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MECHANICAL ENGINEERING

1) $Q = 2000\,m^3/h = 33.3\,m^3/m$ $\quad P = 1.2\,N/mm^2$ $\quad v = 28\,m/s$

$= 1680\,m/min$ $\quad \sigma_t = 40\,MPa = 40\,N/mm^2$

Inside diameter of pipe

$D = 1.13\sqrt{Q/v}$

$= 1.13\sqrt{33.3/1680} = 0.159 = 160\,mm$

Wall thickness of pipe

from table 8.2 $C = 3\,mm$

$t = PD/2 + C$

$= \frac{1.2 \times 160 + 3}{2} = 5.4\,mm \approx 6\,mm$

2) $D = 200mm$ $P = 0.7 N/mm^2$

from table 8.1 $\sigma_t = 14 N/mm^2$

from table 8.2 $C = 9mm$

thickness $t = \frac{PD}{2\sigma_t} + C$

$t = \frac{0.7 \times 200}{2 \times 14} + 9 = 14mm$

Other dimensions of a flanged joint for a cast ion pipe are:

Normenal diameter of bolts:

$d = 0.75t + 10$

$= 0.75 \times 14 + 10 = 20.5mm$ say $21mm$

Number of bolts

$n = 0.0275D + 1.6$

$= 0.0275 \times 200 + 1.6 = 7.1 \simeq 8mm$

Thickness of the flanges

$t_f = 1.5t + 3$

$= 1.5 \times 14 + 3 = 24mm$

Width of the flange.

$B = 2.3d$

$= 2.3 \times 21 = 48.3 \simeq 50mm$

Outside diameter of the bolts

$D_o = D + 2t + 2B$

$= 200 + 2(14) + 2(50) = 328mm$

Pitch circle diameter of the bolts.

$D_p = D + 2t + 2d + 12$

$= 200 + 2(14) + 2(21) + 12 = 282mm$

Circumferential pitch of the bolts.

$$P_c = \frac{\pi \times D_p}{n}$$

$$= \frac{\pi \times 282}{8} = 110.7mm$$

In order to make the joint leak proof, the value of Pc should be between $20\sqrt{d_1}$ to $30\sqrt{d_1}$ where d_1 is the diameter of bolt hole

$d_1 = d + 3$

$= 21 + 3 = 24mm$

$20\sqrt{d_1} = 20\sqrt{24} = 97.9$

$30\sqrt{d_1} = 30\sqrt{24} = 140.9$

Since the circumference pitch is above $20\sqrt{d_1}$ and $30\sqrt{d_1}$ the design is satisfactory.

3) Given $D = 50mm$ or $R = 25mm$ $p = 7N/mm^2$ $\sigma_t = 21MPa = 21N/mm^2$

$\sigma_{tb} = 28MPa = 28N/mm^2$

$$t = R.\left[\sqrt{\frac{\sigma_t + p}{\sigma_t - p}} - 1\right] = 25\left[\sqrt{\frac{21+7}{21-7}} - 1\right] = 10.35 \simeq 11mm$$

Assuming the width of packing as 10mm therefore outer diameter of the packing

$D_1 = D + 2 \times$ width of packing

$= 50 + 2 \times 10 = 70mm$

$\therefore$ force trying to seperate the flanges

$F = \frac{\pi}{4}(D_1)^2 p = \frac{\pi}{4}(70)^2 7 = 26943N$

Since the flange is secured by means of bolts,

$F_b = \frac{F}{2} = \frac{26943}{2} = 13471.5N$

let d_c = core diameter of bolts,

load on each bolt (F_b)

$13471.5 = \frac{\pi}{4}(d_c)^2 \sigma_{tb}$

$= \frac{\pi}{4}(d_c)^2 28 = 21.99(d_c)^2$

$d_c^2 = \frac{13471.5}{21.99} = 612.6$

$d_c = 24.7 \simeq 25mm$

Normenal diameter of bolts,

$d = d_c/0.84 = 25/0.85 = 29.4 \simeq 30mm$

Outer diameter of the flange

$D_o = D + 2t + 4.6d$

$= 50 + 2(11) + 4.6(30)$

$= 210mm$

Pitch circle diameter of bolts

$D_p = D_o - (3t + 20)mm$

$= 210 - (3(11) + 20)$

$= 157mm$

from the diagram

$b = 111.40mm$

$e = 48mm$

Bending moment at section X-X

$M_{xx} = f_3 \times e = 13471.5 \times 48mm$

$= 646632 N \cdot mm$

and section modulus

$Z = \frac{1}{6} b(t_f)^2 = \frac{1}{6} \times 111.40 (t_f)^2$

$= 18.56 (t_f)^2$

We know that $M_{xx} = \sigma_b \times z$

$646632 = 21 \times 18.56 (t_f)^2$

$= 389.76 (t_f)^2$

$$t_f^2 = \frac{646632}{389.76}$$

$$t_f = \sqrt{1659.05}$$

$$t_f = 40.7 \simeq 41mm$$