

Università degli Studi di Padova – Dipartimento di Ingegneria Industriale
Corso di Laurea in Ingegneria Meccanica

Relazione per la prova finale
***VERIFICA STRUTTURALE DI UN SERBATOIO IN PARETE SOTTILE PER
LA COMPETIZIONE MOTOSTUDENT***

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Laureando: *Verlato Filippo*

Padova, 23/06/2026



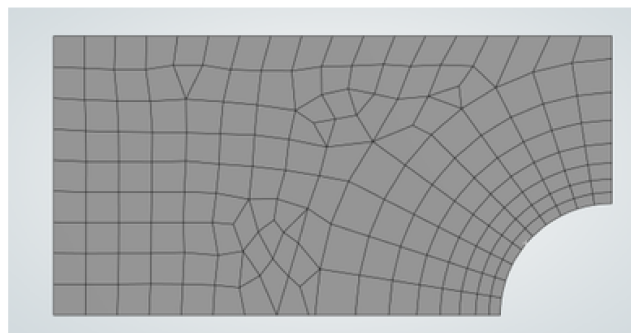
Progettazione della linea benzina e in particolare del serbatoio $\sigma_s = 200$  Lega di alluminio
serie 5000/6000
con trattamento
termico T6 o T9

Spessore minimo

Attacchi a telaio

obiettivo: ricavare il K_t da un'analisi fem $\longrightarrow$ Confronto tra **modello teorico** e **dato ricavato**

1



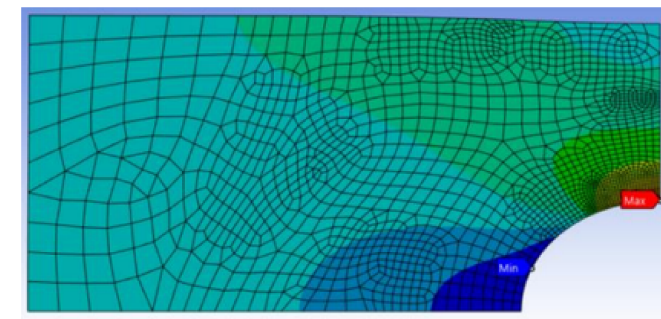
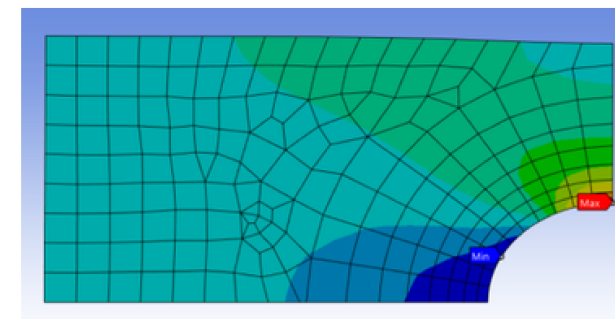
Geometria e meshing

2



Carichi e vincoli

3



Analisi FEM

4

$$\sigma_n = \frac{F}{A} = \frac{P}{bh} = \frac{50000}{50 \cdot 10} = 100 \text{ [MPa]}$$

$$K_{tg,fem} = \frac{\sigma_{pel}}{\sigma_n} = \frac{376}{100} = 3,76$$

$$K_{tg,Peterson} = 3,74 \pm 0,05$$

Calcolo del K_{tg}

5

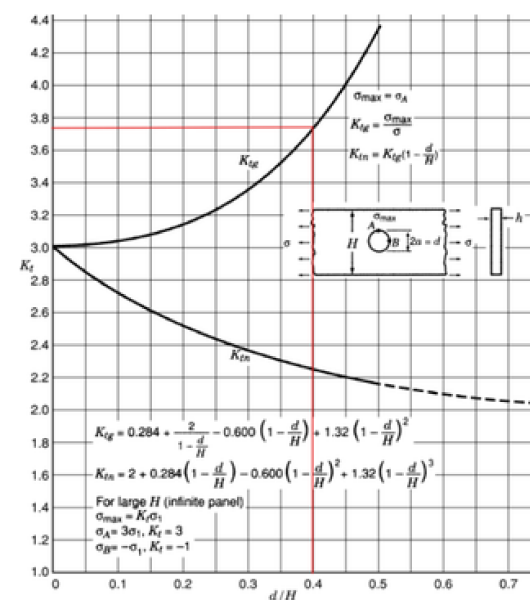


Tabella Peterson

6

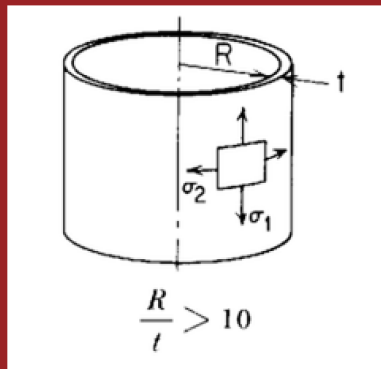
$$K_{tg,fem} = \frac{\sigma_{pel}}{\sigma_n} = K_{tg,Peterson}$$

Confronto con il valore teorico

VENGONO APPLICATI DIVERSI METODI

Condizione di carico: pressione interna p dovuta al riscaldamento del fluido combustibile

CILINDRICO CON FONDI EMISFERICI



$$\frac{R}{t} > 10$$

$$\sigma_{VM} = \sqrt{\left(\frac{pR}{2t}\right)^2 + \left(\frac{pR}{t}\right)^2 - \left(\frac{pR}{2t}\right)\left(\frac{pR}{t}\right)}$$

$$t = 0,08 - 0,16 \text{ mm}$$

EN 13445

$$\sigma_{id} = \sigma_m + \sigma_b, \sigma_{id} < \sigma_{amm}$$

somma della
tensione flessionale
e di membrana

$$t = 2,30 \text{ o } 5,25 \text{ mm}$$

ISO 21029

$$t \leq CC_e f \sqrt{\frac{0,1pS}{K}}$$

S = coeff. saldature
 f = lato corto
 C = metodo di
saldatura
 C_e = rapporto lati
 K = tens. snervamento
 p = pressione

$$t = 1,10 - 1,24 \text{ mm}$$

MANUALE DELL'INGEGNERE MECCANICO

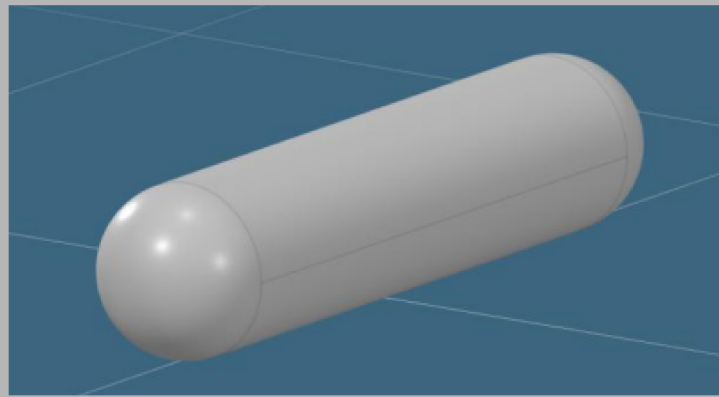
$$\sigma_{ta} = \sigma_{fa} + \left(p * \frac{b}{2s}\right) = \left(6 * \frac{M_A}{s^2}\right) + \left(p * \frac{b}{2s}\right)$$

