Esercitazione 7-

Rapporto di riduzione $r_x = \frac{A_0}{A_f} = \frac{l_f}{l_0}$

Deformazione ideale $\varepsilon_x = \ln r_x$

$F L_0 = A_0 L_0 Y_f \ln(r_x)$

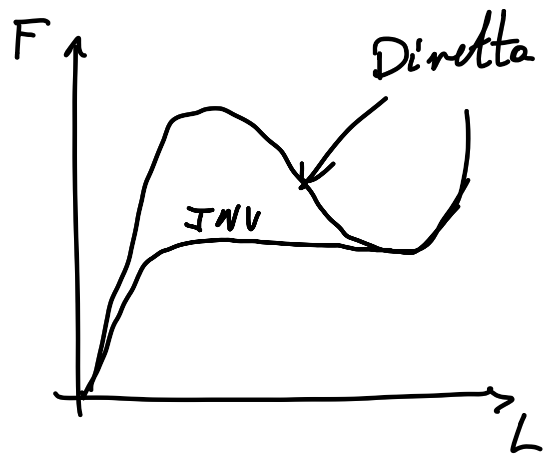
$p A_0 L_0 = A_0 L_0 Y_f \ln(r_x)$

Pressione ideale $p = Y_f \ln(r_x)$

Deformazione reale $\varepsilon_x = a + b \ln(r_x)$ $\begin{cases} a = 0{,}8 \\ b \in [1{,}2 ; 1{,}5] \end{cases}$

Pressione reale per estrusione diretta

$\hookrightarrow p = \bar{Y}_f\left(\varepsilon_x + 2\frac{L_0}{D_0}\right)$ Diretta $\quad p = \bar{Y}_f \varepsilon_x$ Inversa



