# CORE GAPE 的 NORMALIZED 计算 (量化)

已知： $E = \frac{1}{2} B \times H \times V_e$ ， $H = \frac{B}{\mu_a}$ ， $\mu_a = \mu_0 \times \mu_i$

$E_c = \frac{1}{2} \frac{B^2}{\mu_c} \times A_e \times l_e$ ～①式

$E_g = \frac{1}{2} \frac{B^2}{\mu_0} \times A_e \times l_g$ ～②式

total Energy $= E_c + E_g = \frac{1}{2} B^2 A_e \left[ \frac{l_e}{\mu_c} + \frac{l_g}{\mu_0} \right] = \frac{1}{2} B^2 A_e \left[ \frac{l_e}{\mu_0 \cdot \mu_i} + \frac{l_g}{\mu_0} \right]$

$$= \frac{1}{2} B^2 A_e \left[ \frac{l_e + \mu_i l_g}{\mu_0 \mu_i} \right] = \frac{1}{2} B^2 A_e \left[ \frac{1 + \mu_i l_g / l_e}{\mu_0 \cdot \mu_i / l_e} \right]$$

這裏我們定義 $z = 1 + \mu_i \frac{l_g}{l_e}$ ～③式

∴上式可化為 $E = \frac{1}{2} B^2 A_e l_e \frac{z}{\mu_c}$ ～④式 ； $E = \frac{1}{2} L i^2$ ～(4A)式

依照上式等比例，我們可以求出，

$\frac{E_g}{E_c} = \frac{\mu_c}{\mu_0} \frac{l_g}{l_e} = \mu_i \frac{l_g}{l_e} = z - 1$ [①式與②式比較]

$\frac{E_g}{E} = \frac{l_g \cdot \mu_c}{\mu_0 \cdot z \cdot l_e} = \frac{\mu_i l_g}{z\, l_e} = \frac{z-1}{z} = 1 - \frac{1}{z}$ [②式與④式比較]

已知： $NI = H_c \cdot l_c + H_g \cdot l_g = \phi \left[ \frac{l_c}{\mu_c A_c} + \frac{l_g}{\mu_0 A_g} \right]$

一般而言, $A_c = A_g = A_e$ ，又如果 $l_c \gg l_g$ 則 $l_c \simeq l_e$

上式可化為 $\phi = \frac{NI A_e}{\frac{l_e}{\mu_c} + \frac{l_g}{\mu_0}} = \frac{NI \cdot A_e \cdot \mu_c}{l_e + \mu_i l_g}$ ，將 $z \cdot l_e = l_e + \mu_i l_g$ 代入左式 [from ③式]

$B = \frac{\phi}{A_e} = \frac{NI \mu_c}{z \cdot l_e} = \frac{\mu_0 \cdot \mu_i \cdot NI}{z\, l_e}$ ～⑤式

from ⑤式 $\frac{N\phi}{I} = \frac{N^2 \mu_c \cdot A_e}{z\, l_e}$

$$L = \frac{N\phi}{I} = \frac{1}{z} \left( \frac{\mu_0 \mu_i A_e}{l_e} \right) N^2$$ ～⑥式

将⑤式代入④式

$$E = \frac{1}{2}\left[\frac{u_c N I}{Z \cdot l_e}\right]^2 A_e \cdot l_e \frac{Z}{u_c} = \frac{1}{2}\frac{u_c (NI)^2 \cdot A_e}{l_e} \times \frac{1}{Z}$$

$$= \frac{u_0 u_i (NI)^2 A_e}{2\ l_e} \times \frac{1}{Z} \sim ⑦式$$

将⑤式代入①式

$$E_c = \frac{1}{2}\frac{1}{u_c}\left[\frac{u_c \cdot NI}{Z\ l_e}\right]^2 A_e \cdot l_e = \frac{1 \times u_c (NI)^2}{2\ \ l_e} \times \frac{1}{Z^2}$$

$$= \frac{u_0 \cdot u_i (NI)^2 A_e}{2\ l_e} \times \frac{1}{Z^2} \sim ⑧式$$

⑦式减⑧式

$$E_g = E - E_c = \frac{u_0 \cdot u_i (NI^2) A_e}{2 l_e}\ \frac{1}{Z}\left[1 - \frac{1}{Z}\right] \sim ⑨式$$

---

CHECH QP2925 200W 的计算

$A_e = 145\ mm^2$, $l_e = 50.5\ m/m$, $u_i = 2100$, $p_o = 200W$, $\eta = 0.93$, $p_i = 215W$

$Z = 1 + u_i \frac{l_g}{l_e}$，这裡我们 define $\frac{l_g}{l_e} = 1\%$

$i_{LPK} = \frac{2\ p_i}{90V} = 4.78A$

$L = 285uH$

$= 1 + 2100 \times 0.01 = 22$

from ④式

$$\frac{1}{2} L\, i_{LPK}^2 = \frac{1}{2} B^2 A_e \cdot l_e \frac{Z}{u_c} \Rightarrow 285uH \times 4.78^2 A = \frac{B^2 \times 145 \times 10^{-6} m^2 \times 50.5 \times 10^{-3} m \times 22}{4\pi \times 10^{-7} \frac{H}{m} \times 2100}$$

$$0.1067 = B^2 \quad \therefore B = 0.326\ tesla$$

from ⑤式

$$B = \frac{u_0 \cdot u_i N I}{Z \cdot l_e}, \quad N = \frac{B \cdot Z \cdot l_e}{u_0 \cdot u_i I}$$

$$= \frac{0.326\ tesla \times 22 \times 50.5 \times 10^{-3} m}{4\pi \times 10^{-7} \frac{H}{m} \times 2100 \times 4.78A} = 28.7\ turn.$$

亦可 from ⑥式

$$N^2 = \frac{L \times Z \times l_e}{u_0 \cdot u_i\ A_e}, \quad N = \left[\frac{285uH \times 22 \times 50.5 \times 10^{-3} m}{4\pi \times 10^{-7} \times 2100 \times 145 \times 10^{-6} m^2}\right]^{0.5} = 28.76\ turn$$

from $\frac{E_g}{E_c} = Z - 1$, $\left(\begin{matrix} l_g/l_e = 1\% \\ Z = 22 时 \end{matrix}\right)$, $E_c = \frac{E_g}{21} = 4.7\% \times E_g$

已知，No Gape 時， $B = \dfrac{u_0 \cdot u_i \cdot NI}{le}$

with Gape 時 from ⑤式 $B = \dfrac{u_0 \cdot u_i \, NI}{Z \, le} = B_{gape} = B_{core}$

$H_{core} = \dfrac{B}{u_c} = \dfrac{B}{u_0 \cdot u_i} = \dfrac{NI}{Z \, le}$ ～⑩式

$H_{gape} = \dfrac{B}{u_0} = \dfrac{u_i \, NI}{Z \, le}$ ～⑪式

由以推論可知，

$H_{gape} = u_i \times H_{core}$

$B = u_0 \cdot u_i \times H_{core}$

$B = u_0 \times H_{gape}$

$B \neq u_0 \cdot u_i \, H_{gape}$

---

$H_{gape} = \dfrac{2100 \times 28.7\,turn \times 4.78A}{22 \times 50.5 \times 10^{-3} m} = 259307 \dfrac{AT}{m}$

$1 \dfrac{AT}{m} = 4\pi \times 10^{-3} \, Oe \longrightarrow H_{gape} = 259307 \times 4\pi \times 10^{-3} = 3258.5 \, Oe.$

$B = u_0 \times H_{gape} = 4\pi \times 10^{-7} H/M \times 259307 \, AT/M = 0.326 \, tesla.$