Define power & calculate it in ac circuit. power factor & wattless current and active component of ac :-

power in electrical circuit is defined as the rate at which electrical energy is consumed. In d.c circuits it is measured by product of voltage & current. In a.c circuits both current & voltage continuously vary with time. Thats why taking the power at any instant the power for a complete cycle is determined.

Let, the voltage & current in ac circuit is given by

$$E = E_0 \sin \omega t.$$

& $$I = I_0 \sin(\omega t - \delta)$$

$$\text{power}(P) = E \times I$$

$$= E_0 \times I_0 \sin \omega t \sin(\omega t - \delta)$$

$$= E_0 \times I_0 \sin \omega t \times [\sin \omega t \cos\delta - \cos \omega t \sin\delta]$$

$$= E_0 \times I_0 \sin^2 \omega t \cos\delta - E_0 \times I_0 \times \sin \omega t \cos \omega t \sin\delta$$

$$= E_0 \times I_0 \times \sin^2 \omega t \cos\delta - \frac{1}{2} E_0 \times I_0 \times 2 \sin \omega t \sin\delta$$

i.e. Average power for complete cycle

$$\Rightarrow \langle P \rangle = \frac{E_0 \times I_0 \cos\delta \times \int_0^T \sin^2 \omega t \, dt}{\int_0^T dt} - \frac{E_0 \times I_0 \int_0^T \sin^2 \omega t \cos\delta \, dt}{\int_0^T dt}$$

$$\therefore \langle P \rangle = \frac{E_0 \times I_0 \cos\delta \times \int_0^T \sin^2\omega t\, dt}{\int_0^T dt} - \frac{E_0 \times I_0 \int_0^T \sin^2\omega t \cdot \cos\delta\, dt}{\int_0^T dt}$$

But $\dfrac{\int_0^T \sin^2\omega t\, dt}{\int_0^T dt} = \frac{1}{2}$ & $\dfrac{\int_0^T \sin 2\omega t\, dt}{\int_0^T dt} = 0$

i.e $\boxed{\langle P \rangle = \frac{1}{2} E_0 \times I_0 \cos\delta}$

$$\Rightarrow \langle P \rangle = E_{RMS} \times I_{RMS} \times \cos\delta$$

$$\Rightarrow E_{RMS} = \frac{E_0}{\sqrt{2}} \text{ & } I_{RMS} = I_0/\sqrt{2}$$

Here $\cos\delta$ = power factor.

In a.c circuit

$$\cos\delta = \frac{R}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

$E_{RMS} \times I_{RMS}$ = called apparent power.

i.e. True average power = Apparent power × power factor

when power factor is high. most of the available energy can be used in machinery. zero power factor means the circuit contains only inductance and/or capacitance. The average power applied to such circuit is zero.

Here $E_0 I_0 \sin \omega t$ is known as wattless component. It is so because it contributes nothing to the power.

$E_0 I_0 \sin 2\omega t$ is known as active component It alone is responsible for power consumed or delivered.

It follows that in a.c. circuits value of the power can't be determined with help of ammeter or voltmeter, as in case of d.c. The power in ac circuits is only found with the help of a watt-x meter. when H (heat-produced) is proportional to square of the current.

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