UNIT-4

DESIGN OF SPRINGS

Spring:-

Spring is defined as elastic or resilent body whose function is to deflect or deform when load is applied and recover is original position when load is removed

To apply force

- Spring is clutches, brakes
- Spring loaded valves.

To measure force

- Spring balance.

To store energy

- Spring in toys, watches.

To absorb shocks and vibrations.

Types of Springs.

- Helical compression and tension
- Disc spring (or) Bellevel spring
- Leaf (or) Laminated spring
- Torsion spring.

Buckling of Springs:-

Free length of helical compression spring is too large compared to mean coil diameter. The spring act as a flexible column, and buckle under the action of axial load.

In order to avoid the buckling of spring must satisfy the following conditions

$$\frac{L}{D} < \frac{\pi}{\alpha_i}\left[\frac{2(E-G)}{2G+E}\right]^{1/2}$$ (Slenderness ratio)

α – n condition constant for helical compression spring

1 It is required to design a helical compression spring made of oil harden & tempered steel carrying a maximum static load of 1000 N. Maximum deflection is 25 mm. The ultimate ~~tensile strength~~ shear stress and modulus of rigidity of springs are 420 N/mm² & 84 kN/mm² respectively. Spring index is 5. Determine wire diameter, Mean coil diameter. Total number of coils. Total no. of active coils, free length, solid length & pitch. Draw the neat sketch of spring and give the necessary dimension

Given:

$P = 1000\ N$

$G = 84\ kN/mm^2$

$\tau = 420\ N/mm^2$

$C = 5$

$Y_{max} = 25\ mm$

$q = \frac{P_{max}}{\delta_{max}}$

$= \frac{1000}{25}$

$= 40 \, N/mm.$

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Wahl's stress factor.

$K_s = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

$= \frac{19}{16} + \frac{0.615}{5}$

$= 1.3105$

$\tau = \frac{8PC}{\pi d^2} K_s$

$420 = \frac{8 \times 1000 \times 5}{\pi d^2} \times 1.3105$

$d^2 = \frac{8 \times 1000 \times 5 \times 1.3105}{\pi \times 420}$

$d = 7 \, mm$

$C = D/d$

$D = C \times d$

$= 5 \times 7$

$= 35 \, mm.$

$$q = \frac{Gd}{8C^3 n}$$

$$n = \frac{Gd}{q 8 C^3}$$

$$= \frac{84 \times 10^3 \times 7}{40 \times 8 \times 5^3}$$

$n = 15$

End - Plain and Ground.

Total coils $n' = n$

$= 15$

Solid length $L_s = dn$

$= 7 \times 15$

$= 105\,mm$

$l_f = l_s + y + (n'-1) \times$ gap btwn two coils

$= 105 + 25 + (15-1) \times 1$

$= 144\,mm$

$l_f = pn$

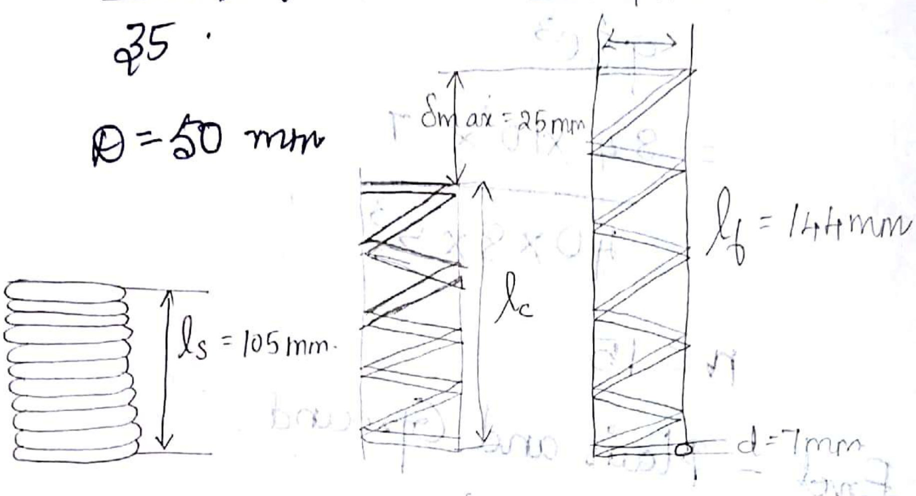
$144 = p \times 15$

$p = 9.6\,mm$.

