

PROGETTO POMPA CENTRIFUGA - MACCHINE 1

$$Q_v = 44 \text{ L/s} = 0.044 \text{ m}^3/\text{s}$$

$$h = 40 \text{ m}$$

3%

$$n = \frac{60f}{m} (1 - s)$$

scorrimento →

frequenza (50 Hz)

↳ n° di coppie polari

I^a soluzione → $m = 1$

$$n = \frac{60 \cdot 50}{1} (1 - 0.03) = 2910 \frac{\text{giri}}{\text{min}}$$

$$\omega = \frac{2\pi n}{60} = \frac{2\pi}{60} \cdot 2910 = 304,73 \text{ rad/s}$$

$$K = \omega \frac{Q_v^{0.5}}{(gh)^{0.75}} = 304,73 \cdot \frac{0.044^{0.5}}{(9.81 \cdot 40)^{0.75}} = 0,7250 \rightarrow \text{diagrammi statici}$$

$$K = 0,7250 \rightarrow \left. \begin{array}{l} \psi = 0.4522 \\ \phi = 0.1247 \\ \eta_{idr} = 0.9198 \\ \eta_v = 0.9637 \\ \eta_{mv} = 0.9152 \end{array} \right\} \text{dal foglio Excel}$$

$$\psi = \frac{gh}{u_2^2} \longrightarrow u_2 = \sqrt{\frac{gh}{\psi}} = 29.46 \frac{m}{s}$$

I° step verifica
(strutturale)

$$\longrightarrow u_2 \leq u_{cr}$$

$$\searrow \text{ghise} : 40 \frac{m}{s}$$

$$\text{acciai} : 60 \frac{m}{s}$$

$$u_2 \leq 40 \quad \underline{\text{OK}} \quad \checkmark$$

$$u_2 = \omega \frac{D_2}{2} \longrightarrow D_2 = \frac{2u_2}{\omega} = \frac{2 \cdot 29.46}{304.73}$$

$$\phi = \frac{Q_v}{\pi D_2 b_2 u_2} = \frac{C_{u2}}{u_2} \quad \begin{array}{l} | \\ = 0.1933 m \\ | \\ = 193.3 mm \end{array}$$

$$b_2 = \frac{Q_v}{\pi D_2 \phi u_2} \quad \begin{array}{l} | \\ = \frac{0.044}{\pi \cdot 0.1933 \cdot 0.1247 \cdot 29.46} = 19.7 mm \end{array}$$

II° step verifica
(fluidodinamico)

$$\longrightarrow 0.02 \leq \frac{b_2}{D_2} \leq 0.3$$

$$\frac{19.7}{193.3} = 0.102 \quad \underline{\text{OK}} \quad \checkmark$$

$\nearrow b_2$
 $\searrow D_2$

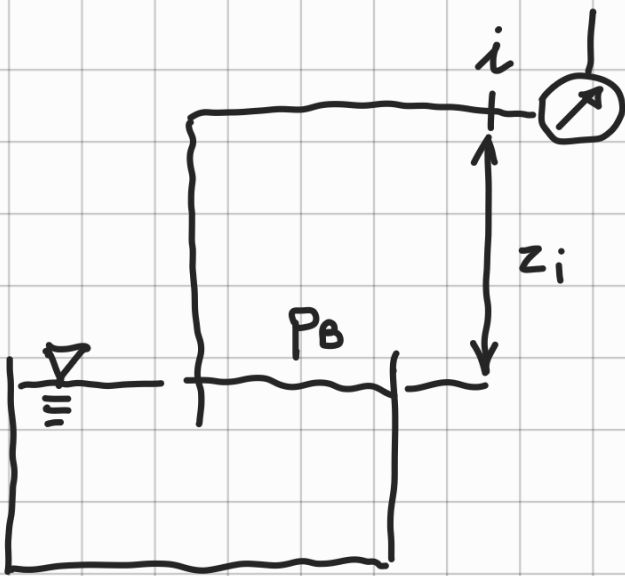
$$D_{IN, NPSH} = 4.79 \left(\frac{Q_v}{n} \right)^{1/3} = 4.79 \cdot \left(\frac{0.044}{2910} \right)^{1/3}$$

$$= 0.1184 \text{ m} = 118.4 \text{ mm}$$

$$NPSH_R = 1.107 \cdot 10^{-3} Q_v^{2/3} n^{4/3}$$

$$= 1.107 \cdot 10^{-3} \cdot 0.044^{2/3} 2910^{4/3}$$

$$= 5.732 \text{ m}$$



$$NPSH_R = \frac{P_B - P_v}{\rho g} - z_i - h_L - x$$

$$P_B = P_{atm} =$$

$$= 101325 \text{ Pa}$$

$$\rho = 1000 \text{ kg/m}^3$$

$$P_v = 2400 \text{ Pa}$$

$$x = 1 \text{ m}$$

$$h_L = 1 \text{ m}$$

$$z_i = \frac{P_B - P_v}{\rho g} - NPSH_R - h_L - x =$$

$$= \frac{101325 - 2400}{1000 \cdot 9.81} - 5.732 - 1 - 1$$

$$= 2.738 \text{ m} \quad (\text{macchina veloce})$$

II° caso $\longrightarrow m = 2$ (4 poli)

$$n = 1455 \text{ giri/min} \longrightarrow \omega = 152.37 \frac{\text{rad}}{\text{s}}$$

$$k = 0.363 \longrightarrow \left. \begin{array}{l} \psi = 0.5211 \\ \phi = 0.0950 \\ \eta_{idr} = 0.8248 \\ \eta_v = 0.9395 \\ \eta_{mv} = 0.9639 \\ \eta_{TOT} = 0.7469 \end{array} \right\} \text{EXCEL}$$

$$u_2 = 27.44 \text{ m/s} \stackrel{?}{\leq} 40 \text{ m/s} \quad \underline{\text{OK}} \checkmark$$

(I° step)

$$D_2 = 360.2 \text{ mm}$$

$$\phi \longrightarrow b_2 = 14.9 \text{ mm}$$

II° step $\longrightarrow \frac{b_2}{D_2} = \frac{14.9}{360.2} = 0.0414$

OK $\checkmark$

$$0.02 \leq \frac{b_2}{D_2} \leq 0.3$$

$$D_{IN, NPSH} = 149.2 \text{ mm}$$

$$NPSH_R = 2.275 \text{ m} \rightarrow z_i = 5.836 \text{ m}$$

$$\text{III}^\circ \text{ CASO} \rightarrow m = 3 \quad (6 \text{ poli})$$

$$n = 970 \frac{\text{giri}}{\text{min}} \rightarrow \omega = 101.58 \frac{\text{rad}}{\text{s}}$$

$$K = 0.242 \rightarrow$$

$$\psi = 0.5441$$

$$\phi = 0.0810$$

$$\eta_{idr} = 0.8039$$

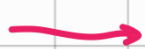
$$\eta_v = 0.9253$$

$$\eta_{mv} = 0.9130$$

$$\eta_{TOT} = 0.6791$$

$$\eta_{idr} < 0.82$$

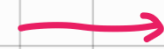
imposizione



$$\eta_{idr} = 0.82$$

se

$$\eta_{idr} < 0.82$$



ricalcolo

$$\eta_{mv}$$

$$\eta_{mv} = \frac{\eta_{TOT}}{\eta_{idr} \cdot \eta_v} = 0.8950$$

$$\eta_{TOT} = \eta_v \eta_{idr} \eta_{mv}$$

$$\eta_{mv} = \frac{\eta_{TOT}}{\eta_{idr} \eta_v} = \frac{0.6791}{0.82 \cdot 0.9253}$$

$$K = 0.242 \longrightarrow \begin{aligned} \psi &= 0.5441 \\ \phi &= 0.0810 \\ \eta_{TOT} &= 0.6791 \\ \eta_{idr} &= 0.82 \\ \eta_v &= 0.9253 \\ \eta_{mv} &= 0.8950 \end{aligned}$$

$$\psi \longrightarrow u_2 = 26.86 \text{ m/s} < 40 \text{ m/s}$$

$$\quad \quad \quad \hookrightarrow D_2 = 528.8 \text{ mm} \quad \underline{\text{OK}} \checkmark$$

$$\phi \longrightarrow b_2 = 12.2 \text{ mm}$$

$$\underline{\text{II}^{\circ} \text{ step}} \quad \frac{b_2}{D_2} = \frac{12.2}{528.8} = 0.023$$

$$\quad \quad \quad \underline{\text{OK}} \checkmark$$

$$D_{IN, NPSH} = 170.8 \text{ mm}$$

$$NPSH_R = 1.325 \text{ m}$$

$$z_i = 6.786 \text{ m}$$

m	1	2	3
n	2910 rpm	1455 rpm	970 rpm
K	0.725	0.363	0.242
η_{TOT}	81.13%	74.69%	67.91%
D_2	193.3 mm	360.2 mm	528.8 mm
z_i	2.378 m	5.836 m	6.786 m



SCELTA $\longrightarrow m = 2$

DIMENSIONAMENTO

$$u = 2$$

$$s = 0.03$$

$$f = 50 \text{ Hz}$$

$$Q_v = 44 \text{ L/s}$$

$$h = 40 \text{ m}$$

$$n = 1455 \text{ rpm}$$

$$K = 0.363 \longrightarrow \psi = 0.5211$$

$$\phi = 0.095$$

$$\eta_{\text{TOT}} = 74.69 \%$$

$$\eta_{\text{idr}} = 82.48 \%$$

$$\eta_v = 93.95 \%$$

$$\eta_{mv} = 96.39 \%$$

$$\psi = \frac{gh}{u_2^2} \longrightarrow u_2 = \sqrt{\frac{gh}{\psi}} \longrightarrow D_2$$

$$D_2 = 360.3 \text{ mm} \longrightarrow D_2 = 360 \text{ mm}$$

$$D_2 = 183 \text{ mm} \begin{cases} \nearrow D_2 = 180 \text{ mm} \\ \searrow D_2 = 185 \text{ mm} \end{cases}$$

$$u_2 = \omega \frac{D_2}{2} = 27.43 \text{ m/s}$$

$$\phi = \frac{Q_v}{\pi D_2 b_2 \xi_2 \eta_v u_2}$$

trascurati in
fase di studio
di fattibilità

↓
da considerare
nel dimensionamento
preliminare!

