Chapter 1 Machine Tools and Machining Operations

1. Power available, $P_m = P_e \eta_m = 2000 \times 0.5 = 1000W$

Also $P_m = p_s Z_w$ and therefore $Z_w = P_m / p_s = \dfrac{1000}{2.73 \times 10^9} = 3.66 \times 10^{-7}$ m^3/s

For finish cut

$$Z_w = a_p f v$$

$$a_p = \frac{Z_w}{fv} = \frac{3.66 \times 10^{-7}}{0.13 \times 10^{-3} \times 1.5} \approx 2mm$$

$$t_{mf} = \frac{l_w}{f} \times \frac{\pi}{1.5}\left(69 \times 10^{-3}\right) = 167s$$

Volume V to be removed in rough cut:

$$V = \frac{\pi}{4}\left[\left(\frac{80}{1000}\right)^2 - \left(\frac{69}{1000}\right)^2\right] \times \frac{150}{1000} = 195 \times 10^{-6} \text{ m}^3$$

$$t_{mr} = \frac{V}{Z_w} = \frac{195 \times 10^{-6}}{3.66 \times 10^{-7}} = 532 \text{ s}$$

$$t_m = t_{mf} + t_{mr} = 167 + 532 = 699 \text{ s}$$

Total production time = 2000(120 + 2 x 15 + 699) = 1698 ks

Alternatively:

Total volume removed = 256 x 10^{-6} m^3

$$Z_w = 3.66 \times 10^{-7} \text{ m}^3/\text{s}$$

Therefore $t_m = \dfrac{vol}{Z_w} = 699$ s

2. (a) Rough cut:

$$P_m = 0.7 \times 3000 = 2100 \text{ w}$$

$$Z_w = \frac{P_m}{p_s} = \frac{2100}{2.3 \times 10^9} = 0.91 \times 10^{-6} \text{ m/s}$$

Volume to be removed $= \frac{50}{10^3} \times \frac{\pi}{4}\left[\left(\frac{100}{10^3}\right)^2 - \left(\frac{76}{10^3}\right)^2\right] = 0.17 \times 10^{-3}\ \text{m}^3$

$$t_{mr} = \frac{0.17}{0.91} \times \frac{10^6}{10^3} = 0.19\ \text{ks} = 190\ \text{s}$$

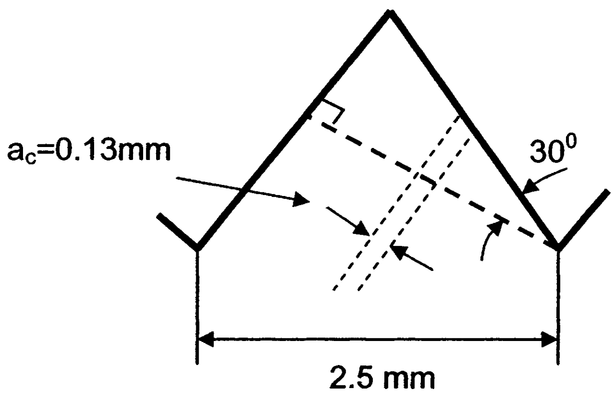
(b) Finish cut:

$f = 0.1$ mm, $a_p = 3$ mm, $v = 1.5$ m/s

$$t_{mf} = \frac{50\pi}{0.1} \times \frac{73}{10^3} \times \frac{1}{1.5} = 76.5\ \text{s}$$

(c) $t_{pr} = 20 + 2 \times 30 + 190 + 76.5 = 347\ \text{s}$

3.

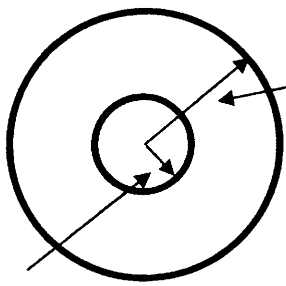


(a) Total tool feed normal to cutting edge = 2.5 cos 30^0 = 2.165 mm

Number of passes = 2.165/ 0.13 ≈ 17

(b) Production time $= 17\left(\frac{250}{2.5 \times 0.8} + 20\right) = 2.465\,\text{s}$

4.



