Tall Vessel

Vessel Height = 25 m
Vessel ID = 2 m
Max. operating Pressure = 2 MPa
Design Pressure = 1.05 × Max. operating Pressure
= 1.05 × 2
= 2.1 MPa

Skirt Height = 5 m
$f = 100\ MPa$ $J = 0.85$
Wind Velocity = 150 km/hr
$C_s = \frac{0.04}{T}$

$$t = \frac{pD_i}{2fJ - P} = \frac{2.1 \times 10^6 \times 2}{2 \times 100 \times 10^6 \times 0.85 - 2.1 \times 10^6}$$

$= 25.015\ mm$

$t_r = t + t_c$ ← Corrosion Allowance
$= 25.015 + 2$
$= 27.015\ mm$

Standard available (near highest) thickness is 28 mm

Corroded shell Thickness $= t - c$

$= 28 - 2$

$= 26\,mm$

Axial stress due to pressure

$$\sigma_{zp} = \frac{p D_i^2}{4t(D_i + t)}$$

$$= \frac{2.1 \times 10^6 \times 2 \times 2}{4 \times 26 \times 10^{-3} \times (2 + 0.002)}$$

$$= 40.34\ MPa$$

Axial stress due to dead load:

Let W_s be the weight of shell for $x\,m$ length

$W_s = \pi D t \times \gamma_s$

$\gamma_s = 7.7 \times 10^{-4}$

$W_s = \pi \times 2 \times 26 \times 10^{-3} \times 7.7 \times 10^{-4} \times (x)$

$= 0.01257x\ MN$

$$\sigma_{zs} = \frac{W_s}{\pi t D} = \gamma_s x \ N/m^2$$

$$= 0.077 x \ MPa$$

Weight of liquid supported for distance x m from top := $\frac{\pi}{4} D^2 \rho g x$

$$= \frac{\pi}{4} \times 4 \times 1000 \times 9.81 \times 10^{-6} \ MN$$

$$= 0.03082 x \ MN$$

$$\sigma_{zL} = \frac{W_L}{\pi D t} = \frac{0.03082 x \ MN}{\pi \times 2 \times 26 \times 10^{-3}}$$

$$= 0.1887 x \ MPa$$

WKT, $\sigma_{zw} = \sigma_{zL} + \sigma_{zs}$

$$= (0.677 + 0.1887) x \ MPa$$

$$= 0.2657 x \ MPa$$

Time Period :

$$T = 6.35 \times 10^{-5} \left(\frac{H}{D}\right)^{3/2} \left(\frac{W}{t}\right)^{1/2}$$

Scanned with CamScanner

Here $w = w_s + w_l$ (in kN)

Replacing x with $H = 25\,m$

$$T = 6.35 \times 10^{-5} \left(\frac{25+5}{2}\right)^{3/2} \times \left(\frac{0.04238 \times 10^{3}}{26 \times 10^{-3}}\right)^{1/2} \alpha^{1/2}$$

$\therefore \quad T = 0.753\,s$

$P_w = 0.05\, V_w^2$ where V_w is wind velocity in km/hr

$\Rightarrow P_w = k_1 k_2 P_w \times D_o$

Total load due to wind

$k_1 = 0.7$ (for cylindrical surface)

$k_2 = 2$ ($\because T > 0.55$)

$D_o = D_i + 2t = 2.056\,m$

$P_w = 0.7 \times 2 \times 0.05 \times (x) \times (150)^2 \times 2.056$

$= 3238.2(x)\ N$

$M_w = \frac{P_w x}{2} = 1619.1\, x^2\ Nm$

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$$\sigma_{z,w,m} : \frac{4M_w}{\pi t(D_i+t)D_i} \approx \frac{4M_w}{\pi t D^2}$$

$$= \frac{4 \times 1619.1 x^2}{\pi \times 26 \times 10^{-3} \times 2^2}$$

$$= 0.0198 x^2 \ MPa$$

Calculating stress due to sesemic load

$$M_s = \frac{C_s W x^2 (3H - x)}{3H^2}$$

$$= \frac{0.04}{0.753} \times (0.04338 (x) \times 10^6) \times \frac{2H}{3} \quad \{x = H\}$$

$$\therefore \ M_s = 0.038 x \ MN$$

$$\sigma_{z,sm} = \frac{4M_s}{\pi t (D_i+t) D_i} \approx \frac{4M_s}{\pi t D^2}$$

$$= \frac{4 \times 0.038 (x) \times 10^6}{\pi \times 26 \times 10^{-3} \times 2^2}$$

$$= 0.465 x \ MPa$$

$$\sigma_z \text{(tensile)} = \sigma_{zp} - \sigma_{zw} + \sigma_{zwM} + \sigma_{zsM} = fJ$$

$$40.34 - 0.2657 x + 0.0198 x^2 + 0.465 x = 100 \times 85 \times 10^{-2}$$

$$= 85$$

$\therefore \; 0.0198x^2 + 0.1995x - 44.66 = 0$

$\therefore \; x_t = 42.72\,m \quad (\text{since } x > 0)$

We, see $x_t > H$

Now, $\sigma_z\,(\text{compression}) = \sigma_{zw} - \sigma_{zp} + \sigma_{zwm} + \sigma_{zsm}$

$= 0.125 \dfrac{Et}{D_o}$

$$0.125\,\frac{Et}{D_o} = \frac{0.125 \times 2\times10^5 \times 0.026}{2.056}$$

$= 316.15$ MPa

$0.2657x - 40.34 + 0.0198x^2 + 0.465x = 316.15$

$\therefore \; 0.0198x^2 + \overset{0.7307}{\cancel{0.1995}}x - 356.49 = 0$

$x_c = 117\,m \quad > H$

$x_c = 117\,m, \quad x_t = 42.72\,m$

Since, $x > H \Rightarrow$ The design is OK