Design of Machine Elements: Lab-(8):

Calculations:

Assumptions: material is isotropic.

→ strain resulting from internal material is small.
→ Thickness 't' is much smaller than diameter of pressure vessel.

Mat. chosen: steel. stress in torsion = 80 mPa
-11- shear = 60 mPa
-11- pump = 120 mPa.

→ steel is commonly used in boilers for its properties.

Calculations: **Given:** $P_i = 2$ MPa, $D_i = 1500$ mm
$n_1 = 0.8$, $n_2 = 0.42$
$CA = 2$ $\sigma_t = 80$, $\sigma_s = 60$, $\sigma_c = 120$.
$n_1 = 1$, $n_2 = 4$.

Longi:

$$t = \frac{P_i D_i}{2\sigma_t n_2} + CA.$$

$$= \frac{2 \cdot 1500}{2 \cdot 80 \cdot 0.8} + 2 \Rightarrow t = 25.437$$
$$\approx 26 \text{mm}.$$

$\therefore t > 8$ mm.

$$d = 6.02\sqrt{t} = 6.02\sqrt{26} = 30.69.$$
$$\Rightarrow \boxed{d = 31 \text{mm}.}$$

$$P_g = (n_1 + 1.875 n_2)\, \pi/4\, d^2 \rho$$

$$= \pi(D-d)\, t\, \sigma_t$$

$P_s = P_t$ to get P.

$$P = d + \frac{(n1 + 1.875(n-2))\pi d^2 \tau}{4L}$$

$$= 31 + \frac{(1 + 4 \cdot 1.875)\pi \cdot 31^2 \cdot 60}{4 \cdot 26800}$$

$$P \geq 216 mm$$

but $2d < p < c + 4/3$

as $c = 6$ for double strap butt joint with no. of rivets per pitch length

$62 < p < 193.9$ $\Rightarrow$ $p = 193.9 mm$

For - Transverse Pitch:

∴ We have no. of rivet in outer row is half no. of rivets in inner row.

min dist. between outer and next row.

$P_{ta} = 0.2p + 1.15d = 0.2 \cdot 193.9 + 1.15 \cdot 31$

$\therefore = 74.43 mm$

Invert: $P_{tb} = 0.165p + 0.67d$

$= 0.165 \cdot 193.9 + 0.67 \cdot 31$

$= 52.7643 \approx 53 mm$

For thickness of straps:

For wider strap, $t_{wi} = 0.75t = 19.07 \approx 20mm$.

For narrow strap, $t_{in} = 0.625t = 15.89 \approx 16mm$.

Now efficiency:

$P_t = (p-d)t\sigma_t = (193.9-31)\cdot 26.80 = 231.10^3 N$

$P_s = (n_1 + 1.875n_2)\pi d^2 \sigma_s/4$

$= (1+4\cdot 1.875)\pi(31^2)\cdot 60/4 = 3.85 \times 10^5 N$.

$P_c = (n_1+n_2)t\phi\sigma_c = (1+4)\cdot 26\cdot 31\cdot 120$

$= 4.73\cdot 10^5 N$

$\eta_{new} = \frac{\min(P_t, P_s, P_c)}{pt\sigma_t} = \frac{231\cdot 10^3}{193.9\cdot 26\cdot 80} = 0.85$

$\therefore \eta_{new} > \eta_{old}$, our analysis is valid.

For circumferential joint:

$\eta = \left(\frac{p_i'}{4}\right)^2 \frac{P_i'}{\epsilon} = \left(\frac{1500}{31}\right)^2 \cdot \frac{2}{60}$

$\Rightarrow \eta = 78.0437 \approx \boxed{79}$

$P_1 = \frac{d}{1-n\epsilon} = 53.4483$

$P_{tc} = 0.33P_1 + 0.67d = 38.431\ mm$

$m = 1.5d = 46.7mm$,

overlap $= 4l + 2m = 131.407\ mm$