$$\sigma_z = \frac{F}{A_{resistente}} = \frac{p(a+b)}{2s(a+b)}$$

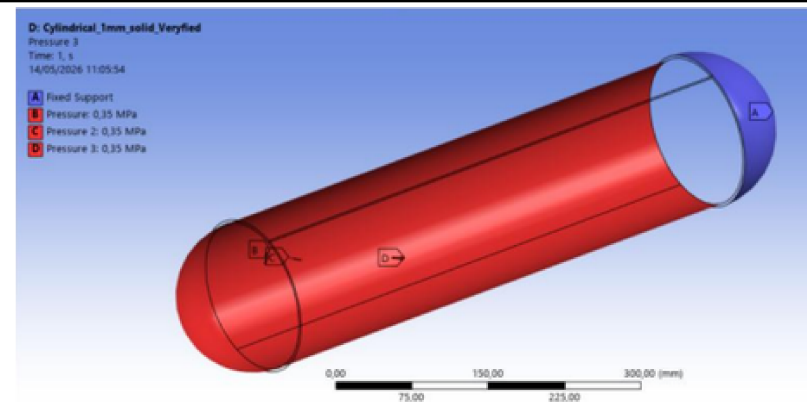
$$\sigma_{VM} = \sqrt{\sigma_z^2 + \sigma_{ta}^2 - \sigma_z \sigma_{ta}} < \sigma_{AMM}$$

$$t = 3,91 \text{ mm}$$

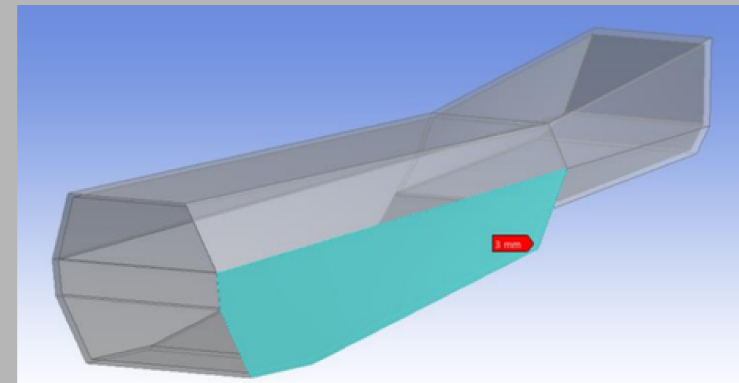
Guscio cilindrico



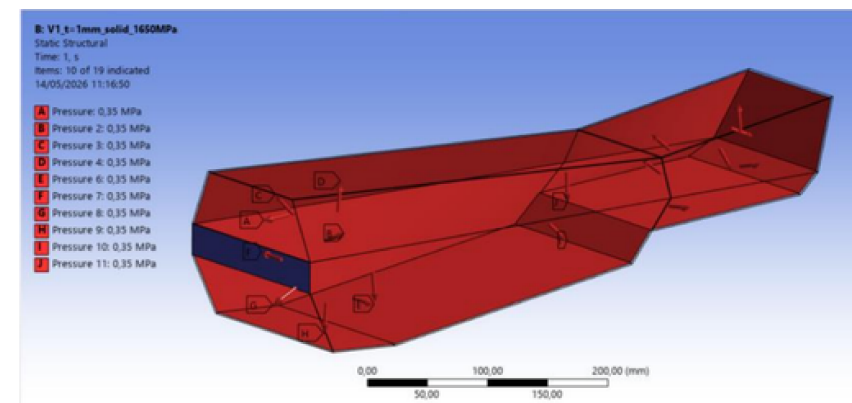
$L = 550 \text{ mm}$
 $R = 75,5 \text{ mm}$
 $t = 3 \text{ mm}$



