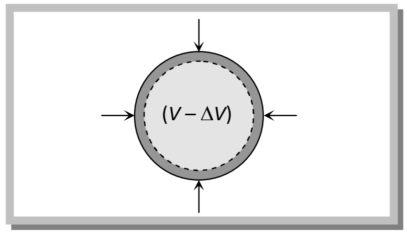
Bulk Modulus.

When a solid or fluid (liquid or gas) is subjected to a uniform pressure all over the surface, such that the shape remains the same, then there is a change in volume.

Then the ratio of normal stress to the volumetric strain within the elastic limits is called as Bulk modulus. This is denoted by K.



$$K = \frac{\text{Normal stress}}{\text{volumetric strain}}$$

$$K = \frac{F/A}{-\Delta V/V} = \frac{-pV}{\Delta V}$$

Where p = increase in pressure; V = original volume; ΔV = change in volume

The negative sign shows that with increase in pressure p, the volume decreases by ΔV i.e. if p is positive, ΔV is negative. The reciprocal of bulk modulus is called compressibility.

C = compressibility = $\frac{1}{K} = \frac{\Delta V}{pV}$

S.I. unit of compressibility is N–1m2 and C.G.S. unit is dyne–1 cm2.

Gases have two bulk moduli, namely isothermal elasticity $E\theta$ and adiabatic elasticity $E\phi$.

(1) Isothermal elasticity ($E\theta$): Elasticity possess by a gas in isothermal condition is defined as isothermal elasticity.

For isothermal process, PV = constant (Boyle's law)

Differentiating both sides PdV + VdP = 0 $\Rightarrow$ PdV = – VdP

$$P = \frac{dP}{(-dV/V)} = \frac{\text{stress}}{\text{strain}} = E_\theta$$

$\therefore E\theta = P$

i.e., Isothermal elasticity is equal to pressure.

(2) Adiabatic elasticity ($E\phi$): Elasticity possess by a gas in adiabatic condition is defined as adiabatic elasticity.

For adiabatic process, PV^γ = constant (Poisson's law)

Differentiating both sides, $P\gamma V^{\gamma-1}dV + V^\gamma dP = 0 \Rightarrow \gamma PdV + VdP = 0$

$$\gamma P = \frac{dP}{\left(\frac{-dV}{V}\right)} = \frac{\text{stress}}{\text{strain}} = E_\phi$$

$\therefore$ $E\phi = \gamma P$

i.e., adiabatic elasticity is equal to γ times pressure. [Where $\gamma = \frac{C_p}{C_v}$]

Note: Ratio of adiabatic to isothermal elasticity $\frac{E_\phi}{E_\theta} = \frac{\gamma P}{P} = \gamma > 1$ $\therefore$ $E\phi > E\theta$

i.e., adiabatic elasticity is always more than isothermal elasticity.