Lecturer: Luay Hashem Abbud
E-mail: LuayHashemAbbud@mustaqbal-college.edu.iq

Design of Cylinder Covers

The cylinder covers may be secured by means of bolts or studs

1. *Design of bolts or studs*

In order to find the size and number of bolts or studs, the following procedure may be adopted.

Let D = Diameter of the cylinder,

p = Pressure in the cylinder,

d_c = Core diameter of the bolts or studs,

n = Number of bolts or studs, and

σ_{tb} = Permissible tensile stress for the bolt or stud material.

We know that upward force acting on the cylinder cover,

$$P = \frac{\pi}{4}(D^2)\,p$$

This force is resisted by n number of bolts or studs provided on the cover.

∴ Resisting force offered by n number of bolts or studs,

$$P = \frac{\pi}{4}(d_c)^2\,\sigma_{tb} \times n$$

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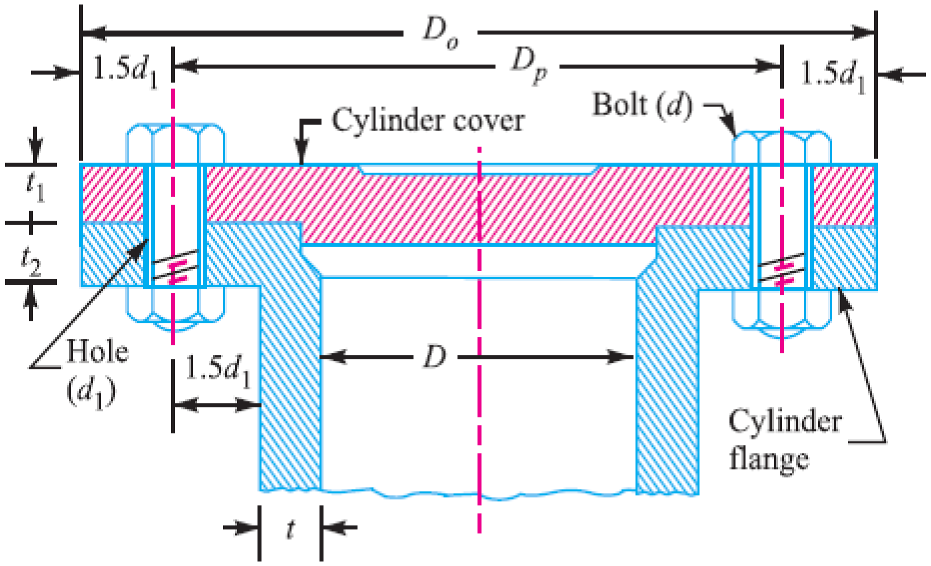
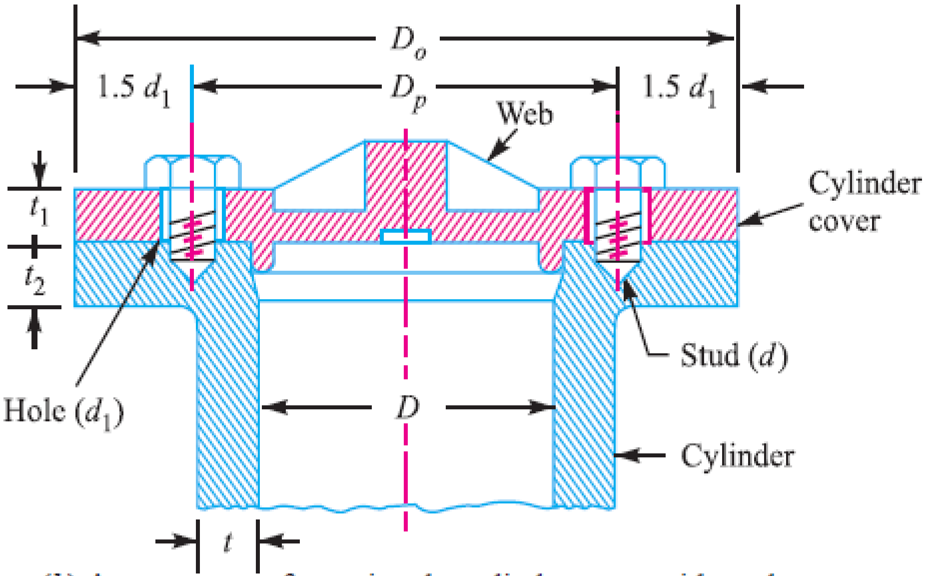


(a) Arrangement of securing the cylinder cover with bolts.



(b) Arrangement of securing the cylinder cover with studs.

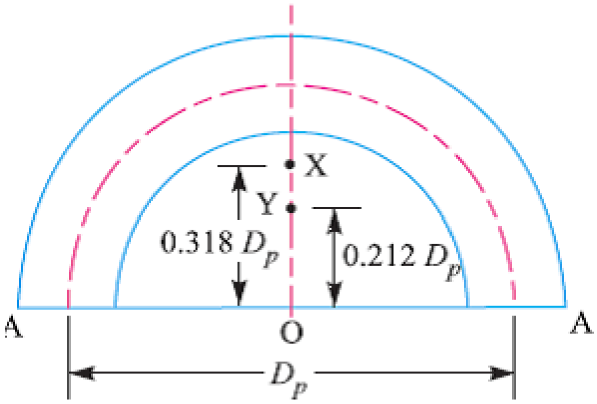
The tightness of the joint also depends upon the circumferential pitch of the bolts or studs. The circumferential pitch should be between 20 $\sqrt{d1}$ and 30 $\sqrt{d1}$, where $d1$ is the diameter of the hole in mm for bolt or stud. The pitch circle diameter (D_p) is usually taken as $D + 2t + 3d1$ and outside diameter of the cover is kept as

$D_o = D_p + 3d_1 = D + 2t + 6d_1$

Where t = Thickness of the cylinder wall.

