IE-352
Section 1, CRN: 5022
Section 2, CRN: 32997
Second Semester 1432-33 H (Spring-2012) – 4(4,1,1)
MANUFACTURING PROCESSES - 2

Tuesday, May 08, 2012 (17/06/1433H)

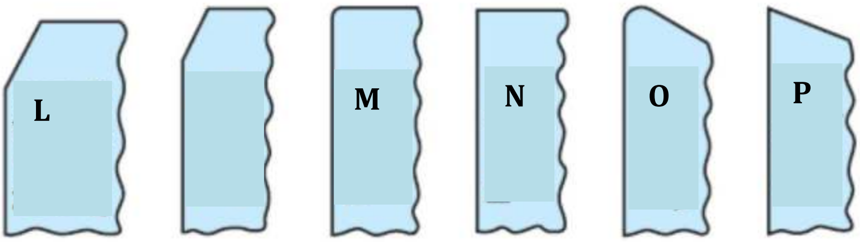
MIDTERM 2 [10 POINTS] ANSWERS

Name: Ahmed M. El-Sherbeeny, PhD	Student Number: 4	Section: Su-8:00 / Su-10:00

Place the correct letter in the box at the right of each question [$\frac{1}{2}$ Point Each]

1. **Which of the inserts below has positive (non-negative) land with honing?** **D**

   a. L
   b. M
   c. N
   d. O (slide 18)
   e. P



2. **How many cutting points exist on a *triangular* insert?** **B**

   a. 3
   b. 6 (slide 15)
   c. 9
   d. 4
   e. 1

3. **What is the best method for securing an insert?** **C**

   a. wing lockpins
   b. inserts mounted with sidescrews
   c. clamping (slide 16)
   d. sharpening the insert
   e. heating the insert

4. **To ensure a cutting tool functions well during interrupted cuts it must have …** **A**

   a. high impact strength (slide 4)

   b. high toughness

   c. high hot hardness

   d. high melting temperature

   e. high thermal conductivity

5. **What *tool* materials have lowest *wear* resistance + highest *chipping* resistance?** **A**

   a. high-speed steels (slide6)

   b. carbides

   c. cast-cobalt alloys

   d. ceramics

   e. cubic boron nitrides

6. **During cutting, what force lies *perpendicular* to the rake face?** **D**

   a. friction force

   b. shear force

   c. normal to shear force

   d. normal to friction force (slide 33)

   e. thrust force

7. **What chip type is associated with metals with low thermal conductivity (e.g *Ti*)?** **C**

   a. built-up edge chips

   b. non-homogenous chips

   c. serrated chips (slide 24)

   d. discontinuous chips

   e. continuous chips

8. **Label the diagram shown below.** **A**

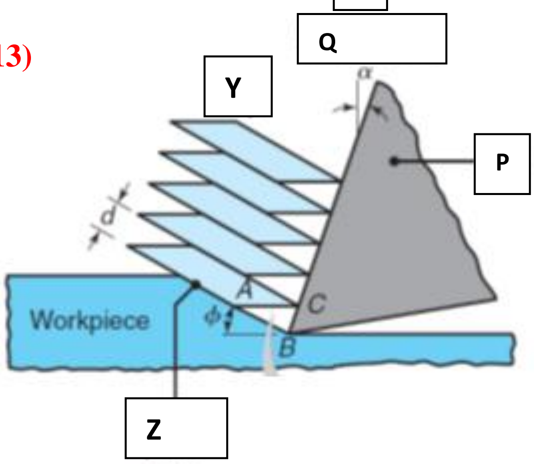
   a. P: tool; Q: rake angle; Y: chip; Z: shear plane (slide 13)

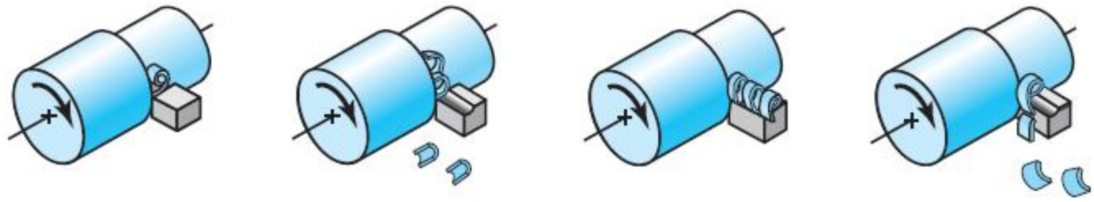
   b. P: chip; Q: rake angle; Y: tool; Z: shear zone

