Questão 01

a) $H_m l_m = N_1 i_1 + N_2 i_2$

$$H_m = \frac{N_1 i_1 + N_2 i_2}{l_m} = \frac{400 \times 2{,}0 - 200 \times 1{,}175}{2\pi \frac{25+20}{2} \times 10^{-2}} = \frac{565}{1{,}41372}$$

$H_m = 399{,}6548$ Ae/m $\xrightarrow{\text{curva}}$ $B_m = 0{,}6$ T

$$\Phi_m = B_m A_m = 0{,}6 \times \pi\left(\frac{r_1 - r_2}{2}\right)^2 = 0{,}6\,\pi\left(\frac{25-20}{2}\right)^2 10^{-4}$$

($\pi\left(\frac{25-20}{2}\right)^2 = 19{,}635$)

$\Phi_m = 0{,}0011781$ Wb

b) $H_m l_m + H_g l_g = N_1 i_1 + N_2 i_2$

$l_m = 1{,}41372 - 0{,}001 = 1{,}41272$ m

$1{,}41272\, H_m + 0{,}001\, H_g = 565$

$$1{,}41272\, H_m + 0{,}001 \frac{B_g}{\mu_0} = 565$$

$1{,}41272\, H_m + 795{,}77285\, B_g = 565$

$B_m A_m = B_g\, 1{,}05\, A_m \Rightarrow B_g = \frac{B_m}{1{,}05} = 0{,}95238\, B_m$

$1{,}41272\, H_m + 757{,}878\, B_m = 565$ (a)

$B_m = 0{,}5$T $\xrightarrow{(a)}$ $H_m = 131{,}704$ Ae/m $\xrightarrow{\text{curva}}$ $B_m \simeq 0{,}1$T

$B_m = 0{,}3$T $\xrightarrow{a}$ $H_m = 238{,}997$ Ae/m $\xrightarrow{\text{curva}}$ $B \simeq 0{,}25$T

⊛ $B_m = 0{,}3$T $\xrightarrow{a}$ $H_m = 265{,}808$ Ae/m $\xrightarrow{\text{curva}}$ $B \simeq 0{,}55$T

$B_m = 9{,}25$T $\xrightarrow{a}$ $H_m = 299{,}743$ $\xrightarrow{\text{curva}}$ $B \simeq 9{,}40$T

⊛ $B_m = 9{,}275$ $\xrightarrow{a}$ $H_m = 237{,}991$ $\longrightarrow$ $B \simeq 0{,}28$T

$B_m = \frac{0{,}3 + 0{,}275}{2} = 0{,}2875 \xrightarrow{a} H_m = 237{,}991$

Solução $B_m \simeq 0{,}29$T

$\Phi_m = B_m A_m = 0{,}29 \times 19{,}635 \times 10^{-4} = 0{,}0005694$ Wb

c) A existência de entreferro exige mais fmm para manter o fluxo magnético no núcleo constante.

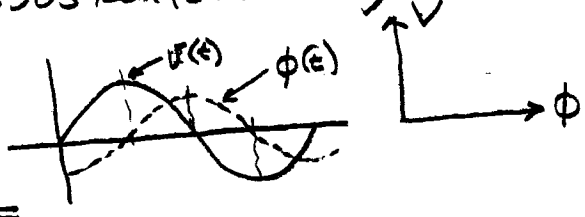
Questão 02

$v_1(t) = 220\sqrt{2}\,\text{sen}(2\pi 60t) = 220\sqrt{2}\,\text{sen}(377t)$

$v_1(t) = N\frac{d\phi}{dt} \rightarrow \phi(t) = \frac{1}{N_1}\int v(t)\,dt = \frac{1}{500}\int 220\sqrt{2}\,\text{sen}(377t)\,dt =$

$= -\frac{220\sqrt{2}}{377\times 500}\cos(377t) = 0{,}00165\,\text{sen}(377t - 90°)$

$\phi(t) = 0{,}00165\,\text{sen}(377t - 90°) =$
$= -0{,}00165\cos(377t)$



$B(t) = \frac{\phi(t)}{K_e A_n} = \frac{0{,}00165}{9{,}8525\times 10^{-2}}\,\text{sen}(377t - 90°) =$

