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

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Drilling Exercise + ANSWERS

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Material-Removal Rate and Torque in Drilling.

A hole is being drilled in a block of magnesium alloy with a $10-mm$ drill bit at a feed of $0.2\, mm/rev$ and with the spindle running at $N = 800\, rpm$. Calculate the following:

a) material-removal rate

b) power dissipated

c) torque on the drill

Given:

- Workpiece material: magnesium alloy
- Process: drilling
- $D = 10\, mm$
- $f = 0.2\, mm/rev$
- $N = 800\, rev/min$

Solution:

a) **material-removal rate**, $MRR = \left[\frac{(\pi)(D^2)}{4}\right](f)(N)$

$$MRR = \left[\frac{(\pi)(10\, mm)^2}{4}\right]\left(0.2\,\frac{mm}{rev}\right)\left(800\,\frac{rev}{min}\right)$$

$$= 12566.37\frac{mm^3}{min} * \left(\frac{1\, min}{60\, s}\right) = 209.44\, mm^3/s$$

► $\mathbf{MRR = 209\, mm^3/s}$

b) **power dissipated**, $Power$

remember, $u_t = \frac{Power}{MRR}$

u_t can be obtained from specific power table in ch.21, for different workpiece materials

$\Rightarrow$ for magnesium alloys, we can use an average value of 0.5 $W \cdot s/mm^3$

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 · s/mm³
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

$$\Rightarrow Power = u_t \cdot MRR = \left(0.5 \frac{W \cdot s}{mm^3}\right) \cdot (209.44\, mm^3/s) = 104.72\, W$$

▶ $\boldsymbol{Power = 105\, W}$

c) **torque on the drill**, $Torque$

$$Power = Torque \cdot \omega$$

$$\Rightarrow Torque = \frac{Power}{\omega} = \frac{104.72\, W}{2\pi N} = \frac{104.72\, N \cdot m/s}{(2\pi)(800\,)\, rad/min} * \frac{60\, s}{min}$$
$$= 1.25\, N \cdot m$$

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

$$Torque = F_c \cdot \frac{D}{2}$$

$$F_c = \frac{Power}{V} = \frac{104.72\, W}{\pi D N} = \frac{104.72\, N \cdot m/s}{\pi(10\, mm)(800\, rev/min)} * \frac{60\, s}{min} * \frac{1000\, mm}{1\, m}$$
$$=$$

$$= 250\, N$$

$$\Rightarrow Torque = F_c \cdot \frac{D}{2} = (250\, N) \cdot \left(\frac{10\, mm}{2} * \frac{1\, m}{1000\, mm}\right) = 1.25\, N \cdot m$$

▶ $\boldsymbol{Torque = 1.25\, N \cdot m}$

Note, compare the surface speed (V) with the feed rate (or linear speed, v)

in this problem:

$$V = \pi DN = (2\pi \, rad/rev)\left(\frac{10}{2} \, mm\right)(800 \, rev/min)$$
$$= 25{,}132.74 \, mm/min = 25.1 \, m/min$$

$$v = fN = (0.2 \, mm/rev)(800 \, rev/min) = 160 \, mm/min$$

i.e. V is much larger than v (157 times larger). Can you explain this?