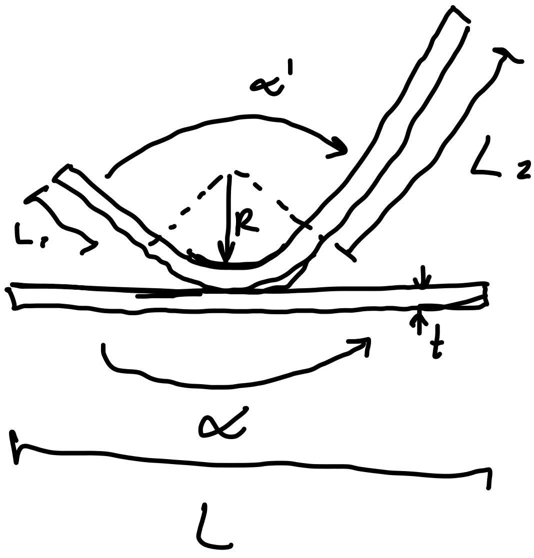
Esercitazione 8 -



L_1 - lunghezza lato 1
L_2 - lunghezza lato 2
A_b → zona allungamento
α' - angolo interno
α - angolo esterno

$$\alpha = \pi - \alpha'$$

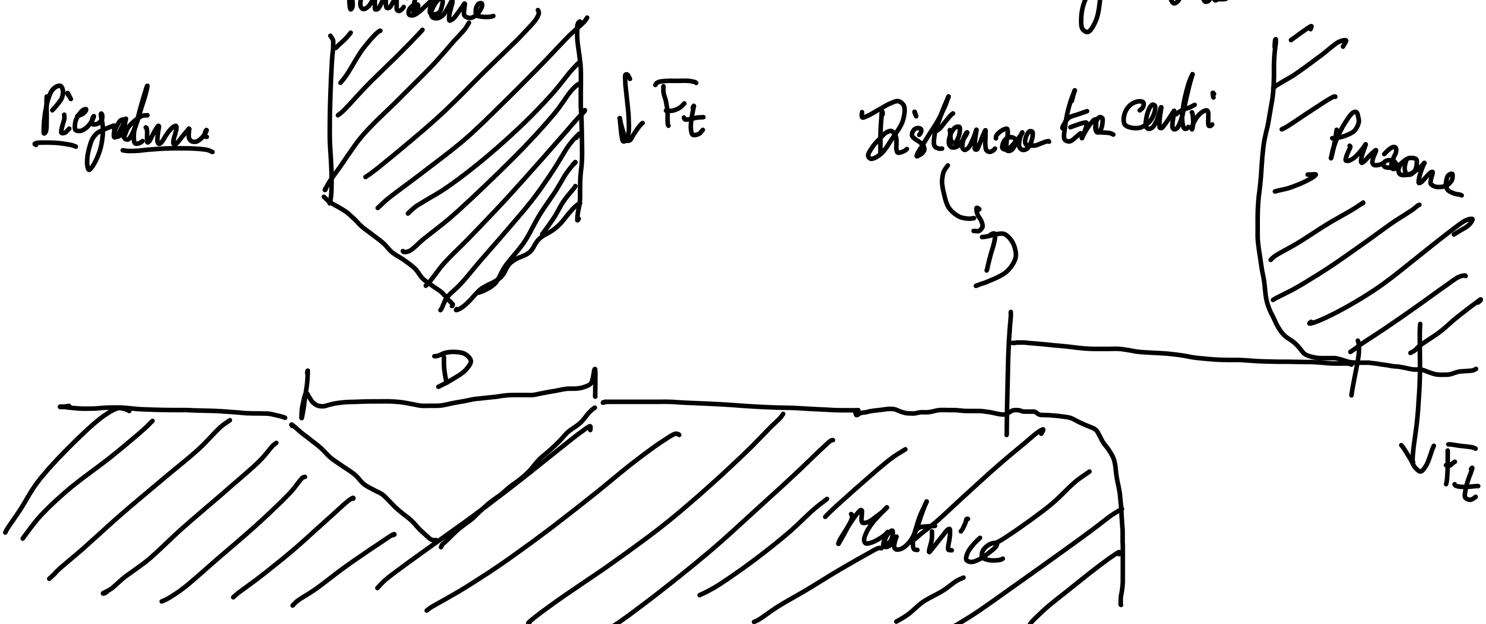
$$L = L_1 + L_2 + A_b$$

$$A_b = \frac{2\pi}{360}\,\alpha\,(R + K_{ba}\,t)$$

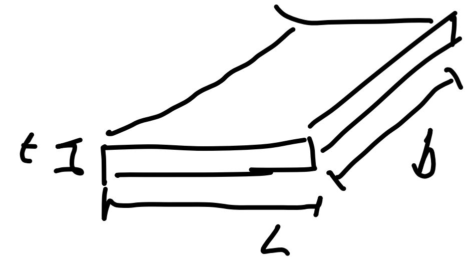
$$K_{ba} \begin{cases} 0{,}33 & \text{se} \quad R < 2t \\ 0{,}5 & \text{se} \quad R \geq 2t \end{cases}$$

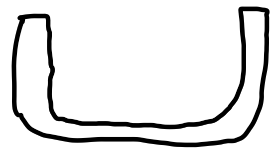
Flangiatura

Piegatura



$$F_t = k_{bt} \frac{bt^2}{D} R_m$$