(a) Radial distance moved by tool = 750 – 300 =450 mm

Therefore number of revolutions of workpiece = 450/ 0.25

$t_m = 450/(0.25 \times 0.5) = 3600\,\text{s}$

(b) $P_m = p_s Z_w = 3.5 \times 10^9 Z_w$ W

$P_{m1} = 3.5 \times 10^9 Z_w = 3.5 \times 10^9 f a_p n_w 2\pi r_1$

$= 3.5 \times 10^9 \times 0.25 \times 10^{-3} \times 6 \times 10^{-3} \times 0.5 \times 1.5\pi = 12.37 kW$

(c) $P_{m2} = 3.5 \times 10^9 \times 0.25 \times 10^{-3} \times 6 \times 10^{-3} \times 0.5 \times 0.6\pi = 4.95 kW$

5.

a) $v = \pi d_0 n = \pi \times 0.5 \times 6 = 9.42$ m/s

$A_c = f a_p = 0.25 \times 12 \times 10^{-6} = 3 \times 10^{-6}$ m^2

$Z_w = v A_c = 9.42 \times 3 \times 10^{-6} = 28.27 \times 10^{-6}$ m^3/s

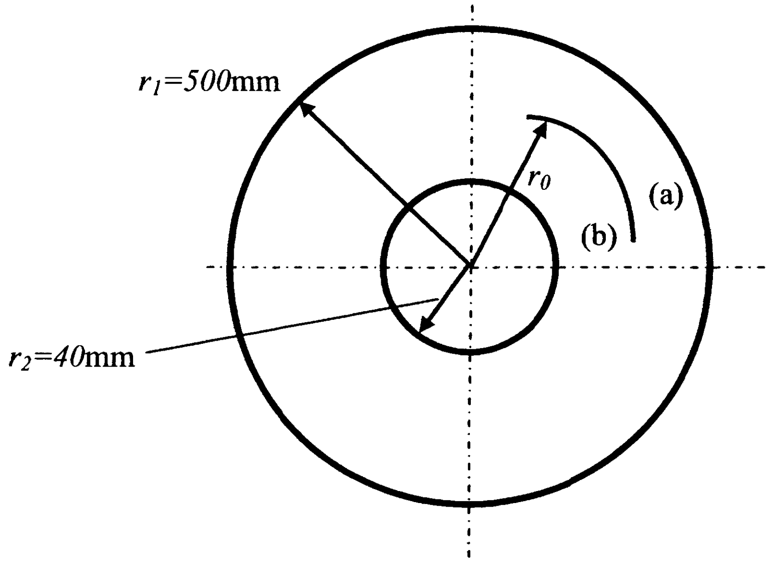
$P_m = p_s Z_w = 2.6 \times 10^9 \times 28.27 \times 10^{-6} = 73.51$ kW

b) $p_s = F_c / A_c$ or $F_c = A_c p_s$

$F_c = 3 \times 10^{-6} \times 2.6 \times 10^9 = 7.8$ kN

c) $t_m = \dfrac{125}{0.25} \times \dfrac{1}{6} = 83.33$ s

6.



Region (a) maximum power: $P_m = p_s Z_w$

$$Z_w = \frac{3000}{2.27\times10^9} \text{ m/s} \qquad (1)$$

When the rotational frequency rises to critical value:

$$Z_w = fa_p n_w \times 2\pi r_0 \qquad (2)$$

Combining (1) and (2)

$$r_0 = \frac{3000}{2.27\times10^9 \times 9\times10^{-3} \times 0.25\times10^{-3} \times 0.7\times 2\pi} = 0.24 \text{ m}$$

V, volume removed in period (a):

$$V = \frac{\pi}{4}\left(1^2 - 0.48^2\right)\times 5\times10^{-3}$$

Machining time in period (a):

$$t_{ma} = \frac{V}{Z_w} = \frac{\frac{\pi}{4}\left(1^2 - 0.48^2\right)\times 5\times10^{-3}}{\left(3000/2.27\times10^{-9}\right)} = 2.285 \text{ ks}$$

Machining time in period (b):

$$t_{mb} = \frac{r_0 - r_2}{fn_w} = \frac{200.4}{0.25\times0.7} = 1.145 \text{ ks}$$

$$t_m = t_{ma} + t_{mb} + 600 = 4.03 \text{ ks}$$

For 50 components $t_{pr} = 50\times 4.03 = 201.5$ ks