$$\xi_e = \text{ostruzione} = 0.95$$

$$b_2 = \frac{Q_v}{\pi D_2 \phi \xi_2 \eta_v u_2}$$

$$= 16.7 \text{ mm} \rightarrow 17 \text{ mm}$$

$$D_2 = 360 \text{ mm}$$

$$b_2 = 17 \text{ mm}$$

$$D_{IN} = 4.79 \left(\frac{Q_v}{n} \right)^{1/3}$$

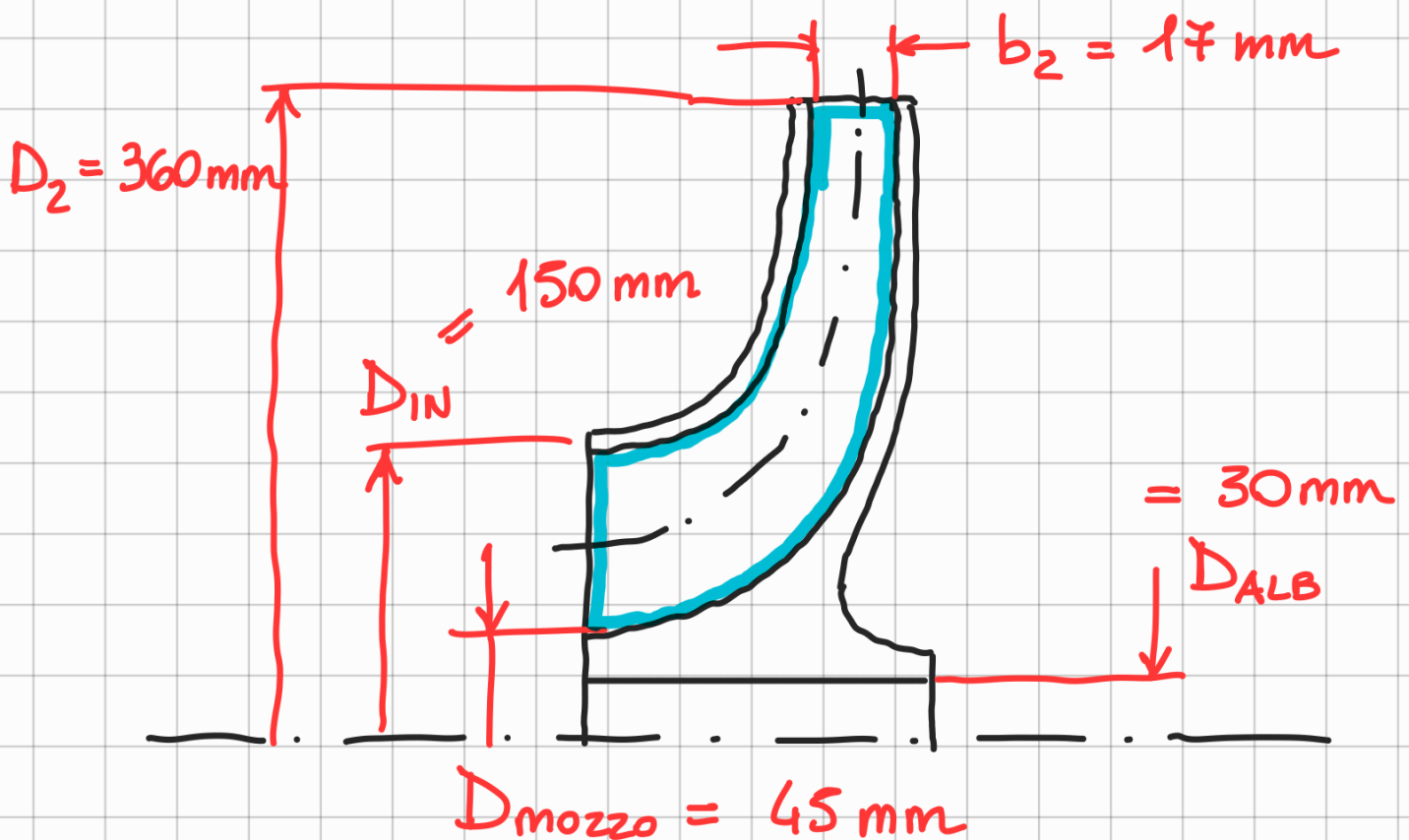
$$= 149.2 \text{ mm}$$

$$D_{IN} = 150 \text{ mm}$$

diametri
unificati
delle
condotte

$$D = 150 \text{ mm}$$

CONDOTTO MERIDIANO



$$D_{ALB, \min} = \sqrt[3]{\frac{16 M_t}{\pi \tau_{adm}}} \quad (\text{MP}_2)$$

$\tau_{adm} = 30 \frac{\text{N}}{\text{mm}^2}$

$$P_{alb} = \frac{P_{idr}}{\eta_{TOT}} = \frac{\rho g Q_r h}{\eta_{TOT}} =$$

$$= \frac{1000 \cdot 9.81 \cdot 0.044 \cdot 40}{0.7468}$$

$$= 23.1 \text{ kW}$$

$$P_{alb} = M_t \cdot \omega \rightarrow M_t = 151.4 \text{ Nm}$$

$$= 151400 \text{ Nmm}$$

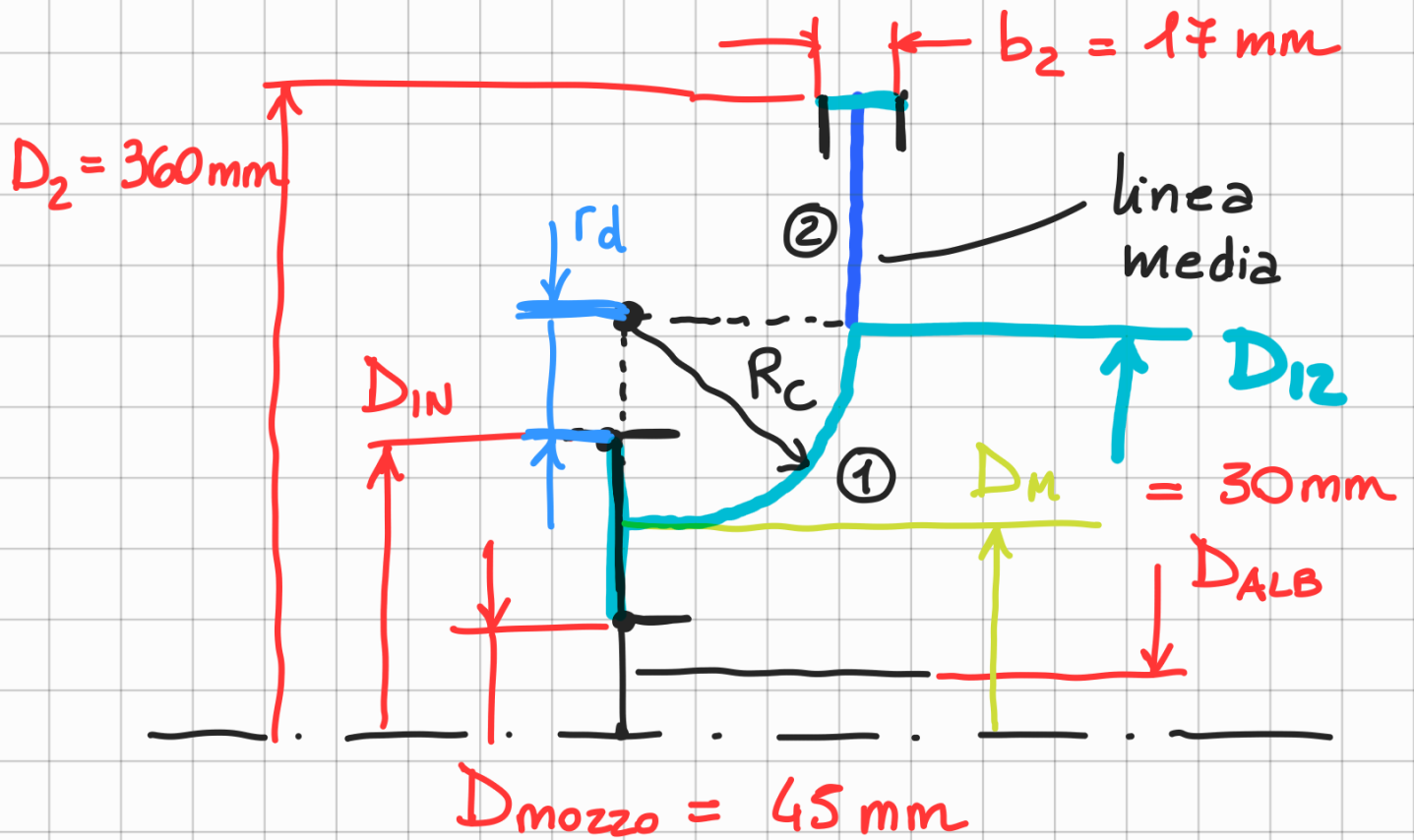
$$D_{alb, min} = \sqrt[3]{\frac{16.151400}{\pi \cdot 30}} = 29.51 \text{ mm}$$

$$D_{alb} \geq D_{alb, \min} \quad D_{alb} = 30 \text{ mm}$$

(guardare tabelle
profilati in
acciaio)