   c. P: tool; Q: relief angle; Y: chip; Z: shear plane

   d. P: chip; Q: relief angle; Y: tool; Z: shear zone

   e. P: tool; Q: shear angle; Y: chip; Z: shear plane





H M N P

9. **In which diagram(s) –above– does the chip hit the *workpiece* and break off?** A

a. M (slide 28)

b. P

c. H

d. N

e. H and M

10. **Which of the following are ALL signs of a sharp (non-"dull") tool ?** B

a. tool tip radius < depth of cut; $-ve$ rake angle; chips are produced

b. tool tip radius < depth of cut; $+ve$ rake angle; chips are produced (slide 71)

c. tool tip radius < depth of cut; $+ve$ rake angle; no chips produced

d. tool tip radius > depth of cut; $-ve$ rake angle; chips are produced

e. tool tip radius > depth of cut; $+ve$ rake angle; chips are produced

Questions 11-20. In a turning operation, a carbide tool ($n = 0.25$) was first used in machining a workpiece using the following parameters: $V = 250\ \frac{m}{min}$, $t_o = 3.5\ mm$, $\alpha = 14°$ and the $f\ =\ 0.75\ mm/rev$. This resulted in a chip thickness of $5.2\ mm$. The process was then repeated (under similar conditions) after doubling the feed, and increasing the cutting speed by 50%.

Given:

- Turning operation
- Carbide tool ($n = 0.25$)
- First Operation
  - cutting speed: $V_1 = 250\ \frac{m}{min}$
  - feed: $f_1 = 0.75\ \frac{mm}{rev}$
  - thicknesses: $t_0 = 3.5\ mm,\ t_c = 5.2\ mm$
  - rake angle: $\alpha = 14°$
- Second Operation
  - cutting speed: $V_2 = V_1 + 0.5V_1 = 1.5V_1$
  - feed: $f_2 = 2f_1$
  - note, all other variables are assumed not to have changed

E

11. **What is the *chip-compression ratio* in the first operation?**

a. 0.67

b. 18.2

c. 0.055

d. 0.19

e. 1.49

$$\boldsymbol{CCR} = \frac{1}{r} = \frac{t_c}{t_0} = \frac{5.2\ mm}{3.5\ mm} = \mathbf{1.49}\ (\boldsymbol{note\ how\ CCR\ is}\ > 1)$$

E

12. **What is the *material removal rate* in the first operation?**

a. 10.94 $\frac{mm^3}{s}$

b. 656 $\frac{mm^3}{s}$

c. 656,250 $\frac{mm^3}{s}$

d. 39,375 $\frac{mm^3}{s}$

e. $\mathbf{10,938\ \frac{mm^3}{s}}$

Since turning operation is involved ⇒

$$\boldsymbol{R_{MR}} = f t_0 V = (0.75\ mm)(3.5\ mm)\left[\left(250\ \frac{m}{min}\right)\left(1000\ \frac{mm}{m}\right)\left(\frac{min}{60\ s}\right)\right]$$

$$= \mathbf{10,938\frac{mm^3}{s}}$$

B

13. **What is the *shear angle* in the first operation?**

a. 52.0°

b. 38.0°

$$\tan\phi_1 = \frac{r\cos\alpha}{1 - r\sin\alpha}$$

From Q11,

$$r = \frac{1}{CCR} = \frac{1}{1.49\ mm} = 0.673$$

$$\Rightarrow \boldsymbol{\phi_1} = \tan^{-1}\left[\frac{0.673\cos 14°}{1-0.673\sin 14°}\right] = \tan^{-1} 0.780 = \mathbf{38.0°}$$

c. 14.0°

d. 26.5°

e. 28.0°

D

14. What is the *shear strain* in the first operation?

a. 3.03

b. 0.485

c. 0.578

d. 1.73

$\gamma = \cot\phi + \tan(\phi - \alpha)$

$\Rightarrow \gamma = \cot 38.0° + \tan(38.0° - 14°) = \mathbf{1.73}$

e. 2.06

15. **How much *power* will the lathe draw in performing the first operation with a mechanical efficiency of 85% and total specific energy of 4.5 $\frac{J}{mm^3}$?**

