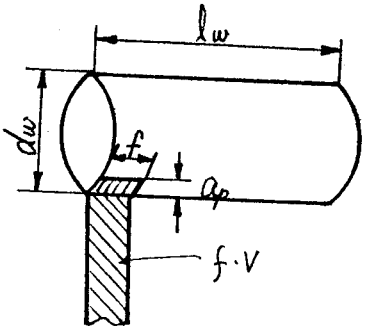
제 1 장

문제 1 풀이



이용할 수 있는 최대동력 P_m :

$P_m = P_e \cdot \eta_m = 2000 \times 0.5 = 1000\ W$

그런데 $1\ giga = 10^9$, $1\ W = 1\ J/sec$

$\therefore P_m = P_s \cdot Z_{w\,max}$ 에서

$$\therefore Z_{w\,max} = \frac{P_m}{P_s} = \frac{1000\ J/sec}{2.73 \times 10^9\ J/m^3}$$

$$= \underline{3.663 \times 10^{-7}\ m^3/sec}$$

Max. power 이용시의 Z_w

끝 다듬질에 대하여 $Z_{w\,max} = a_{p\,max} \cdot f \cdot V$

$$\therefore a_{p\,max} = \frac{Z_{w\,max}}{f \cdot V} = \frac{3.663 \times 10^{-7}}{(0.13 \times 10^{-3}) \times 1.5}$$

$$= \underline{2\ mm}$$

끝 다듬질에서 Max. power 이용시의 back engagement.

황삭후 표면적 (최후 가공할 표면적) $= \pi \cdot d_e \cdot l_w$

단위 시간의 절삭면적 $= f \cdot V$

$$\therefore t_{mf} = \frac{l_w \cdot \pi \cdot d_e}{f \cdot V} = \frac{(150\times10^{-3}) \times \pi \times (d_m + a_{p_{max}} \times 2) \times 10^{-3}}{(0.13 \times 10^{-3}) \times 1.5}$$

$$= \frac{150}{0.13} \times \frac{\pi(65+2\times2) \times 10^{-3}}{1.5} = 167 sec$$

황삭에서 제거되어야 할 체적 V :

$$V = \frac{\pi}{4}\left[\left(\frac{80}{1000}\right)^2 - \left(\frac{69}{1000}\right)^2\right] \times \frac{150}{1000} = 195\times10^{-6} m^3$$

$$\therefore t_{mr} = \frac{V}{Z w_{max}} = \frac{195\times10^{-6} m^3}{3.663\times10^{-7} m^3/sec} = 532 sec$$

$$\therefore 총가공시간 = 2000\,(120 + \underline{2} \times 15 + 167 + 532) \times 10^{-3} Ksec$$

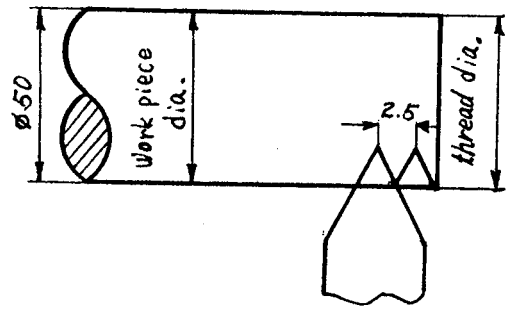
* 1 : 황삭 (rough cutting) 시간.
1 : 다듬질 (finish cutting) 시간.

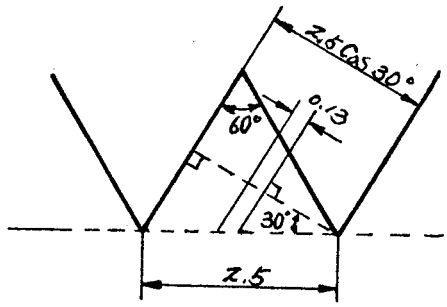
$$= 1698 ksec.$$

[답]

총가공시간 = 1698 ksec

문제 2 풀이





(1) 공구 통과수 $= \dfrac{2.5 \cos 30°}{0.13} = 17$

(2) 총가공시간 $= (\text{No. of passes}) \times \left(\dfrac{l_w}{f \cdot n_w} + 20\right)$

