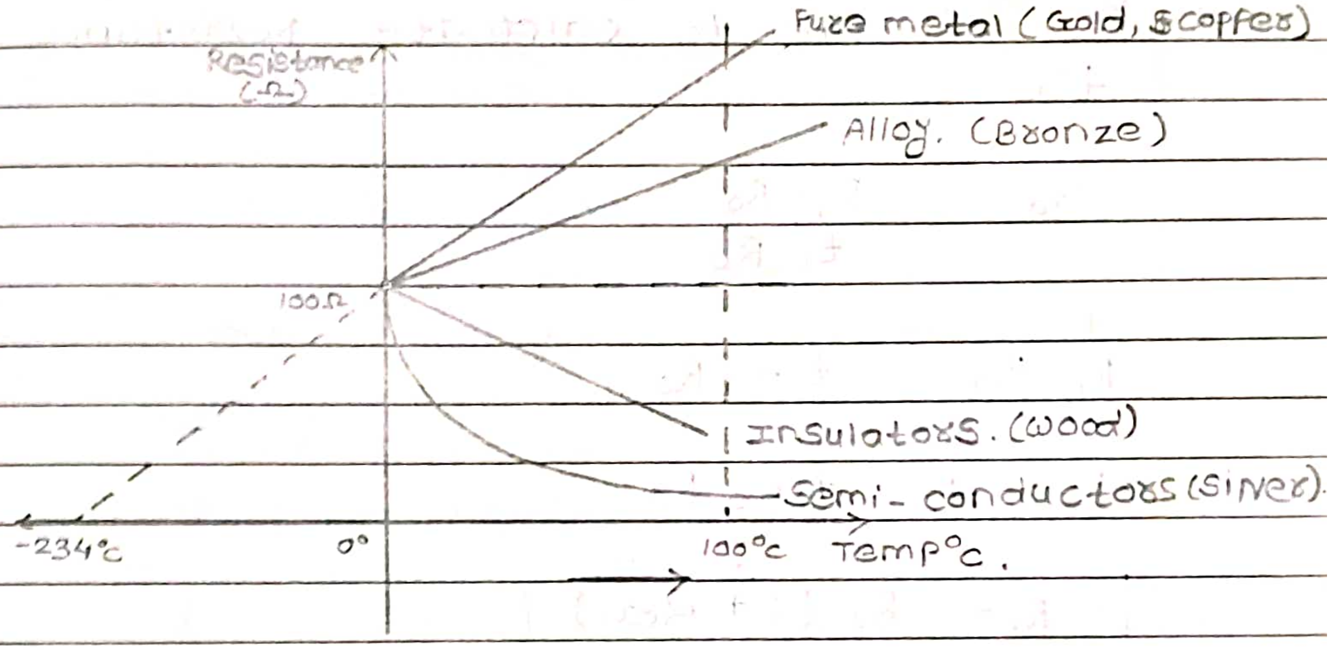
unit - 6

Work Power & energy.

* Resistance : $R = \frac{\rho l}{A}$

* Effect of Temp. on Resistance Value for different material

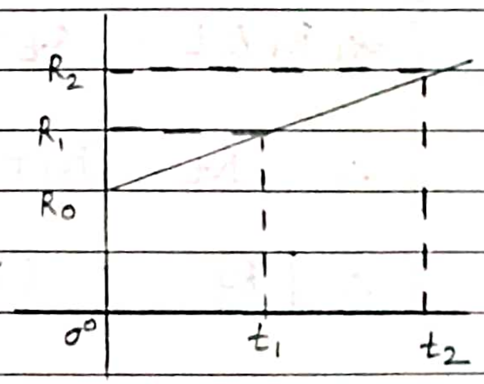


* RTC (Resistance Temp. coeff.)

The Ratio of change in Resistance per °C to the Resistance at t°c.

$$\alpha = \frac{\Delta R \text{ per } ^\circ c}{R \text{ at } t^\circ c} \quad /^\circ c.$$

$$\therefore \alpha_1 = \frac{\left(\frac{R_2 - R_1}{t_2 - t_1}\right)}{R_1}$$



$$\alpha_0 = \frac{\left(\frac{R_1 - R_0}{t_1 - 0}\right)}{R_0}$$

$$\text{Slope} = \frac{R_2 - R_1}{t_2 - t_1} = \frac{y_2 - y_1}{x_2 - x_1}.$$

$\therefore \boxed{\alpha_t = \frac{\text{Slope of Graph}}{R \text{ at } t^\circ c} /^\circ c.}$

* Use of RTC to calculate Resistance at $t^\circ c$.

