IE-352
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Second Semester 1438-39 H (Spring-2018) – 4(4,1,2)
"MANUFACTURING PROCESSES – 2"

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Milling Exercise 2 + ANSWERS

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Material-removal Rate, Power Required, and Cutting Time in Face Milling

Assume that $D = 150\,mm$, $w = 60\,mm$, $l = 500\,mm$, $d = 3\,mm$, $v = 0.6\,m/min$ and $N = 100\,rpm$. The cutter has 10 inserts, and the workpiece material is a high-strength aluminum alloy. Calculate the following:

a) material-removal rate, MRR

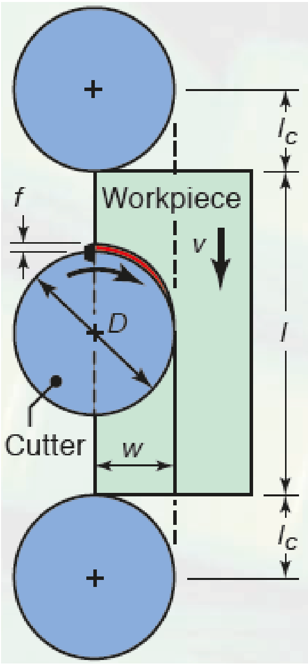
b) cutting time, t

c) feed per tooth, f

d) estimated power required, $Power$

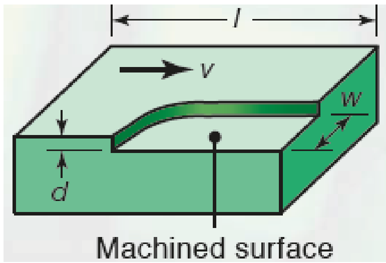
Given:

- Process: face milling (according to figure on the right)
- Workpiece material: *high-strength* aluminum alloy
- $D = 150\,mm$
- $w = 60\,mm$
- $l = 500\,mm$
- $d = 3\,mm$
- $v = 0.6\,m/min$
- $N = 100\,rev/min$
- $n = 10$



Solution:

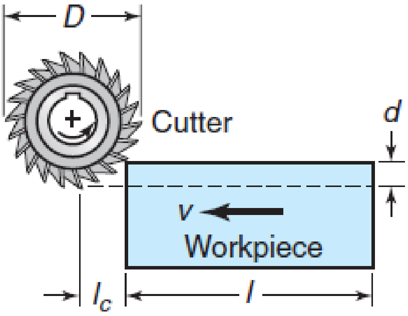
a) **material-removal rate**, $MRR = wdv$ (see figure)

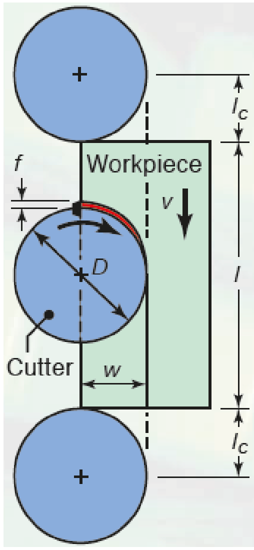


$$\Rightarrow MRR = wdv = (60\ mm)(3\ mm)\left(600\ \frac{mm}{min}\right)$$
$$= (108{,}000\ mm^3/min)\left(\frac{1\ min}{60\ s}\right) = 1800\ mm^3/s$$

► $\boldsymbol{MRR = 1{,}800\ mm^3/s}$

b) **cutting time**, t





$$t = \frac{l + 2l_c}{v}$$

- Note, can you explain here why it's $2l_c$ instead of l_c ?
- Also, can you explain here why $l_c = D/2 = 75\ mm$?

$$\Rightarrow t = \frac{l + 2(D/2)}{v} = \frac{500\ mm + 150\ mm}{600\ mm/min} = 1.083\ min$$

► $\boldsymbol{t = 65.0\ s}$

Let's test the above assumption. Just as with peripheral milling, l_c for face milling can be determined from the following formula (note how in face milling, d is replaced with w; compare the two figures above):

$$l_c = \sqrt{w(D - w)} = \sqrt{(60\ mm)\cdot(150\ mm - 60\ mm)} = 73.485\ mm$$

$$\Rightarrow t = \frac{l + 2l_c}{v} = \frac{500\ mm + 146.97\ mm}{600\ mm/min} = 1.078\ min$$

► $\boldsymbol{t = 64.7\ s}$

Thus the first assumption was justified.

c) **feed per tooth,** f

$$f = \frac{v}{N \cdot n} = \frac{600\ mm/min}{(100\ rev/min) \cdot (10\ teeth/rev)} = 0.60\ mm/tooth$$

▶ $\boldsymbol{f = 0.6\ mm/tooth}$

d) **estimated power required,** $Power$

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

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

$\Rightarrow$ for *high-strength* aluminum alloy, we can assume a value of 1.1 $W \cdot s/mm^3$

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

$$\Rightarrow Power = u_t \cdot MRR = \left(1.1\ \frac{W \cdot s}{mm^3}\right) \cdot \left(1800\ \frac{mm^3}{s}\right) = 1{,}980\ W$$

▶ $\boldsymbol{Power = 1.98\ kW}$