Per forme più complesse

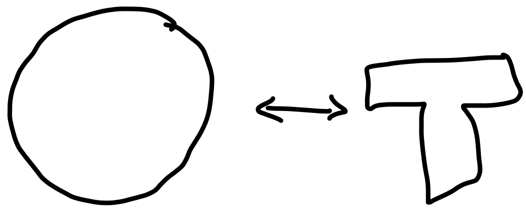
$$F = k_x p A_0$$

$$k_x = 0{,}98 + 0{,}02 \left(\frac{C_x}{C_c}\right)^{2{,}25}$$

$$\frac{C_x}{C_c} \in [1;6]$$

$C_x \rightarrow$ perimetro della sezione effettiva

$C_c \rightarrow$ circonferenza di un cerchio con area della stessa sezione



Esercizio 1

$Y_f = 180\,MPa \quad n = 0{,}2$

$D_0 = 150mm \quad D_f = 50mm$

$$r_x = \frac{A_0}{A_f} = \frac{\frac{\pi}{4} D_0^2}{\frac{\pi}{4} D_f^2} = 9$$

$$\varepsilon_x = \ln(r_x) = 2{,}2$$

$$\bar{Y}_f = \frac{K\varepsilon^n}{n+1} = 175{,}6\ MPa$$

$$p = \bar{Y}_f \ln(r_x) = 386{,}32\ MPa$$

$$F_{id} = p A_0 = \frac{\pi D_0^2}{4} = 6827\ kN$$

$$F_{tot} = F_{id} + F_{ATT} + F_{ridondante}$$

$$= F_{id} + 0{,}25 F_{TOT} + 0{,}3\ F_{ideale}$$

$$= \frac{1{,}3\ F_{ideale}}{0{,}75} = 11811\ kN$$

Esercitazione 2

$Y_f = 425\ MPa$

$D_0 = 100\ mm$

$D_f = 20\ mm$

$F_1 = 10\ MN$

$F_2 = 20\ MN$

$$A_0 = \frac{\pi D_0^2}{4} = 0{,}000785\ mm^2$$

$$A_f = \frac{\pi D_f^2}{4} = 3{,}14 \times 10^{-4}\ m^2$$

$$r_x = \frac{A_0}{A_f} =$$

Forza Ideale $F = A_0 \bar{Y}_f \ln(r_x)$

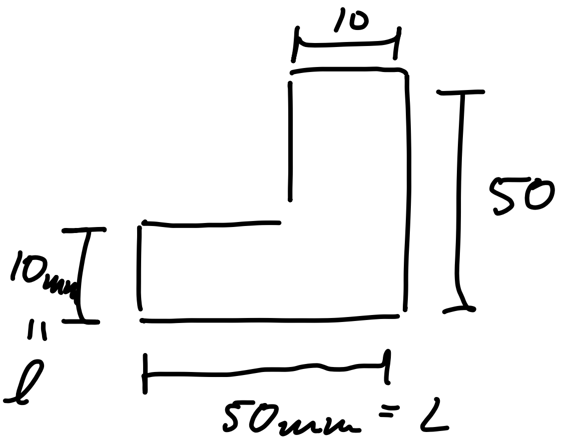
$\bar{Y}_f = Y_f$ perché a caldo

Forza Richiesta

$F = 10{,}6\ MN > F_1$

$\Rightarrow F_2$

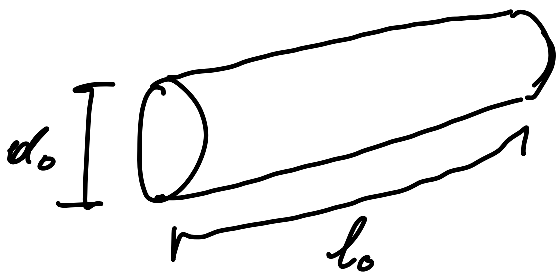
Esercizio 3



$Y_f = 50\ MPa$

$d_0 = 100\ mm$

$l_0 = 150\ mm$



$a = 0{,}8$

$b = 1{,}2$

$A_0 = \frac{\pi}{4} D_0^2 = 7853{,}98\ mm^2$

$A_f = L^2 - (L-l)^2 = 900\ mm^2$

$A_0 l_0 = A_f l_f \Rightarrow l_f = l_0 \frac{A_0}{A_f} = 1309\ mm$

Non circolare

$\varepsilon_x = a + b \ln\left(\frac{A_0}{A_f}\right) = 3{,}4$

diretta

$p = Y_f\left(\varepsilon_x + 2\frac{l_0}{D_0}\right) = 320\ MPa$

$F = k_x\, p\, A_0$

$$\frac{C_x}{C_c} = \frac{200\,mm}{106,3\,mm} = 1,88$$

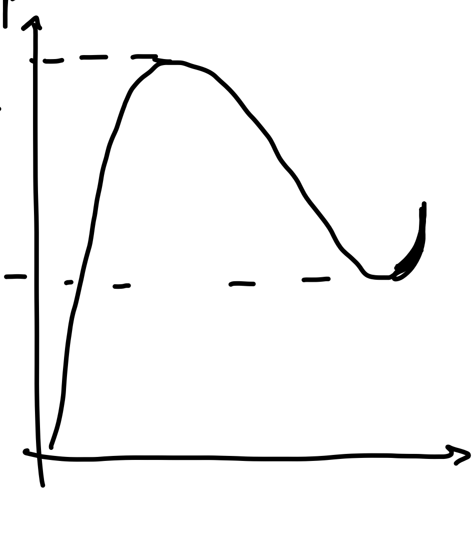
$$A_f = \frac{\pi D_{eq}^2}{4}$$

$$C = \pi D_{eq}$$

$$C_c = \pi \sqrt{\frac{A_f\, 4}{\pi}} = 106,3\,mm$$

