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Applications of springs

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Applications of springs

Expression for deflection of spring

Now length of one coil $= \pi D$ or $2\pi R$

$\therefore$ Total length of the wire $=$ Length of one coil $\times$ No. of coils or $l = 2\pi R \times n$.

As the every section of the wire is subjected to torsion, hence the strain energy stored by the spring due to torsion is given by equation (16.20).

$\therefore$ Strain energy stored by the spring,

$$U = \frac{\tau^2}{4C} \, . \, \text{Volume} = \frac{\tau^2}{4C} \, . \, \text{Volume}$$

$$= \left(\frac{16W.R}{\pi d^3}\right)^2 \times \frac{1}{4C} \times \left(\frac{\pi}{4} d^2 \times 2\pi R.n\right)$$

$$\left(\because \quad \tau = \frac{16WR}{\pi d^3} \text{ and Volume} = \frac{\pi}{4} d^2 \times \text{Total length of wire}\right)$$

$$= \frac{32W^2R^2}{Cd^4} .R.n = \frac{32W^2R^3 \, . \, n}{Cd^4} \qquad \text{...(16.25)}$$

Work done on the spring = Average load × Deflection

$$= \frac{1}{2} W \times \delta \qquad (\because \quad \text{Deflection} = \delta)$$

Applications of springs

Equating the work done on spring to the energy stored, we get

$$\frac{1}{2}\, W.\delta = \frac{32W^2R^3\,.\,n}{Cd^4}$$

$$\therefore \qquad \delta = \frac{64WR^3n}{Cd^4} \qquad \text{...(16.26)}$$

Expression for stiffness of spring

The stiffness of spring,

$$s = \text{Load per unit deflection}$$

$$= \frac{W}{\delta} = \frac{W}{\dfrac{64\,.\,WR^3\,.\,n}{Cd^4}} = \frac{Cd^4}{64\,.\,R^3\,.\,n} \qquad \text{...(16.27)}$$

Note. The solid length of the spring means the distance between the coils when the coils are touching each other. There is no gap between the coils. The solid length is given by

$$\text{Solid length} = \text{Number of coils} \times \text{Dia. of wire} = n \times d \qquad \text{...(16.28)}$$

Applications of springs

Problem 16.35. *A closely coiled helical spring is to carry a load of 500 N. Its mean coil diameter is to be 10 times that of the wire diameter. Calculate these diameters if the maximum shear stress in the material of the spring is to be 80 N/mm².*

Sol. Given :

Load on spring, $W = 500$ N

Max. shear stress, $\tau = 80$ N/mm²

Let d = Diameter of wire

D = Mean diameter of coil

∴ $D = 10\,d$.

Using equation (16.24), $\tau = \dfrac{16WR}{\pi d^3}$

$$80 = \frac{16 \times 500 \times \left(\frac{D}{2}\right)}{\pi d^3}$$

$$= \frac{8000 \times \left(\frac{10d}{2}\right)}{\pi d^3}$$

$$80 \times \pi d^3 = 8000 \times 5d$$

$$d^2 = \frac{8000 \times 5}{80 \times \pi} = 159.25$$

$$d = \sqrt{159.15} = 12.6 \text{ mm} = \mathbf{1.26\ cm.} \quad \text{Ans.}$$

$$D = 10 \times d = 10 \times 1.26 = \mathbf{12.6\ cm.} \quad \text{Ans.}$$

Problem 16.39. *A closely coiled helical spring of mean diameter 20 cm is made of 3 cm diameter rod and has 16 turns. A weight of 3 kN is dropped on this spring. Find the height by which the weight should be dropped before striking the spring so that the spring may be compressed by 18 cm. Take $C = 8 \times 10^4$ N/mm².*

Sol. Given :

Mean dia. of coil, $D = 20$ cm $= 200$ mm

$\therefore$ Mean radius of coil, $R = \frac{200}{2} = 100$ mm

Dia. of spring rod, $d = 3$ cm $= 30$ mm

Number of turns, $n = 16$

Weight dropped, $W = 3$ kN $= 3000$ N

Compression of the spring, $\delta = 18$ cm $= 180$ mm

Modulus of rigidity, $C = 8 \times 10^4$ N/mm²

Let h = Height through which the weight W is dropped

W = Gradually applied load which produces the compression of spring equal to 180 mm.

Now using equation (16.26),

$$\delta = \frac{64 W . R^3 . n}{C d^4}$$

$$\delta = \frac{64W.R^3.n}{Cd^4}$$

or $$180 = \frac{64 \times W \times 100^3 \times 16}{8 \times 10^4 \times 30^4}$$

or $$W = \frac{180 \times 8 \times 10^4 \times 30^4}{64 \times 100^3 \times 16} = 11390 \text{ N}$$

Work done by the falling weight on spring

$$= \text{Weight falling } (h + \delta) = 3000\,(h + 180) \text{ N-mm}$$

Energy stored in the spring $= \frac{1}{2}\, W \times \delta$

$$= \frac{1}{2} \times 11390 \times 180 = 1025100 \text{ N-mm.}$$

Equating the work done by the falling weight on the spring to the energy stored in the spring, we get

$$3000(h + 180) = 1025100$$

or $$h + 180 = \frac{1025100}{3000} = 341.7 \text{ mm}$$

$\therefore$ $$h = 341.7 - 180 = \mathbf{161.7 \text{ mm.}}$$ **Ans.**


Thank You