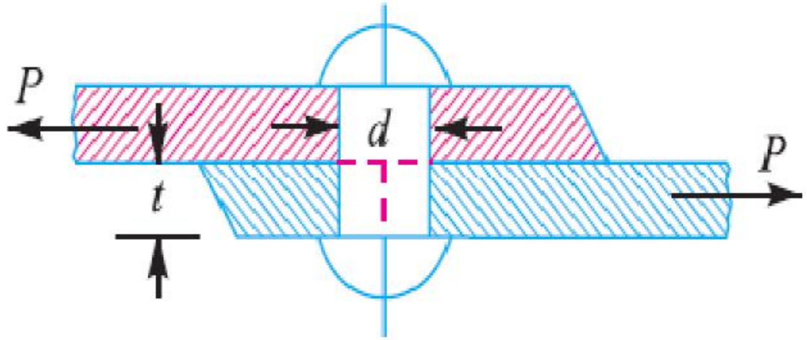
MACHINE DESIGN

Bearing Stress

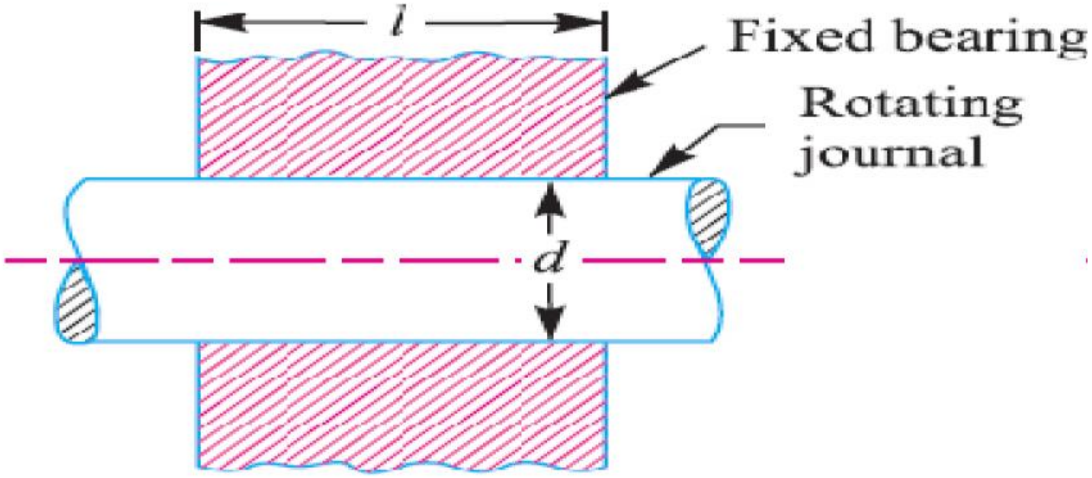
A localised compressive stress at the surface of contact between two members of a machine part, that are relatively at rest is known as **bearing stress or crushing stress.**

consider a riveted joint subjected to a load P as shown in Figure. The bearing stress or crushing stress (stress at the surface of contact between the rivet and a plate).

$$\sigma_b \,(\text{or } \sigma_c) = \frac{P}{d.t.n}$$



where
d = Diameter of the rivet,
t = Thickness of the plate,
$d.t$ = Projected area of the rivet, and
n = Number of rivets per pitch length in bearing or crushing.



Journal supported in a bearing

$$p_b = \frac{P}{l.d}$$

where

p_b = Average bearing pressure,

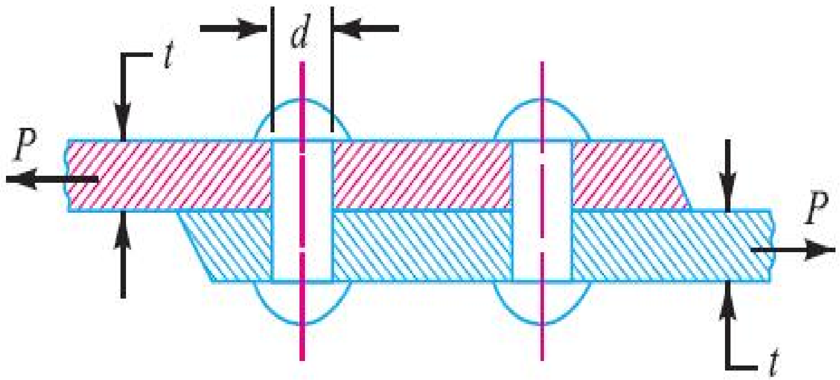
P = Radial load on the journal,

l = Length of the journal in contact, and

d = Diameter of the journal.

Example(4): Two plates 16 mm thick are joined by a double riveted lap joint as shown in Figure. The rivets are 25 mm in diameter.
Find the crushing stress induced between the plates and the rivet, if the maximum tensile load on the joint is 48 kN.

