EXPERIMENT NO. 3(A)
HELICAL SPRING TEST

OBJECTIVE

a. To find the stiffness of the spring.

b. To draw a curve by plotting load against deflection and find the stiffness and modulus of rigidity of the spring from the L-δ curve.

c. To compare theoretical and experimental stiffness and also modulus of rigidity.

d. To find the shear stress induced in the spring.

THEORY

Springs are machine/structure components which undergo significant deformation when loaded and their compliance enables them to store readily recoverable mechanical energy. A spring formed by winding wire into a helix along the surface of a cylinder is called helical spring.

If a helical spring of circular cross section is subjected to an axial load, any section of the spring will develop shear stresses and of these shear stresses the greater part is torsional stress.

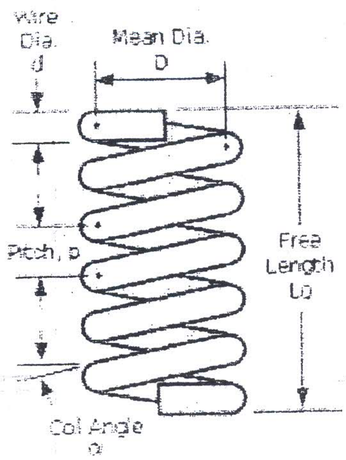


Fig: Helical Spring Geometry

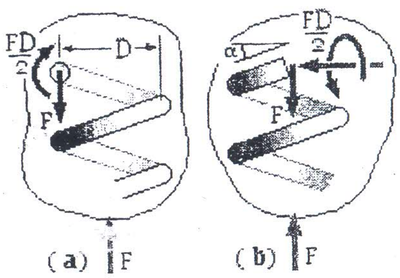


Fig: Free body of spring

Total shear stress is given by

$$\tau_t = \tau_d + \tau_t = F/A + Tr/J = F/A(1+2R/r)$$

Deflection of the helical spring is given by, $\delta = 8FD^3N_a / Gd^4$

Stiffness, $F/\delta = Gd^4/8D^3N_a$

Where

τ_d = Direct shear stress

τ_t = Torsional shear stress

F = Axial Load

A = Cross sectional area of the wire

T = Torsion = FD/2

G = Modulus of rigidity

$J = \pi r^4/2 = \pi d^4/32$ = Polar moment of inertia

$d = 2r$ = Dia. of wire spring

r = Wire radius

D = Mean diameter of the spring

R = Mean radius of the spring

$N_a = N_t - N_d$ = No of active turns in the spring

N_t = No. of total coils

N_d = No. of inactive coils (depends on end condition)

APPARATUS

a. Instron machine

b. Height Gage

PROCEDURE

a. Measure the diameter of the spring wire and note the number of turns (N).

b. Measure the outer or inner diameter of the spring and hence find the mean radius of the spring.

c. Place the spring in proper position inside the compression gauge and start the instron machine.

d. Place height gauge by the side of the spring and locate a convenient reference position of the spring.

e. At no load record the height gage reading. Apply load continuously and uniformly at an interval of 5 kg. and record the height gauge reading corresponding to the reference position.

f. Perform the experiment for both load increasing and load decreasing.

g. Plot Load-deflection curve in a graph paper and calculate the stiffness of the spring.

EXPERIMENTAL DATA

Height of the Spring (free length), L :

Diameter of Spring Wire, d :

No. of active Turns, N_a :

Outer diameter of spring, D_o :

Inner diameter of spring, D_i :

Mean radius of spring, R :

Height gauge constant :

Obs.	Load	Increasing Load			Decreasing Load		
		Initial height gauge reading (IHG)	Height gauge reading (HG)	Deflection of spring (HG-IHG)	Initial height gauge reading (IHG)	Height gauge reading (HG)	Deflection of spring (HG-IHG)

EXPERIMENT NO. 3(B)

HYDROSTATIC PRESSURE TEST OF THIN WALLED CYLINDER

OBJECTIVE

1. To find the value of the bursting pressure of the PVC pipe.
2. Compare the theoretical bursting pressure with that of the experimental value.
3. Calculate the tensile strength of the pipe material from the bursting pressure.
4. Observe the type of failure and schematically show how it failed.

