IE-352
Section 1, CRN: 48700/1/2
Section 2, CRN: 48703/4/5
Section 3, CRN: 48706/7/8
Second Semester 1434-35 H (Spring-2014) – 4(4,1,2)
"MANUFACTURING PROCESSES – 2"

Thursday, April 24, 2014 (24/06/1435H)

MIDTERM 2 ANSWERS

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Place the correct letter in the box at the right of each question [½ Point Each]

1. ***Classify*, respectively, the following geometric symbols: ◎, ⌭, ○:** E

   A. location, form, location

   B. form, form, form

   C. location, location, location

   D. form, form, location

   E. location, form, form (*slides 4. 5, 6, 7*)

Questions 2-3. Examine the feature control frame shown below and answer the questions to follow.

⌖	Ø0.1	A	B	C

2. **How do you read the feature control frame shown above?** C

   A. position GT of feature is a 0.1-diam. cylind. zone relative to datums A, B, C at Ⓜ

   B. position GT of feature is a 0.1-diam. cylind. zone relative to datums $A, B,$ C at Ⓛ

   C. position GT of feature is a 0.1-diam. cylind. zone relative to datums A, B, C at Ⓢ
   (*slides 4. 8, 9, 32*)

   D. cylindricity GT of feature is a 0.1-diam. cylind. zone relative to datum A, B, C at Ⓜ

   E. cylindricity GT of feature is a 0.1-diam. cylind. zone relative to datums A, B, C at Ⓢ

3. **The feature control frame above can be used for a hole in which type of fit?** **A**

   A. interference fits (*slide 4. 32*)

   B. clearance fits

   C. transition fits

   D. clearance or interference fits

   E. any type of fit

4. **The major difference between flatness and parallelism tolerance for a plane is …** **B**

   A. parallelism tolerance must have a material condition modifier

   B. parallelism tolerance must be defined relative to a datum (*slide 4. 20, 23*)

   C. parallelism tolerance must have a material modifier & be defined relative to a datum

   D flatness tolerance must be defined relative to a datum

   E. flatness tolerance must have a material condition modifier

5. **For the system shown below, $GT_{LMC} =$** **E**

   A. 0.002

   B. 0.003

   C. 0.005

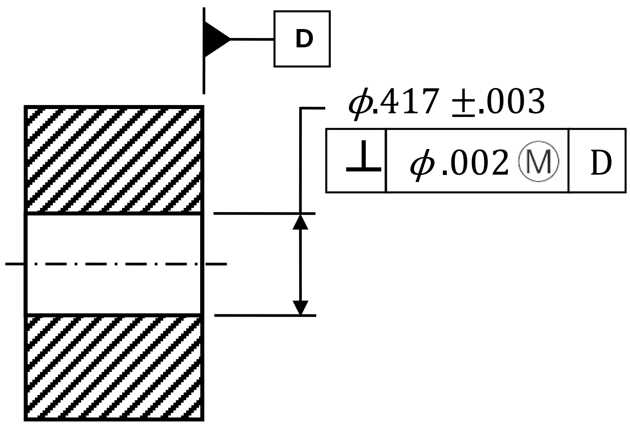
   D. 0.006

   E. 0.008 $V_C = \phi_{MMC} + Geom.Tol.$

   $= [.417 - .003] - .002 = 0.412$

   $GT_{LMC} = LMC - V_C = [0.417 + 0.003] -$

   $0.412 = \mathbf{0.008}$ (*slide 4. 27*)



6. **Repeat P5 above given *no* material condition modifier is defined in the FCF.** **A**

   A. $\mathbf{0.002}$ no material condition modifier ⇒ RFS ⇒ $GT_{LMC} = GT = \mathbf{0.002}$ (*slide 4. 13*)

   B. 0.003

   C. 0.005

   D. 0.006

   E. 0.008

7. **Which of the following machining parameters is *always* smaller than unity (<1)?** C

A. r and γ

B. μ and γ

C. r and η_{mech} (*slides 5. 13, 39*)

D. u_t and η_{mech}

E. μ and u_t

8. **Which of the following machining parameters is not "unitless" (i.e. has units)?** B

A. r

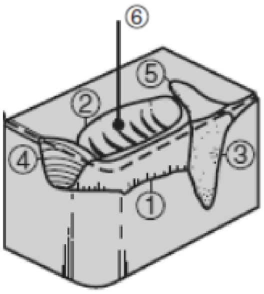
B. u_t (*slides 5. 36-38*)

