Ans (1)

DEPARTMENT OF CHEMICAL ENGINEERING
MODEL ANSWER
PROCESS EQUIPMENT DESIGN-I
AS-4169

Answers of multiple choice questions

(i) (a)

(ii) (c)

(iii) (b)

(iv) (d)

(v) (a)

(vi) (c)

(vii) (b)

(viii) (a)

(ix) (d)

(x) (a)

Sol^n (2):— given that:- A vessel

outside diameter $(D_o) = 1.6\,m$
operating pressure $(P) = 5\,kg/cm^2$
permissible stress $(f) = 1020\,kg/cm^2$
welded joint efficiency $= 85\%$

(a) Calculation of required thickness of vessel:-

$$\boxed{t = \frac{P D_o}{2fJ + P}}$$

allowable pressure is taken 5% excess of operating pressure$(P) = 5 \times 1.05$

$$\boxed{P = 5.25\ kg/cm^2}$$

Now, Calculation of shell thickness(t):-

$$t = \frac{5.25 \times 1.6}{2 \times 1020 \times 0.85 + 5.25}$$

$$t = 4.83 \times 10^{-3}\ m$$

$$\boxed{t = 4.83\ mm}$$

2mm corrosion allowance is assumed:-

$$t = 4.83 + 2 = 6.83 \simeq 7\,mm$$

$\boxed{t = 7\,mm}$ with corrosion allowance.

For safe design, ~~Beshati~~ purpose, rechecking of answer will be based on ~~t/Di~~ (t/D_i) ratio & maximum stress (F_R) (Resultant stress):

(1) $$\frac{t}{D_i} = \frac{4.83}{1.6 \times 10^{3} - 2 \times 4.83} = 0.00303$$

(2) $t = 0.00303$ ... (I)

from eqn (I) it is cleared that the $\left(\frac{t}{D_i}\right)$ ratio is much less than 0.25 (standard condition). Hence the thickness calculated is correct.

(2) Recheking of answer based on stress:-

$$f_c = \frac{P(D_i+t)}{2t} = \frac{5.25\,(1590.34+4.83)}{2\times 4.83} = 866.94\ kg/cm^2$$

$$D_i = D_o - 2t = 1.6\times10^3 - 2\times4.83 = 1590.34\ mm$$

longitudinal stress:—

$$(f_l) = \frac{P D_i}{4t}$$

$$\Rightarrow f_l = \frac{5.25\times 1590.34}{4\times 4.83}$$

$$\Rightarrow f_l = 432.15\ kg/cm^2$$

stress due to wt. of shell

$$f_w = \frac{W}{\pi t(D_i+t)}$$

$$\Rightarrow f_w = \frac{2000\ \cancel{\times}1}{\pi\times4.83(4.83+1590.34)}$$

$$\Rightarrow f_w = 0.08\cancel{266}\ kg/mm^2$$

$$\Rightarrow f_w = \cancel{0.8109}\ 0.08266\ kg/mm^2$$

$$\Rightarrow f_w = 0.08266\times10^2\ kg/cm^2$$

$$\Rightarrow f_w = 8.266\ kg/cm^2$$

$$f_a = f_l + (f_w) \Rightarrow f_l - f_w = 432.15 - 8.266$$

$$\Rightarrow f_a = 423.884\ kg/cm^2$$

$$\Rightarrow \boxed{f_a = 423.884\ kg/cm^2}$$

Stress due to offset piping (torque is induced)

$$\boxed{f_s = \frac{2T}{\pi t D_i (D_i + t)}}$$

$$= \frac{2 \times 300 \times 10^3}{9.81 \times 3.14 \times 4.83 (1590.34 + 4.83) \times 1590.34}$$

$$= 1.58966 \times 10^{-3} \text{ kg/mm}^2$$

$$\boxed{f_s = 0.158 \text{ kg/cm}^2}$$

$$\boxed{f_R = \left[f_c^2 - f_a \times f_c + f_a^2 + 3 f_s^2 \right]^{1/2}}$$

$$f_R = \left[866.94^2 - 423.884 \times 866.94 + 423.884^2 + 3 \times 0.158^2 \right]^{1/2}$$

$$f_R = 750.85 \text{ kg/cm}^2$$

Permissible stress $> f_R$

$$\boxed{1020 \text{ kg/cm}^2 > 750.85 \text{ kg/cm}^2} \quad \text{— (II)}$$

hence, the eq^n (I) & (II) improved the design is safe.