$$D_{\text{mozzo}} = (1.4 \div 1.5) D_{\text{alb}}$$

scelta $\rightarrow D_{\text{mozzo}} = 1.5 D_{\text{alb}}$
 $= 45 \text{ mm}$



- ① → arco di circonferenza di 90°
 - ② → tratto rettilineo verticale
- linea media

$$R_c = r_d + \frac{D_{IN} - D_M}{2}$$

$$r_d = (0.05 \div 0.06) D_2$$

$$r_d = 0.05 D_2 = 0.05 \cdot 360 = 18 \text{ mm}$$

$$D_M = \frac{D_{IN} + D_{Mozzo}}{2} = \frac{150 + 45}{2} = 97.5 \text{ mm}$$

$$R_c = 18 + \frac{150 - 97.5}{2} = 44.25 \text{ mm}$$

$$D_{12} = D_{IN} + 2r_d = 150 + 2 \cdot 18 = 186 \text{ mm}$$

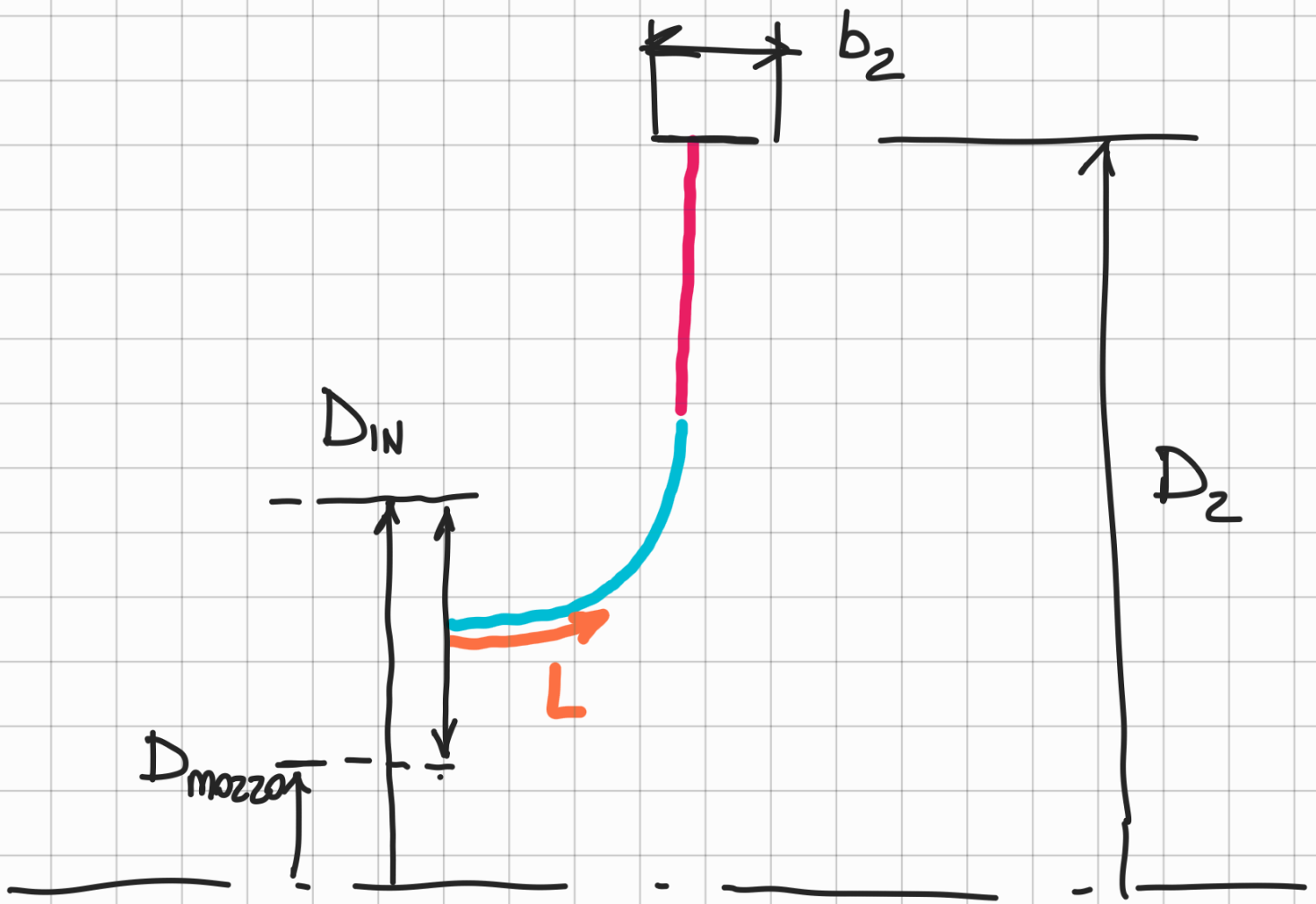
$$L_{TOT} = L_{①} + L_{②}$$

$$L_{①} = \frac{1}{\cancel{4} \atop 2} \cdot \cancel{2} \pi R_c = \frac{\pi R_c}{2}$$