C. γ

D. μ

E. η_{mech}

9. **Label the cutting tool diagram shown below** A



A. ①: flank wear; ②: crater wear; ③: depth-of-cut line; ⑥: thermal cracks (*slide 5.62*)

B. ①: crater wear; ②: flank wear; ③: depth-of-cut line; ⑥: thermal cracks

C. ①: flank wear; ②: crater wear; ③: thermal cracks; ⑥: depth-of-cut line

D. ①: flank wear; ②: thermal cracks; ③:depth-of-cut line; ⑥:crater wear

E. ①: flank wear; ②: crater wear; ③: outer metal chip notch; ⑥: thermal cracks

10. **The *Taylor Tool Life* equation measures time to develop which type of wear?** D

A. KT

B. R

C. VN

D. VB (*slides 5. 52, 53*)

E. VB_{max}

E

11. **Allowable notch wear is given by the symbol: …**

A. KT

B. R

C. VN

D. VB

E. VB_{max} (*slides 5. 52, 53*)

A

12. **Maximum crater wear is given by the following symbol: …**

A. KT (*slides 5. 64*)

B. R

C. VN

D. VB

E. VB_{max}

Questions 13-20. In an orthogonal cutting operation using a coated carbide tool ($n = 0.6$), $t_o = 0.39\ mm$, $V = 35\ m/min$, $\alpha = 18°$ and the $w = 9\ mm$. It is observed that $t_c = 0.85\ mm$, $F_c = 720\ N$ and $F_t = 345\ N$.

D

13. **What is the value of the *chip-thickness ratio*?**

A. 2.18

B. 0.33

C. 3.02

D. 0.46

E. 1.0

$$chip - ratio = r = \frac{t_0}{t_c} = \frac{0.39\ mm}{0.85\ mm} = \mathbf{0.46}$$

B

14. **What is the value of the *shear angle*?**

A. 14.1°

B. 27.0°

C. 75.9°

D. 63.0°

E. 72.0°

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} = \frac{(0.458)(\cos 18°)}{1 - (0.458)(\sin 18°)} = 0.508$$

$$\boldsymbol{\phi} = \tan^{-1} 0.508 = \mathbf{27.0°}$$

C

15. **What is the value of the *shear strain*?**

A. 1.96

B. 0.67

C. 2.12

D. 1.16

E. 0.16

$$\boldsymbol{\gamma} = \cot\phi + \tan(\phi - \alpha) = \frac{1}{\tan 27.0°} + \tan(27.0° - 18°) = \mathbf{2.12}$$

D

16. **What is the value of the *chip velocity*?**

A. 76.3 m/min

B. 5.7 m/min

C. 91.7 m/min

D. 16.1 m/min

E. 17.5 m/min

$$\boldsymbol{V_c} = V \cdot r = (35\ m/min) \cdot (0.458) = \mathbf{16.1\ m/min}$$

E

17. **What is the magnitude of the *coefficient of friction*?**

A. 1.05

B. 7.49

C. 0.13

D. 2.63

E. 0.95

$$\boldsymbol{\mu} = \frac{F_t + F_c\tan\alpha}{F_c - F_t\tan\alpha} = \frac{345 + 720\tan 18°}{720 - 345\tan 18°} = \mathbf{0.952}$$

B

18. **How much *energy* is required for 10 minutes of cutting?**

A. 25.2 kJ

B. 252 kJ

C. 43.2 kJ

D. 0.72 kJ

E. 1512 kJ

$$\boldsymbol{Power_{tot}} = F_c V = 720\ (N) * 35\left(\frac{m}{min}\right) = 25{,}200\left(\frac{N \cdot m}{min}\right)$$

$$= 25.20\left(\frac{kJ}{min}\right)$$

$$\boldsymbol{U_{tot}} = Power_{tot} * time = 25.20\left(\frac{kJ}{\cancel{min}}\right) * 10(\cancel{min}) = 252\ kJ$$

D

19. **What is the effect on *tool life* of doubling the cutting speed?**

A. reduction in tool life by 50.0%

B. reduction in tool life by 31.4%

C. reduction in tool life by 66.0%

D. reduction in tool life by 68.5%

E. reduction in tool life by 34.0%

$$\boldsymbol{V_1 T_1^n = V_2 T_2^n \Rightarrow \left(\frac{T_2}{T_1}\right)^n = \frac{V_1}{V_2} \Rightarrow \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{1/n} = 0.5^{(1/0.6)} = 0.314}$$

$$\boldsymbol{\Rightarrow \frac{T_1 - T_2}{T_1} = 1 - 0.314 = 0.685}$$

i.e. doubling the cutting speed has resulted in a 68.5% reduction in tool life

C

20. **What is the effect on *material removal rate* of doubling the cutting speed?**

