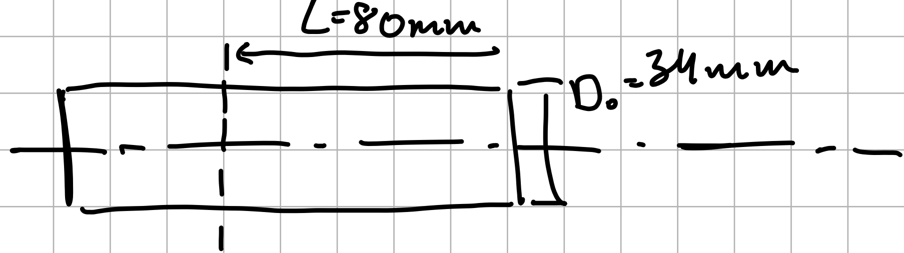
Esercitazione 10 -

Tornitura - Esercizio 5



$D_f = 32$ mm

$P_c = ?$

$\eta = 80\%$

$f = 0{,}2$ mm/giro

$a_p = \frac{D_0 - D_f}{2} = 1$ mm

$v_c = 150$ m/min

$k_{c0,4} = 2100$ MPa

$x = 0{,}16$

$k_{re} = 60°$

$$k_c = \frac{k_{c0,4} \cdot 0{,}4^x}{f^x} \left(\frac{1}{\sin k_{re}}\right)^x = 2401 \text{ MPa}$$

$$F_c = k_c f a_p = 480{,}2 \text{ N}$$

$$P_c = \frac{F_c \cdot v_c}{60 \cdot 1000} = 1{,}2 \text{ kW}$$

$$P_g = \frac{P_c}{\eta} = 1{,}5 \text{ kW}$$

Verifica di deflessione

$d = 0{,}01$ mm → deflessione massima

$E = 200000$ MPa

$0{,}1 \frac{mm}{giro} < f < 0{,}4 \frac{mm}{giro}$ $\qquad e = 1$ mm

$t_{rapido} = 6s$

$$d = \frac{F_c L^3}{3EJ} \qquad F_c \leq \frac{3EJd}{L^3} = 768\,N$$

$$J = \frac{\pi}{64} D_0^4 =$$

$$F_c = k_{c0,4} \cdot 0{,}4^x f^{1-x} a_p \left(\frac{1}{\sin\kappa_{re}}\right)^x$$

1 passata $a_p = 1mm$ → passate per completare l'operazione.

2 passate $a_p = 0{,}5\,mm$

$$f_{1,passata} = \sqrt[1-x]{\frac{F_c}{0{,}4^x_{a_p} k_{c0,4} \left(\frac{1}{\sin\kappa_{re}}\right)^x}} = 0{,}35\ mm/giro$$

$$f_{2,passate} = \sqrt[1-x]{\frac{F_c}{0{,}4^x_{a_p} k_{c0,4} \left(\frac{1}{\sin\kappa_{re}}\right)^x}} = 0{,}8\ mm/giro$$