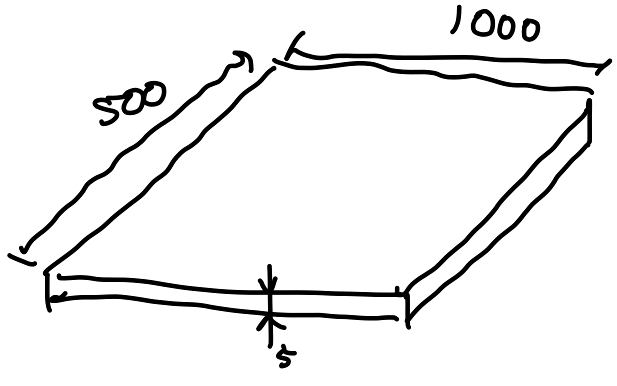
R_m - resistenza meccanica

$$k_{bt} = \begin{cases} 1{,}33 & \text{piega a V} \\ 0{,}33 & \text{flangiatura} \\ 2{,}5 & \text{piegatura ad U} \end{cases}$$

Esercizio 1 Piegatura

$R_m = 400$ MPa

$F_{MAX} = 120$ kN



$b = 1000$ mm

$D = 66$ mm

$D_2 = 33$ mm

$t = 5$ mm

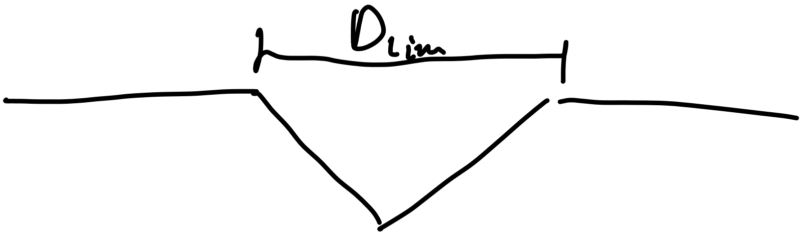
$k_{b,f} = 1{,}33$

$$F_{t,1} = k_{bf} \frac{bt^2}{D_1} = 201{,}5 \text{ kN} > F_{MAX}$$

$$F_{t,2} = k_{b,f} \frac{bt^2}{D_2} = 403 \text{ kN} > F_{MAX}$$

Nessuno dei due va bene

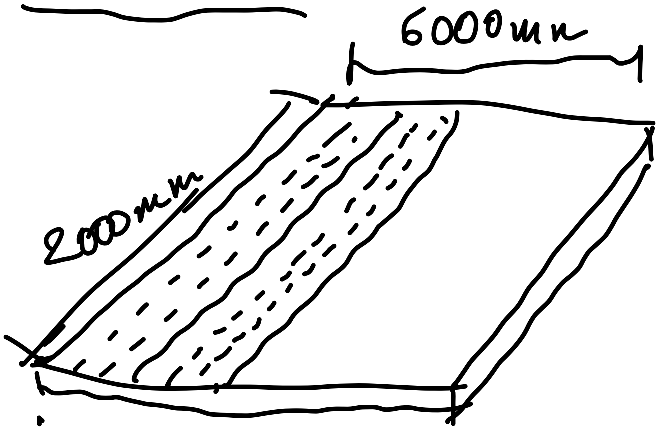
Qual'è D tale che vada bene:



$$D_{lim} = k_{bf} \frac{bt^2}{F_{MAX}} \qquad D_{lim} = 111 \text{ mm}$$

↳ Forse è comodo trovare questo prima e poi giudicare

Esercizio 2



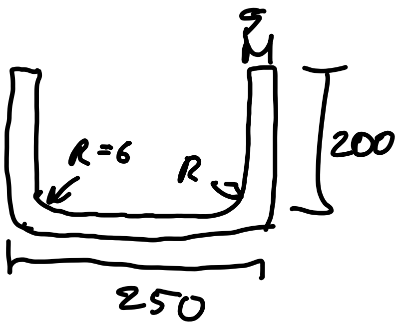
↳ Numero di lamiere per fare 10000 pezzi

$N_p = 10000$

$R_m = 250$ MPa

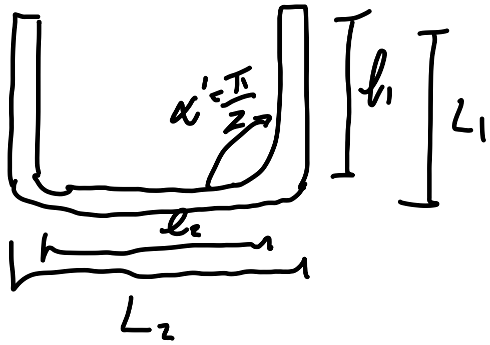
Difettosità 5%

$b = 2000$ mm



$l_1 = L_1 - t - R = 189$ mm

$l_2 = L_2 - 2t - 2R = 238$ mm



Allungamento $A_b = \frac{2\pi\alpha}{360}(R + k_{ba} t)$

$R = 6\ mm$

$2t = 10\ mm$

$$k_{ba} = \begin{cases} 0,33 & se\ R < 2t \leftarrow \\ 0,5 & se\ R > 2t \end{cases}$$

$$A_b = \frac{2\pi}{360} \cdot (180 - \alpha')(R + k_{ba} t) = 22\ mm$$

$$l_{tot} = 2 l_1 + l_2 + 2 A_b = 630\ mm$$

$$n_{\substack{pezzi \\ per\,lamiera}} = \frac{l_{lamiera}}{l_{tot}} = 9,52\ pezzi \Rightarrow 9\ pezzi\ per\ lamiera.$$

$$n_{pezzi\ totale} = \frac{N_{pricanti}}{1-s} = 10527\ pezzi$$

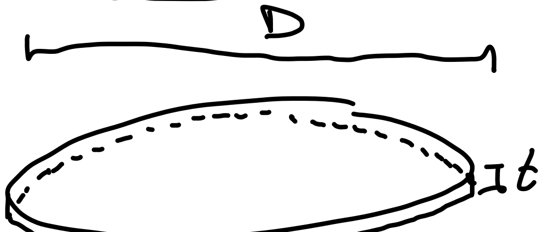
$s = 0,05$

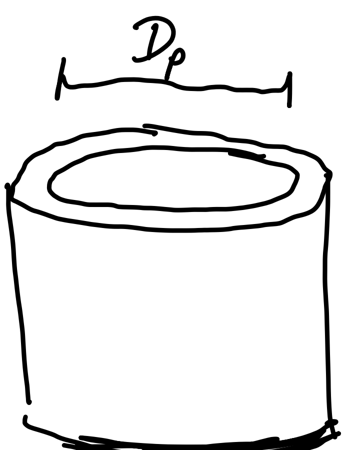
$$n_{lamiere} = \frac{n_{pezzi,tot}}{n_{\substack{pezzi\ per \\ lamiera}}} = 1169,67$$