$\frac{l_f}{D} < 3$

$\frac{144}{35} \approx 4.114$

$D = 50$ mm



1. Spring loaded safety valves is required to blow off at the pressure of 1.5 N/mm². Diameter of valve is 60 mm. Maximum lift of the valve is 15 mm. Design a suitable helical spring for the safety valve for the following data. Initial compression of spring is 25 mm.

Given

$P_1 = 1.5$ N/mm²

$d_v = 60$ mm.

$P = W/A$

$W = P \times A$

$\delta_{max} = 25 + 15$
$= 40$ mm

$A_v = \frac{\pi d_v^2}{4}$

$= \frac{\pi \, 60^2}{4}$

$= 2827.4$ mm².

$W = A_v \cdot P_1$
$= 4241.1$ N

Spring index = 6

Modulus of rigidity = 0.84×10^5 MPa

Allowable shear stress

$$\tau = K_s \frac{8PC}{\pi d^2}$$

$$K_s = \frac{4C-1}{4C-4} + \frac{0.615}{C}$$

$$= \frac{23}{20} + \frac{0.615}{6}$$

$$= 1.2525$$

$$450 = \frac{1.25 \times 8 \times 4241 \times 6}{\pi d^2}$$

$$d^2 = 179.9$$

$$d = 13.4 \text{ mm}$$

$$C = D/d$$

$$D = 80 \text{ mm}$$

$$q = \frac{P_{max}}{\delta_{max}}$$

$$= \frac{4241}{40}$$

$$= 106 \text{ N-mm}$$

$$q = \frac{Gd}{8C^3 n}$$

$$106 = \frac{0.84 \times 10^5 \times 13.4}{8 \times 6^3 \times n}$$

$$n = 6 \text{ turns}$$

Square and Grooved end

$n' = n+2$

$= 6+2$

$= 8$ turns.

$l_s = d(n+2)$

$= 14(8)$

$= 112$ mm.

$l_f = l_s + \delta_{max} + (n'-1)$ gap between the coils

$= 112 + 40 + 7 \times 1$

$= 159$ mm.

$l_f = pn + 2d$

$159 = p \times 6 + 2 \times 14$

$= 6p + 28$

$p = 22$ mm

pitch = $\frac{\text{Free length}}{(N_t - 1)}$

$= \frac{159}{7}$

1. A helical compression spring is to be designed for the operating load of range of 90 N to 135 N and deflection for variable load is 7.5 mm. Permissible shear stress for spring materials is 480 N/mm². The modulus of rigidity is 0.8×10^5 N/mm². Spring index $C = 10$. Design the spring.

$P_{max} = 135$ N

$P_{min} = 90$ N

$\delta = 7.5$ mm

$\tau = 480$ N/mm²

$G = 1.8 \times 10^5$ N/mm²

$C = 10$

Solution :-

Coil diameter

$$\tau = K_s \frac{8 P_{max} C}{\pi d^2}$$

$$K_s = \frac{4C-1}{4C-4} + \frac{0.615}{C}$$

$$= \frac{39}{36} + \frac{0.615}{10}$$

$$K_s = 1.144$$

$$480 = (1.144) \frac{8 \times 135 \times 10}{\pi d^2}$$

$$d = 2.86 \text{ mm.}$$

Active coil

$$q = \frac{Gd}{8C^3 n}$$

$$q = \frac{P_{max} - P_{min}}{\delta}$$

$$q = \frac{135 - 90}{7.5}$$

$$= 6$$

$$q = \frac{P_{max}}{\delta_{max}}$$

$$6 = 135 / \delta_{max}$$

$$6 = \frac{1.8 \times 10^5 (2.86)}{8 (10)^3 n}$$

$n = 4.76$

$n = 5$ coils.

End Condition.

Squared and Ground.

Total coils $n' = n + 2$

$= 7$

Solid length