Lamiere poligonali



$L = 550 \text{ mm}$
 $R_{\text{insc}} = 75,5 \text{ mm}$



raggio valutato
nella sezione
maggiore

$t = 1 \text{ mm}$

$\sigma_{\text{max}} = 2500 \text{ MPa}$

$t = 2 \text{ mm}$

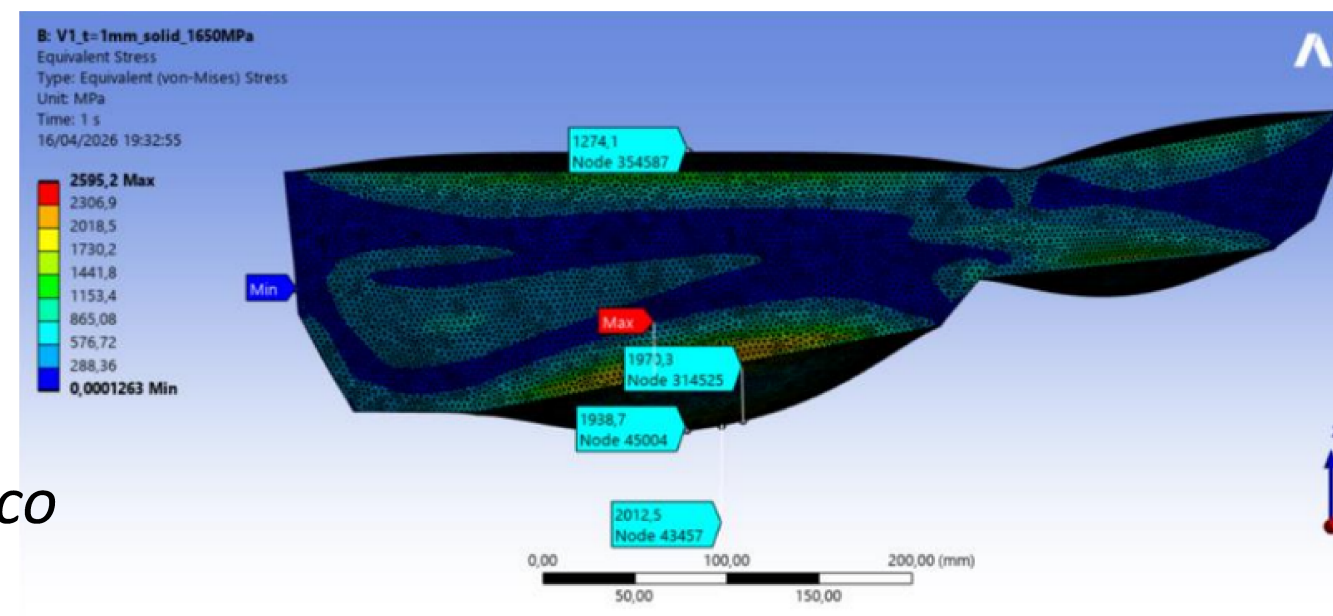
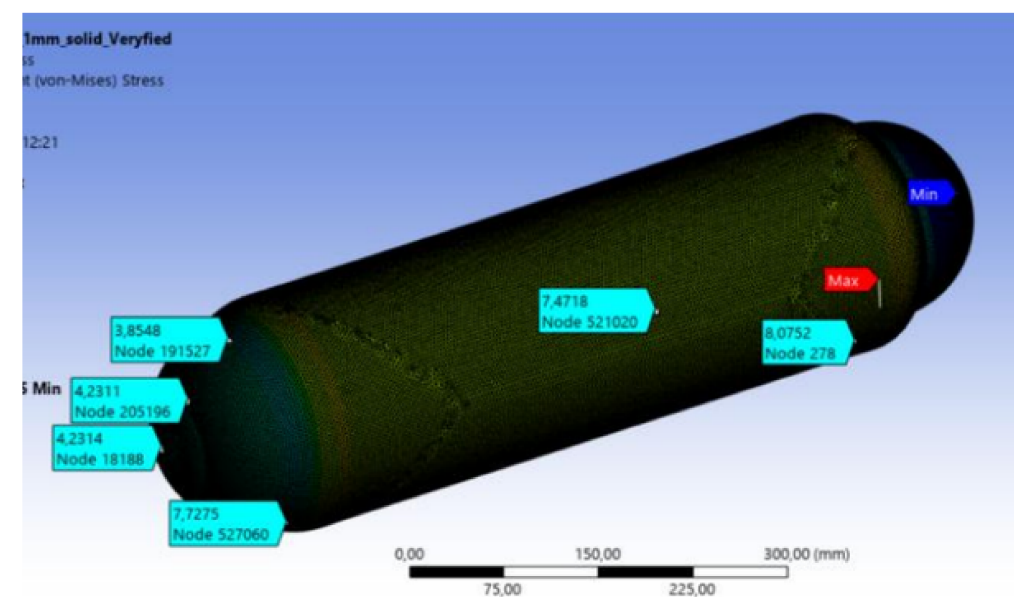
$\sigma_{\text{max}} = 670 \text{ MPa}$

$t = 3 \text{ mm}$

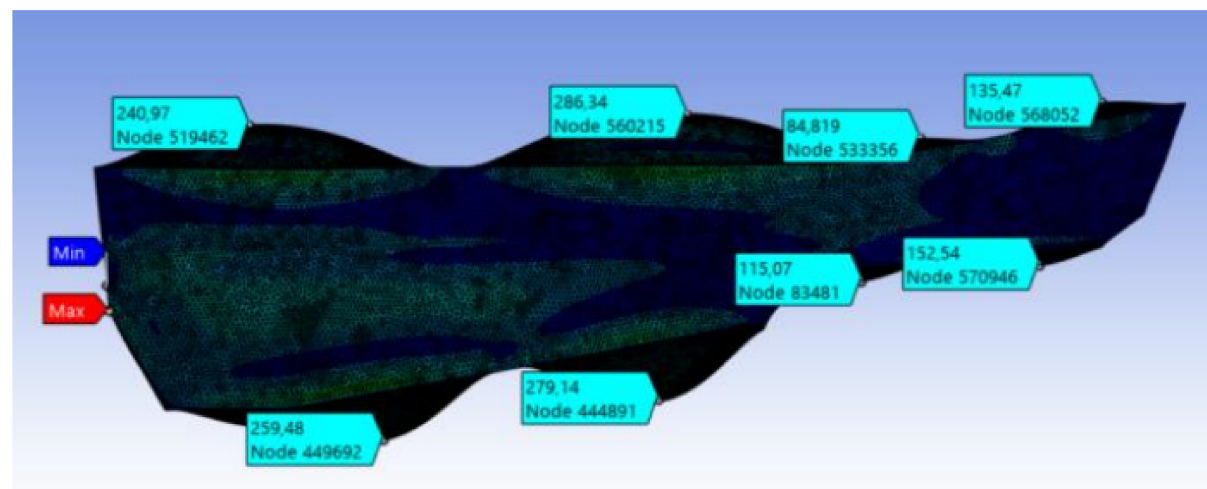
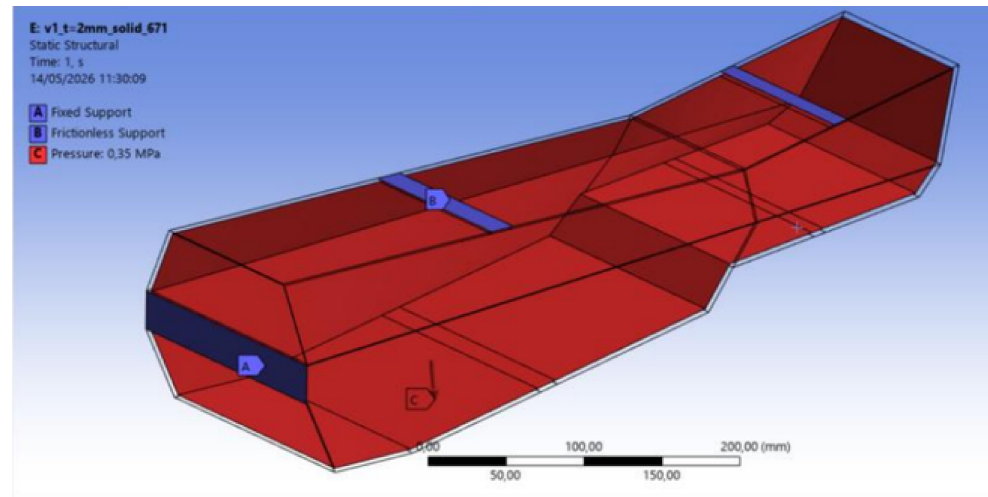
$\sigma_{\text{max}} = 80 \text{ MPa}$

