to the ac line), then the lamp will glow dimly. This is because the choke coil and the iron core increase the impedance of the circuit.

(e) A choke coil is needed in the use of fluorescent tubes with ac mains because it reduces the voltage across the tube without wasting much power. An ordinary resistor cannot be used instead of a choke coil for this purpose because it wastes power in the form of heat.

Question 7.23:

A power transmission line feeds input power at 2300 V to a stepdown transformer with its primary windings having 4000 turns. What should be the number of turns in the secondary in order to get output power at 230 V?

Answer

Input voltage, V_1 = 2300

Number of turns in primary coil, n_1 = 4000

Output voltage, V_2 = 230 V

Number of turns in secondary coil = n_2

Voltage is related to the number of turns as:

$$\frac{V_1}{V_2}=\frac{n_1}{n_2}$$

$$\frac{2300}{230}=\frac{4000}{n_2}$$

$$n_2=\frac{4000\times 230}{2300}=400$$

Hence, there are 400 turns in the second winding.

Question 7.24:

At a hydroelectric power plant, the water pressure head is at a height of 300 m and the water flow available is 100 $m^3 s^{-1}$. If the turbine generator efficiency is 60%, estimate the electric power available from the plant (g= 9.8 m s^{-2}).

Answer

Height of water pressure head, h = 300 m

Volume of water flow per second, V = 100 m^3/s

Efficiency of turbine generator, n = 60% = 0.6

Acceleration due to gravity, g = 9.8 m/s^2

Density of water, ρ = 10^3 kg/m^3

Electric power available from the plant = $\eta \times h\rho gV$

= $0.6 \times 300 \times 10^3 \times 9.8 \times 100$

= 176.4×10^6 W

= 176.4 MW

Question 7.25:

A small town with a demand of 800 kW of electric power at 220 V is situated 15 km away from an electric plant generating power at 440 V. The resistance of the two wire line carrying power is 0.5 Ω per km. The town gets power from the line through a 4000-220 V step-down transformer at a sub-station in the town.

(a) Estimate the line power loss in the form of heat.

(b) How much power must the plant supply, assuming there is negligible power loss due to leakage?

(c) Characterise the step up transformer at the plant.

Answer

Total electric power required, P = 800 kW = 800×10^3 W

Supply voltage, V = 220 V

Voltage at which electric plant is generating power, V' = 440 V

Distance between the town and power generating station, d = 15 km

Resistance of the two wire lines carrying power = 0.5 Ω/km

Total resistance of the wires, R = (15 + 15)0.5 = 15 Ω

A step-down transformer of rating 4000 − 220 V is used in the sub-station.

Input voltage, V_1 = 4000 V

Output voltage, V_2 = 220 V

Rms current in the wire lines is given as:

$$I = \frac{P}{V_1}$$

$$= \frac{800 \times 10^3}{4000} = 200 \text{ A}$$

(a) Line power loss = I^2R

= $(200)^2 \times 15$

= 600×10^3 W

= 600 kW

(b) Assuming that the power loss is negligible due to the leakage of the current:

Total power supplied by the plant = 800 kW + 600 kW

= 1400 kW

(c) Voltage drop in the power line = IR = 200 × 15 = 3000 V

Hence, total voltage transmitted from the plant = 3000 + 4000

= 7000 V

Also, the power generated is 440 V.

Hence, the rating of the step-up transformer situated at the power plant is 440 V − 7000 V.

Question 7.26:

Do the same exercise as above with the replacement of the earlier transformer by a 40,000-220 V step-down transformer (Neglect, as before, leakage losses though this may not be a good assumption any longer because of the very high voltage transmission involved). Hence, explain why high voltage transmission is preferred?

Answer

The rating of a step-down transformer is 40000 V−220 V.

Input voltage, V_1 = 40000 V

Output voltage, V_2 = 220 V

Total electric power required, P = 800 kW = 800×10^3 W

Source potential, V = 220 V

Voltage at which the electric plant generates power, V' = 440 V

Distance between the town and power generating station, d = 15 km

Resistance of the two wire lines carrying power = 0.5 Ω/km

Total resistance of the wire lines, R = (15 + 15)0.5 = 15 Ω

$P = V_1 I$

Rms current in the wire line is given as:

$$I = \frac{P}{V_1}$$

$$= \frac{800 \times 10^3}{40000} = 20 \text{ A}$$

(a) Line power loss = I^2R

= $(20)^2 \times 15$

= 6 kW

(b) Assuming that the power loss is negligible due to the leakage of current.

Hence, power supplied by the plant = 800 kW + 6kW = 806 kW

(c) Voltage drop in the power line = IR = 20 × 15 = 300 V

Hence, voltage that is transmitted by the power plant

= 300 + 40000 = 40300 V

The power is being generated in the plant at 440 V.

Hence, the rating of the step-up transformer needed at the plant is 440 V − 40300 V.

Hence, power loss during transmission = $\frac{600}{1400} \times 100 = 42.8\%$

In the previous exercise, the power loss due to the same reason is $\frac{6}{806} \times 100 = 0.744\%$.

Since the power loss is less for a high voltage transmission, high voltage transmissions are preferred for this purpose.

*********** END **********