THEORY

A pressure vessel is a container that holds a liquid, vapor, or gas at a different pressure other than atmospheric pressure at the same elevation. There are many types of pressure vessels. Cylinders are usually considered to be thin if $D/t \geq 20$.

The stress state in the wall is essentially triaxial and initial analysis gives the principal components without need for resolution :

a. Axial Stress σ_a, sometimes called the *longitudinal stress,*
b. Tangential Stress, σ_h, also referred to as the *hoop* or *circumferential stress,*
c. Radial stress, σ_r. . . all of which are taken to be positive tensile.

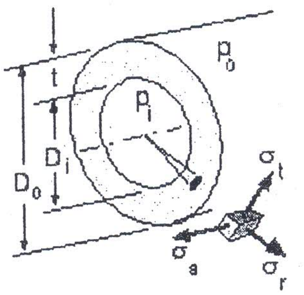
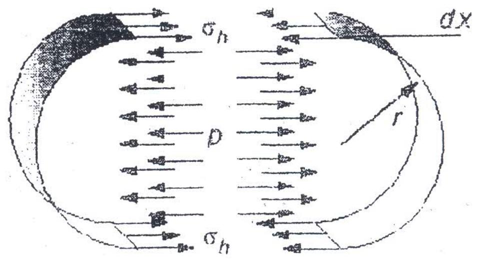


Fig : Stress developed in the wall of a pressure vessel

Stresses are assumed uniform along the wall thickness. For thin walled cylinder (or pipe) radial stress is negligible and may fail either by either of the two modes.

i. Due to circumferential (hoop) stress

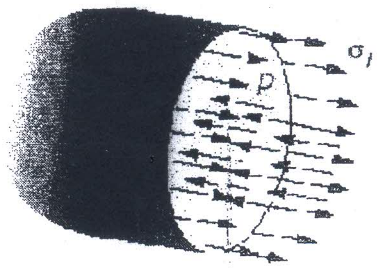


The hoop stress yields, $2.\sigma_h.t.dx = P.2.r.dx = P.D.dx$

$\sigma_h = PD/2t$ ....(1)

Where P = internal pressure, D = Diameter and t = thickness.

ii. Due to longitudinal normal stress:



The longitudinal stress is given by

$\sigma_l .t.2\pi r = P.\pi r^2$

$\sigma_l = PD/4t$ ....(2)

Comparing (1) and (2), it is obvious that if the material is homogeneous then for the same pressure $\sigma_l = 0.5\sigma_h$. So the pressure vessel will usually burst due to the circumferential stress.

APPARATUS

1. PVC pipe testing bed.
2. Thermometer.
3. Slide calipers.
4. Stop watch.

PROCEDURE

1. Record the day temperature.
2. Measure outside diameter and thickness of the PVC pipe.
3. Apply hydrostatic pressure by means of the hydraulic loading unit.
4. Pressure will gradually increase and reach a maximum value. As soon as the pressure starts the stop watch.
5. Record the pressure at which failure occurs.
6. Stop the stop watch at the failure point. Note the time between maximum pressure and failure.
7. Observe the type of failure.

RESULTS AND DISCUSSION

1. Identify the type of failure and draw a sketch of the failure.
2. Draw a line diagram of the experimental set up.
3. Calculate the longitudinal (meridional) and circumferential (hoop) normal stresses in the walls at the time of bursting.
4. What will be the effect on the failure pressure if the temperature changes?
5. Discuss how the rate of loading can affect the failure pressure.
6. What will be the failure pressure of the test specimen if it is subjected to uniform external hydrostatic pressure?
7. The time calculated in step 6 of procedure has some relation with the ductility of the material –discuss.
8. Critically discuss the experimental set up and suggest ways for its improvement.