IE-352
Section 1, CRN: 13536
Section 2, CRN: 30521
First Semester 1432-33 H (Fall-2011) – 4(4,1,1)
MANUFACTURING PROCESSES - 2

Machining Exercises Answers

Name:	Student Number: 42

Answer ALL of the following questions [2 Points Each].

1. Let $n = 0.5$ and $C = 90$ in the *Taylor* equation for tool wear. What is the percent increase in tool life if the cutting speed is reduced by (a) 50% and (b) 75%?

Solution:

Taylor Equation for tool life:

$$VT^n = C$$

$$n = 0.5; C = 90$$

$$\Rightarrow VT^{0.5} = 90 \Rightarrow V_1 {T_1}^{0.5} = V_2 {T_2}^{0.5}$$

a) $V_2 = 0.5V_1$

$$\Rightarrow V_1 {T_1}^{0.5} = 0.5 V_1 {T_2}^{0.5}$$

$$\Rightarrow {T_1}^{0.5} = 0.5 {T_2}^{0.5}$$

$$\Rightarrow \left(\frac{T_2}{T_1}\right)^{0.5} = 2$$

$$\Rightarrow \sqrt{\frac{T_2}{T_1}} = 2$$

$$\Rightarrow \frac{T_2}{T_1} = 4$$

$$\Rightarrow \textit{increase in tool life} = \frac{T_2 - T_1}{T_1} = \frac{T_2}{T_1} - 1 = 3$$

$$\Rightarrow \textit{i.e. increase in tool life is } 300\%$$

b) $V_2 = 0.25V_1$ **(since speed *decreases* by 75%)**

$$\Rightarrow {T_1}^{0.5} = 0.25 {T_2}^{0.5}$$

$$\Rightarrow \left(\frac{T_2}{T_1}\right)^{0.5} = 4$$

$\Rightarrow \frac{T_2}{T_1} = 16$

$\Rightarrow$ *increase in tool life* $= \frac{T_2 - T_1}{T_1} = 16 - 1 = 15$

$\Rightarrow$ ***i.e. increase in tool life is*** $\mathbf{1500\%}$ $(\boldsymbol{i.e.\,15 - fold})$

2. Taking carbide as an example and using the equation for mean temperature in turning on a lathe, determine how much the feed should be reduced in order to keep the mean temperature constant when the cutting speed is doubled.

Solution:

equation for mean temperature in turning on a lathe,

$T_{mean} \,\alpha\, V^a f^b$

Given: $T_{mean} = C_1; V_2 = 2V_1;$ *for carbide:* $a = 0.2,\ b = 0.125$

$\Rightarrow C_1 = C_2 V^{0.2} f^{0.125}$

$\Rightarrow V_1^{\,0.2} f_1^{\,0.125} = (2V_1)^{0.2} f_2^{\,0.125}$

$\Rightarrow \left(\frac{f_2}{f_1}\right)^{0.125} = 0.5^{0.2}$

$\Rightarrow \frac{f_2}{f_1} = 2^{-\left(\frac{0.2}{0.125}\right)} = 2^{-1.6} = 0.330$

$\Rightarrow$ *reduction in feed* $= \frac{f_1 - f_2}{f_1} = 1 - 0.330 = 0.670$

$\Rightarrow$ ***i.e. reduction in feed is*** $\mathbf{67\%}$

3. An orthogonal cutting operation is being carried out under the following conditions: $t_o = 0.1\,mm$, $t_c = 0.2\,mm$, width of cut $= 5\,mm$, $V = 2\,m/s$, $rake\ angle = 10°$, $F_c = 500\,N$, and $F_t = 200\,N$. Calculate the percentage of the total energy that is dissipated in the shear plane.

Note, for detailed solution, see similar exercise:"cutting force exercise 2.PDF"

Givens: thicknesses: $t_o = 0.1\,mm$; $t_c = 0.2\,mm$

angles: $\alpha = 10°$

velocities: $V = 2\,m/s$

forces: $F_c = 500\,N$; $F_t = 200\,N$; $F_s = ?$; $F_n = ?$

Required: %ge of total energy dissipated in primary shearing zone

i.e. $\frac{U_s}{U_{tot}}(100) = \frac{Power_s}{Power_{tot}}(100) = ?$

Solution:

$$\frac{Power_s}{Power_{tot}} = \frac{F_s V_s}{F_c V}$$

Strategy: we have F_c *and* V*, and we need to find* F_s *and* V_s

- V_s *can be obtained if we have shear angle (*ϕ*), from,*

$$V_s = V\frac{\cos\alpha}{\cos(\phi - \alpha)}$$

  - *and* ϕ *can be obtained from,*

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

  - *and r can be obtained from,*

$$r = \frac{t_o}{t_c} = \frac{0.1\,mm}{0.2\,mm} = 0.5$$

  - *now, working back* ⇒

$$\phi = \tan^{-1}\left[\frac{0.5\cos 10°}{1 - 0.5\sin 10°}\right] = \tan^{-1} 0.539 = 28.3°, \text{ and:}$$

$$V_s = 2\ m/s \frac{\cos 10°}{\cos(28.3° - 10°)} = (2\ m/s) * 1.037 = 2.075 m/s$$

