AC Generator

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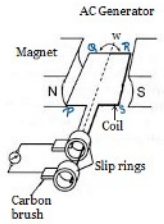
AC Generator :-

AC generator is a device which produces electrical energy from mechanical energy.

Principle :-

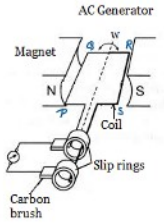
It is based on the phenomenon magnetic induction according to which whenever magnetic flux linked with a conductor or coil changes, emf is induced in the coil.

Construction :-



1. Armature : Coil PQRS consisting of large number of turns of copper wire wound over a soft iron core called armature.
2. Field Magnet : There are two poles of strong electromagnet.
3. Slip Ring : The ends of two coils connected to two hollow metallic ring 1 and 2.
4. Brushes : There are two flexible metal plates i.e. called brushes and it kept in contact with sliding ring.

Working :-



Consider a coil PQRS free to rotate in a uniform magnetic field $\vec{B}$. The axis of rotation of the coil is perpendicular to the field $\vec{B}$. The flux through a coil, when its normal makes an angle θ with field is given by :-

$$\phi_B = BA\cos\theta \quad \text{——①} \qquad A = \text{Area of coil}$$

If the coil rotates with an angular velocity ω and turns through an angle θ in time t, then

$$\theta = \omega t$$

then eqⁿ ① : $\phi_B = BA\cos(\omega t)$ ——②

As the coil rotates, the magnetic flux linked with it changes. An induced emf is setup in the coil which is given by

$$\xi = \frac{-d\phi_B}{dt}$$

$$\xi = -\frac{d}{dt}\{BA\cos(\omega t)\} \qquad \text{from eqⁿ ②}$$

$$\xi = BA\omega\sin\omega t$$

If the coil has N turns then the total induced emf will be

$$\xi = NBA\omega\sin\omega t \quad \text{——③}$$

Thus the induced emf varies sinusoidally with time t.

The value of induced emf is maximum, when $\sin\omega t = 1$ or $\omega t = 90^\circ$, denoted by $\mathcal{E}_0$

$$\mathcal{E}_0 = NBA\omega$$

Therefore,

from eqn (3) :-

$$\mathcal{E}_t = \mathcal{E}_0 \sin\omega t$$

Special Cases :-

(i) When $\omega t = 0^\circ$, the plane of the coil is perpendicular to $\vec{B}$.

$$\mathcal{E}_t = 0$$

(ii) When $\omega t = \frac{\pi}{2}$, the plane of the coil is parallel to field $\vec{B}$.

$$\mathcal{E}_t = \mathcal{E}_0 = NBA\omega$$

(iii) When $\omega t = \pi$, the plane of the coil again perpendicular to $\vec{B}$.

$$\mathcal{E}_t = 0$$

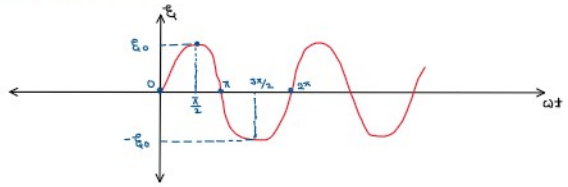
(iv) When $\omega t = \frac{3\pi}{2}$, the plane of the coil is again parallel to $\vec{B}$.

$$\mathcal{E}_t = -\mathcal{E}_0 = -NBA\omega$$

(v) When $\omega t = 2\pi$, the plane of the coil again becomes perpendicular to $\vec{B}$ after completing one rotation.

$$\mathcal{E}_t = 0$$

As the coil continously rotate in the same sense, the same cycle of changes repeats again and again, the graph between emf $\mathcal{E}$ and time ωt is a sine curve. Such an emf is called sinusoidal or alternating emf. Both the magnitude and direction of this emf changes regularly with time.



Ques. A circular coil of area 200 cm^2 and 25 turns rotates about its vertical diameter with an angular speed of 20 ms^{-1} in a uniform horizontal magnetic field of magnitude 0.05 T. The maximum voltage induced in the coil is [NCERT]

$$\mathcal{E}_0 = NBA\omega$$

$$\mathcal{E}_0 = 0.5 \text{ volt}$$

Given :-

$A = 200 \times 10^{-4}\ m^2$

$N = 25$

$\omega = 20$ m/sec

$B = 0.05T$