arrotondato per eccesso

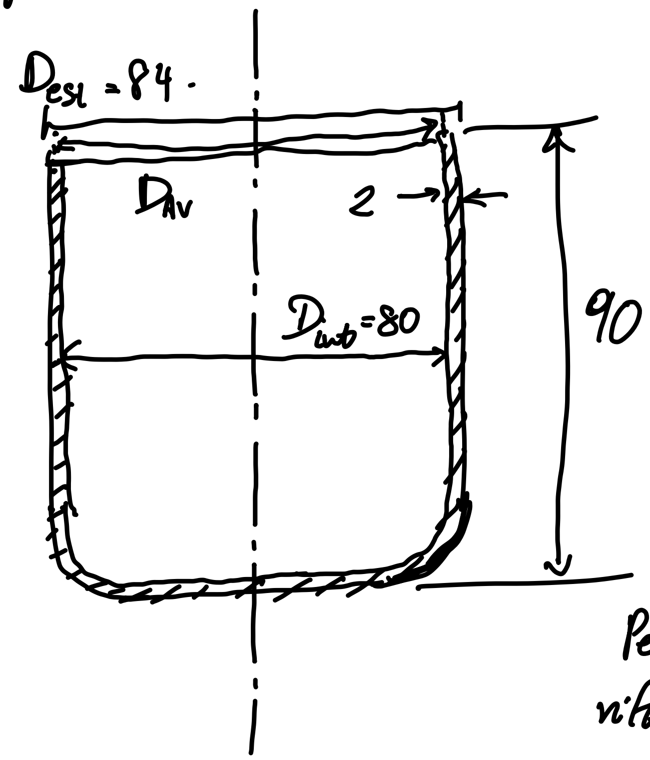
$n_{lamiere} = 1170$ lamiere

Imbutitura





$A_{partenza} \approx A_{finale}$



$$D_{AV} = \frac{D_{est} + D_{int}}{2} = 82mm$$

$$\frac{\pi D^2}{4} = \pi D_{AV} h + \frac{\pi}{4} D_{AV}^2$$

$$D = \sqrt{4 D_{AV} h + D_{AV}^2} = 190{,}37mm$$

Per tenere a conto della rifilitura approssimiamo per eccesso:

$$D \approx 195mm$$

Per evitare grinze

$$\frac{t}{D} > 0{,}01$$

$t = 2$ $\quad \frac{2}{195} = 0{,}0103$

$D = 195mm$

$\Rightarrow$ NO GRINZE

N° passaggi $\quad DR = \frac{D}{D_p} = \frac{195}{80} = 2{,}43 > DR = 2$

$\Rightarrow$ sono necessari più passaggi

Imporre $DR_1 = 1{,}5$

$$D_{p,1} = \frac{D}{DR_1} = 130\,mm$$ → Diametro prima imbutitura

$$DR_2 = \frac{D_{p,1}}{D_{p,2}} = \frac{130}{80} = 1{,}625 < LDR$$

$= D_p$ se non servissero più processi ← // seconda

$$D = \sqrt{4 D_{AV} h + D_{AV}^2}$$

$$h = \frac{D^2 - D_{AV}^2}{4 D_{AV}}$$

$$D_{AV} = D_p + t$$

Dopo prima imbutitura

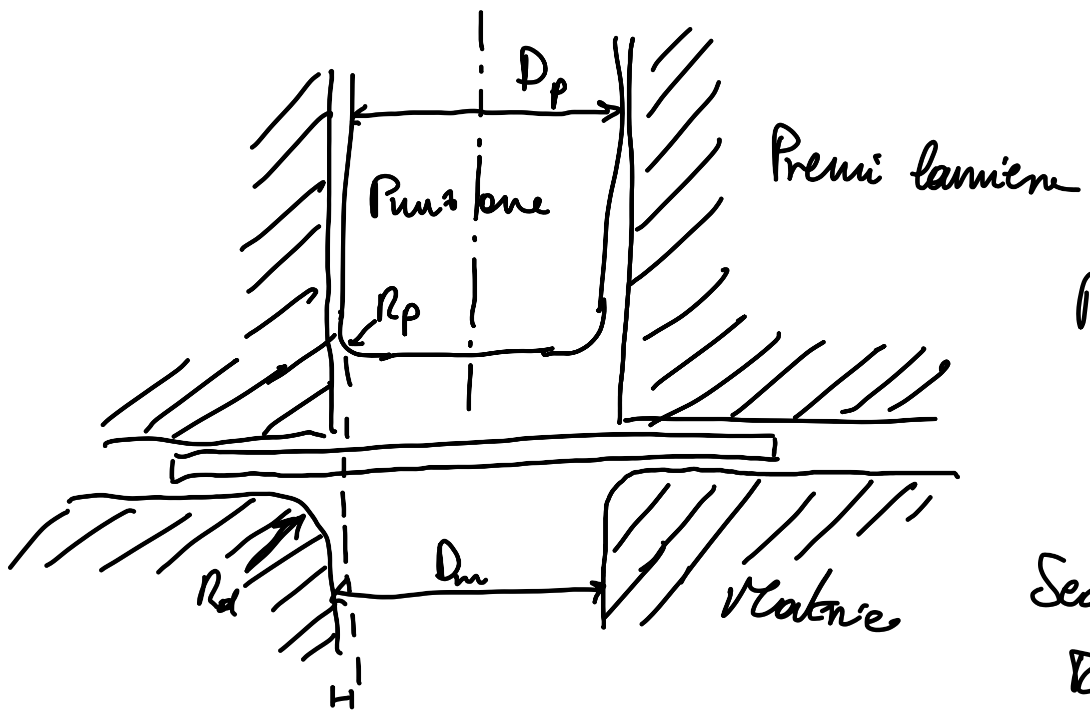
$$h_1 = \frac{D^2 - (D_{p,1}+t)^2}{4(D_{p,1}+t)} = 39{,}02\,mm$$

$$h_2 = \frac{D^2 - (D_{p,2}+t)^2}{D_{p,2}+t} = 95{,}42\,mm$$

h dopo prima

h dopo seconda

Matrice di imbutitura:



Prima imbutitura:

$R_d = 4t$

$R_p = (5-6)t$

Seconda imbutitura

$R_d = (3-4)t$

g

$R_p = (5-6)t = R_d$

$g = 1{,}1t = 2{,}2\,mm$

$D_m = D_p + 2g$

$D_{m,1} = D_{p,1} + 2g = 134{,}4\ mm \rightarrow$ Diametro matrice prima imbutitura

$D_{m,2} = D_{p,2} + 2g = 84{,}4\ mm \rightarrow$ " seconda "

$F_1 = \pi D_{p,1}\, t\, R_m \left(\dfrac{D}{D_{p,1}} - 0{,}7\right) \rightarrow$ Forza punzone seconda imbutitura

$= 329{,}7\,kN$

$F_2 = \pi D_{p,2}\, t\, R_m \left(\dfrac{D_{p,1}}{D_{p,2}} - 0{,}7\right) \rightarrow$ Forza punzone seconda imbutitura