Note how shear velocity is higher (4%) than cutting speed

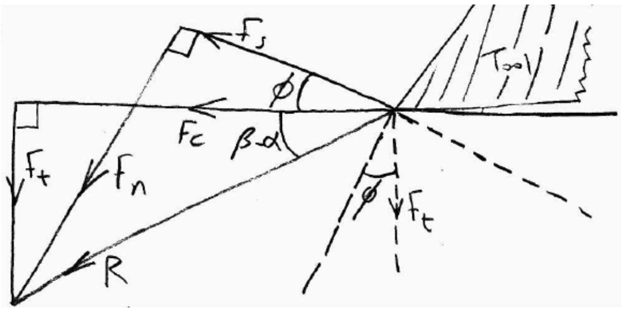
- *F_s is now required and can be obtained force circle,*

  by resolving component of

  F_c along F_s direction, and

  F_t opposite to F_s direction

  $\Rightarrow$



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

$$= (500\ N)\cos 28.3° - (200\ N)\sin 28.3°$$

$$= 440\ N - 94.9\ N = 345\ N$$

- Substituting values of V_s and F_s into $\frac{Power_s}{Power_{tot}} = \frac{F_s V_s}{F_c V} \Rightarrow$

$$\frac{Power_s}{Power_{tot}} = \frac{(345\ N)(2.075\ m/s)}{(500\ N)(2\ m/s)} = \frac{718.875}{1000} = 0.719$$

⇒%ge of total energy dissipated in shearing is approximately 72%

Note, you can check your answer by calculating %ge of energy dissipated due to friction (which should 28%; see "cutting force exercise 1.PDF"), and adding the two values, which should amount to exactly 100%.

4. For a turning operation using a ceramic cutting tool, if the speed is increased by 50%, by what factor must the feed rate be modified to obtain a constant tool life? Use $n = 0.5$ and $y = 0.6$.

Given:

$$V_2 = V_1 + 0.5V_1 = 1.5V_1$$

$$T_2 = T_1$$

$$n = 0.5;\ y = 0.6$$

Required: $\frac{f_2}{f_1} = ?$

Solution:

Taylor tool life equation for turning operation:

$$VT^n d^x f^y = C_1 \Rightarrow$$

$$V_1 T_1{}^n d_1{}^x f_1{}^y = V_2 T_2{}^n d_2{}^x f_2{}^y$$

since $T_2 = T_1$*, and assuming constant depth of cut (d)* ⇒

$$V_1 f_1{}^y = 1.5 V_1 f_2{}^y \Rightarrow$$

$$\left(\frac{f_2}{f_1}\right)^{0.6} = \frac{1}{1.5} \Rightarrow$$

$$\frac{f_2}{f_1} = 1.5^{-\frac{1}{0.6}} = 0.509$$

⇒feed must be modified by a factor of 50.9%

5. Using the equation for surface roughness to select an appropriate feed for $R = 1\,mm$ and a desired roughness of $1\,\mu m$. How would you adjust this feed to allow for nose wear of the tool during extended cuts? Explain your reasoning.

Given:

$$R = 1\,mm = 1 * 10^{-3}\,m$$

$$R_t = 1\,\mu m = 1 * 10^{-6}\,m$$

Required:

- $f = ?$
- how to adjust feed to account for nose wear

Solution:

- *equation for surface roughness,*

$$R_t = \frac{f^2}{8R} \Rightarrow$$

$$f = \sqrt{(8R)R_t} = \sqrt{(8 * 10^{-3}\,m)(1 * 10^{-6}\,m)} = \sqrt{8 * 10^{-9}\,m^2} =$$

$$= 8.94 * 10^{-5}\,m/rev = 0.089 * 10^{-3}\,m/rev \Rightarrow$$

⇒ appropriate feed is 0.089 mm/rev

- *when nose wear occurs ⇒*

radius (R) will increase ⇒

to keep the surface roughness (R_t) the same

⇒ the feed must also increase