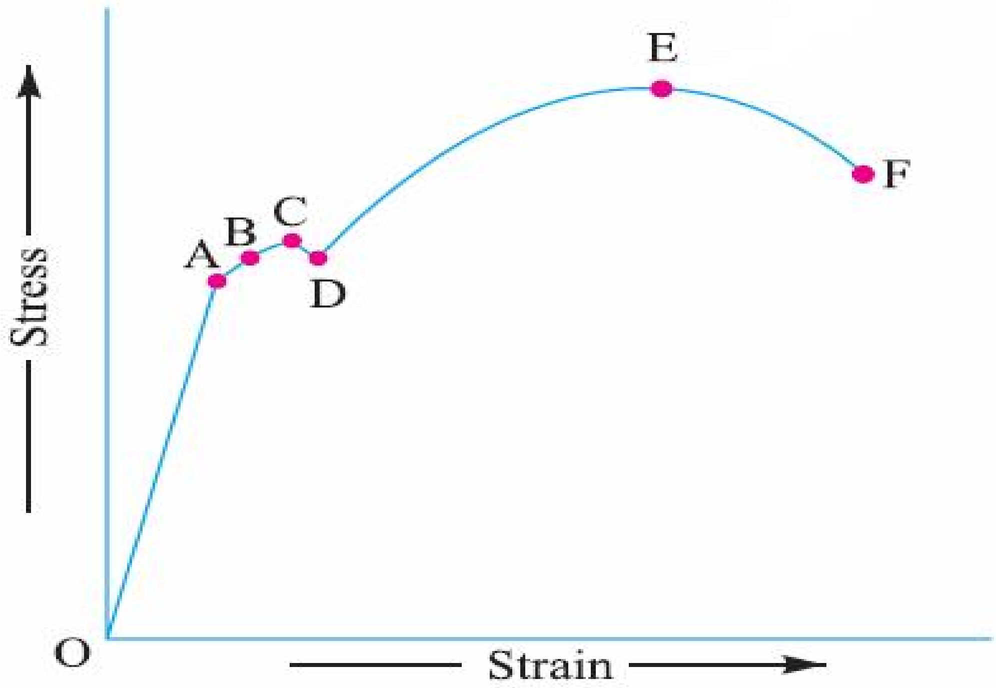
Solution. Given : $t = 16$ mm ; $d = 25$ mm ;
$P = 48$ kN $= 48 \times 10^3$ N



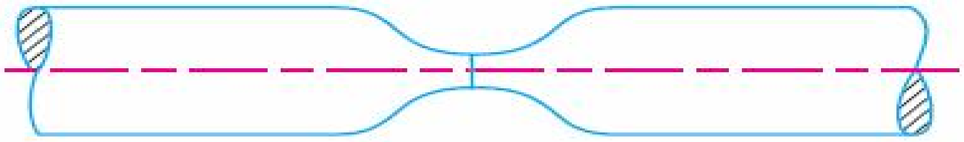
Since the joint is double riveted, therefore, strength of two rivets in bearing (or crushing) is taken. We know that crushing stress induced between the plates and the rivets,

$$\sigma_c = \frac{P}{d.t.n} = \frac{48 \times 10^3}{25 \times 16 \times 2} = 60 \text{ N/mm}^2 \textbf{ Ans.}$$

Stress-strain Diagram



(a)



(b) Shape of specimen after elongation.

Percentage reduction in area. It is the difference between the original cross-sectional area and cross-sectional area at the neck (*i.e.* where the fracture takes place). This difference is expressed as percentage of the original cross-sectional area.

Let A = Original cross-sectional area, and

a = Cross-sectional area at the neck.

Then reduction in area $= A - a$

and percentage reduction in area $= \dfrac{A - a}{A} \times 100$

Percentage elongation. It is the percentage increase in the standard gauge length (*i.e.* original length) obtained by measuring the fractured specimen after bringing the broken parts together.

Let l = Gauge length or original length, and

L = Length of specimen after fracture or final length.

$\therefore$ Elongation $= L - l$

and percentage elongation $= \dfrac{L - l}{l} \times 100$

Working Stress

When designing machine parts, it is desirable to keep the stress **lower** than the **maximum or ultimate stress** at which failure of the material takes place. This stress is known as the **working stress or design stress**. It is also known as safe or **allowable stress**.