$$= \frac{\pi}{2} \cdot 44.25 = 69.51 \text{ mm}$$

$$L_{②} = \frac{D_2 - D_{12}}{2} = \frac{360 - 186}{2} = 87 \text{ mm}$$

$$L_{TOT} = 69.51 + 87 = 156.51 \text{ mm}$$



$$L = 0$$

$$A = A_{IN} = \frac{\pi}{4} (D_{IN}^2 - D_{mozzo}^2)$$

$$= \frac{\pi}{4} (150^2 - 45^2)$$

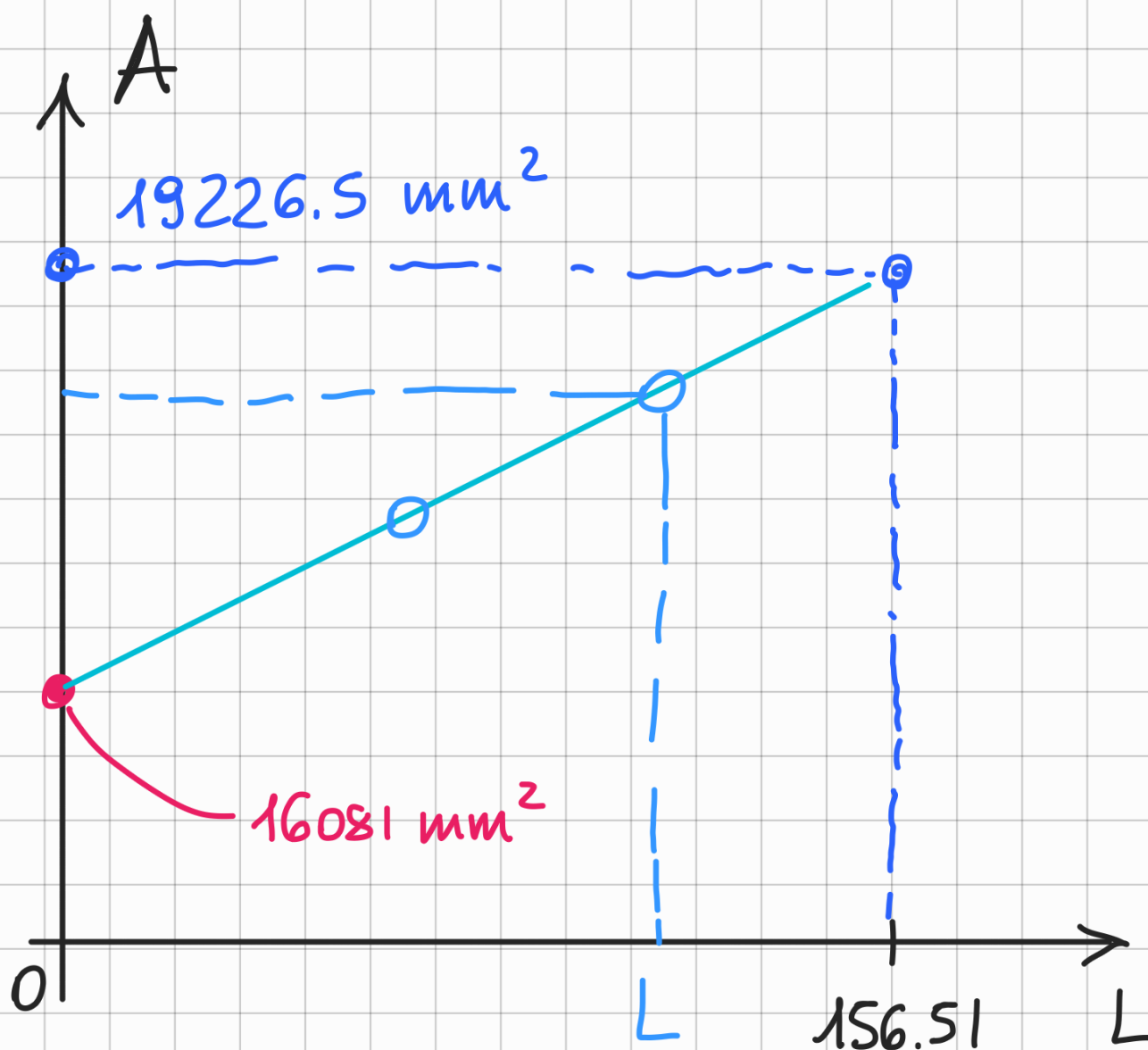
$$= 16081 \text{ mm}^2$$

$$L = L_{TOT}$$

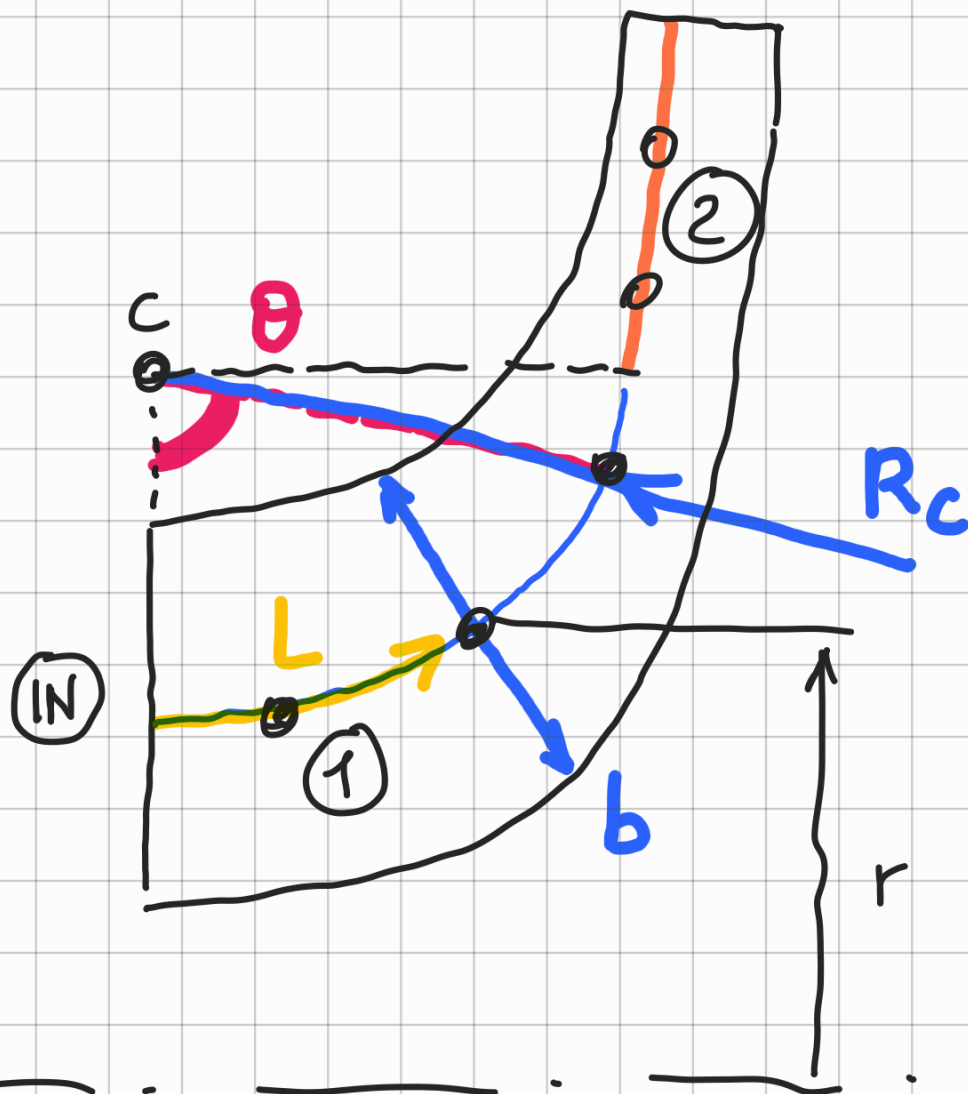
$$A = \pi D_2 b_2$$

$$= \pi \cdot 360 \cdot 17$$

$$= 19226.5 \text{ mm}^2$$



$$A(L) = A_{IN} + \frac{A_2 - A_{IN}}{L_{TOT}} \cdot L$$



$$A(L) = 2\pi r(L) \cdot b(L)$$

nel tratto ①

$$\theta [^\circ] \rightarrow \theta (\text{rad})$$

$$L = R_c \theta$$

$$r(L) = \frac{D_{12}}{2} - R_c \cos \theta$$

nel tratto ②

$$0 \leq \Delta L \leq \boxed{\frac{D_2 - D_{12}}{2}}$$

$L_{(2)}$ 

$$L = \frac{\pi}{2} R_c + \Delta L$$

$$r(L) = \frac{D_{12}}{2} + \Delta L$$

tratto ①

$$\theta = 30^\circ \left(\frac{\pi}{6} \text{ rad} \right)$$

$$L = R_c \theta = 44.25 \cdot \frac{\pi}{6}$$
$$= 23.17 \text{ mm}$$

$$r(L) = \frac{D_{12}}{2} - R_c \cos \theta$$
$$= \frac{186}{2} - 44.25 \cdot \cos \frac{\pi}{6}$$
$$= 54.68 \text{ mm}$$

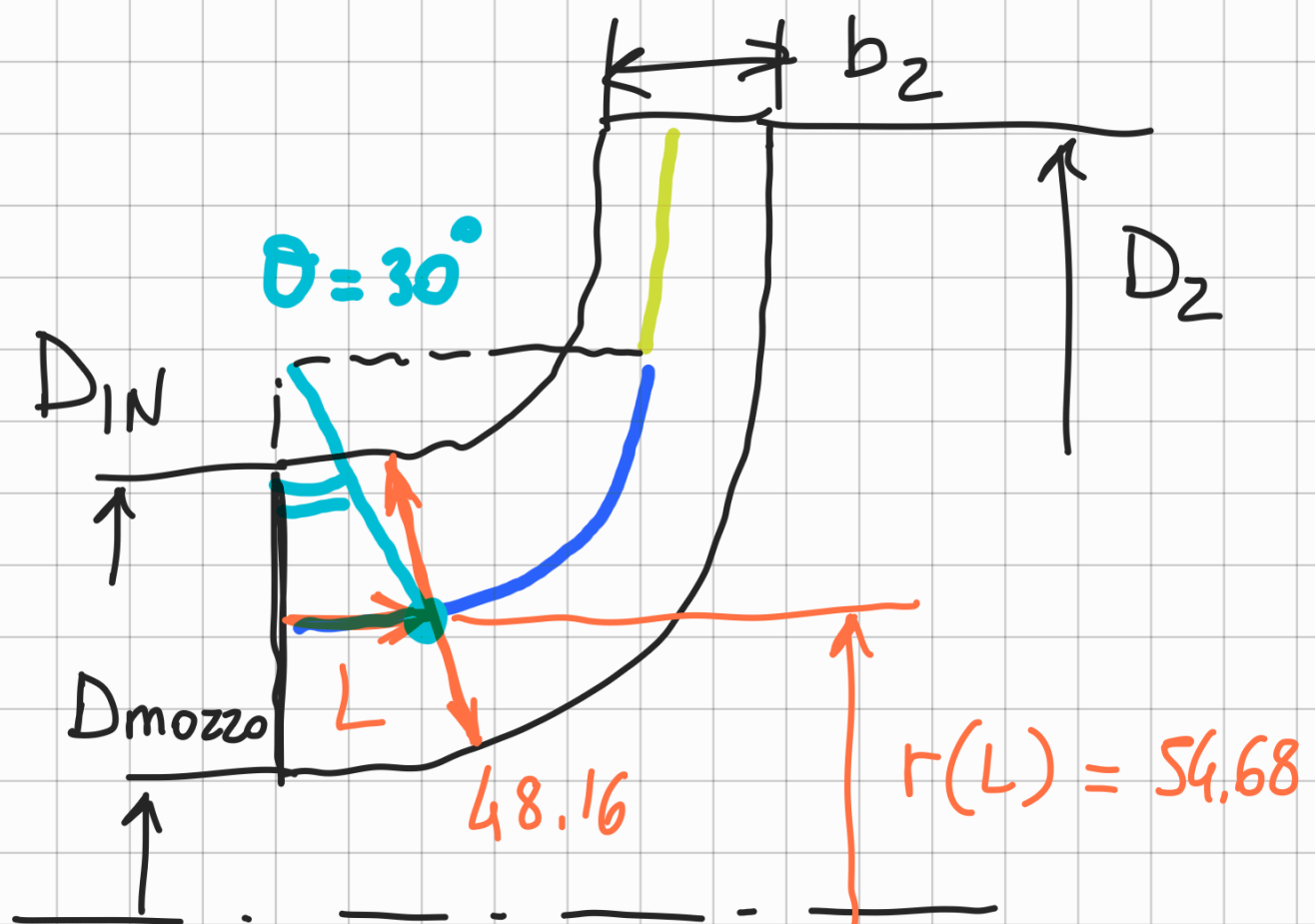
$$A(L) = A_{IN} + \frac{A_2 - A_{IW}}{L_{TOT}} \cdot L$$