$= 17\left(\dfrac{250}{2.5 \times 0.8} + 20\right) = 2.465\ \text{ksec}$

단, feed(f) = pitch(p),

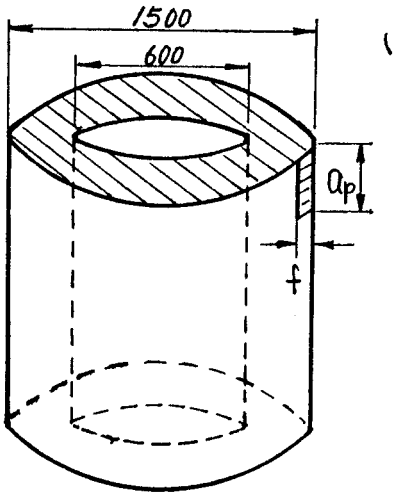
n_w ; 工作物의 회전수.

[답]

(1) 공구 통과수 = 17 회

(2) 총 가공시간 = 2.465 ksec

문제 3 풀이



(1) 공구가 운동하여야 할 반경상의 거리

$= \frac{1500}{2} - \frac{600}{2} = 450\ mm$

가공물의 회전수 $= \frac{450}{f} = \frac{450}{0.25} = 1800$

∴ 가공시간 t_m :

$$t_m = \frac{450}{f \cdot n_w} = \frac{450}{f} \times \frac{1}{n_w}$$

$= 1800 \times \frac{1}{0.5} = 3600\ sec$

$= 3.6\ Ksec.$

(2) $P_{m_1} = P_s \cdot Z_{w_1} = P_s (f \cdot a_p \cdot V_1)$

$= P_s (f \cdot a_p \cdot 2\pi r_1 \cdot n_w)$

$= 3.5 \times 10^9 J/m^3 \times (0.25 \times 10^{-3}) \cdot (6 \times 10^{-3})$

$\times (1.5\pi)\ m^3 \times 0.5 s^{-1} = 12.37\ KJ/sec$

$= 12.37\ KW$

* $1\ \frac{Joule/sec}{work} = \frac{1\ Watt}{power}$

(3) $P_{m_2} = P_s \cdot Z_{w_2} = P_s (f \cdot a_p \cdot V_2) = P_s (f \cdot a_p \cdot 2\pi r_2 \cdot n_w)$

$= 3.5 \times 10^9 J/m^3 \times (0.25 \times 10^{-3} \times 6 \times 10^{-3} \times 0.6\pi)\ m^3$

$\times 0.5 s^{-1}$

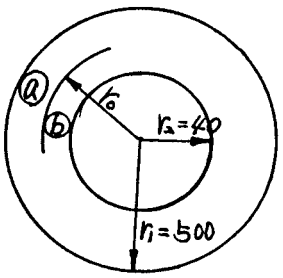
$= 4.948\ KJ/sec = 4.948\ KW.$

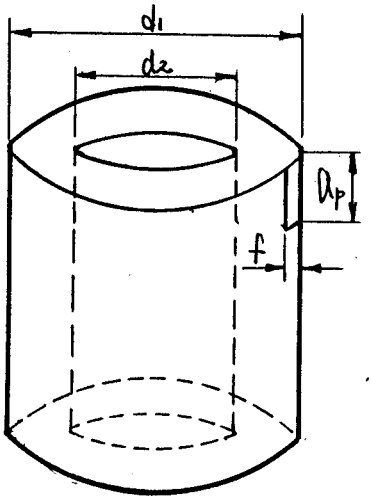
[답] (1) 총 가공시간 $= 3.6$ Ksec

(2) $P_{m1} = 12.37\ KW$

(3) $P_{m2} = 4.946\ KW$

문제 4 풀이





ⓐ 구역에서 최대동력 P_m :

$$P_m = P_s \cdot Z_w$$

$$\therefore Z_w = \frac{P_m}{P_s} = \frac{3000\ W}{2.27\times10^9\ J/m^3} = \frac{3000\ J/sec}{2.27\times10^9\ J/m^3}$$

$$= \frac{3000}{2.27\times10^9}\ m^3/sec \quad \cdots\cdots\cdots ①$$

회전속도가 임계치로 낮아질때

$$Z_w = f\cdot a_p \cdot V = f\cdot a_p \cdot 2\pi r_o n_w \quad \cdots\cdots ②$$

