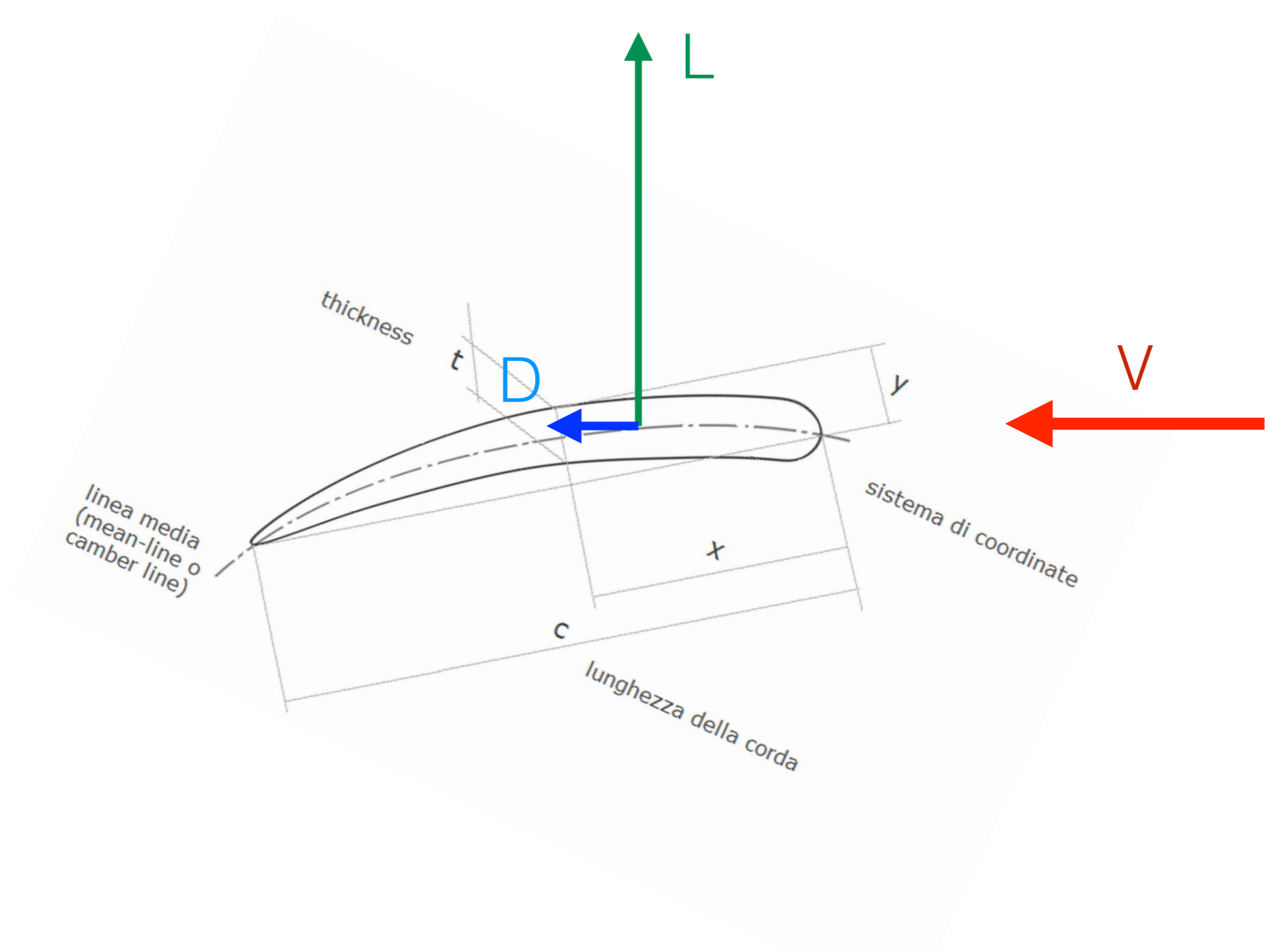


LEZIONE 7-8



Schiere di pale

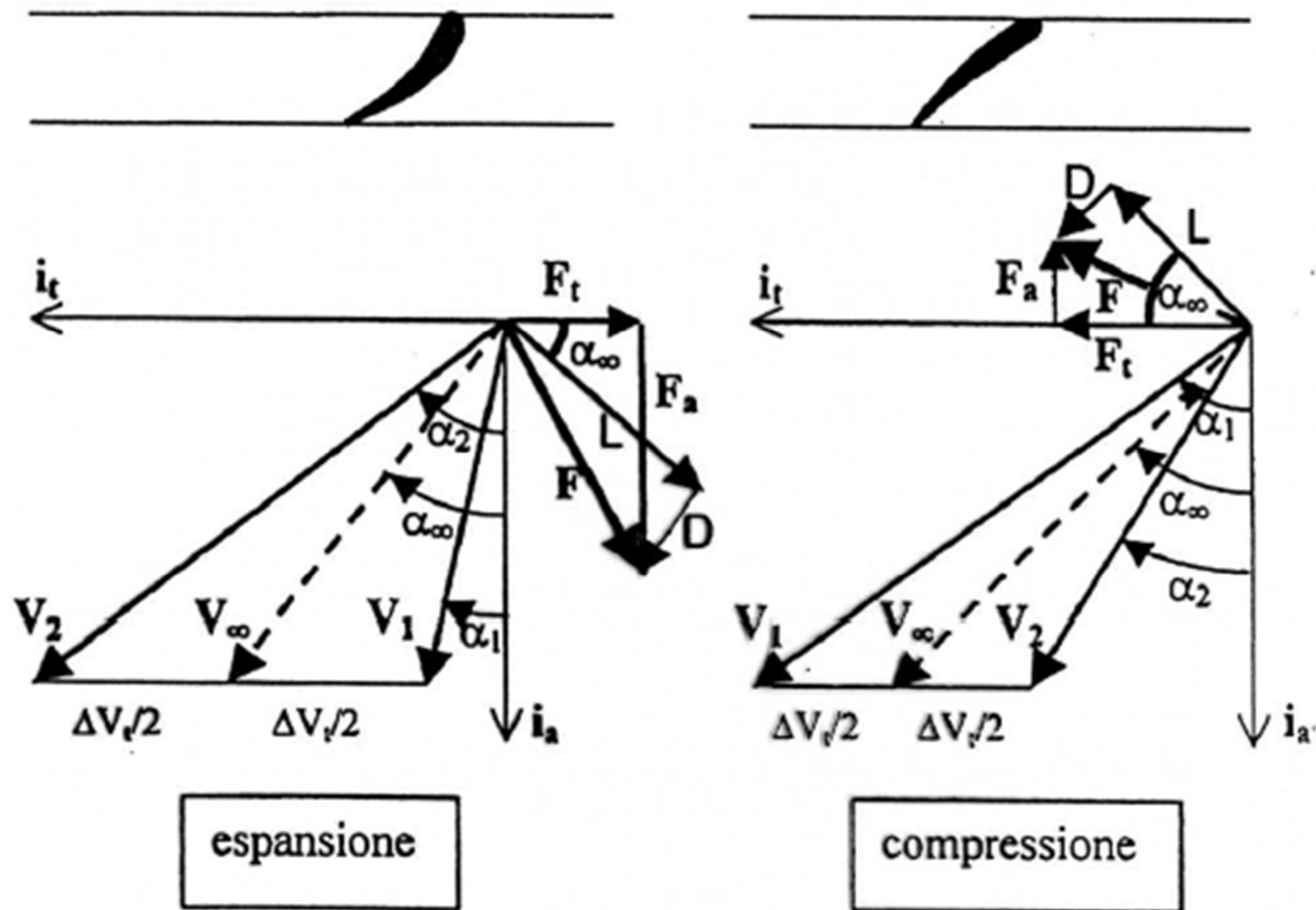
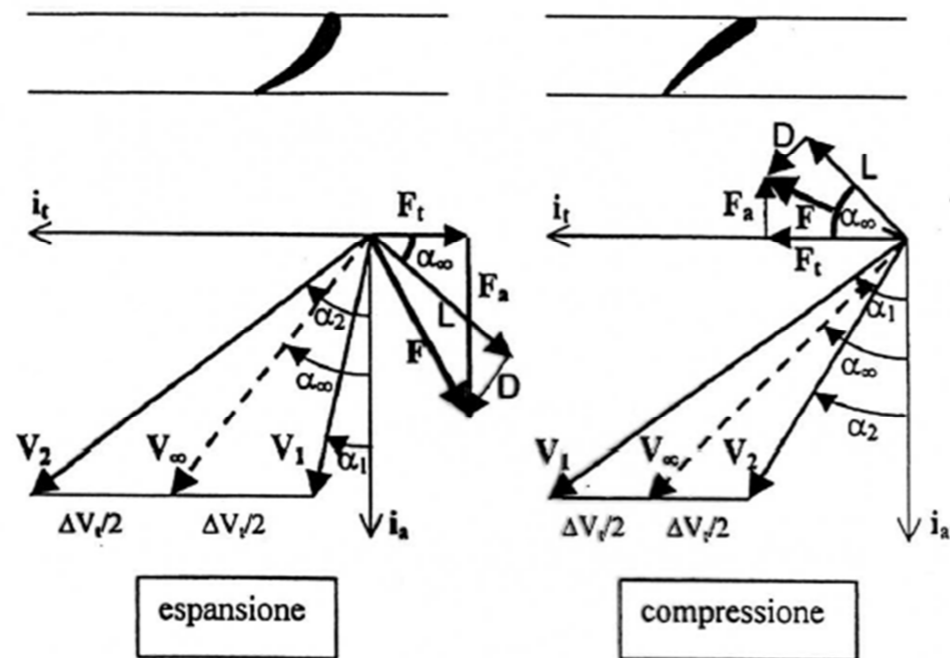