$\alpha_0 = \frac{R_1 - R_0}{t_1 \cdot R_0}$

$R_1 - R_0 = t_1 \alpha_0 R_0$

$R_1 = R_0 + t_1 \alpha_0 R_0$

$\boxed{\therefore R_1 = R_0 (1 + \alpha_0 t_1)}$

If R_1 = Resistance value at $t_1^\circ c$
R_t = —II— at $t^\circ c$

$\alpha_1 = \frac{\frac{R_t - R_1}{t - t_1}}{R_1}$ $\quad \therefore \alpha_1 = \frac{R_t - R_1}{R_1 \cdot \Delta t}$

$\alpha_1 R_1 \Delta t = R_t - R_1$

$\therefore R_t = R_1 + \alpha_1 R_1 \Delta t$

$\therefore \boxed{R_t = R_1 (1 + \alpha_1 \Delta t)}$

$\therefore \boxed{R_{final} = R_{intial} (1 + \alpha_{intial} \cdot \Delta t)}$

** Effect of Temp on RTC
Temp ↑↑↑ RTC ↓↓↓ (Always).

* case 1 :- from $t_1^\circ c$ to $t_2^\circ c$

$R_2 = R_1 (1 + \alpha_1 (t_2 - t_1))$ — ①

* case 2 :- from $t_2^\circ c$ to $t_1^\circ c$

$R_1 = R_2 (1 + \alpha_2 (t_1 - t_2))$ — ②

Divide eqn ① by R_2 & eqn ② by R_1

$1 = \frac{R_1}{R_2} (1 + \alpha_1 (t_2 - t_1))$ — ③

$1 = \frac{R_2}{R_1} (1 + \alpha_2 (t_1 - t_2))$ — ④

$\frac{R_2}{R_1} = 1 + \alpha_1 (t_2 - t_1)$ — ⑤ From ③.

$\frac{R_2}{R_1} = \frac{1}{1 + \alpha_2 (t_1 - t_2)}$ — ⑥

$1 + \alpha_1 (t_2 - t_1) = \frac{1}{1 + \alpha_2 (t_1 - t_2)}$

After further solving,

$\alpha_2 = \frac{\alpha_1}{1 + \alpha_1 (t_2 - t_1)}$ & $\alpha_1 = \frac{\alpha_2}{1 + \alpha_2 (t_1 - t_2)}$

$\therefore \alpha_{final} = \dfrac{\alpha_{intial}}{1+\alpha_{intial}\cdot\Delta t}$

* RTC at $t^\circ c$ of Resistivity

$$\alpha_1 = \dfrac{\left(\dfrac{\rho_t - \rho_1}{t-t_1}\right)}{\rho_1} /^\circ c.$$

Q. If the Temp. coeff. of Resistance for aluminium is 0.003934 /°c at 30°c. calculate temp. coeff. of resistance at 70°c & 100°c.

→

$\alpha_{30^\circ} = 0.003934 /^\circ c$

$\alpha_{70}, \alpha_{100} = ?$

$\alpha_{final} = \dfrac{\alpha_{intial}}{1+\alpha_{intial}\cdot\Delta t}$

$\alpha_{70} = \dfrac{0.003934}{1+0.003934\times(70-30)}$

$= 0.\cancel{00399} /^\circ c$

$\alpha_{100} = \dfrac{0.003934}{1+0.003934\times(100-30)}$

$= 3.08 \times 10^{-3} /^\circ c$

Q. A coil has Resistance of 50 Ω at 25°c when it's temp is increased to 100°c resistance increases to 70 Ω. calculate Resistance temp. coeff at 25°, 100° & 0°c.

→ $R_1 = 50\ \Omega$ at $t_1 = 25^\circ c$

$R_2 = 70\ \Omega$ at $t_2 = 100^\circ c$

$R_2 = R_1(1+\alpha_1(t_2-t_1))$

$70 = 50(1+\alpha_1 75)$

$70 = 50 + 3750\alpha_1$

$\boxed{\alpha_{25} = 5.333 \times 10^{-3} /^\circ c}$

Q. A coil of insulated copper wire has resistance of 120 Ω at 25°C when the coil is connected across 220V the current after some time is 1.5 A. Calculate Temp of coil assuming Temp. coeff of Resistance of copper wire is 0.00394 /°C at 25°C.