A. increase in the MRR by 50%

B. decrease in the MRR by 50%

C. doubling of the MRR

D. increase in the MRR by 200%

E. increase in the MRR by 150%

$$\boldsymbol{\frac{MRR_2 - MRR_1}{MRR_1} = \frac{wt_0 V_2 - wt_0 V_1}{wt_0 V_1} = \frac{V_2 - V_1}{V_1} = \frac{V_2}{V_1} - 1 = 2 - 1 = 1}$$

i.e. doubling the cutting speed has resulted in a 100% increase in material removal rate (i.e. doubling of MRR)

Equations, Data, Diagrams You May Find Useful

$$\log x^p = p\log x,\quad \log xy = \log x + \log y,\quad \log\frac{x}{y} = \log x - \log y$$

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

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

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

$$Shear\ Stress = \frac{F_s}{Area\ of\ the\ shear\ plane}$$

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

$$\phi = 45° + \frac{\alpha}{2} - \frac{\beta}{2}\ (\text{when } \mu = 0.5 \sim 2)$$

$$\Rightarrow \phi = 45° + \alpha - \beta$$

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

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

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

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

$$Power = F_c V$$

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

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

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

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

- *Carbide tools*: $a = 0.2$, $b = 0.125$
- *High-speed steel tools*: $a = 0.5$, $b = 0.375$

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

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

$$\eta_{mech} = \frac{Power_c}{Power_{source}}$$

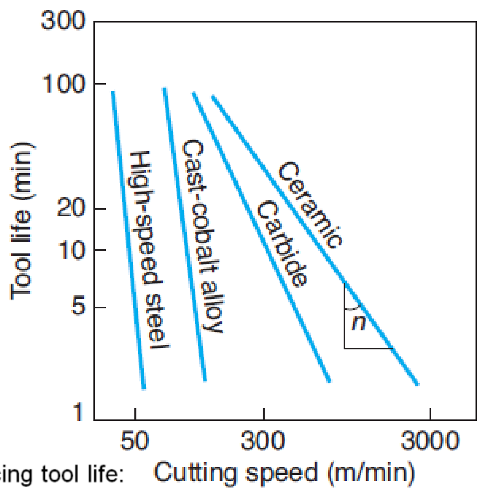
$$\mu = \frac{F}{N} = \frac{F_t + F_c\tan\alpha}{F_c - F_t\tan\alpha}$$

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

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

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

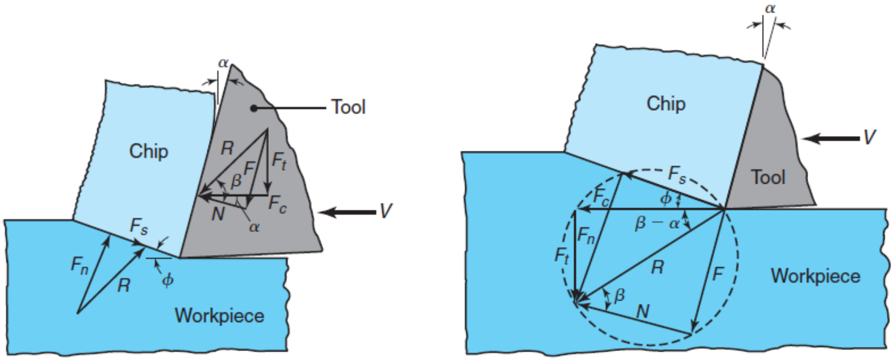


- Recommended cutting speed is one producing tool life:
  - 60-120 min: high-speed steel tools
  - 30-60 min: carbide tools

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

Approximate Range of Energy Requirements in Cutting Operations at the Drive Motor of the Machine Tool (for Dull Tools, Multiply by 1.25)

Material	Specific energy $W \cdot s/mm^3$
Aluminum alloys	0.4–1
Cast irons	1.1–5.4
Copper alloys	1.4–3.2
High-temperature alloys	3.2–8
Magnesium alloys	0.3–0.6
Nickel alloys	4.8–6.7
Refractory alloys	3–9
Stainless steels	2–5
Steels	2–9
Titanium alloys	2–5



(a) (b)