Dettagli mesh:
sizing 2,5 mm
tetraedri

patch conforming quadratico



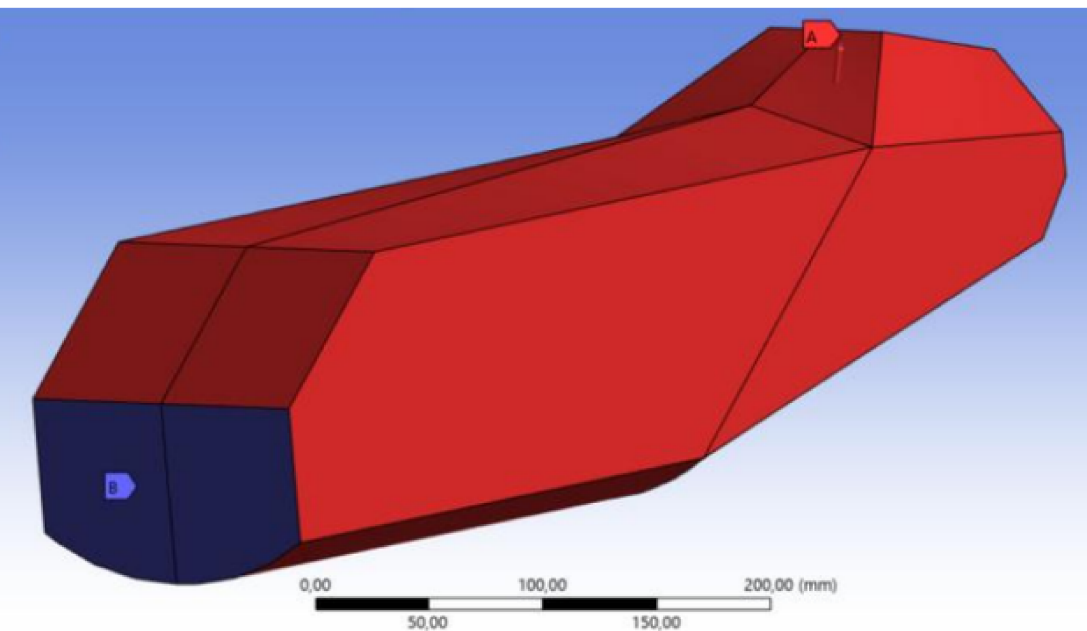
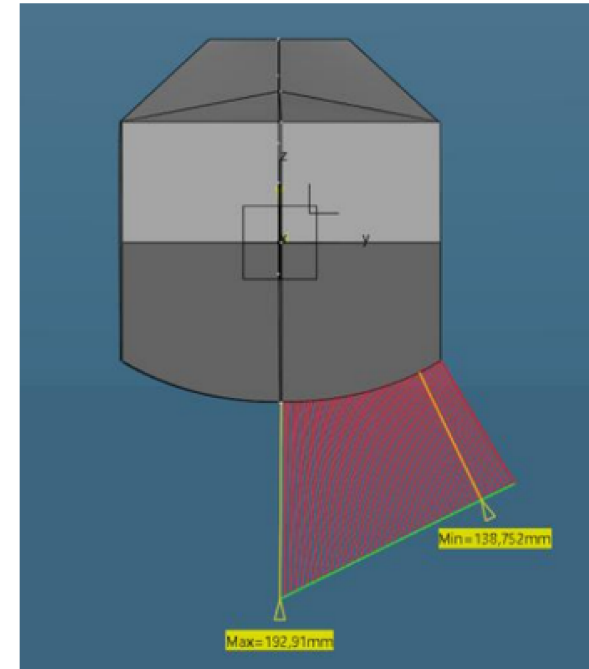
Poligonale con irrigiditori