(b) <u>Calculation of torispherical head.</u>

Given :- for first approximation

$R_i = D_o = R_o$, $r_i = r_o = 6\% D_o$

Outside diameter of shell $(D_o) = 1.6\,m$

$$\boxed{h_o = R_o - \left[\left(R_o - \frac{D_o}{2}\right) \times \left(R_o + \frac{D_o}{2} - 2r_o\right)\right]^{1/2}} \quad \text{— (1)}$$

$$h_o = 1.6 - \left[\left(1.6 - \frac{1.6}{2}\right) \times \left(1.6 + \frac{1.6}{2} - 2 \times 0.06 \times 1.6\right)\right]^{1/2}$$

$$h_o = 1.6 - 1.329$$

$$h_o = 0.271\,m$$

$$\boxed{\frac{D_o^2}{4R_o} = \frac{1.6^2}{4 \times 1.6}}$$

$$\boxed{\frac{D_o^2}{4R_o} = 0.4\,m} \quad \text{—— (2)}$$

$$\left(\frac{D_o r_o}{2}\right)^{1/2} = \left(\frac{1.6 \times 0.06 \times 1.6}{2}\right)^{1/2}$$

$$\boxed{\left(\frac{D_o r_o}{2}\right)^{1/2} = 0.277\,m} \quad \text{—— (3)}$$

Out of three quantities calculated from eqn (1), (2) & (3). The least value from these three eqn is $\boxed{h_o = 0.271\,m}$

Therefore,

Effective external height $h_E = h_o$

Now, $$\frac{h_E}{D_o} = \frac{0.271}{1.6} = 0.16$$

Thickness of the head is determined from eqn.

$$t = \frac{P D_o C}{2 f J}$$

$$t = \frac{5.25 \times D_o \times C}{2 \times 1020 \times 0.85}$$

$$\boxed{\frac{t}{D_o} \times \frac{1}{C} = 0.00302} \quad (4)$$

$$\boxed{\frac{h_E}{D_o} = 0.16}$$

h_E/D_o	$\frac{t}{D_o}$	C	$1/C$	$\frac{t}{D_o} \times \frac{1}{C}$	
0.16	0.002	3.8	0.263	0.002 × 0.263 = 0.00052	
0.16	0.005	2.45	0.408	= 0.00204	Nearest value of eqn (4)
0.16	0.01	1.95	0.512	= 0.00512	
0.16	0.02	1.85	0.541	= 0.0108	
.16	>>0.04	1.65	0.606	= 0.02424	

hence,

$$\frac{t}{D_o} = 0.005$$

$$t = 0.005 \times 1.6$$

$$\Rightarrow \quad t = 8 \times 10^{-3} \text{ m}$$

$$\Rightarrow \quad \boxed{t = 8 \text{mm}}$$

if 2mm corrosion allowance is consider

$$t = 8+2$$

$$\boxed{t = 10 \text{mm}}$$

Compare to outside diameter ($D_o = 1.6$), 10mm is very small. Hence the first approximation does not introduce any considerable error in the result.

For next approximation

$$R_o = R_i + t$$
$$= 1.6 + 0.01$$
$$= 1.61$$

Then,

$$h_o = 1.61 - \sqrt{\left(1.61 - \frac{1.6}{2}\right)\left(1.61 + \frac{1.6}{2} - 2 \times 0.06 \times 1.6\right)}$$
$$= 1.61 - 1.34$$

$$\boxed{h_o = 0.269\,m}$$

$$\boxed{\frac{D_o^2}{4R_o} = \frac{1.6^2}{4 \times 1.61} = 0.397\,m}$$

$$\left(\frac{D_o r_o}{2}\right)^{1/2} = \left(\frac{1.6 \times 0.06 \times 1.6}{2}\,m\right)^{1/2}$$

$$\boxed{\left(\frac{D_o r_o}{2}\right)^{1/2} = 0.277}$$

least value is $h_o = 0.269\,m \approx h_E$

$$\frac{h_E}{D_o} = \frac{0.269}{1.6}$$
$$= 0.168$$
$$\frac{h_E}{D_o} \approx \cancel{0.17}\ 0.16$$

hence the second approximation also give the same

$$\frac{t}{D_o} = 0.005$$

$$\boxed{t = 8\,mm}$$ → thickness for torispherical head.