poiché $f > f_{MAX}$

⇒ imponiamo $f_{2,passate} = 0{,}4\ mm/giro$

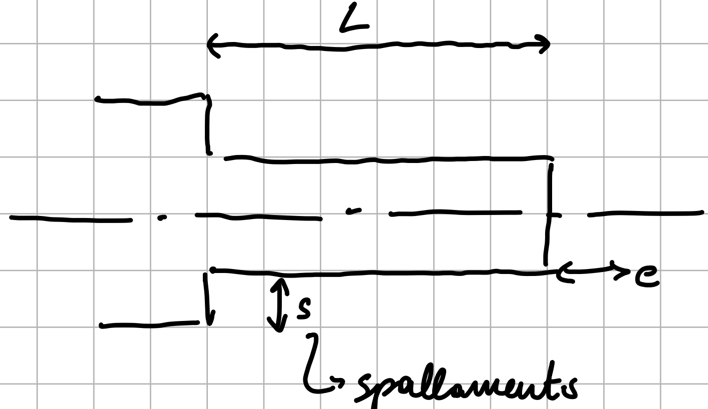
1 passata

$$n_1 = \frac{V_c}{\pi D_0} = 1404\ giri/min$$

2 passate

$$n_1 = \frac{V_c}{\pi D_0} = 1404\ giri/min$$

$$n_2 = \frac{V_c}{\pi D_{o,2}} = 1447 \ \frac{giri}{min}$$



$s_1 = a_{p,1} = 1mm$

$S_2 = a_{p,2} = 0,5mm$

$$T_{m\,1,passata} = \frac{L+e+s_1}{f_{1,passata} \cdot n_1} = 0,17 \ min$$

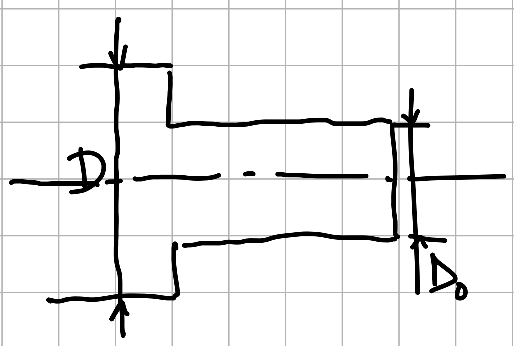
tempo di ritorno ad inizio

$$T_{m2,passate} = \underbrace{\frac{L+e+s_2}{f_2 \cdot n_1}}_{\text{Prima passata}} + \frac{L+e+s_2}{f_2 \cdot n_2} + t_{rapido} = 0,385 mm$$

0,4 mm/giro → f_2

⇒ 1 passata è meglio.

Esercizio 6 - TdE 29-06-2009



$D = 50mm$

$D_0 = 40mm$

$k_{c0,4} = 2100 \ MPa$ $\quad x = 0,29$ $\quad A = 70mm^2$

$N_{passate} = 2$ $\quad a_p = 1mm$ $\quad R_a = 1,6 \mu m$

$r_\varepsilon = 0{,}4\,mm \quad k_{re} = 95° \quad z = 4$

$\eta = 0{,}7 \quad p = 30\,N/mm^2 \quad \mu = 0{,}15 \quad v_c = 170\,m/min$

$$f = \sqrt{\frac{32 R_a r_\varepsilon}{1000}} = 0{,}14\ mm/giro$$

$$F_c = k_{c0,4}\, 0{,}4^x f^{1-x} a_p \left(\frac{1}{\sin k_{re}}\right)^x = 400\,N$$

$$P_c = \frac{F_c \cdot v_c}{60 \cdot 1000} = 1{,}13\,kW$$

$$P_g = \frac{P_c}{\eta} = 1{,}619\,kW < \underset{\underset{5\,kW}{\parallel}}{P_a}\ ✓$$