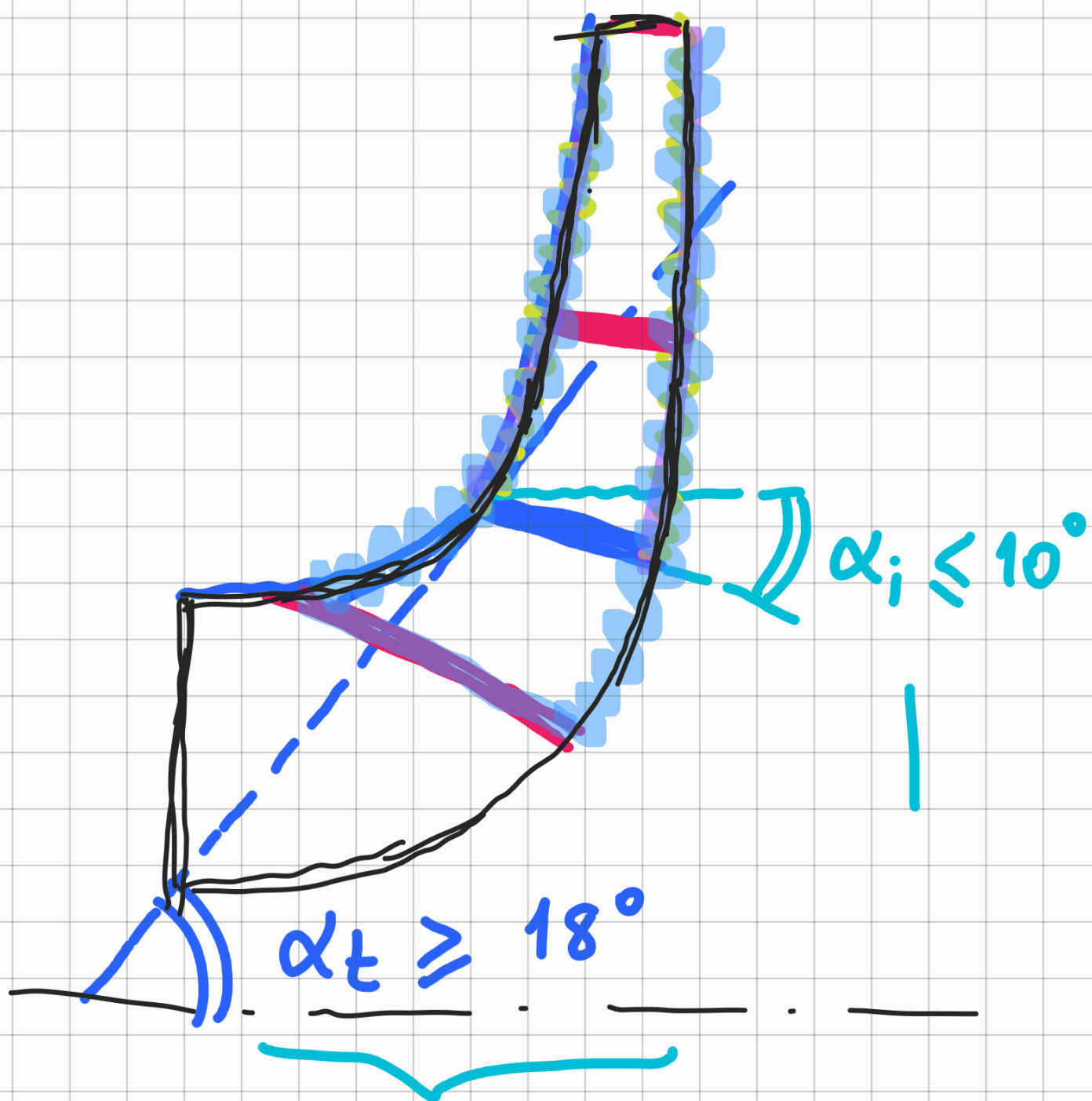
$$= 16081 + \frac{19226.5 - 16081}{156.51} \cdot 23.17$$

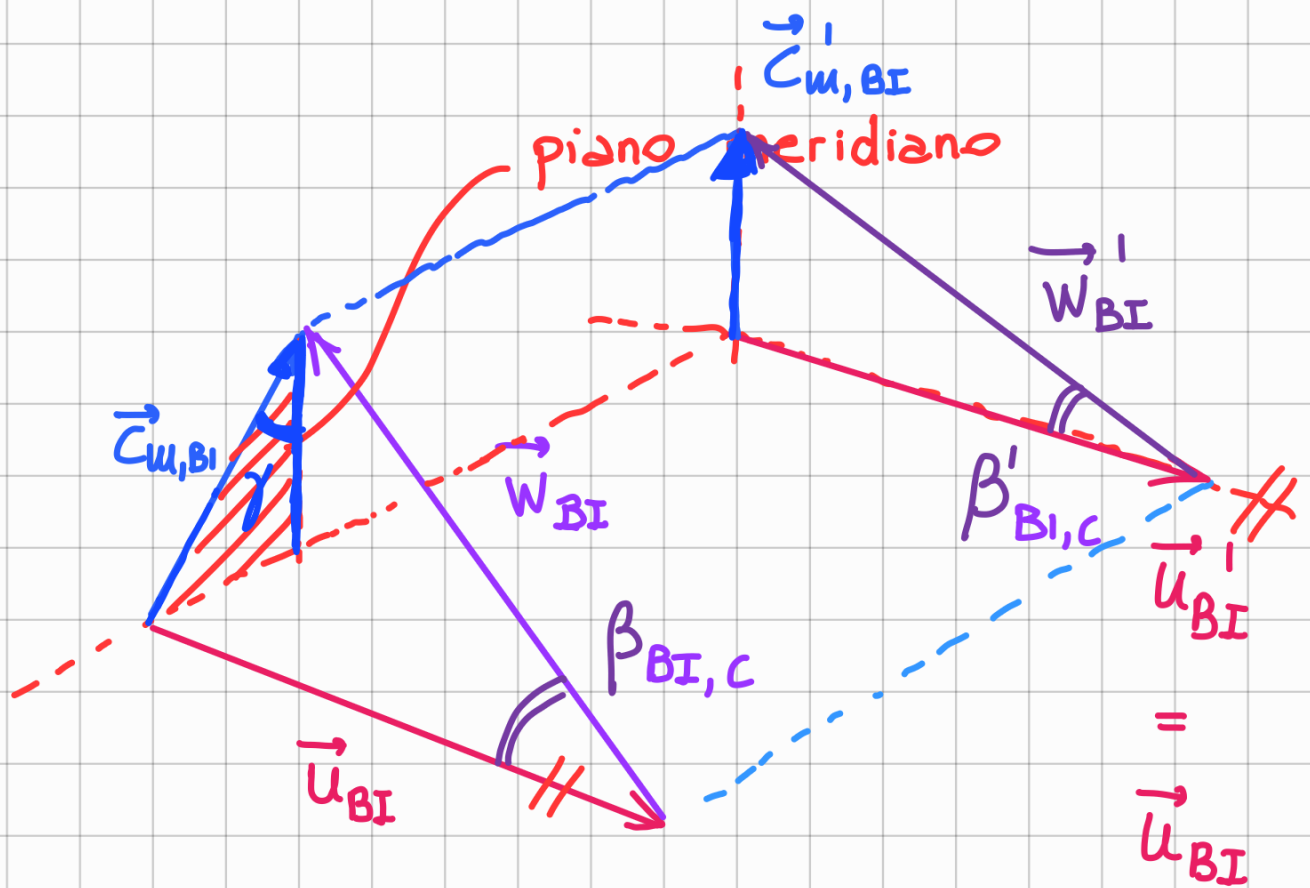
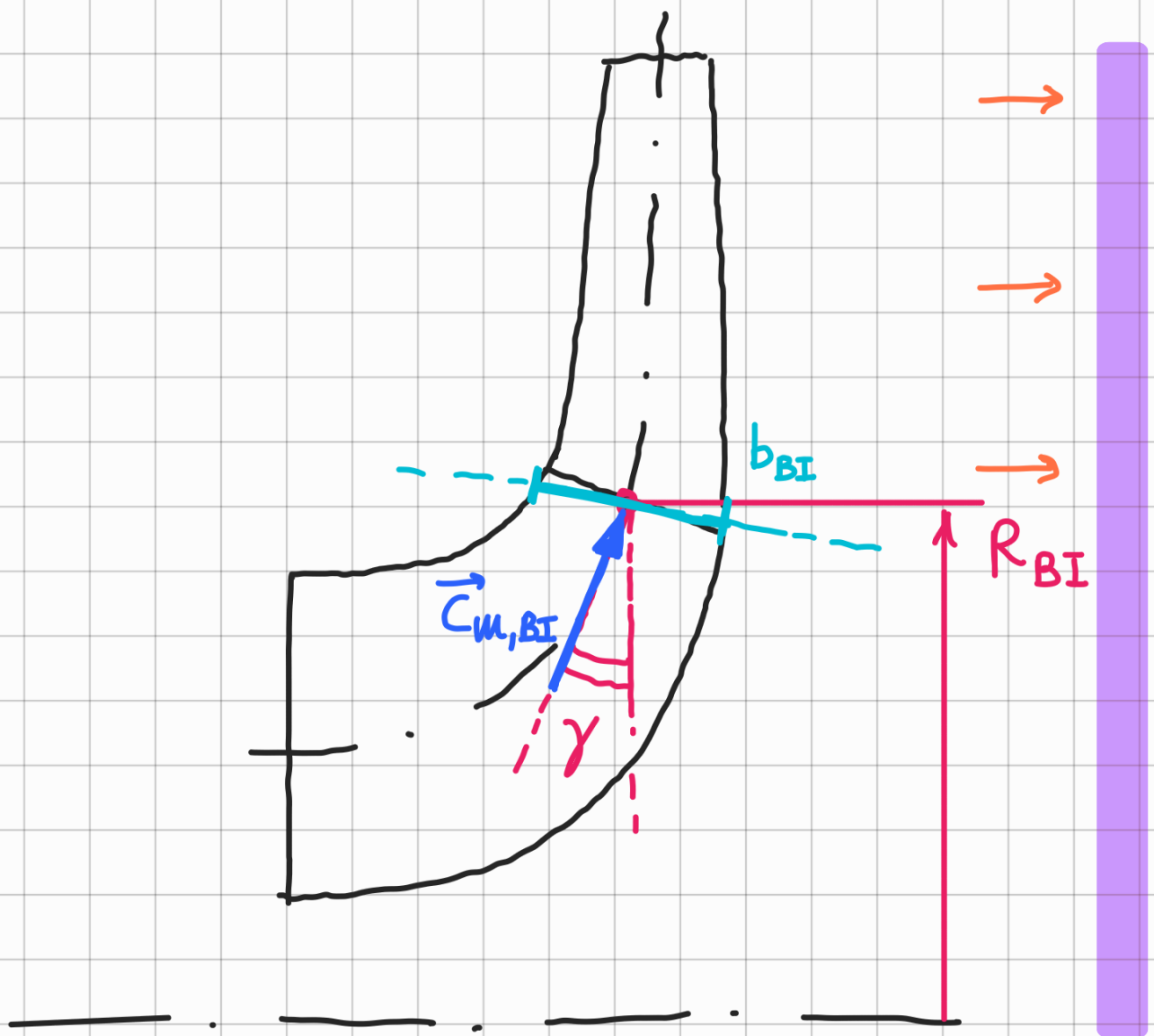
$$= 16546.7 \text{ mm}^2$$