$= 232{,}5\,kN$

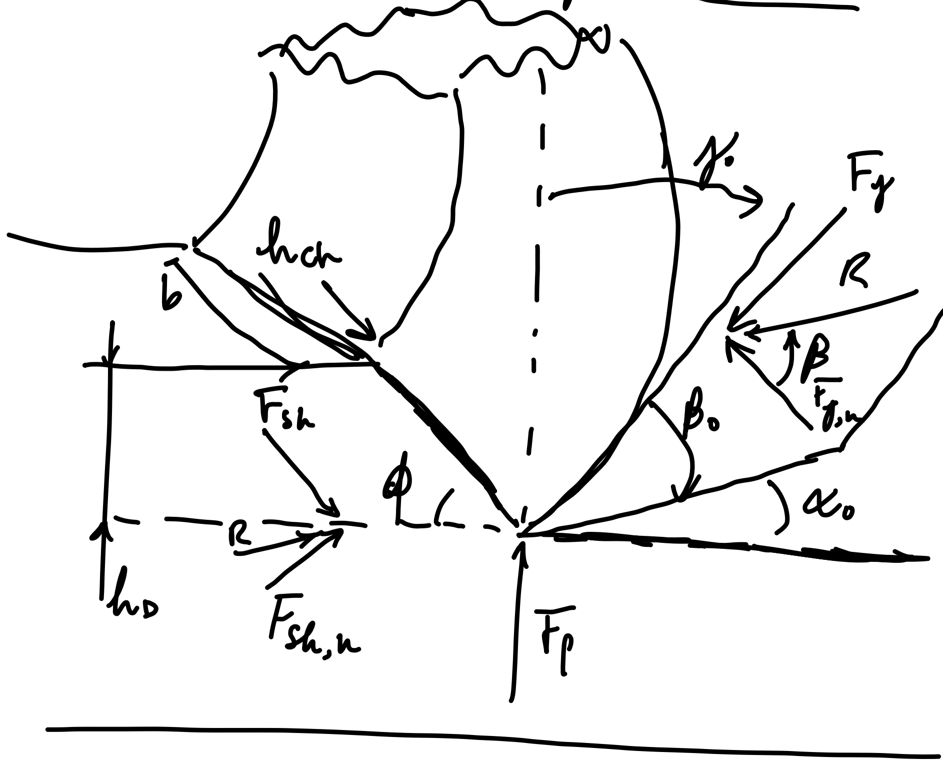
Forza premi lamiera $\rightarrow F_{h,1} = 0{,}015\, R_s\, \pi \left(D^2 - (D_{p,1} + 2{,}2t + 2R_d)^2\right)$

$= 297{,}8\,kN$

Forza su secondo premi-lamiera $\rightarrow F_{h,2} = 0{,}015\, R_s\, \pi \left(D_{p,1}^2 - (D_{p,2} + 2{,}2t + 2R_d)^2\right)$

$= 129{,}55\,kN$

Teoria di Asportazione per truciolo



α_0 - angolo inferiore

β_0 - angolo solido

γ_0 - angolo di spoglia superiore

h_D - altezza di truciolo indeformato

h_{ch} -> altezza truciolo

ϕ - angolo di scorrimento

$$r_c = \frac{h_D}{h_{ch}}$$ -> fattore di ricalcamento

b - larghezza truciolo

$$\tan(\phi) = \frac{r_c \cos(\gamma_0)}{1 - r_c \sin(\gamma_0)}$$

$$\mu = \tan(\beta) = \frac{F_\gamma}{F_{\gamma,n}}$$ coefficiente d'attrito

$F_\gamma = R \sin\beta$

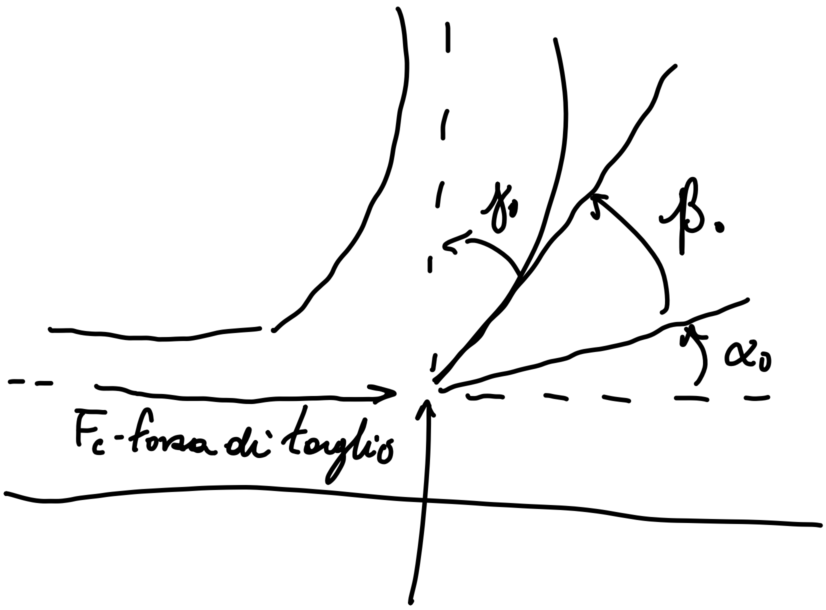
$F_{\gamma N} = R \cos\beta$

τ_{sh} - tensione tangenziale media sul piano di scorrimento

A_{sh} - Area piano di scorrimento

σ_{sh} - tensione normale media sul piano di scorrimento

$$\tau_{sh} = \frac{F_{sh}}{A_{sh}} \rightarrow A_{sh} = \frac{h_D\, b}{\sin\phi}$$