$$k_x = 0,98 + 0,02 \left(\frac{C_x}{C_c}\right)^{2,25} = 1,06$$

$F = k_x\, p\, A_0 = 2,7\,MN$



$$p_i = Y_f\left(\varepsilon_x + 2\frac{L_0}{D_0}\right)$$

$$p_f = Y_f\, \varepsilon_x$$

$$p_{AV} = \frac{1}{L}\int_0^L p(L)\, dL$$

$$p_{AV} = Y_f\left(\varepsilon_x + \frac{L_0}{D_0}\right)$$

$p_{AV} = 245\,MPa$

$E = F \cdot l$

$= k_x\, p_{AV}\, A_0\, L = 365951\,J$

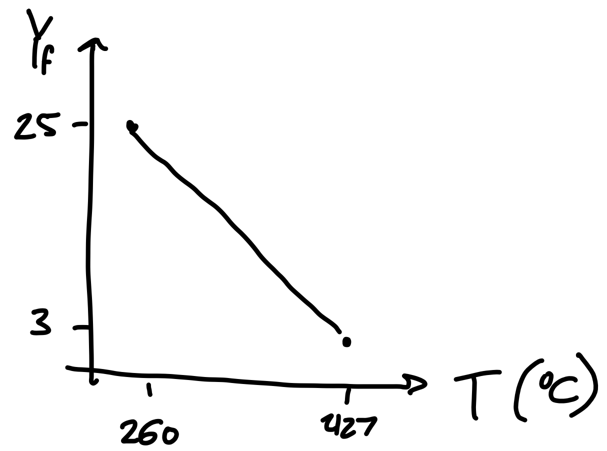
Esercizio 4

$d_f = 25\,mm$

$d_0 = 50\,mm$
$l_0 = 1000\,mm$

$Y_f(260°C) = 23\,MPa$

$Y_f(427°C) = 3\,MPa$



$F_{MAX} = 750\,kN$

$$F = A_0 Y_f \left(a + b \ln r_x + \frac{2 L_0}{D_0}\right)$$

$$A_0 = \frac{\pi D_0^2}{4} = 1963{,}5\,mm^2$$

$$A_f = \frac{\pi D_f^2}{4} = 490{,}87\,mm^2$$

$$r_x = \frac{A_0}{A_f} = 4$$

$$Y_f = 23 + \frac{3{,}5 - 23}{427 - 260}(T - 260)$$

$$= 23 - 0{,}1\,(T - 260)$$

$$Y_f = 49 - 0{,}1\,T$$

$$F = A_0 Y_f \left(a + b \ln(r_x) + \frac{2L}{D_0}\right)$$
$$= A_0 (49 - 0{,}1 T)\left(a + b \ln(r_x) + 2\frac{L}{D_0}\right)$$

$$T = \frac{1}{0,5}\left(49 - \frac{F}{A_0\left(a+b\ln(r_x)+2\frac{L}{D_0}\right)}\right)$$

Esercizio 6

$Y_f = 420\ MPa$

$D_0 = 38mm$

$L_0 = 200mm$

$D_f = 20mm$

$$F = A_0 Y_f\left(a+b\ln(r_x)+2\frac{L_0}{D_0}\right) = 6,528\ MN$$

$$A_0 = \frac{\pi D_0^2}{4} = 1134\ mm^2$$

$$A_f = 314\ mm^2$$

$$r_x = 3,65$$

$$k_x = 1$$

$$E = F_{AV} L$$

$$p_{AV} = Y_f\left(\underbrace{\varepsilon_x}_{a+b\ln(r_x)} + \frac{L}{D}\right) = 3193,5\ MPa$$

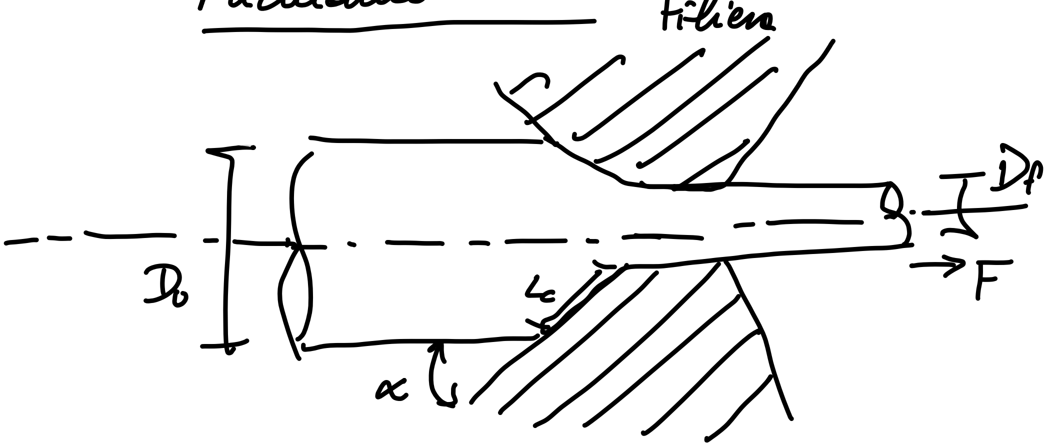
$$E = p_{AV} V$$

$$V = \frac{\pi \cdot 38^2}{4} \cdot 200 = 226,825\ mm^2$$

$$E = 724359\ J$$

Trafilatura

Richiamo Teoria



$$D = \frac{D_0 + D_f}{2}$$ Diametro Medio

Lunghezza di contatto $L_c = \frac{D_0 - D_f}{2\sin(\alpha)}$

Sforzo ideali di trafilatura $\sigma_{dif} = \bar{Y}_f \ln \frac{A_0}{A_f}$

$$\sigma_f = \bar{Y}_f \left(1 + \frac{\mu}{\tan\alpha}\right) \phi \ln \frac{A_0}{A_f}$$