$$M_r = 3\mu p A \frac{D}{2} = 31500\ Nmm = 31{,}5\ Nm$$

$$M_c = F_c \frac{D_f}{2} = 7600\ Nmm = 7{,}6\ Nm$$

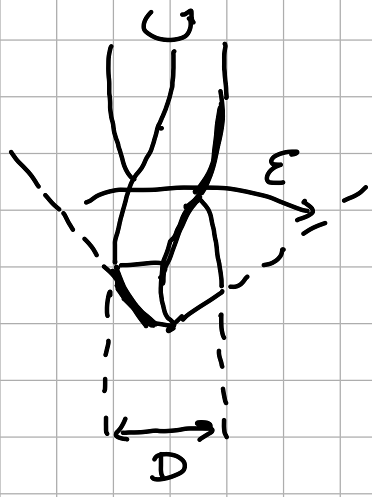
$$\Rightarrow M_r > M_c\ ✓$$

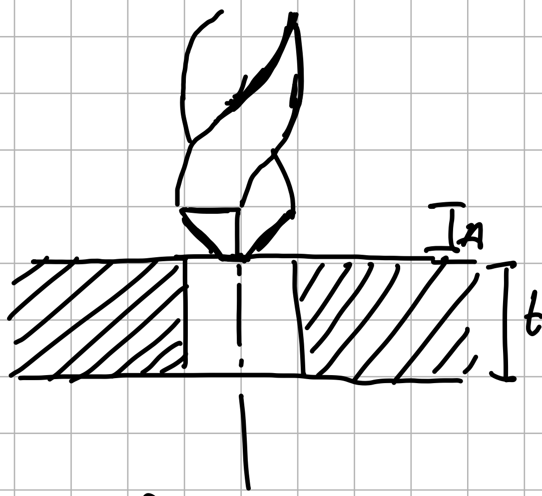
$$D_f = D_0 - 2a_p$$

se $M_r = M_c \quad p = \dfrac{M_c}{3\mu A D/2} = 7{,}24\ MPa$

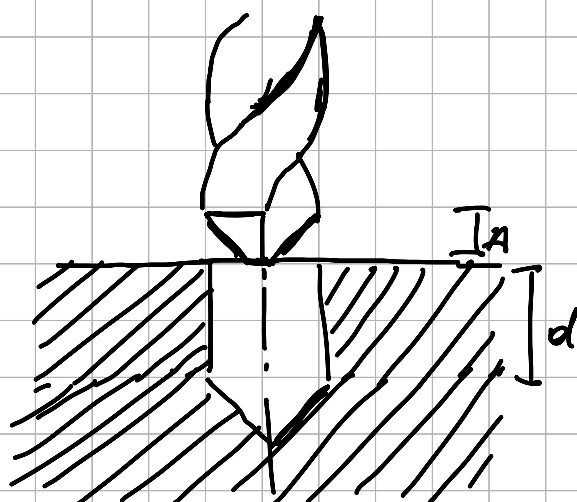
↳ Pressione minima richiesta.