Design of cylinder cover plate

The thickness of the cylinder cover plate (t_1) and the thickness of the cylinder flange (t_2) may be determined as discussed below:



Semi-cover plate of a cylinder.

We know that the bending moment at *A-A*,

$$M = \frac{\text{Total bolt load}}{2}(OX - OY) = \frac{P}{2}(0.318\, D_p - 0.212\, D_p)$$

$$= \frac{P}{2} \times 0.106\, D_p = 0.053\, P \times D_p$$

Section modulus, $$Z = \frac{1}{6} w\, (t_1)^2$$

Where w = Width of plate

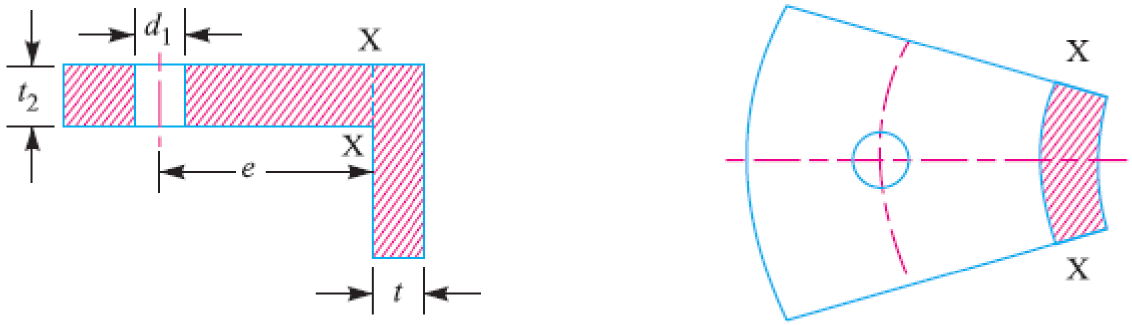
= Outside dia. of cover plate – 2 × dia. of bolt hole

$= D_o - 2d_1$

Knowing the tensile stress for the cover plate material, the value of t_1 may be determined by using the bending equation, *i.e.*, $\sigma_t = M / Z$.

Design of cylinder flange

The thickness of the cylinder flange (t_2) may be determined from bending consideration. A portion of the cylinder flange under the influence of one bolt is shown in Figure.



e = Pitch circle radius – (Radius of bolt hole + Thickness of cylinder wall)

$$= \frac{D_p}{2} - \left(\frac{d_1}{2} + t\right)$$

∴ Bending moment, $M = \text{Load on each bolt} \times e = \frac{P}{n} \times e$

Radius of the section *X-X*,

$$R = \text{Cylinder radius} + \text{Thickness of cylinder wall} = \frac{D}{2} + t$$

Width of the section *X-X*,

$$w = \frac{2\pi R}{n}$$, where n is the number of bolts.

Section modulus, $Z = \frac{1}{6} w (t_2)^2$

Knowing the tensile stress for the cylinder flange material, the value of t_2 may be obtained by using the bending equation *i.e.* $\sigma_t = M / Z$.

Problem 4

A steam engine cylinder has an effective diameter of 350 mm and the maximum steam pressure acting on the cylinder cover is 1.25 N/mm2. Calculate the number and size of studs required to fix the cylinder cover, assuming the permissible stress in the studs as 33 MPa.

Solution

$D = 350$ mm ; $p = 1.25$ N/mm^2 ; $\sigma_t = 33$ MPa = 33 N/mm^2

We know that the upward force acting on the cylinder cover,

$$P = \frac{\pi}{4} \times D^2 \times p = \frac{\pi}{4}(350)^2\ 1.25 = 120\ 265 \text{ N}$$

Assume that the studs of nominal diameter 24 mm are used. From Table 1 (coarse series), we find that the corresponding core diameter (d_c) of the stud is 20.32 mm.

∴ Resisting force offered by n number of studs,

$$P = \frac{\pi}{4} \times (d_c)^2\, \sigma_t \times n = \frac{\pi}{4}(20.32)^2\ 33 \times n = 10\ 700\ n \text{ N}$$

$n = 120\ 265 / 10\ 700 = 11.24$ say 12

Taking the diameter of the stud hole ($d1$) as 25 mm, we have pitch circle diameter of the studs,

$D_p = D + 2t + 3d_1 = 350 + 2 \times 10 + 3 \times 25 = 445$ mm ...(Assuming $t = 10$ mm)

∴Circumferential pitch of the studs

$$= \frac{\pi \times D_p}{n} = \frac{\pi \times 445}{12} = 116.5 \text{ mm}$$

We know that for a leak-proof joint, the circumferential pitch of the studs should be between 20 $\sqrt{d1}$ to 30 $\sqrt{d1}$, where d_1 is the diameter of stud hole in mm.

∴ Minimum circumferential pitch of the studs

$= 20\sqrt{d1} = 20\sqrt{25} = 100$ mm

and maximum circumferential pitch of the studs

$= 30\sqrt{d1} = 30\sqrt{25} = 150$ mm

Since the circumferential pitch of the studs obtained above lies within 100 mm to 150 mm, therefore the size of the stud chosen is satisfactory.

∴ Size of the stud = M 24