$$\phi = 0{,}88 + 0{,}12 \frac{D}{L_c}$$

$$\bar{Y}_f = \frac{k\varepsilon^n}{n+1} = \frac{k\left(\ln \frac{A_0}{A_f}\right)^n}{n+1}$$ Tensione di Flusso Medio

$F = \sigma_d A_f$ Forza di tiro

$P = F v_f$ Potenza

$E = F L_f$

L_f: Lunghezza Finale

Esercizio 1

$D_0 = 10\,mm$

$D_f = 8\,mm$

$v_f = 0{,}8\,m/s$

$$D = \frac{D_0 + D_f}{2} = 9\,mm$$

$$L_c = \frac{D_0 - D_f}{2\tan\alpha} = 5{,}76\,mm$$

$\mu = 0{,}3$

$$\phi = 0{,}88 + 0{,}12 \frac{D}{L_c} = 1{,}07$$

$k = 1300\ MPa$

$n = 0{,}3$

$$A_0 = 78{,}53\ mm^2$$

$$A_f = 50{,}26\ mm^2$$

$$\bar{Y}_f = \frac{k \ln\left(\frac{A_0}{A}\right)^n}{n+1} = 785\ MPa$$

$$\sigma_d = \bar{Y}_f \left(1 + \frac{\mu}{\tan\alpha}\right) \phi \ln \frac{A_0}{A_f} = 1012\ MPa$$

$$F = \sigma_d A_f = 50863\ N \qquad P = F v_f = 25431\ W$$

Consideriamo ora l'ottone

$$P = \bar{Y}_f \underbrace{\left(1 + \frac{\mu}{\tan\alpha} \phi \ln \frac{A_0}{A_f}\right) A_f\ v_f}_{cost}$$

$$P = \bar{Y}_f \cdot cost$$

$$cost = \frac{P}{\bar{Y}_f} = \frac{P_{ottone}}{\bar{Y}_{f\,ottone}} =$$

Da tabelle data

$$P_{ottone} = \bar{Y}_{f\,ottone} \frac{P_{inox}}{\bar{Y}_{f\,inox}} = \frac{k_{ottone}\varepsilon^n}{n+1} \cdot \frac{P_{inox}}{\bar{Y}_{f\,inox}}$$

$k_{ottone} = 895 \ MPa$

$\eta_{ottone} = 0{,}49$

$P_{ottone} = 13{,}1 \ kW$

Esercizio 2

$P_{el} = 30 \ MWh$

$G = 1500 \ kg$

$n = 1000$ vergelle

$D_f = 7mm$

$\frac{D_o}{D_f} = 1{,}1$

$\bar{Y}_f = 450 \ MPa$

$\alpha = 8'$

$\mu = 0{,}15$

$D = \frac{D_o + D_f}{2} = 7{,}35 \ mm$

$L_c = \frac{D_o - D_f}{2 \sin\alpha} = 7{,}51 mm$

$\phi = 0{,}88 + 0{,}12 \frac{D}{L_c} = 1{,}23$

$A = 46{,}57 mm^2$

$A_f = 38{,}48 mm^2$

$\sigma_d = \bar{Y}_f \left(1 + \frac{\mu}{\tan\alpha}\right) \phi \ln \frac{A_o}{A_f} = 218 MPa$