Teoria della Foratura





Foro Passante



Foro Cieco

$$n = \frac{V_c}{\pi D}$$

$$v_f = n f$$

Passante

$$T_m = \frac{t + A}{V_f}$$

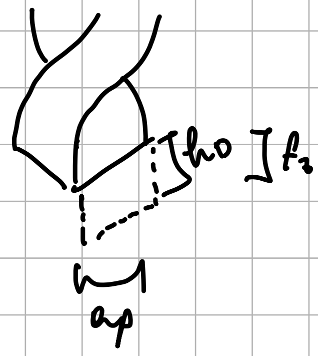
Cieco

$$T_m = \frac{d + A}{V_f}$$

$$A = 0{,}5\, D \tan\left(90 - \frac{\varepsilon}{2}\right)$$

Area a punta

$$Q = \frac{\pi D^2}{4} v_f$$ ← Tasso d'Asportazione



$$f_z = f/z$$

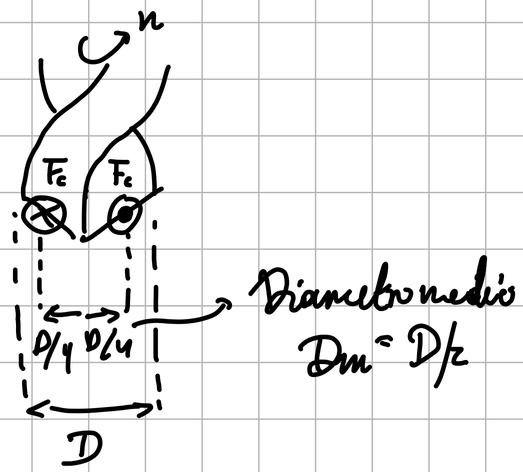
$$h_D = f_z \sin(\varepsilon/2)$$

$$A_D = f_z \cdot a_p$$

$$A_D = \frac{fD}{4}$$

$$F_c = k_c A_D$$

$$M_c = F_c \cdot 2 \cdot D/4 = \frac{F_c D}{2}$$



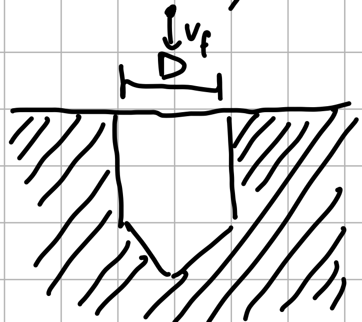
$$P_c = M_c \omega$$

$$\omega = \frac{2\pi n}{60}$$

$$k_c = \frac{k_{cs}}{h_D^x}$$

Foratura - Esercizio 1

$D = 12{,}7\,mm$



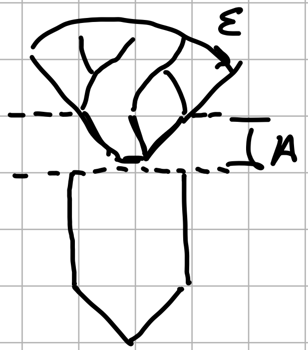
$V_c = 25\ m/min$

$f = 0{,}3\ mm/giro$

$\varepsilon = 118°$

$$n = \frac{V_c}{\pi D} = \frac{25}{\pi \cdot 12{,}7 \times 10^{-3}} = 626\ giri/min$$

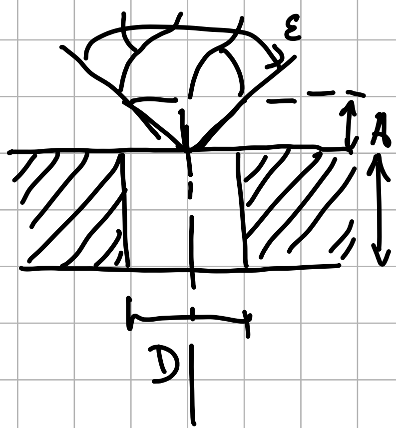
$V_f = n f = 188 \ mm/min$



$$T_m = \frac{d + A}{V_f} = 20{,}3\,s$$

$$Q = \frac{\pi D^2}{4} V_f = 23815 \ mm^3/min$$

Foratura - Esercizio 2



$D = 25 \, mm$

$t = 80 \, mm$

$k_{cs} = 1800 \ \frac{N}{mm^2}$

$x = 0{,}15$ $\quad v_c = 125 \ m/min$

$\varepsilon = 120°$ $\quad e = 2 mm$

$L = 2D$

$$n = \frac{V_c}{\pi D} = 1592 \text{ giri}/min$$

$V_f = f \cdot n = 159{,}2 \ mm/min$

$A = D/2 \tan(90 - \varepsilon/2) = 7{,}22 \ mm^2$

$$T_m = \frac{l + A + e}{V_f} = 0{,}372\ min \approx 22{,}3\ s$$

$$A_D = \frac{f}{2} \cdot \frac{D}{2} = 0{,}625\ mm^2$$

$$h_D = f_z \sin\left(\frac{\varepsilon}{2}\right) =$$

$$k_c = \frac{k_{cs}}{h_D^x} = \frac{k_{cs}}{\left[f_z \sin \frac{\varepsilon}{2}\right]^x} = 2883\ \frac{N}{mm^2}$$

$$F_c = k_c A_D = 1801\ N$$

$$M_c = F_c \cdot D/2 = 22{,}5\ Nm$$

$$\omega = \frac{2\pi n}{60} = 167\ \frac{rad}{s}$$

$$P_c = \frac{M_c \omega}{1000} = 3{,}76\ kW$$

Foratura - Esercizio 3

$l = 50mm$
$D = 25mm$
$k_c = 1800\ N/mm^2$
$x = 0{,}15$
$f = 0{,}1\ mm/giro$
$v_c = 125\ m/min$
$e = 2mm$