Solⁿ. (3) :- given that,

Internal pressure (P_i) = 140 MN/m2

Internal diameter (D_i) = 250 mm

yeild point of steel (σ_y) = 430 MN/m2

factor of safety (fos) = 1.4

Wall thickness calculation by various failure theories.

(1) Maximum principal stress Theory :-

$$\frac{\sigma_y}{(fos)} = P_i\left(\frac{k^2+1}{k^2-1}\right)$$

∴ fos = factor of saftey

$$\frac{430}{1.4} = 140\left(\frac{k^2+1}{k^2-1}\right)$$

$$\left(\frac{k^2+1}{k^2-1}\right) = \frac{430}{140 \times 1.4}$$

$$\left(\frac{k^2+1}{k^2-1}\right) = 2.19$$

$$(k^2+1) = (k^2-1) \times 2.19$$

$$k^2+1 = 2.19k^2 - 2.19$$

$$2.19k^2 - k^2 - 2.19 - 1 = 0$$

$$1.19k^2 - 3.19 = 0$$

$$k^2 = \frac{3.19}{1.19}$$

$$k^2 = 2.68$$

$$\boxed{k = 1.637}$$

we know that,

$$K = \frac{D_o}{D_i}$$

$$D_o = KD_i$$
$$= 1.637 \times 250$$
$$D_o = 409.32 \text{ mm}$$

hence, wall thickness will be,

$$t = \frac{D_o - D_i}{2}$$

$$t = \frac{409.32 - 250}{2}$$

$$\boxed{t = 79.66 \text{ mm}} \quad \text{——— (1)}$$

(2) Maximum strain theory :-

$$\frac{\sigma_y}{(fos)} = P_i \left[\frac{(1-\mu) + (1+\mu)K^2}{(K^2-1)} \right]$$

Assume :- Poision ratio for steel material $(\mu) = 0.3$

$$\frac{430}{1.4} = 140 \left[\frac{(1-0.3) + (1+0.3)K^2}{(K^2-1)} \right]$$

$$\Rightarrow \frac{430}{1.4 \times 140} = \left[\frac{0.7 + 1.3K^2}{(K^2-1)} \right]$$

$$\Rightarrow 2.19 = \left[\frac{0.7 + 1.3K^2}{(K^2-1)} \right]$$

$\Rightarrow \quad 2.19(K^2-1) = 0.7 + 1.3K^2$

$\Rightarrow \quad 2.19K^2 - 2.19 = 0.7 + 1.3K^2$

$\Rightarrow \quad 2.19K^2 - 1.3K^2 - 2.19 - 0.7 = 0$

$\Rightarrow \quad 0.89K^2 - 2.89 = 0$

$\Rightarrow \quad K^2 = \frac{2.89}{0.89}$

$\Rightarrow \quad \boxed{K = 1.802}$

Now,

$K = \frac{D_o}{D_i} \Rightarrow KD_i = D_o$

$\Rightarrow 1.802 \times 250 = D_o$

$\Rightarrow 450.5 = D_o$

$\boxed{D_o = 450.5 \text{ mm}}$

wall thickness based on "Maximum strain theory"

$t = \frac{D_o - D_i}{2}$

$t = \frac{450.5 - 250}{2}$

$\boxed{t = 100.25 \text{ mm}}$ — (2)

