WORK DONE PER UNIT VOLUME IN DEFORMING A BODY

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Whenever a body is deformed by the application of an external force the body gets strained.

The work done is stored in the body in the form of energy called elastic potential energy or the energy of strain.

There are three types of strain

i)Longitudinal

ii)Volume

iii)Shearing

Work done per unit volume for longitudinal strain

When a wire of length L and area of cross section A is stretched by a force F,acting along its length,the elongation produced is *l*.

$$Y = \frac{stress}{strain} = \frac{F/A}{l/L} = \frac{FL}{Al}$$

$$F = \frac{YAl}{L}$$

$$\frac{F}{A} = \frac{Yl}{L}$$

For small increase in length dl,the work done is given by

$$dW = Fdl = \frac{YAl}{L} dl$$

$$W = \int dW = \int_0^l \frac{YAl}{L} dl = \frac{YAl^2}{2L}$$

Where W is the total work done in increasing the length of the wire by an amount l .

Volume of the wire =AL

$$Work\ done\ per\ unit\ volume = \frac{YAl^2}{2LAL} = \frac{YAl^2}{2AL^2} = \frac{Yl^2}{2L^2} = \frac{1}{2}\frac{Yl}{L}\frac{l}{L}$$

Energy/Work done per unit volume=½ stress x linear strain

Similarly for volume strain

Energy/Work done per unit volume=½ stress x Volume strain

For shearing strain

Energy/Work done per unit volume=½ stress x Shearing strain

1. Calculate the elastic energy stored up in a wire originally 5 meters long and 10^{-3} m in diameter which has been stretched by 3×10^{-4}m due to a load of 10 kg.($g=9.8m/s^2$)

Elastic energy stored=$YAl^2/2L$ or ½ Force x extension

$L=5m$, $l=3 \times 10^{-4}m$, $F=10 \times 9.8= 98N$

Elastic energy stored=$\frac{1}{2} \times 98 \times 3 \times 10^{-4}= .0147J$

2. Find the work done per unit volume in stretching a wire of 1 sq mm cross section and 2m long through .1mm.
$Y=2 \times 10^{11}$ pa

Work done per unit volume=½ stress x strain

strain=l/L=.1 x 10-3/2=.05 x 10-3=5 x 10^{-5}

Stress=Y x strain=2 x 10^{11} x 5 x 10^{-5}=10^{7}N/m^2

Work done per unit volume=½ x 5 x 10^{-5} x 10^{7}=2.5 x 10^{2}J

THANK YOU