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20CH30020

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FLUID FLOW AND DESIGN LAB

ASSIGNMENT

Given information ⇒

Design Pressure = 2.5 MPa
Design Temperature = 200°C
Shell ID = 1.5 m
Gasket material = Asbestos
Gasket width = 1.6 mm
Allowable stress for Shell and Flange = 100 MPa
Allowable stress for Bolting = 138 MPa
Hub Thickness = 12 mm
Distance b/w outer shell and Gasket = 6 mm
weld Joint efficiency = 0.85
$m = 2.75$, $y = 25.5$ MPa

We have,

$$\frac{d_o}{d_i} = \sqrt{\frac{y - P(m)}{y - P(m+1)}}$$

$$\frac{d_o}{d_i} = \sqrt{\frac{25.5 - (2.75)(2.5)}{25.5 - (3.75)(2.5)}}$$

$$\frac{d_o}{d_i} = 1.0747$$

Now, we have

$$\text{(Shell Thickness) } g_o = \frac{pD_o}{2fJ + p} = \frac{2.5\,(1.5 + 0.002 + g_o)}{2 \times 100 \times 0.85 + 2.5}$$

$172.5 g_o = 3.755 + 2.5 g_o$

$g_o = 0.022 \text{ m}$

Considering corrosion allowance $= 0.002 \text{ m} \ (t_c)$

$g = g_o + t_c$

$= 0.022 + 0.002$

$= 0.024 \text{ m}$

Next Standard Thickness available $= 0.025 \text{ m} \ (25 \text{ mm})$

Shell Outer Diameter = Shell Inner Diameter + 2 (Shell Thickness)

$= 1.5 + (2 \times 0.025)$

$= 1.55 \text{ m}$

Now we have

Gasket Inner Diameter, $d_i = 1.55 + 2(0.006)$

$= 1.562 \text{ m}$

As Gasket is placed 6mm from outer shell.

$\frac{d_o}{d_i} = 1.0747 \Rightarrow d_o = 1.0747 \times 1.562 \Rightarrow d_o = 1.6787 \text{ m}$

Minimum Gasket width $= \frac{d_o - d_i}{2} = \frac{1.6787 - 1.562}{2} = 0.0583 \text{ m}$

$\Rightarrow b_o = \frac{0.0583}{2} = 0.02917 \text{ m} \quad (29.17 \text{ mm}).$

Since $b_o \ (29.17 \text{ mm}) > 6.3 \text{ mm}$

$b = 2.5 \sqrt{b_o} = 2.5 \sqrt{29.17} = 13.5 \text{ mm}$

We also have

$$G = d_o - 2b$$
$$= 1.6787 - (2 \times 0.0135)$$
$$= 1.6517 \text{ m}$$

Bolt Load because of Design Pressure $= \frac{\pi G^2 \times P}{4}$

$$= \frac{\pi \times (1.6517)^2 \times 2.5}{4}$$

$$= \underline{\underline{5.353 \text{ MN}}}$$

Bolt Load due to Adequate Compression $= 2\pi G b m p$

$$= 2 \times \pi \times 1.6517 \times 0.0135 \times 2.75 \times 2.5$$

$$= \underline{\underline{0.963 \text{ MN}}}$$

Total Operating Load (W_o) $= (5.353 \text{ MN} + 0.963 \text{ MN})$

$$= \underline{\underline{6.315 \text{ MN}}}$$

Bolt Load under bolting up condition (W_g) $= \pi G b y$

$$= \pi \times 1.6517 \times 0.0135 \times 25.5$$

$$= \underline{\underline{1.785 \text{ MN}}}$$

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Minimum bolting Area $= \frac{W_o}{S_o}$ $(S_o = 138\ MPa)$ ↳ Given

$= \frac{6.315}{138} = 0.0457 m^2$

Selection of Bolt ⇒ we know that if dimension of bolt is M (a × b) .... dimensions

Root Area $= \frac{\pi}{4} (a - b^2)^2 \times 10^{-6} m^2$

n (no. of bolts) $= \frac{\text{Bolting Area}}{\text{Root Area}}$ (Next suitable multiple of 4)

Also,

① ← $c_1 = B + 2(g_1 + R)$

② ← $c_2 = \frac{n B_s}{\pi}$

|| c_1, c_2 should be as close as possible. ||

(i) M(18×2) ⇒ Root Area $= \frac{\pi}{4} (18 - 2^2)^2 \times 10^{-6}$

M 18×2

$= 1.5399 \times 10^{-4} m^2$

$n = \frac{4.57 \times 10^{-2}}{1.5399 \times 10^{-4}} \approx 297$

therefore actual $n = 300$

From ① and ② we get

$c_1 = 1.55 + 2(0.012 + 0.027) = 1.628\ m$

$c_2 = \frac{300 \times 0.075}{\pi} = 7.16\ m$

P.T.O ⇒.

(ii) M 20x2 Root Area $= \frac{\pi}{4}(20-4)^2 \times 10^{-6}$

M 20x2

$= 0.201 \times 10^{-3}\ m^2$

$n = 227.66$

≈ 228

From ① and ②

$c_1 = 1.55 + 2(0.012 + 0.03) = 1.634\ m$

$c_2 = \frac{228 \times 0.075}{\pi} = 5.44\ m$

Similarly	c_1	c_2
M 22x2	1.64 m	4.297 m
M 24x2	1.644 m	3.53 m
M 27x2	1.65 m	2.67 m
M 30x2	1.662 m	2.1 m
→ $\boxed{\text{M 33x2}}$	$\boxed{1.668\ m}$	$\boxed{1.666\ m}$ → Best choice
M 36x3	1.674 m	1.62 m
M 39x3	1.678 m	1.53 m
M 42x3	1.684 m	1.27 m

Therefore we select M 33x2, bolt circle diameter $\approx 1.668\ m$

$c_1 = 1.668$

$n = \frac{0.0457 \times 10^6}{\frac{\pi}{4}(33-2^2)^2} \approx 69$ bolts classmate

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$n \approx 69$ bolts

$\Rightarrow$ we have to consider next multiple of 4

$\therefore$ $\boxed{n = 72 \text{ bolts}}$

Flange Outer Diameter $= 1.668 + 0.033 + 0.002$

$= 1.703$

Finally we have $\Rightarrow$

Gasket Inner Diameter $= 1.562$ m

Gasket Outer Diameter $= 1.6787$ m

Gasket width $= 0.0583$ m

Bolt Circle Diameter $= 1.668$ m

No. of Bolts $= 72$ bolts

Flange Outer Diameter $= 1.703$ m