→ $t_1 = 25°C$

$R_1 = 120\,\Omega$

$V = 220V$

$I = 1.5\,A$

$\alpha_{25°C} = 0.00394\ /°C$

$t_2 = ?$

$$R_2 = \frac{V}{I} = \frac{220}{1.5} = 146.66\,\Omega$$

$$R_{fina} = R_{intial}\,(1+\alpha_{intial}\,(t_2-t_1))$$

$$146.666 = 120\,(1 + 0.00394\,(t_2 - 25))$$

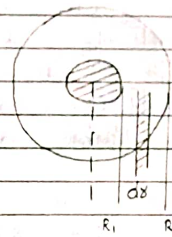
$$146.666 = 120\,(1 + 0.00394\,t_2 - 0.0985)$$

$$146.666 = 120 + 0.4728\,t_2 - 11.82$$

$$\boxed{t_2 = 81.4°C}$$

* Insulation Resistance :-

$$R_c = \frac{\rho l}{a}$$



Here

$a = 2\pi r l$

$l = dr$ ... For small part

$$\therefore R_i = \frac{\rho\, dr}{2\pi r l}$$

$$= \int_{R_1}^{R_2} \frac{\rho\, dr}{2\pi r l}$$

$$= \frac{\rho}{2\pi l}\int_{R_1}^{R_2} \frac{dr}{r} = \frac{\rho}{2\pi l}\left[\log_e r\right]_{R_1}^{R_2}$$

$$R_i = \frac{\rho}{2\pi l}\ \log_e R_2 - \log_e R_1$$

$$R_i = \frac{\rho}{2\pi l}\ \log_e \boxed{\frac{R_2}{R_1}}$$

Q. A single core cable has its conductor diameter as 5 cm & outer diameter as 7 cm, the resistivity of conductor & insulator are $1.75 \times 10^{-8}\ \Omega m$ & $9 \times 10^{12}\ \Omega m$ Respectively. Calculate resistance of conductor & insulator for cable of length 200m

→

$d_c = 5cm$ $\quad$ $d_{out} = 7cm$

$\rho_c = 1.75 \times 10^{-8}\ \Omega m.$

$\rho_i = 9 \times 10^{12}\ \Omega m$

$R_c = ?$ $\quad R_i = ?$ $\quad l = 200m.$

$\therefore R_c = \frac{\rho l}{a}$ $\quad a = \pi r^2$

$a = \pi \times (2.5 \times 10^{-2})^2$

$a = 1.963 \times 10^{-3}$

$R_c = \frac{1.75 \times 10^{-8} \times 200}{1.963 \times 10^{-3}}$

$\boxed{R_c = 1.785 \times 10^{-3}}$

$R_i = \frac{9 \times 10^{12}}{2\pi \times 200} \log_e \left[\frac{0.035}{0.025}\right]$

$\boxed{R_i = 2.4098 \times 10^{9}}\ \Omega$

* Fundamental quanties & their units.

7 Fundamental quanties

1. length
2. mass
3. luminious intensity
4. Amount of matter.
5. current
6. Time
7. Temp.

2 Supplementary quantity.
Solid angle & plane angel

Fundamental quantities are divided into 3 parts.
1. mechanical
2. electrical
3. thermal.

1. mechanical:

i] mass: Amount of matter present in body (kg).

ii] velocity

iii] acc^n: Rate of change of velocity (m/s^2)

iv) Force :- The push & pull is applied on a body due to which body will change it's state.

$F = ma$ Newton → unit.

v) weight :- Gravitational force applied on body by earth.

$\omega = mg$ unit → kg.

g → Gravitation constant = 9.81.

vi) work :- Joule → unit.

W = Force x displacement.

vii) workdone per unit time is power.

viii) Torque :- $\boxed{T = F \times R}$ Nm → unit.

* Relation betn Torque & power

$W = F \times d = 2\pi RF$

$t = \frac{60}{N}$ sec

$P = \frac{W}{t} = \frac{2\pi R \cdot F \cdot N}{60}$

$\omega = \frac{2\pi N}{60}$

$P = F \times R \times \omega$ $\boxed{P = T \times \omega}$ W.

* electrical quantities & units

① electric work :-

movement of charge in electric ckt is workdone by the circuit

$W = V \times Q.$ $I = \frac{Q}{t}$

$W = V \times It$ $\therefore Q = It$

we know $V = iR$.

$\boxed{W = I^2Rt \ J}$

② Electrical power :

Power = $\frac{\text{workdone}}{\text{time}} = \frac{W}{t} = \frac{VIt}{t} = \boxed{VI}$ watt

$= I^2R$ ω.

③ electrical energy :-

Total amt of or ability to do work is energy.

Elect. energy = Power x time
= $P \times t$

Energy = $VIt = I^2Rt$ J

1 ω-hr = 3600 J or ω-sec
1 kω-hr = 3600 $\times 10^3$ J or ω-sec.

* Thermal quantities & units.