식 ①과 ② 에서

$$r_o = \frac{Z_w}{f\cdot a_p \cdot n_w \cdot 2\pi} = \frac{3000}{2.27\times10^9} \times \frac{1}{(0.25\times10^{-3})(5\times10^{-3})\times0.7\times2\pi} = 0.2404\,m$$

$$\therefore d_o = 0.4808\,m$$

ⓐ 구역에서 제거될 체적 V :

$$V = \frac{\pi}{4}(d_i^2 - d_o^2) \cdot a_p = \frac{\pi}{4}(1^2 - 0.4808^2) \times 5 \times 10^{-3}$$

최대동력 사용시에 ⓐ구역에서의 가공시간 t_{ma} :

$$t_{ma} = \frac{V}{\Sigma w} \quad \frac{\frac{\pi}{4}(1^2 - 0.4808^2) \times 5 \times 10^{-3}}{3000/2.27 \times 10^9} = 2.2845 \text{ Ksec}$$

최대동력을 사용할수 없을때 ⓑ 구역에서의 가공시간 t_{mb} :

$$t_{mb} = \frac{r_o - r_2}{f \cdot n_w} = \frac{0.2404 - 0.04}{0.25 \times 10^{-3} \times 0.7} = \frac{0.2004}{0.25 \times 10^{-3} \times 0.7} = 1.145 \text{ Ksec}$$

$$\therefore t_m = t_{ma}^{\text{Ksec}} + t_{mb}^{\text{Ksec}} + 600 \text{ sec}$$

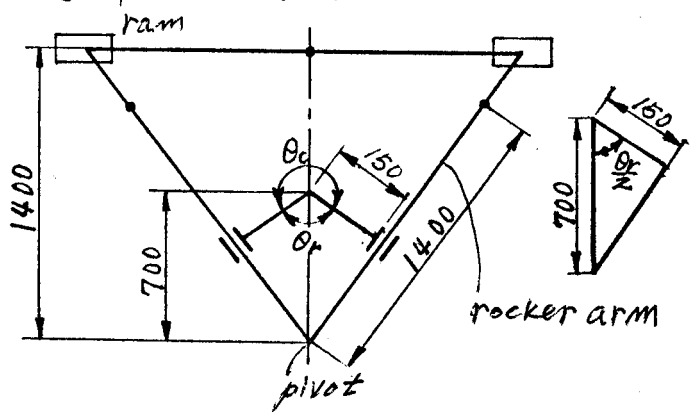
$$= 2.2845 + 1.145 + 0.6 = 4.03 \text{ Ksec}$$

$\therefore$ 50 Components 에 대한 가공시간.

$$= 50 \times 4.03 = 201.5 \text{ Ksec}.$$

[답] 총 가공시간 = 201.5 ksec.

문제 5 풀이



$\cos\frac{\theta_r}{2} = \frac{0.15}{0.7}$

$\therefore \theta_r = 2\times\cos^{-1}\frac{0.15}{0.7}$

$= 155.260^\circ$

$= 2.7$ rad.

$\therefore \theta_c = 2\pi - 2.7$

$= 3.54$ rad.

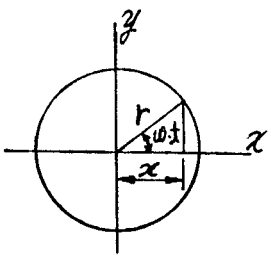
그런데 $\omega = 2\pi N = 2\pi \times 0.3 = 1.872$ rad/sec.

각속도 1sec당 crank회전수.

(1) 절삭 행정시간 $= \frac{\theta_c}{\omega} = \frac{3.54}{1.872} = 1.89$ sec

(2) 귀환 행정시간 $= \frac{\theta_r}{\omega} = \frac{2.7}{1.872} = 1.44$ sec

(3)

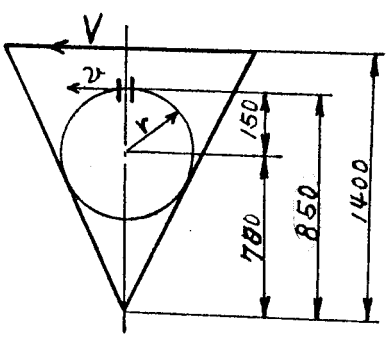


$x = r\cdot\cos t$

$\therefore \dot{x} = V = -r\omega\cdot\sin t$

$\therefore |\dot{x}|_{max} = r\cdot\omega$ at $\frac{\pi}{2}$

즉 행정 중앙에서 최대 속도를 갖는다.