Figura 5.11: Portanza e resistenza agenti sui profili di schiere piane di pale.

Schiere di pale



$$L = F_t \cos \alpha_\infty - F_a \sin \alpha_\infty$$

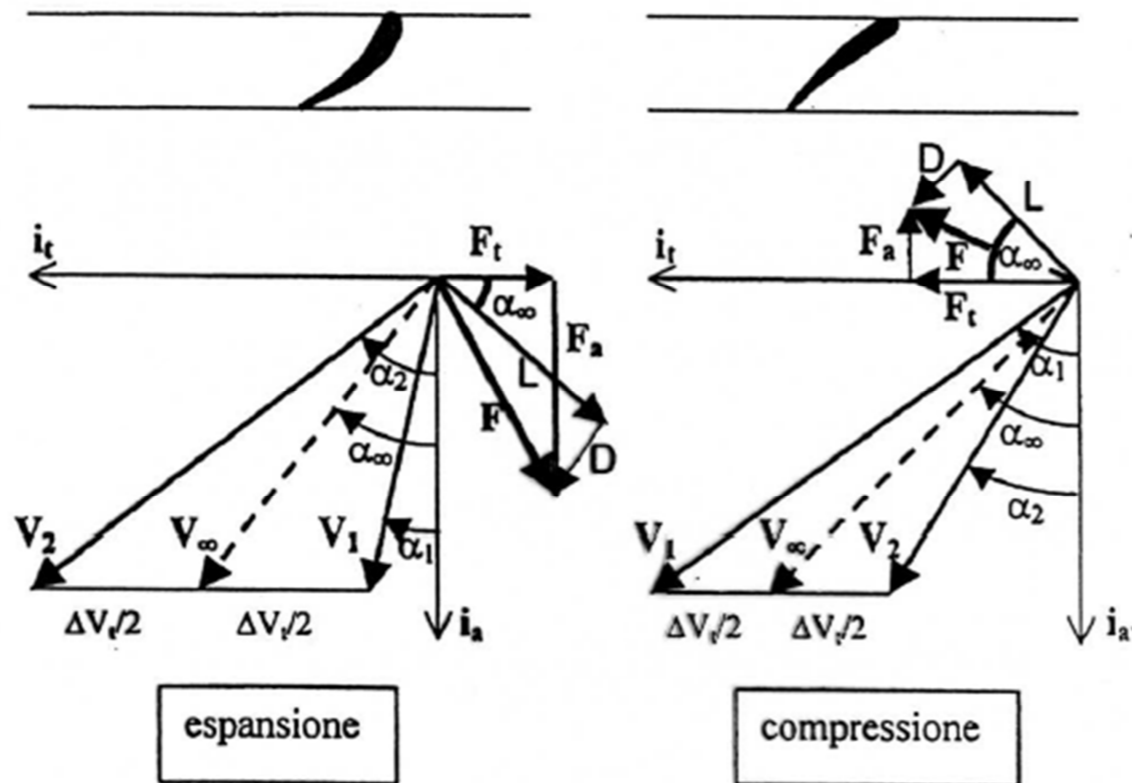
$$D = F_t \sin \alpha_\infty + F_a \cos \alpha_\infty$$

$$F_a = -(L \sin \alpha_\infty - D \cos \alpha_\infty)$$

$$F_t = L \cos \alpha_\infty + D \sin \alpha_\infty$$

Figura 5.11: Portanza e resistenza agenti sui profili di schiere piane di pale.

Schiere di pale



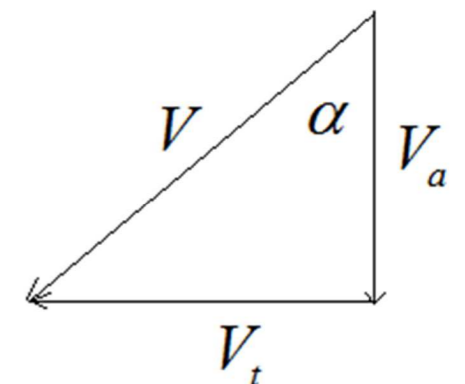
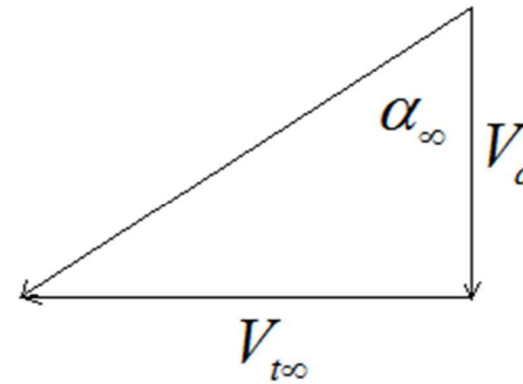
$$c_L = \frac{L}{\frac{1}{2} \rho c \cdot V_\infty^2}$$

$$c_D = \frac{D}{\frac{1}{2} \rho c \cdot V_\infty^2}$$

Figura 5.11: Portanza e resistenza agenti sui profili di schiere piane di pale.