$F = \sigma_d A_f = 8388 N$

$G_{OUT} = \eta \ G = 15 \cdot 10^6 \ kg$

$\rho = 7{,}8 \frac{kg}{dm^3} = 7800 \frac{kg}{m^3}$

$$G_{TOT} = \overbrace{l_0 A_0}^{V_0} \rho$$

$$l_0 = \frac{G_{TOT}}{\rho A_0} = 4{,}129 \times 10^6 \, m$$
$$= 4129 \, km$$

$$A_0 l_0 = A_f l_f$$

$$l_f = l_0 \frac{A_0}{A_f} = 5000 \, km$$

Esercizio 3

$Y_f = 400 \, \varepsilon^{0,3}$

$n_{pezzi} = 150$

$k = 400$

$G = 1400 \, kg$

$n = 0{,}3$

$D_0 = 10 \, mm$

$D_f = 8{,}5 \, mm$

$\mu = 0{,}2$

$\alpha = 8'$

$$D = \frac{D_0 + D_f}{2} = 9{,}25$$

$$L_c = \frac{D_0 - D_f}{2 \sin\alpha} = 5{,}33 \, mm$$

$$\phi = 0{,}88 + 0{,}12 \frac{D}{L_c} = 1{,}09$$

$$A_0 = \frac{\pi D_0^2}{4} = 78{,}53 \, mm^2$$

$$A_f = \frac{\pi D_f^2}{4} = 56{,}75 \, mm^2$$

$$\bar{Y}_f = \frac{k \left(\ln \frac{A_0}{A_f} \right)^n}{n+1} = 221{,}5 \, MPa$$

1) $\sigma_d = \bar{Y}_f \left(1 + \frac{\mu}{\tan\alpha}\right) \phi \ln \frac{A_0}{A_f} = 195{,}2 \ MPa$

2) $F = \sigma_d A_f = 11066 \ N$

3) $r\% = \frac{A_0 - A_f}{A_0} = 27{,}7\%$

$G_{TOT} = n_{persone} G = 2{,}1 \cdot 10^5 \ kg$

$l_f = \frac{G_{TOT}}{\rho A_f} = 0{,}474 \cdot 10^6 \ m = 474 \ km$

$E = F \cdot l_f = 5245 \ MJ$

$E_{EL} = \frac{E}{\eta} \cdot \frac{1}{3600} = 1{,}94 \ MWh$

<u>Esercizio 4</u>

$l_0 = 100 \ mm$

$k = 200 \ MPa$

$n = 0{,}25$

$D_0 = 32 \ mm$

$D_f = 18 \ mm$

$A_0 = 804{,}24 \ mm^2$

$A_f = 254{,}46 \ mm^2$

$\frac{A_0}{A_f} = 3{,}16$

Condizione limite di trafilatura $\rightarrow \bar{Y}_f \ln \frac{A_0}{A_f} \leq Y_f$
(trascurando attrito)

$$\bar{Y}_f = \frac{k\varepsilon^n}{n+1} \qquad Y_f = k\varepsilon^n$$

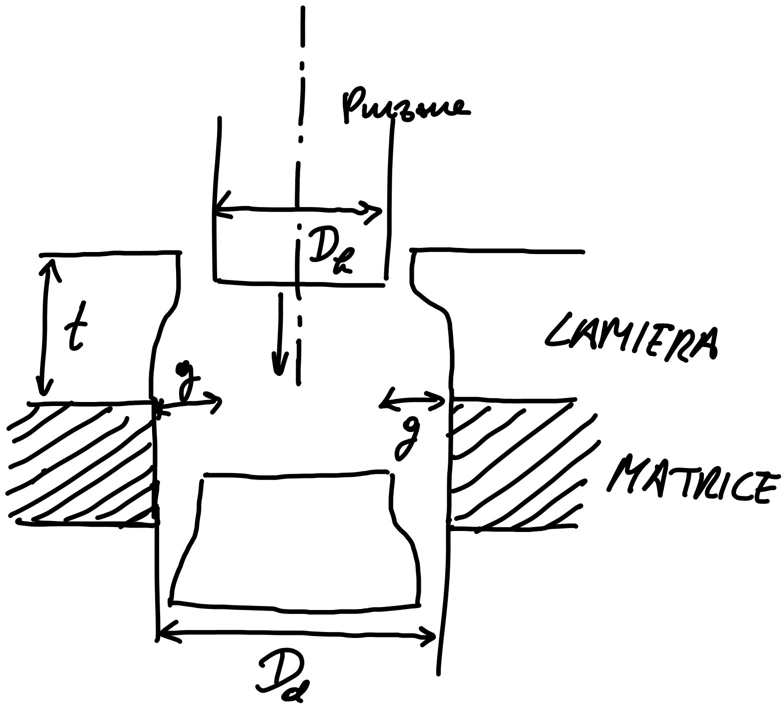
$$\frac{\cancel{k\varepsilon^n}}{n+1} \ln\left(\frac{A_0}{A_f}\right) \le \cancel{k\varepsilon^n}$$