$V : v = 1.4 : 0.85$

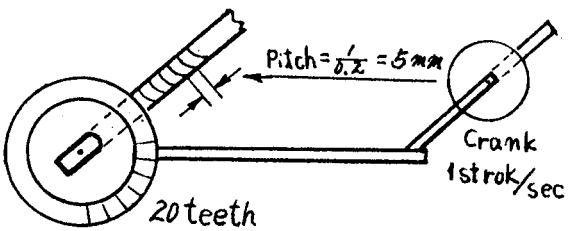
$\therefore V = \frac{1.4\times v}{0.85} = \frac{1.4(2\pi rN)}{0.85}$

$= \frac{1.4\times 2\pi\times 0.15\times 0.3}{0.85} = 0.465$ m/sec

[답] (1) 절삭 행정시간 $= 1.89$ sec

(2) 귀환 행정시간 $= 1.44$ sec, (3) 최대속도 $= 0.465$ m/sec

문제 6 풀이



1 mm 당 0.2 씩

$\therefore$ pitch $p = \frac{1}{0.2} = 5\,mm$

(1) 가공물의 이송 f :

$$f = \frac{1}{20} \times 5 = 0.25\,mm/sec \quad (= V_f)$$

(2) 100mm 의 변을 가로질러 절삭하여 갈 때 가공시간이 적게들며,

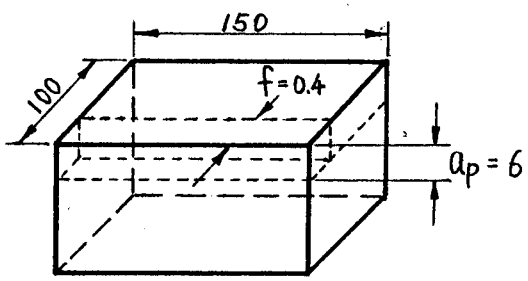
$$t_m = \frac{100\,mm}{f\,mm/sec} = \frac{100}{0.25} = 400\,sec$$

[답]

(1) 가공 물의 이송속도 $V_f = 0.25\,mm/sec$

(2) 최소 가공 시간 $t_m = 400\,sec$

문제 7 풀이



(1) $t_m = \frac{100}{2f} = \frac{100}{2\times 0.4}$

two strokes per sec

$= 125$ sec

(for 1 component)

∴ 800 components 에 대한 가공시간

$= 125 \times 800$ sec $= 100$ ksec

(2) 행정중 접촉시간 $= \frac{l_w}{V} = \frac{0.15\,m}{0.5\,m/sec} = 0.3$ sec

행정중 비접촉시간 $= \frac{0.5}{\text{(two cutting strokes/sec}} - 0.3 = 0.2$ sec

→ 2왕복/sec → $\frac{1}{2}$ sec/왕복)

∴ 비 접촉시간과 접촉시간의 비 $= \frac{0.2}{0.3} = 0.67 = 67\%$

(3) $Z_w = f \cdot a_p \cdot V = \frac{0.4}{1000} \times \frac{6}{1000} \times 0.5 = 10^{-6} \times 1.2\,m^3/sec$

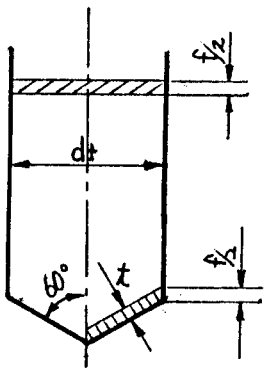
$= 1.2\,\mu \cdot m^3/sec$

[답] (1) 총 절삭시간 $= 100$ ksec

(2) 비 접촉시간과 접촉시간 비 $= 67\%$

(3) 단위시간당 절삭량 $= 1.2\,\mu \cdot m^3/sec$

문제 8 풀이



(1) $Z_w = \frac{\pi}{4} \cdot d_t^2 \cdot (f \cdot N_t)$

$= \frac{\pi}{4}\left(\frac{12}{1000}\right)^2 \cdot \left(\frac{0.25}{1000}\right) \times 5$