Schiere di pale

$$c_F = \frac{F_t}{\frac{1}{2} \rho c \cdot V_\infty^2} = \frac{s \rho V_a \cdot (V_{t1} - V_{t2})}{\frac{1}{2} \rho c \cdot V_\infty^2}$$



$$V_a = V_\infty \cos \alpha_\infty$$

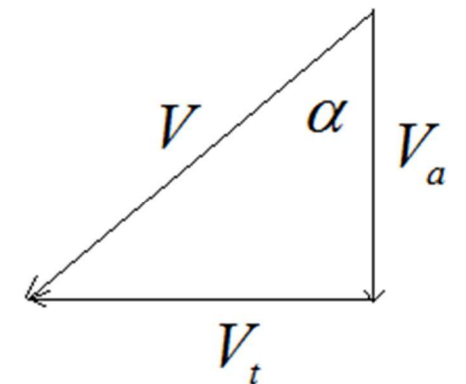
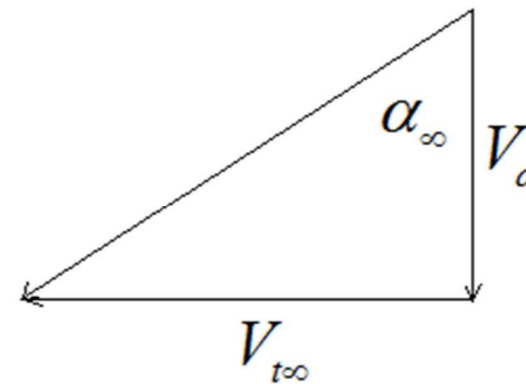
$$V_{t1,2} = V_a \tan \alpha_{1,2}$$

$$c_F = \frac{F_t}{\frac{1}{2} \rho c \cdot V_\infty^2} = \frac{s \rho V_a \cdot (V_{t1} - V_{t2})}{\frac{1}{2} \rho c \cdot V_\infty^2} = 2 \left(\frac{s}{c} \right) \cos^2 \alpha_\infty (\tan \alpha_1 - \tan \alpha_2)$$

Schiere di pale

$$c_P = \frac{F_a}{\frac{1}{2} \rho c \cdot V_\infty^2} = \frac{s \Delta p_0 - F_t \tan \alpha_\infty}{\frac{1}{2} \rho c \cdot V_\infty^2} = \frac{s \Delta p_0}{\frac{1}{2} \rho c \cdot V_\infty^2} - c_F \tan \alpha_\infty$$

$$y = \frac{\Delta p_0}{\frac{1}{2} \rho V_2^2} \quad \text{coeff. di perdita}$$



$$c_P = \left(\frac{s}{c} \right) y \left(\frac{V_2}{V_\infty} \right)^2 - c_F \tan \alpha_\infty$$

$$V_a = V_\infty \cos \alpha_\alpha$$

$$V_{t1,2} = V_a \tan \alpha_{1,2}$$

$$c_P = \left(\frac{s}{c} \right) y \frac{\cos^2 \alpha_\infty}{\cos^2 \alpha_2} - 2 \left(\frac{s}{c} \right) (\tan \alpha_1 - \tan \alpha_2) \sin \alpha_\infty \cdot \cos \alpha_\infty$$

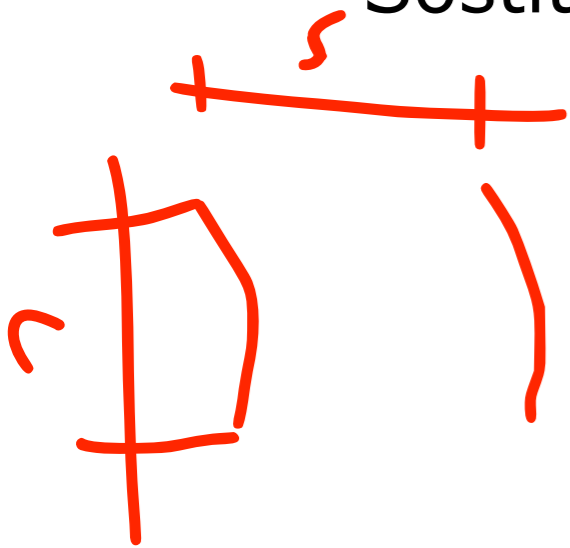
Schiere di pale

Possiamo trovare allora

$$\underline{c_L} = \underline{c_F} \cos \alpha_\infty - \underline{c_P} \sin \alpha_\infty$$

$$\underline{c_D} = \underline{c_F} \sin \alpha_\infty + \underline{c_P} \cos \alpha_\infty$$