$$\ln\left(\frac{A_0}{A_f}\right) \le n+1$$

$$3{,}16 = \frac{A_0}{A_f} \le e^{n+1}$$

$$e^{n+1} = e^{1+0{,}25} = 3{,}49 \rightarrow \text{Non è verificata}$$

Tranciatura / Punzonatura



$D_p \rightarrow$ Dimensione del punzone

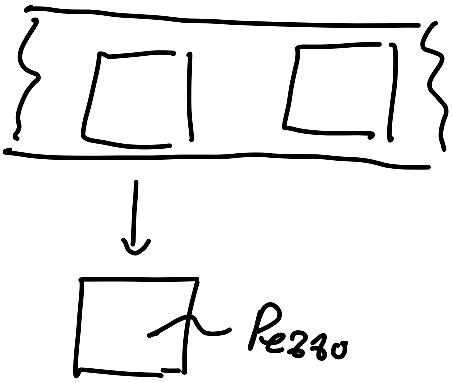
$D_b \rightarrow$ Diametro della matrice

$g \rightarrow$ gioco

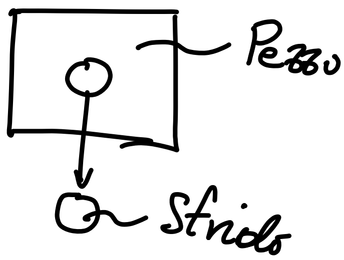
$t \rightarrow$ spessore lamiera

$l \rightarrow$ perimetro del materiale da tagliare

Tranciatura



Punzonatura



$D - D_b$

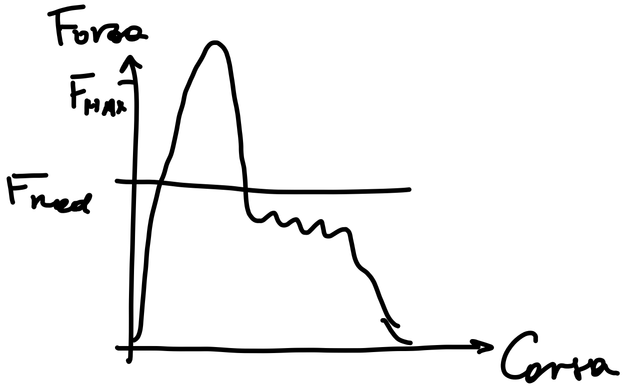
$D_a = D - 2g$

$D_a = D$

$D_b = D + 2g$

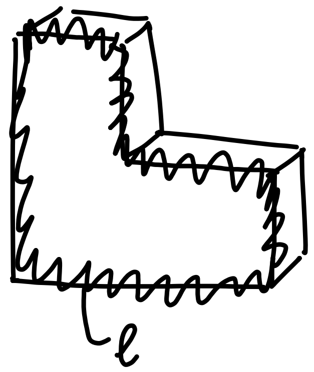
$g = A_g t \qquad A_g \in [0{,}045 - 0{,}075]$