$$t = 2 \text{ mm}$$

$$\sigma_{max} = 280 \text{ MPa}$$

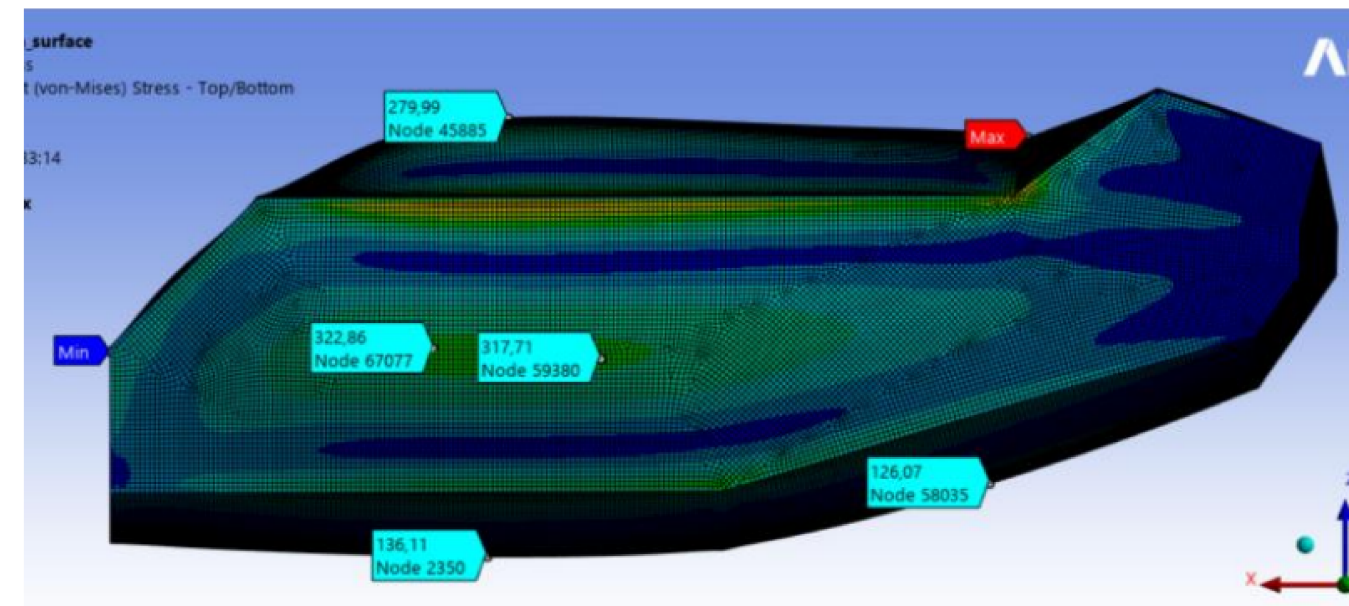
Lamiere curve



Mesh di tipo shell

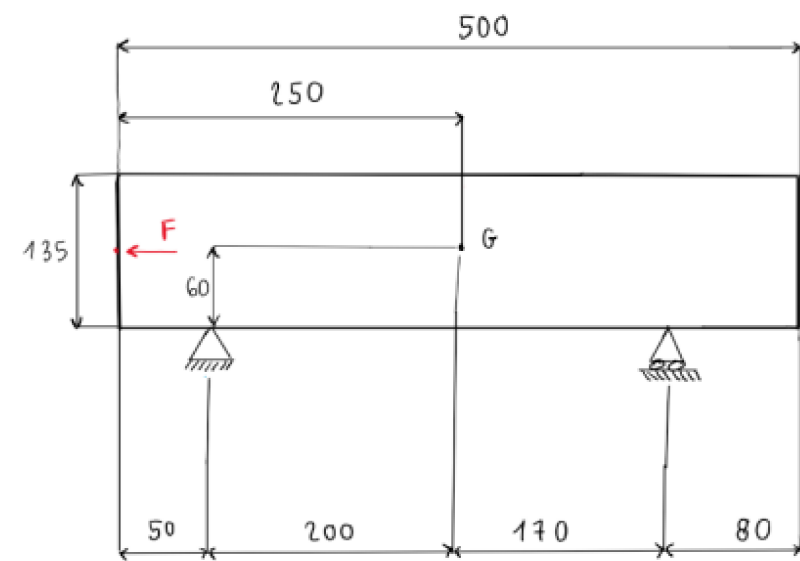
$$L = 550 \text{ mm}$$

$$R_{insec} = 75,5 \text{ mm}$$

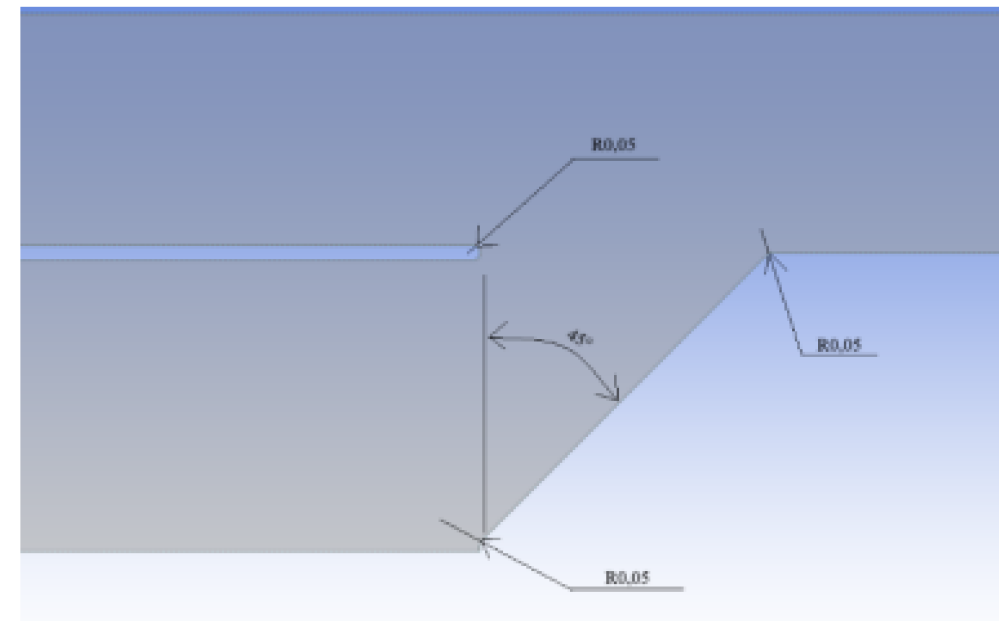


$$t = 2 \text{ mm}$$

$$\sigma_{max} = 140 \text{ MPa nella faccia curva}$$

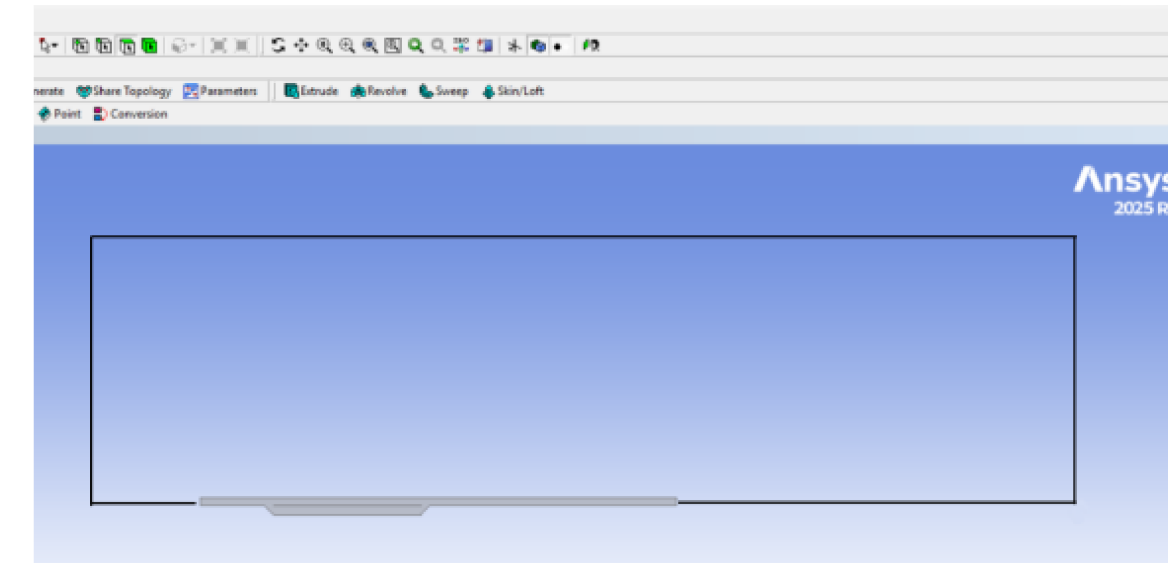


Geometria del
modello e quote

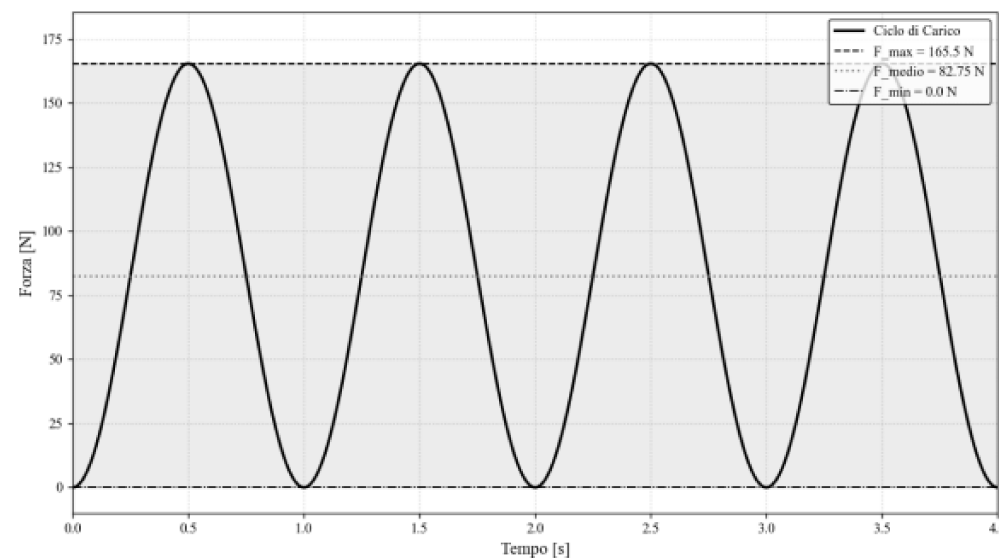


Raggi di raccordo

$R0,05$