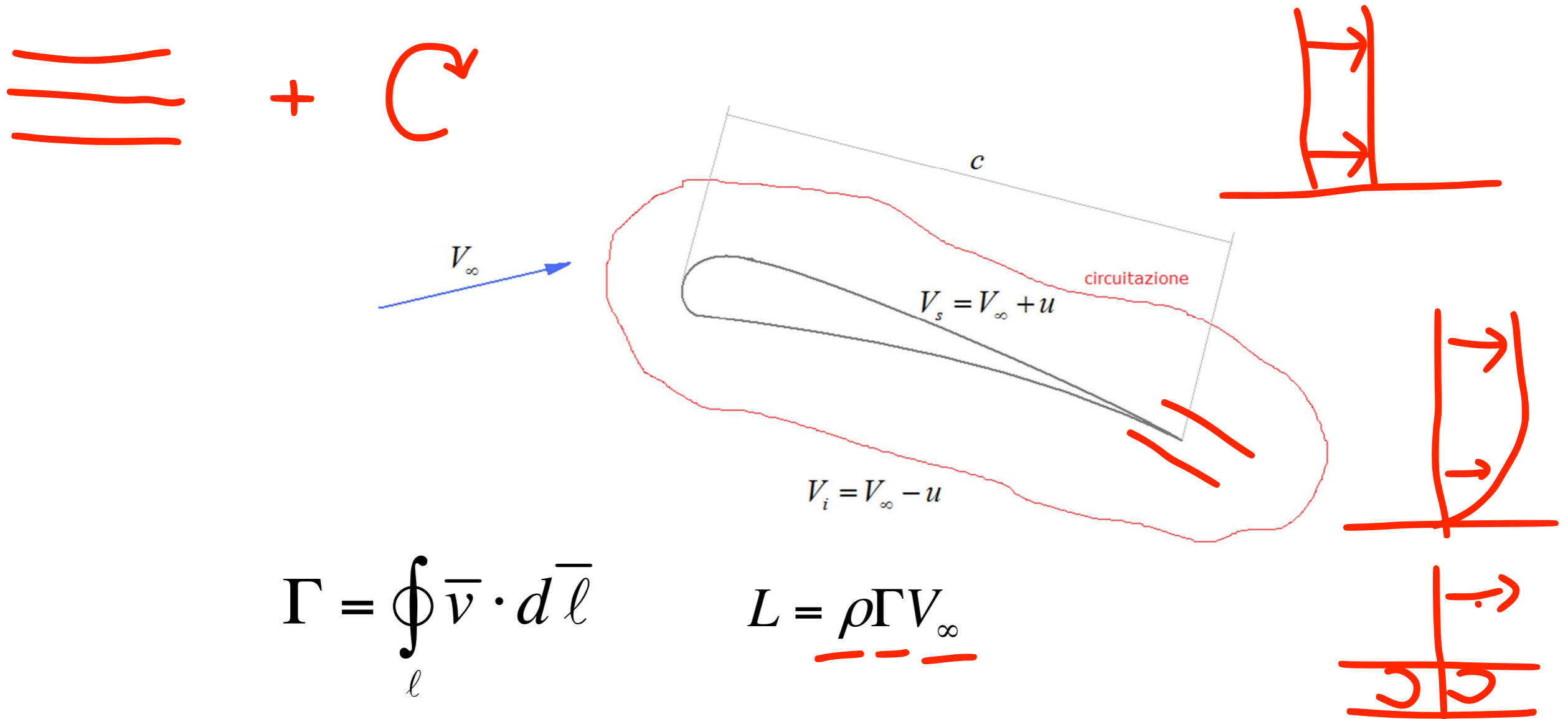
Sostituendo c_F e c_P si ottiene



$$c_L = 2 \left(\frac{s}{c} \right) (\tan \underline{\alpha_1} - \tan \underline{\alpha_2}) \cos \underline{\alpha_\infty} - c_D \tan \alpha_\infty$$

