Perancangan Mesin Listrik

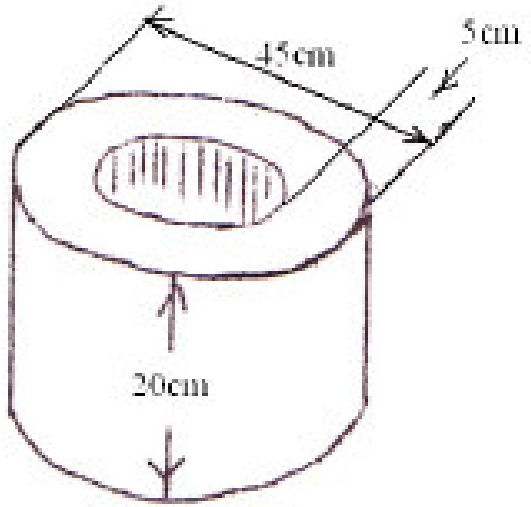
Soal-soal Perancangan Kumparan Medan

Perancangan Kumparan Medan

Contoh 1.

Sebuah koil kumparan medan pada inti bulat dengan lebar 20cm, tebal 5cm dan diameter luar 45 cm menghasilkan rugi daya 0,1 W/cm^2. Tentukan ampere-turn yang sesuai jika tegangan terminal 50V dan faktor ruang $S_f = 0,6$

($\rho = 2\mu\Omega/cm^3$)



Field coil

Perancangan Kumparan Medan

Contoh 1.

Diketahui :

$h_f = 20cm$ $d_f = 5\ cm$ $\rho = 2\mu\Omega/cm^3$

$d_{luar} = 45cm$ $Loss/cm^2 = 0{,}1\ W/cm^2$

$V = 50\ Volt$ $S_f = 0{,}6$

Tanya : $I_f T_f = ?$

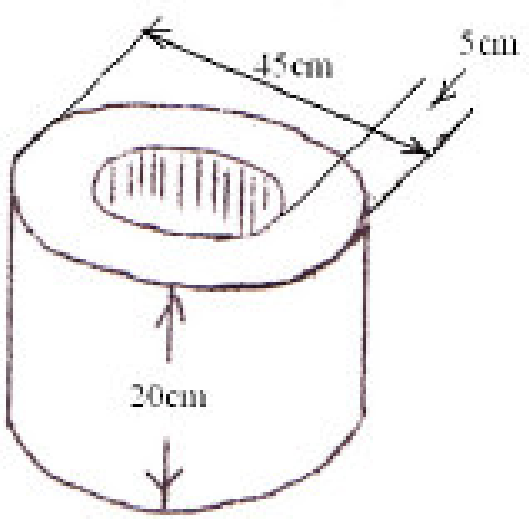
Jawab.

$Loss = V_f I_f = (Loss/cm^2)$luas permukaan luar koil cm^2

$V_f I_f = (Loss/cm^2)\pi(d_{luar})h_f$

$(50)I_f = (0{,}1)\pi(45)(20)$

$I_f = 5{,}65\ A$



Field coil

Perancangan Kumparan Medan

Contoh 1.

$$S_f = \frac{a_f T_f}{h_f d_f}, \quad 0.6 = \frac{a_f T_f}{20 \times 5}$$

$$a_f T_f = 60$$

$$a_f = \frac{\rho L_{mt} I_f T_f}{V_f}$$

$L_{mt} = \pi \times$ diameter rata-rata koil

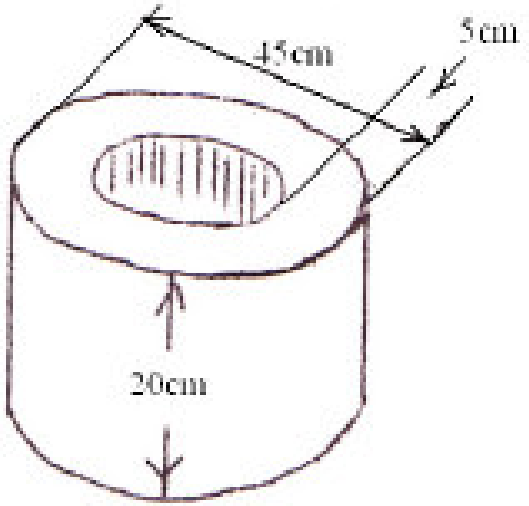
$$L_{mt} = \pi \times 40$$

$$a_f = \frac{2 \times 10^{-6} \times \pi \times 40 \times 5.65 T_f}{50}$$

$$a_f = 2.84 \times 10^{-5} T_f$$

$$2.84 \times 10^{-5} T_f^2 = 60 \quad or \quad T_f \approx 1454$$

maka $I_f T_f = 5.64 \times 1454 = 8212.3$



Field coil

Perancangan Kumparan Medan

Latihan 1.

Hitunglah ampere-turn koil pada contoh 1 diatas jika lebar koilnya adalah 15 cm !

Perancangan Kumparan Medan

Contoh 2.