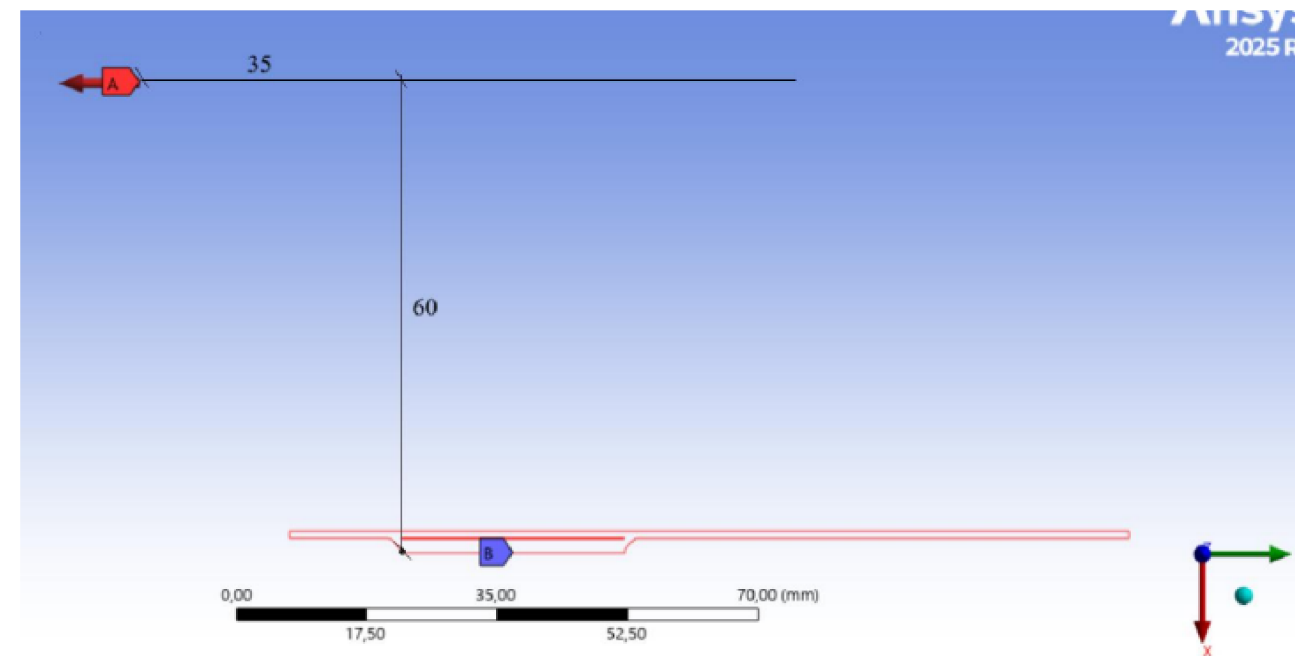


Modello 2d



Ricavo del carico

carico ricavato moltiplicando l'azione dinamica
del liquido in staccata per un coefficiente
arbitrario che rappresenta l'effetto di sloshing



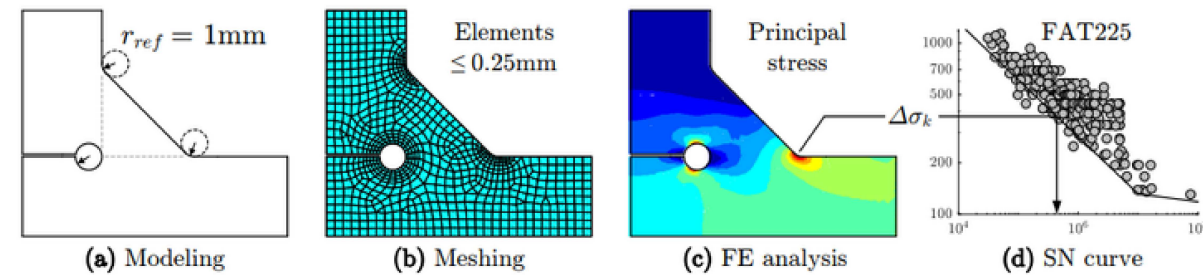
Carichi e vincoli

- Forza puntuale agente in direzione y
- Vincolo di tipo "fixed support" sul lato inferiore della piastra del supporto
- Intensità della forza rapportata alla larghezza totale del serbatoio e non alla larghezza del giunto