$= 10^{-9} \times 141.3\ m^3/sec$

$= 10^{-6} \times 0.1413\ m^3/sec$

$= 0.1413\ \mu \cdot m^3/sec$

(2) $t = \frac{f}{2} \cdot \sin kr = \frac{0.25}{2} \cdot \sin 60° = 0.108\ mm$

(3) $T = F \cdot r$, 그런데 $V = 2\pi r N_t$

$\therefore r = \frac{V}{2\pi N_t}$

$\therefore T = F \cdot \frac{V}{2\pi N_t} = \frac{P_m}{2\pi N_t}$

그런데 $P_m = P_s \cdot Z_w$

$\therefore T = \frac{P_s \cdot Z_w}{2\pi N_t} = \frac{(2\times10^9 J/m^3) \cdot (10^{-6} \times 0.1413\ m^3/sec)}{2\pi \times 5/sec}$

$= \frac{(2\times10^9 N/m^2) \cdot (10^{-6} \times 0.1413\ m^3/sec)}{2\pi \times 5/sec}$

$= 10^3 \times 0.0089808\ Nm = 9\ Nm$

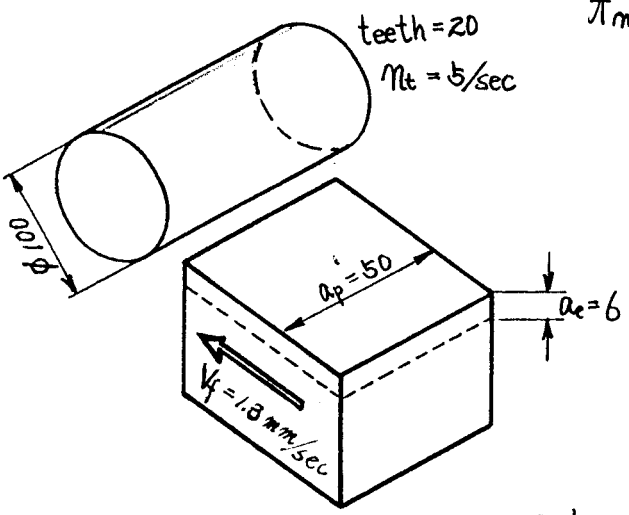
[답]

(1) 단위 시간당 최대 절삭량 $= 0.1413\ \mu \cdot m^3/sec$

(2) Chip의 두께 $t = 0.108\ mm$

(3) 드릴의 토오크 $T = 9\ N \cdot m$

문제 9 풀이



$$t_{max} = \frac{2 V_f}{N \cdot n_t} \sqrt{\frac{a_e}{d_t}}$$

$$= \frac{2 \times 1.3}{20 \times 5} \sqrt{\frac{6 \times 10^{-3}}{100 \times 10^{-3}}}$$

$$= 6.37 \times 10^{-3} \, mm$$

$$= 6.37 \times 10^{-6} \, m$$

$$= 6.37 \, \mu m$$

$$P_s = 1.4 \left(1 + \frac{25 \times 10^{-6}}{t_{max}}\right) = 6.9 \, GJ/m^3$$

$$= 6.9 \times 10^9 \, J/m^3$$

(1) $Z_{w\,max} = a_p \cdot a_e \cdot V_f$

$$= \frac{50}{1000} \times \frac{6}{1000} \times \frac{1.3}{1000}$$

$$= 390 \times 10^{-9} \, m^3/sec = 390 \times 10^{-3} \, \mu m^3/sec$$

$$= 0.39 \, \mu m^3/sec$$

(2) $P_m = P_s \cdot Z_{w\,max} = (6.9 \times 10^9 \, J/m^3) \times (0.39 \, \mu m^3/sec)$

$$= 2.691 \times 10^9 \, \mu J/sec$$

$$= 2.691 \times 10^3 \, J/sec$$

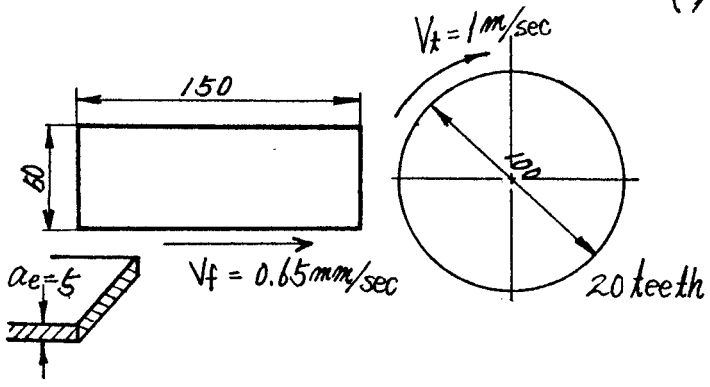
$$= 2.691 \, kW$$

[답]