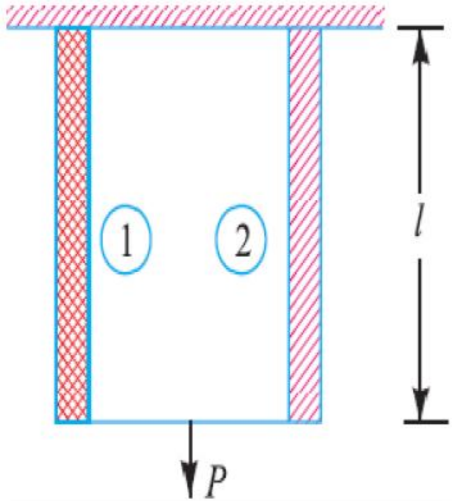
Factor of Safety

Factor of safety (n) ≥ 1

It is defined, in general, as the **ratio of the maximum stress to the working stress.** Mathematically,

$$\text{Factor of safety} = \frac{\text{Maximum stress}}{\text{Working or design stress}}$$

Stress in Composite Bars



1. The extension or contraction of the bar being equal, the strain *i.e.* deformation per unit length is also equal.
2. The total external load on the bar is equal to the sum of the loads carried by different materials.

$$P = P_1 + P_2 \qquad \delta l_1 = \delta l_2$$

$$\varepsilon = \frac{\sigma_1}{E_1} = \frac{P_1}{A_1 . E_1}$$

$$\delta l_1 = \frac{P_1 . l}{A_1 . E_1} \qquad \delta l_2 = \frac{P_2 . l}{A_2 . E_2}$$

$$\delta l_1 = \delta l_2$$

$$\frac{P_1 . l}{A_1 . E_1} = \frac{P_2 . l}{A_2 . E_2} \quad \text{or} \quad P_1 = P_2 \times \frac{A_1 . E_1}{A_2 . E_2}$$

Stresses due to Change in Temperature - Thermal Stresses

Let l = Original length of the body,

t = Rise or fall of temperature, and

α = Coefficient of thermal expansion,

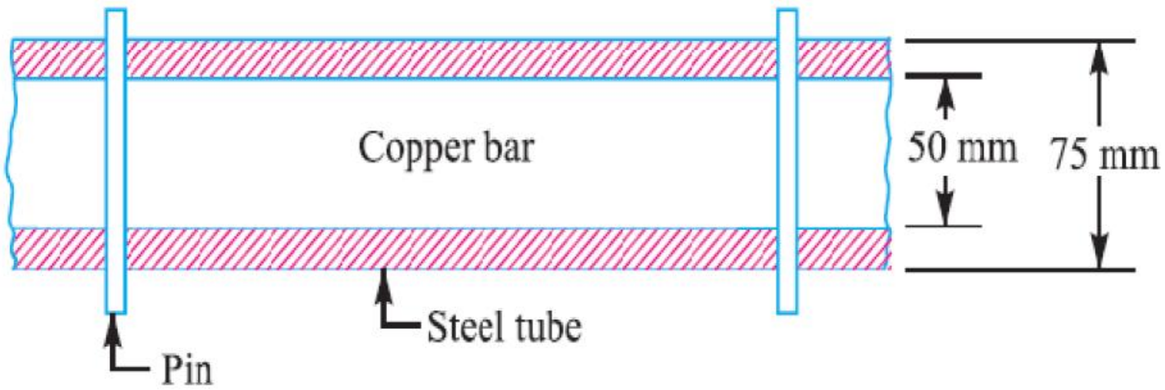
$\therefore$ Increase or decrease in length,

$$\delta l = l.\alpha.t$$

If the ends of the body are fixed to rigid supports, so that its expansion is prevented, then compressive strain induced in the body,

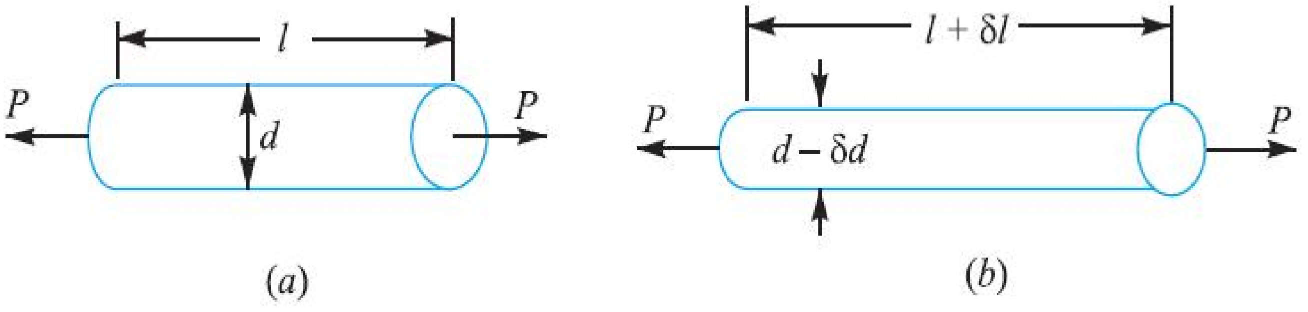
$$\varepsilon_c = \frac{\delta l}{l} = \frac{l.\alpha.t}{l} = \alpha.t$$

$\therefore$ Thermal stress, $\sigma_{th} = \varepsilon_c.E = \alpha.t.E$



Linear and Lateral Strain

Consider a circular bar of diameter *d* and length *l*, subjected to a tensile force *P* as shown in this Figure.



Poisson's Ratio

$$\frac{\text{Lateral strain}}{\text{Linear strain}} = \text{Constant}$$