Ipotesi sul modello 2d

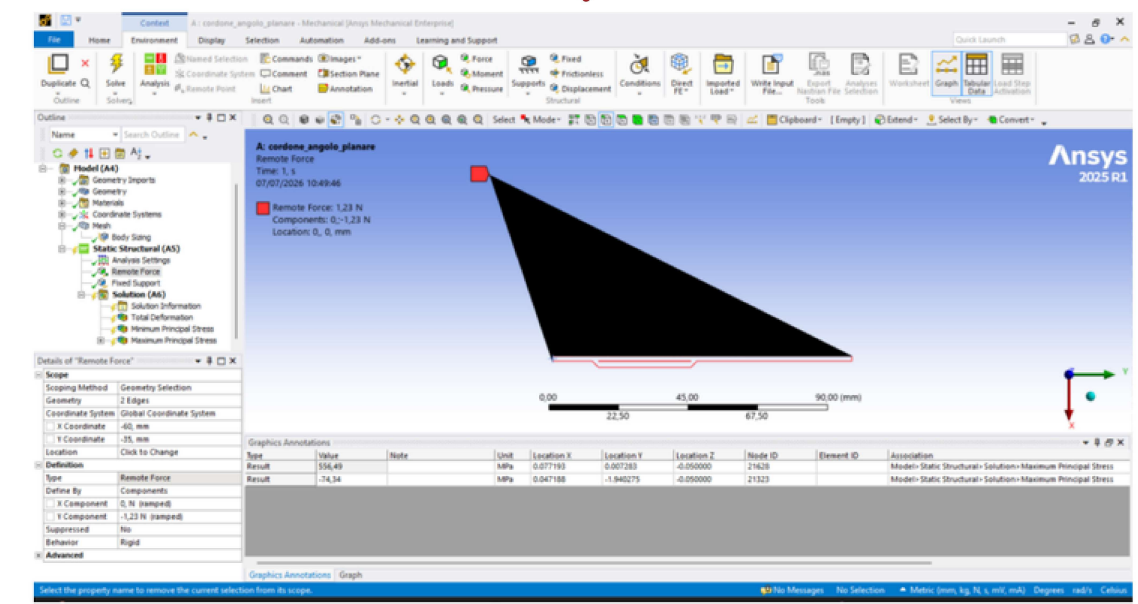
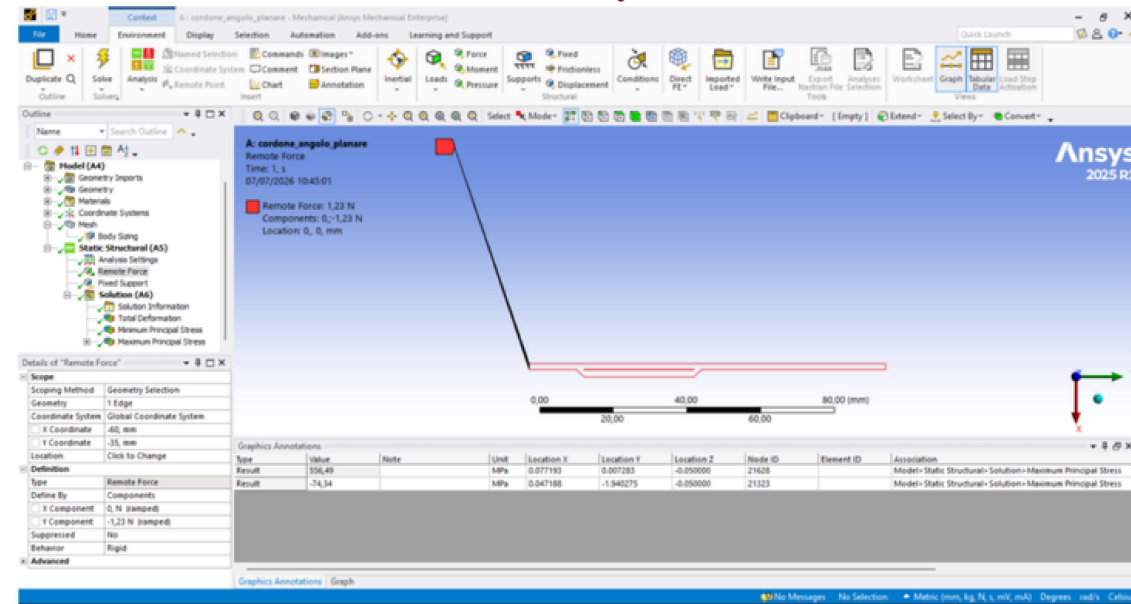
Un unico giunto rappresentato in sezione longitudinale
Spessore del serbatoio di 1,5 mm
Spessore della piastra del giunto di 2 mm
Serbatoio parallelepipedo a sezione quadrata
Saldatura a cordone d'angolo a penetrazione parziale
Raggi di raccordo del cordone e della radice di 0,05 mm

Ipotesi sulla disposizione dei carichi

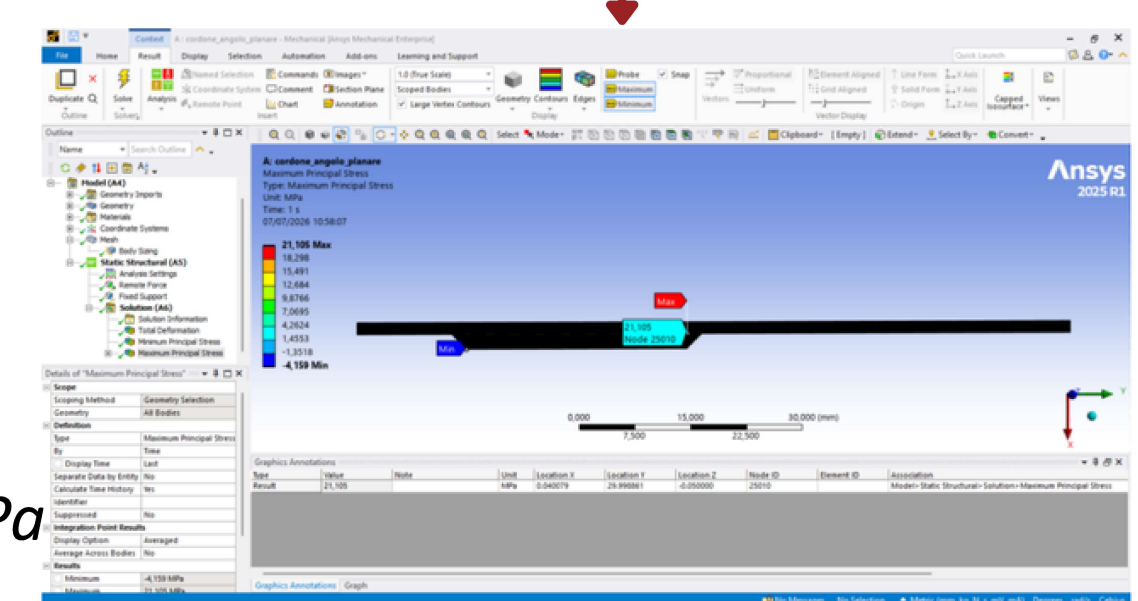
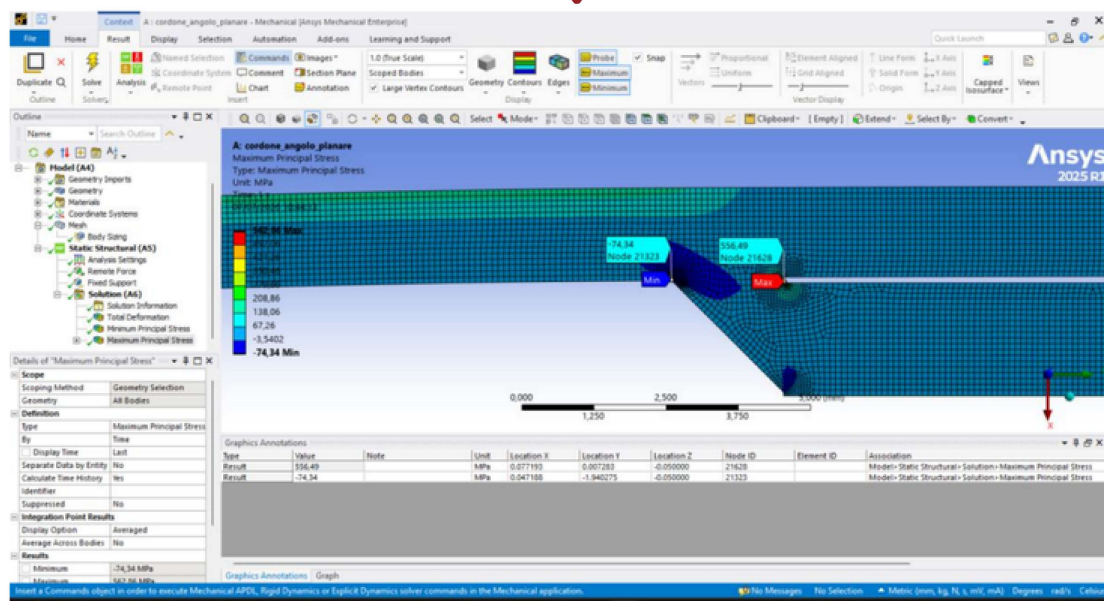