$$c_D = \left(\frac{s}{c} \right) y \frac{\cos^3 \alpha_\infty}{\cos \alpha_2}$$

teorema di Kutta-Jukowsky



$$\Gamma = \oint_{\ell} \bar{v} \cdot d\bar{\ell}$$

$$L = \rho \Gamma V_\infty$$

$$\Delta p = p_i - p_s = \frac{1}{2} \rho (V_s^2 - V_i^2) = 2\rho u V_\infty$$

$$\Gamma = 2cu$$

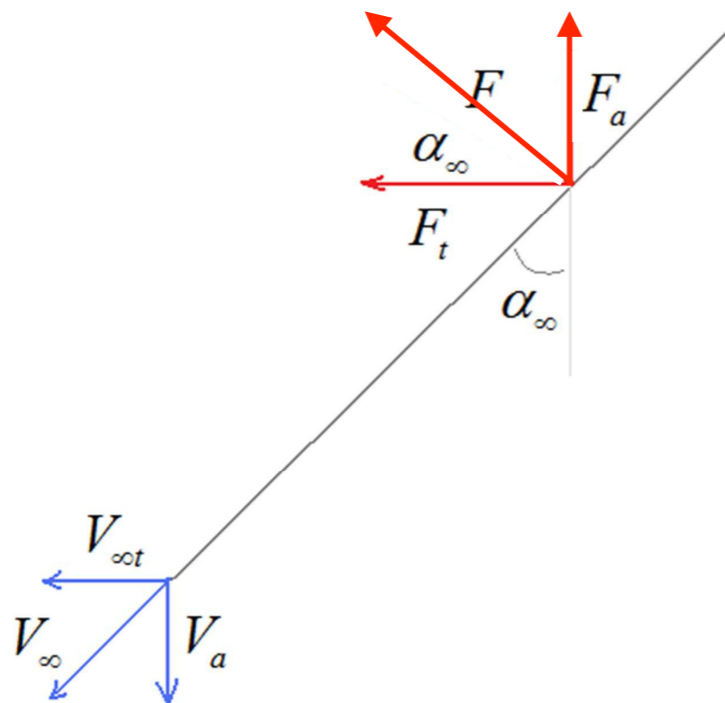
Schiere di pale

$\Delta p_0 = 0$ ipotesi perdite nulle

$$F_a = s\rho V_{\infty t} (V_{2t} - V_{1t})$$

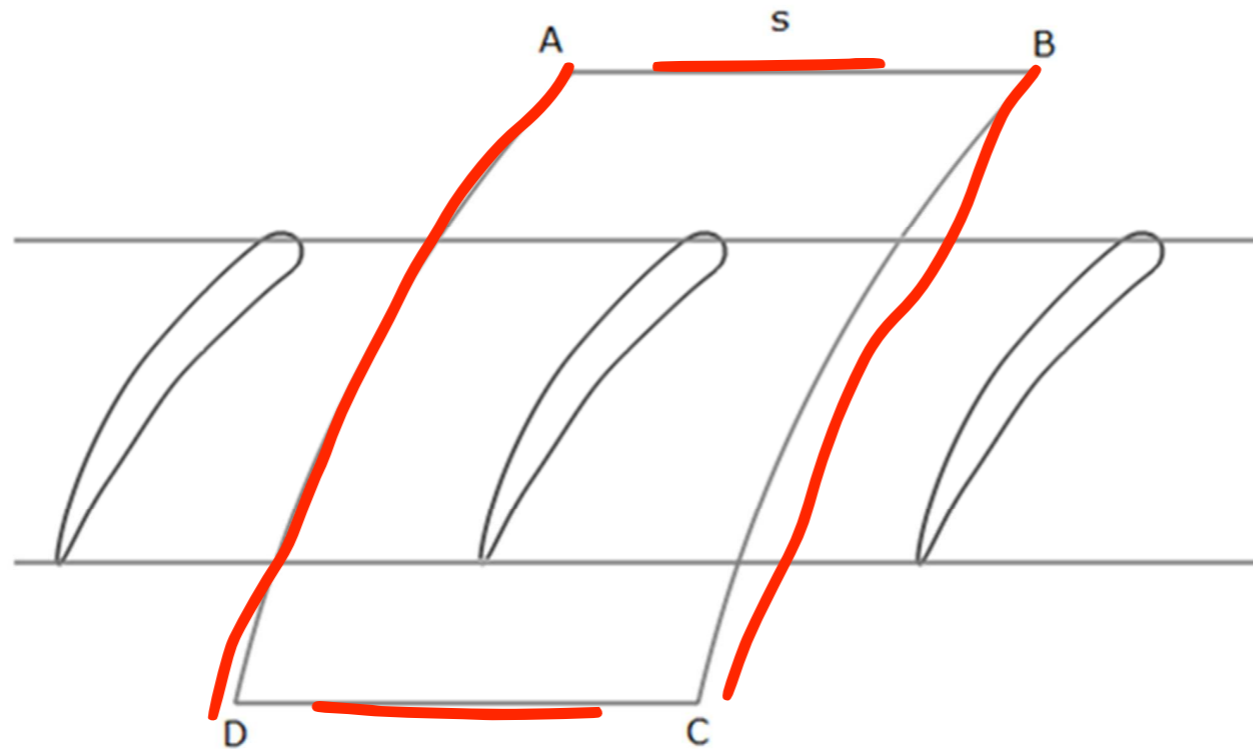
$$F_t = s\rho V_a (V_{1t} - V_{2t})$$

$$\frac{V_{\infty t}}{V_a} = -\frac{F_a}{F_t} = \tan \alpha_{\infty}$$



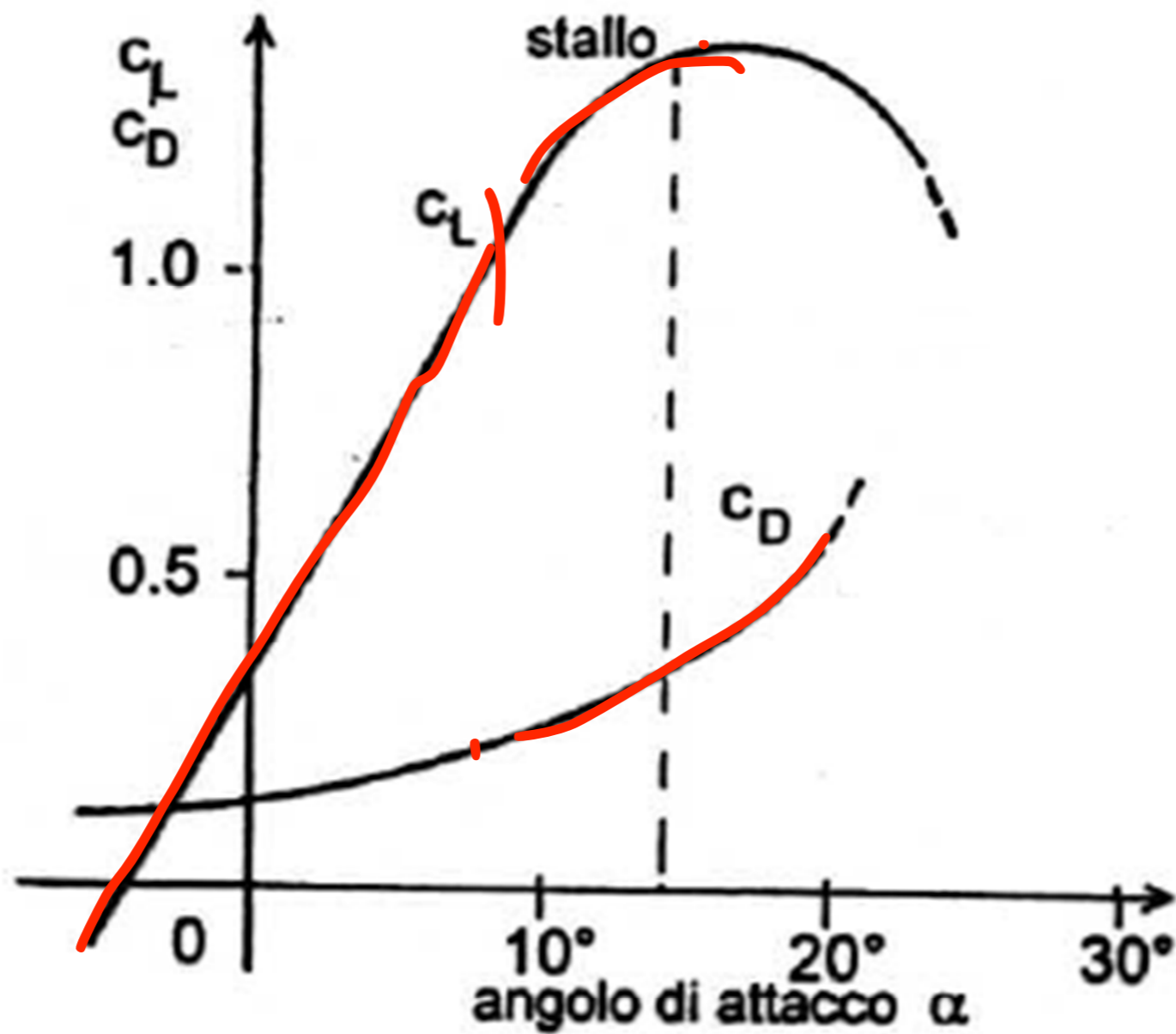
$$F = \frac{F_t}{\cos \alpha_{\infty}} = \rho \frac{V_a}{\cos \alpha_{\infty}} s (V_{1t} - V_{2t}) = \rho V_{\infty} s (V_{1t} - V_{2t}) = L$$

Schiere di pale

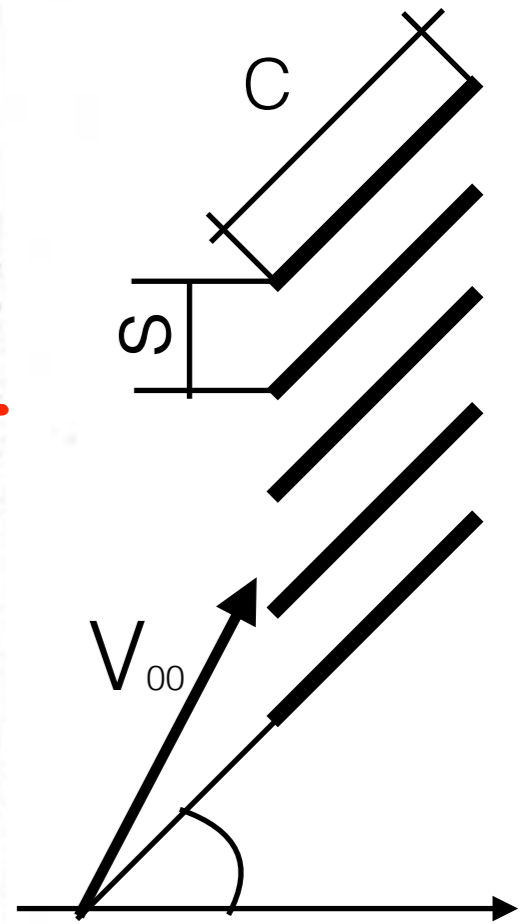
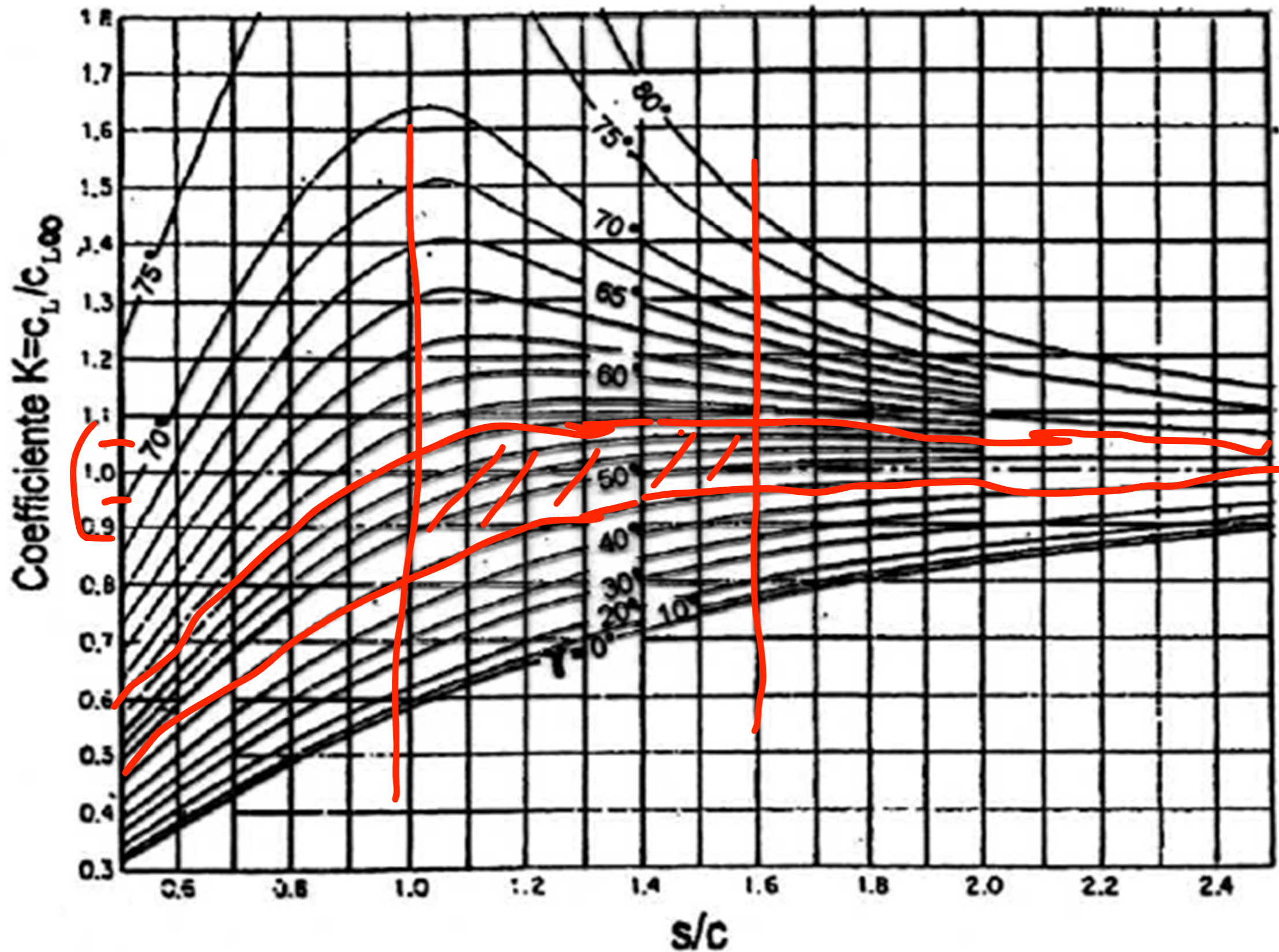


