IE-352
Section 1, CRN: 48700/1/2
Section 2, CRN: 48706/7/8
Second Semester 1437-38 H (Spring-2017) – 4(4,1,2)
"MANUFACTURING PROCESSES – 2"

Wednesday, March 22, 2017 (23/06/1438H)

Exercise: Cutting Forces and Power - 2

Name:	Student Number: 4

A shaper tool making orthogonal cutting, has a (10) degrees rake angle. The feed rate= 0.2 mm/rev, the depth of cut is 2 mm. The cutting speed is 100 m/min. The main cutting force is 3600 N and the feed (thrust) force is 2400 N. The shear angle is (35) degrees.

i. Draw the Merchant diagram

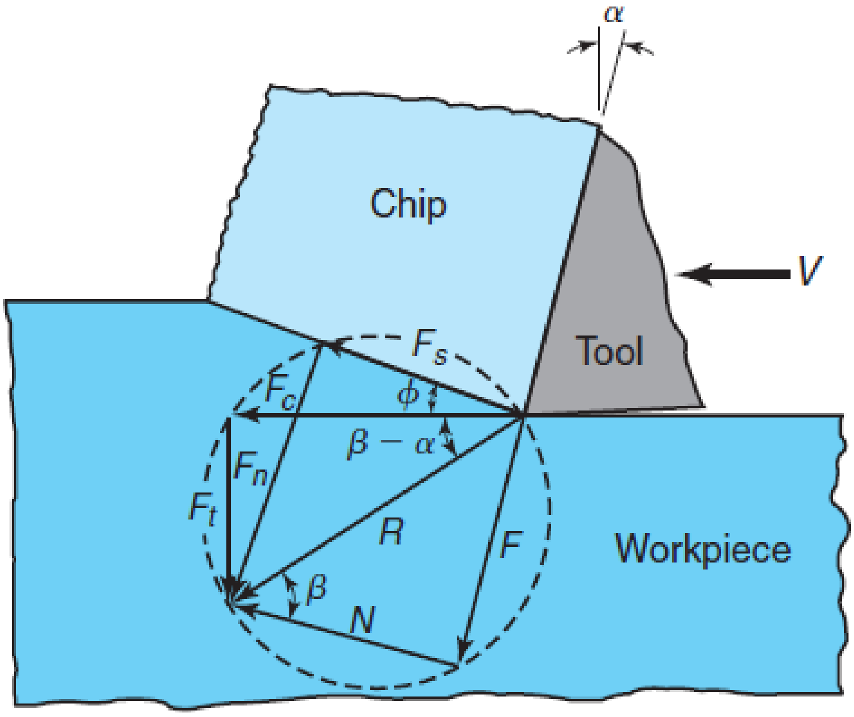
ii. Calculate,
   (a) the coefficient of friction.
   (b) the shear stresses on the shear plane
   (c) the normal stress on the rake face
   (d) the friction power
   (e) the shearing power
   (f) the machining power

the specific cutting energy

A shaper tool making orthogonal cutting, has a (10) degrees rake angle. The feed rate= 0.2 mm/rev, the depth of cut is 2 mm. The cutting speed is 100 m/min. The main cutting force is 3600 N and the feed (thrust) force is 2400 N. The shear angle is (35) degrees.

i. Draw the Merchant diagram

Note, the word "draw" implies that this must be done to scale (suggestion, use scale of 2 cm: 1,000 N). The lengths of the forces in the diagram should be used to verify the actual values of the forces.



ii. Calculate,

(a) the coefficient of friction.

