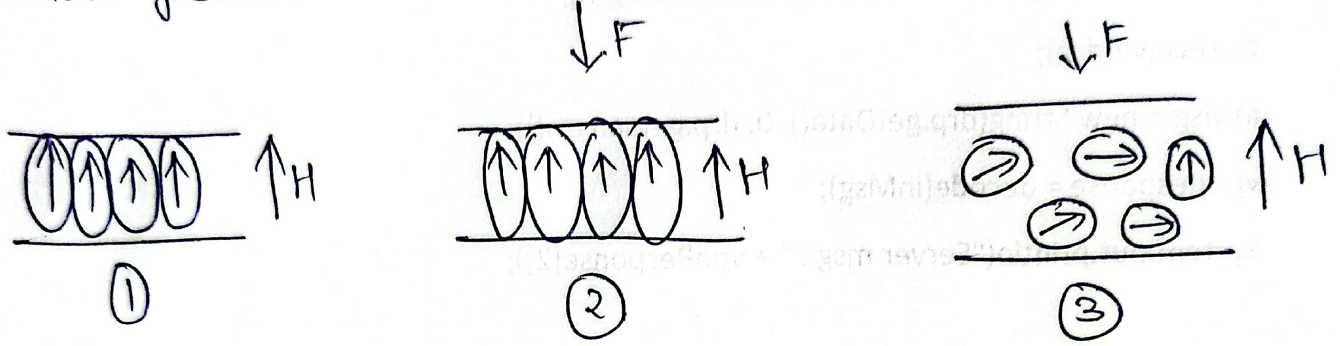
⇒ Villari Effect -

* when an external magnetic field is applied to a ferromagnetic material, the dipoles get arrayed in the same direction.

* now, when an external force is applied in the direction opposite to magnetic field, the dipoles get distorted.

* the force changes the direction and structure of the dipole in a random fashion.



* formula,

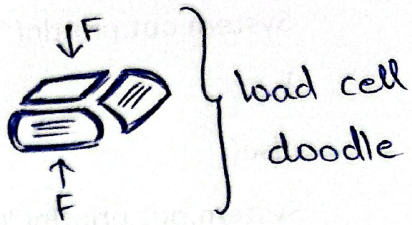
$$\Rightarrow \quad T = \frac{C\pi\phi}{32l}\left(D_o^4 - D_i^4\right)$$

T → torque
D_i → inner diameter
D_o → outer diameter
ϕ → angle
l → length of shaft.

* maximum stress, $S_m = \dfrac{16 D_o T}{\pi\left(D_o^4 - D_i^4\right)}$

⇒ Load Cell & it's types -

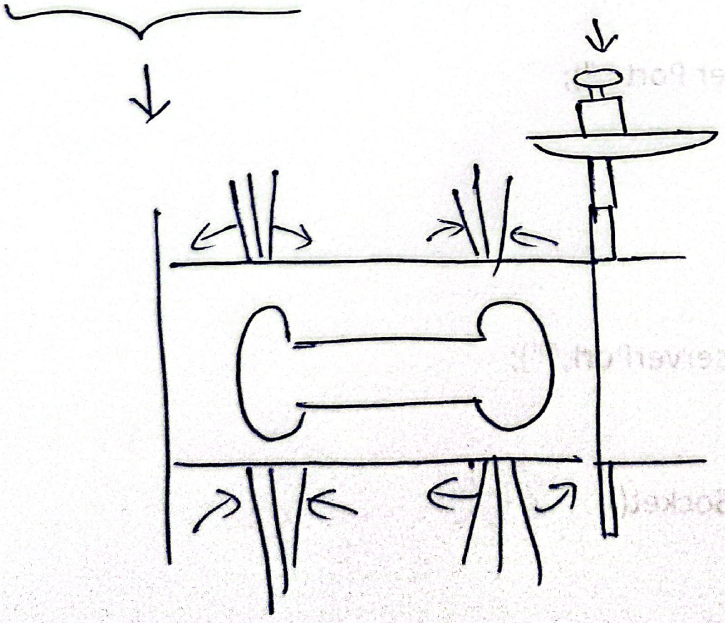
* electromechanical device.
* force transducer (force → electric signal)
* measures force, torque, pressure
* types - ① mechanical
② electrical.