$$\Gamma = s(V_{1t} - V_{2t}) \quad \rightarrow \quad L = \rho V_{\infty} \Gamma$$

Effetto schiera sulle prestazioni del profilo



Effetto schiera sulle prestazioni del profilo



ugelli e diffusori

Distinguiamo due casi:

- 1) Nell'elemento abbiamo un incremento di velocità a spese di una riduzione di pressione. Questi saranno gli *ugelli*.
- 2) Nell'elemento l'energia cinetica diminuisce ed aumenta la pressione. Questi saranno i *diffusori*.

ugelli

(Ma < 0,3)

$$\underline{p_{01}} = \underline{p_1} + \frac{1}{2} \rho c_1^2 \quad \rightarrow \quad \underline{c_1^2} = \frac{2}{\rho} (p_{01} - p_1)$$

$$p_{01} = p_2 + \frac{1}{2} \rho c_{2s}^2 \quad \rightarrow \quad c_{2s}^2 = \frac{2}{\rho} (p_{01} - p_2)$$

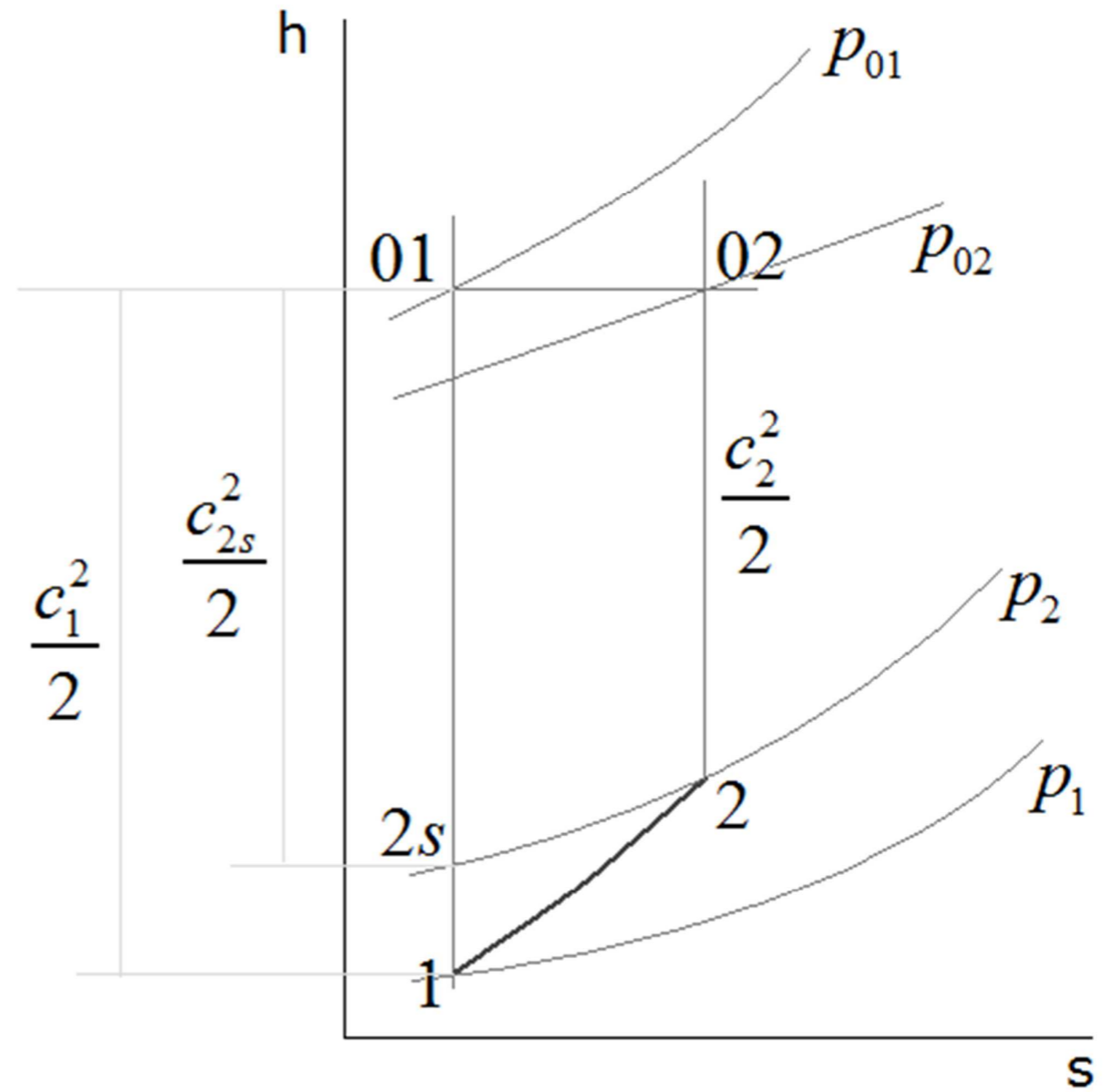
$$\underline{p_{02}} = p_2 + \frac{1}{2} \rho c_2^2 \quad \rightarrow \quad c_2^2 = \frac{2}{\rho} (p_{02} - p_2)$$

