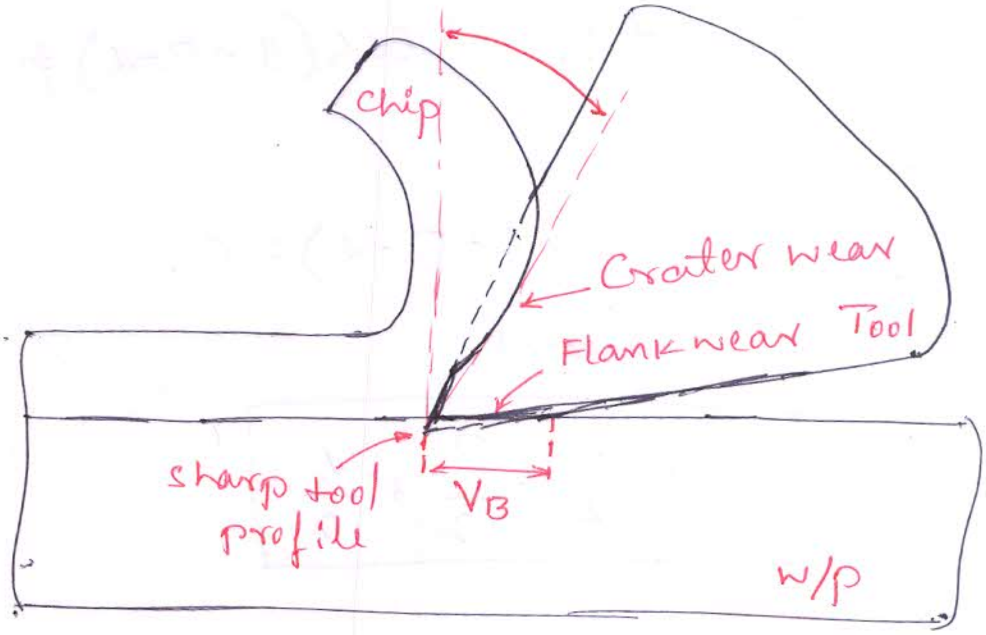
on the rake face of the tool results in the formation of a pit or depression at the tool-chip interface. Due to rubbing of chip on the tool face, chip carry away the metal from the tool face by means of diffusion process.



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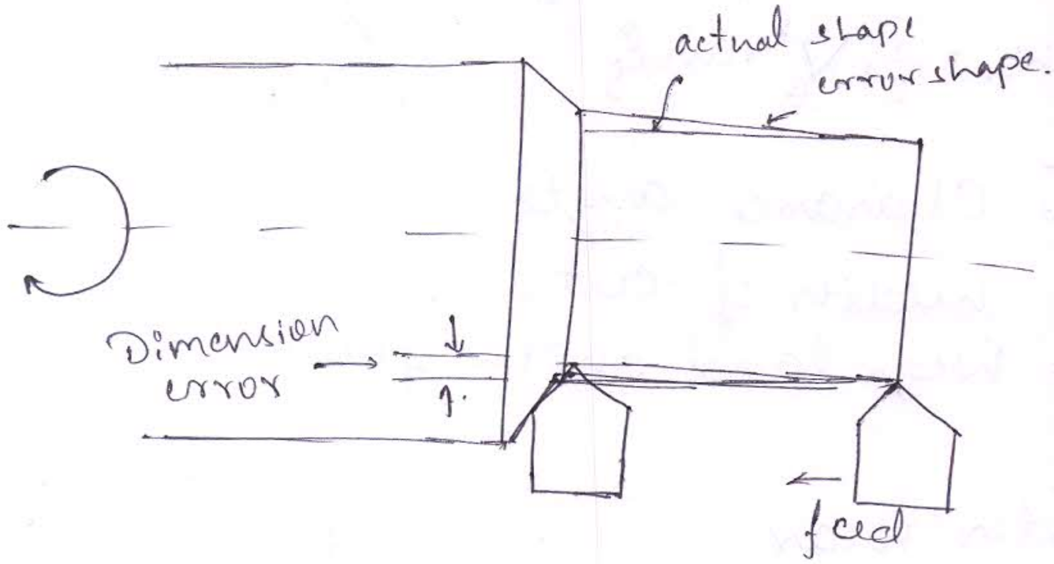
Flank wear

Flank is the clearance face of the cutting tool, along which the major cutting edge is located. Because of the clearance, initial contact is made along the cutting edge. The wear which occurs at flank face of the tool is called flank wear. Wear occurs due to friction between the machined surface of the w/p and the tool flank. The flank wear region is known as wear land and is measured by the width of wear land. If the width of wear land exceeds 0.5-0.6 mm the excessive cutting forces the cause tool failure

3

3) Corner Wear

wear occurs on the tool corner. Can be considered as a part of the wear land and respectively flank wear. Since there is no distinguished boundary between the corner wear and flank wear land. We consider corner wear as a separate wear type because of its importance for the precision of machining. 2



5) Tool wear equations.

Abrasive wear

The volume of abrasive wear per time depends upon.