Notch stress approach

Differenza nell'impostazione
della remote force



Tensione principale
massima alla radice



$$\sigma_{max} = 560 \text{ MPa}$$

$$\sigma_{max} = 21,1 \text{ MPa}$$

Table 3.5 Notch stress fatigue resistance for aluminium as-welded

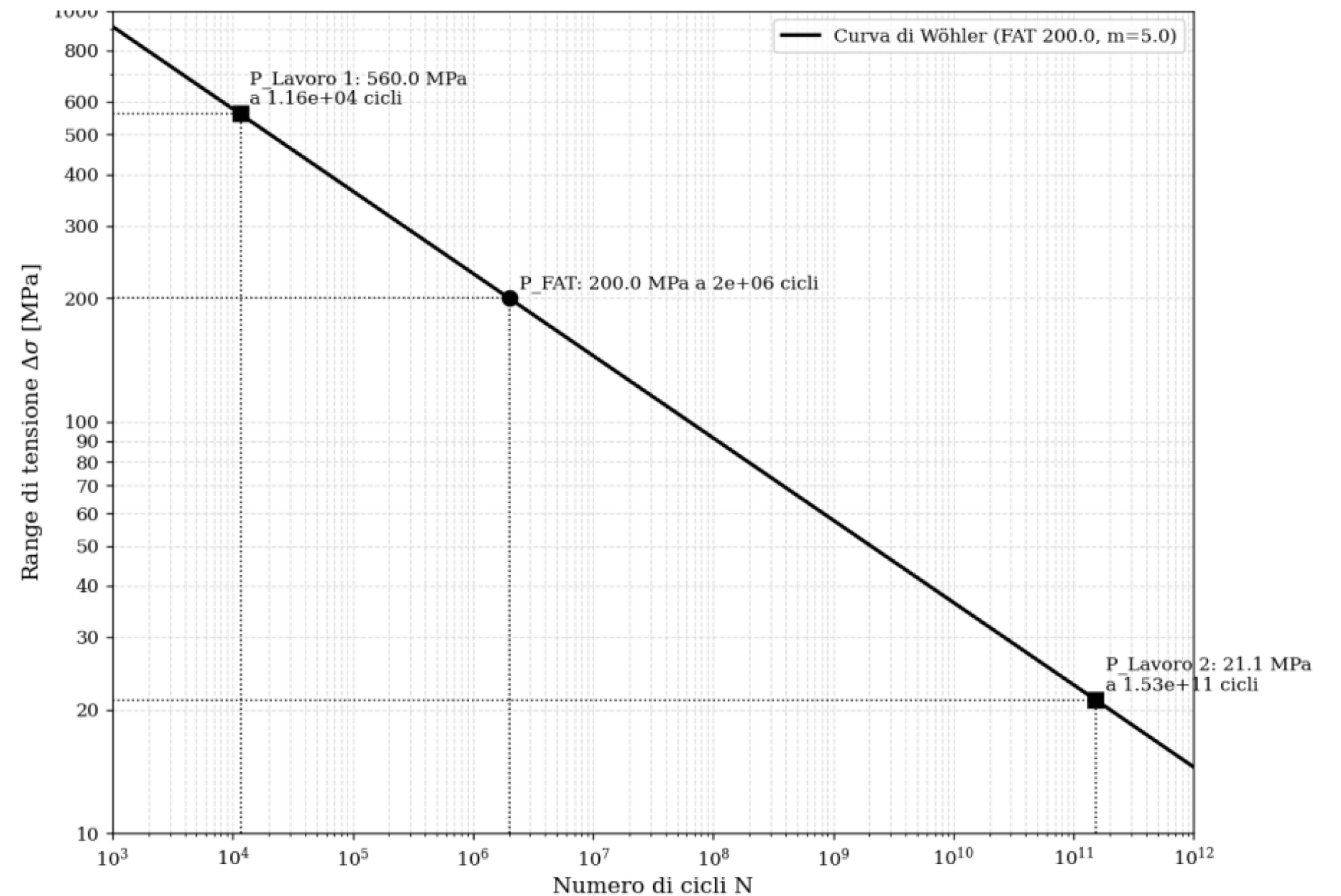
Reference radius (mm)	Spot of max stress	Normal stress	Shear stress
		FAT	FAT
1.00	Weld toe	71	63
1.00	Weld root	71	63
0.30	Weld toe	95	70
0.30	Weld root	110	80
0.05	Weld toe	160	90
0.05	Weld root	200	120

Slope exponent of S-N curve

Normal stress: $m = 3.0$ at wall thicknesses $t \geq 7$ mm and $m = 5.0$ at $t < 7$ mm

Shear stress: $m = 5.0$ at wall thicknesses $t \geq 7$ mm and $m = 7.0$ at $t < 7$ mm

Scelta della classe FAT



Curva di Wohler

$$\Delta\sigma^k * N = \text{costante}$$

Si assume assenza del
limite a fatica

$$N_1 = 1,16 * 10^4 \text{ cicli}$$

$$N_2 = 1,53 * 10^{11} \text{ cicli}$$

Spessore minimo per $p = 3,5$ bar

Alluminio

Lamiera Poligonale

Lamiera Curva

Irrigidita

Estesa

$$1,5 < t < 3 \text{ mm}$$

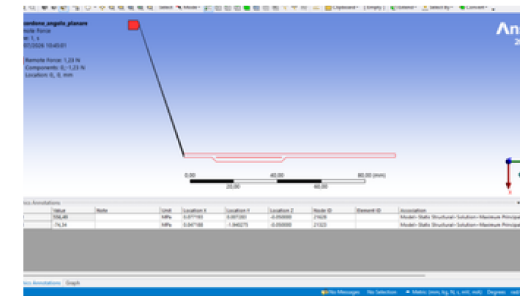
$$t > 3 \text{ mm}$$

$$t < 1,5 \text{ mm}$$

Durata in vita per saldature sottoposte al carico dinamico

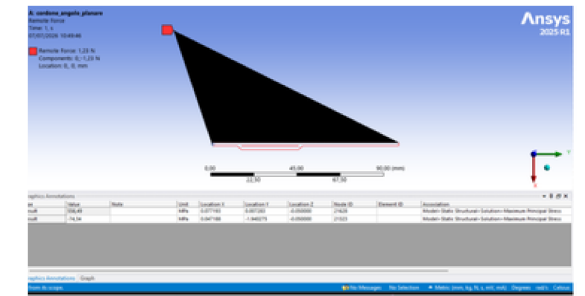
Penetrazione parziale, saldatura ad angolo

Configurazione 1



$$N = 1,16 * 10^4$$

Configurazione 2



$$N = 1,53 * 10^{11}$$

Valori diversi e discostati tra loro

Modello troppo semplificato, necessità di una geometria 3d