C

a. 2.07 kW

b. 49.2 kW

c. 57.9 kW

- cutting power is related to power from source through:
  $Power_c = Power_{source} * \eta_{mech}$
  or
  $$Power_{source} = \frac{Power_c}{\eta_{mech}}$$
- also, total specific energy:
  $$u_t = 4.5\frac{J}{mm^3} = \frac{total\ cutting\ power}{material\ removal\ rate} = \frac{Power_c}{R_{MR}}$$
  - from Q12:
    $$R_{MR} = 10{,}938\frac{mm^3}{s}$$
  - Thus,
    $$Power_c = u_t * R_{MR} = \left(4.5\ \frac{J}{mm^3}\right)\left(10{,}938\ \frac{mm^3}{s}\right) = 49{,}219\ \frac{J}{s}$$
    $$= 49.2\ kW$$
- Substituting into the source power equation:
  $$\boldsymbol{Power_{source}} = \frac{Power_c}{\eta_{mech}} = \frac{49.2\ kW}{0.85} = \mathbf{57.9\ kW}$$

d. 2.86 kW

e. 41.8 kW

E

16. **What is the %ge drop in *tool life* between the two operations (use $y = 0.6$)?**

a. 50.0 %

b. 20.8 %

c. 80.2 %

d. 3.7 %

e. 96.3 %

- *Taylor tool life equation for turning operation:*

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

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

- *assuming constant depth of cut (d or t_0)* $\Rightarrow$

$$\left(\frac{T_2}{T_1}\right)^{n=0.25} = \left(\frac{V_1}{V_2=1.5V_1}\right)\left(\frac{f_1}{f_2=2f_1}\right)^{y=0.6} = \left(\frac{1}{1.5}\right)(0.5^{0.6}) = 0.440 \Rightarrow$$

$$\frac{T_2}{T_1} = 0.440^{\frac{1}{0.25}} = 0.440^4 = 0.0374$$

- $\Rightarrow$ ***decrease (drop) in tool life*** $=$

$$\frac{T_1 - T_2}{T_1} = 1 - \frac{T_2}{T_1} = 1 - 0.0374 = 0.963 = \mathbf{96.3}\%$$

C

17. **Repeat Q16 assuming no change in feed occurs between the 2 operations.**

a. 50.0 %

b. 20.8 %

c. 80.2 %

- $f_2 = f_1$ *and from Q16* $d_2 = d_1 \Rightarrow$ *TTL* equation is reduced to:

  $VT^n = C \;\Rightarrow$

  $V_1 {T_1}^n = V_2 {T_2}^n \;\Rightarrow$

  $$\left(\frac{T_2}{T_1}\right)^n = \frac{V_1}{V_2 = 1.5V_1} = \frac{1}{1.5} \;\Rightarrow$$

  $$\frac{T_2}{T_1} = \left(\frac{1}{1.5}\right)^{\frac{1}{n=0.25}} = \left(\frac{1}{1.5}\right)^4 = 0.198$$

- $\Rightarrow$ ***decrease (drop) in tool life*** $=$

  $$\frac{T_1 - T_2}{T_1} = 1 - \frac{T_2}{T_1} = 1 - 0.198 = 0.802 = \mathbf{80.2}\%$$

d. 3.7 %

e. 96.3 %

18. **What tool *tip radius* produces a desired roughness of $2.5\ \mu m$? (first operation)** B

a. $0.176\ mm$

b. $28.1\ mm$

equation for surface roughness,

$$R_t = \frac{{f_1}^2}{8R} \Rightarrow$$

$$\boldsymbol{R} = \frac{{f_1}^2}{8R_t} = \frac{(0.75mm)^2}{8\left[(2.5\ \mu m)\left(\frac{mm}{1000\ \mu m}\right)\right]} = \boldsymbol{28.13\ mm}$$

c. $0.028\ mm$

d. $37.5\ mm$

e. $176\ mm$

19. **What is the percentage rise in *mean temperature* between the 2 operations?** D

a. 25.3 %

b. 81.7 %

c. 20.8 %

d. 18.3 %

- using equation for mean temperature in turning on a lathe,

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

  or: $T_{mean} = C\ V^a f^b$

- using $a = 0.2$, $b = 0.125$ (since given this is carbide tool)

  $T_{mean} = C\ V^a f^b \Rightarrow$

  $$\frac{T_{mean_2}}{T_{mean_1}} = \left(\frac{V_2 = 1.5V_1}{V_1}\right)^{a=0.2} \left(\frac{f_2 = 2f_1}{f_1}\right)^{b=0.2} = (1.5^{0.2})(2^{0.125}) = 1.183$$

- ***⇒ increase (rise) in mean temperature =***

  $$\frac{T_{mean_2} - T_{mean_1}}{T_{mean_1}} = \frac{T_{mean_2}}{T_{mean_1}} - 1 = 1.183 - 1 = 0.183 = \mathbf{18.3}\%$$

e. 79.2 %

E

20. **What *cutting force* is required for the first operation?**

a. 205 kN

b. 7.87 kN

c. 131 kN

d. 197 N

e. $\mathbf{11.8\ kN}$

- Cutting power is related to the cutting force via the following relation,

$$Power_{c_1} = F_{c_1} * V_1 \Rightarrow$$

$$F_{c_1} = \frac{Power_{c_1}}{V_1}$$

- Using value of $Power_c = 49.2\ kW$ as calculated from Q15 and given $V_1 = 250\ \frac{m}{min} \Rightarrow$

$$\boldsymbol{F_{c_1}} = \frac{49{,}200\ \frac{J}{s}}{\left(250\ \frac{m}{min}\right)\left(\frac{min}{60\ s}\right)} = 11{,}813\ \frac{N \cdot m}{m} = \mathbf{11.8\ kN}$$