$= 9{,}695\,\text{sen}(377t - 90°)$

a) $B_{ef} = \frac{0{,}695}{\sqrt{2}} = 0{,}491\ T$

b) $\phi(t) = 0{,}00165\,\text{sen}(377t - 90°) = -0{,}00165\cos(377t)\ Wb$

$v_2(t) = N_2\frac{d\phi}{dt} = 290\times 0{,}00165\times 377\cos(377t - 90°) =$

$= 180{,}395\,\text{sen}(377t) = 127{,}559\sqrt{2}\,\text{sen}(377t)\ V$

c) $V_2 = 127{,}559\ V$

d) $\mathcal{F}_{mmm_n} = \mathcal{R}_n\Phi_m$

$\mathcal{R}_n = \frac{1}{\mu}\frac{l}{A} = \frac{1}{2000\times 4\pi\cdot 10^{-7}}\frac{3{,}6}{0{,}95\times 25\times 10^{-4}} = 603112{,}1\ Ae/Wb$

$\mathcal{F}_{mmm} = 603112{,}1\times 0{,}00165 = 995{,}1\ Ae$

$\mathcal{F}_{mm} = N_1 i_1 \rightarrow i_1 = \frac{995{,}1}{500} = 1{,}990\ A$

Questão 03

a) $H_n l_n + H_g l_g = Ni$; $\frac{B_n}{\mu} l_n + \frac{B_g}{\mu_0} l_g = Ni$; $B_n = B_g$

$$\frac{B_n}{1100 \times 4\pi.10^{-7}} (2 \times 0{,}90 + 2 \times 0{,}85) + \frac{B_n}{4\pi.10^{-7}} 0{,}0024 = 400 \times 5$$

$$B_n = 0{,}450\,T$$

b) $W_n = \frac{B_n^2}{2\mu} V_n = \frac{0{,}45^2}{2 \times 4\pi.10^{-7} \times 1100} (2 \times 0{,}90 + 2 \times 0{,}85) \times 0{,}05^2 =$

$= 0{,}641\ j$

$W_g = \frac{B_g^2}{2\mu_0} V_g = \frac{0{,}45^2}{2 \times 4\pi \times 10^{-7}} 2 \times 9{,}0012 \times 0{,}05^2 = 0{,}483\ j$

$\frac{W_g}{W_n} = \frac{0{,}483}{0{,}641} = 0{,}7535$

$\frac{W_n}{V_n} = 73{,}247$ $\qquad$ $\frac{W_g}{V_g} = 80572{,}001$

c) O entreferro armazena a maior parte da energia por unidade de volume. Se o aço fosse melhor ($\mu/\mu_0 \times 2500$) W_n cairia para $0{,}282\ j$ e W_n/V_n para $32{,}229\ j$

Questão 03 – Para $l_m = 0{,}6\ m$

$$H_m l_m + H_g l_g = Ni$$

$$\frac{B_m}{\mu} l_m + \frac{B_g}{\mu_0} l_g = Ni \quad \text{e} \quad B_m = B_g$$

$$\frac{B_m}{1100 \times 4\pi \cdot 10^{-7}} 0{,}6 + \frac{B_m}{4\pi \cdot 10^{-7}} 0{,}0024 = 400 \times 5$$

$$434{,}0579\, B_m + 1909{,}8548\, B_m = 2000$$

$$B_m = 0{,}85327\ T$$

a) $B_g = B_m = 0{,}853\ T$

$$W_m = \frac{B_m^2}{2\mu} V_m = \frac{0{,}85327^2}{2 \times 1100 \times 4\pi \cdot 10^{-7}} 0{,}6 \times 0{,}25 \times 10^{-2} = 0{,}395\ j$$

$$W_g = \frac{B_g}{2\mu_0} V_g = \frac{0{,}85327^2}{2 \times 4\pi \times 10^{-7}} \times 0{,}0024 \times 25 \times 10^{-2} = 1{,}738\ j$$

b) $\frac{W_g}{W_m} = \frac{1{,}738}{0{,}395} = 4{,}40$

c) O entreferro armazena a maior parte da energia. Se o material magnético fosse melhor (aço Si) o armazenamento de energia no material magnético seria menor ainda.