(8) <u>Maximum strain energy theory:-</u>

$$\frac{\sigma_y}{(FOS)} = \frac{P_i\sqrt{6+10K^4}}{2(K^2-1)}$$

$$\frac{430}{1.4\times140} = \frac{\sqrt{6+10K^4}}{2(K^2-1)}$$

$$\Rightarrow 2.19 = \frac{\sqrt{6+10K^4}}{2(K^2-1)}$$

$$\Rightarrow 2(K^2-1)\times2.19 = \sqrt{6+10K^4}$$

$$\Rightarrow 4.38K^2 - 4.38 = \sqrt{6+10K^4}$$

$$\Rightarrow (4.38K^2-4.38)^2 = 6+10K^4$$

$$\Rightarrow (4.38K^2)^2 - 2\times4.38K^2\times4.38 + 4.38^2 = 6+10K^4$$

$$\Rightarrow 19.18K^4 - 38.37K^2 + 19.18 = 6+10K^4$$

$$\Rightarrow 19.18K^4 - 10K^4 - 38.37K^2 + 19.18 - 6 = 0$$

$$\Rightarrow 9.18K^4 - 38.37K^2 + 13.18 = 0$$

$$K^2 = 3.802$$

$$\Rightarrow K = 1.949$$

Now,

$$K = \frac{D_o}{D_i} \Rightarrow KD_i = D_o$$

$$\Rightarrow 1.949\times250 = D_o$$

$$\Rightarrow 487.47 = D_o$$

$$\boxed{D_o = 487.47\,mm}$$

Wall thickness based on "Maximum strain energy theory"

$$t = \frac{D_o - D_i}{2}$$

$$\Rightarrow t = \frac{487.47 - 250}{2}$$

$$\Rightarrow \boxed{t = 118.735\,mm} \quad (3)$$

(4) **Maximum shear theory :-**

$$\frac{\sigma_y}{(fos)} = \left(\frac{2k^2}{k^2-1}\right) P_i$$

$$\Rightarrow \frac{430}{1.4 \times 140} = \left(\frac{2k^2}{k^2-1}\right)$$

$$\Rightarrow (2.19)(k^2-1) = 2k^2$$

$$\Rightarrow 2.19k^2 = 2.19 - 2k^2 = 0$$

$$\Rightarrow 0.19k^2 - 2.19 = 0$$

$$\Rightarrow k^2 = \frac{2.19}{0.19}$$

$$\Rightarrow k = 3.395$$

Now,

$$K = \frac{D_o}{D_i} \Rightarrow KD_i = D_o$$

$$\Rightarrow 3.395 \times 250 = D_o$$

$$\Rightarrow 848.76 = D_o$$

$$\boxed{D_o = 848.76\,mm}$$

Thickness based on "Maximum shear theory"

$$t = \frac{D_o - D_i}{2}$$

$$t = \frac{848.76 - 250}{2}$$

$$\boxed{t = 299.38 \text{ mm}}$$

Sol^n:- (4) given data:- A fractionating tower

outside diameter of tower $= 3000$ mm $= 3$ m

tangent to tangent length of tower $= 5000$ mm $= 5$ m

Tray spacing $= 1$ m

$R_i = D_o$; $r_i = 0.1 D_o$

$f = 8.6 \times 10^6$ kgf/m^2

$E = 19.9$ kgf/mm^2

$E = 19.9 \times 10^6$ kgf/m^2

Density of steel $= 7850$ kg/m^3

$w/m = 10.4$ kg/m

(1) Determination of shell thickness without stiffeners

Assume: (1) at full vacuum at 400°C, pressure $= 0.1$ MN/m^2

(2) ~~Assum~~ torispherical head used.

At initial approximation $D_o = D_i$ & $R_i = D_o$

$$h_i = R_i - \sqrt{\left(R_i - \frac{D_i}{2}\right) \times \left(R_i + \frac{D_i}{2} - 2r_i\right)}$$

$$\Rightarrow h_i = 3 - \sqrt{\left(3 - \frac{3}{2}\right) \times \left(3 + \frac{3}{2} - 2 \times 0.1 \times 3\right)}$$

$$\Rightarrow h_i = 3 - \sqrt{5.85}$$

$$\Rightarrow h_i = 3 - 2.41$$

$$\Rightarrow \boxed{h_i = 0.58 \text{ m}}$$

Effective length of the tower without stiffener:

$$L_e = \text{tangent to tangent length} + \frac{2}{3}(h_i)$$

$$L_e = 5 + \frac{2}{3}(0.58)$$

$$\boxed{L_e = 5.38 \text{ m}}$$

Therefore,

$$\frac{D_o}{L_e} = \frac{3}{5.38} = 0.55 \simeq 0.6$$

$\Rightarrow$ Based on $\left(\frac{D_o}{L_e}\right)$ value, get the value of K & m from code book.