$$\tan(\beta-\alpha)=\frac{F_t}{F_c}=\frac{2400\ N}{3600\ N}=0.6667$$

$$\beta-10°=\tan^{-1}0.6667=33.69$$

$$\beta=10+33.69=43.69°$$

$$\boldsymbol{\mu}=\tan\beta=\tan 43.69°=\mathbf{0.96}$$

(b) the shear stresses on the shear plane

$$\tau_s=\frac{F_s\sin\emptyset}{t_0 w}$$

$$F_s=F_c\cos\emptyset-F_t\sin\emptyset$$
$$=(3600)(\cos 35)-(2400)(\sin 35)=1572.36\ N$$

$$\boldsymbol{\tau_s} = \frac{F_s \sin \emptyset}{t_0 w} = \frac{(1572.36\ N)(\sin 35)}{(2\ mm)(0.2\ mm)} = \mathbf{2255} \frac{\boldsymbol{N}}{\boldsymbol{mm^2}}$$

(c) the normal stress on the rake face

$$\sigma = \frac{N}{t_c w}$$

We need to find both N and t_c

$$\frac{t_0}{t_c} = \frac{\sin \emptyset}{\cos(\emptyset - \alpha)}$$

$$t_c = \frac{\cos(\emptyset - \alpha)}{\sin \emptyset} t_0 = \frac{\cos(35° - 10°)}{\sin 35°}(2\ mm) = 3.160\ mm$$

Now, consider the R-N-F triangle:

$$N = R \cos \beta = \sqrt{{F_c}^2 + {F_t}^2} * \cos \beta = \sqrt{3600^2 + 2400^2} * \cos 43.69°$$

$$= 4326.66 * 0.7231 = 3128.55\ N$$

$$\boldsymbol{\sigma} = \frac{N}{t_c w} = \frac{3128.55\ N}{(3.160\ mm)(0.2\ mm)} = \mathbf{4950}\ \frac{\boldsymbol{N}}{\boldsymbol{mm^2}}$$

(d) the friction power

$$Power\ for\ friction = U_f = FV_c$$

We need to find both F and V_c

Consider again the R-N-F triangle:

$$F = R \sin \beta = 4326.66 * \sin 43.69° = 4326.66 * 0.6908 = 2988.67\ N$$

$$\frac{V}{\cos(\emptyset - \alpha)} = \frac{V_c}{\sin \emptyset}$$

$$V_c = \frac{\sin \emptyset}{\cos(\emptyset - \alpha)} V = \frac{\sin 35°}{\cos(35° - 10°)}(100\ m/min) = 63.29\ m/min$$

$$\boldsymbol{U_f} = FV_c = (2988.67\ N)(63.29\ m/min) = 189{,}145\ N \cdot \frac{m}{min} = \mathbf{3.15\ kW}$$

(e) the shearing power

$$Power\ for\ shearing = U_s = F_s V_s$$

We have F_s and we need to find V_s:

$$V_s = \frac{\cos \alpha}{\cos(\emptyset - \alpha)} V = \frac{\cos 10°}{\cos(35° - 10°)}(100\ m/min) = 108.66\ m/min$$

$$U_s = F_s V_s = (1572.36\ N)(108.66\ m/min) = 170{,}855\ N \cdot \frac{m}{min} = \mathbf{2.85\ kW}$$

(f) the machining power

$$\boldsymbol{Machining\ power} = \boldsymbol{U_t} = F_c V = (3600\ N)\ (100\ m/min)$$

$$= 360{,}000\ N \cdot \frac{m}{min} = \mathbf{6.00\ kW}$$

Check Answer:

$U_t = U_f + U_s = 3.15\ kW + 2.85\ kw = 6.00\ kW$

(g) the specific cutting energy

$$\boldsymbol{u_t} = \frac{U_t}{wt_0V} = \frac{6.00\ kW}{(2\ mm)(0.2\ mm)(100\ m/min)}$$
$$= \frac{6{,}000\ W}{(2\ mm)(0.2\ mm)(100\ \cancel{m/min})}\left(\frac{1\ \cancel{m}}{1000\ mm}\right)(60\ s\cancel{/min})$$
$$= \mathbf{9.0\ W \cdot s/mm^3}$$

Note, compare this to the table showing specific energy requirements for different materials.