Equations, Data, Diagrams You May Find Useful

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} \Rightarrow r = \frac{t_0}{t_c} = \frac{\sin\phi}{\cos(\phi-\alpha)} \qquad \alpha_e = \sin^{-1}\left(\sin^2 i + \cos^2 i \sin\alpha_n\right)$$

$$T = \frac{0.000665 Y_f}{\rho c}\sqrt[3]{\frac{V t_0}{K}}$$

$$r = \frac{t_0}{t_c} = \frac{V_c}{V}$$

$$T_{mean} \propto V^a f^b$$

$$\gamma = \frac{AB}{OC} = \frac{AO}{OC} + \frac{OB}{OC} \Rightarrow \gamma = \cot\phi + \tan(\phi - \alpha)$$

$$VT^n = C \qquad T = \left(\frac{C}{V}\right)^{1/n}$$

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

$$VT^n d^x f^y = C$$

$$\phi = 45^\circ + \frac{\alpha}{2} - \frac{\beta}{2}$$

$$\Rightarrow \phi = 45^\circ + \alpha - \beta \text{ (when } \mu = 0.5 \sim 2)$$

$$T = C^{1/n} V^{-1/n} d^{-x/n} f^{-y/n}$$

$$T \approx C^7 V^{-7} d^{-1} f^{-4}$$

$$Power = F_c V$$

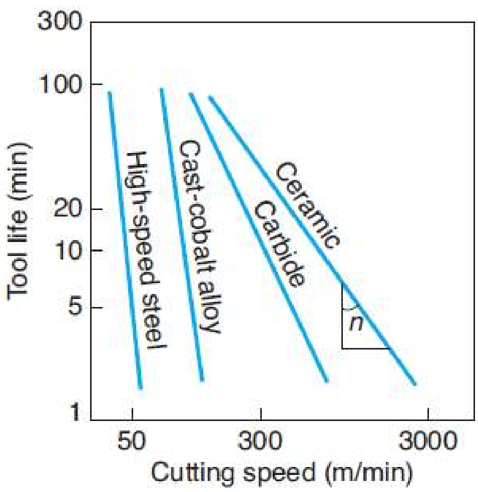
$$\text{Power for friction} = F V_c$$

$$\text{Power for shearing} = F_s V_s$$

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

$$r = \frac{t_0}{t_c} = \frac{V_c}{V} \qquad u_t = u_s + u_f \qquad u_s = \frac{F_s V_s}{w t_0 V}$$

$$u_f = \frac{F V_c}{w t_0 V} = \frac{F r}{w t_0}$$



Ranges of n Values for the Taylor Equation (21.20a) for Various Tool Materials

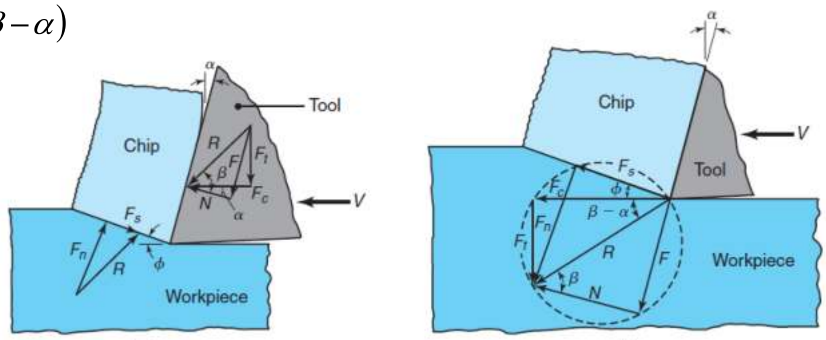
High-speed steels	0.08–0.2
Cast alloys	0.1–0.15
Carbides	0.2–0.5
Coated carbides	0.4–0.6
Ceramics	0.5–0.7

$$\mu = \frac{F}{N} = \frac{F_t + F_c\tan\alpha}{F_c - F_t\tan\alpha}$$

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

$$F_n = F_c\sin\phi + F_t\cos\phi$$

$$F_t = R\sin(\beta-\alpha) \text{ or } F_t = F_c\tan(\beta-\alpha)$$



(a) (b)