Foratura
$\phi 24$
$\varepsilon = 120°$
$f = 0{,}1mm/giro$
$v_c = 125m/min$

Alesatura
$z = 8$
$f = 0{,}3mm/giro$
$V_c = 20\ m/min$

Foratura

$$n_f = \frac{V_c}{\pi D} = 1658\ giro/min$$

$v_f = f \cdot n = 165{,}8\, m/min$

$A = 0{,}5\, D \tan\left(90 - \frac{\varepsilon}{2}\right) = 6{,}93\, mm$

$T_m = \frac{b + A + e}{V_f} = 0{,}355\, min = 21{,}3\, s$

$A_D = \frac{f}{2} \cdot \frac{D}{2} = 0{,}6\, mm^2$

$k_c = \frac{k_{cs}}{h_D^{x}} = \frac{k_{cs}}{\left(\frac{f}{2} \sin\frac{\varepsilon}{2}\right)^x} = 2883\, MPa$

$F_c = k_c A_D = 1730\, N$

$M_c = F_c \frac{D}{2} = 20{,}8\, Nm$

$\omega = \frac{2\pi n}{60} = 173{,}6\, \frac{rad}{s}$

$P_c = \frac{M_c \cdot \omega}{1000} = 3{,}6\, kW$

<u>Alesatura</u>

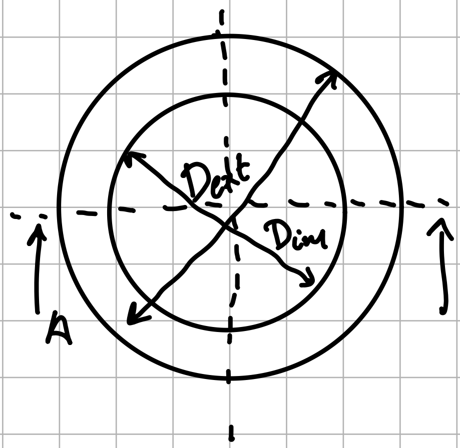
$n = \frac{v_c}{\pi D} = 255$ giri/min

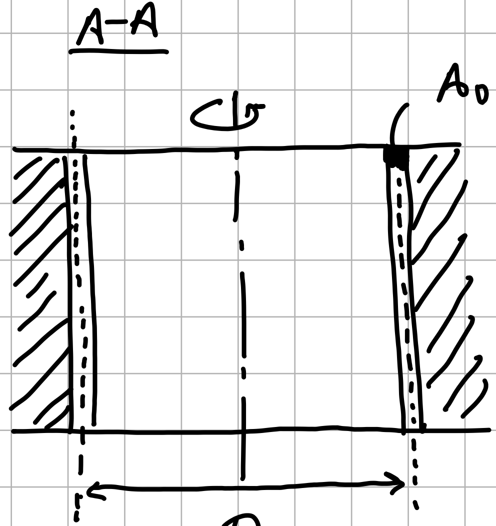
$v_f = f \cdot n = 76{,}5\, mm/min$

Alesatura $\Rightarrow A = 0$

$T_m = \frac{t + e}{V_f} = \frac{50 + 2}{76{,}5} = 0{,}68\, min = 40{,}8\, s$

$$A_D = \frac{D_{ext} - D_{int}}{2} \cdot \frac{f}{z} = 0{,}019\,mm^2$$





D_m ↳ Diametro medio $= \frac{D_{ext} + D_{int}}{2}$

$$k_c = \frac{k_{cs}}{h_D^{\,x}} =$$

$h_D = f_z$ per alesatura

$$f_z = \frac{f}{z}$$

$$\Rightarrow k_c = \frac{k_{cs}}{h_D^{\,x}} = \frac{k_{cs}}{(f/z)^x} = 2946\,\frac{N}{mm^2}$$

$$F_c = k_c \cdot A = 56\,N$$

$$M_c = z \cdot F_c \cdot \frac{D_m}{2}$$

$$M_c = z \cdot F_c \cdot \frac{(D_{ext} + D_{int})}{4} = 5{,}5\,Nm$$

$$\omega = \frac{2\pi n}{60} = 26{,}7\,\frac{rad}{s}$$

$$\Rightarrow P_c = M_c \cdot \omega = 146\,W$$

Teoria Utensili da Taglio / Usura

Usura Taylor

↳ $\boxed{v_c T^n = C}$

v_c - velocità di taglio (m/min)
T - durata utensile (min)
n - esponente (materiale utensile e pezzo)
C - costante che dipende da condizioni di lavoro (a_p, f)

Forma Generalizzata

$v_c T^n f^m a_p^p HB^q = k$

↳ Rimane lo stesso il fattore più importante.

