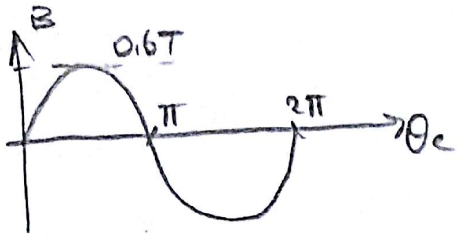
⊛ ϕ_{pp} calculation



$B = B_{max} \cdot \sin(\theta_e)$

$\phi_{pp} = \int B \cdot dA \qquad dA = r \cdot d\theta \cdot dl$

$$\phi_{pp} = \int_0^l \int_{\theta}^{\theta+\pi} B_{max} \cdot \sin(\theta_e)\, r\, d\theta\, dl = B_{max} \cdot r \cdot l \cdot \int_{\theta}^{\theta+\pi} \sin(\theta_e)\, d\theta = B_{max} \cdot r \cdot l \cdot \left(\cos\theta - \cos(\theta+\pi)\right)$$

$\phi_{pp} = 2 B_{max} \cdot r \cdot l \cdot \cos\theta \Rightarrow$ **$\phi_{pp} = 2.1\,mWb \times \cos\theta$**

OR $\phi_{pp} = B_{avg} \cdot A_{pole} \ldots$

⊛ N_{ph} calculation;

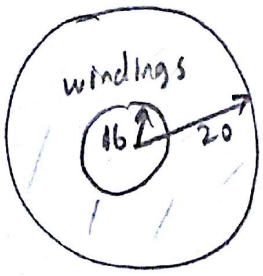
$n = 1500 = \frac{120 f}{P_{R_2}} \Rightarrow f = 25\,Hz$.

$E_{rms} = 4.44 \cdot N_{ph} \cdot f \cdot \phi_{pp} \cdot k_w$ (assume $k_w = 1$)

E_{rms}: 24V; f: 25; ϕ_{pp}: 2.1m

$\Rightarrow$ **$N_{ph} = 103$ turns/phase**

⊛ I, P calculation;



$Total\_area = \pi(20^2 - 16^2) = 452\,mm^2$

$winding\ area = 452\,mm^2 \times fill\ factor = 317\,mm^2$ (fill factor: 0.7)

$Total\ conductors = N_{ph} \times (\#\ of\ phase) \times 2 = 618$ (2: return)

$wire\_area = 317\,mm^2 / 618 = 0.51\,mm^2$

$dia\_wire = 0.8\,mm$ and $J = 4\,A/mm^2$

Pick AWG 20 cable (dia = 0.812mm)

$I = \dot{J}A \Rightarrow I = 2\,A_{rms}$ (4 ↑, 0.5↘1)

$P = 3 \times E_a \times I$

$P = 3 \times 24 \times 2 \Rightarrow \boxed{P = 144\ Watts}$

(A) Cu loss, winding resistance.

$R = \frac{\rho \ell}{A}$, $A \rightarrow 0.5\,mm^2$

$\ell = N_{ph} \times (38mm + 105mm)/2 = 29m$ / phase

$\rho = 1.68 \times 10^{-8}\ \Omega m$

$\boxed{R_{wdg} = 0.97\ \Omega/ph}$

$P_{cu\text{-}loss} = 3 \times I_{rms}^2 \times R_{wdg} \Rightarrow \boxed{P_{cu\text{-}loss} = 11.6\ W}$ (I_{rms}^2: 2)

$\eta = 0.925$

(A) winding distribution.

$k_d = 1$

$k_p = 1$

# of coils = 3