$$K = 0.516$$
$$m = 2.49$$

(1) Shell thickness calculation for elastic stability:-

$$\boxed{P = KE\left(t/D_o\right)^m} \quad \text{—— (1)}$$

$$0.1 \times \cancel{10^6} = 0.516 \times 19.9 \times \cancel{10^6} \times 9.81\left(\frac{t}{D_o}\right)^{2.49}$$

$$\frac{0.1}{0.516 \times 19.9 \times 9.81} = \left(\frac{t}{3}\right)^{2.49}$$

$$9.927 \times 10^{-4} = \left(\frac{t}{3}\right)^{2.49}$$

$$0.0622 = \left(\frac{t}{3}\right)$$

$$t = 0.186 \text{ m}$$

$$t = 186 \text{ mm}$$

$\Rightarrow$ Checking for plastic deformation

$$P = 2 \times f\left(\frac{t}{D_o}\right) \frac{1}{1 + \dfrac{1.5U\left(1 - 0.2\frac{D_o}{L_e}\right)}{100\left(t/D_o\right)}}$$

<u>Assume</u>: out of roundness for new vessels.

$U = 1.5$

$$P = 2 \times 8.6 \times 10^6 \times 9.81\left(\frac{0.186}{3}\right) \frac{1}{1 + \dfrac{1.5 \times 1.5\left(1 - 0.2 \times 3/5.38\right)}{100\left(\frac{0.186}{3}\right)}}$$

$$\Rightarrow P = 1046138 4 \times \frac{1}{1 + \frac{1.98}{6.2}}$$

$$\Rightarrow P = 10461384 \times 0.758$$

$$\Rightarrow P = 7931299.4\ N/m^2$$

$$\Rightarrow \boxed{P = 7.93\ MN/m^2}$$

Since $\boxed{7.93\ MN/m^2 > 0.1\ MN/m^2}$

The calculated thickness is safe against plastic deformation.

(2) If stiffers are used, the effective length of the tower will be reduced to 1 m (tray spacing)

$L = 1$

$D_o = \frac{3}{1} = 3$

$= 4949472 \times 0.765$

$= 3786346.08$

$= 3.78\ MN/m^2$

$$\boxed{3.78\ MN/m^2 > 0.1\ MN/m^2}$$

Therefore the calculated thickness is sufficient for plastic deformation.

(b) Design of stiffening ring involves first select a standard structure and then to check for required moment of Inertia calculated.

$$\boxed{I_{Req} = \frac{D_o^2 L \left(t + \frac{A_s}{L}\right) f}{12 \times E}}$$

$$= \frac{3^2 \times 1 \left(0.088 + \frac{A_s}{1}\right) \times 8.6 \times 10^6}{12 \times 19.9 \times 10^6}$$

$I_{Req} = 0.324(0.088 + A_s)\ m^4$

$= 0.324(0.088 + A_s)\ m^4$

from chart (code book)

ISMC, max. sectional area $= 62.93\ cm^2$

$= 62.93 \times 10^{-4}\ m^2$

$I_{Req} = 0.324(0.088 + 0.006293)$

$= 0.030\ m^4$

But $I_{actual} = 0.0151\ m^4$

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here

$$\boxed{I_{req} > I_{actual}}$$

Not satisfied the safe design condition

Therefor the correct value of I_{req} can be obtained ~~by~~ from chart (Codebook - IS-2825-1969) (Appendix f)

$\frac{L}{D_0}$ at 400°C

$\frac{L}{D_0} = \frac{1}{3}$ & 400°C

$$\boxed{\begin{aligned} \text{factor } A &= 0.000026 \\ f/E &= 0.000026 \end{aligned}}$$

$\frac{L}{D_0} = 0.33$

↳ from appendix F, for fig. F.2 (IS-2825-1969)

