IE-352
Section 3, CRN: 48706/7/8
Section 4, CRN: 58626/7/8
Second Semester 1438-39 H (Spring-2018) – 4(4,1,2)
"MANUFACTURING PROCESSES – 2"

Monday, March 26, 2018 (09/07/1439H)

Quiz 3 [10 Points] ANSWERS

Name:	Student Number: 43	Section (circle): M-W ; S-M-T-W

Answer the following question.

During a turning operation, a workpiece is being cut at $V = 100\,m/min$. The machining power is found to be $3\,kW$. The feed is $0.2\,mm/rev$, and depth of cut is $0.5\,mm$. The bar is machined to a diameter of $50\,mm$ and its length is $250\,mm$.

a) What is the material removal rate in mm^3/s? [*1 Point*]

b) What is the initial bar diameter? [*1 Point*]

c) What is the rotational speed of the workpiece in rev/min? [*1 Point*]

d) What is the feed rate in mm/min? [*1 Point*]

e) What is the main cutting force in $Newtons$? [*1 Point*]

f) What is the specific cutting energy in both N/mm^2 and $W \cdot s/mm^3$? [*2 Points*]

g) What is the torque on the spindle in $N \cdot m$? [*1 Point*]

h) Estimate the necessary machining time. [*1 Point*]

i) If this process was to be presented as an orthogonal model, what would be the values of w and t_o? [*1 Point*]

Given:

- Process: turning
- $V = 100\,m/min$
- $Power = 3\,kW$

- $f = 0.2\, mm/rev$ (note that this is not the linear speed, v)
- $d = 0.5\, mm$
- $D = 50\, mm$ (note, this is D_f, since problem is stating *machined to*)
- $l = 250\, mm$

Solution:

a) **material-removal rate**, $MRR = dfV$

$$\Rightarrow MRR = dfV = (0.5\, mm)(0.2\, mm)(100{,}000\, mm/min)$$
$$= (10{,}000\, mm^3/min)(1\, min/\, 60\, s) = 166.67\, mm^3/s$$

▶ $\boldsymbol{MRR = 167\, mm^3/s}$

b) **initial bar diameter**, D_o

$$d = \frac{D_o - D_f}{2}$$

$$\Rightarrow D_o = 2d + D_f = 2(0.5\, mm) + 50\, mm = 51\, mm$$

▶ $\boldsymbol{D_o = 51\, mm}$

c) **rotational speed**, $N\ [rev/min]$

$$V = \pi D_{avg} N$$

$$D_{avg} = \frac{D_o + D_f}{2} = \frac{51\, mm + 50\, mm}{2} = 50.5\, mm$$

$$\Rightarrow N = \frac{V}{\pi D_{avg}} = \frac{100{,}000\, mm/min}{(\pi\, rad/rev)(50.5\, mm)} = 630.32\, rev/min$$

▶ $\boldsymbol{N = 630\, rev/min}$

d) **feed rate**, $v\ [mm/min]$

$$v = fN = (0.2\, mm/rev)(630.32\, rev/min) = 126.06\, mm/min$$

▶ $\boldsymbol{v = 126\, mm/min}$

e) **main cutting force**, $F_c\ [N]$

$$Power = F_c \cdot V$$

$$\Rightarrow F_c = \frac{Power}{V} = \frac{3{,}000\ W}{100\ m/min} = \frac{3{,}000\ N \cdot m/s}{100\ m/min} * \frac{60\ s}{min} = 1{,}800\ N$$

$$\blacktriangleright \quad \boldsymbol{F_c = 1.80\ kN}$$

f) **specific cutting energy,** u_t $[N/mm^2]$ and $[W \cdot s/mm^3]$

$$u_t = \frac{Power}{MRR} = \frac{3{,}000\ W}{166.67\ mm^3/s} = \frac{3{,}000\ W}{166.67\ mm^3/s} = 18.0\ W \cdot s/mm^3$$

$$= 18.0\ \frac{N \cdot \frac{m}{s}}{\frac{mm^{\not{3}\,2}}{s}} \cdot \frac{1000\ \not{mm}}{1\ m} = 18{,}000\ N/mm^2$$

$$\blacktriangleright \quad \boldsymbol{u_t = 18.0\ W \cdot s/mm^3 = 18{,}000\ N/mm^2}$$

g) **torque on the spindle,** Torque $[N \cdot m]$

$$Torque = \frac{Power}{\omega} = \frac{3000\ W}{2\pi N} = \frac{3000\ N \cdot m/s}{(2\pi)(630.32\ )\ rad/min} * \frac{60\ s}{min}$$
$$= 45.45\ N \cdot m$$

Another solution (also good way to check your answer):

$$Torque = F_c \cdot D_{avg}/2 = (1800\ N) \cdot (50.5\ mm/2)(1\ m/1000\ mm)$$
$$= 45.45\ N \cdot m$$

$$\blacktriangleright \quad \boldsymbol{Torque = 45.5\ N \cdot m}$$

h) **cutting time,** t

$$t = \frac{l}{fN} = \frac{250\ mm}{(0.2\ mm/rev)(630.32\ rev/min)} = 1.983\ min$$

$$\blacktriangleright \quad \boldsymbol{t = 1.98\ min}$$

i) w, t_o

$w = d = 0.5\ mm$

$t_o = f = 0.2\ mm$

TABLE 21.1 Conversion key: turning operation vs. orthogonal cutting.

Turning Operation	Orthogonal Cutting Model
Feed f =	Chip thickness before cut t_o
Depth d =	Width of cut w
Cutting speed v =	Cutting speed v
Cutting force F_c =	Cutting force F_c
Feed force F_f =	Thrust force F_t

$$\blacktriangleright \quad \boldsymbol{w = 0.5\ mm}$$

$$\blacktriangleright \quad \boldsymbol{t_o = 0.2\ mm}$$

Summary of Turning Parameters and Formulas

N = Rotational speed of the workpiece, rpm
f = Feed, mm/rev
v = Feed rate, or linear speed of the tool along workpiece length, mm/min
= fN
V = Surface speed of workpiece, m/min
= $\pi D_o N$ (for maximum speed)
= $\pi D_{avg} N$ (for average speed)
l = Length of cut, mm
D_o = Original diameter of workpiece, mm
D_f = Final diameter of workpiece, mm
D_{avg} = Average diameter of workpiece, mm
= $(D_o + D_f)/2$
d = Depth of cut, mm
= $(D_0 - D_f)/2$
t = Cutting time, s or min
= l/fN
MRR = mm^3/min
= $\pi D_{avg} d f N$
Torque = N · m
= $F_c D_{avg}/2$
Power = kW or hp
= (Torque)(ω), where $\omega = 2\pi N$ rad/min

Note: The units given are those which are commonly used; however, appropriate units must be used and checked in the formulas.