* mechanical - ① hydraulic load cell
② pneumatic " "

* electrical - ① strain gauge load cell (resistance based)
② capacitance based " "
③ LVDT " " (inductance based)

* strain gauge → most common.



⇒ Tachometer -

* measures rotational speed.
* tachometers can be classified based on -
  1. data acquisition (contact, non-contact)
  2. data type (analog, digital)
  3. power (mechanical, electrical)
* majorly used ⇒ mechanical, electrical, non-contact.

① Mechanical Tachometers -

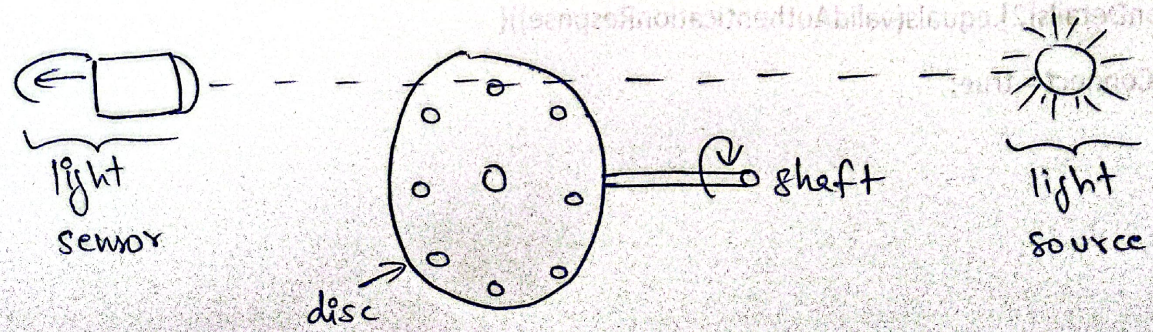
* Revolution counter
* Hand speed indicator
* Tachoscope
* Centrifugal Tachometer
* Resonance Tachometer

② Electrical Tachometers -

* Eddy current / Drag cup tachometer
* Tachogenerator (AC & DC)

③ Contactless Tachometers -

* magnetic pickup tachometer
* photo-electric tachometer
* stroboscope



⇒ film sensor -

* basically smart sensors
* produced by depositing films of different thickness on appropriate substrates.
* have varying electrical and mechanical properties.
* types - ① thick film ② thin film.

Thick film -

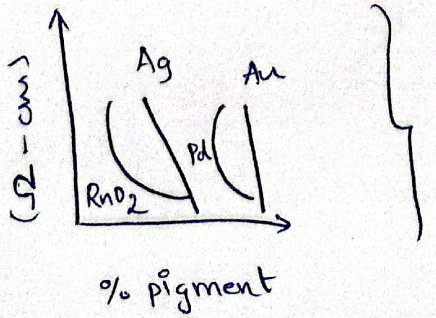
* used for producing resistors, capacitors and conductors.
* process - ① select and prepare the substrate
② prepare the coating material in paste/paint form
③ paste/paint the material on substrate
④ firing the sample produced in ③ in oxidising atmosphere at programmed temperature format.

* used substrates - ① Alumina - 9.5 6.5×10^{-6} 0.36 W/cm
② Beryllia - 7 7.5×10^{-6} 2.5 W/cm

(9.5 / 7 : dielectric constant; 6.5×10^{-6} / 7.5×10^{-6} : thermal expansion co-efficient; 0.36 W/cm / 2.5 W/cm : thermal conductivity.)

* there should be no difference btw thermal conductivities of substrate & the coated material which would cause stress and leads to zero offset, instability.

* applications - ① temperature sensing → thermophiles, thermistors (Au, Pt, Mn, Co)
② pressure " → $Al_2O_3 + Bi_2Ru_2O_7$
③ gas " → $SnO_2 + Pd$; hydrophobic $SiO_2 \cdot H_2$
④ humidity " → resistive film, capacitive film
⑤ industry → ceramic - metal with Au/Ag oxide.



} variation graph.