$k_1 - k_2 - (k_2 - 1) \cdot 1$

$$\eta_{is} = \frac{p_{02} - p_2 - (p_{01} - p_1)}{\cancel{p_{01}} - p_2 - (\cancel{p_{01}} - p_1)} = \frac{p_{02} - p_2 - (p_{01} - p_1)}{p_1 - p_2} = 1 \cdot \frac{\Delta p_0}{p_1 - p_2}$$

Diffusori

$$\eta_{is} = \frac{h_{2s} - h_1}{h_2 - h_1} = \frac{c_1^2 - c_{2s}^2}{c_1^2 - c_2^2}$$



Diffusori

(Ma < 0,3)

$$\eta_{is} = \frac{p_{01} - p_1 - (p_{01} - p_2)}{p_{01} - p_1 - (p_{02} - p_2)} = \frac{p_2 - p_1}{p_2 - p_1 + (p_{01} - p_{02})} = \frac{1}{1 - \frac{\Delta p_0}{p_2 - p_1}}$$

coeff. recupero di pressione:

$$c_p = \frac{p_2 - p_1}{p_{01} - p_1}$$

Diffusori

(Ma < 0,3)

Legame tra c_p e η_{is}

$$\eta_{is} = \frac{p_2 - p_1}{\underline{p_2} - \underline{p_1} + (\underline{p_{01}} - \underline{p_{02}})}$$

$$\frac{1}{\eta_{is}} = \frac{\underline{p_2} - \underline{p_1} + (p_{01} - p_{02})}{\underline{p_2} - \underline{p_1}} = \frac{p_{01} - p_1 - (p_{02} - p_2)}{\underline{p_2} - \underline{p_1}} = \frac{1}{c_p} - \frac{p_{02} - p_2}{p_2 - p_1}$$

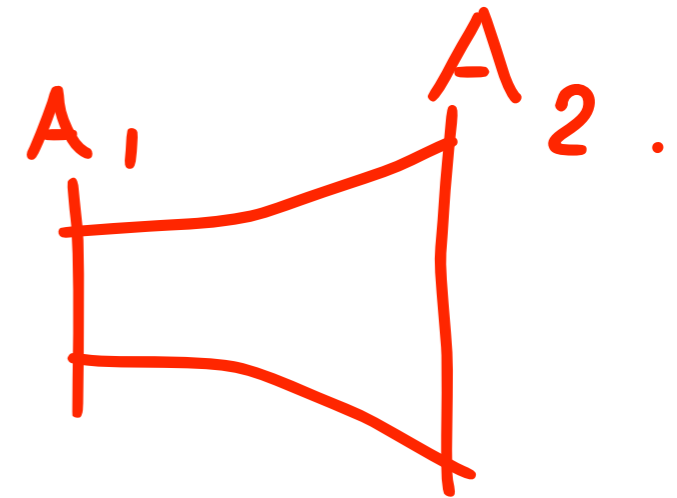
$$c_{pi} = \frac{p_2 - p_1 + (p_{01} - p_{02})}{p_{01} - p_1}$$

Diffusori

(Ma < 0,3)

$$p_2 = p_{02} - \frac{1}{2} \rho c_2^2$$

$$p_1 = p_{01} - \frac{1}{2} \rho c_1^2$$



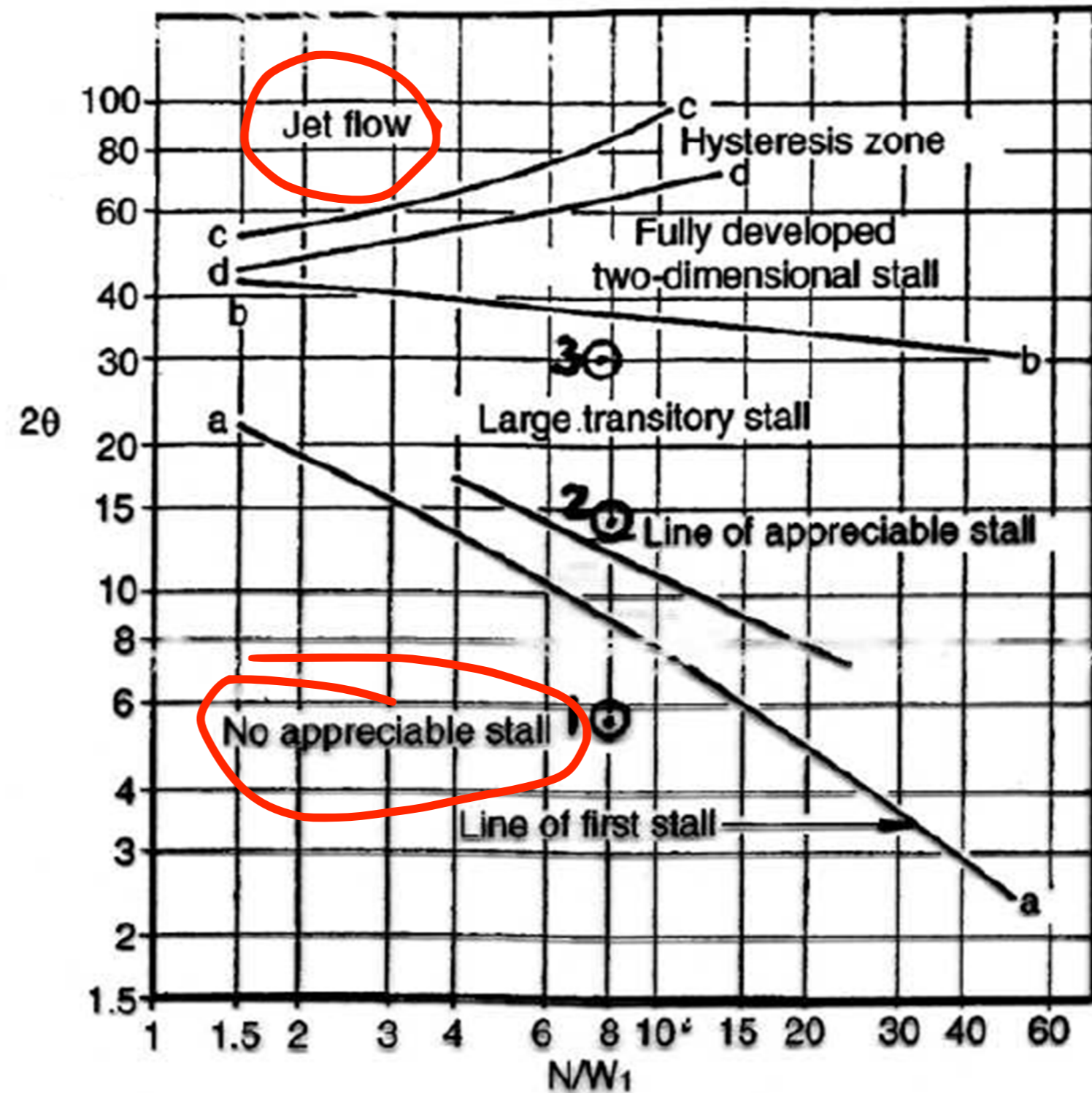
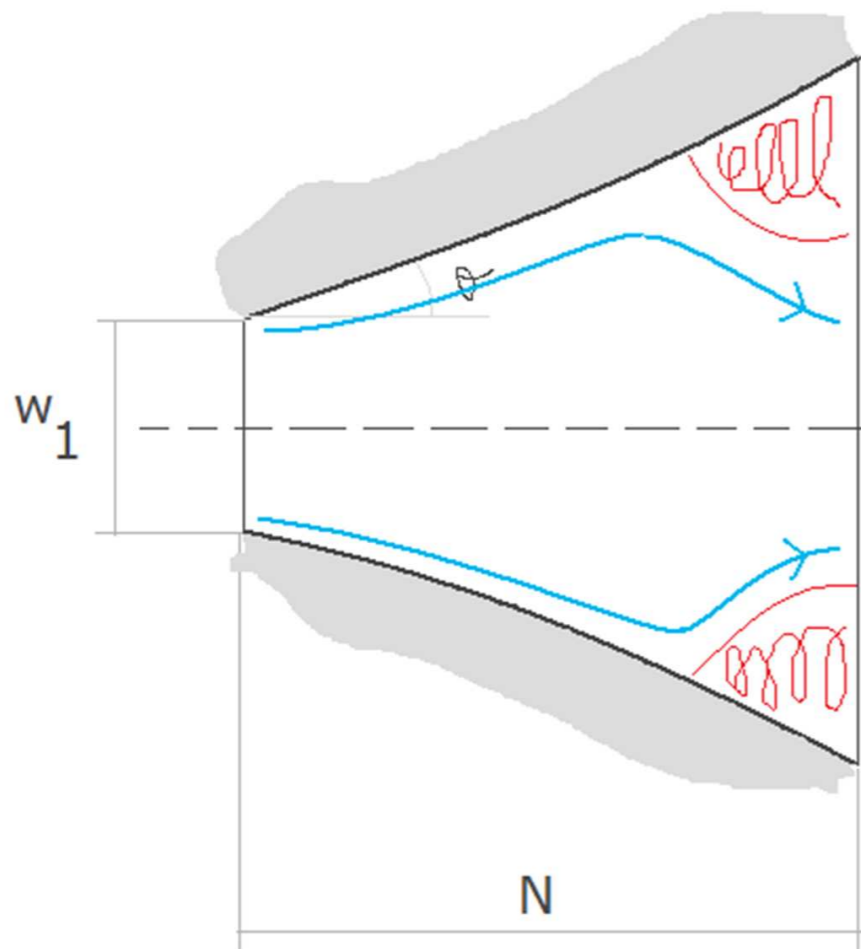
$$c_{pi} = \frac{c_1^2 - c_2^2}{c_1^2} = 1 - \left(\frac{c_2}{c_1} \right)^2 = 1 - \left(\frac{A_1}{A_2} \right)^2 = 1 - \frac{1}{A_R^2}$$