(1) 단위 시간당 최대 절삭량 = 0.39 $\mu m^3/sec$

(2) 최대 동력 = 2.691 kW

문제 10 풀이



(1) $V_t = \pi \cdot d_t \cdot N_t$

$\therefore N_t = \dfrac{V_t}{\pi \cdot d_t}$

$= \dfrac{1000 mm/sec}{\pi \times 100 mm}$

$= 3.18 sec^{-1}$

(2) $Z_w = a_p \cdot a_e \cdot V_f$

$= \dfrac{50}{1000} \times \dfrac{5}{1000} \times \dfrac{0.65}{1000}$

$= 10^{-9} \times 162.5 \ m^3/sec$

$= 10^{-3} \times 162.5 \ \mu \cdot m^3/sec$

$= 0.1625 \ \mu \cdot m^3/sec$

(3) $t_m = \dfrac{l_w + d_t}{V_f} = \dfrac{150 + 100}{0.65} = 385 sec$

$\therefore$ 총 가공시간 $= 1000 (180 + 385) = 565 ksec$

Text P. 16 식(44) (4) $t_{max} = \dfrac{V_f}{N \cdot n_t} = \dfrac{0.65}{20 \times 3.18} = 0.0102 mm$

[답]

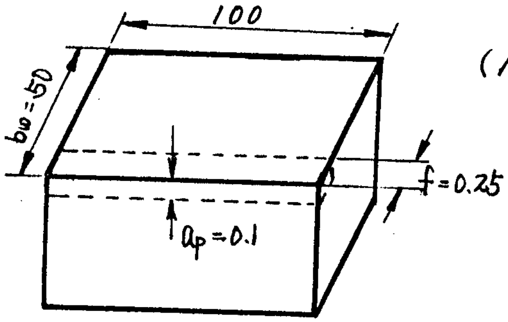
(1) Cutter의 회전수 $N_t = 3.18 sec^{-1}$

(2) 단위 시간당 최대 절삭량 $Z_w = 0.1625 \ \mu \cdot m^3/sec$

(3) 총 가공시간 $t_m = 565 \ ksec$

(4) Chip의 최대 두께 $t_{max} = 0.0102 \ mm$

문제 11 풀이



(1) 필요 절삭 행정수 $= \dfrac{b_w}{f} = \dfrac{50}{0.25} = 200$

(연삭에서는 되돌아올 때도 연삭 함)

단위 시간의 절삭행정수 $= 2\,S^{-1}$

(table의 왕복회수 1sec → 1stroke당 $\frac{1}{2}$ sec → 2 strokes/sec)

$\therefore t_m = \dfrac{200}{2} = 100\,sec$

(2) $Z_w = f \cdot a_p \cdot V_{trav} = \dfrac{0.25}{1000} \times \dfrac{0.1}{1000} \times \dfrac{250}{1000}$

$= 10^{-9} \times 6.25\ m^3/sec$

$= 10^{-3} \times 6.25\ \mu \cdot m^3/sec$

$= 0.00625\ \mu \cdot m^3/sec$

(3) $P_m = P_s \cdot Z_w = (25 \times 10^9\,J/m^3) \times (10^{-6} \times 0.00625\,m^3/sec)$

$= 156.25\ J/sec = 156.25\,W$

(4) $P_m = F_t \cdot V_t = F_t \cdot \pi d_t n_t$

$\therefore F_t = \dfrac{P_m}{\pi \cdot n_t \cdot d_t} = \dfrac{156.25\,W}{\pi \times 60\,S^{-1} \times 150/1000\,m}$

$= 5.53\ W sec/m = 5.53\ J/sec \cdot sec/m$

$= 5.53\ J/m = 5.53\ N$ ※ $1W = 1J/sec$, $1J = 1N \times 1m$

[답] (1) 절삭 시간 $t_m = 100\,sec$

(2) 단위 시간당 최대 절삭량 $= 0.00625\ \mu \cdot m^3/sec$

(3) 최대동력소모 $P_m = 156.25\,W$

(4) 최대접선력 $F_t = 5.53\,N$