$$A(L) = 2\pi r(L) \cdot b(L)$$

$$b(L) = \frac{A(L)}{2\pi r(L)} = 48.16 \text{ mm}$$







$$\gamma = 16.09^\circ$$

$$R_{BI} = 80.74 \text{ mm}$$

$$b_{BI} = 32.23 \text{ mm}$$

$$u_{BI} = R_{BI} \omega$$

$$\operatorname{tg} \beta_{BI,c} = \frac{C_{m,BI}}{u_{BI}}$$

$$\operatorname{tg} \beta'_{BI,c} = \frac{C'_{m,BI}}{u_{BI}}$$

$$\operatorname{tg} \beta'_{BI,c} = \frac{C'_{m,BI}}{C_{m,BI}} \cdot \operatorname{tg} \beta_{BI,c}$$

$$C'_{m,BI} = C_{m,BI} \cos \gamma$$

$$\frac{C'_{m,BI}}{C_{m,BI}} = \cos \gamma$$

$$\operatorname{tg} \beta'_{BI,c} = \cos \gamma \operatorname{tg} \beta_{BI,c}$$

$$\operatorname{tg} \beta'_{BI,c} = \cos \gamma \cdot \frac{\mu_{BI}}{\mu_{BI}}$$

$$= \frac{\cos \gamma}{R_{BI} \omega} \cdot \frac{Q_v}{2\pi R_{BI} b_{BI} \eta_v \xi_{BI}}$$

$$\xi_{BI} = 1 - \frac{Z S_n'}{\pi D_{BI} \sin \beta'_{BI,c}}$$

n° pale

spessore palare

$$1) \quad \xi_{BI} = 1$$

$$u_{BI} = \omega R_{BI}$$

$$= 152.37$$

$$= 12.3 \text{ m/s}$$

$$\tan \beta'_{BI,c} = \frac{Q_v \cos \gamma}{\eta_v \pi D_{BI} b_{BI} \xi_{BI} u_{BI}}$$

$$= \frac{0.044 \cos 16.09^\circ}{0.9395 \pi \cdot 0.1615 \cdot 0.03223 \cdot 1 \cdot 12.3}$$

$$= 0.2237 \longrightarrow \beta'_{BI,c} = \tan^{-1} 0.2237$$

$$= 12.6^\circ$$

$$\xi_{BI} = 1 - \frac{Z_{Sn}}{\pi D_{BI} \sin \beta'_{BI,c}} = 1 - \frac{7 \cdot 0.005}{\pi \cdot 0.1615 \cdot \sin 12.6^\circ} = 0.684$$

$$2) \quad \xi_{BI} = 0.684$$

$$\begin{aligned} \operatorname{tg} \beta'_{BI,c} &= \frac{Q_v \cos \gamma}{\eta_v \pi D_{BI} b_{BI} \xi_{BI} u_{BI}} \\ &= \frac{0.044 \cos 16.09^\circ}{0.9395 \cdot \pi \cdot 0.1615 \cdot 0.03223 \cdot 0.684 \cdot 12.3} \\ &= 0.327 \rightarrow \boxed{\beta'_{BI,c} = 18.1^\circ} \end{aligned}$$

$$\xi_{BI} = 0.778$$

$$3) \quad \xi_{BI} = 0.778$$

$$\operatorname{tg} \beta'_{BI,c} = 0.2875$$

$$\hookrightarrow \beta'_{BI,c} = 16.0^\circ$$

$$\xi_{BI} = 0.750$$

$$4) \xi_{BI} = 0.750$$

$$\hookrightarrow \operatorname{tg} \beta'_{B1,c} = 0.2981$$

$$\hookrightarrow \beta'_{B1,c} = 16.6^\circ$$

$$\xi_{BI} = 0.759$$

$$5) \xi_{BI} = 0.759$$

$$\hookrightarrow \operatorname{tg} \beta'_{B1,c} = 0.2949$$

$$\hookrightarrow \beta'_{B1,c} = 16.4^\circ$$

$$\xi_{BI} = 0.756$$

$$6) \xi_{BI} = 0.756$$

$$\operatorname{tg} \beta'_{B1,c} = 0.2959 \rightarrow \beta'_{B1,c} = 16.5^\circ$$

$$\xi_{BI} = 0.757$$

$$0.7 \leq \xi_{BI} \leq 0.8$$

$$Z = 5 \div 8$$

$$s_n' \geq 3 \text{ mm}$$

→ linea guida!

$$\beta'_{BI,c} = 16.5^\circ$$

INGRESSO

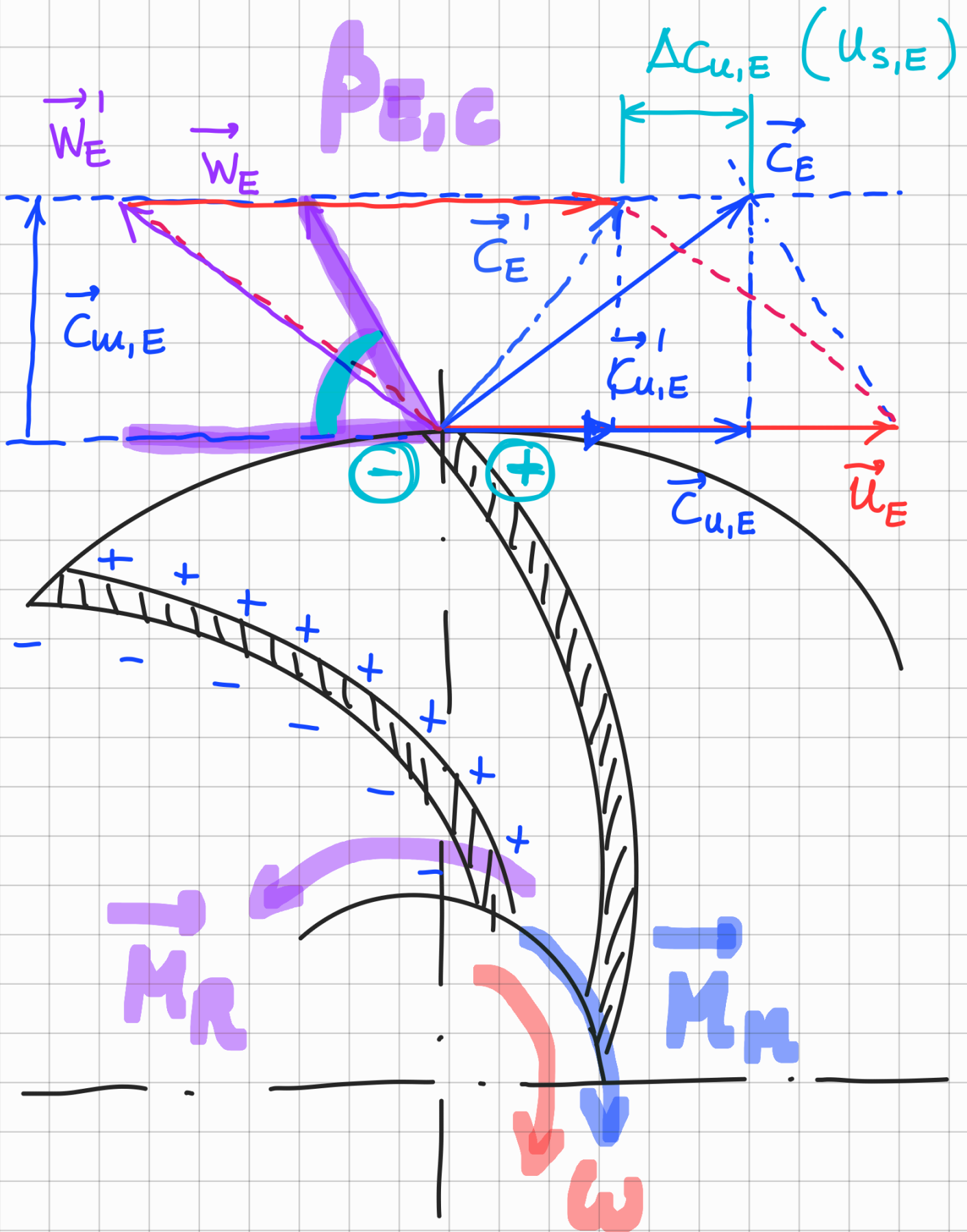
$$\xi_{BI} = 0.757$$

$$\gamma = 16.09^\circ$$

$$R_{BI} = 80.74 \text{ mm}$$

$$b_{BI} = 32.23 \text{ mm}$$

USCITA GIRANTE - ANGOLO
COSTRUTTIVO



$$gh_t = u_E c_{u,E} - \cancel{u_I c_{u,I}}$$

$$= 0 \text{ m/s}$$

$$gh_t = u_E c_{u,E}$$

$$c_{u,E} = u_E - \frac{c_{u,E}}{\tan \beta_{E,C}} - u_E \left(\frac{\Delta c_{u,E}}{u_E} \right)$$

$$c_{u,E} = u_E - \frac{Q_v}{\eta_v \pi D_E b_E \zeta_E \tan \beta_{E,C}} - u_E \left(\frac{\Delta c_{u,E}}{u_E} \right)$$

$$gh_t = u_E c_{u,E}$$

$$\frac{gh_t}{u_E^2} = u_E^2 - \frac{u_E^2 Q_v}{\gamma_v \pi D_E b_E \zeta_E \tan \beta_{E,c}} - u_E^2 \left(\frac{\Delta C_{u,E}}{u_E} \right)$$

$$u_E^2$$

$$\frac{gh_t}{u_E^2} = 1 - \frac{Q_v}{\gamma_v \pi D_E b_E \zeta_E \tan \beta_{E,c} u_E} - \frac{\Delta C_{u,E}}{u_E}$$