Now,

Assume $A_s = 11.70\ cm^2$

$$I_{req} = \frac{3^2 \times 1\,(0.088 + 0.001170) \times 0.000026}{12}$$

$I_{req} = 1.738 \times 10^{-6}\ m^4$

$I_{actual} = 186.7\ cm^4$

$= 186.7 \times 10^{-8}$

$= 1.86 \times 10^{-6}\ m^4$

Now,

$$\boxed{I_{req} < I_{actual}}$$

No. of stiffners required (n) = tangent to tangent length / tray spacing

$\Rightarrow$ $n = 5 - 1$

$\Rightarrow$ $n = 4$

Total wt. of rings $= n \pi D_o \times w/m$

$= 4 \times 3.14 \times 3 \times 10.4$

$= 391.872$ kg

Saving the shell material for using stiffening rings,

$(W) = \pi D_o (t_{2} - t_1) \times L \times \rho_s$

where, t_2 = shell thickness without stiffeners

t_1 = shell thickness with stiffeners

so,

$W = 3.14 \times 3 (0.186 - 0.088) \times 5 \times 7850$

$$\boxed{W = 36234 \text{ kg}}$$

Therefore, use of stiffening rings will be advantageous in this case.

Note:- This problem may also solve by Alternative method using chart from Appendix F from code book (IS-2825-1969) and table 3.1 from code book (IS-2825-1969) given that,

Density of process fluid $(\rho_f) = 1050\ kg/m^3$

plate size $= 0.9m \times 1.8m$

Density of steel $(\rho_s) = 7800\ kg/m^3$

tank closed by = flat covers.

max. diameter of tank(d) = 2.6 m

~~the~~ length of tank(L) = 5 m

Thickness of the plate for shell fabrication = 6mm

Thickness of plate for closure = 8mm

Capacity of storage tank $(V_{given}) = 25 m^3$

Now,

Cross sectional area of tank $= \frac{\pi}{4}(D)^2$

$$\Rightarrow (A_t) = \frac{3.142}{4}(2.6)^2$$

$$\Rightarrow \boxed{(A_t) = 5.309\ m^2} \quad (1)$$

Volume of storage tank $= (A_t) \times (\text{Length of tank})$

$$\Rightarrow (V_t) = 5.309 \times 5$$

$$\Rightarrow \boxed{(V_t) = 26.545\ m^3} \quad (2)$$

% Excess volume available in storage tank

$$= \left(\frac{V_t - V_{given}}{V_{given}}\right) \times 100$$

$$= \left(\frac{26.545 - 25}{25}\right) \times 100$$

$\boxed{\text{\% excess volume} = 6.18\%}$ —— (3)

circumference of shell of a tank

$= \pi D$

$= 3.142 \times 2.6$

$= 8.1692\ m$

~~given~~ 6mm thick shell plate :-

weight of process fluid $= 25 \times \rho_f$

$(W) = 25 \times 1050$

$(W) = 26250\ kg$

Surface area of shell $= \pi DL$

$= 3.142 \times 2.6 \times 5$

$\boxed{\text{surface area of shell} = 40.846\ m^2}$ —— (4)

now, weight of one m^2 of shell can be calculated as,

$= (\text{one } m^2 \text{ of shell}) \times \text{shell thickness} \times \rho_{shell}$

$= 1.0 \times 1.0 \times 0.006 \times 7800$

$= 46.8\ kg \Rightarrow wt/1m^2 = 46.8\ kg/1m^2$

total weight of shell $=$ ~~40.846~~

$= \text{Surface Area of shell} \times \text{wt of } 1m^2 \text{ shell}$

$= 40.846 \times 46.8$

$\boxed{\text{total wt. of shell} = 1911.6\ kg}$ —— (5)

∴ for the closing the shell, 8 mm thickness plate is used,

So,

Surface area of both cover plates $= \frac{\pi}{4}(D)^2 \times 2$

$= \frac{\pi}{4}(2.6)^2 \times 2$

$= 10.61\ m^2$

then, Weight of one m^2, 8 mm thick plate will be

$= 1.0 \times 1.0 \times 0.008 \times 7800$

$= 62.4\ kg$

Total weight of cover plates

$=$ Surface area of both cover plates $\times$ (weight of 1 m^2 8 mm thick plate)

$= 10.61 \times 62.4$

$= 662.064\ kg$

Now,

total weight of empty tank along with cover plates $=$ (total wt. of shell) $+$ (total wt. of cover plates)