1) The no. of abrasive particle in the rubbing medium that are in contact with the tool at any time
2) The normal pressure
3) The rate of sliding

$$W_{abr} = C_1 N V t$$ 2

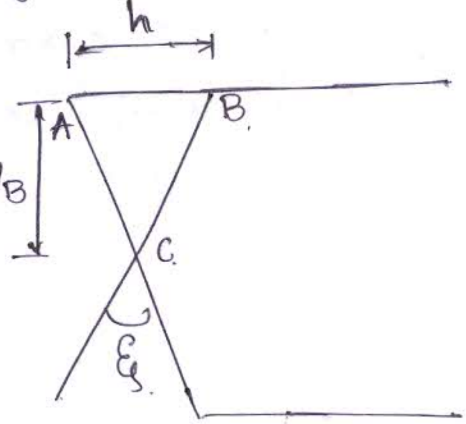
Adhesive tool wear

Flank wear

The flank wear volume during steady wear plane is given by.

$$\cancel{W_{fl}} = \frac{\cancel{C_2 P l}}{\cancel{\sigma_0}}$$

$$W_{fl} = \frac{1}{2} V_B b h.$$



where $h = V_B \tan \xi_s$. 2

$$W_{fl} = \frac{1}{2} b V_B^2 \tan \xi_s.$$

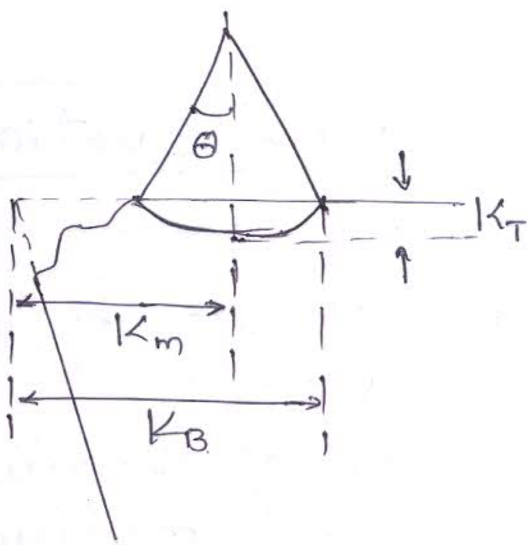
where

ξ_s = Clearance angle

b = width of cut

V_B = Wear land on the flank.

Creater wear



Let

R = radius of curvature

θ = Included angle 2

Creater wear volume is given by the relation

$$W_{cr} = \frac{1}{2} b R^2 (\theta - \sin\theta)$$

$$W_{cr} = \frac{b R^2 \theta^3}{12}$$

Diffusion Wear.

Flank wear.

Diffusion mass M_f across the flank face in time t_f is given with wear.

$$M_f = 2C_0 h_f b \sqrt{\left(\frac{D_0 t_f}{\pi}\right)} \times \exp\left[-Q/(2RT_f)\right]$$

where

C_0 = Concentration of the diffusing constituent

h_f = Flank wear land length

b = width of cut

D_0 = Constant

t_f = time

Q = Active energy for the diffusion process

T_f = Flank face temperature.

2

Diffusion at the Rake face

$$M_c = 2C_0 l_c b \sqrt{\frac{D_0 t_c}{\pi}} \exp\left[-\frac{Q}{2RT_c}\right]$$

Where

T_c = average rake face temp.

l_c = length of chip-tool interface

t_c = time during which diffusion takes place.

2

6) It is clear that if the tool life is reduced by 65%, then the cutting speed has been increased ~~to~~ a certain extent.

~~Let~~ $n = 0.2$

Thus taylor's tool life equation

$$V_1 T_1^{\,n} = C.$$

$$V_1 T_1^{\,0.2} = C. \quad \text{——} \; (1).$$ 2

If the tool life is reduced to 65% and cutting speed has been increased.

Let V_2 be the increased speed.

$$\text{Tool Life} = T_2 = T_1 - 0.65T_1$$

$$T_2 = 0.35T_1$$

Tool life eqn at increased speed.

$$V_2 T_2^{\,0.2} = C \quad \text{——} \; (2).$$

$$V_2 (0.35T_1)^{0.2} = C \quad \text{——} \; (2).$$ 2

equate eqn (1) & (2) we get.

$$V_1 T_1^{\,0.2} = V_2 (0.35\,T_1)^{0.2}$$

or $\quad V_1 = V_2 (0.35)^{0.2}$

$$\text{Thus } V_2 = 1.23\,V_1$$

$$\% \text{ change in speed} = \frac{V_2 - V_1}{V_1} \times 100$$

$$= \frac{1.23V_1 - V_1}{V_1} \times 100$$ 6

$$\% \text{ Change} = 23.3\%$$

7)

Chip length $= l_2 = 96$ mm.

Uncut chip length $= l_1 = 240$ mm

$\alpha = 20^\circ$

Depth of cut $= t = 0.6$ mm

$F_c = 2400$ N.

$F_t = 240$ N.

1) Shear plane angle (ϕ).

$$\phi = \tan^{-1}\left(\frac{r\cos\phi}{1 - r\sin\phi}\right)$$

where

$$r = \frac{t_1}{t_2} = \frac{l_2}{l_1} = \frac{960}{240} = 0.4.$$ 3

$$\phi = \tan^{-1}\left(\frac{0.4\cos 20^\circ}{1 - 0.4\sin 20^\circ}\right).$$

$$\phi = 23.5^\circ$$

2) Chip thickness (t_2)

w.k.t $\quad r = \frac{t_1}{t_2}$.

$$0.4 = \frac{0.6}{t_2}.$$

$$t_2 = \frac{0.6}{0.4}$$ 2

$$t_2 = 1.5 \text{ mm}.$$

3) Friction angle (β)

w.k.t $\quad \beta = \tan^{-1}(\mu)$

but, $\mu = \dfrac{F_c \sin\alpha + F_t \cos\alpha}{F_c \cos\alpha - F_t \sin\alpha}$

$$\mu = \frac{2400 \sin 20 + 240 \cos 20}{2400 \cos 20 - 240 \sin 20}$$

$\mu = 0.48$ 3

$\beta = \tan^{-1}(\mu)$

$\beta = \tan^{-1}(0.48)$

$\beta = 25.6^\circ$

4) Resultant cutting force (R)

w.k.t,

$R = \sqrt{F_c^2 + F_t^2}$

$= \sqrt{2400^2 + 240^2}$ 2

$R = 2412\,N.$