Magnetic Circuit

Given:

B_{ag} = 0,1T

Thickness = 2,5cm

N = 800 turns

Task: determine the current in the 800-turns coil.

1) Drawing and calculate the middle lengths (L) and the square units areas (S)

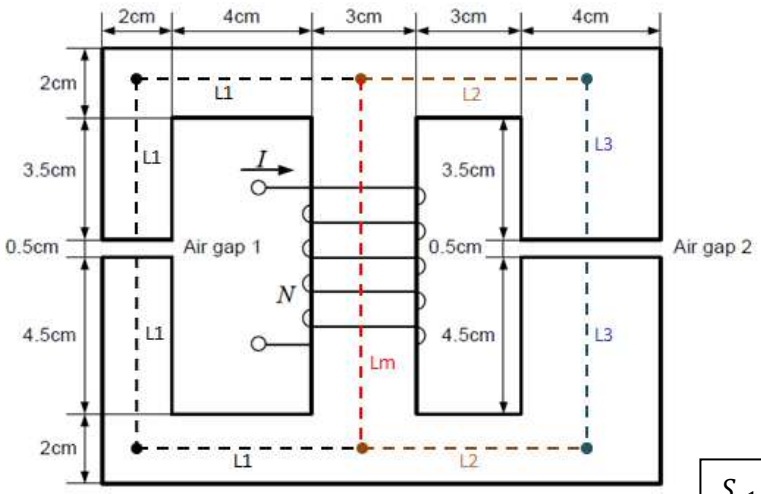


Figure 1. Magnetic circuit with the air-gaps.

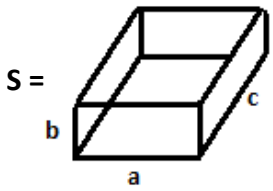
L1 = 23cm ≙ 0,23m

L2 = 13cm ≙ 0,13m

L3 = 10cm ≙ 0,10m

Lm = 10,5cm ≙ 0,105m

Lag1+2 = 0,5cm ≙ 0,005m



$S_{c1} = S_{c2} = 2{,}5cm \cdot 2cm = 5cm^2$

$S_{c3} = 2{,}5cm \cdot 4cm = 10cm^2$

$S_{cm} = 2{,}5cm \cdot 3cm = 7{,}5cm^2$

$S_{ag1} = (a + b)(c + b)$

$= (2cm + 0{,}5cm)(2{,}5cm + 0{,}5cm)$

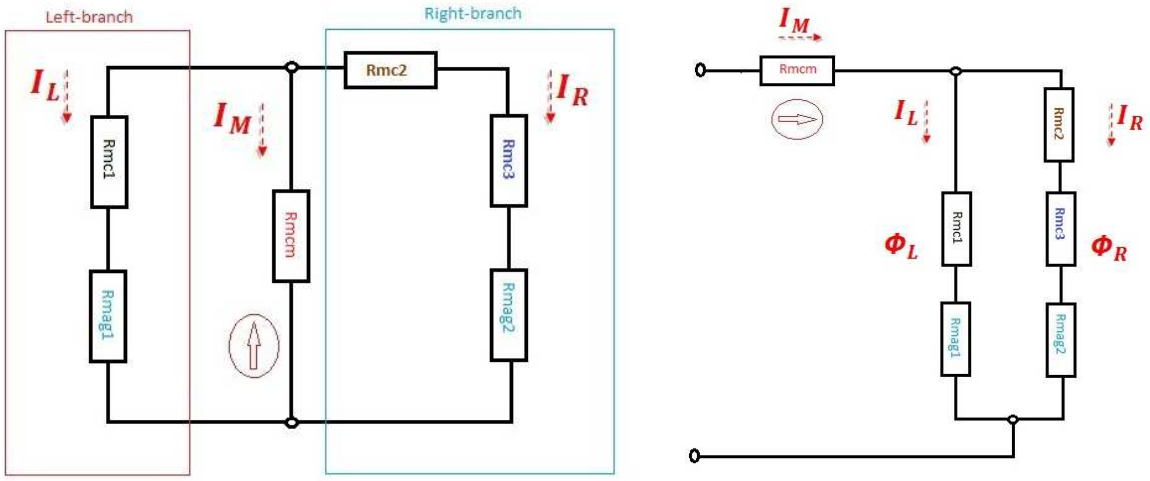
$= 7{,}5cm^2$

$S_{ag2} = (a + b)(c + b)$

$= (4cm + 0{,}5cm)(2{,}5cm + 0{,}5cm)$

$= 13{,}5\ cm^2$

2) Determine the equivalent circuit diagram.