Diffusori

Legame tra c_p , η_{is} e c_{pi}

$$\frac{c_p}{c_{pi}} = \frac{p_2 - p_1}{p_{01} - p_1} \cdot \frac{p_{01} - p_1}{(p_2 - p_1) + (p_{01} - p_{02})} = \eta_{is}$$

Diffusori



Diffusori

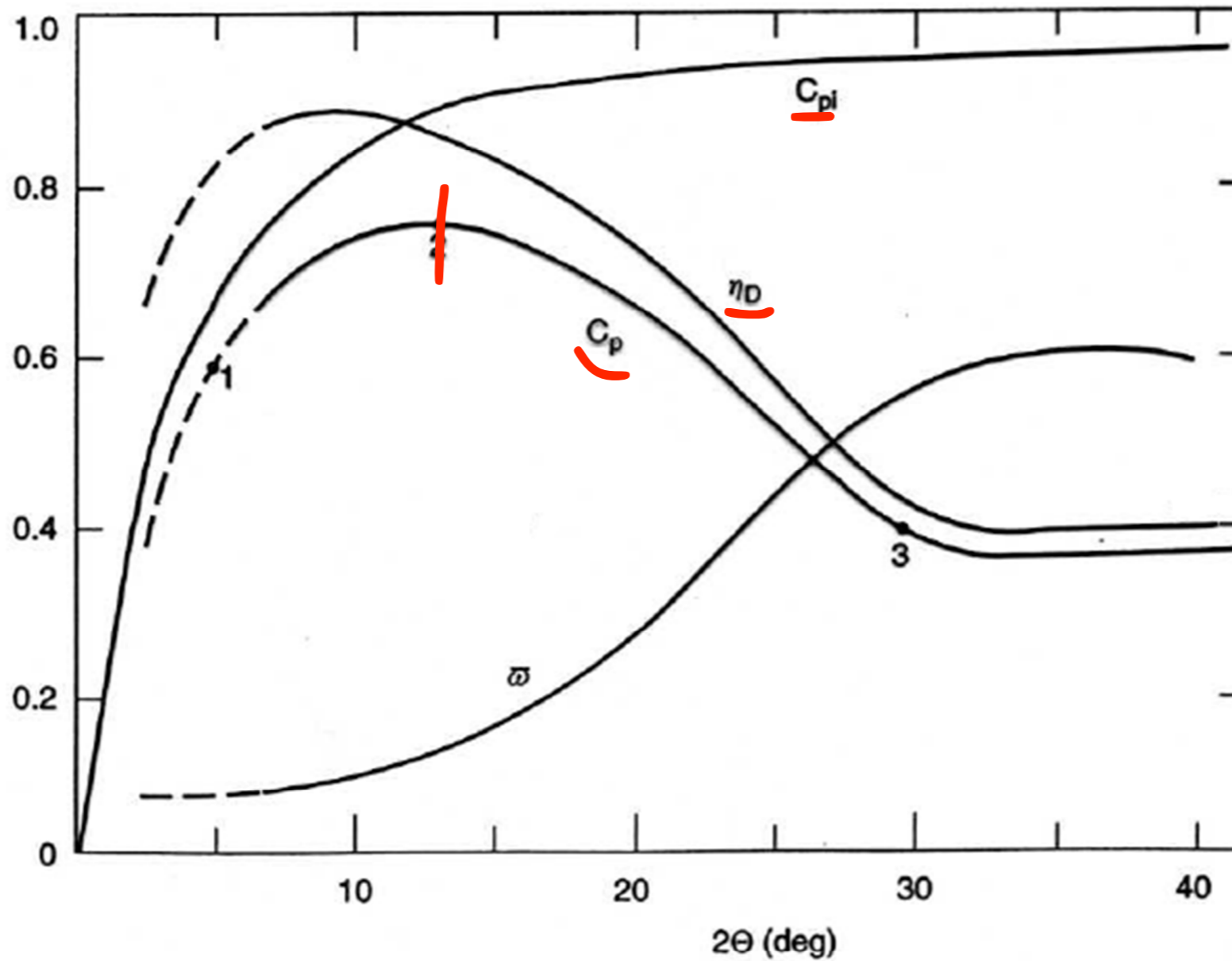


FIG. 2.16. Typical diffuser performance curves for a two-dimensional diffuser, with $L/W_1 = 8.0$ (adapted from Kline *et al.* 1959).

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[https://www.youtube.com/watch?
v=JhIEkEk7igs&list=PL0EC6527BE871ABA3&index=8](https://www.youtube.com/watch?v=JhIEkEk7igs&list=PL0EC6527BE871ABA3&index=8)