$$\psi_t$$

$$\frac{C_{u,E}}{u_E} = \phi$$

$$\psi = \frac{gh}{u_E^2}$$

$$\psi_t = \frac{gh_t}{u_E^2}$$

$$\eta_{idr} = \frac{gh}{gh_t} \quad (\text{macchina operatrice})$$

$$\frac{gh_t}{u_E^2} = \psi_t = \left[\frac{gh}{\eta_{idr}} \right] \left[\frac{1}{u_E^2} \right]$$

$$\psi_t = \frac{\psi}{\eta_{idr}}$$

note

$$\frac{\psi}{\eta_{idr}} = 1 - \frac{Q_v}{\eta_v \pi D_E b_E \xi_E u_E \underbrace{\tan \beta_{E/C}}_{\frac{\Delta C_{u,E}}{u_E}}}$$

$$\xi_E = 1 - \frac{z s_n'}{\pi D_E \sin \beta_{E,c}}$$

$$\frac{\Delta C_{u,E}}{u_E} = \frac{\sqrt{\sin \beta_{E,c}}}{z^{0.7}}$$

$$1) \xi_E = 1; \quad \frac{\Delta C_{u,E}}{u_E} = 0$$

$$\frac{gh}{\eta_{idr} u_E^2} = 1 - \frac{Q_v}{\eta_v \pi D_E b_E \xi_E u_E \tan \beta_{E,c}} - \frac{\Delta C_{u,E}}{u_E}$$

$$\tan \beta_{E,c} = \frac{Q_v}{\eta_v \pi D_E b_E \xi_E u_E \left(1 - \frac{gh}{\eta_{idr} u_E^2} - \frac{\Delta C_{u,E}}{u_E} \right)}$$

$$D_E = 360 \text{ mm}$$

$$h = 40 \text{ m}$$

$$b_E = 17 \text{ mm}$$

$$\eta_{idr} = 0.8248$$

$$u_E = 27.43 \text{ m/s}$$

$$\eta_v = 0.9395$$

$$\tan \beta_{E,c} = 0.2417 \rightarrow \beta_{E,c} = 13.6^\circ$$

$$\xi_E = 1 - \frac{z s_n}{\pi D_E \sin \beta_{E,c}} = 0.8683$$

$\nearrow 7$
 $\nearrow 5 \text{ mm}$
 $\searrow 13.6^\circ$

$$\frac{\Delta C_{u,E}}{u_E} = \frac{\sqrt{\sin \beta_{E,c}}}{z^{0.7}} = \frac{\sqrt{\sin 13.6^\circ}}{7^{0.7}} = 0.1241$$

$$2) \quad \xi_E = 0.8683 \quad \frac{\Delta C_{uE}}{u_E} = 0.1241$$

$$\operatorname{tg} \beta_{E,c} = 0.4203 \rightarrow \beta_{E,c} = \boxed{22.8^\circ}$$

$$\xi_E = 0.9201$$

$$\frac{\Delta C_{u,E}}{u_E} = 0.1594$$

$$3) \quad \xi_E = 0.9201$$

$$\frac{\Delta C_{u,E}}{u_E} = 0.1594$$

$$\operatorname{tg} \beta_{E,c} = 0.4639 \rightarrow \beta_{E,c} = \boxed{24.9^\circ}$$

$$\xi_E = 0.9265$$

$$\frac{\Delta C_{u,E}}{u_E} = 0.1661$$

$$4) \quad \xi_E = 0.9265$$

$$\frac{\Delta C_{u,E}}{u_E} = 0.1661$$

$$\operatorname{tg} \beta_{E,C} = 0.4761 \rightarrow \boxed{\beta_{E,C} = 25.5^\circ}$$

$$\xi_E = 0.9280$$

$$\frac{\Delta C_{u,E}}{u_E} = 0.1679$$

$$5) \quad \xi_E = 0.9280$$

$$\frac{\Delta C_{u,E}}{u_E} = 0.1679$$

$$\operatorname{tg} \beta_{E,C} = 0.4761$$

$$\boxed{\beta_{E,C} = 25.6^\circ}$$

$$\xi_E = 0.9284$$

$$\frac{\Delta C_{u,E}}{u_E} = 0.1684$$

$$[0.9 \leq \xi_E \leq 0.95]$$

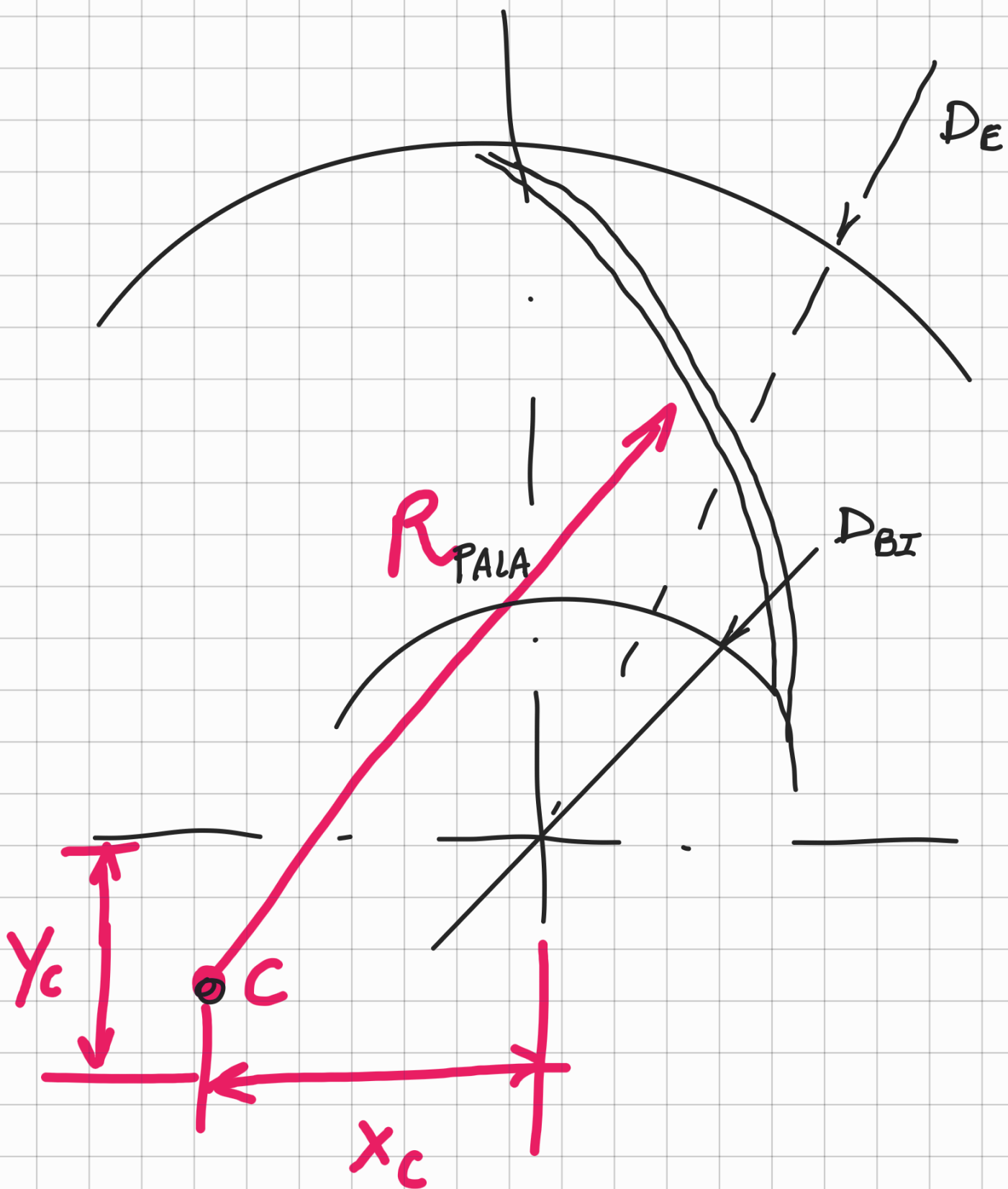
2 step
verifica

$$[\beta_{E,C} - \beta'_{B1,C} \leq 10^\circ]$$



$$25.7^\circ - 16.5^\circ = 9.2^\circ$$

ok!



$$R_{PALA} = \frac{R_{BI,C} (\epsilon^2 - 1)}{2(\epsilon \cos \beta_{E,C} - \cos \beta'_{BI,C})}$$