Forza di avanzamento

$$F_c = R\cos(\beta - \gamma_0)$$

$$F_f = R\sin(\beta - \gamma_0)$$

$$F_{sh} = R\cos(\phi + \beta - \gamma_0)$$

$$F_{sh,N} = R\sin(\phi + \beta - \gamma_0)$$

$$F_{sh} = F_c\cos(\phi) - F_f\sin(\phi)$$

$$F_{shN} = F_c\sin(\phi) + F_f\cos(\phi)$$

$$\tau_{sh} = \frac{F_{sh}}{A_D/\sin\phi} = \frac{F_c\cos\phi - F_f\sin\phi}{h_D b/\sin\phi}$$

$$A_D = h_D \cdot b$$

$$\tau_{sh} = \frac{F_c\sin(\phi)\cos(\phi + \beta - \gamma_0)}{h_D\, b\cos(\beta - \gamma_0)}$$

Minimizzazione dell'energia richiesta per effettuare il taglio

Equazione di Merchant

$$\boxed{\phi = \frac{\pi}{4} + \frac{\gamma_0}{2} - \frac{\beta}{2}}$$

Equazione di Pijspanen

$$\phi = \frac{\pi}{4} + \frac{\gamma_0}{2}$$

$$F_c = \tau_{sh} \frac{h_D b \cos(\beta - \gamma_0)}{\sin(\phi)\cos(\phi + \beta - \gamma_0)}$$

$$F_f = \tau_{sh} \frac{h_D b \sin(\beta - \gamma_0)}{\sin\phi \cos(\phi + \beta - \gamma_0)}$$