3) Calculation all of the magnetic reluctances for the left branch (Rm)

$$Rmc1 = \frac{L1}{S_{c1} \cdot \mu_r \cdot \mu_0}$$

$$Rmc1 = \frac{0{,}23m}{5cm^2 \cdot 600Hm^{-1} \cdot 4\pi \cdot 10^{-7}}$$

$$\text{Rmc1} = 610.093{,}948\,\frac{A}{Wb}$$

$$Rmag1 = \frac{Lag1}{S_{ag1} \cdot \mu_r \cdot \mu_0}$$

$$Rmag1 = \frac{0{,}005m}{7{,}5cm^2 \cdot 4\pi \cdot 10^{-7}}$$

$$Rmag1 = 5.305.164{,}77\frac{A}{Wb}$$

Total Reluctance of the left branch:

$$Rm_{left} = \text{Rmc1} + Rmag1$$

$$Rm_{left} = 610.093{,}948\,\frac{A}{Wb} + 5.305.164{,}77\frac{A}{Wb} = 5.915.258{,}718\frac{A}{Wb}$$

4) Calculation all of the magnetic reluctances for the right branch (Rm)

$$Rmc2 = \frac{L2}{S_{c2} \cdot \mu_r \cdot \mu_0}$$

$$Rmc2 = \frac{0{,}13m}{5cm^2 \cdot 600Hm^{-1} \cdot 4\pi \cdot 10^{-7}}$$

$$\text{Rmc2} = 344.835{,}71\frac{A}{Wb}$$

$$Rmc3 = \frac{L3}{S_{c3} \cdot \mu_r \cdot \mu_0}$$

$$Rmc3 = \frac{0{,}10m}{10cm^2 \cdot 600Hm^{-1} \cdot 4\pi \cdot 10^{-7}}$$

$$\text{Rmc3} = 132.629{,}12\,\frac{A}{Wb}$$

$$Rmag1 = \frac{Lag1}{S_{ag1} \cdot \mu_r \cdot \mu_0}$$

$$Rmag1 = \frac{0{,}005m}{7{,}5cm^2 \cdot 4\pi \cdot 10^{-7}}$$

$$Rmag1 = 5.305.164{,}77\frac{A}{Wb}$$

Total Reluctance of the right branch:

$$Rm_{right} = Rmc2 + Rmc3 + Rmag2$$

$$Rm_{right} = 344.835{,}71\frac{A}{Wb} + 132.629{,}12\,\frac{A}{Wb} + 2.947.313{,}761\,\frac{A}{Wb} = 3.424.778{,}591\frac{A}{Wb}$$

5) Determine magnetic Flux and magnetomotive force in the left Air gab

$$\Phi_{left} = B_{ag} \cdot S_{ag1}$$
$$= 0{,}1T \cdot 7{,}5cm^2$$
$$= 7{,}5 \cdot 10^{-5}\,Wb$$

$$\Theta_{left} = \Phi_{left} \cdot Rm_{left}$$
$$= 7{,}5 \cdot 10^{-5}\,Wb \cdot 5.915.258{,}718\frac{A}{Wb}$$
$$= 443{,}644\ \text{A}$$

6) Determine magnetic Flux and magnetomotive force in the right Air gab

$$\Phi_{right} = \frac{\Theta_{left}}{Rm_{right}}$$
$$= \frac{443{,}644\ \text{A}}{3.424.778{,}591\frac{A}{Wb}}$$
$$= 1{,}3 \cdot 10^{-4}\,Wb$$

$$\Theta_{left} = \Theta_{right}$$

7) Calculations for the middle branch

$$Rmcm = \frac{Lm}{S_{cm} \cdot \mu_r \cdot \mu_0}$$

$$Rmcm = \frac{0{,}105m}{7{,}5cm^2 \cdot 600Hm^{-1} \cdot 4\pi \cdot 10^{-7}}$$

$$\text{Rmcm} = 185.680{,}767\,\frac{A}{Wb}$$

$$\Phi_{middle} = \Phi_{left} + \Phi_{right}$$
$$= 7{,}5 \cdot 10^{-5}\,Wb + 1{,}3 \cdot 10^{-4}\,Wb$$
$$= 2{,}05 \cdot 10^{-4}\ \text{Wb}$$

$$\Theta_{middle} = \Phi_{middle} \cdot Rmcm$$
$$= 2{,}05 \cdot 10^{-4}\ \text{Wb} \cdot 185.680{,}767\,\frac{A}{Wb}$$
$$= 38{,}064\ \text{A}$$

8) Total calculations and result

$$\Theta_{total} = \Theta_{left/right} + \Theta_{middle}$$

$$= 443{,}644 + 38{,}064 \text{ A}$$

$$= 481{,}70 \text{ A}$$

Total supply current:

$$\boldsymbol{I_{middle}} = \frac{\Theta_{total}}{\text{turns}_{\text{middle}}}$$

$$= \frac{481{,}70 \text{ A turns}}{800 \text{ turns}}$$

$$= \mathbf{0{,}602\ A}$$