Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

$R_m = \dfrac{0.4}{4\pi \times 10^{-7} \times 2000 \times 5 \times 10^{-4}} = \mathbf{3.18 \times 10^5\ At/Wb}$; $\Phi = 1.2 \times 5 \times 10^{-4} = 0.6$ mWb, $F = \Phi R_m = 191$ At; $I = \dfrac{191}{400} = \mathbf{0.477\ A}$

2.2

$I_2 = \dfrac{240}{4} = \mathbf{60\ A}$; $a = 10$, $I_1 = \dfrac{60}{10} = \mathbf{6\ A}$; $Z' = a^2 \times 4 = \mathbf{400}\ \Omega$; check: $\dfrac{2400}{400} = 6$ A

2.3

full load: output 16 kW, $\eta = \dfrac{16}{16 + 0.3 + 0.5} = \mathbf{95.2}\%$

half load: copper loss $\dfrac{1}{4} \times 500 = 125$ W, $\eta = \dfrac{8}{8 + 0.3 + 0.125} = \mathbf{95.0}\%$

2.4

$x = \sqrt{\dfrac{300}{500}} = \mathbf{0.775}$; $0.775 \times 20 = \mathbf{15.5\ kVA}$; output 12.4 kW, losses 2×300 W: $\eta = \dfrac{12.4}{13.0} = \mathbf{95.4}\%$

3.1

$I_c = \dfrac{150}{220} = 0.682$ A, $R_c = \dfrac{220}{0.682} = \mathbf{323}\ \Omega$

$I_m = \sqrt{3.0^2 - 0.682^2} = 2.92$ A, $X_m = \dfrac{220}{2.92} = \mathbf{75.3}\ \Omega$

rated $I_1 = \dfrac{25\,000}{2200} = \mathbf{11.4\ A}$

$R_{eq} = \dfrac{400}{11.4^2} = 3.10\ \Omega$; $Z_{eq} = \dfrac{75}{11.4} = 6.60\ \Omega$

$X_{eq} = \sqrt{6.60^2 - 3.10^2} = \mathbf{5.83}\ \Omega$, both HV side

3.2

iron: $R = \dfrac{0.3}{4\pi \times 10^{-7} \times 3000 \times 4 \times 10^{-4}} = \mathbf{1.99 \times 10^5\ At/Wb}$

gap: $R_{gap} = \dfrac{10^{-3}}{4\pi \times 10^{-7} \times 4 \times 10^{-4}} = \mathbf{1.99 \times 10^6\ At/Wb}$, ten times the iron

$\Phi = \dfrac{250 \times 2}{2.19 \times 10^6} = \mathbf{0.228\ mWb}$; $B = \dfrac{0.228 \times 10^{-3}}{4 \times 10^{-4}} = \mathbf{0.571\ T}$

$L = \dfrac{N^2}{R_m} = \dfrac{250^2}{2.19 \times 10^6} = \mathbf{28.6\ mH}$

3.3

(a) A: $120{\times}24{+}300{\times}8{+}300{\times}0.01{\times}16 = \mathbf{5.33\ kWh}$; B: $60{\times}24{+}400{\times}8{+}400{\times}0.01{\times}16 = \mathbf{4.70\ kWh}$

(b) 0.62 kWh a day = 228 kWh a year = RMB 182 a year; $\dfrac{900}{182} = \mathbf{4.9\ years}$

(c) A: $2.88 + 7.2 = 10.1$ kWh; B: $1.44 + 9.6 = 11.0$ kWh; now **A** loses less, so B never repays

(d) A: $\sqrt{120/300} = 0.63$; B: $\sqrt{60/400} = 0.39$; choose the transformer whose best-efficiency load is close to the load it carries for most of its energy: low core loss for a lightly loaded unit, low copper loss for a heavily loaded one

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