A 440V, dc shunt generator develops 7200 ampere-turns/pole in the field winding and has 6 poles. Depth of the field coil 3.5 cm, mean length of the turn 120cm, field coil height 18cm, the resistivity is $2.1\text{x}10^{-6}\Omega$ cm. If the cooling surface required is $15cm^2/watt$ and 15% of the voltage is absorbed in the field rheostat, find the number of turns and cross-sectional area of the field winding conductor. Consider heat dissipation only from the inside and outside cylindrical surfaces of the coil.

Perancangan Kumparan Medan

Number of turns $T_f = \frac{\text{ampere turns} I_f T_f}{\text{field current} I_f}$

field current $I_f = \frac{field\ copper\ loss\ V_f I_f}{voltage\ across\ each\ coil\ V_f}$

$Inside\ and\ outside\ cylindrical\ surface\ \approx 2L_{mt}h_f = 2 \times\ 120\ \times 18 = 4320cm^2$

Since 15 cm^2 is dissipating 1.0 W, 4320cm^2 dissipates $\frac{4320}{15} = 288W$

Voltage across each coil $V_f = \frac{0.85V}{P} = \frac{0.85 \times 440}{6} = 62.33V$

Therefore $I_f = \frac{288}{62.33} = 4.62A\ \ and\ \ T_f = \frac{7200}{4.62} \approx 1558$

$$a_f = \frac{\rho L_{mt} I_f T_f}{V_f} = \frac{2.1 \times 10^{-6} \times 120 \times 7200}{62.33} = 0.028 cm^2$$

Perancangan Kumparan Medan

Contoh 3.

Each pole of a dc generator is required to produce 19000 ampere turns. The gap flux/pole is 0.2Wb. The leakage coefficient for the pole = 1.2 and the flux density in the pole core of circular cross section is 1.5T. The field coil has a radial depth of 15cm and can dissipate $0.05W/cm^2$ of the outside cylindrical surface without overheating. Determine the diameter of the wire, number of turns and height of the coil. Voltage across the coil may be taken as 60V and space factor 0.7.

Perancangan Kumparan Medan

Diamter of the bare wire $d_w = \sqrt{\frac{4a_f}{\pi}}$

$$a_f = \frac{\rho L_{mt}(I_f T_f)}{V_f}$$

Let the resistivity of copper $\rho = 0.021 \Omega/m/mm^2$

$L_{mt} = \pi(d_i + 2t_i + d_f)$

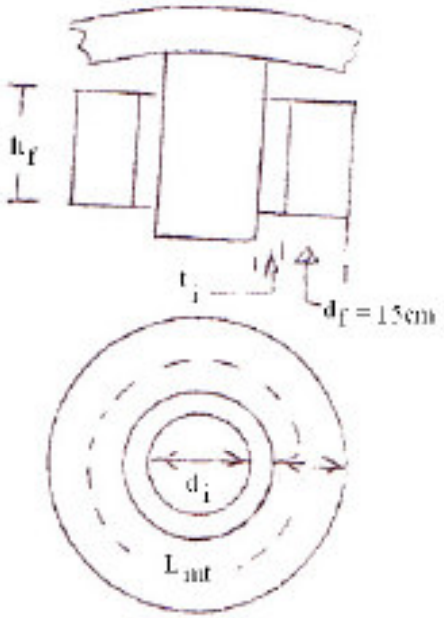
Cross sectional area of the pole $A_P = \frac{\phi \times LC}{B_P} = \frac{0.2 \times 1.2}{1.5} = 0.16m^2$

Diameter of the pole body $A_P = \sqrt{\frac{4A_P}{\pi}} = \sqrt{\frac{4 \times 0.16}{\pi}} = 0.45m$

$L_{mt} = \pi(45 + 2 \times 1 + 15) = 194.7\text{cm}$ *with the assumption that* $t_i = 1.0\text{cm}$

$$a_f = \frac{0.021 \times 1.947 \times 19000}{60} = 12.94mm^2$$

$$d_w = \sqrt{\frac{4 \times 12.94}{\pi}} \approx 4mm$$



Perancangan Kumparan Medan

$$\text{Loss} = V_f I_f = \frac{V_f(I_f T_f)}{T_f}$$

$$= Loss/cm^2 \times \text{outside cylindrical surface } \pi(d_i + 2t_i + 2d_f)h_f \text{ in cm}^2$$

$$= \frac{60 \times 19000}{T_f} = \pi(45 + 2 \times 1 + 2 \times 15)h_f$$

$$h_f T_f = 94252.8 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$\text{Since space factor } S_f = \frac{a_f T_f}{h_f d_f}, \quad 0.7 = \frac{12.94 \times 10^{-2} T_f}{h_f \times 15}$$

$$or\ h_f = 0.0123 T_f \quad \ldots\ldots\ldots\ldots\ldots (2)$$

From equations 1 and 2, $0.0123 T_f^2 = 94252.8$

Perancangan Kumparan Medan

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Therefore, number of $turns/pole\ T_f = \sqrt{\frac{94252.8}{0.0123}} \approx 2765$

Height of the field coil $h_f = 0.0123 \times 2765 \approx 34cm.$