Usura - Esercizio 1

$T = 15 \, min$

$C = 250 \, \frac{m}{min}$

$n = 0{,}122$

$v_c = ?$

a) $v_c T^n = C$

$v_c = \frac{C}{T^n} = 179{,}66 \, \frac{m}{min}$

b) T se $v_{c2} = .95 v_c$

↳ $v_{c2} = v_c - 0{,}05 \, v_c = 170{,}67 \, \frac{m}{min}$

$$V_{c2} T_2^{\,n} = C$$

$$T_2 = \left(\frac{C}{V_{c2}}\right)^{1/n} = 22{,}83 \text{ min}$$

$$\Delta T = \frac{T_2 - T_1}{T_1} \cdot 100 = 52\%$$

Esercizio 2

$Ra = 1{,}6 \mu m$

$r_\varepsilon = 0{,}4 mm$

$V_c = 180 m/min$

$C = 250 m/min$

$n = 0{,}122$

$k_{c0,4} = 2100 MPa \quad x = 0{,}16$

$P_{disp} = 6 kW \quad \eta = 0{,}8$

$k_{re} = 60°$

$$P_c = \eta P_{disp} = 4800 W$$

$$P_c = F_c v_c$$

$$\Rightarrow F_{c,max} = \frac{P_c}{v_c} = 1600 N$$

$$Ra = \frac{f^2}{32 r_\varepsilon}$$

$$\Rightarrow f = \sqrt{32 Ra\, r_\varepsilon} = 0{,}14 \text{ mm/giro}$$

$$F_c = k_c f a_p = k_{c0,4}\, 0{,}4^x f^{1-x} a_p \left(\frac{1}{\sin k_{re}}\right)^x =$$

$$a_p = \frac{F_c}{k_{c0,4}\, 0{,}4^x f^{1-x}} (\sin k_{re})^x = 4{,}49 \text{ mm}$$

$$V_c T^n = C$$

$$T = \sqrt[n]{\frac{C}{V_c}} = 14{,}7 \text{ min}$$

Esercizio 3

$n_{pezzi} = 300$

$D = 50\ mm \qquad L = 300\ mm$

passo $= 1mm \Rightarrow f = 1mm/giro$

$v_c = 40\ m/min$

$C = 70\ m/min$

$n = 0{,}122$

a) $n = \frac{v_c}{\pi D} = 254{,}6$ giri/min

$T_m = \frac{L}{f n} = 1{,}178\ min$

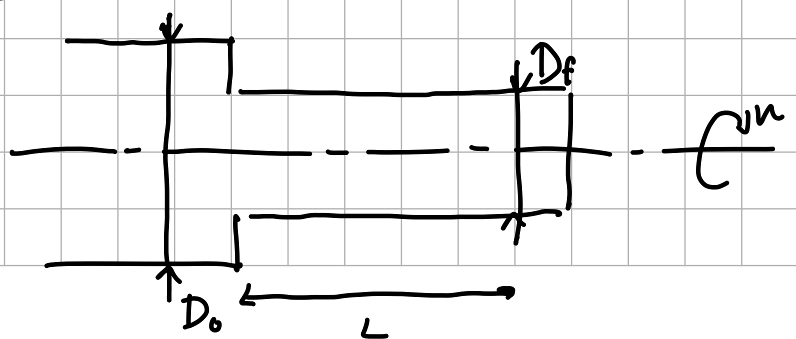
- - - - - - - - - - - -

$v_c T^n = C \Rightarrow T = \left(\frac{C}{v_c}\right)^{1/n} = 98{,}2\ mm$

$N_{filettature} = \frac{T}{T_{min}} = 83{,}36$ filettature ≈ 83 filettature

$N_{TAGLIENTI} = \frac{n_{pezzi}}{n_{filetture}} = 3{,}6 \approx 4$

Esercizio 4



$D_0 = 12\,mm$ $\quad a_p = 0{,}8\,mm$
$D_f = 10\,mm$ $\quad f = 0{,}2\,mm/giro$ $\quad \Rightarrow T_1 = 10\,min$
$L = 70\,mm$ $\quad v_c = 150\,m/min$