① Heat energy :

$H = I^2 R t$ J

The flow current through any material produces heat energy.

② Specific heat capacity :-
The quantity of heat required to change the temp of 1 kg of substance by 1° K is known as specific heat capacity

$c = \frac{Q}{m \Delta t}$ J/kg-°K.

③ Sensible heat :-
Amt of heat Gain or lost by substance is known as sensible heat of substance.

Sensible heat = $mc\Delta t$ J

④ Latent heat :-
Amt of heat required to change the state of substance keeping same temp.

Latent heat = $m \times L$
↳ mass

↳ Specific ... in

derivation, formula & unit.
↳ Imp.

⑤ Specific enthalpy :- (L)
Amt of heat require to change the state of 1 kg of substance without change in temp is known as specific enthalpy

⑥ Calorific value :-
Amt of heat produce by completly burning the unit mass of substance (kJ/kg) → unit.

⑦ Water equivalent of container :-
When water is heated in a container the container is also heated to take in account of this heat water equivalent of container must be known.

$\% \eta = \frac{O/P\ P}{I/P\ P} \times 100$

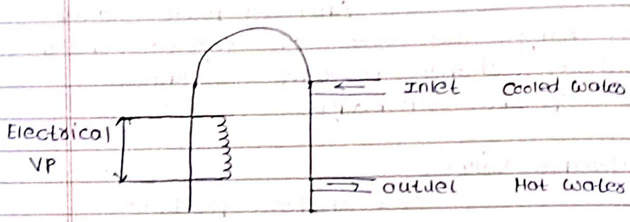
① Electrical to mechanical conversion :-

P_{in} → [Motor] — [Pump] → lifting of water
η_m η_p

② Mech to electrical.

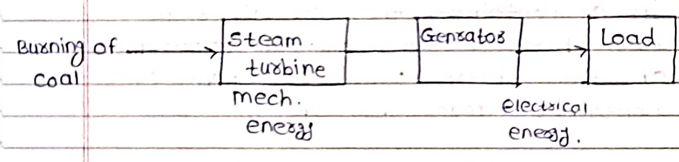
Hydro Power Plant → [Turbine] — [Generator] → Electrical O/P energy
↳ [load.]

③ Electrical to Thermal.



Ex: Gyser, Iron, Furnance.

④ Thermal to electrical:
Thermal power plant.



Q. A motor pump set lifts 1000 m^3 of water to a height of 15m /hr. if the efficiency of motor is 85% & η_p = 75%. Calculate the monthly bill of set if it is used 5hrs /per day for 30 days with the rate of 6 rs per unit.

→

m: 1000m^3

h = 15 m per hour

η_m = 85% , η_p: 75%

$$\eta_m \times \eta_p = \frac{O/P\ P}{I/P\ P}$$

$$P_{in} = \frac{P_{out}}{\eta_m \times \eta_p}$$

$$E_{out} = mgh$$
$$= 10^6 \times 9.81 \times 15$$

$$P_{out} = \frac{147.15 \times 10^6}{time} = \frac{147.15 \times 10^6}{3600}$$
$$= 40.875 \times 10^3\ \omega.$$

$$\therefore P_{in} = \frac{40.875 \times 10^3}{(0.85 \times 0.75)}$$

$$P_{in} = 64.117 \times 10^3\ \omega$$

$$P_{in} = 64.117\ kw.$$

Energy consumption per day

$= 64.117 \times 5$ kwh

$= 320.565$ kwh

Energy consumption per month

$= 320.565 \times 30$ kwh or units

$= 9617.55$ units

$\therefore$ monthly bill $= 320.585 \times 30 \times 6$

$= 57705.3$ /-.

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Date

Q. Find the current drawn by crain motor by rising the mass of 1000 kg through the Height of 25m in 20 Sec the Supply is 440 volts DC. Gear efficiency is 80% & motor efficiency is 70%.

→

Given: 1000 kg = m

$h = 25\,m$ for 20 sec

$V = 440\,V$

$I = ?$ $\quad \eta_g = 80\%$ $\quad \eta_m = 70\%$

$$E_{out} = mgh$$
$$= 1000 \times 9.81 \times 25$$
$$= 245250 \quad J$$

$$P_{out} = \frac{245250}{20} = 12262.5 \quad W$$

$$P_{in} = \frac{P_{out}}{\eta_g \times \eta_m}$$

$$P_{in} = \frac{12262.5}{0.80 \times 0.70} = 21897.321 \quad W$$

$$P_{in} = VI$$

$$21897.321 = 440 \times I$$

$$\therefore \boxed{I = 49.766 \quad A}$$