Esercizio 1



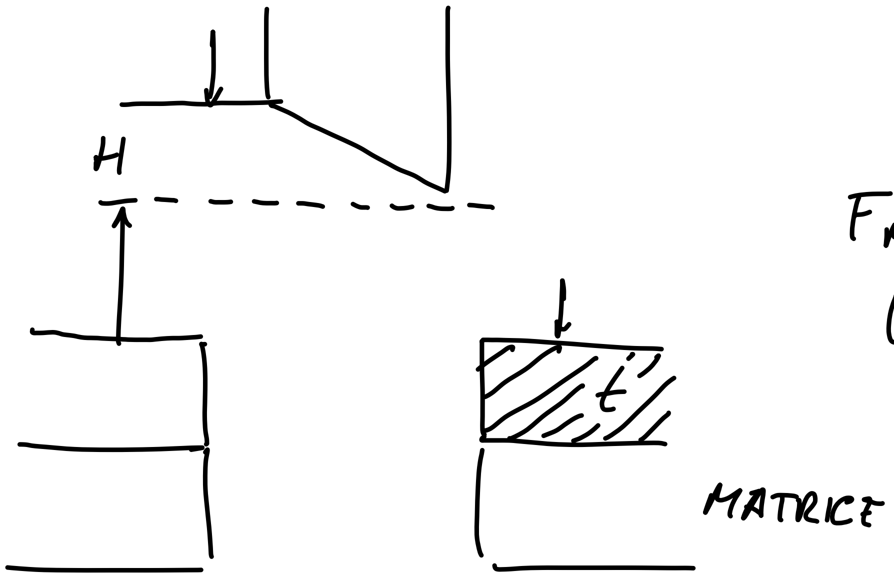
$F_{MAX} = R_t\, t\, l \qquad R_t \rightarrow$ sollecitazione tangenziale

$R_t = 0{,}7 - 0{,}8\, R_m$



$F_{med} = F_{MAX} \cdot \lambda$

$E = \lambda F_{MAX} \cdot t$



$F'_{MAX} = F_{med} \dfrac{t}{t+H}$

↳ Si riduce la forza

Esercizio I

$t = 5\ mm$

$l_{int} = 756{,}6\ mm$

$F_{MAX} = 4000\ kN$

$l_{est} = 680\ mm$

$E_{dep} = 7\ kJ$

$R_t = 0{,}8 R_m$

$R_m = 900\ MPa$

$F_{max,int} = R_t\ l_{int} \cdot t = 2724\ kN$

$F_{MAX} = R_t\ l_{est}\ t = 2448\ kN$

$F_{tot} = 5172\ kN > 4000\ kN$ della macchina, si fanno operazioni separatament

Tabella
↓
$\lambda = 0,35$

$E_{int} = \lambda F_{MAX,int} = 4,76\ kJ$

$E_{est} = \lambda F_{MAX,est} = 4,28\ kJ$

Esercizio 2

$t = 1,8\ mm$

$R_m = 900\ MPa$

$F_{disp} = 12000\ kN$

$E_{disp} = 40\ kJ$

$l = \frac{1}{4} \cdot 2\pi 200 + 2\pi \cdot 250) + 2 \cdot 50 + 2 \cdot (60 + 6 + 60)$

$= 158\ mm$

$R_t = 0,8 R_m = 720\ MPa$

$F_{MAX} = R_t \cdot l \cdot t = 1374\ kN$
$\Rightarrow OK$

Tabella $\rightarrow \lambda$

$E = \lambda F_{MAX} \cdot t = 1,1\ kJ < E_{disp}$
$\Rightarrow OK$

Esercizio 3

$R_m = 1180\ MPa$

$h_c = t = 3\ mm$

$d = 30mm$

$F_{MAX} = R_t l t = 127kN$

$E = \lambda F_{MAX} t = 210 J$

$\lambda = 0,55$

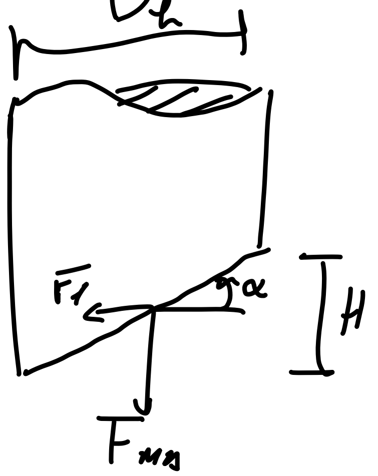
(3) $H = 1,5t$ $\quad F'_{MAX} = F_{MAX} \cdot \dfrac{t}{H+t} = 51 kN$

Tabella $\rightarrow A_g = 0,06$

$g = A_g t = 0,18 mm$

(5) $D_{DISCO} = \dfrac{D_{MAX} - D_{MIN}}{2} = 30,15 = D_b$ MATRICE

Punzone D_h



$\tan\alpha = \dfrac{F_t}{F'_{MAX}}$ $\quad F_t = F'_{MAX} \dfrac{H}{D_h}$

$F_t = F'_{MAX} \tan\alpha$

$\tan\alpha = \dfrac{H}{D_h}$ $\quad F_t = 7634 N$