第二十一章　磁介质

21.1 解：　　$\chi_m = \mu_r - 1$

$\therefore \quad \chi_{mAl} = 1.000023 - 1 = 0.000023 > 0$

属于顺磁质

$\chi_{mCu} = 0.9999912 - 1 = -0.0000088 < 0$

属于抗磁质

21.2 解：（1）　　$\int \boldsymbol{H} \cdot \mathrm{d}\boldsymbol{l} = 2\pi r H = NI$

$$H = \frac{N}{2\pi r} I$$

$$= \frac{400}{0.4} \times 20$$

$$= 2.0 \times 10^4 \ \mathrm{A/m}$$

（2）　　$$M = \frac{B}{\mu_0} - H = \frac{1.0}{4\pi \times 10^{-7}} - 2.0 \times 10^4$$

$$= 7.76 \times 10^5 \ \mathrm{A/m}$$

（3）对于非软性物质

$$\chi_m = \frac{M}{H} = \frac{7.76 \times 10^5}{2.0 \times 10^4} = 38.8$$

（4）　　Q　$M = i_s$

$\therefore \quad I_s' = 2\pi r i_s$

$$= 0.4 \times 7.76 \times 10^5$$

$$= 3.1 \times 10^5 \ \mathrm{A}$$

$\mu_r = 1 + \chi_m = 39.8$

21.3 解：由于通电流的导体为同心的圆柱或圆筒，故其磁场分布必然相对于O轴对称，即在与电缆同轴的圆柱面上各点的$\dot{\boldsymbol{H}}$大小相等，方向与电流I成右手螺旋关系。假设圆柱内电流垂直纸面向外，圆筒内电流垂直纸面向里，取轴上一点O为圆心，半径为r的圆周为积分环路L，使其绕向与电流右手螺旋关系。由安培环路定理

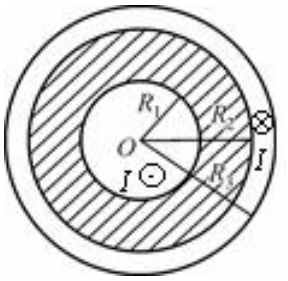

图 21.3

（1）当$r < R_1$时　　$\int_L \dot{\boldsymbol{H}} \cdot \mathrm{d}\dot{\boldsymbol{l}} = I'$

$$H \cdot 2\pi r = \frac{Ir^2}{R_1^2}$$

$$H = \frac{Ir}{2\pi R_1^2}$$

$$B = \mu_0 \mu_{r_1} H = \frac{\mu_0 \mu_{r_1}}{2\pi R_1^2} Ir$$

（2）当$R_1 < r < R_2$时　　$\int_L \dot{\boldsymbol{H}} \cdot \mathrm{d}\dot{\boldsymbol{l}} = I$

$$H \cdot 2\pi r = I$$

$$H = \frac{I}{2\pi r}$$

$$B = \mu_0 \mu_{r_2} H = \frac{\mu_0 \mu_{r_2} I}{2\pi r}$$

（3）当$R_2 < r < R_3$时　　$\int_L \dot{\boldsymbol{H}} \cdot \mathrm{d}\dot{\boldsymbol{l}} = I - I''$

$$H \cdot 2\pi r = I - \frac{r^2 - R_2^2}{R_3^2 - R_2^2} I$$

$$H = \frac{I}{2\pi r}\left(\frac{R_3^2 - r^2}{R_3^2 - R_2^2}\right)$$

$$B = \mu_0 \mu_{r_1} H = \frac{\mu_0 \mu_{r_1} I}{2\pi r\left(R_3^2 - R_2^2\right)}\left(R_3^2 - r^2\right)$$

（4）当$r > R_3$时　　$\int_L \dot{\boldsymbol{H}} \cdot \mathrm{d}\dot{\boldsymbol{l}} = 0$

$$H = 0 \qquad B = 0$$

21.4 解：（1）　　$\int \dot{\boldsymbol{H}} \cdot \mathrm{d}\dot{\boldsymbol{l}} = NI$

$$2\pi r H = NI$$

$$H = \frac{N}{2\pi r} I$$

$$= \frac{200}{0.1} \times 0.1 = 200 \text{ A} \cdot \text{m}$$

$$B = \mu_0 \mu_r H = 4\pi \times 10^{-7} \times 4200 \times 200$$

$$= 1.06 \text{ T}$$

（2）

$$\int \boldsymbol{B} \cdot \mathrm{d}\boldsymbol{l} = \mu_0 NI$$

$$B_0 = \frac{\mu_0 NI}{2\pi r} = \frac{4\pi \times 10^{-7} \times 200 \times 0.1}{0.1}$$

$$= 2.5 \times 10^{-4} \text{ T}$$

$$B' = B - B_0 = 1.06 - 2.5 \times 10^{-4} \quad 1.06 \text{ T}$$