Esercizio 1

$\gamma_0 = 15°$

$h_D = 0{,}3$ mm

$h_{ch} = 0{,}65$ mm

$$r_c = \frac{h_D}{h_{ch}} = \frac{0{,}3}{0{,}65} = 0{,}46$$

$$\tan\phi = \frac{r_c \cos(\gamma_0)}{1 - r_c \sin(\gamma_0)} = 0{,}5044$$

$\phi = \arctan(0{,}5044) = 26{,}8°$

$\gamma = \tan(\phi - \gamma_0) + \cot(\phi) = 2{,}19$

↳ deformazione di taglio

Esercizio 2

$F_c = 1470\ N$

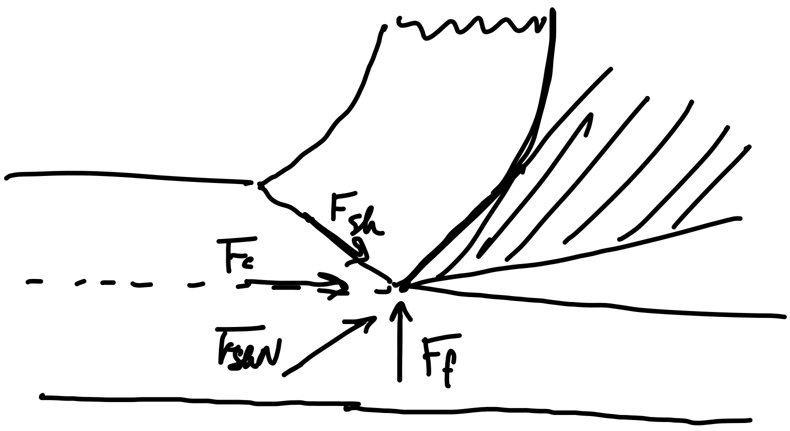
$F_f = 1589\ N$

$\gamma_0 = 8°$

$b = 5\ mm$

$h_0 = 0{,}6\ mm$

$r_c = 0{,}38$



$$\tan(\phi) = \frac{r_c \cos \gamma_0}{1 - r_c \sin \gamma_0} = 0{,}3916$$

$\phi = \arctan(0{,}3916) = 21{,}38°$

$F_{sh} = F_c \cos\phi - F_f \sin\phi = 789{,}3\ N$

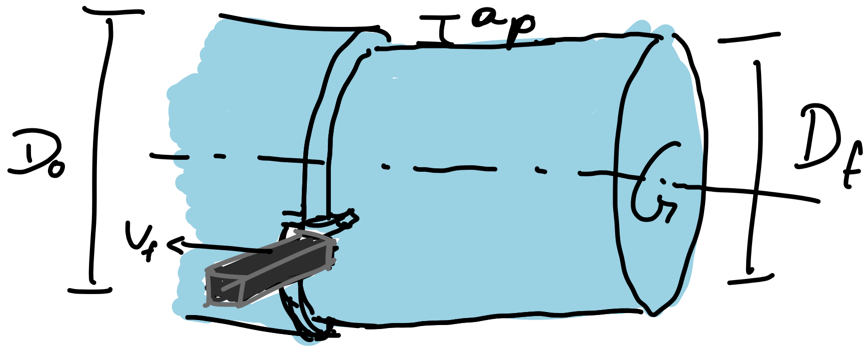
$$A_{sh} = \frac{h_0 b}{\sin\phi} = 8{,}23\ mm$$

$$\tau_{sh} = \frac{F_{sh}}{A_{sh}} = 95{,}9 \frac{N}{mm^2}$$

$$\phi = 45° + \frac{\gamma_0}{2} - \frac{\beta}{2} \Rightarrow \beta = 2\left(\phi - 45 - \frac{\gamma_0}{2}\right) = 52{,}44°$$

$$\mu = \tan(\beta) = 1{,}2913$$

Tornitura



$$D_f = D_0 - 2a_p$$

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

V_f - velocità di avanzamento

$V_f = n f$ $\qquad f \to$ avanzamento a giro $\left[\frac{mm}{giro}\right]$

$n \to$ velocità di rotazione $\left[\frac{giri}{min}\right]$

velocità di taglio

$V_c = n \pi D_0$

$A_D = f \cdot a_p$

↳ Sezione di truciolo indeformata

$a_p = 3,5\,mm$ → serve della roba dallo tornitura

Esercizio 3

$f = 0,2\ mm/giro$

$\gamma_0 = 8°$

$F_c = 1450\,N$

$F_f = 900\,N$

① $\mu = ?$

② $\tau_{sh} = ?$

③ $F_{sh} = ?$

$$\mu = \tan\beta = \frac{F_\gamma}{F_{\gamma N}} = \frac{F_f \cos(\gamma_0) + F_c \sin(\gamma_0)}{F_c \cos(\gamma_0) - F_f \sin(\gamma_0)} = 0,834$$

$$\beta = \tan^{-1}(\mu) = 40°$$

② $$\tau_{sh} = \frac{F_{sh}}{A_D/\sin\phi} = \frac{F_c \cos\phi - F_f \sin\phi}{a_p f/\sin\phi} = 530\,MPa$$

$A_D = a_p f$ $\quad \phi$? $$\tan(\phi) = \frac{r_c \cos(\gamma_0)}{1 - r_c \sin(\gamma_0)} = 0,386$$

$$\phi = \tan^{-1}(0,386) = 21°$$

$$A_D = a_p \cdot f = 0,7\,mm^2$$

③ $$F_{sh} = \tau_{sh} A_{sh} = 1000\,N$$

Esercizio 4

$a_p = 3mm$

$f = 0,15$ mm/giro

$\gamma_0 = 6°$ angolo di spoglio superiore

$\tau_{sh} = 520 MPa$

$\phi = 27,5°$

3 $F_c = ?$

$$F_c = \tau_{sh} \frac{A_D}{\sin\phi} \cdot \frac{\cos(\beta - \gamma_0)}{\cos(\phi + \beta - \gamma_0)} = 0,9 kN$$

$A_D = a_p f = 0,45 mm^2$

$$\phi = \frac{\pi}{4} + \frac{\gamma_0}{2} - \frac{\beta}{2}$$

$$\beta = \frac{\pi}{2} + \gamma_0 - 2\phi = 41°$$

$$F_f = F_c \tan(\beta - \gamma_0) = 0,63 kN$$