$T_{passivo} = 2s$ $\qquad v_c = 125\,m/min$

$T_{bitacciume} = 10s$ $\qquad \Rightarrow T_2 = 25\,min$

$T_{cambio\,utensile} = 3\,min$

$$n = \frac{v_c}{\pi D_0} = 3978{,}9\ \frac{giri}{min}$$

$$T_{sgrossatura} = \frac{L+s}{fn} = 0{,}089\,min = 5{,}33s$$

$v_f = fn$

<u>Esercizio 4</u>

$v_c T^n = C \qquad \ln(C) = \ln(v_c) - n\ln(T)$

$$\begin{cases} \ln(C) = \ln(v_{c1}) + n\ln(T_1) \\ \ln(C) = \ln(v_{c2}) + n\ln(T_2) \end{cases}$$

$$\ln(C) = \ln(150) + n\ln(10)$$
$$\ln(C) = \ln(125) + n\ln(25)$$

$$\ln(150) + n\log(10) = \ln(125) + n\log(25)$$

$n\,[\ln 25 - \log 10) = \log 150 - \log 125$

$n \ln \frac{25}{10} = \log 150/125$

$\Rightarrow n = 0{,}199$

$C = v_c T^n = 237{,}18 \text{ min}$

$v_c T^n = C$

$T = \left(\frac{C}{v_c}\right)^{1/n} = 20{,}53 \text{ min}$

$T_{pezzi} = T_{sgrosso} + T_{posizion} + T_{finitura} + T_{cambio/pz}$

$n_{pezzi} = \frac{T}{T_{sgross}} = 112{,}4 \text{ pezzi}$

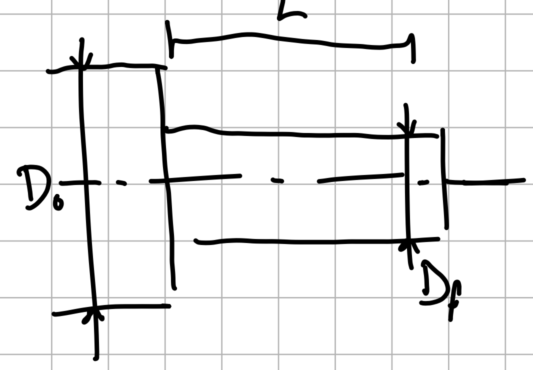
$T_{cambi/pz} = \frac{T_{cambio}}{n_{pezzi}} = 1{,}65$

$T_{pz} = 18{,}39 s$

Avendo 8h disponibile

$n_{pezzi} = \frac{8 \cdot 3600}{T_{pz}} = 1521 \text{ pezzi}$

Esercizio 5



$v_c = ?$

$L = 200\,mm$
$D_0 = 40\,mm$
$D_f = 36\,mm$

$f = 0{,}5\ mm/giri$

$C = 230\ m/min$ $\qquad n = 0{,}122$

$C = v_c T^n \qquad v_c = \pi\, n_{giri} \cdot D_0$

$$T_m = \frac{L}{V_f} = \frac{L}{nf}$$

$$T = 2T_m$$

$$C = v_c (2T_m)^n = v_c \left(\frac{2L}{nf}\right)^n$$

$$n = \frac{v_c}{\pi D_0} \qquad C = v_c \left(\frac{2L\pi D_0}{v_c f \cdot 1000}\right)^n = v_c^{1-n}\left(\frac{2L\pi D_0}{f \cdot 1000}\right)^n$$

$$\Rightarrow v_c = \sqrt[1-n]{C \cdot \left(\frac{f \cdot 1000}{2L\pi D_0}\right)^n} \Rightarrow v_c = 258\ m/min$$