$$\epsilon = \frac{D_E}{D_{BI}}$$

$$X_{C,PALA} = - R_{PALA} \cdot \sin \beta_{E,C}$$

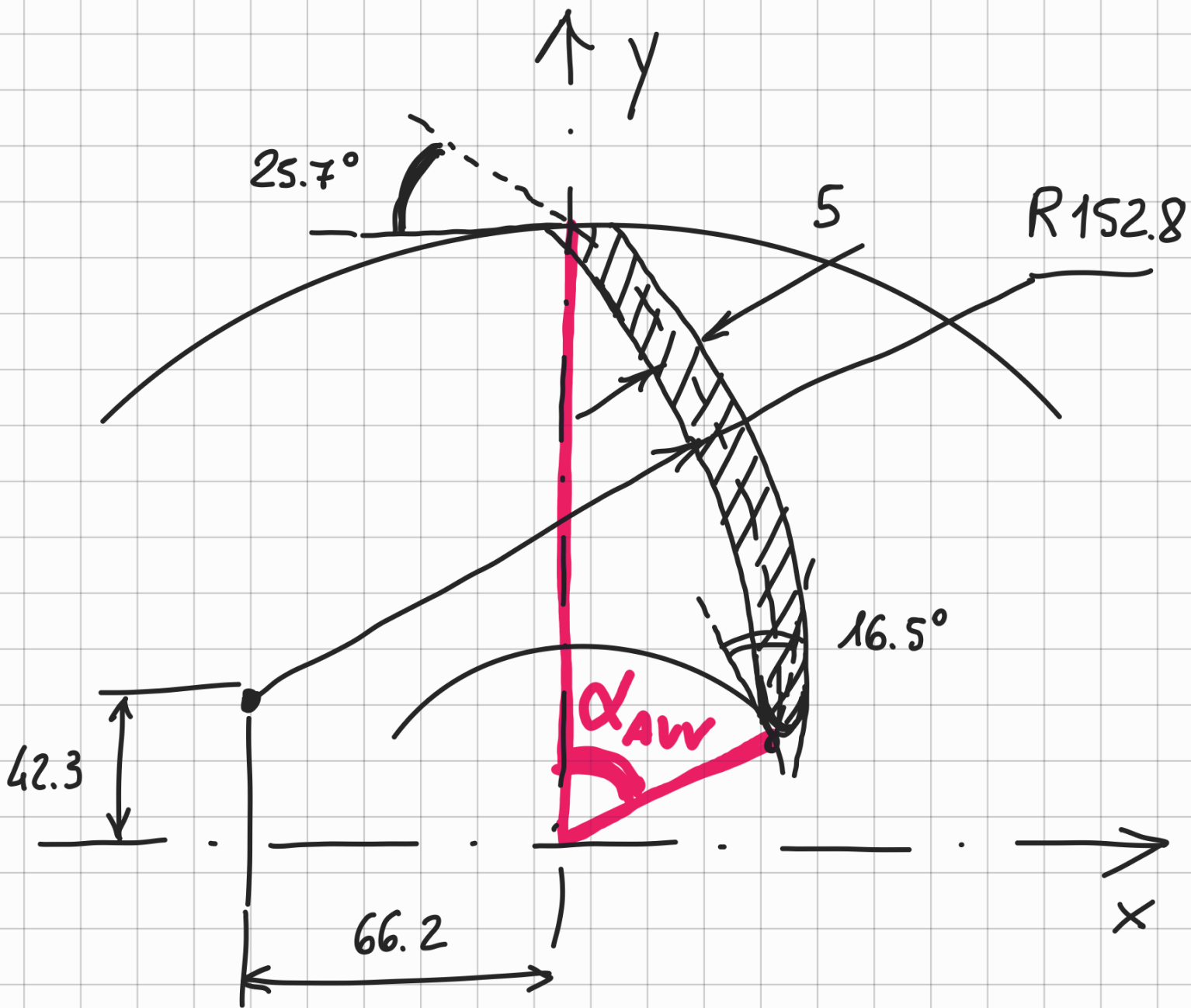
$$Y_{C,PALA} = \frac{D_E}{2} - R_{PALA} \cos \beta_{E,C}$$

$$\epsilon = \frac{360}{161.5} = 2.23$$

$$\begin{aligned} R_{PALA} &= \frac{R_{BI,C} (\epsilon^2 - 1)}{2(\epsilon \cos \beta_{E,C} - \cos \beta'_{BI,C})} \\ &= \frac{80.74 (2.23^2 - 1)}{2(2.23 \cos 25.7^\circ - \cos 16.5^\circ)} \\ &= 152.8 \text{ mm} \end{aligned}$$

$$X_{C, PALA} = -66.2 \text{ mm}$$

$$y_{C, PALA} = 42.3 \text{ mm}$$



$$90^\circ \leq \alpha_{AVV} \leq 120^\circ$$

$$z = 8 \quad \leftarrow \quad z = 5$$

$$\alpha_{AV} \approx 90^\circ$$

VOLUTA

criterio del vortice libero

↳ corrente in uscita
dalla girante
effonda liberamente
senza operare
ulteriori scambi
di energia



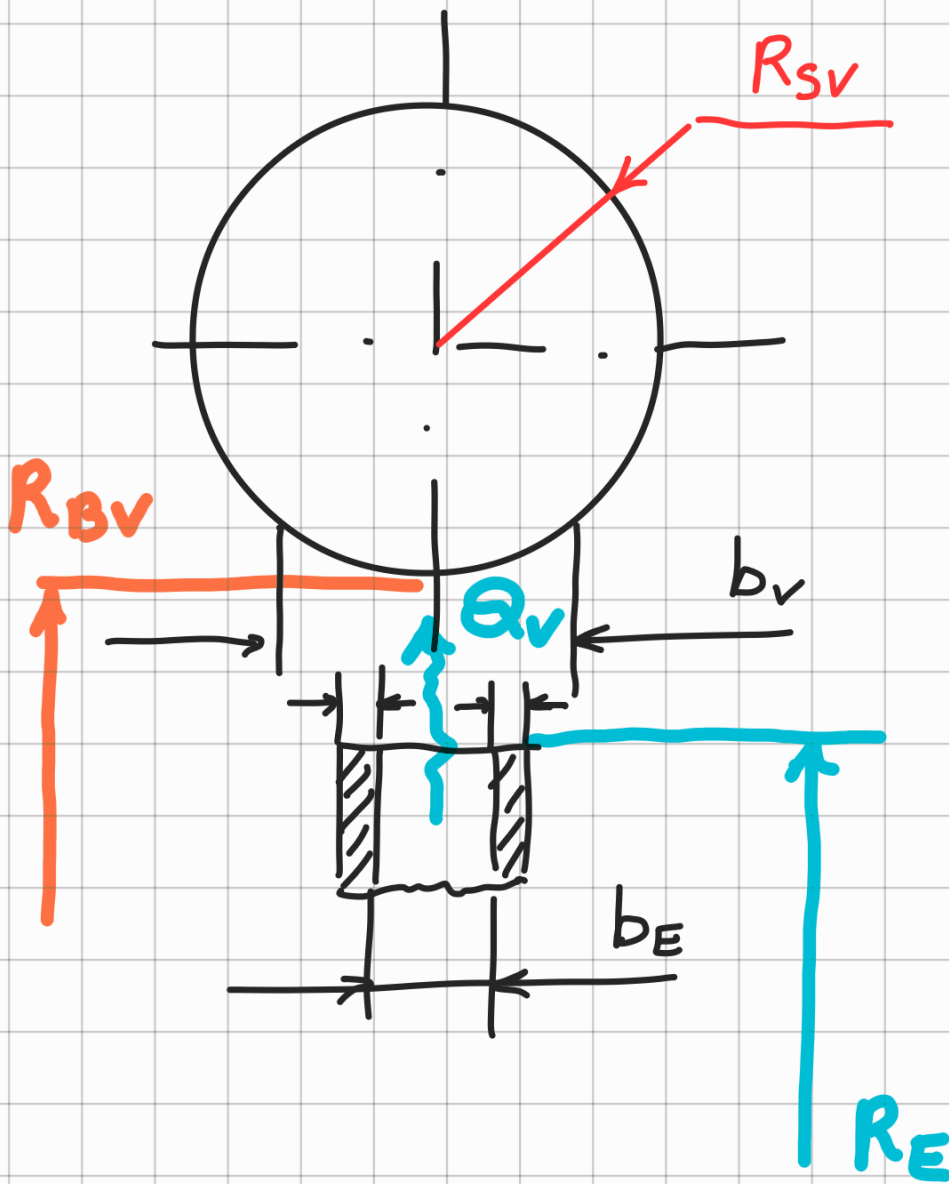
conservazione
del momento
della quantità
di moto



$$r_i u_i = \text{cost}$$

scelta progetto →

voluta a
sezione
circolare



R_{sv} : raggio
sezione
voluta

b_v : larghezza
di base
voluta

R_{Bv} : raggio
base
voluta

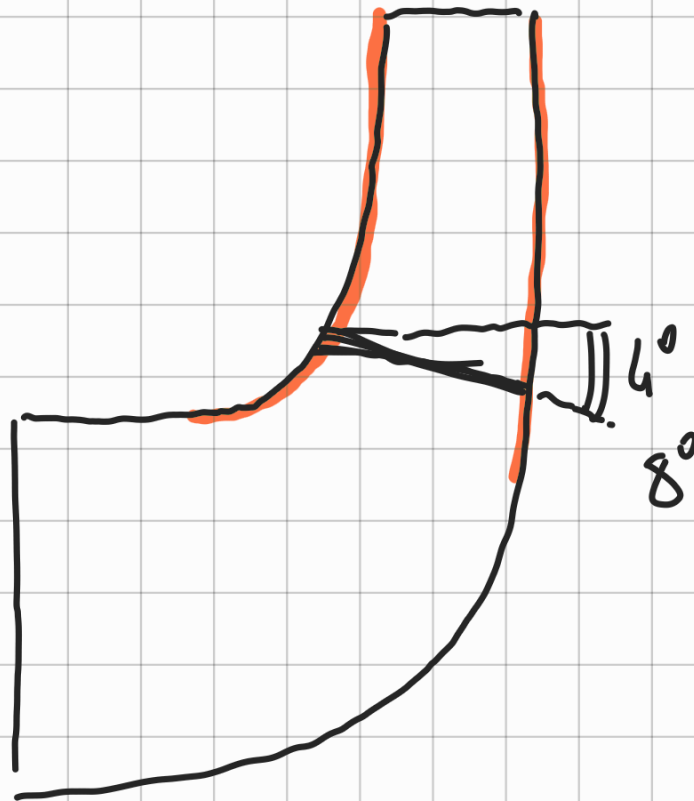
— . — . — asse
macchina

$$R_{Bv} = \underline{(1.04 \div 1.12)} R_E$$

$$b_v = \underline{(1.5 \div 2)} b_E$$

$$b_v = \underline{30 \text{ mm}} \rightarrow \frac{b_v}{b_E} = \frac{30}{17} = \underline{1.765} \text{ OK!}$$

$$R_{Bv} = \underline{190 \text{ mm}} \rightarrow \frac{R_{Bv}}{R_E} = \frac{190}{180} = \underline{1.056} \text{ OK!}$$



$$\frac{\Delta p}{L}$$