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, April 02, 2018 (16/07/1439H)

Quiz 4 [10 Points] ANSWERS

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

Answer the following question.

A hole is being drilled using a $30-mm$ twist drill bit, at a hole depth of $100\,mm$, cutting speed of $300\,rpm$, feed of $0.25\,mm/rev$, and specific cutting resistance of $2000\,N/mm^2$. Calculate the following [*1 Point each*]:

a) chip area

b) main cutting force

c) drill velocity (i.e. feed rate)

d) machining time

e) material-removal rate

f) quantity of material (volume) removed

g) power dissipated

h) torque on the drill

i) motor power required if machine efficiency in 85%

j) How long will it take to perform this operation if the speed is increased by 20% and the feed is decreased by 25%?

Given:

- Process: drilling
- Workpiece parameters:
  - $D = 30\,mm$
  - $l = 100\,mm$

  - $K_s = 2000\ N/mm^2$

- Tool parameters:
  - $N = 300\ rev/min$
  - $f = 0.25\ mm/rev$

Solution:

a) **chip area**, A_{chip}

$$A_{chip} = \frac{fD}{4} = \frac{(0.25\ mm)(30\ mm)}{4} = 1.875\ mm^2$$

► $\boldsymbol{A_{chip} = 1.88\ mm^2}$

b) **main cutting force**, F_c

$$F_c = sp.cutting\ force * undeformed\ chip\ area$$
$$= K_s * A_{chip} = \left(2000\frac{N}{mm^2}\right)(1.875\ mm^2) = 3{,}750\ N$$

► $\boldsymbol{F_c = 3.75\ kN}$

c) **feed rate**, v

$$v = f \cdot N = \left(0.25\frac{mm}{rev}\right)(300\ rev/min) = 75\ mm/min$$

► $\boldsymbol{v = 75.0\ mm/min}$

d) **machining time**, t

$$t = \frac{l + D/4}{fN} = \frac{(100\ mm) + (30\ mm/4)}{(0.25\ mm/rev)(300\ rev/min)} = 1.433\ min$$

► $\boldsymbol{t = 1.43\ min = 86.0\ s}$

e) **material-removal rate**, MRR

$$\Rightarrow MRR = \frac{\pi D^2}{4} \cdot fN = \pi\left(\frac{30^2\ mm^2}{4}\right) \cdot \left(0.25\frac{mm}{rev}\right) \cdot (300\ rev/min)$$
$$= 53014.38\ mm^3/min = 883.57\ mm^3/s = 53.01\ cm^3/min$$

► $\boldsymbol{MRR = 883.6\ mm^3/s = 53.0\ cm^3/min}$

f) **volume removed**, material

$$material = material\ removal\ rate * cutting\ time$$
$$= MRR * t = (53.01\ cm^3/min) \cdot (1.433\ min) = 75.99\ cm^3$$

► $\boldsymbol{vol. removed = 76.0\ cm^3}$

g) power dissipated, **Power**

- $Power = u_t \cdot MRR$

Note, $u_t = 2000 \frac{N}{mm^2} * \frac{1\ m/s}{1000\ mm/s} = 2.0\ W \cdot s/mm^3$

$$\Rightarrow Power = (2.0\ W \cdot s/mm^3) \cdot \left(883.6 \frac{mm^3}{s}\right) = 1767.15\ W$$

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

$$Power = F_c \cdot V = F_c \cdot \left(2\pi \cdot \frac{D}{2} \cdot N\right)$$
$$= (3{,}750\ N)$$
$$\cdot \left[\left(\pi \frac{rad}{rev}\right)(30\ mm)\left(300\ \frac{rev}{min}\right)\left(\frac{1\ m}{1000\ mm}\right)\left(\frac{1\ min}{60\ s}\right)\right]$$
$$= (3{,}750\ N) \cdot \left(0.471 \frac{m}{s}\right) = 1767.15\ N = 1.77\ kN$$

► $\boldsymbol{Power = 1.77\ kN}$

h) **torque on the spindle,** Torque

$$Torque = F_c \cdot D/2 = (3{,}750\ N) \cdot \left(30 \frac{mm}{2}\right)\left(1 \frac{m}{1000\ mm}\right) = 56.25\ N \cdot m$$

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

$$Torque = \frac{Power}{\omega} = \frac{1767.15\ W}{2\pi N} = \frac{1767.15\ N \cdot m/s}{(2\pi)(300\ )\ rad/min} * \frac{60\ s}{min}$$
$$= 56.25\ N \cdot m$$

► $\boldsymbol{Torque = 56.3\ N \cdot m}$

i) **Motor Power**, $Power_m$

$$motor\ efficiency: \eta_m = 0.85 = \frac{Power}{Power_m}$$

$$\Rightarrow Power_m = \frac{Power}{\eta_m} = \frac{1.76715\ kW}{0.85} = 2.079\ kW$$

► $\boldsymbol{Power_m = 2.08\ kW}$

j) Given for condition 2:

$$N_2 = N_1 + 0.2N_1 = 1.2N_1 = 1.2 * 300\ rev/min = 360\ rev/min$$

$$f_2 = f_1 - 0.25f_1 = 0.75f_1 = 0.75 * 0.25\ mm/rev = 0.1875\ mm/rev$$

$$\Rightarrow t_2 = \frac{l + D/4}{f_2 N_2} = \frac{(100\ mm) + (30\ mm/4)}{(0.1875\ mm/rev)(360\ rev/min)} = 1.593\ min$$

► $\boldsymbol{t = 1.59\ min = 95.6\ s}$

Note, we could calculate the increase in machining time as follows:

$$\frac{t_2 - t_1}{t_1} = \frac{\frac{l + D/4}{f_2 N_2} - \frac{l + D/4}{f_1 N_1}}{\frac{l + D/4}{f_1 N_1}} = \frac{f_1 N_1}{f_2 N_2} - \frac{f_1 N_1}{f_1 N_1} = \frac{f_1 N_1}{(0.75 f_1)(1.2 N_1)} - 1$$

$$= \frac{1}{0.9} - 1 = 0.1111 = 11.1\%$$