$w' = 1911.6 + 662.064$

$w' = 2573.664\ kg$

$\boxed{w' \simeq 2574\ kg}$ —— (6)

Effective span between the support $l_1 = \frac{L}{2} = \frac{5}{2}$

$= 2.5\ m$

Maximum tensile bending stress in the shell plate :

$$f = \frac{D\,(W+w)\,l_1^2 \times 1\cancel{00}}{8\,L \times 0.098\,(D^4 - d^4)} \quad kg/cm^2$$

∴ outside diameter of tank = i.D. + 2 × thickness

$$= 260 + 2 \times 0.60$$

$$= \cancel{380\ cm}$$

$$\boxed{D = 261.2\ cm}$$

$$f = \frac{261.2\,(26250 + 2574) \times 2.5^2 \times 1}{8 \times 500\,(0.098)\,(261.2^4 - 260^4)}$$

$$\boxed{f = 14.13\ kg/cm^2} \qquad \text{— (7)}$$

maximum tensile stress in shell plates is negligible.

$$\text{Maximum shear force} = \frac{(W + w')\,l_1}{2L}$$

$$= \frac{(26250 + 2574)\,2.5}{2 \times 5.0}$$

$$= 7206\ kg$$

$$\text{maximum direct stress} = \frac{\text{max. shear force}}{\text{cross sectional area of hollow tank}}$$

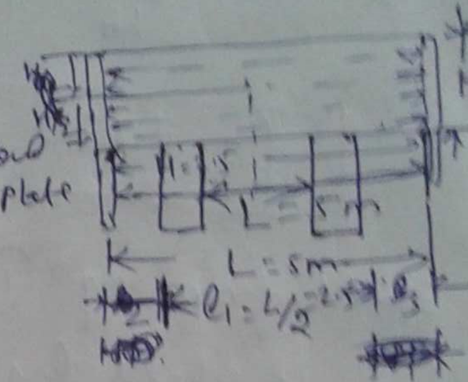
$$= \frac{7206 \times 4}{\pi\,(D^2 - d^2)}$$

$$= \frac{7206 \times 4}{3.14\,(261.2^2 - 260^2)}$$

$$\boxed{\text{maximum direct stress} = 14.67\ kg/cm^2} \qquad \text{— (8)}$$

total fluid pressure on each cover plate, when the tank is full.

$$\begin{pmatrix}\text{wt of fluid}\\ \text{on each cover plate}\end{pmatrix} = \rho_f \times A_p \times H/2$$



$$= \frac{1050 \times \pi \times d^2 \times 4}{4}$$ where A_p = Cross sectional area of plate

$$= \frac{1050 \times \pi \times 2.6 \times 1.3}{4} \quad H = 2.7$$

wt of fluid on each cover plate $= \cancel{6964.9}$ 7243.5

$$\boxed{\simeq \cancel{6965\ kg}\ 7244\ kg} \quad \text{—— (9)}$$

The pressure is assumed as uniformly distributed on the surface area of the cover plates,

Therefore,

$$\text{Avg. pressure } p = \frac{\text{wt of fluid on each cover plate}}{\text{cross sectional area of cover plate}}$$

$$= \frac{7244 \times 4}{3.14(260)^2}$$

$$\boxed{\text{Avg Pres.}(p) = 0.1365\ kg/cm^2}$$

So, maximum stress on cover plate in bending

$$f = \frac{3}{16}\frac{p d^2}{t_{plate}^2} = \frac{3}{16} \times \left(\frac{0.1365 \times 260^2}{0.8^2}\right)$$

$$= \quad = \cancel{2962.7\ kg/cm^2}$$

$$\boxed{f = 2703.3\ kg/cm^2} \quad \text{—— (10)}$$

Since the stress on cover plate (eq^n (10)) is very high.

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Therefore 10mm cover plate thickness is used

$$f = \frac{3}{16} \times \left(\frac{0.1365 \times 260^2}{(1.0)^2} \right)$$

$$\boxed{f = 1730 \ kg/cm^2} \quad \text{--- (11)}$$

~~Still~~ from eqn (11) we found that the stress value is still high.

So provide vertical angle stiffeners of 75X75X6mm and

The angle ring of 75X75X6mm. (from steel table)