Copper and Electricity: Transformers and the Grid

Answers

1. Which of the following are true statements about a step-up transformer?

a) The voltage across the secondary coil is greater than the voltage across the primary.

True (as long as the input voltage is alternating).

b) There are fewer turns on the secondary coil than the primary.

False. A step-up transformer has more turns on the secondary coil.

c) The output power is greater than the input power.

False. This is impossible. In an ideal transformer, the power out is the same as the power in. In reality, the power out is slightly less.

d) The current in the secondary coil is greater than the current in the primary coil.

False. To get the same power going in as is coming out, the transformer draws a bigger current from its supply than the current it supplies to its load.

e) Attaching a 6 V battery to the primary coil will produce a bigger voltage on the secondary coil.

False. A battery is d.c.. The output voltage will be zero.

2. Imagine you want to supply electricity to a remote house, which has a peak requirement of 11.5 kW. The 3 km cable to the house has a resistance of 50Ω. It is suggested that the transmission cables use the same voltage as the house - 230 V. Work through the parts to see if this is sensible (use the peak power for all the parts).

a) What will the current in the transmission cable be?

$I = P/V$

$I = 11{,}500/230$

$I = 50$ A

b) What will the joule heating in the cable be?

Joule heating $= I^2R$

$= 50 \times 50 \times 50$

Joule heating = 125,000 W

c) What is the total input power needed to provide 11.5 kW to the house?

136,500 W

d) How efficient is this system?

8.4%

(11,500 × 100 ÷ 136,500)

Imagine that we increase the supply voltage by a factor of 30.

e) How much smaller will the current in the cables be?

30 times smaller.

f) How much smaller will the joule heating be?

900 times smaller. (It depends on the square of current and $30^2 = 900$.)

We will need a step-down transformer at the house to get the voltage back to 230 V.

g) What will be the turns ratio of the step down transformer?

30:1

h) Why do we need to reduce the voltage?

To make it safe. A supply voltage of 6,900 V would be very hazardous.

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